Writing the Physics Laboratory Report

Laboratory reports are intended to provide a permanent record of experimentation and research. Notes, data, and analysis are written in a durable notebook. In the physics classroom, these writings form the basis for laboratory grades but also provide valuable experience since researchers in many disciplines follow similar practices.

I. Basic rules:

- The lab is to be written on the *right hand pages only* in your composition book.
- The lab starts out with its title, the date, and the names of the lab group
- The lab must be neat and legible.
- The sections must appear in order (Title, Purpose, Apparatus and Procedure, Data, Evaluation of Data, and Conclusion). Do not combine sections unless specifically told to do so.
- The lab must be written in ink or typed. If printed lab information or graphs are used, they must be:
  - cut to fit within the page. NO "FOLDOUTS"
  - attached individually. DO NOT stack several graphs on top of each other.
  - attached with tape or glue. NO STAPLES
- Sentences must be complete, spelling accurate, and grammar correct.
- Your composition book has lots of pages. Do not try to make the lab report fit on one or two pages. Many of our labs will take several pages to fit all of the required information.
- Graphs and drawings must neat – straight lines must be drawn with a ruler.

Important: The following may cause your lab report to be "ungradeable" and result in a zero score or severely reduced score:

1. **Pages torn out of lab book. This is never acceptable, and in the research lab it may cause research credibility to be questioned. If errors are made, simply line through them (even a whole page). Lined out material will not count against you.**
2. **Graphs or other information "stuffed" in the book and not attached with tape or glue. If graphs are "stacked" on top of each other, only the top graph will be graded. The others will be counted as missing.**
3. **If a substantial portion of the lab is missing (i.e., data, evaluation of data, and/or conclusion), the lab will not be graded.**
4. **Plagiarism and copying are serious academic offenses. While all other sections of the lab report *should* closely resemble those of your lab groups, the conclusion *must not*. Lab reports with identical (or substantially identical) conclusions will receive scores of zero and may be referred for disciplinary action. Even if asked, do not permit others to copy your conclusions.**

II. Laboratory Report Contents and Structure

Your lab report must be titled and must identify those who worked with you. In addition, it will be divided into clearly labeled sections: purpose, apparatus, procedure, raw data, data evaluation, and conclusion. These sections are described below. All of these sections are required, and they must appear in the order listed.

1. Purpose: This is a short statement which identifies the physical system or phenomena being studied and the goal of the lab. In physics, this usually means that we are attempting to identify a mathematical model that will describe and/or predict the behavior of similar systems.

Example: To develop a mathematical model relating position and time for an object moving with a constant speed.

The purpose statement should be written *before* the laboratory work is done. If it is written or rewritten later, it must not reflect any of the conclusions of the lab work.

2. Apparatus: This section should provide a complete list of equipment needed. A diagram should also be provided showing how this apparatus is assembled. Sketch carefully and use a ruler when necessary. The parts of the diagram should be labeled clearly.

3. Procedure: This is a written, step-by-step set of instructions for using the apparatus to conduct the experiment and collect data. A rough draft should be written *before* the lab experiment is conducted, and the final version should include corrections and modifications developed during the experiment. The instructions should include details such as number of trials, number of variables, and identifying data that needs to be recorded.

Lab equipment and materials vary from location to location. Variables such as masses, lengths, and distances should not be listed in the directions unless they are critical to the performance of the lab.

Bad example: The experiment is repeated using 0.324 kg, 0.182 kg, and 0.00583 kg masses.

Good example: The experiment is repeated using three additional, different masses.

The procedure is also *not* a diary of your lab and should be written accordingly. Don't use phrases such as "...then we took the timer and we let the car go."

If procedures are repetitive, use phrases like "repeat steps 5 – 9 using a different mass".

Once you have written your procedure it is a good idea to have another person read it and decide whether or not the instructions are sufficient for repeating your experiment.

4. Data: This is one of the simplest sections of the lab. Data *actually recorded* during the experiment is listed here in a table. Only the raw data can be included. *No averages or converted units may be listed!*

The table must be clearly titled, and column headings must include appropriate units. Accompanying details such as physical values held constant should be included outside the table. If a recorded value was taken for a multiple trial (for example, if a pendulum is allowed to swing 10 times and the time recorded) include that information as well.

When conducting the lab and taking data, good experimental procedure is important. Your plan should ensure that you have:

- an appropriate range of data. When possible, the highest value for the independent variable should be 10 times the lowest value.
- multiple trials when necessary. When timing events manually, or whenever the result could include human error or subjective elements, you should conduct multiple trials.
- good quality data. Your group should try to have the graphing program running and enter the data as you go so that you can identify problems early, before you spend an entire class period collecting bad data!

Be absolutely sure to write down every bit of information that you can. If equipment (such as a cart or spring) is numbered or color-coded, write that information down. When writing your data tables, be sure to also record constant values used.

5. Evaluation of Data: This section includes all calculations performed on data. Calculations include unit conversions and averaging. This section should also be presented in a logical order.

First, show one complete sample of each type of calculation performed, using actual data for the sample. Label the sample clearly (for example: Sample calculation for averaging time) and include units in all parts of your calculation.

Second, present graphical analysis for each experiment. Locate the table of data for each graph as close to the graph as possible. The table should have column headings that include the appropriate units. The graph should have a title or heading and must be large enough to be useful (at least 7 cm on a side) and visible. If drawn by hand, *use a ruler for all straight lines*. Axes must be clearly labeled with scales, titles, and units. Data points should appear clearly and accurately. *Only regression lines should be shown on graphs. Connecting lines are never to be used.* If using Graphical Analysis or Excel, turn off connecting lines.

Do not print graphs directly from Graphical Analysis. Instead, copy and paste graphs and data tables into Microsoft Word so that you can adjust their size to better fit your lab book and to save on paper.

If a graph is not initially linear you must apply the appropriate linearization technique. Include a short statement with the graph indicating *why* you are linearizing. All graphs in a series must be included, and must appear in the order produced. For graphs in a series, one data table showing all appropriate columns for all the graphs in the series is acceptable. Regression data should be included with each graph if such data contributed to the decision to linearize. Regression data *must* be included with the linearized graph.

Following each linearized graph, include its equation. Be sure that units and variables are shown appropriately. Include intercept values, or, if the intercept can be excluded using our 5% rule, indicate that clearly by writing **5% rule** with the equation.

> **5% Rule:** Since we are working in the lab with real data, there is some experimental error. As long as these errors are small, we will still be very effective at proving our results. For y-intercept values, we often know that the intercept value should be zero, but our regression data shows a non-zero intercept. For our class (not for experimental science in general) we will apply the 5% rule as follows:
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> > If by reasoning, you conclude that the intercept *should* be zero, you may disregard the actual value IF the intercept value is less than 5% of the highest value on the y axis.

6. Conclusion: *This is the most important part of the lab write-up*. The conclusion is intended to be a written report of the experiment. The conclusion should include reference to all aspects of the experiment, and should be written in a way that allows a reader to understand the lab and its results.

Your duty in writing the conclusion is to use the data from your lab to answer the question or problem posed in the purpose statement of the lab. To do this, you must actually state the results (equations from graphs or other data analysis) and explain them, part by part. Explanations must reflect the actual meaning of slopes and intercepts. If experiments show that there is no relation between independent and dependent variables, explain this in terms of your equations.

All of this must follow a logical path so that a reader will not be forced to "read between the lines" to decide whether or not to agree with you. You must convince the reader that your conclusion is correct and repeatable by using your data and analysis. The Physics Laboratory Write-up Checklist is an excellent way to make sure that you have satisfied all of these requirements. Finally, if the lab allows you to develop a general equation that applies to the phenomena, reveal this to the reader and explain the terms of the equation.

Lastly, if your data does not provide satisfactory proof, you must explain how the experiment failed. This is only necessary if your data has unexplainable intercepts or does not reflect dependencies as other groups data does. You will know this because we will have compared results in class. Your explanation must not be general (human error, poor equipment) but must be based on specific procedural analysis. You must explain *how* procedural errors or defective equipment caused the error and demonstrate, either by explanation or mathematical analysis, why these factors would cause the specific error in the data.

III. This sounds hard – how can I get it right the first time?

Before the first lab report is due, I will make a sample lab report available to you. The sample will be an example for all of the rules above. Once you begin writing lab reports according to this format, you will begin to realize that it's all really common sense.