Physical Science 20
Lab Manual

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Lab Safety

Safety is essential in a science lab, due to the serious risks that can occur from mishandled chemicals, glassware and other material. It is vital that all students are aware of the lab's safety equipment, in particular where it is stored and how to use it. Additionally, students need to act in a conscientious and cautious manner when conducting an experiment or working in the lab.

Safety Equipment

Eyewash Station

An eyewash is used to flush out one or both eyes if they have been contacted with a chemical or abrasive substance. In serious cases, flushing should occur immediately for at least ten minutes (or more, depending on the nature of the substance) using a water faucet.

Safety Shower

The safety shower is used for two purposes: for major chemical spills onto a person's body or if a person's clothing has caught fire. If a chemical has spilled on clothing, it is important that contaminated clothing is removed once in the safety shower, to prevent further injury to the skin.

First Aid Kit

The first aid kit contains a number of items for dealing with minor cuts, burns and scrapes. Inform Ms. Hayduk of any injuries incurred during a lab, regardless of how severe they are.

Fire Extinguisher

Fire extinguishers should be used for putting out small to medium sized fires that are uncontrolled. Before using a fire extinguisher, it is important to ensure it is appropriate for the type of fire. An ABC fire extinguisher, or an all-purpose fire extinguisher, is the most common, because it will put out the most common types of fire – ordinary combustibles, flammable liquids and electrical fires.

Spill Kit

A spill kit contains a number of absorbent substances that can be used to neutralize and safety clean up chemical spills in the lab. A serious chemical spill includes substances that cannot be handled safely (highly corrosive) or an unknown mixture of chemicals. If a serious chemical spill occurs, find Ms. Hayduk immediately; do not attempt to clean up the spill. Ensure that other students remain clear of the area.

Personal Protective Equipment

Personal protective equipment refers to all clothing, helmets and eyewear designed to protect the wearer from injury. Prior to any lab, Ms. Hayduk will inform you which equipment is required to be worn during the activity. Students must wear all of this equipment for the duration of the lab, even if they have completed the activity, provided they are still in the lab area.

Specific Emergency Procedures

Fire

- If the fire is small, use the appropriate fire extinguisher on the fire or extinguish it with a lid or blanket.
- To use a fire extinguisher, follow the acronym PASS: pull out the pin, aim the nozzle at the base of the fire, squeeze the trigger and sweep the spray along the base of the fire until it is extinguished.

- If the fire is large and cannot be controlled, leave the room immediately and pull the fire alarm. All students should file out of the building in a calm manner to the designated meeting spot outside. The last student out of the room should shut the door to impede spread of the fire.
- If a fire alarm goes off during an experiment, students should shut off all gas and heat sources before exiting the lab.

Spill

- If the spill is a harmless substance (e.g. water, vinegar), clean it up immediately with paper towel.
- If the spill is a more hazardous substance, inform Ms. Hayduk immediately. She will clean the spill with the spill kit. If possible, block the spill from spreading and remove any books, bags or personal items from the area.
- If more than one hazardous chemical spills in the same area, especially if they are of unknown composition, tell Ms. Hayduk and evacuate the room immediately. She will assess the danger and take steps to decontaminate the area

Injury

- For minor injuries, use the first aid kit. Make sure to clean any cuts or scrapes before applying a bandage.
- For serious injuries, inform Ms. Hayduk immediately and use a cell phone or the office phone to call 911. Make sure to tell EMS if the injury was caused by contact with a chemical (or broken glass contaminated with chemical).

Laboratory Safety Procedures

This list of safety procedures is general and does not cover all aspects of safety in the lab. It is important that students use common sense and caution when working in the science lab; ask for help when instructions or procedures are unclear.

1. Behave in a calm, professional, responsible manner at all times.
2. No food in the lab at any time.
    - Beverages are allowed provided they are in re-sealable containers.
    - Never eat any materials being used for experiments.
3. Use the appropriate personal protective equipment for the activity you (or others) are performing.
    - Do not remove your PPE until you are instructed to do so by the teacher.
4. Keep yourself, your equipment and your workstation clean before, during and after the lab.
    - Handle equipment with care.
    - Wash glassware thoroughly with soap and water.
    - After handling chemicals, wash hands thoroughly with soap and water.
    - Keep aisles and table tops clear of bags and books.
5. Dispose of materials properly.
    - Do not dump any chemicals down the drain unless instructed to by the teacher.
    - Do not put any solid material in the drains.
    - Sharp materials (e.g. dissection pins, broken glass) should be disposed of in the proper waste container – never in the garbage can.
6. Do not touch any chemicals or equipment you have not been instructed to handle.
    - Do not smell or taste chemicals.
    - Do not try any unauthorized experiments.

- Do not enter the science storage room.
7. Never leave your lab station unattended.
8. Dress appropriately.
    - Tie back long hair.
    - Avoid wearing loose or dangling clothes or jewelry around chemicals or open flames.
    - Wear closed-toed shoes.
9. Report any accident or incident immediately.

Students who do not follow these safety procedures will not be permitted in the science lab.

WHMIS

WHMIS stands for Workplace Hazardous Material Information System. It is a program designed to protect workers (e.g. students and teachers) who are handling chemicals on a regular basis. There are three key elements to WHMIS:

1. Labels,
2. Safety data sheets; and,
3. Education and training.

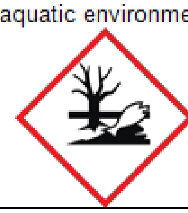
As a student, your primary concern will be with labels and safety data sheets (SDS).

Labels

The purpose of a WHMIS label is to identify the product as controlled and alert the user to the hazards and safe handling procedures of the product. The label provides a summary of the important information about the substance.

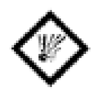
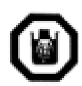
As a student, your responsibility is to ensure that any chemicals left in the lab in beakers, flasks or test tubes are labelled with your name, a date and some indication of what is included in the container. You can do this with marker or wax pencil straight on the glassware, or with a paper label firmly attached.

Hazard Symbols

GHS01 Explosive 	GHS02 Flammable 	GHS03 Oxidising 
GHS04 Gas Under Pressure 	GHS05 Corrosive 	GHS06 Acute Toxic 
GHS07 Harmful / Irritant / Skin sensitiser 	GHS08 Carcinogen / Germ cell mutagen / Reproductive toxin 	GHS09 Hazardous to the aquatic environment 

International Hazard Symbols

Not all products and substances are controlled by WHMIS, so they may not have WHMIS labels or symbols. These are other symbols you may see on other household products. The border of the symbol represents the level of danger, and the symbol inside represents the specific hazard. "Danger", shown with an octagon, is the biggest threat. "Caution", given by an upside down triangle, is a smaller threat but should still be considered dangerous!

	Danger	**Warning**	**Caution**
Poison			
Flammable			
Explosive			
Corrosive			

Safety Data Sheets

Safety data sheets (SDS) are used to give more detailed information about the product than the information on the WHMIS label. The information includes:

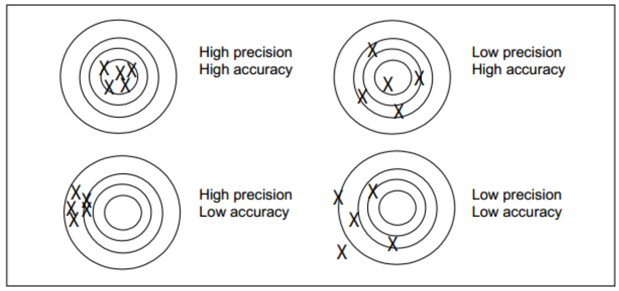
1. Chemical Identification (name, uses, restrictions, supplier information)
2. Hazards (symbol and specific statements)
3. Ingredients and Composition
4. First Aid Measures
5. Fire-Fighting Measures
6. Accidental Release Measures
7. Handling and Storage
8. Exposure Controls and Personal Protection
9. Physical and Chemical Properties
10. Reactivity
11. Toxicological Information
12. Ecological Information (optional)
13. Disposal Considerations (optional)
14. Regulatory Information (optional)
15. Date of Revisions

SDS are available online. It is expected that all students will review the SDS for any chemicals they have not previously handled prior to every lab so they know the safety hazards and the personal protective equipment they should wear.

Experimental Error and Measurements

Accuracy and Precision

Experimental error is the difference between a measurement and the true value, or between two measured values. The amount of error is determined by accuracy and precision.



Accuracy tells how close a measured value is to the theoretical, accepted or "true" value. If this value is unknown, then the accuracy of a measurement cannot be determined.

Precision measures how close two or more measurements are to each other. Precision can also be called "repeatability" or "reproducibility". A measurement that is highly precise, or highly reproducible, will give values that are very close.

Experimental Error

Experimental errors are **unavoidable** influences in performing an experiment or making a measurement that affect the accuracy of the results. "Human errors" are not considered sources of experimental error, since they can be eliminated by careful technique and repeating the procedure if mistakes are made.

Systematic errors, or bias, are a type of experimental error that affect accuracy of a measurement. They are generally caused by flaws in equipment, and are generally difficult to detect. These errors are "one-sided", meaning they will usually give results that are close to each other, but are not close to the true value. Systematic errors can be caused by uncalibrated measuring instruments and flaws in instrument construction.

Random errors affect the precision of a measurement. These errors are "two-sided" because they can fluctuate above or below the true value in repeated trials. Random errors can be reduced by repeating the procedure and taking average values or by using better quality instruments. Common sources of random errors include estimating a measurement that is between graduations on an instrument or recording a value that fluctuates during the reading.

GENERAL Sources of Error

Random error (inconsistencies) in reading measurements	Residue from pouring from one container to another
Contaminants on equipment or in chemicals	Lots of measurements that increase uncertainty in calculations
Calibration of measuring tools (systematic error)	Subjectivity of reading measurements at eye-level (parallax error)
Impurities in chemicals	Reaction does not go to completion
Not enough trials or data	Volume or volume changes are too small to read easily
Heat loss to the environment	Unexpected side reactions

Calculating Experimental Error

Accuracy of Equipment

All measuring equipment has precision depending on the smallest unit of measurement on the instrument.

- Digital Devices:
  - Give the exact reading on the device.
  - The error is half of the last decimal place.

  Example: On a scale with one decimal place, a measurement could be 12.6 g ±0.05 g. This means the mass is somewhere in the range of 12.55 g to 12.65 g.
- Analog Devices:
  - Read to one-half of the smallest graduation.
  - The error is one-half of one graduation.

  Example: For example, a ruler that has graduations of 1 mm must have a measurement that ends in .0 mm or .5 mm, and that length is precise to ±0.5 mm .

Digital equipment and some chemistry glassware generally has a specified accuracy that is written on the instrument. With glassware, some equipment is deliberately very precise (e.g. volumetric flasks), while others are not really intended to be used for measurements (e.g. beakers).

Percent Error

Percent error is the difference in accuracy between a measured, or experimental, value and the true, or accepted, value. It is calculated as follows:

$$\%\ Error = \frac{|Experimental - Accepted|}{Accepted} \times 100$$

The vertical lines on the top of the equation indicates absolute value, which means that negative signs are ignored. If you get a negative answer, record the value without the negative sign.

Percent error can only be used if the true value is known, or can be calculated.

Percent Yield

Percent yield indicates how much product was actually created based on the “ideal”, theoretical amount that could be created if the reaction went perfectly. The equation used is:

$$\%yield = \frac{actual}{theoretical} \times 100$$

Percent Difference

Percent difference is used in place of percent error when the true value is unknown. It is used to find the precision of repeated measurements (experimental values, E). The equation used is:

$$\%\ Difference = \frac{|E_1 - E_2|}{\left(\frac{E_1 + E_2}{2}\right)} \times 100$$

Unit Conversions and Scientific Notation

Metric Unit Conversions

To convert between metric units in the same "category", use the staircase method:

Tera	Giga	Mega	Kilo	Hecto	Deca	**BASE**	Deci	Centi	Milli	Micro	Nano	Pico
T	G	M	k	h	da		d	c	m	µ	n	p
10^{12}	10^{9}	10^{6}	1000	100	10	**1**	0.1	0.01	0.001	10^{-6}	10^{-9}	10^{-12}

To move to a smaller unit, **multiply** by the number of steps it takes to get to the right prefix.
For example, 5 km = (5×10000) cm = 50000 cm, since it takes five steps to get from kilo to centi.

To move to a larger unit, **divide** by the number of steps it takes to get to the right prefix.
For example, 30 mg = (30÷1000) g = 0.03 g, since it takes three steps to get from milli to "base".

Scientific Notation

Scientific notation is used for very large or very small numbers, which are common in science! It is written as a product (multiplication) between a number between 1 and 10 and a power of 10.

3.45×10^{5} is a big number. It has a positive exponent.

2.31×10^{-4} is a small number. It has a negative exponent.

Many scientific calculators have a button that allows the user to enter numbers in scientific notation. It may be "EXP", "$\times 10^{x}$", "EE" or "$y^{1/x}$". It is important that students learn to use this function on their own calculator, to make calculations with scientific notation easier.

To convert to scientific notation:

1. Create a number between 1 and 10 by moving the decimal (for whole numbers, it is after the last digit) to the left. There should be only one non-zero number before the decimal.
2. Count the number of spaces the decimal moves to determine the exponent on the 10.
   a. If the decimal moves left, the exponent is positive.
   b. If the decimal moves right, the exponent is negative.

Example: 3 346 000 000 = 3.346×10^{9}

The decimal moved from the right of the last zero nine places to the left, which gives the exponent of 9. This number has four significant digits, but more could be added by putting zeros or removed by rounding (e.g. 3.346 to 3.35).

To convert to standard form:

1. Multiply the two terms (the decimal between 1 and 10 and the power of 10) together; to ensure you are multiplying or dividing properly. Ask, "Is it reasonable?" after doing a calculation. If you get an answer of 1000 km in 1 m, and you know kilometres are much bigger than metres, you should recognize that the answer does not make sense and there was an error in the calculation.

Comparing Values of Scientific Notation

Numbers with higher exponents on the 10 are greater:

$10 > 3$ $4 > -1$ $-2 > -5$

For numbers with the same exponent, numbers with a larger decimal value are greater:

$$6.43 \times 10^5 > 2.17 \times 10^5$$

$$3 \times 10^{-2} > 1 \times 10^{-2}$$

Factor-Label Method

The factor-label method, also called dimensional analysis, is a problem solving method used for unit conversions and stoichiometric calculations. It is based on the idea of "cancelling" units to get the desired result. To get from one unit to another, conversion factors are used to change the units to the correct ones.

Example: How many inches are in 32 km?

The unit conversions here are:

1.6 km = 1 mile   1 mile = 5280 ft   1 ft = 12 inches

A grid is used to show the work – horizontal lines indicate "divide" (like in a fraction) and vertical lines indicate "multiply" (multiplication signs can also be used).

32 km	1 mile	5280 ft	12 inches
	1.6 km	1 mile	1 ft

Units that are on both the top and the bottom can be crossed out, like this:

32 ~~km~~	1 ~~mile~~	5280 ~~ft~~	12 inches
	1.6 ~~km~~	1 ~~mile~~	1 ~~ft~~

This leaves the answer in inches. To get the value, multiply the numbers on the top together, and divide by the numbers on the bottom:

= (32 × 1 × 5280 × 12) ÷ (1.6 × 1 × 1)
= 2027520 ÷ 1.6
= 1 267 200 inches

Remember to ALWAYS include units in the final answer!

Common Unit Conversions

Length	1 in = 2.54 cm 3.28 ft = 1 m 1 mile = 1.61 km	1 mile = 5280 ft 1 ft = 12 in
Mass	1 oz = 28.3 g 1 kg = 2.20 lb	1 lb = 16 oz
Volume	1 fl oz = 29.6 mL 1 cup = 237 mL	1 tbsp = 3 tsp 1 cup = 16 tbsp = 8 fl oz 1 US pint = 2 cups 1 US quart = 4 cups 1 US gallon = 16 cups
Temperature	$°C = (°F - 32) \times \frac{5}{9}$	$°F = \frac{9}{5} \times °C + 32$

Lab Assessment and Evaluation

Why Do Labs?
Labs can be useful for many reasons.

- Labs can be used to introduce a new topic. It can be helpful to refer to what you saw during a lab when learning the science behind a new concept or when doing new calculations.
- Labs can be used to practice a new topic. This may include collecting experimental data and performing calculations with it, or visually confirming something you have only seen on paper or in a video.
- Labs can be used to deepen understanding of a topic, by applying concepts to new situations.

Lab Goals
Each lab has *Essential Learning* goals listed. These points should help you to understand the purpose of the lab and to connect it with the appropriate concepts we cover in class.

Assessment
Students are encouraged to work with a partner to collect data during the lab, and with a small group to complete the discussion questions. These responses may be collected and assessed, depending on the lab. <u>Each student should have their own copy of the lab data, calculations and discussion questions</u>.

Students can expect to have questions related to all labs on quizzes and unit tests. These questions will be intended to assess understanding of the lab process and encourage students to make sense of lab data.

Evaluation
Lab questions on summative assessments like quizzes and tests will be given a point score (out of a certain number). Assignments handed in will be graded on a rubric based on the learning goals. Each assignment will be assigned a score from the following table.

Score	Abbreviation	Percentage
Advanced	A+	100%
Proficient	A	85%
Functional	B	70%
Developing	C	55%
Insufficient Evidence	IE	0%
Not Submitted	NHI	0%

An assignment will be given a grade of IE for the following reasons:

Reason	Solution
Missing significant parts of the assignment, or assignment has many major errors	Assignment must be redone and resubmitted, but will receive a late mark.
Assignment was not submitted by the late deadline	Student may choose to do an alternate assignment for that grade, but will receive a late mark.
Assignment was plagiarized (see below)	For the first offense, the assignment must be redone and resubmitted, will receive a late mark and will be given the grade of the original assignment. For subsequent infractions, the assignment will be given a mark of zero (R).

Proficiency Rubric

<table>
<tr><th>ADVANCED
Fully meeting grade level expectations, with enriched understanding</th><th>PROFICIENT
Fully meeting grade level expectations</th></tr>
<tr><td colspan="2">Phrases and descriptors often associated with these levels…</td></tr>
<tr><td>With great insight…
You show a deep and well-developed understanding...
• Consistently applies concepts to new situations
• Extends ideas beyond and draws connections to real world situations
• Thoroughly explains concepts and consistently demonstrates a deep understanding of the concept or skill
• Demonstrates understanding of interconnected details by drawing complex connections to other concepts and models
• Can teach the concept to other students
• Works independently or works confidently and collaboratively in groups
• Consistently uses established skill set for problem solving and selects the most appropriate tools/ strategies for the situation and can explain why (justify) this method was chosen
• Solves problems in multiple ways
• Describes and analyzes topics with detailed and insightful supporting evidence
• Not only clearly understands the outcome but begins to assess the impacts and challenges on self, the class, society and the environment
• Consistently reflective and solution-oriented
• Engages in a variety of contexts and accurately uses new vocabulary
• Problem solving is an integral part of your work and discussions with the teacher include reflective discussion on what worked or didn't and why

The teacher might hear phrases like:
These are the strategies/attempts/examples that I tried and here's what I learned... and why I used it... Here is how I justify my thinking/ reasoning/choices...</td><td>On your own …
• You are becoming confident in applying the concept to new situations
• You explain concepts with detail and consistently demonstrate an understanding of the concept or skill
• You demonstrate an understanding of interconnected details by drawing connections
• Key elements of the essential learning goals are included and demonstrated
• Few refinements are needed
• You work independently or collaboratively when required
• You have an established skill set
• You can analyze relevant information and convey your own thoughts and connections to the outcome/concept
• You can ask strong questions and support analysis with relevant details and examples
• When problem solving with a teacher, you come with questions and possible solutions. You are looking for a conversation which asks you questions to help you think through the assessment. The work submitted after the discussion is original to you (i.e. you have considered the discussion and made a decision that reflects how you can best demonstrate your knowledge.)

The teacher might hear phrases like
I'm wondering about this aspect. Here are a few ideas that I have...
I think this is a possible solution because...
I wonder if...</td></tr>
<tr><td>In general:
Excellent job. Perfect. You totally got it, and you were able to explain it really well.</td><td>In general:
You get it, but you made a few minor errors. You might have missed part of the explanation, or had a mistake in your explanation, reasoning or calculations.</td></tr>
</table>

FUNCTIONAL Mostly meeting grade level expectations	**DEVELOPING** Marginally meeting grade level expectations	**INSUFFICIENT EVIDENCE** Not meeting grade level expectations
With assistance/help you can… • Demonstrate a basic understanding of the concept but need more practice to apply • Key elements of the concept are left out of the explanation. • Begin to examine, describe, or explain concepts or skill but more attention to detail is required to fully demonstrate understanding of the topic. • Show a developing skill set When problem solving with a teacher, you are looking for answers to general questions. The work submitted after the discussion is improved based only on the teacher's ideas. *The teacher might hear phrases like:* I don't understand.... Do you think this is what I should say? Is this right? Am I on the right track? How do I do this? *You may need to improve on…* • Making connections to texts, self and others need to be explored • Asking questions and supporting your analysis with details and examples • Seeking assistance only as needed and working toward increasing independence	*Even with assistance you are struggling to...* • Identify key elements of the concept • Demonstrate an understanding of the topic • Go beyond an emerging skill set • Interpret the context or meaning of the problem *The teacher might hear phrases like* I don't get it. Where do I start? I don't understand what this means. I can't do this. This is too hard. *You probably need to…* • Revisit this topic to develop your understanding of the concept • Pay more attention to detail • Talk with your teacher about strategies to try • Learn or relearn some things before you begin or redo this assessment	*Even though you submitted an assignment, you have…* • Misunderstood the intent of the assessment, or failed to respond based on the Essential Learning goals • Missed key elements of the assessment that are needed to demonstrate your understanding of the concept • Made major errors that make it difficult to determine your level of proficiency • Not completed the work independently or plagiarised your responses *You need to…* • Talk with your teacher about the next steps you need to take
In general: Mostly good, but you made some errors that show you might not completely understand. You might have missed an important part of the explanation.	In general: Not so good – you made some big mistakes or your explanation does not show that you know what you're talking about. You had some good parts, but other parts weren't great.	See the table on why you may have received an IE!

Lab 1. Wave Simulator

Essential Learning:

- Describe waves using appropriate terminology.
- Identify characteristics of transverse and longitudinal waves.

Background Information:
A mechanical wave is the movement of energy through a medium, using interactions between the particles of the medium. The direction of particle movement defines the type of wave. Waves can be described using four main characteristics: amplitude, speed, wavelength, and frequency.

Materials:

- Electronic device with Internet access to use the Physics Classroom Simple Wave Simulator (http://bit.ly/1KmWZUl)

Procedure:
There is no specific procedure in this assignment. Play with the settings on the simulator until you feel you can accurately and completely answer the discussion questions. For the first five questions, use the "Wave as a Rope" setting.

Discussion:

1. Come up with a description of each of the following terms, <u>including the units</u> for each!
    a. frequency period wave speed wavelength amplitude
2. How does adjusting the frequency affect the wave? Does it make a difference horizontally, vertically or both? Explain if any other wave characteristics are affected by changing the frequency.
3. How does adjusting the wave speed affect the other characteristics of the wave?
4. How does adjusting the amplitude affect particle motion (the little dot on the wave) and the shape of the wave? Does it affect any other characteristics of the wave?
5. Predict what would happen to the other characteristics if you could decrease the wavelength.
6. Compare the particle motion and wave motion for the wave as a rope and the wave as sound. In your comparison, identify each wave representation as longitudinal or transverse.

Lab 2. Slinky Waves

Essential Learning:

- Describe characteristics of transverse and longitudinal waves using appropriate terminology.
- Design simple tests to answer questions about the nature of waves.

Materials:

It may be helpful to use a cell phone that can record in slow motion for certain parts.

- Slinky
- Measuring tape
- Stopwatch
- Masking tape

Procedure:

There is no fixed procedure for this lab. Perform tests with the slinky until you feel confident answering each of the discussion questions. You are expected to be working with the slinky for a significant portion of the lab time.

Discussion:

1. What controls the amplitude of the slinky wave? (How do you make a wave with a large or small amplitude?) Does changing the amplitude affect any other characteristics of the wave? Does the wave stay in the slinky longer if it has a large amplitude or a small amplitude?
2. What determines the frequency of the wave? What determines the wave speed? What determines the wavelength? How are these characteristics related?
3. Propose and test a hypothesis for how you could make the wave speed slower.
4. Is the slinky fixed-end or free-end? Explain how you know based on the wave behaviour. Don't just say, "because I'm holding the end."
5. What happens when two pulses meet each other from opposite ends? Is it different when the pulses are on opposite sides or the same side? Explain.

Lab 3. Speed of Sound with Echoes

Essential Learning:

- Experimentally determine the speed of sound in air using two methods.

Background Information:

Sound is type of three-dimensional, mechanical wave. It spreads due to a pressure disturbance creates as sound is formed. Recall that speed can be calculated using the following equation:

$$v = \frac{d}{t}$$

Where v is speed in m/s, d is distance in m and t is time in seconds. The speed of sound in air can also be estimated based on air temperature, using the equation:

$$v = 331 + 0.6T$$

Where T is the temperature of the air in °C.

Materials:

- Stopwatch
- Tape measure
- Thermometer

Procedure:

To perform this lab, you will experimentally calculate the speed of sound in air using echoes off the side of the school.

1. Measure the length of your pace. Record this value, then determine how many of your paces there are in 75 metres.
2. Starting with your back to the wall of the school, walk 75 metres in a straight line out, then turn to face the wall.
3. Clap your hands at a regular rate. Adjust your clapping so that each clap occurs at the same time as the previous clap's echo. Once the claps and echoes are synchronized, start timing at the beginning of one clap and stop after ten claps. Record this time.
4. Repeat Step 3 four more times to collect five readings in total.
5. Use the thermometer to calculate the air temperature.

Calculations:

1. Use the distance and time to determine the experimental speed of sound. This step involves some thinking – it is not as simple as distance divided by time!
2. Use the temperature to determine the speed of sound based on the air temperature.

Discussion:

1. Do a percent difference calculation. Explain why these values might differ. Which would you expect to be more accurate? Why?
2. What factors might affect how the sound waves from your claps travelled towards the wall and bounced back to your ears? Explain.
3. How could you improve your data for determining the speed of sound with echoes?

Lab 4. Reflection in Mirrors

Essential Learning:

- Determine how rays of light reflect off the surface of plane and curved mirrors.
- Identify the characteristics of images in plane and curved mirrors.

Background Information:

Image characteristics are:

Type	Real (can be projected onto a screen)		Virtual (only exists within the mirror or lens)
Orientation	Upright (faces the same way as the object)		Inverted (flipped over relative to the object)
Size	Smaller	Equal	Magnified, or larger
Location	Where the image is located relative to the object		

There are three types of mirrors. Plane mirrors are flat. Convex mirrors are curved away from the light source, and concave mirrors curve towards. The images formed in curved mirrors change based on the type of mirror and the distance the object is from the mirror.

Materials:

- Plane mirror
- White paper, protractor paper
- Pencil, coloured pencils
- Ruler, protractor
- Straight pin
- Cardboard
- Ray box
- Two metre sticks, four optical bench legs
- Curved mirror, mirror holder
- Candle, candle holder
- Index card, card holder

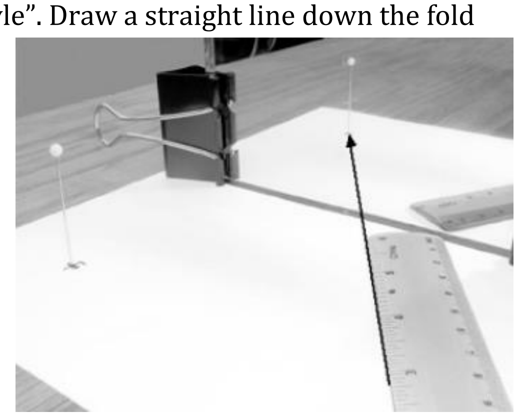
Procedure:

Part A: Reflection with Plane Mirrors

1. Use protractor paper for this procedure. Line the mirror up along the flat edge of the protractor so the back of the mirror (not the block) is touching the line. You may need to prop the mirror up so that the front edge of the mirror is touching the table.
2. Aim the ray box so the light hits the centre mark of the protractor. Mark the incident ray and the reflected ray with one colour of coloured pencil. Move the mirror, then trace the lines **using a ruler**.
3. Repeat so you have three sets of incident and reflected rays in three different colours.

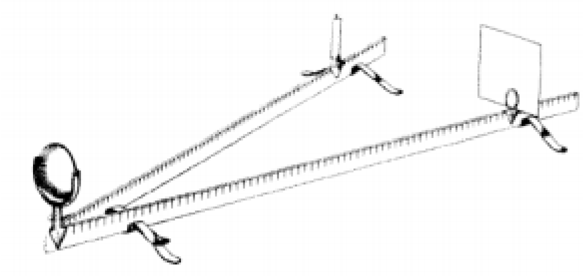
Part B

1. Fold a piece of paper into two equal halves, "hamburger style". Draw a straight line down the fold using a pencil. Label one half "OBJECT" and the other half "IMAGE".
2. Line the mirror up along the line so the back of the mirror (not the block) is touching the line.
3. Draw a + somewhere on the paper on the OBJECT side. Stick a pin into the centre of the plus sign.
4. Look along the paper at the reflection of the pin in the mirror. From where your eye is, draw a straight line with a ruler to where the pin appears to be in the mirror. Be very careful to line this up accurately!



5. Repeat Step 4, looking from a different angle.
6. Remove the mirror and extend both sight lines onto the IMAGE side of the paper until they cross.

<u>Part C</u>



1. Set up your metre sticks, mirror, candle and index card according to the picture on the right. The "zero metre" ends of the metre sticks need to be touching. The mirror needs to be at the "zero metre" with the concave side facing the candle.
2. Have Ms. Hayduk check your set up before proceeding.
3. Start the candle and the index card at the same distance from the mirror. Slowly slide them together along the metre sticks until a clear, focused image is visible on the paper screen. Record this distance, including units, as the centre of curvature, C. Record the characteristics of the image at this distance.
4. The focal length, *f*, is half of the distance to C. Record this distance, including units.
5. Place the candle at each of the following distances: 3 times the focal length, between C and F, at F and 0.5 times the focal length. Slide the index card to find an image, if possible, and record the characteristics of the image, including the distance from the mirror.
6. Flip the mirror so that the convex side is facing the candle. Move the candle from the far end of the metre stick towards the mirror and observe the image in the mirror. Record your observations.

Discussion:

1. Make a chart for the results in Part A that compares the incident angle (incoming ray with the normal line at 90°) and the reflected angle (outgoing ray with the normal at 90°). Explain whether your results are what you would expect.
2. Using your paper from Part B, compare where your object is located compared to your image. Explain whether this is what you would expect.
3. What are the characteristics of an image in a plain mirror?
4. Come up with a general rule that describes the characteristics of images in concave mirrors, as the object moves from far away closer to the mirror.
5. Give an example of a use for a concave (converging) mirror is used. Explain, based on what you know about the images produced in concave mirrors.
6. Describe the characteristics of an image in a convex mirror. Give an example of a use for a convex (diverging) mirror. Explain.

Lab 5. Refraction and Snell's Law

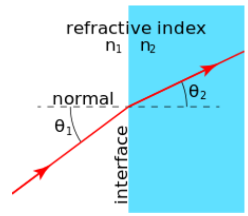
Essential Learning:

- Apply Snell's Law to calculate the refractive index of acrylic.

Background Information:

When light travels from one medium to another, the wave speed changes. This causes the wave to refract, meaning the direction of the wave changes. The angles of the incoming and refracted ray are related by Snell's Law, which is given by the equation:

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$



The refractive index, n, is a unitless number that describes how light waves move through a medium compared to light in a vacuum. A higher number indicates that light moves slower through that medium.

Total internal reflection occurs when a light ray gets "trapped" inside a medium; the light ray is completely reflected within the medium and does not pass through. This can occur when light is in a medium with a higher refractive index than the medium surrounding it. The incident angle must be at or bigger than a certain limiting angle, called the critical angle. The critical angle can be calculated using the formula:

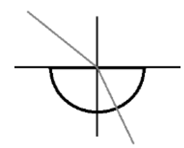
$$\sin\theta_c = \frac{1}{n}$$

Materials:

- Acrylic block
- Ray box
- Ruler
- Protractor
- White paper
- Coloured pencils

Procedure:

1. Fold the paper into four equal quarters. Be accurate! Unfold the paper and trace the lines using a pencil and ruler.
2. Place the block so the flat edge is along one of the lines. Trace the circular side of the block.
3. Aim the ray box so the light ray hits the centre of the folded lines at the flat edge of the block. With a coloured pencil, mark two points along the incident ray and the point where the refracted ray leaves the curved edge of the block. Move the block, then use a ruler to trace both rays.



4. Repeat Step 3 two more times, using a different colour for each set of rays.
5. Aim the ray box at the curved edge of the block so the light ray hits the centre point of the paper. Adjust the angle until the light ray completely reflects within the block. Mark the point of the incoming ray. Move the block and use a ruler to trace the line.

Calculations:

1. For each set of rays, use a protractor to determine the angles made between each incident and refractive ray and the normal.
2. Determine the refractive index for the acrylic for each set of rays. Find an average of the three calculated values.
3. Use a protractor to determine the critical angle of the acrylic. Check your answer using the refractive index you calculated.

Discussion:

1. Explain why the light “bends” when it enters the block.
2. Give and explain an example of this type of refraction in “real life”.
3. Explain three reasons why the calculated index of refraction may be slightly different for each trial.

Lab 6. Types of Reactions

Essential Learning:

- Identify types of chemical reaction in a practical setting, including identifying products.
- Write and balance chemical equations for reactions.

Background Information:
There are four major types of chemical reactions in inorganic chemistry: synthesis, decomposition, single displacement and double displacement. Each type of reaction can be identified by the composition of the reactants and products.

Signs of a chemical reaction include production of light, production of a gas, production of a solid (a precipitate), significant change in temperature or significant change in colour. However, the most important element in identifying a chemical reaction is the formation of a new chemical species that was not previously present in the system.

Safety:
Please wear safety glasses for this lab. Avoid getting chemicals in contact with skin; if contact occurs, wash hands well with soap and water. At Station 2, do not look directly at the burning magnesium.
Please dispose of all waste in the proper disposal containers.

Procedure:
There are five stations in this lab. The stations do not need to be completed in order.

At each station, follow the directions. Be sure to record the reactants used and observations from before and after each reaction.

Discussion:

1. For each of the five reactions, write and balance the chemical reaction, including states.
2. Identify which type of reaction you observed at each station.
3. For each station, briefly explain how you know a reaction occurred.

Lab 7. Double Displacement

Essential Learning:

- Predict and confirm whether double displacement reactions will occur, using solubility rules.
- Understand how solubility affects how a precipitate forms in a reaction.

Background Information:
Double displacement reactions have the general form AC + BD → AD + BC. In this lab, you will perform a specific type of double displacement reaction called a <u>precipitation reaction</u>, where two aqueous solutions are mixed together to form an ionic solid called a <u>precipitate</u>.

Whether these reactions will occur is determined by the solubility rules for ionic compounds. <u>Solubility</u> is a physical property that indicates how much of a compound will dissolve in a specific amount of solution; it is a scale that ranges from very soluble (100% dissolved) to minimally soluble (very small amount dissolves, and then a solid forms). No ionic compounds are 100% insoluble; all of them will dissolve a small amount before a solid will form.

The most obvious sign of a precipitation reaction is a change in colour, since often the solutions being mixed are clear, colourless solutions. Any colour change, gas formation or visible particles is an indication of a reaction.

Safety:
Please wear safety glasses for this lab. Avoid getting chemicals in contact with skin; if contact occurs, wash hands well with soap and water. Please dispose of all waste in the proper disposal containers. Do not put any solids down the drain.

Materials:

- Solutions (0.10M): $Pb(NO_3)$, Na_2CO_3, $FeCl_3$, $CuSO_4$, $Ba(NO_3)_2$, KI, $AgNO_3$ and NaOH
- Small test tubes (8)
- Test tube rack
- Well plate
- Eight pipettes
- Data sheet from Ms. Hayduk

Procedure:

1. Label each test tube and pipette with the name of one compound. It's important that these do not get mixed up, or a precipitate may form in the pipette!
2. Add approximately 2 mL of each solution into the correct test tube. (2 mL is about 2 cm at the bottom of the tube.)
3. Use the pipettes to mix a small amount (about five drops) of two solutions together in a well. Do this for each pair of solutions.
4. Observe for reactions. If a precipitate forms, identify the colour of the solid; otherwise, write NR.
5. Dispose of all waste into the waste bucket. <u>Do not put anything down the drain.</u>

Discussion:

1. Use the solubility rules for every combination of reactants.
    a. If a solid formed, was it supposed to? If so, what was it?
    b. If a solid did not form, was one supposed to form? If so, why might it have not? (Hint: think about what you know about the definition of solubility.)
2. Choose two of the reactions that occurred in this lab and write full equations for each, including states.
3. Are there any sources of error in this lab? Explain.
4. How is an aqueous substance different from a liquid substance?

Lab 8. Preparing a Solution

Essential Learning:

- Use molar mass to determine the correct mass of a solid to make a solution with a specific concentration.
- Follow a procedure to accurately prepare a solution.

Background Information:
Citric acid and sodium hydroxide react in a double displacement reaction, called neutralization, to produce sodium citrate and water. The procedure to perform this reaction is called titration; in it, an indicator is used to show when the solution being analyzed changes from acidic to basic. The indicator is called phenolphthalein. It is clear in an acid and magenta in a base.

Safety:
Please wear safety glasses for this lab. Wash hands with soap and water if any solid or solution contacts your skin.

Materials:

- Solid citric acid ($C_6H_8O_7$)
- Distilled water
- Electronic balance
- 50-mL volumetric flask and stopper
- Weigh boat
- Funnel
- Wax pencil
- Beaker
- Pipette and bulb
- Burette and burette clamp
- Ring stand
- 250-mL Erlenmeyer flask
- Phenolphthalein
- 0.5 M sodium hydroxide (NaOH)
- White paper

Pre-Lab Question:
In this lab, you will make 50.0 mL of citric acid solution that has a concentration of 0.10 mol/L. Determine the mass of solid citric acid needed to make this solution.

Procedure:

Part A: Preparing Solutions

1. Weigh the calculated mass of solid citric acid in a weigh boat.
2. Use the funnel to add the solid to the volumetric flask. Rinse the weigh boat with distilled water into the flask to ensure no solid residue is left on the weigh boat.
3. Add distilled water to the volumetric flask so that the bottom of the meniscus touches the top of the 50-mL graduation.
4. Put the stopper in the top of the flask and invert several times until all of the solid is dissolved.
5. Write your name and your partner's name on a clean, dry beaker (on the glass) with wax pencil. Pour your solution into the beaker.

Part B: Testing Solutions

1. Use a pipette to transfer 10.0 mL of your citric acid solution from the beaker to the Erlenmeyer flask. Be accurate.
2. Add three drops of phenolphthalein to the acid.
3. Record the initial volume of sodium hydroxide in the burette.

4. Put the white paper underneath the flask, and the flask underneath the tip of the burette.
5. Turn the valve on the burette to add the sodium hydroxide solution slowly to the acid. Swirl. Stop as soon as there is any visible pink that does not disappear from swirling.
6. Record the final volume of sodium hydroxide in the burette. Subtract the final volume from the initial volume to determine the volume added.
7. Repeat steps 1-6 until you have two trials where the amounts of sodium hydroxide added are within 0.5 mL of each other.

Discussion:

1. Calculate the number of moles of citric acid and of sodium hydroxide you used in your titration.
2. Identify and explain three significant sources of experimental error in this lab. Remember that sources of error are factors that influence the accuracy of your results that are **unavoidable**.

Lab 9. Percent Yield

Essential Learning:

- Calculate theoretical, actual and percent yield in a laboratory setting.
- Identify sources of experimental error.

Background Information:

When calcium carbonate and hydrochloric acid are mixed, a double displacement reaction occurs, followed by a decomposition reaction. One of the resulting products is carbon dioxide gas. The mass of gas produced can be found by determining the difference between the mass of the reactants and the mass of the products; any change is explained by the escaping gas.

The theoretical yield of carbon dioxide can be calculated using stoichiometry, based on the amounts and concentrations of reactants being combined. In most cases, the theoretical yield should be higher than the actual yield, since it is uncommon for a reaction to go to 100% completion.

Materials:

- Calcium carbonate
- Hydrochloric acid (1.0 mol/L)
- Scoopula
- 25-mL graduated cylinder
- 250-mL Erlenmeyer flask
- Electronic balance

Procedure:

1. Find and record the mass of an empty Erlenmeyer flask and an empty graduated cylinder.
2. Measure approximately 0.10 g of calcium carbonate into the flask. Record the exact mass of calcium carbonate used. <u>Do not put anything back into the container of calcium carbonate</u>. You will do your calculations based on the mass you used!
3. Measure 20.0 mL of hydrochloric acid into the graduated cylinder.
4. Find the mass of the hydrochloric acid and graduated cylinder.
5. Pour the hydrochloric acid into the flask and swirl the flask until the reaction stops fizzing.
6. Find the mass of the flask and liquid products.
7. Rinse all glassware well with distilled water and pour waste down the drain.

Calculations:

1. Write and balance the reaction occurring in this lab.
2. Calculate the percent yield for the carbon dioxide, based on the amount of calcium carbonate used. The acid is in excess.

Discussion:

1. Identify and explain three significant sources of experimental error in this lab. Remember that sources of error are factors that influence the accuracy of your results that are **unavoidable**.

Lab 10. Specific Heat Capacity

Essential Learning:

- Experimentally determine the specific heat capacity of a substance.

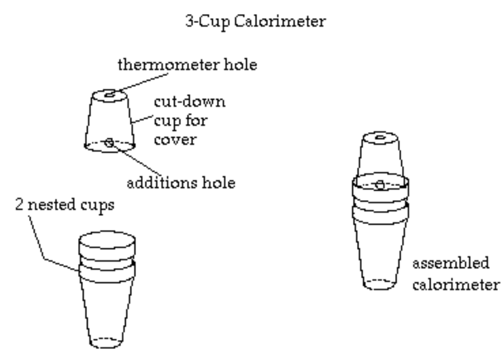
Background Information:

Specific heat capacity is a measure of how much energy it takes to heat up a specific mass of a substance by 1°C. A substance that has a high specific heat capacity will hold on to heat better, but will also take longer to heat up. A calorimeter is a well-insulated vessel that is used to measure temperature changes of a substance or reaction. In general, it is assumed that no heat is lost from the calorimeter, making it an isolated system.

Materials:

- Metal rods
- Thermometers
- Styrofoam cup calorimeters
- Electronic balance
- Tongs
- Graduated cylinder, 100-mL

Procedure:



1. Record the mass of the dry metal rod.
2. Submerge the metal rod into the hot water bath for at least five minutes. Complete steps 3-7 during this time.
3. Construct the calorimeter as shown in the image.
4. Record the mass of the clean, dry calorimeter.
5. Add enough cold tap water to the calorimeter to fully submerge the metal rod. Record the mass of the full calorimeter.
6. Record the temperature of the cold water.
7. Record the temperature of the hot water bath, using the digital reading.
8. Carefully pull the metal rod from the hot water and immediately submerge it in the water in the calorimeter. Close the calorimeter quickly and insert the thermometer.
9. Gently swirl the contents of the calorimeter while observing the temperature. Do not stir with the thermometer. Record the final temperature of the water when it has stopped changing.
10. Empty and dry the calorimeter. Put the metal rod back into the hot water bath.
11. Repeat the procedure from steps 4-11 two more times.
12. Use water displacement in the graduated cylinder to find the volume of the metal rod.

Calculations:

1. Calculate the specific heat capacity of the metal <u>three times</u>, then find an average value.
2. Calculate the density of the metal using the equation $\rho = m/V$.

Discussion:

1. Which metal did you have? Justify your answer using its appearance, its specific heat capacity and its density. You will need to look up densities of metal online!
2. Calculate the percent error of your specific heat capacity. Explain three significant sources of experimental error in this lab (*unavoidable*) that affected your result.

Lab 11. Cooling Curve of Paraffin

Essential Learning:

- Use technology to create a cooling curve for paraffin wax, to experimentally determine its melting/freezing point.

Background Information:

As a substance is heated or cooled, the temperature changes, reflecting the average kinetic energy of the molecules. At the melting point or boiling point, a phase change will occur. During a phase change, the temperature of a substance remains constant as molecules break apart. Substances that are being heated and going through phase changes to more energetic states (solid → liquid → gas) are endothermic processes. Cooling a substance (gas → liquid → solid) is an exothermic process.

Materials:

- Paraffin in a 50-mL beaker
- Water
- Hot plate
- 250-mL beaker
- Temperature probe
- Laptop

Procedure:

1. Put the probe into the hot water in the beaker for about a minute so it is warmer than room temperature. This will prevent the wax from hardening on it.
2. Remove the small beaker from the water.
3. Put the probe into the wax, then start graphing on the computer. Stir the substance gently, scraping the wax off the sides of the beaker.
4. Stir the substance until it has the consistency of mashed potatoes, then hold the probe still. Continue to record temperatures as the temperature of the substance starts to drop below the plateau, until it reaches approximately 50°C.
5. Remove the thermometer. Gently scrape any substance off the thermometer back into the beaker. Place the beaker back into the warm water.
6. Print your graph. Do not close the window on the computer until you are sure your graph has printed.

Discussion:

1. Label the melting point on the graph. Indicate the temperature.
2. Indicate on the graph when the substance is a solid and a liquid.
3. Is this process endothermic or exothermic? How do you know?
4. Explain what is happening to the <u>molecules</u> of the substance at each point throughout the cooling process: before the plateau, during the plateau and after the plateau.

Lab 12. Enthalpy of Solution

Essential Learning:

- Experimentally determine the enthalpy of solution for two solids
- Determine accuracy of experimental data and identify sources of error

Background Information:

Ionic compounds being dissolved in water is considered a chemical change, since heat is produced or absorbed, depending on the solid. When the energy stored in the chemical bonds is higher than the energy needed to break them, the reaction is exothermic. The reaction is endothermic when the amount of energy needed to break the bonds is higher than the energy released when they are broken. During these processes, any extra energy produced or energy needed is exchanged with the water in which the reaction is occurring.

Materials:

- Solid calcium chloride
- Solid ammonium nitrate
- Distilled water
- Digital thermometer
- Electronic balance
- Styrofoam cup
- 50-mL graduated cylinder
- Glass rod

Procedure:

1. Place the Styrofoam cup on the electronic balance and tare the scale. Add one scoopula of solid calcium chloride. Record the exact mass used. Do not put any solid back in the container!
2. Measure 40.0 mL of water in the graduated cylinder. Measure the temperature of the water using the temperature probe.
3. Pour the water into the Styrofoam cup. Stir with the glass rod to dissolve the solid. Record the maximum (highest or lowest) temperature reached using the temperature probe. You will need to use your best judgment to determine when the temperature has reached a maximum.
4. Rinse the cup well with distilled water and dry it out. Repeat Steps 1-3 to do a second trial.
5. Repeat Steps 1-4 with ammonium nitrate. You should have two sets of data for each solid.

Calculations:

1. Write the thermochemical equations for each solid dissolving in water. Include the theoretical enthalpy of solution from the chart in your reference package.
2. For <u>each trial</u>, determine the experimental enthalpy of solution, then take an average of the two values for each solid.
3. Calculate percent error for each solid, comparing the theoretical and experimental values for enthalpy. Be sure all values have the same units.

Discussion:

1. Identify and explain at least three significant sources of experimental error in this experiment.

Lab 13. Careers Project

Essential Learning:

- Identify and describe one or more careers in a physical science field including examining roles, responsibilities and requirements.
- Analyze trends in physical science careers in Saskatchewan and Canada.
- Reflect on a career of personal interest in the physical science field.

Project Outline:

The goal of this project is to allow you to have some familiarity with careers that require an understanding of physical science. This field is extremely varied, as it includes any occupations that use chemistry and physics in their day-to-day responsibilities.

For this project, you will find a (real) job posting on SaskJobs.ca for a career in a physical science field. Create a resume using proper formatting, for an imaginary person who is qualified for the job. The resume should be 1-2 pages long and should include all the details found in a typical resume.

In addition to the resume, you will write 1-2 paragraphs that explain whether this career would be one in which you would be interested.

Be sure to include a copy of the job posting, and not just a link. Job postings are not online forever, and Ms. Hayduk needs to be able to see what you have chosen!

Please plan to complete most of this project at home. There will be limited class time available to work on it.

Resume:

Your resume should contain the following sections. Each one will take research to fill in.

1. Personal information
   Include your name, address, phone number and email address – this can be made up, since it is a resume for a fake person.
2. Skills
   What skills does the person applying for this job need to have? Are there any specifically listed in the job posting? What else might be useful? Look at some sample resumes on the internet to get some ideas of good skills to have. Don't list any that aren't relevant to the job.
3. Employment History
   What experience does your fake person need to have to be a good candidate for the job? Is it an entry-level position or a more senior position? You will need to look up some other companies that hire people for similar positions.
   What sort of responsibilities would your person have had at these jobs? List a few for each, and make sure they match the skills you listed before.
   How long did your person spend at each job before applying for this one? You may want to decide how old they are – and remember that most people are 22 or 23 years old when they finish an undergraduate university degree.
4. Education
   Where did your person go to school? What degree(s) did they get? When did they graduate?

Does your person have any additional training or certificates that may be useful for this job? Check the job posting to see if any are listed. Make sure you look up what each one means and how long it takes to get it!

Other Information:

DO NOT COPY YOUR RESUME OFF THE INTERNET.

It is expected that you will do appropriate amounts of research to fill in each section of your resume. Please ask Ms. Hayduk for help if you aren't sure where to find the information. My Blueprint is a great starting resource!

You should also look at resume templates to get an idea of how your resume should be formatted. If you were applying for the job for real, you would want your resume to look polished, easy to read and free of spelling errors and typos. Make sure you don't have inconsistencies in your timeline on your resume.

Evaluation:

Your project will be given a mark using the lab rubric at the front of the lab manual.

Lab 14. Student-Directed Study

Essential Learning:

1. Develop a proposal for a scientific investigation related to a topic of study in physical science.
2. Design and conduct an experiment following established scientific protocols; OR, design and construct a model or prototype following established scientific protocols and the engineering design process.
3. Conduct suitable research to develop original content and materials.
4. Present the results of a scientific investigation in a professional and competent manner, using scientific language.

Project Outline:

Each student must complete one of the options below. Students will be given approximately two weeks (ten school days) of class time to complete the project. On the project due date, projects will be presented in a science-fair style format.

Students have the option of working individually or with one partner for this project. Please note that partners will receive the same grade for the project, regardless of division of work.

During the fair, students will be required to prepare a presentation board that shows key research and results. Additionally, any physical models or demonstrations should be displayed. The mark for this project will be based on the project proposal, the presentation of the project to Ms. Hayduk (3-5 minutes) and the materials displayed during the fair. No other materials should be submitted. Students should expect that presentations may go into lunch/after school on this day.

Project Options:

1. Scientific Investigation (Experiment/Lab)

   Design an experiment to answer a question relevant to a physical science topic. Conduct the experiment and analyze the results. Your experiment should follow the scientific method seen throughout the course and should be designed to minimize sources of error as much as possible.

   Ideally, for this option, the question should not have an obvious result, and should be interesting and meaningful. However, this needs to be balanced with the amount of time available to complete the experiment.

2. Design Project (Model/Prototype)

   Create a model or prototype that can solve a problem or answer a question relevant to a physical science topic. Do research to determine some possible options and to understand the scientific concepts in more depth. Then, use the engineering design process to create a model that demonstrates a solution to the problem.

Keep in mind that the engineering design process includes a testing phase, so it is not acceptable to create a model or prototype that has not been tested in some way. If budget is a constraint, alternative solutions can be discussed with Ms. Hayduk.

Project Ideas:

This list is not exhaustive. Ideas will need to be made more specific from those listed here:

alternate combustible fuels, ideal material for piping, ideal material for electrical wiring, rust prevention, effectiveness of green cleaners, effect of temperature on sound, effect of medium on sound, best de-icer, expansion and contraction of matter in various temperatures, chemistry in mining, chemistry of pollution, insulated coffee mug, exercise clothes, winter clothes, sleeping bag, water softener, water heater, water purifier, cooking pots, thermometer, car mirrors, home insulation, materials science, agricultural chemistry, sonar and echolocation, fibre optics, textiles, consumer products, musical instruments,

Proposal:

This proposal needs to be about 1-2 pages long and should address the following points:

- Name and Partner's Name (if applicable)
- Project Focus:
    - What is your main topic or area of interest?
    - What is the <u>specific question or problem</u> to be resolved?
    - How is this topic relevant to the course? Be specific. What concepts have we studied in class that will be useful for your project?
- Project Plan:
    - What preliminary research do you need to do? (What do you need to learn about or look up before you start to do your investigation or project?)
    - How are you planning to answer the question or solve the problem? Include, where applicable:
        - Lab procedure
        - Sketch of model/design
        - What data do you need to collect? (what are you trying to find out, and how will you get measurements that will help you find that out?)
    - How will you present your findings? (Charts, tables, images, text, etc… be specific!)
    - What materials, resources and equipment are needed?
    - What is your timeline for getting the work done? Include specific dates.

It is okay if the final product differs slightly from the original project proposal. However, major changes (different topic, different product, etc.) need to be discussed with Ms. Hayduk as soon as possible.

Once proposals are submitted, Ms. Hayduk will review and return them by the next class. Students must submit a proposal and have it approved prior to starting their project. Students who do not submit a proposal by the deadline will receive a grade of IE for that section of the project.

Presentation:

Your presentation will be assessed on two main criteria:

- Do you have a good understanding of the scientific content? This means that you know your topic well enough that you can identify what are the most important parts to mention. You can use proper scientific terms, and you explain it correctly. When Ms. Hayduk asks you a question, you can answer it correctly or with a reasonable hypothesis.
- How good is your presentation? You should be professional, speak clearly and be engaging. Your presentation should be no more than five minutes (no exceptions) and should not be a memorized speech or read off your project board. Your information should be summarized and presented in a logical order; you do not need to explain every piece of information on your project board!

Project:

Ms. Hayduk will read your whole project board. It should be presented in order and should have the following sections:

1. Introduction
   a. Purpose *(1-2 sentences)*
      - What are you trying to figure out? This should be specific and should be something you can perform an experiment/build a model to answer.
   b. Background Information *(1-2 pages, not including images)*
      - Give some detailed information on the topic you choose for your project. Think about what a reader needs to know to understand your experiment and results, and include that information. All information in this section should include in-text citations where necessary.
2. Experimental *(1-2 pages)*
   a. Materials
      - Make a complete list of materials you will need to do your testing.
   b. Procedure
      - Make a numbered list of steps (in third person, like writing a recipe) that explains how to do the testing. Someone else should be able to follow these instructions independently and get the same results as you. For examples, check other labs in this lab manual!
3. Data and Observations *(1 page)*
   Include all observations, calculations and data from the testing. Do not include any discussion or analysis here – just information.
4. Analysis *(1-2 pages, not including images)*
   - In general, you are explaining the significance of your observations. Be sure to address your purpose. Include discussion about your findings, any sources of error, what your conclusions are and any next steps in testing, if you had more time or more resources.
5. Conclusion
   - Write a concise summary that answers the question you asked in your purpose. Do not include any information that you didn't already discuss.
6. Works Cited
   - Include ALL sources, in APA format. Be sure to also cite these sources within the text of your report whenever you use information from someone else, including images.

Evaluation:

Each section of your project will be given a mark using the lab rubric at the front of the lab manual. Absolutely no late assignments will be accepted for this project.