PHYS 506 – Advanced Laboratory Spring 2010

Instructor:	Dr. Kristan L. Corwin
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Office hours:	by appointment, **CW332**
Class Time/Place:	Laboratory: Tu, Th 1:30 -4:20 **CW 311**
	Recitation: Monday 2:30 – 3:20

Attendance during laboratory time is mandatory, not optional (unless extenuating circumstances exist and prior arrangements are made with the instructor).

Course Description: **PHYS 506. Advanced Physics Laboratory.** (3) This laboratory will acquaint you with "classic" experiments related to the quantum structure of matter and with modern experiments similar to those which you might encounter in research laboratories today. You will learn techniques of data taking and analysis. You will learn how to keep a data book. You will gain some familiarity with modern research apparatus and with concepts used in current physics research. You will learn how to search out literature on a project and to think your way through an experiment without being led by the hand through each step. You will learn how to write a comprehensible report on your experiment, following roughly the same format you would use in writing a research publication in physics. You will also learn to present a comprehensible oral description of your work.

Web site: All electronic documents for the course will be posted on k-state online, including sample lab reports, lab write-ups, additional procedures and supplementary materials, homework assignments and solutions, and grades.

E-mail: I will communicate with you frequently by email, so please **check your university email account regularly**. If you typically use another account, set up forwarding from your university account to your physics or other account.

Texts and Lab Notebooks:

Required: 1) An Introduction to Error Analysis, The study of uncertainties in physical measurements, 2nd edition, by John R. Taylor, publisher: University Science Books (trade paperback).

2) Lab Notebook: Students should purchase a quadrille-ruled laboratory notebook (not a loose-leaf or spiral notebook) in which to record all data. In these data books they will record all laboratory data, with enough English prose that another student could read it (see how to keep a data book). For each experiment done, each student will write a final report as a separate document.

Recommended: 1) *Experiments in Modern Physics*, A.Melissinos, AP, 2002.
You can buy this on Amazon for $66, and I suggest you do. This is a new revision of a very old book, originally written in 1966. Many of the experiments are "classics" for which the physics has not changed over this time, and the older version of the book differs little from the new. The

techniques in the older version are totally out of date, however. This text is of use in this course for background reading and to supplement the material provided in the lab write-ups.

2) A textbook on modern physics, such as *Modern Physics* by Tipler and Llewellyn, Freeman, or *Modern Physics* by Taylor, Zafiratos, and Dubson, Prentice Hall.

3) The website of MIT's Junior Lab appears to be an excellent resource: http://web.mit.edu/8.13/www/index.shtml

Schedule: *Recitation:* (M 2:30-3:20) . Monday recitation will have many uses, including lectures on error analysis, oral interviews, and oral presentations. Lectures will focus on material ***beyond*** Ch 1-3, which were covered in Phys 325 for the last 3 years.

Each student will **present** one experiment during the course of the semester, in a **10 min talk** (with 2 min for questions, just like an APS meeting). You may choose any experiment that you have done, but efforts will be made to avoid duplication.

Also, several times during the semester, you and your laboratory partners, as a group, will give an **oral interview** with the instructor. You will be expected to understand the physics of the experiment and how the experiment itself worked. This interview will give the instructor a chance to explore to what extent you really understood what you were doing and to clear up any residual questions. The interview will cover the most recently completed experiment. You will be asked to find an hour outside of class for this, but that will occur in lieu of your Monday recitation that week.

Laboratory time: (T,U 1:30-4:20) Attendance during this time is not optional. You should come **on time** and stay for the whole period. (exceptions may be made occasionally to end at 4 pm to allow attendance of departmental colloquia). During this time you will perform, with one or two laboratory partners, about seven experiments over the course of the semester. These are to be chosen from the list below. Each experiment will take you typically two weeks to complete. It is more important to do the experiment right than it is to stay on some preset schedule. You should read the write-up and enough additional literature BEFORE STARTING THE EXPERIMENT so that you understand what the main idea is. Your instructor may ask you a few questions to be sure that you have done this before you start. You will record your laboratory work and data in your data book. After you complete the experiment you will analyze the results and write a formal report, largely outside of class. The final report will be due on Friday, ~ one week following the period in which you complete the experiment. You will not be allowed to start a new experiment if you have more than one completed experiment for which you have not turned in a report. Do not procrastinate.

Available Experiments:

"Classic"

1. Millikan Oil Drop	2 wks
2. e/m Hoag	1 wk
3. Microwave Optics	1+ wks

Atomic structure/quantum mechanics/modern physics

4. Electron Diffraction	1+

5. X-ray Diffraction 2
6. Nuclear magnetic resonance 2
/ electron spin resonance
7. Zeeman effect 2
8. Lifetime of the μ meson 2
9. SQUID 2
10. Scanning tunneling microscope 2
11. Saturation Spectroscopy in Rb 2

Additional Potential Experiments:

12. Torsion Oscillator "Classic"
13. Paul Trap (some development required)

Currently "defunct" experiments:

Rutherford scattering	*2 wks*
Interferometer	*1+ wks*
Moessbauer effect	*2*
Photon and particle detectors	*2*
Atomic spectra of the elements	*2-*

The schedule will be developed over the course of the semester.

Deadlines: Lab Reports are due one week after the lab is completed, and may be submitted electronically through k-state online file upload. If they are submitted by Friday at 11:59 pm after they are due, no points will be deducted. After that, points may be deducted for late reports.

If your document is created on a Macintosh, I may have trouble reading figures unless you include them carefully. Keep copies of your lab reports until the end of the semester… I might lose it, or the file might be corrupted. Homework on data analysis will be assigned from time to time, due at class time Monday unless otherwise stated.

Guidelines for data taking:

The biggest single problem students have with keeping a good data book is not writing enough English prose to make a comprehensible record of what is what. Here are some suggestions which should help you to organize a data book so that both another student and YOU will be able to read it one month from now.

- For each experiment, start a new section in the book. Start with a short title, then a sentence or two about what the experiment is all about. Make a sketch of the apparatus, enough to illustrate the main ideas.
- On each page write the date, what you are doing, and what you got. Use a "diary" format: write things in the order in which they happen: record what you tried to do, what you did, and what you got. Enter data usually in tables: if you prepare a data table, with columns labeled with a description of what you are entering and the units, it will force you to think about what you are doing. Never enter just a page of numbers or unlabelled data. Do not do excessive amounts of scratch work in your data book, but DO write out calculations.

Never put loose sheets of paper into your data book, but if you have written something on separate paper that turns out to be important, DO tape it into your notebook. If you want to put in computer printout, glue or tape it in. Also, write the file name of relevant data, along with the conditions under which it was taken, in your notebook whenever you save a file.

- Make multiple copies of data files regularly. *(Last year, a floppy drive crashed, breaking the x-ray experiment and erasing the groups' only copy of most of the data.)*
- It is OK for one student to make the original data table as you go, but the others in the group should fill in their own tables in their own books immediately afterwards. Each student must keep a data book.
- The bottom line is that another student, or your instructor, should be able to read the book and tell what experiment you were doing, when you did it, how you did it, and what you got. You may be graded from time to time on your data book.

Laboratory write-ups:

For each experiment done, each student will write a final report as a separate document. This write-up should be submitted electronically by file upload on k-state online in .pdf or .doc format. The write-up should be modeled on a research article as it would be submitted to a research journal in physics. It should include an abstract, an introduction discussing the principle of the experiment (the idea, the concept, not concrete details), an experimental section describing the apparatus (concrete details go here), the data-taking procedure and a summary of the data, usually in tabular form (the original data should be in the data book), a data analysis section including an assessment of experimental error, and a conclusion and discussion section in which the results are discussed. Students should feel free to end the discussion section with personal theories, comments, philosophical observations, unanswered questions, etc. which pertain to the experiment. This is a good place to be creative. Any questions posed in the experimental description sheets should be answered somewhere in the report, as an appendix if not in the body of the report. A sample write-up is available, designed to give only an illustration of the possible contents of a report, as is a checklist and additional guidelines.

Special note about use of web materials in writeups:

You are not allowed to cut-and-paste text at any time in any form into any report unless it is enclosed by quotation marks and the reference given. If you wish to cut-and-paste a figure into your report, you must cite the reference. The appearance, without attribution, in your writeup of any material cut-and-pasted, or even closely paraphrased, from the web is a violation of the KSU Honor Code. You may use the web for reference reading, but you must write your report in your own words. See also the sample write-up.

Grading: Your grade will be determined primarily by:

1) (80 %) Grades on your lab write-ups, influenced by performance on oral interviews and occasional review of log book.
2) (10 %) Homework and potentially quizzes on Error Analysis.
3) (10 %) An oral presentation of at least one lab.

Grading scale, subject to change:

>90% for an A, >80% for a B, > 70% for a C, > 60% for a D, otherwise an F

Lab Report Rubric: *(adapted with permission from Dr. David T. Marx)*
Lab reports are worth 100 points each. While grading, I will write many comments on your reports, but will not generally indicate a certain number of points deducted for particular errors or omissions. Instead, I will consider your participation in class, performance in oral discussions of the project, the level of effort required to prepare the report, and most importantly the content of the report itself. Failure to do a pre-lab exercise may result in the loss of 10 points.

Score 100: The student has shown enthusiasm for the subject matter by using a creative means of analysis, correct additional analyses, or performed additional experimentation beyond that indicated in the lab manual. The student has demonstrated an exceptionally high degree of mastery of the subject matter. The student has performed well beyond the expected level.

Score 90: The student has shown enthusiasm for the experiment and shown insight into the physical phenomena. The student has demonstrated a degree of mastery of the subject matter. The student attempted to do additional analysis or experiments. The student performed significantly above the expected level.

Score 80: The student has gained some insight into the physical phenomena under study and demonstrated some mastery of the subject matter. All steps in the experiment were carried out correctly. The student performed above the expected level.

Score 70: The student carried out the minimum necessary work described by the lab manual. The student performed at the expected level.

Score less than 70: The student has not performed all of the requisite tasks specified in the lab manual. The student has not shown a good faith effort to carry out the experiment or the student clearly does not understand the experiment. The student has performed below the expected level.

Disabilities: If you have any condition such as a physical or learning disability, which will make it difficult for you to carry out the work as I have outlined it or which will require academic accommodations, please notify me and contact the Disabled Students Office (Holton 202), in the first two weeks of the course.

Plagiarism: Plagiarism and cheating are serious offenses and may be punished by failure on the exam, paper or project; failure in the course; and/or expulsion from the University. For more information refer to the "Academic Dishonesty" policy in K-State Undergraduate Catalog and the Undergraduate Honor System Policy on the Provost's web page: http://www.ksu.edu/honor/.
By turning in any assignment, you implicitly acknowledge compliance with this statement:
"On my honor, as a student, I have neither given nor received unauthorized aid on this academic work."