Introduction

The general physics sequence at PSU consists of both lecture and laboratory work. Concurrent registration in both the lecture and laboratory courses is required. The purpose of the laboratory course is to provide a hands-on learning experience that a lecture course cannot provide. Since the laboratory course serves more than one lecture section taught by more different professors, the lab and lecture will not always introduce topics at the same time. However, the laboratory course, in general, tries to follow the progress of the lecture courses.

Location: Rooms 113 & 161, Science Building 2

Required Materials:

1. This Laboratory Manual.
2. Laboratory Notebook: 8 1/2" x 11", quadrille-ruled (this means each page is graph paper), and bound. You may continue to use the same notebook from one quarter to the next. Typically, students use two notebooks during the year.
3. Your physics textbook used in the lecture course
4. Pen. Pencils may only be used for plotting data and data tables.
5. Calculator. Any ordinary calculator will suffice.

Laboratory Procedures:

1. *Read the description of the experiment and the corresponding chapter in the textbook before entering the laboratory*. You will learn more and enjoy the experience better if you come to class prepared. Your teammates and your instructor will expect that you have done this.

2. The class will start with a briefing by your instructor. He or she will briefly describe the goals and methods of the laboratory exercise. If the topic has not been covered in lecture, your instructor may give a short lecture on the subject.

3. You will then be asked to perform the experiment. The laboratory course is a collaboratory experience. Experiments are performed with one or two team members (no more). If you do not have a teammate, notify your instructor.

4. Record all of your data and observations in your laboratory notebook. The laboratory notebook is an essential facet of this course. It will be described in detail below.

5. Prepare a report in your notebook for review by your instructor. The requirements for this report vary depending on whether it is a Formal Lab Report in an Informal Lab Report. The difference will be explained at the end of this section.

Your Laboratory Notebook

Nowadays all professional experimental work in physics takes place in an atmosphere of close collaboration, whether the team consists of 4 or 400 colleagues. The work may be conducted at a university, national lab, or industry and often there is collaboration among these different groups. While the experiment is being conducted the team generally has *one lab notebook* that is shared by the members as they come on and off shift. Arriving colleagues must have a reference at hand detailing the procedures, problems, and successes of the experiment as it progresses. Those working on data analysis or theory for the project may receive copies of pertinent pages from the notebook by fax or mail. So typically *the lab notebook is a group notebook and remains in the lab*. No one ever takes it home.

A shared notebook is inconvenient for a general physics course. Students will be allowed to take their notebooks home to write their reports, thus each student will have their own notebook. Preparation and data sections must be filled out in the lab session, however, and the data itself should be identical to that of your lab partner.

In all other ways, strive to layout your notebook similar to the way professional scientists do. Guidelines are included below. Though you may not plan to become a scientist, this type of organized, systematic writing down of your experience and thoughts will help you to understand one part of the scientific method and to clarify your thinking in other areas of study.

GUIDELINES FOR LAYOUT

1. Why you should not staple, glue or otherwise add pages to the notebook: It looks highly suspicious (to us and to scientists in general – like something was added in long after the actual experiment was performed. Hey, it happens, believe it or not.).

2. Why we record all work as legibly and neatly as possible *in ink*: Pencils and erasable pens are not acceptable! Useful data and crucial information can be lost if the experimenter erases it, mistakenly believing it to be wrong or irrelevant. The habit of writing in ink and crossing out mistakes with one straight line (allowing one to go back and read it, if necessary) is considered best practice and is one we hope to develop in the student of science.

3. Setting up your notebook:
   - The first page of the notebook should be reserved for a Table of Contents and for your instructor's records.
   - For easy reference, be sure all right-hand pages are numbered before beginning the first experiment.
   - Use *consecutive right-hand pages* to record all formal work done in and out of the laboratory. Left-hand pages should be used for rough notes and calculations. This now standard format has arisen from scientists' efforts to make their lab notes easy to reference by their colleagues and others who might wish to examine them.

*********READ THIS READ THIS READ THIS READ THIS!!!************

FORMAL VS INFORMAL LAB REPORTS: See the Laboratory Schedule to find out which type of report you should write for a particular exercise. Informal lab reports consist of notes taken during each lab. You must do all the work specified in the manual for that day's experiment. The instructor will check that you did all the work including answering the preparation questions, completing data tables and answering the final conclusion question. You will not receive credit for the experiment unless you have the instructor check and initial your notebook before you leave the lab.

Preparing The Formal Lab Report

Each formal lab report should contain the following:

- **Heading**, for each new day in the laboratory, in the upper right-hand corner of a new page write:

  Student's Name
  PSU ID number
  Lab Partner's Name
  Date & Time of lab
  Name of Instructor
  Title and # of exp.

- **Preparation Section**: For each of the lab experiments, you are expected to talk with your lab partner about the concepts, speculate, and make predictions before you actually start doing the experimental work. This process is very important for developing a feeling for scientific collaboration and a scientific mode of thinking. Your predictions and answers to questions in this section should be recorded neatly at the beginning of each lab report. In this section, don't worry about getting the "right answer" -- just record your understanding of the concepts before the lab. At the end you will have a chance to show what new insights, if any, the experiment has provided. (In a professional group collaboration, this process may take weeks or even years. Here it may take 10-15 minutes.)

- **Procedure**: Write down the procedure -- *not exactly the words in the lab manual* -- but make it descriptive enough that anyone reading your procedural notes would be able to repeat your experiment and get similar results. A distinct feature of scientific method as opposed to other types of scholarly activity is REPRODUCIBILITY of results. That is what gives science its predictive power. A discovery is not considered valid unless the result is repeatable by others. Scientists must learn to write down their procedures very carefully.

- **Raw Data Section**: Data are pieces of information to which meaning has been attached. They are the basis of scientific discovery and interpretation. This section may include data tables where you have recorded your measurements, diagrams such as those used for electric circuit displays, or other *observations* that might be useful in reaching a final result. Speculation and theory do not belong here. Be sure that table headers have names for columns and dimensions of the quantities (tables of naked numbers are practically meaningless).

- **Analysis Section**: Complete the required calculations using your data. Include error calculations and estimates. No measurement is exact – there is always some uncertainty involved, even if it's only the uncertainty inherent in an instrument. It is important for scientists to be clear and honest about experimental error. You will receive a take-home tutorial to help you understand error analysis.

  Graphs should be drawn to a large scale, preferably covering one notebook page. When making slope calculations, read points on the fit line or curve rather than particular data points (this would bias your result). Clearly mark the points used for the slope calculation and include as many actual data points as possible in the evaluation (those that lie on the fit line).

- **Critical Conclusions, Insights, and Inquiry**: *Arguably, the most important section of the lab report.* The conclusion from an experiment is what an experimentalist presents first to the scientific world, even before the data. Abstracts submitted for a conference presentation or appearing at the beginning of a scientific article contain not the data or procedure, but the conclusion and how it compares with theory. (The data had better back up the claim, however.) The word "critical" here means you are critiquing your own work -- the reader needs to know that you have examined it critically from all angles.

Questions you should answer in your conclusion must include, but are not limited to the following:

- What are the main results of your experiment? How do they compare or contrast with theory?

- Has your initial understanding of the situation or concepts changed? How?

- If you were to repeat the experiment, how would you change it, if at all? Perhaps you can think of ways to be more efficient, or you might change the order for some reason or use different equipment. Give specific details.

- Perhaps you can think of ways to be more efficient, or you might change the order for some reason or use different equipment. BE CREATIVE! But be specific.

- Write down two questions not answered in your text that were stimulated in your mind by the experiment. These should show some extended critical thinking.

- Was this lab exercise too easy or too difficult? Explain.

- What was confusing about this experiment?

GRADING POLICY

It is the student's responsibility to register for the class under the "graded" or "pass/no-pass" option. We will **not** sign petitions for changing grade options after the university's deadline.

Graded option students

Your final grade will be based on the cumulative score you have earned for all lab exercises and the Lab Final. Letter grades will likely be based on the traditional scale:

- 90% or better is an A
- 80% to 89% is a B
- 70% to 79% is a C
- 60% to 69% is a D

Your instructor has the freedom to alter this scale as he or she sees fit.

Additionally,

- **You must complete every lab.** If you miss **one** lab, there will be an opportunity to make it up during the scheduled make-up week. If you anticipate missing a second lab, talk to your instructor. Do not wait until the end of the term and then attempt to remedy the problem. You will fail the course.

- Formal lab reports must be turned in at the beginning of the following lab session (one week after you perform the experiment). *Your lab report will suffer a 1-point reduction for each day it is late to a maximum of –50%.*

Pass/No-Pass option students must earn at least enough points to earn a C^- to receive a "pass" grade

Incomplete grades

The Incomplete (*I*) grade is reserved for students who have suffered medical emergencies or some other unusual hardship. An instructor will only consider giving an *I* grade if a student provides written evidence (e.g., a letter from a physician) concerning the hardship.

GENERAL PHYSICS LABORATORY

LAB SCHEDULE FOR PH204/PH214

Lab meeting	Laboratory activity	Point Value
1	Introductory Tutorial Vector Tutorial	10 5
2	Equilibrium of Forces *****Formal Lab Report Required****	15
3	Gravitational Acceleration & The Atwood Machine	10
4	Centripetal Force *****Formal Lab Report Required****	20
5	Hooke's Law & the Simple Harmonic Oscillator	10
6	Conservation of Momentum & Energy *****Formal Lab Report Required****	20
7	Moment of Inertia	10
8	Hydrostatic Pressure	10
9	LAB EXAM Following the exam: Makeup any ONE of the preceding experiments.	30
		140 (Total)

GENERAL PHYSICS LABORATORY

LAB SCHEDULE FOR PH205/PH215

Lab session	Laboratory activity	Point Value
1	Introduction Exercise 1: Electric Field Hockey (page 7)	10
2	Ex. 2: Electric Charges and Electric forces (page 9)	20

	*****Formal Lab Report Required****	
3	Ex. 3:Electric Circuits 1 (page 14)	10
4	Ex. 4: Electric Circuits 2 (page 20) *****Formal Lab Report Required****	20
5	Ex. 5: Capacitors & Capacitance Voltage In Circuits (page 26)	10
6	Ex. 6: Magnetic Fields, Magnetic Induction and Lenz's Law (page 30)	10
7	Ex. 7 Transformers and Alternating Current (page 35) *****Formal Lab Report Required****	20
8	Make-up week: Students may make up ONE experiment this week	
9	LAB FINAL	30
		130 (Total)

GENERAL PHYSICS LABORATORY

LAB SCHEDULE FOR PH206/PH216

Lab session	**LABORATORY ACTIVITY**	Possible points
1	Exp.1: Standing Waves on a String	10
2	Exp. 2: Resonant Frequencies Of A Tube	20 Formal Report
3	Exp. 3: Refraction and Reflection	10
4	Exp. 4: Lenses	20 Formal Report
5	Exp. 5: Interference and Diffraction	10

6	Exp. 6: Light Intensity and Polarization	20 Formal Report
7	Exp. 7: Specific Heat and Latent Heat	10
8	Make-Up Week	–
9	LAB FINAL	30
		130 (total)