PHYS 2010/2110/2020/2120 Laboratory: Learning Outcomes, Lab Reports, and Grading Rubric

Learning Outcomes for PHYS 2010/2110/2020/2120 Labs

1) Technical Writing

The successful student will write about technical information in a manner that is clear, concise, and correct. The goal is to model professional writing that may be found in a research laboratory, hospital or medical facility, or workplace such as a veterinarian clinic, engineering or construction company. The entirety of your writing in the lab report should consist of complete sentences, proper paragraphs, smooth transitions, proper spelling – good writing practices that you have learned in your composition classes.

2) Hands-On Activity

The student will develop good experimental technique, including proper setup and care of equipment, conducting experiments and analyzing results in order to observe physical phenomena, assess experimental uncertainty, and make meaningful comparisons between experiment and theory.

3) Critical Thinking

The student will practice making good decisions in unscripted situations, such as how to portray data, or how to identify and correct procedural errors during lab. The student will gain experience with how to interpret data and use it to draw conclusions.

What should your Lab Report look like?

Like the lab reports you may have done in other science classes, a PHYS 2010/2110/2020/2120 lab report will consist of several sections: Introduction, Data, Data Analysis, Error Analysis, and Conclusions. Most lab reports should contain no more than one page of written text, primarily the Introduction and Conclusion. This text should be well written, and it should be your writing – distinctly different from that of your lab partner or anyone else performing the lab. Details of the expectations for the different sections follow.

The **Introduction** should be a short paragraph, 3-5 sentences long, that captures the reason for doing the lab: What do you expect to learn? On what concepts will you focus? How will you test or use these concepts? Much of the information needed to write this can be found in the Goals and Introduction section of the Experiment in question. This is an opportunity to practice identifying the most relevant information and writing a concise synthesis of it (it thus aligns with the Technical Writing outcome). We expect original writing, not cut-and-paste, or cut-and-paste with selected word changes that maintain the original sentence structure. One approach is to read the stated goals at the end of the Goals and Introduction section and rephrase them in your own voice in a short paragraph.

Your lab experience is an important opportunity to do hands-on work; to "get a feel" for how things move, pull, and react; and to learn how to use physical and electronic lab equipment (see the Hands-On Activity outcome). One must be an active participant in this process; it is not sufficient to watch a knowledgeable lab partner perform the experiment. Each lab partner must do each part of each step to get the full experience: demand it of yourself, and of your lab partner. The TA will assess your level of participation. Professional lab work requires gathering high-quality data and presenting it in a way that communicates its meaning to others. You will practice this by gathering data, recognizing and correcting any mistakes you make during lab, then presenting the final data in the form of tables of numbers that are clearly labeled. This part makes up the **Data** section (it is the outcome of performing the Procedure in the lab document). During lab, feel free to jot down your data in a notebook or scratch paper (though be careful to label the numbers). Later, as you write up the lab, organize your data for presentation in your report and label it so that a reader can clearly see what has been measured. Your data tables may be written by hand, but must be legible. You should never change values that you have recorded in this transcription process. It is here that you would also share any graphs that you capture as part of acquiring data. Always be sure to label your graphs and give each a figure number so that they may be referred to easily in any written responses in the lab report.

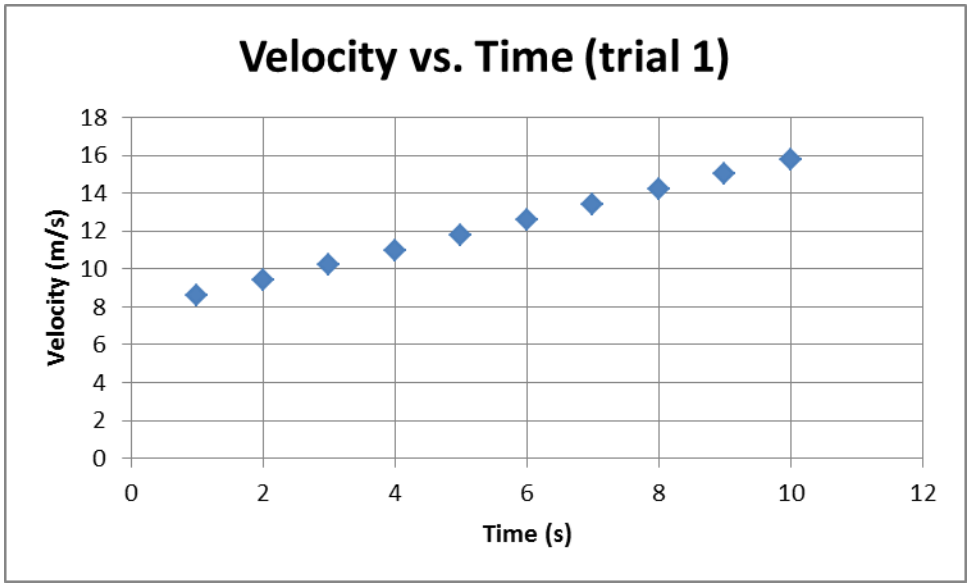
The calculations you perform in the **Data Analysis** section tie the lab experience to the problem solving you do in recitation and homework, providing practical applications to those more abstract problems. They demonstrate real-life situations in which calculations are repeated with one or more variables changed (often in a spreadsheet or computer program) to analyze the behavior of a system subject to different conditions. You should always show your work for each calculation. When a particular calculation is repeated several times, you should show at least one example of the calculation, and may simply display the results for the others. For example, you might be asked to calculate the velocity for three different trials. You should show one full calculation, and then just show the results of the other two calculations, as seen below. Remember that while you may handwrite your lab report, your presentation must be legible and clear.

$$v_1 = at = 9.8\ \text{m/s}^2 \quad 0.95\ \text{s} = 9.3\ \text{m/s}$$

$$v_2 = 8.4\ \text{m/s}$$

$$v_3 = 9.9\ \text{m/s}$$

Graphs (a.k.a. plots, or charts in Excel) are used to visually express the behavior of a physical phenomenon. The **Data Analysis** section is the place where you develop the facts from which you will draw conclusions. Any graphs you create to show the results of your analysis should have a title and labeled axes with units noted in the axis labels. For example, in the graph shown, the student



has labeled both axes with units and noted in the title that this data represents the first of several trials. Remember that you are communicating your analysis to a reader, and clear labels along with any written explanation that you feel aids your presentation are warranted. Always be sure to label your graphs and give each a figure number so that they may be referred to easily in any written responses in the lab report.

In some of the labs, you will gather data to test and confirm well-understood physical relationships, such as the conservation of energy. Because the answer can be predicted accurately through well-established relationships, you can compare your experimental results with this "theoretical" answer and discuss the amount and cause of the differences. This reflection leads one to envision how to do the experiment better next time. The **Error Analysis** section also employs the mathematical field of statistics to help you understand the uncertainty in your measurements and to decide the statistical significance of your results. Again, your calculations should be detailed, clear, and legible.

The **Conclusions** section should connect with the Introduction section in the way they would in a written paper, while the Data, Data Analysis and Error Analysis section are the "meat of the sandwich" where the facts are established and relationships developed that support the conclusions. In particular, the written sections should employ all of the good writing practices you learned in your composition courses – complete sentences, proper paragraphs, smooth transitions, correct spelling; after all, we are practicing *professional* technical writing. In the Conclusions, you must answer the specific questions that appeared in bold throughout the instructions. You should also address other, less specific questions. For example, what were the sources of error that may have affected the results of your lab? How could those errors be eliminated in a future experiment? Are there errors that we always will encounter, like the reaction time of a student using a stopwatch? Did the lab help you to solidify your understanding of physics concepts, and if so, which ones? Are there other questions or ideas the lab has prompted you to investigate? These are the kinds of questions you should consider as you write the final, concluding statements in your lab report. Thus, the Conclusions section should consist of several short paragraphs, each responding to a specific question asked in lab, plus a longer paragraph that summarizes your thoughts on the broader questions listed above, which apply to all experiments.

Rubric for PHYS 2010/2110/2020/2120 Labs

Criteria:	Ratings:			Points:
Prelab Questions: Concepts and calculations on central ideas of the lab.	Typically one point per question, partial points available on some questions, submitted and graded in Canvas.			5
Introduction: A short paragraph describing, in your own words, the purpose and goals of the Experiment.	Complete, concise, unique writing. 2 points	Weak representation of experimental goals. 1 point	Introduction absent or plagiarized. 0 points	2
Data: **A) Participation:** The TA will assess your level of participation during the data-gathering phase of the Experiment.	Actively contributing participant. 2 points	Passive or part-time participant. 1 point	Disengaged or absent. 0 points	2
B) Data/Graph Presentation: Data/Graphs are organized and presented clearly, legibly, labels clearly identify each item.	Organized, legible, labeled. 2 points	Data/Graph is present but moderately disorganized 1 point	Data/Graph is not present at all, or is present but very disorganized 0 points	2
Data Analysis: **A) Calculations** Calculations are correct; a sample calculation, including equation, is shown for each major calculation.	Correct; samples are correct and clearly presented. 3 points	One or two mistakes in calculations. An organization or presentation issue. 2 points	Multiple calculation mistakes. Poor organization or presentation of results 1 point	No calculations presented. 0 points	3

B) Graph Presentation: Graphs portray the data correctly, in a way that helps to convey information; labels clearly identify each item. If no graphs are required for Data Analysis, these 2 points are automatically awarded assuming each other section of the lab report is complete.	Correct, helpful, labeled. 2 points	Missing axes or title labels. Data plotted improperly. 1 point	No graphs presented. 0 points	2

Error Analysis: Calculations are correct and clearly presented, including equations.	Correct, clearly presented. 2 points	Some analytical mistakes or presentation issues 1 point	Not presented (when required). 0 points	2

Conclusions: **A) Answer Questions:** Answer each of the questions posed in the previous sections using information and facts developed in the previous sections.	Correct, thoughtful answers, articulated well. 3 points	Answers partially correct or articulated poorly. 2 points	Answers mostly incorrect and articulated poorly. 1 point	No answers or plagiarized work. 0 points	3
B) Discussion: Discuss what worked well in your Experiment and what did not. How would you improve your Experiment in the future? Describe how the lab experience relates to the lecture and recitation sections of the course, and to life and careers.	Meaningful insights. 2 points	Simplistic insights. 1 point	No insights; plagiarized. 0 points		2

Writing Practices: The lab report employs all of the good writing practices you learned in your composition courses.	Complete sentences, proper paragraphs, smooth transitions, correct spelling. 2 points	Imperfect or weak use of these practices. 1 point	Plagiarized work. 0 points	2