Lab Reports:
A Manual for Students

Math/Science/Technology Department
Yarmouth High School – 2002

Writing a Lab Report

Scientists, engineers, and mathematicians write lab reports for a variety of reasons. In fact, lab reports are the most frequent type of document written in engineering. The goal of a lab report is simple and important: document your findings and communicate their significance.

What they do:

- Persuade others to accept or reject hypotheses by presenting data and interpretations
- Detail data, procedures, and outcomes for future researchers
- Provide an archival record for reference and document a current situation for future comparison

A good lab report does more than present data; it demonstrates the writer's comprehension of the concepts behind the data. Merely recording the expected and observed results is not sufficient; you should also identify how and why differences occurred, explain how they affected your experiment, and show your understanding of the principles the experiment was designed to examine. Bear in mind that a format, however helpful, cannot replace clear thinking and organized writing. You still need to organize your ideas carefully and express them coherently.

Lab reports are generally constructed in this order (some parts may not be required – check with your teacher):

Parts of a Lab Report

1. Cover Page
2. Introduction
   a) Purpose
   b) Hypothesis
   c) Materials
   d) Procedure
3. Theory/Essay of Relevant Principles
4. Analysis and Conclusion
5. Supporting Documents: Data Tables, Graphs, Diagrams, Sample Calculations

Cover Page

<u>Should Include</u>: Title
Name
Due Date
Partner(s) Name(s)
Course Title
Teacher's Name
Class Period

Staple in the upper left corner, no plastic or cardboard covers.

Introduction:
Purpose, Hypothesis, Materials, Procedure

The introduction orients the reader to what will be presented in your report and helps them understand what you did and why you did it. The results of your experiment are not discussed here (they are discussed in the conclusion). Break each of the following topics out as separate items. Be as clear and concise as you can.

Purpose (*What did you hope to learn or discover?)*

e.g. *The purpose of this lab is to determine the effect the distance from a light source has on the observed intensity of a 100-watt light bulb.*

e.g. *The purpose of this lab is to determine the heat of fusion of ice.*

Hypothesis *(What did you think would happen and why?)*

e.g. The hypothesis is that observed light intensity decreases directly as a function of the distance from the source.

e.g. The hypothesis is that observed light intensity is inversely proportional to the square of the distance from the source.

Sometimes you will be asked to conduct an experiment to verify a known relationship or stated value in order to demonstrate the proper use of equipment or mastery of mathematical formulas. In this case there might only be a purpose for the experiment and not a hypothesis.

Procedure
This section should summarize the steps you followed in performing the experiment in chronological order. Refer to any diagrams or sketches you have included for the details. Do note any differences in the procedures you actually followed from what was specified in the lab directions. The procedure should have enough detail that a literate person could duplicate the experiment to check its findings simply by reading your procedure. This section should be a small part of the report. Depending on the lab and/or teacher preference, you may be asked to write this section in paragraph form or step by step with the steps numbered.

Materials
For the list of materials used include the quantities and sizes. Include safety and incidental equipment but not to include common items such as pens and calculators.

Tips for the introduction:
Many people find it is easier to write the introduction **when they have finished the materials and procedure section,** and the **discussion of relevant principles** because the **aim of your study** might be **clearer** in your mind.
DO NOT:
- **talk about your results** here
- **show off** knowledge by writing an essay on topics related to the study but not directly relevant to the portions of a good introduction.

Theory/Essay of Relevant Principles

The essay of relevant principles should give background information (historical and/or theoretical) about the problem and **how it relates to the lab**. When writing this section it is helpful to think about the level of expertise of the reader. Generally you should assume that you are writing to one of your classmates. In other words someone who should have a basic understanding of the terms and equipment being used. You should still define the important terms as they relate to your experiment. This is the section where you will **discuss why things work the way they do.** If formulas are involved you should explain why they are being used.

What follows is a <u>sample portion</u> of an essay of relevant principles regarding model rocket engine thrust:

According to *The Handbook of Model Rocketry* the thrust of a rocket engine is the amount of force, or push, produced when it is operating. The jet of gas rushing out of the nozzle produces a force, due to conservation of momentum, according to Newton's Third Law of Motion. Stated simply "for every acting force there is an equal and opposite directed reacting force." The thrust of a model rocket engine is rarely constant. It changes with time. There are several aspects to the thrust curve that corresponds to different stages of the engine performance. *Maximum thrust* is the highest amount of force produced by the engine during operation, regardless of when that occurs during the period of operation. This maximum thrust produces a "peak" on the thrust curve. (See Fig. 2) The thrust curve for a model rocket engine is a plot of force versus time. (See Fig. 3)

Average thrust is a derived, or calculated, number. It is determined by dividing the total impulse (the product of force and time) by the duration. It indicates what the thrust *would be* if it were constant from ignition to burnout. Mathematically, the average value of a continuous function is $\frac{\int_a^b f(t)dt}{b-a}$ and in this case is the area under the thrust curve divided by the length of time the propellant burns. From a graphical standpoint, it corresponds to a constant function on the same interval that has the same area as that of the thrust curve. (See Fig. 4) Average thrust is an essential piece of information for altitude prediction. It also gives you an indication of how much your model rocket will accelerate and roughly how fast it will be going when it leaves the launch rod.

Analysis and Conclusion

Using complete sentences and paragraph form write your paragraphs which sum up the findings of the entire lab. In this section, the results should be **interpreted** and their significance explained. Begin the discussion by interpreting your specific results and end it more broadly by placing your results in context. The relationship between the variables should be discussed and trends/patterns should be logically analyzed. Don't declare the experiment a success or failure. If poor results were obtained, discuss the results you expected as well as those you received. Your predictions should be based on what might happen if part of the lab were changed or how the experimental design could be changed. Be mindful of units and proper precision when discussing measurements.
Use these questions to guide your writing in this section: What were your results? What was your percent error and any sources of error? Do the results confirm your hypothesis? What are any areas for further study? How can the experiment be improved in light of possible errors?

- **Provide a statement of results**
  In other words, what did you find out? Evaluate the results in view of the purpose of the experiment. If your purpose was to determine the heat of fusion of ice then you should state what you determined that value to be. When you analyze your results, what do the results mean and why are they important? It is not necessary to list all your results and data. You should report on trends and describe the most important findings.
- **Percent error (if comparing to a known value) and sources of error**
  The sources of error, if any, should make sense for the type of error you have. If there were differences, how can you account for them? Saying "human error" implies you (or your lab partner) are incompetent. Be specific; for example, the sample was affected by air temperature, or calculated values did not take into account friction. How did the sources of error affect the results?
- **Did the results prove the hypothesis?**
  If not, can you account for the discrepancy?
- **How can the experiment or procedure be improved in light of possible errors?**
  This is particularly useful if you designed the thing you're testing (e.g. a rocket engine test stand, or an electrical circuit, or a biological eco-column).
- **What would happen if something different was tried? What are areas for further study?**
  Try to focus on areas that would use similar principles to those involved in your lab. It is unnecessary to include statements such as "I learned a lot from this experiment..."

What follows is a <u>sample portion</u> of a conclusion regarding the amount of energy it takes to melt ice:

The heat of fusion of ice was determined to be 72.5 cal/g. This is close to the accepted value of 80 cal/g with a –9.4% error. The lower value would indicate that it took less energy to melt the ice than what it should have. Some possible explanations for this would be that heat energy from another source besides just the water bath contributed to the ice melting. Other sources could include the hands of the experimenter used to transfer the ice from the cooler to the water and the fact that the sun was shining on the uncovered water during the experiment. Better results might be observed if tongs were used to transfer the ice and a calorimeter with a close fitting lid were used instead of a glass beaker. This might prevent unwanted energy from entering the water bath. A future study of heat transfer with respect to melting ice could be to test the effects of ice surface area on melting. Would various samples of ice with the same mass exhibit different values for the heat of fusion if the ice had larger surface areas or different shapes?

Supporting Documents

Depending on the project and/or the teacher it may be permissible to weave these parts within the text of the lab report to support your writing. If they are added at the end of the report be sure they are referred to in the text (ex. "see table 1” or “refer to figure 4”)

Data Tables

It is important for the data to be well organized. Generally, numerical data should be set out in tables. Tables and figures are often used in a report to present complicated data. Use the following guidelines to incorporate them effectively.

- If you have multiple tables and figures they must be numbered and have self-explanatory titles so that the reader can understand their content without the text.
- Tables and figures are numbered independently of each other (i.e., Table 1 and 2, and then Figure 1 and 2 as well).
- Tables are labeled at the top and figures at the bottom.
- If a spreadsheet is used to perform calculations you will usually be asked to include a copy of the spreadsheet that shows the formulas used.

- Each table or figure MUST be introduced within the text, and the comment should point out the highlights.
- Tables and figures are assigned numbers in the order they are mentioned in the text.
- Tables are referred to as tables, and all other items (graphs, photographs, drawings, diagrams, maps, etc.) are referred to as figures.
- Tables and figures may be placed at the end of the paper, or within the text as soon as possible after they are mentioned without interrupting the text (i.e., at the end of a paragraph or section). Check with your teacher for their preference.

Formatting:

- Units are placed in the header portion of tables.
- Do not print gridlines but do place borders around your table. You should not have empty cells with borders around them.
- Conform to rules for precision when recording data and in your calculations. Your teacher may have additional guidance regarding rounding off your calculations.
- Bottom faces out when printed sideways on the paper.
- Centering your data in the column generally is easier to read but you may need to make a determination after your entries have been made. When in doubt, go with what you think is easiest to read and be consistent.

Sample Data Tables and Spreadsheets (including formulas):

Table 1. Heat of Fusion of Ice Data

Trial Number	Mass of Calorimeter (g)	Mass of Water and Calorimeter (g)	Initial Temp of Water (°C)	Final Temp of Mixture (°C)	Total Mass of Mixture (g)
1	3.49	141.21	40.8	30.2	154.66
2	3.50	136.31	70.0	59.4	146.53
3	3.49	127.62	58.4	45.0	142.04

Table 2. Heat of Fusion of Ice Calculations

Trial Number	Mass of Water (g)	Change in Temp of Water (C°)	Change in Temp of Ice (C°)	Mass of Ice (g)	Heat of Fusion (cal/g)	Percent Error (%)
1	137.72	10.6	30.2	13.45	78.3	-2.08
2	132.81	10.6	59.4	10.22	78.3	-2.06
3	124.13	13.4	45.0	14.42	70.3	-12.1

Table 3. Heat of Fusion of Ice Calculations (showing formulas)

Change in Temp of Water (C°)	Change in Temp of Ice (C°)	Total Mass of Mixture (g)	Mass of Ice (g)	Heat of Fusion (cal/g)
=+G8-H8	=+H8-F8	154.66	=+K8-C8	=+((D8*1*I8)-(L8*1*J8))/L8
=+G9-H9	=+H9-F9	146.53	=+K9-C9	=+((D9*1*I9)-(L9*1*J9))/L9
=+G10-H10	=+H10-F10	142.04	=+K10-C10	=+((D10*1*I10)-(L10*1*J10))/L10

Graphs:

Because graphs are very visual, readers can pick up what you want to show them quickly and easily.

Overall:

- Graphs should be simple, clean, and free of elaborate detail.
- If the graph contains different symbols, their meaning should be clearly indicated.
- Always use the same system of symbols throughout your paper so as not to confuse your reader.
- No legend unless graphing more than one curve(line).
- The graph should have an appropriate title in the header or may simply represent a plot of the dependent vs. independent variable.
- The title and legend of a graph should include all the information necessary so that its significance should be understood without referring to the text.
- The graph should be a full page with a white background. It may be appropriate however at times to have smaller size graphs embedded within a document. In that case the graph should be easy to read.
- Bottom faces out when printed sideways on the paper.
- Be careful with gridlines. Determine whether they are useful or just cluttering up your graph.

Axes:

- By convention, the independent variable is plotted on the X-axis and the dependent variable is plotted on the Y-axis.
- Clearly label each axis with respect to what was measured, quantity measured, and units in which the quality was measured.
- Choose the appropriate scale units (length of intervals) so that the graph will not distort actual data points.
- Make sure that the scale points on a given axis have equal intervals.

Data Points:

- If you are determining a mathematical model given real data, the real data is indicated as markers while the model is a line (curve).
- If an equation for the line of best fit is requested it should either be embedded in the graph or placed under the title.
- If you plot average values on a graph, you should include a graphic representation of the amount of variation present in the data. You do that by adding vertical bars on either side of each of the point that will illustrate the range of values obtained for this measurement, or the standard deviation or standard error of the mean.

Graphs generally belong to one of the following types:

- scatter plots (point graphs)
- histograms and bar graphs

Scatter plots: to be used when the independent variable (x-axis) is numerical and continuous. Lines are often added to scatter plots to clarify trends in the data. It is especially important to do so if data from several treatments are plotted on the same graph.
Should you connect the dots with a line or should you draw a smooth line (or best-fit curve)? You have to use your best judgement. If you decide to draw a best-fit curve, you need to indicate clearly if it is drawn by hand or if it is mathematically generated. In the later case, you will need to give its equation.

Histograms and bar graphs: to be used when the independent variable (X-axis) is non-numerical or discontinuous, or represents a range of measurements rather than a single measurement.

Sample Scatter plot Graph:

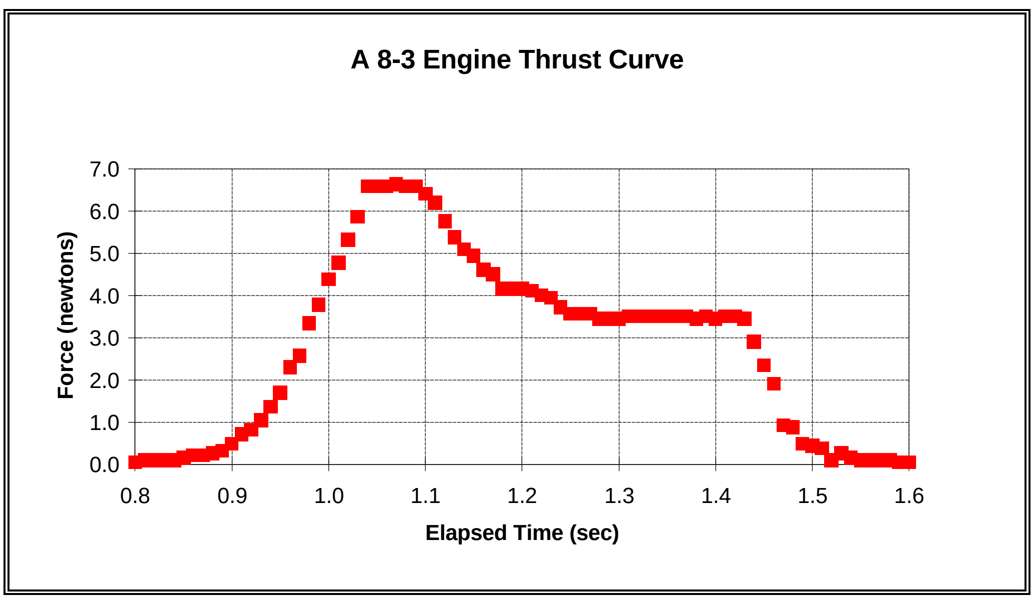

Figure 3

Sample Calculations:

This section is to demonstrate that you understand the proper use of formulas and canceling of units. Start with a formula used, substitute values (including units), and show how you work he problem down to an answer. Remember to include units in your final answer. You will need to include a legend for any unusual abbreviations you use. Sample calculations are just that: a "sample" of what you did mathematically. It is not necessary, for example, to show the same calculations for every trial you did. You will usually use some type of software such as Equation Editor in this section and in the rest of the lab.

<u>Sample Calculations</u>:

1. Heat of Fusion:

<u>water</u> <u>ice</u>

$Q_{lost} = Q_{gained}$

$mcDT = mH_f + mcDT$

therefore,

$$H_f = \frac{\left[(mc\Delta T)_{water} - (mc\Delta T)_{ice}\right]}{m_{ice}}$$

Using the data for trial #1:

$$H_f = \frac{\left[\left(137.72g \bullet 1.0\frac{cal}{gC^\circ} \bullet 10.6C^\circ\right) - \left(13.45g \bullet 1.0\frac{cal}{gC^\circ} \bullet 30.2C^\circ\right)\right]}{13.45g} = \boxed{78.3\ cal/g}$$

2. Percent Error:

$$\%Error = \left[\frac{(ExperimentalValue - HypotheticalValue)}{HypotheticalValue}\right] \bullet 100\%$$

Using the data for trial #1:

$$\%Error = \left[\frac{\left(78.3\frac{cal}{g} - 80.0\frac{cal}{g}\right)}{80.0\frac{cal}{g}}\right] \bullet 100\% = \boxed{-2.1\%}$$

where:

Q = Heat (in calories), m = mass (in grams), DT = change in temperature (in C°)

c = specific heat (in $\frac{cal}{gC^\circ}$*),* H_f *= heat of fusion (in* $\frac{cal}{g}$*)*

Works Cited:
Generally you will follow the “works cited” format for referencing source material used in your lab. See the English departments manual “The Write Stuff” for guidance. Sometimes your teacher may ask for a different technique such as an annotated bibliography.

Additional Advice and Tips:

- Strive for logic and precision and avoid ambiguity, especially with pronouns and sequences
- Keep your writing impersonal; avoid the use of the first person (i.e. I or we)
- Use the metric system of measurement and abbreviate measurements without periods (i.e. cm kg)
- Spell out all numbers beginning sentences or less than 10 (i.e. "two explanations of six factors").
- Write numbers as numerals when greater than ten (i.e. 156) or associated with measurements (i.e. 6 mm or 2 g)
- Have someone review and critique your report before submission
- Write the report as if you were writing to other students who are taking a similar course but have not done this experiment. Assume that they have some familiarity with the subject matter but no expertise.
- The last thing to do before turning a report in is to **read it**. Correct all typographical errors and other mistakes, and ensure that you have said what you wanted to say!
- Be consistent in the use of tense throughout a paragraph--do not switch between past and present. It is best to use past tense.
- Be sure to back up your work somewhere in case your original is lost.

SCIENCE LAB SAFETY

The science lab is a place for academic inquiry. As such, you are expected to conform to the standards established for a classroom situation. In the lab it is necessary that you follow directions carefully, and that you observe all safety precautions. If you do not know what you are doing it is very easy to hurt yourself, someone else or the equipment used in the lab. Below is a set of general guidelines for your safety.

I. General Safety Procedures

1. Do only authorized experiments.

2. Never work without supervision in the lab.

3. Become familiar with the lab. Know where safety things are such as the fire alarm, fire extinguishers, fire blanket, sand, "Spill-Arrester," first aid kit, eyewash and shower.

4. Adequately prepare for each experiment including prelab write up (lab log). Follow directions carefully. If you don't understand something, ask the instructor.

5. Keep lab work area free of personal possessions.

6. Report any injury or accident to the instructor immediately.

7. Move with caution in the lab. Running or loud talking is not permitted. Horseplay will result in disciplinary action.

8. Food or beverages must not be brought into or consumed in the lab.

9. Clean work area when done.

10. Wash hands when you're finished cleaning your area.

11. Use common sense at all times. THINK before you act.

II. Personal Safety

1. Wear aprons and safety glasses at all times in the lab unless told by the instructor that they are not needed.

2. Contact lenses must not be worn in the lab since there is the distinct possibility that chemicals may infuse under the lenses and cause eye damage.

3. In case of burns rinse with cold water for 15 minutes. Get further treatment if necessary.

4. In case of chemical burns rinse with water for 15 minutes. Neutralize chemicals with the proper reagent (see instructor). Get further treatment if necessary.

5. Rinse chemicals from clothes and neutralize with the proper reagent (see instructor).

6. In case of chemicals in the eyes, flood eyes and face with water from the eyewash for 15 minutes. See your doctor for immediate attention.

7. Never taste any chemical or solution.

8. Work at a safe distance from your apparatus. Tie back long hair or loose clothing. Do not lean over the lab table or sit on the lab tables.

III. Lab Safety Techniques

1. Smell a chemical only when necessary and then only by wafting a small amount of the vapor with the hand toward the nose.

2. All chemicals with toxic fumes and poisonous gases must be handled under the hood.

3. Never pipette by mouth. Use the rubber bulbs provided.

4. When extracting chemicals from dropping bottles, never lay the pipettes on the tabletop.

5. When pouring an acid or an alkali, never set the top on the tabletop.

6. When diluting acids, always pour the acid slowly into the water. "Do as you autta, add acid to watta."

7. When heating chemicals in a test tube, always point the mouth of the tube away from yourself and others.

8. Don't weigh any chemicals directly on the balance pan. Use weighing paper on a suitable container.

9. Don't weigh hot objects on the balance. Allow to cool first.

IV. Chemical Safety

1. Keep tops on all chemicals and solutions.

2. Label all chemicals and solutions. Discard all waste or unlabeled chemicals and solutions in the proper containers.

3. Never return unused chemicals to the reagent bottles.

4. Clean up all spills immediately. Use "Spill-Arrester" or other suitable material to neutralize any spills.

V. Biological Safety

1. Never use a cutting device of scalpel with more than one cutting edge. Always store scalpel in dissecting kit with sharp edge down.

2. Do not hand hold specimens while cutting. Secure specimen in dissecting pan with pins.

VI. Glass Safety

1. Check all glassware for cracks before use.

2. Never heat an empty or sealed container.

3. Glass tubing must be fire polished before use.

4. Use care in handling hot glass. It cools slowly. Hot glass should be placed on the wire gauze.

5. When inserting glass tubing into a rubber stopper, lubricate both glass and stopper with water or glycerin. Hold the glass with a towel and insert with a twisting motion. Don't use undue force when inserting or removing glass tubing.

VII. <u>Fire or Explosion Safety</u>

1. Keep flammable liquids away from open flames.

2. Extinguish all fires immediately with the appropriate extinguisher.

VIII. <u>Electrical Safety</u>

1. Remember that the human body is a conductor of electricity.

2. Never handle electrical connections with wet hands or when standing in or near water.

3. Use well insulated leads in all electrical work.

IX. <u>Radiation Safety</u>

1. Only low level radioactive materials will be used in this course.

2. These materials will be used only by the instructor.

<u>Safety Contract</u>

The science lab is a workshop for serious study. I understand that anyone working in the science lab must think and practice safety. I have read and understand the above safety precautions and realize that this is only a partial list. I will follow these and other safety precautions as directed by the instructor.

Signature _________________________

Date _________________________

Instructor's initials _____________

Sample Lab Report

Introduction

- **What were you trying to do/prove?**
- **How did you do this?**
- **What do you think would happen (what was your hypothesis)? Why?**

Theory/Essay of Relevant Principles

Light:

- What is light and how does it travel?
- Compare and contrast transverse and longitudinal waves
- Compare and contrast reflection and refraction
- Describe what happens when light hits a convex mirror and a concave mirror
- Describe what happens when light hits a convex lens and a concave lens (include diagrams)

Lenses:

- Describe the meaning of focal length, object distance, image distance, object size, and image size
- Explain how lenses are used in cameras and in eyeglasses (nearsighted as well as farsighted)
- Explain how you could find the focal length of a lens

Conclusion

- **What were your results?**
  - Were the ratios equal?
  - How did your experimental results, your scale diagrams, and your calculations compare?
  - What did you determine the focal length of the mystery lens to be?
  - Explain any differences that existed.

- **Explain what your graphs show.**
  - Are the variables related? Explain how and why.

- **Describe your sources of error, how they affected the results and how they could be reduced.**

- **Did the results prove your hypothesis? Explain.**

- **What would happen is you did something differently? Why?** (i.e. If you used a concave lens instead of a convex lens)?

- **Do you think the same relationship would exist with mirrors? Explain.**

Sample Rubric:

Section	CATEGORY	Exceeds	Meets	Partially Meets	Does Not Meet
intro	**Question/Purpose**	The purpose of the lab or the question to be answered during the lab is clearly identified and stated.	The purpose of the lab or the question to be answered during the lab is identified, but is stated in a somewhat unclear manner.	The purpose of the lab or the question to be answered during the lab is partially identified, and is stated in a somewhat unclear manner.	The purpose of the lab or the question to be answered during the lab is erroneous or irrelevant.
intro	**Experimental Hypothesis**	Hypothesized relationship between the variables and the predicted results is clear and reasonable based on what has been studied.	Hypothesized relationship between the variables and the predicted results is reasonable based on general knowledge and observations.	Hypothesized relationship between the variables and the predicted results has been stated, but appears to be based on flawed logic.	No hypothesis has been stated.
intro	**Procedures**	Procedures are listed in clear steps. Each step is numbered and is a complete sentence.	Procedures are listed in a logical order, but steps are not numbered and/or are not in complete sentences.	Procedures are listed but are not in a logical order or are difficult to follow.	Procedures do not accurately list the steps of the experiment.
intro	**Materials**	All materials and setup used in the experiment are clearly and accurately described.	Almost all materials and the setupu used in the experiment are clearly and accurately described.	Most of the materials and the setup used in the experiment are accurately described.	Many materials are described inaccurately OR are not described at all.
intro	**Replicability**	Procedures appear to be replicable. Steps are outlined sequentially and are adequately detailed.	Procedures appear to be replicable. Steps are outlined and are adequately detailed.	All steps are outlined, but there is not enough detail to replicate procedures.	Several steps are not outlined AND there is not enough detail to replicate procedures.
intro	**Experimental Design**	Experimental design is a well-constructed test of the stated hypothesis.	Experimental design is adequate to test the hypothesis, but leaves some unanswered questions.	Experimental design is relevant to the hypothesis, but is not a complete test.	Experimental design is not relevant to the hypothesis.
essay	**Scientific Concepts**	Report illustrates an accurate and thorough understanding of scientific concepts underlying the lab.	Report illustrates an accurate understanding of most scientific concepts underlying the lab.	Report illustrates a limited understanding of scientific concepts underlying the lab.	Report illustrates inaccurate understanding of scientific concepts underlying the lab.

Section	CATEGORY	Exceeds	Meets	Partially Meets	Does Not Meet
conclusion	**Conclusion**	Conclusion includes whether the findings supported the hypothesis, possible sources of error, and what was learned from the experiment.	Conclusion includes whether the findings supported the hypothesis and what was learned from the experiment.	Conclusion includes what was learned from the experiment.	No conclusion was included in the report OR shows little effort and reflection.
conclusion	**Error Analysis**	Experimental errors, their possible effects, and ways to reduce errors are discussed.	Experimental errors and their possible effects are discussed.	Experimental errors are mentioned.	There is no discussion of errors.
conclusion	**Analysis**	The relationship between the variables is discussed and trends/patterns logically analyzed. Predictions are made about what might happen if part of the lab were changed or how the experimental design could be changed.	The relationship between the variables is discussed and trends/patterns logically analyzed.	The relationship between the variables is discussed but no patterns, trends or predictions are made based on the data.	The relationship between the variables is not discussed.

Section	CATEGORY	Exceeds	Meets	Partially Meets	Does Not Meet
supporting documents	**Data**	Professional looking and accurate representation of the data in tables and/or graphs. Graphs and tables are labeled and titled.	Accurate representation of the data in tables and/or graphs. Graphs and tables are labeled and titled.	Accurate representation of the data in written form, but no graphs or tables are presented.	Data are not shown OR are inaccurate.
supporting documents	**Drawings/Diagrams**	Clear, accurate diagrams are included and make the experiment easier to understand. Diagrams are labeled neatly and accurately.	Diagrams are included and are labeled neatly and accurately.	Diagrams are included and are labeled.	Needed diagrams are missing OR are missing important labels.
supporting documents	**Variables**	All variables are clearly described with all relevant details.	All variables are clearly described with most relevant details.	Most variables are clearly described with most relevant details.	Variables are not described OR the majority lack sufficient detail.
supporting documents	**Calculations**	All calculations are shown and the results are correct and labeled appropriately.	Some calculations are shown and the results are correct and labeled appropriately.	Some calculations are shown and the results labeled appropriately.	No calculations are shown OR results are inaccurate or mislabeled.
supporting documents	**Background Sources**	Several reputable background sources were used and cited correctly. Material is translated into student's own words.	A few reputable background sources are used and cited correctly. Material is translated into student's own words.	A few background sources are used and cited correctly, but some are not reputable sources. Material is translated into student's own words.	Material is directly copied rather than put into students own words and/or background sources are cited incorrectly.

Section	CATEGORY	Exceeds	Meets	Partially Meets	Does Not Meet
overall	**Components of the report**	All required elements are present and additional elements that add to the report (e.g., thoughtful comments, graphics) have been added.	All required elements are present.	One required element is missing, but additional elements that add to the report (e.g., thoughtful comments, graphics) have been added.	Several required elements are missing.
overall	**Spelling, Punctuation and Grammar**	One or fewer errors in spelling, punctuation and grammar in the report.	Two or three errors in spelling, punctuation and grammar in the report.	Four errors in spelling, punctuation and grammar in the report.	More than 4 errors in spelling, punctuation and grammar in the report.
overall	**Appearance/ Organization**	Lab report is typed and uses headings and subheadings to visually organize the material.	Lab report is neatly handwritten and uses headings and subheadings to visually organize the material.	Lab report is neatly written or typed, but formatting does not help visually organize the material.	Lab report is handwritten and looks sloppy with cross-outs, multiple erasures and/or tears and creases.