Phys 1426: Modern Physics Laboratory, Spring 2012
Phys 1626: Writing Option

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Lectures	Th 11:00-11:50 am	~~105 Allen~~ 324 OEH	**G. Dutt**
Laboratory	Th 1:00-3:50 pm	318 OEH	**M. Steger**

1626 10649 Mod. Phys. Lab./Writ. **(by appointment) G. Dutt**

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The course manual will be distributed on courseweb. Print only what you need on a given day!
E-mail: We frequently use e-mail for announcements and distributing course material. Please, read your e-mail regularly, and make sure that your account is not over quota!

INTRODUCTION

This course is aimed at training students in the area of experimental physics. Even for those students who are more inclined towards theoretical physics, this part of training is invaluable. The purpose of Modern Physics Lab is to give you hands-on experience with some of the experimental bases of modern physics and, in the process, to deepen your understanding of the relations between experiment and theory. You will do experiments on phenomena whose discoveries led to major advances in physics. The data you obtain will have the inevitable systematic and random errors that obscure the relations between the macroscopic observable of our sensory experience and the physical laws that govern the submicroscopic world of atoms and nuclei. You will be challenged to learn how each of the experimental setups works, to master its manipulation so that you obtain the best possible data, and then to interpret the data in light of theory and a quantitative assessment of the errors. We believe you will find satisfaction in observing, measuring and understanding phenomena many of which would have won you the Nobel Prize if you had discovered them.

The course is organized so that it offers students a great deal of flexibility in selecting the projects and performing the experiments. Students will decide what experiments to perform, what approach to use, and the amount of time he/she would like to devote to the project. Although the standard lab hours are from 1-4 pm every Thursday, students are welcome to conduct measurements in other times during the week when the laboratory is open. Students are required to do independent reading, to think deeply about the physics behind the measurements, to analyze the data, to reach their own conclusions, and to write up the report.

Great advances have been achieved in our understanding of nature enabled by the development of advanced and sensitive instrumentation. Much of this is general purpose and not specific to one experiment, so that it can be applied to explore new ideas. Thus you will familiarize yourselves with modern instrumentation such as oscilloscopes, multichannel analyzers, lasers, and other computer-interfaced instruments. You will also learn a variety of experimental techniques, such as achieving high vacuum, particle counters, resonance, etc.

Experimental physics requires studying and measuring the world around us in a quantitative way. We model these observations and measurements and develop theories that can explain the observations and make new predictions. In the best of worlds, theory and experiment complement each other, sometimes one leading and the other lagging, but it is experiment that has the final word.

Note that experimentation is *not* the same as "confirming a theory." Experiment reveals the true physics of nature to within uncertainties and may invite the development of new theory (experiment cannot confirm theory, only fail to disprove it). Although many of the projects in this course involve classic experiments supported by well-established theory, you should treat your work as an independent attempt to probe some physical phenomenon, observe new phenomena, and test predictions. You must decide appropriate boundaries for the precision and accuracy of your measurements, and you must determine the sources and extent of uncertainties or error in your analysis.

Textbooks

I strongly recommend (but do not require) that you buy the following text:

- Data Reduction and Error Analysis for the Physical Sciences, 3rd Edition, by P.R. Bevington and D.K. Robinson (McGraw-Hill: 2003): The Bevington and Robinson (B&R) text contains a comprehensive treatment on error analysis and will be useful throughout your career.

The following texts may be useful in doing the experiments, and are available with Dr. Ramer upon request:

- Experiments in Modern Physics by Adrian Melissinos (Academic Press: 1966 1st Edition & 2003 2nd Edition): Please consult these before and during your investigations. Material which is essential to the understanding of an experiment, and that can be found in the Melissinos text, may be omitted from the Lab Guides.
- The Art of Experimental Physics by Daryl Preston and Eric Dietz (John Wiley: 1991)
- The Art of Electronics by P. Horowitz and W. Hill (Cambridge University Press).

Procedure

Over the course of the semester you must carry out three experiments in teams of two or three students. The list of the labs available is posted on courseweb along with the lab manuals and a detailed course schedule. You will have approximately four weeks to complete each experiment. In general, you **must** read the lab manual and read about the physics of the experiment before you come to class, since the majority of lab time will be taken in learning to use the equipment, collecting data, and in preparing your presentations and reports if time permits. Further, if you do not pass your pre-lab examination, you will not be permitted to continue with the experiment.

Grading Policy:

Students are expected to do three lab projects during the semester, plus the introductory project on data analysis and R programming. Because of limited resources students may work in pairs except for the introductory project. For each project, each student is expected to record the experimental procedure and data in separate notebooks. Each laboratory notebook should be distinctly a product of the student who recorded the data and performed experiment. However, you are of course encouraged to collaborate and discuss the experiment, the data and the analysis with your team members. <u>Failure to hand in a notebook for a lab on time without prior permission will drop your final grade by one letter grade. All course deadlines are on the course schedule in courseweb and a printed copy will be posted in the lab.</u>

The data-analysis project and report as well as other assigned HWs counts 10%, the lab notebooks count as 60% (20% each), the two project presentations count as 20%, and the final lab report counts as 10% of the total grade.

Pre-lab examination guidelines

Pre-lab exams are private sessions with only the instructor and/or TA and lab coordinator present. The pre-lab exam is pass/fail only. One of the team members will be asked by the instructor to explain the physics behind the experiment; the other team member(s) will then explain the experimental goals and procedure.

You will not know beforehand who will explain what, so each team member must be prepared to explain all parts. For this reason, you must prepare for this exam together.

A rubric for evaluating pre-lab preparedness is available on courseweb. It is a good idea to prepare your presentation using this rubric. If your presentation falls short of a satisfactory mark, the instructor may assign additional work or ask you to repeat the exam during the following class meeting.

In addition, you will each submit to the TA your pre-lab notes (written in your lab notebook) documenting your pre-lab preparation. These notes should outline the experiments that you are going to perform and what you expect to measure. Please, don't just "copy and paste" material from the manual. Prelabs should contain the "working equations" that you will use to analyze the data, give examples of data analysis using "dummy data", and outline the error analysis. Your instructor or TA will check your "Prelabs", date and initial them, and give them back to you.

Lab Notebooks

One critical objective of this course is to instill habits of record keeping that will serve you well in future research. Specific requirements and tips for maintaining your notebooks are listed on the web as Notebook Rubric. Read the document carefully, and ask the instructor/TA if you are unsure of what to do on any point. Since many of you may not have kept a careful laboratory notebook before, don't be hesitant to ask questions.

Student notebooks should be handed in one week after the experiment is done.

Public Project presentations

In addition to lab notebooks, each team will prepare two brief oral presentations during the semester (see posted schedule for the dates). The 20 min presentation (plus 5 minutes for questions) will be made to the entire class two weeks after the last day of the lab. The presentation need not follow precisely the lab writeup; it should be engaging and educational. Your instructors and peers will evaluate your presentation and give you feedback. The instructor will NOT take the peer feedback into account for the grade, so it is fine to give constructive criticism of your friends.

Twenty minutes is a short time, so it is essential that you rehearse your presentation as you would if you were giving an invited presentation at a meeting of the American Physical Society. Please review the Society guidelines at http://www.aps.org/meet/guidelines.cfm. We suggest a maximum of 12 - 14 slides and strongly suggest preparing your presentation electronically (e.g.LaTeX or MS Power Point) and using the LCD projector for the cleanest most professional presentation possible. I will also make available templataes and give tips on making good presentations.

Lab Report

In addition to lab notebooks, one final lab report should also be submitted on any one of the three experiments you carried out during the semester. The report will be graded on the basis of clarity (explain what physics underlying the experiment, what apparatus you used, what did you measure, how did you analyze, what did you find), and correctness of analysis. New ideas, extra analysis, etc. can earn bonus points. Each report should have the following sections:

1) Introduction (15% weight): about 2 pages, which explain the physics behind the experiment. Important formulas should be given, and the essential physics explained.
2) Experimental Methods (35% weight): 2-4 pages, details of all the apparatuses and materials used in the experiment. Neat labeled sketches, either hand-drawn or computer-aided, are a must. How were the measurements carried out, and how was the data analyzed.
3) Results and analysis (35% weight): 2 – 4 pages, Summary of all the data acquired in the experiment and their analysis (including tables, graphs, images, etc.).
4) Discussion and conclusions: 1 page, Summary of the main results of the experiment, and the

conclusions from these results.
5) Bibliography/References.
6) Style and English plus last 2 sections: 15% weight.

Reports should be in PDF format (only!) and should be uploaded to courseweb under the Reports section. Note that converting from Word to PDF sometimes results in missing symbols and messy equations, so you must check your PDF before uploading. I recommend learning LaTeX for preparing your lab reports, and can provide additional resources for this if requested.

Guidelines for preparation of formal laboratory reports for students taking the "Writing Option" (Phys. 1626)

If you take the Writing Option, you must submit two "formal reports" on two different labs that you have done. Deadlines for submission will be stated in the lab schedule.

Even if you take the writing option, you still have to submit your lab notebooks and a regular final lab report as per the requirements for all the other students.

The formal reports are expected to be significantly better than the ordinary lab reports in style of writing, completeness, and content. The format to be followed is roughly that required for manuscripts submitted to scientific journals. There are many conventions and formal rules that must be observed when submitting papers for publication and you may find some of them tedious and time consuming, but editors are merciless in returning poor manuscripts. Your instructor will play the role of the editor in this course and will suggest improvements. The first draft of your paper will be returned to you with comments, and after a discussion with your instructor, you will submit the second and final draft.

Please, write your paper on a computer, and upload PDFs (only!) to the assignment area provided on courseweb. Note that converting from Word to PDF sometimes results in missing symbols and messy equations, so you must check your PDF before uploading. I recommend learning LaTeX for preparing your lab reports, and can provide additional resources for this if requested. In addition, a hard copy must be turned in for the FINAL draft of each report, or if requested by the instructor.

Use double line spacing. Insert all figures and tables (with captions) at the end of the text (one figure per page), after the list of references! Inserting figures into the text creates problems with page breaks etc.! Use the equation editor in Word for equations. In Latex, this is much easier, and gives professional looking results. Write the text in a single column. Your file will be returned to you with comments (using the COMMENT feature of Adobe Acrobat). Always make a back-up copy of your work and keep it in a safe place. If you wish to discuss your report in person with your instructor, please make an appointment.

The style of writing should be clear and concise. Do not say the same thing over and over in different ways. Avoid excessive use of the passive voice. It is acceptable to write "We varied distance x ...." rather than "The distance x was varied ....".

Do not copy or rewrite chapters of textbooks; you are not likely to improve on the original. There are no bonus points for "overweight" reports. More likely you will be asked to get rid of the excess bulk through strenuous exercise.

Even though this is writing exercise, the physics should be correct and should be explained correctly.

It may be a good idea to ask one of your fellow students to read and criticize your report before you hand it in. If he or she gets frustrated reading your report, your instructor probably feels the same way. It sometimes helps to put your paper aside for a day or so and then read it.

If you have never read a paper in a scientific journal, go the library and find a recent issue of "American Journal of Physics". Pick an article that you find interesting, read it carefully and pay attention to style of writing and format of presentation. BUT: Do not try to duplicate the print layout of the published article (like two columns, inserted figures etc). Some students have wasted far too much time on making MS WORD or Latex do tricks! This is a writing exercise, not a printing exercise.

Your report should have a title. Use the name of the assignment or pick your own title.

The report should be preceded by an "Abstract". The abstract states in a few concise sentences (less than about 200 words) what you have done and what you concluded from your work.

The body of the report typically contains several sections:

I. Introduction

An introduction gives the reader a preview and a "road map" of your report. It should inform the reader about the background of your work, the scope of your investigations, and point to the sections where specific details are to be found. The introduction should briefly present the basic theory of your experiment and give the equations that you used. Equations must be incorporated into the text, i.e., they must be part of a grammatically correct sentence. It is not permissible to simply write "dangling" equations.

II. Experimental Methods

This section contains the details of your experiment, the experimental equipment and apparatus, and the methods that you used to analyze the data.

A figure of the experimental setup is much better than long verbal descriptions. It is not necessary to restate in the body of the text what is obvious from the figure, but each figure should have a "caption". The caption appears below the figure and contains only brief information required to understand the figure. Figures are numbered and referred to in the text as Fig. X. Place figures at the end of the paper. Do not copy and paste figures from the lab manual.

Describe how you used the apparatus, how you obtained the "raw data" and how you deduced the final results from the raw data. Be explicit and give the equations that you used. Equations are to be numbered in sequence and are referred to in the text as Eq. x.

Describe how you arrived at estimates for experimental errors. This section does not contain actual data. It is roughly equivalent to the "prelab" reports, but skip the part where you analyze "dummy data".

III. Results and Analysis

In this section you will present the raw data that you accumulated in the lab and give the results of your analysis. If you use tables to display the data, the tables must have a "table heading" which identifies the quantities in that table (including units, of course). Place tables at the end of the document, not in the body of the text.

It is often better to present your results in the form of graphs rather than tables. You will plot, for instance, the reflected light intensity as a function of the incident angle. This is usually much more informative than tables of numbers. Use R or equivalent for graphing data and import the graphs into WORD/Latex. Place figures at the end of the document, not in the body of the text.

All data graphs count as figures and are numbered in sequence (Fig. 1, 2 ...). Provide captions which clearly say what is shown. Label the axes in all graphs. For data points use circles, squares or other symbols to distinguish different sets of points. Error bars on data points are usually required.

IV. Conclusions, Summary

This last section of the text contains the conclusions of your work. The introduction stated your goals; here you draw the bottom line and judge if you achieved those goals. If you did not quite succeed in all respects, discuss the problem and suggest improvements for future work.

V. References:

If you refer to published source material (textbooks, journal articles) in the text of your report, number the references in sequence as they appear in the text (in square brackets, [ ], for instance). A list of published work (Title: References) should appear at the end of your report. You can use WORDs INSERT/ FOOTNOTE/ENDNOTE feature for this. But Latex has a special package that does a better job, known as Bibtex.

Grading of writing option course:
The grade given for the Writing Option course is based only on the submitted formal reports and is independent of that for the lab/lecture course.

SPECIAL ACCOMMODATIONS FOR DISABILITY

If you have a disability that requires special testing or other accommodations, you need to notify both the instructor and the Office of Disability Resources and Services no later than the 2nd week of the term. You may be asked to provide documentation of your disability to determine the appropriateness of accommodations. The Office of Disability Resources and Services is located in the William Pitt Union, Room 216. Call 648-7890 (Voice or TDD) to schedule an appointment.

ACADEMIC INTEGRITY

All students and instructors in this course are expected to follow the University of Pittsburgh academic integrity guidelines. If you are not aware of the specifics, you should obtain a copy of these guidelines from the CAS Dean's Office, 140 Thackeray Hall, or look them up on page 9 of the CAS publication "First-Year Viewpoint, 1999-2002" or on the College of Arts and Sciences Web page. Violations of these guidelines by a student may result in a zero score for an examination or a failing grade for the entire course.