Physics 221 Classical Physics II Lab

Gustavus Adolphus College Spring 2007

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Lab Texts: *An Introduction to Error Analysis*, John R. Taylor, Second Edition
PHY221 Lab Manual - Spring 2007

Course Objectives

1. Experience keeping a laboratory notebook
2. Preparation of formal laboratory reports
3. Formal introduction to data analysis and error propagation
4. Exposure to modern laboratory techniques
5. Exploration of laws relating to waves, thermodynamics and optics

Course Policy and Evaluation

1. **Lab Materials**: Each student must purchase two (2) 5x5 Quadrille Ruled Composition Notebooks (Ampad 26-251) available at the Book Mark. Students should also bring a calculator to each lab period.

2. **Lab Attendance**: Each student will register for one lab section each week. Students must arrange with the instructor in advance to attend another lab section or to schedule another time to perform the lab; they may do so only for a valid health or school-related reason.

3. **Lab Groups**: Students will work in groups of 2 or possibly 3. It is essential that **ALL** members of the group are completely familiar with the measurements and the data analysis.

4. **Preparation for Laboratory**: The laboratory manual (available from the Book Mark) must be brought to the lab each week. Students are expected to be thoroughly familiar with the purpose and general procedures of the experiment **before** coming to lab. They are also expected to have completed the heading and purpose portions of their notebook before coming to lab. Advance preparation is an absolute requirement for the efficient use of the limited lab time.

5. **Pre-Lab Quizzes**: A pre-lab quiz will be given each week via the WebAssign program on the world wide web. The due date/time for the student's quiz responses will be 15 minutes before lab class begins each Wednesday.

6. **Informal Lab Reports**: An informal lab report is required for each of the experiments for which a formal report is not requested. **The report is due in PHY220 class at 12:30 PM on the Tuesday following the performance of the lab the previous week.** These reports will be written entirely in the student's lab notebook, and thus two such notebooks will be needed for the course. Informal reports will be graded on a 10-point basis, and *there will be a one-point-per-day penalty for late reports.* **Each student should write his/her own lab report, even though the experiments were performed with a partner or partners.** *Lab notebooks submitted which are found to be identical (or nearly identical) will have the total grade points divided among the identical papers.*

7. **Formal Lab Reports**: Two formal lab reports are required as indicated on the schedule above. **Formal reports will be due two weeks after the lab is performed**, and will be graded on a 20-point basis. Formal reports should be double spaced on white 8.5" x 11" paper using a 12-point font. Graphs should be generated by computer (using Sigmaplot or Logger Pro) and incorporate proper scales and identification. If possible, electronically "paste" your graphs in the text of your report document. All formulas, equations and algebraic expressions should be entered using the Equation Editor, and superscripts must be used for numbers in scientific notation (e.g. 4.3×10^{10} , **NOT** 4.3e10). *There will be a one-point-per-day penalty for late formal reports.* **Even if he/she had a lab partner, each student must submit his/her own (original) formal lab report.** *Formal reports submitted which are found to be identical (or nearly identical) will have the total grade points divided among the identical papers.*

8. **Lab Final**: In the last lab period, there will be a final exam; each student will do this experimental and paper/pencil exercise on their own. This will test students on the essentials of particular labs, setting up equipment, making measurements with equipment, skills in analyzing data and performing error analysis, and solving a practicum problem.

9. **Incompletes**: A grade of incomplete will be given only for work not completed due to circumstances beyond the control of the student.

10. **Evaluation**:

Informal Labs	55%	A	94 - 100	C+	74 - 78
Formal Labs	15%	A-	90 - 94	C	70 - 74
Pre-Lab Quizzes	10%	B+	86 - 90	C-	66 - 70
Final Exam	20%	B	82 - 86	D+	62 - 66
		B-	78 - 82	D	58 - 62

Assignment of final letter grades may also take into account the instructor's subjective evaluation of the student's attendance, initiative, participation, preparation, and evidence of improvement.

Tentative Laboratory Schedule

Dates	Lab Number	Title
February 7	1	Radiation and Statistics
February 14	2a,2b	Density & Archimedes; Bernoulli
February 21	3	Oscillations and Simple Harmonic Motion
February 28	4	Oscilloscopes and Ultrasonic Imaging
March 7	5	*__Standing Waves__
March 14	6	Fourier Analysis of Musical Instruments
March 21	7	Snell's Law of Refraction
March 28	8	Lenses
April 4	*** No Lab – Spring Break ***	
April 11	9a,9b	Diffraction and Interference; Spectrometer
April 18	10	*__Specific Heat__
April 25	11	Heat Transfer: Newton's Law of Cooling
May 2	12	The Ideal Gas Law
May 9	13	The Heat Engine
May 16		Lab Final

*** Formal Report Required**

Explanation of Lab Reports

The laboratory manual will describe the experiment and the procedures to be followed in performing the measurements. Your lab report should not be a repetition of this outline, but rather a concise and stand-alone report of your measurements, observations and analysis.

A satisfactory report must fulfill two requirements. First, someone not thoroughly familiar with the subject should be able to read the report intelligently and get a complete and accurate idea of its significance; second, someone reasonably familiar with the subject should be able to grasp the essential features of the report by a rapid survey. These things are possible if the report is properly arranged, and if the main results are grouped and isolated from the preliminary steps.

The notebook should include your preparation for lab, sketches or diagrams to explain the experiment, data collected, initial graphs done as the data is collected, comments on difficulties encountered while collecting data, changes made to overcome difficulties, sample calculations, data analysis, results and answers to questions asked in the lab manual.

Pre-lab Preparations:

Carefully read through the section of the laboratory manual to understand the purpose of the lab and the methods to be used. The heading, theory and purpose portions of your report must be completed and in the lab notebook before you come to lab. (**DO NOT** just leave blank sections in the lab book to be "filled in later" with this pre-lab information.) Then, take the pre-lab quiz on WebAssign, making sure to complete it 15 minutes before lab class starts.

In-lab Work:

Check the apparatus assigned to you to be sure that you have all of the pieces of equipment needed. Prepare your experimental setup and decide on a procedure to follow in collecting data. Keep a record of your experimental methods in your notebook.

As you take data, write it directly into the notebook. Include the units and estimates of the uncertainties. **DO NOT** collect data or other information on other sheets of paper first and then transfer them to your notebook. Your notebook should be a running record of what you have done, not a formal (all-mistakes-eliminated) report. If possible, make a graph while taking data to see if everything looks satisfactory. Most physical quantities will appear to vary continuously and thus should yield a smooth curve. If your data looks questionable, take additional points or duplicate previous points. You cannot just "throw out" data points because they do not seem to fit a result you expect. You should carefully note in your notebook why you think the data may be incorrect. (Was there some change in the apparatus or your procedure?) If applicable, you should do sample calculations to make sure that the data is reasonable.

If you need to change a section of your notebook or if you have re-taken some data **DO NOT** erase or tear out sections of your notebook that you want to change. Instead, indicate in the notebook what you want to change and why (the data could possibly be useful in the future). Then simply cross out the unwanted sections and proceed with the new work.

Post-lab Work:

Carry out the analysis of data in your notebook and indicate your final results clearly. Make sure that you perform correct unit and error analysis. If repeated calculations are used, you need only show one sample calculation. Scotch-tape in final graphs so that they can be examined easily. Answer all questions that were asked in the lab handout and add any additional comments that you consider pertinent.

Reports should be written in good but sparse English prose, with proper attention to spelling, syntax, grammar and legibility. Aims, in order of decreasing priority, should be completeness and accuracy, clarity, and brevity.

Content and Organization

I. Heading: Title of experiment; date performed; your name; your partner's name.

II. Theory and Purpose: First, in a short sentence or two, state the precise purpose of this particular experiment. (Is a quantity to be measured? Is a law of physics to be verified? Is a phenomenon to be observed?) Then, give a brief explanation of the relevant theory, including any formulas or equations that will be bused in the analysis of the experiment.

III. Procedure, Data and Calculations: For each portion of your experiment:

A. Give a brief statement of the experimental method. It should be complete enough so that you could repeat the experiment using the notebook only and so that a "knowledgeable" individual who has never read the lab manual could follow the steps that you performed. Include a list of apparatus and a sketch or circuit diagram where appropriate.

B. Show your data in tabular and/or graphic form, including an estimate of the errors or uncertainties. *Data should be entered in the lab notebook as they are taken.* All graphs must be fully identified and titled.

C. Perform analysis of the data including sample calculations for all major steps, and give a comparison of results to accepted values, if available. A complete analysis of errors and error propagation should be included.

IV. **Conclusions**: A statement as to the results of the experiment as you performed it. What knowledge of the physical phenomenon was obtained? Indicate what you measured, the error involved, specific sources of error, and improvements that might be made in either procedure or equipment. Do not just include a list of every possible error which might occur in the experiment: make a rough estimate the magnitude of possible errors and what affect they would have on your result. In particular, errors are going to be one or more of the following: random, systematic, or due to weaknesses in the model used. You should deliberately consider each of these.