Classical High School

AP Physics

Instructor: Mr. Butler

Laboratory Report Outline

The lab report should include the following sections written in the order shown.

Title/Cover Page

Introduction

a) **Purpose/Objective**
b) **Hypothesis**

Experimental Data

a) **Tables**
b) **Diagrams**

Calculations

Results

a) **Tables**
b) **Diagrams**
c) **Graphs**
d) **Summary of Trends/Patterns**

Conclusions

a) **Purpose/Objective**
b) **Error Analysis**

Lab Questions

***The following pages provide a detailed format of the elements included in each of the sections listed above.**

Classical High School

Instructor: Mr. Butler
AP Physics
Laboratory Report Format

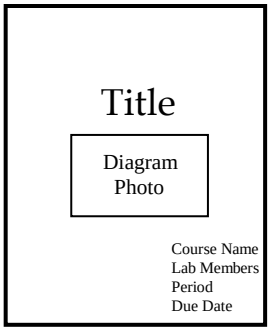
The following outlines the format required for writing lab reports in this course. The sections are to be arranged in the sequence given below. Each section must include the correct heading and subheadings. Your lab report must be typed. Grade will be determined by the content and quality of the report based on the criteria given below. Each lab team will turn in one report. Use the lab checklist to assist you when writing your lab report. Refer to the lab rubric for specific criteria and point assignment. Follow the basic lab report writing format given here.

Title/Cover Page

The title/cover page should include the following information:

a) Title of laboratory experiment (above centered)
b) Diagram or photo of experimental set up
c) Course name (AP Physics B, AP Physics C, General Physics)
d) Names of lab team members
e) Period/Due Date

** Example*



Introduction

The introduction contains **two**, narrowly focused subsections which provides the reader with a summary of the purpose, objective, method and hypothesis of the laboratory experiment. Each subsection should be written using one or two sentences which are precise, but concise statements. The key is to use one or two sentences that summarize the most important and relevant ideas.

Purpose/Objective: This states the objective, goal, or purpose of the experiment and provides the reader with an understanding of the principles being tested. This subsection consists of two parts: The first sentence states the goal/purpose/objective of the lab. The second sentence is a summary which describes the method involved in determining the purpose/objective.

The following are good examples of an introduction.

1. The purpose of this experiment was to identify the specific element in a metal powder sample by determining its crystal structure and atomic radius. These were determined using the Debye-Sherrer (powder camera) method of X-ray diffraction.
2. The purpose of this experiment was to test the validity of Newton's Second Law and to determine a value for ***g***, the acceleration due to gravity. These were determined using the Linear Cart Acceleration method.

Hypothesis:

Introduction: Most students believe that they are going to be experimenting anytime they are given a laboratory assignment in science. However, more often than not, students are doing something other than experiments. This is not necessarily bad. A good deal of science is observational and descriptive. For example, the study of bio-diversity usually involves looking at wide variety of specimens and maybe sketching and recording their unique characteristics. However, there are other times when we are trying to verify specific relationships between quantities in nature which we may suspect is valid, but which we have no evidence to support. Without any proof, we have no justification about making claims for these relationships.

To learn about what is not known or to verify a specific relationship, the so-called "scientific method" might be carried out and an actual experiment may be conducted. It does not matter that your experiment has been done a thousand times before or that your teacher already knows the results. What matters is that you don't know the results and that you can independently find a verifiable answer. In real experiments, hypotheses should be written before the actual experiment is carried out.

What Is a Hypothesis: A hypothesis is a clear, concise, and reasonable prediction about expected results based on what principles have been studied. A hypothesis is a tentative statement that proposes a possible explanation to some phenomenon or event. A useful hypothesis is a **testable** statement which includes a prediction. A hypothesis should not be confused with a theory. Theories are general explanations based on a large amount of data. For example, the theory of evolution applies to all living things and is based on wide range of observations. However, there are many things about evolution that are not fully understood such as gaps in the fossil record. Many hypotheses have been proposed and tested.

Why is a Hypothesis Important: The key word is **testable**. That is, you will perform a test of how two physical quantities might be related. This is when you are doing a real experiment. You are testing real physical quantities of nature. Usually, a hypothesis is based on some previous observation such as noticing that in November many trees undergo color changes in their leaves as the average daily temperatures are dropping or that the swing of a pendulum is changes as its length changes. A hypothesis makes a definite prediction, usually stating it in mathematical terms, about the precise relationship between two quantities. Any laboratory procedure you follow without a hypothesis is really not a valid experiment. It is just an exercise or demonstration of what is already known.

Writing a Formalized Hypothesis: The ultimate value of a formalized hypothesis is that it forces us to think about what results we should look for in an experiment and what results we expect to obtain. Formalized hypotheses contain two physical quantities. One is "independent" and the other is "dependent." The independent quantity is the one you, the "scientist" control and the dependent quantity is the one that you observe and/or measure. The idea here is one of cause and effect. State predicted relationships between quantities, what type of graph curves should be expected, and what values should be obtained from calculations.

The following is a good example of a formalized hypothesis.

It is predicted that the inward force of an object moving in a horizontal circle will change proportionally as the square of speed of the object is changed; provided that the mass of the object and its radius from the center of the circle are held constant. Graphically, a plot of **F vs v** should yield a parabola and a plot of **F vs v^2** should yield a straight line with the slope representing the ratio of the object's mass to the circular radius, **m/r**.

Experimental Data

Present experimental data in an organized fashion using tables. Experimental data are those values for physical quantities which were measured and collected during the laboratory experiment. Results are values that are the product of calculations. Experimental data are not results! Be certain to distinguish between them and save the presentation of your results until later in the lab report. You can choose the format and design of the tables, but the presentation of the data must be clear, organized, and complete. Experimental data must be presented so that they are clear to the reader. Whatever table format you choose to use to display the data, be certain to include the name of each quantity with its correct unit. In a data table, it is necessary to indicate the name and units of a quantity only once. Each table should be numbered and given a title heading that identifies what type of data the table shows.

Example: The following is a good example of a data table.

Table 1: Air sample length and Hg height difference

Trial	Length of air sample (mm)	Hg height difference (mm)
1	122.5	51.0
2	116.2	94.4
3	111.4	126.7
4	106.2	174.3
5	103.6	197.9

Calculations

This section shows the calculations that were made for obtaining the numerical values of specific physical quantities related to the laboratory investigation. Calculations must be typed and must be organized! **For each calculation, only one set of data needs to be shown as an example.** Numbers and headings that identify a specific calculation are to accompany each calculation. Calculations in the lab report are to appear in the same sequence as they appear in the laboratory sheets. Each calculation must show mathematical steps, proper units, and an answer with proper units. It is important to show how the value of each physical quantity was obtained. For each physical quantity that you calculate, four (4) components are needed to show how the calculation was obtained.

1) Number/Name of physical quantity being calculated.
2) Formula that was used to calculate the physical quantity. The formula should be in symbolic form with no units shown.
3) Example calculation using one set of experimental data.
4) Answer: Shown in bold text with symbol, value, and correct units.

The following is a good example of a calculations format.

1. Average Time

t_{Avg} = (t_1 + t_2 + t_3) / # of trials
= (3.09 s + 3.09 s + 3.13 s) / 10
t_{Avg} = 2.97 s

2. Acceleration

$a = 2d/ t^2$
$= 2 (200 cm) / (2.97 s)^2$
$a = 45.3 cm/s^2$

Results:

Tables: Results obtained from analysis/calculations need to be presented in summary tables. Results are not experimental data! Results are values that are the product of calculations. As with tables for experimental data, the presentation of results must be clear, organized, and complete and presented so that they are clear to the reader. Give each results table a number and descriptive title. Each column should be labeled with the name of the quantity and should include correct units. It is necessary to indicate the name and units of a quantity only once.

Graphs: Graphs are an important part of any lab report. Their purpose is to communicate and present experimental data and results in a visual context and to allow interpretation of the data in terms of any patterns or mathematical relationships that may exist between the experimental data and/or calculated physical quantities. Your interpretation of the collected experimental data and results and the conclusions that you draw will primarily rely on the graphs you generate. It is for this reason that you must pay special attention to generating a meaningful graph.

Each graph must be computer generated and include the following components:

a) **Title:** The title should state the physical quantities which were plotted (y vs x) and also what the focus of the experiment was.

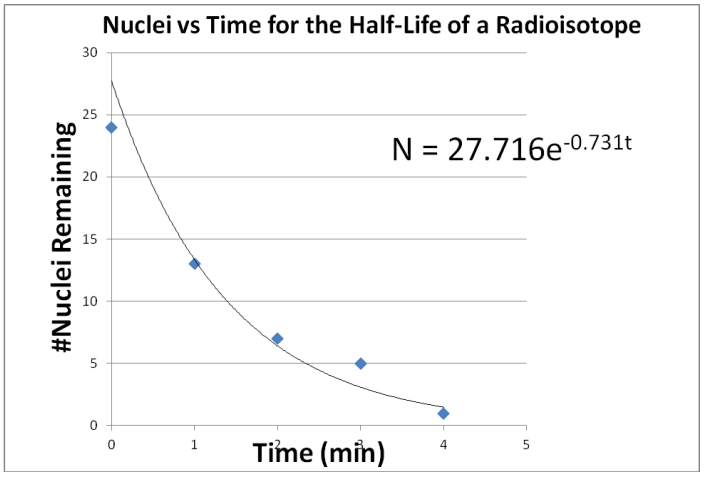
b) **Axis Labels:** Each axis (x and y) should state the name of the physical quantity along with its unit.

c) **Axis Scale:** Each axis must include a scale showing the limits of the values for that physical quantity and also a few intermediate values spaced at equal intervals. Excel will do this for you when you make a graph.

d) **Data Points/Curves:** Each data set must be plotted on the graph. Points for each data set must be clearly displayed on the graph and the points must be fit with a best-fit curve that represents their mathematical relationship or function.

e) **Equation:** An equation identifying the graph curve and the precise mathematical relationship between the plotted physical quantities must be included and shown next to its curve on the graph.

Example:



Summary: Results are not only dominated by graphs and tables. It is important to state all significant results explicitly in written form. This is the most important part of the results section. It allows the reader to quickly determine precisely which results were obtained. Do not go into detail about what exactly the data mean in a strict sense. Don't interpret the results; simply report them! Leave this to the conclusions section. However, if you find a significant difference between data groups, point out what the difference is.. Use a few sentences to draw attention to significant trends in your results and then summarize what results have been obtained.

Conclusions:

The conclusion section should include the following **two** subsections:

Purpose/Objective:

The conclusions section discusses the results in the context of the entire experiment. Interpret and explain what the results mean in terms of the purpose/objective. The objective or purpose stated in the introduction is examined to determined whether the experiment succeeded and to state whether the quantitative results support predictions and are consistent with the principles being studied. Experimental results are compared to predictions made in the hypothesis and this comparison is analyzed in relation to the principles being tested. If the original purpose was achieved and the hypothesis confirmed, or if it was not, state this and explain how the results verify this by using the experimental data as evidence. You should explain the logic that allows you to accept or reject the original hypothesis. One way to analyze numerical results and to discuss them in the context of the conclusion is to site the results from observations, graphs and of course calculation results.

The following is a good example of a Purpose/Objective.

> Analysis of the results confirm the original hypothesis and verify that the original purpose of this experiment was achieved. Graph I shows the trend between velocity and time predicted and the slope of this graph is the experimental value of the acceleration of the system. Using a least-squares fitting package, the acceleration was found to be a_{exp} = slope = (59.1 ±1.5) cm/s^2. The value of the acceleration predicted by substituting measured values of the masses and g = 980 cm/s^2 into equation (2) was (60.9 ±0.1) cm/s^2. The percent discrepancy between the two values is only 3.0%. The good agreement between the measured value of the acceleration of the system and the value predicted by Newton's second law provides justification for the validity of Newton's second law.

Error Analysis

All experiments involve error. Deviations from the stated principles and predicted results will always occur to some degree. As part of your conclusions you will need to analyze the experiment and identify the errors that may have been present. Determine and identify the causes/source of the error and explain precisely how the error could have affected the experimental results. Pay attention to the errors that existed in the experiment, both where they originated and what their significance is for interpreting the reliability of conclusions. Analyze each to determine the predicted effect it would produce in the results. Explain the logic which shows this precise effect and how it could account for the observed deviation. Compare this predicted effect to those observed in your experimental results to determine the validity of your explanation. For example, if your analysis for an identified error source predicts a larger value for a measured or calculated quantity, then you should observe this trend in the experimental results. If you don't observe this trend in the data, you can't attribute this source to this error.

The following is a good example of an Error Analysis.

> The difference between the measured and predicted values of acceleration can be attributed to the influence of error factors from two primary sources. These possible error sources have been identified as follows:
> 1. Time measurement: Inaccurate time measurement has been identified as one possible error source Since the cart travels down the incline more quickly at higher angles, reaction time at these higher angles might be slower, thereby giving a longer measurement for the travel time of the car down the incline. The greater time value would cause the calculated value of acceleration to be skewed lower. An examination of acceleration results confirms this trend.

Note: Only one source has been given in this example. Your lab will most likely have more!

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Lab Questions:

Typically there will be questions to answer at the end of a laboratory experiment. Provide complete and thoughtful responses in terms of lab data, observations, results and conclusions.

Classical High School
Physics
Instructor: Mr. Butler
Laboratory Report Writing Guide and Checklist

Basic Lab Report Writing Format

1. Write in the 3rd person only. Restrict the use of all pronouns: I, we, they, he, she, etc.
2. Arrange lab sections in the same sequence as given in the lab format.
3. Text and font should be consistent throughout the report.
4. Include all section headings and subheadings using **bolded** text.
5. Subheadings should use a slightly smaller font than section headings.
6. Write report using single spaced text.
7. Proof read the report for continuity, grammar/spelling, and completeness.

Writing Format

☐ Writing Format: 3rd person w/Correct font consistency and spacing
☐ Headings/Subheadings: Sequenced and correctly formatted

Title/Cover Page

☐ Correct title/Diagram or Photo
☐ Course Name/Names of lab team members/Due Date
☐ Title and all text aligned correctly

Introduction/Hypothesis

☐ Purpose/Objective Statement: Clear, complete, concise, and accurate
☐ Method Statement: Clear, complete, concise, and accurate
☐ Hypothesis Statement: Clear, complete, and concise-Includes a reasonable prediction in the form of a mathematical relationship based on the principles being investigated.

Experimental Data

☐ Data Tables: Accurate, complete and clearly distinguished
☐ Table Headings: Correctly numbered and labeled

Calculations

☐ Physical Quantities: Correctly calculated, named and numbered
☐ Equations/Formulas: Correct and in symbolic form-Example/Answer bolded w/correct units

Results

☐ Tables/Graphs: Both are complete and accurate
☐ Summary: Significant observations, results and trends are indentified

Conclusions ☐ Purpose/Objective: Conclusions use supporting evidence w/accurate and complete analysis and interpretation of results
☐ Error Analysis: Accurate and complete analysis of experimental error

Lab Questions

☐ Questions: Answered thoroughly using data and evidence

Laboratory Report
Student Responsibilities

Laboratory Title _____

Due Date _____

Course (Circle One) AP Physics B AP Physics C General Physics

	Name	Lab Report Responsibility
Team Captain	_____	_____
Team Members	_____	_____
	_____	_____
	_____	_____
	_____	_____
	_____	_____
	_____	_____
	_____	_____

Classical High School

AP Physics

Instructor: Mr. Butler

Laboratory Report Scoring Guide

15 Points: Writing Format **_____ pts.**

- ☐ Written in third person
- ☐ Font (point - spacing – consistency)
- ☐ Headings/Subheadings

05 Points: Title-Cover Page **_____ pts.**

- ☐ Correct title
- ☐ Correct diagram/photo
- ☐ Names of all lab partners
- ☐ Course name/Due date
- ☐ Title and text aligned correctly

10 Points: Introduction **_____ pts.**

- ☐ Purpose/Method statement is clear, complete, concise, and accurate
- ☐ Hypothesis-Graphical/Mathematical verification complete, concise, and accurate

15 Points: Experimental Data & Calculations **_____ pts.**

- ☐ Data tables complete
- ☐ Table headings included-correctly numbered and labeled
- ☐ All required physical quantities calculated
- ☐ Each physical quantity identified and numbered
- ☐ Formulas correct and in symbolic form-Example w/correct units

25 Points: Results **_____ pts.**

- ☐ Results tables complete-Headings included and correct
- ☐ Correct graph-Title and axis complete and correct
- ☐ Data points/Curve fitting are complete and accurate
- ☐ Equation is shown-Correct mathematical relationship
- ☐ Results summary-significant results clearly stated and summarized

20 Points: Conclusions **_____ pts.**

- ☐ Purpose/Objective verified using supporting evidence
- ☐ Conclusions accurate/Results compared to hypothesis predictions
- ☐ Accurate and complete analysis of experimental error

10 Points: Lab Questions **_____ pts.**

- ☐ All questions answered thoroughly using supporting data and evidence

Total Score=_____

Checked boxes indicate incomplete or missing information.