Physics 1313
Fundamentals of Physics

Laboratory Manual

Fall 1998 Edition

Professor R. Stroynowski

Fundamentals of Physics

Simply stated, physics is the experimental investigation of natural phenomena with an eye towards understanding how matter and light interact with themselves and with each other. In this course (Physics 1313) we will concentrate on the behavior of matter. It is useful to keep in mind that physics is a whole lot more than just mathematics. Mathematics serves as the language of physics and is the means by which we express our ideas about physics (what we normally call "theories".) To decide whether or not our physics ideas, or theories, describe nature, we need to conduct careful observations of nature. By "careful observations" I mean observations of nature that produce evidence that is either consistent or contradictory with the theory we are testing. Devising means to collect the supporting or damning evidence for a particular physical theory is the heart of experimental physics. Hopefully, you will get a taste of this in Physics 1313.

This is the laboratory manual for Physics 1313, *Fundamentals of Physics.* The laboratory sessions are intended to provide you with the opportunity to understand better the physics principles discussed in lecture and to learn the basic skills of general scientific investigation: experimentation, data collection, analysis and conclusion, and simple error analysis. These four aspects are interrelated. Your conclusions depend on your analysis and the quality of the data you collect, which will, in turn, depend on the care taken in performing the experiment.

Structure of the Lab:

1. This manual contains the instructions for all of the laboratory sessions this semester. These consist of the theory the experiment is testing and instructions on how to perform the experiment with the available equipment. To minimize wasting your time and to augment your physics comprehension, you are urged to read carefully and to understand these instructions *before* arriving.

2. In the conduct of each experiment, you will use the associated lab form. This form will give you adequate space for the collection of data, your mathematical analysis, conclusions and error analysis. The entire experiment will be performed in the two-hour lab period. Turn in your complete report at the end of the lab period. You will not be pressed for time if you prepare for the lab by reading the lab write-up. Although experiments and data collection will often be done in pairs or small groups, all analysis, conclusions and error analysis should be done *individually*. This will enhance your self-confidence in your mental powers.

Note: If you have a problem understanding a result or coming to a conclusion, see me. You need not feel uncomfortable in asking for assistance. Lab Reports should be submitted at the end of the lab period and will be returned the following week.

3. Grades: Lab reports will be graded by the teaching assistant. Scores will be determined according to the following basis:

40% Data Collection/Analysis
30% Conclusions
30% Error Analysis

5. Make-up Policy: If a student cannot attend the regularly assigned period, the experiment can be performed during the make-up session at the end of the semester. You should notify me as soon as possible if a lab is to be missed during the regularly scheduled time. Notice that if you miss many labs, you will have only a very limited amount of time at the end of the semester to catch up.

How to read this manual:

Each experiment contains several important terms with which you will need to be familiar before starting the experiment. These important terms will appear in **boldface** (e.g., **force** or **angular momentum**) upon their first mention in the text. The student is responsible for obtaining a thorough understanding of these terms before coming to the laboratory.

Numbers will always be cited with units included. There are several types of quantities involved in these experiments. **Scalar** quantities will be written either as numbers (e.g., 9.81 m/s^2) or as a symbol. Symbols for scalar quantities will appear in italics. Here are a few examples:

g = the magnitude of the gravitational acceleration at the Earth's surface
F = the magnitude of the force vector
W = the weight of an object

Vectors, the quantities with not only value but also a direction, will either appear as an arrow in a diagram, or more frequently by their appropriate symbol. Symbols for vector quantities will appear in **boldface**. Following are a few examples of vectors and their symbols:

F = force vector

N = normal force

v = velocity

p = momentum

Parts of a Typical Lab Report:

Abstract: After you *finish* an experiment, write a summary of the experiment's objective, the procedure to accumulate data and the conclusion, if any, reached. The abstract should be brief - no more than three or four sentences. Abstracts permit the instructor to see if you understood *why* you were doing what the lab instructions told you to do.

Data Collection: This contains the actual results of measurements and observations. Usually, this means numbers. It is necessary that you always report the units along with the data (i.e. meters, grams, ohms et cetera). In addition, try to maintain an accuracy of <u>three significant digits</u>[*] ("sig-figs") whenever possible (e.g. <u>9.81</u> m /s^2) in collected and calculated/extended data. In some cases, you may have a reason to include four or more significant digits.

Analysis: This section is devoted to showing how the data is related to the *theory*. This usually means showing some explicit calculations, but not always. Graphs are also included in the analysis part of an experiment. See Appendix B for an explanation of graphing techniques. Graphs should be neat and both axes well labeled with appropriate units.

For repeated calculations of the same type, you only need to show *all the steps* for one example unless you are concerned about partial credit. Units should be included in your calculations. If your result is in ohms, for example, and your data consists of measurements of volts and amps, your calculations should show how your final result is expressed in ohms. A result without units is a result without meaning.

---

[*] See Appendix A for an explanation of significant digits.

Conclusion: The conclusion section is one of the most important parts of your report. In writing your conclusion, you will draw on everything you have done up to that point, your study of the theory, your set-up of the experiment and data collection, as well as your analysis of the data. The main question you should consider when writing a conclusion is, "What did I learn from this experiment, from *my* data, and from *my* analysis?" You are not required to have results which "prove" the theory. Your job is to verify whether or not the theoretical model you utilized is consistent with the data collected in your experiment. Most of the time, there will be discrepancies. As a scientist-in-training, you will be required to notice any patterns in your data or the analysis of that data. For instance, you may see a relationship between the extension of a spring and the amount of weight suspended from it. Your next task is to see if this pattern relates to the pattern suggested by the theory. If your data does not support the theory, does it have a unique pattern of its own, or does it appear random? In the conclusion, you are expected to answer these questions as well as explain your reasons for making such claims. If you state that the equipment was inappropriate for the experiment performed, you will need to elaborate. Do not let the theory govern what you think is a good conclusion; the task of the experimentalist is to give evidence for the validity of theory.

Error Analysis: This is an important part of both your analysis and conclusion. In this part, you will attempt to estimate the precision of your measurement and explain why your experimental results were not exactly what you expected. State where the numerical error was introduced in the experiment. Did it come from the equipment? From the user of the equipment? Does the error seems to have a pattern, such as always being less than expected? You may be asked to estimate the percent or actual error of the numbers you record. Instructions on how to estimate error are included in Appendix A.