Instructor: Dr. Keti Kaadze
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Email: keti@phys.ksu.edu (Put “phys 506” in subject heading)
Office hours: by appointment, CW43B
Class Time/Place: Laboratory: Tu, Th 1:30 -4:20 CW 311
Recitation: Monday 1:30 – 2:20 CW 311

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. 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.

Learning Outcomes:
• Have a solid foundation in the basics of experimental physics.
• Have hands-on experience with common mathematical, computational and experimental tools.
• Have good skills related to the collecting, recording and analysis of data.
• Be capable of communicating information, scientific or otherwise, in both written and verbal form.
• Adequate preparation to succeed in graduate studies in physics or other technical disciplines, or in professional schools.

Texts and Lab Notebooks:
Required:
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 you 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, you will write a final report as a separate document, modeled on a published article.

Recommended:
1) Experiments in Modern Physics, A.Melissinos, AP, 2002. This is a new revision of a very old book, originally written in 1966. As 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) 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

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.

Schedule:
Recitation: (M 1:30-2:20). 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 many years.

Each student will present one experiment during the course of the semester, in a 10-12 min talk with an additional ~3-5 min for questions. You may choose any experiment that you have done, but efforts will be made to avoid duplication of the same experiment by member of the same group.

Also, after the first and second labs are graded, 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 clarify expectations of the report, explore to what extent you really understood what you were doing, and to clear up any residual questions.

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. During this time you will perform, with one or two laboratory partners, about six or seven experiments over the course of the semester. These are to be chosen from the list below. Each experiment will take you two weeks to complete. It is more important to do the experiment well 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 the main idea. You will record your laboratory work and data in your data book. During the period of the experiment, you need to analyze data both in class and outside of class, bringing questions to your instructor as they arise. If you wait, you risk falling behind! The last week of classes, both recitation and laboratory time, will be fully devoted to oral presentations and discussions. Thus, you should plan completing all experiments one week before classes are over. See below for requirements on submission of lab reports.

I prefer every student to do at least one of (‡x-ray, electron diffraction) and at least one of (†Zeeman, Sat Abs, NMR).

Available Experiments:
(* Sign indicates experiment available for first laboratory sessions)

Classical Physics:
1. *Millikan Oil Drop
2. *e/m Hoag
3. *Microwave Optics
4. *Torsional Oscillator

Atomic structure/quantum mechanics/modern physics
5. ‡Electron Diffraction
6. ‡X-ray Diffraction
7. Lifetime of the μ particle
8. †Zeeman effect
9. SQUID
10. Scanning tunneling microscope
11. †Saturation Spectroscopy in Rb (?)
12. †Nuclear Magnetic Resonance
13. *Noise Fundamentals
14. Fourier Methods
**Deadlines**: Lab Reports are due Friday the week after the lab is completed (i.e. 8-10 days after the completion of the lab). You may submit the report on Monday following the Friday deadline but you will get 90% of earned grade. **You will not be allowed to start a new experiment if you have more than one lab report due submission.** The report may be submitted electronically through k-state online file dropbox. The filename must contain your last name, the consecutive integer number of the lab for you, and the short name of the experiment. For example: smith_lab_1_xray.pdf. **Keep copies of your data and lab reports until the end of the semester… my copy might be lost or electronically corrupted.** Homework on data analysis will be assigned from time to time, due at class time Monday unless otherwise stated.

**General Laboratory safety regulations:**
1) Wear safety glasses at all times when operating the pulsed nitrogen laser. NEVER look directly into the laser beam.
2) No food or drinks are allowed in the lab at any time. (Radioactive sources in the lab, when ingested, could be very harmful).
3) No flip-flops or open-toed shoes should be worn in the laboratory.
4) There are radioactive sources located in the lab, and respect must be given to these sources. **Do not open the drawer containing those sources, or handle any sources**, unless they are specifically required for the present experiment, and you have been instructed in their proper handling.
5) Use the tools available to you in the lab for your work, but please do not misalign or disconnect other experiments in the lab.
6) When working with high-voltage sources, keep one hand behind your back or in your pocket. Avoid grounding yourself.
7) Wear gloves and goggles when working with liquid nitrogen. Do not throw liquid nitrogen at or toward classmates.
8) Be aware of all special safety concerns for each laboratory before beginning the experiment.

**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 1-3 months 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 measured. 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 or staple it into your notebook. If you want to put in a computer printout, glue, tape, or staple 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. **(One 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:

1) An abstract, summarizing in 1 Paragraph the goal, experimental approach, results, uncertainty, and agreement or disagreement within experimental error with expected (or accepted) value.
2) An introduction discussing the motivation, the principle of the experiment (the key idea or concept, without concrete details) and the background or context of the experiment;
3) An experimental section describing the apparatus (concrete details go here), the data-taking procedure and a summary of the data, sometimes in tabular or graphical form (the original data should be in the data book);
4) A data analysis section that includes details of your calculations and an assessment of experimental error;
5) A discussion section in which the comparison between experiment and theory is made, the possible pitfalls of the experiment are identified, and attempts to improve the measurement are described (if not already covered in the analysis section). 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.
6) A conclusion section, in which all important experimental results are summarized, and experiment and theory are compared again. This section will almost always contain a statement like: “We tested the Compton effect by measuring the angle at which gamma rays are scattered and comparing it to the prediction made by Eq. (1). The measured and predicted angles agreed to within 5%, which is within (or NOT within) the experimental uncertainty of 10%. (if not within, you need to give more details about why your experiment and theoretical prediction disagreed).

**Plagiarism Alert!!** Special note about use of web materials in write-ups:

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 write-up 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.

**Grading:** Your grade will be determined primarily by:

1) (600 pts) Grades on your lab write-ups. Each lab report is worth 100 points. The grade on lab report will be influenced by performance on oral interviews and as well as 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.
2) (100 pts) Homework on Error Analysis and one presentation on an article from Nature Physics or Physical Review Letters (PRL) about experimental results of your choice. Total of 100pts will be split into 75 pts on homework and 25 pts on presentation
3) (100 pts) One oral presentations of a 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

**Statement Regarding Students with Disabilities:** Students with disabilities who need classroom accommodations, access to technology, or information about emergency building/campus evacuation processes should contact the Student Access Center and/or their instructor. Services are available to
students with a wide range of disabilities including, but not limited to, physical disabilities, medical conditions, learning disabilities, attention deficit disorder, depression, and anxiety. Contact the Student Access Center at accesscenter@k-state.edu, 785-532-6441.

**Statement Regarding Academic Honesty:** Kansas State University has an Honor and Integrity System based on personal integrity, which is presumed to be sufficient assurance that, in academic matters, one's work is performed honestly and without unauthorized assistance. Undergraduate and graduate students, by registration, acknowledge the jurisdiction of the Honor and Integrity System. The policies and procedures of the Honor and Integrity System apply to all full and part-time students enrolled in undergraduate and graduate courses on-campus, off-campus, and via distance learning. The Honor and Integrity System website can be reached via the following URL: [www.k-state.edu/honor](http://www.k-state.edu/honor). A component vital to the Honor and Integrity System is the inclusion of the Honor Pledge, which applies to all assignments, examinations, or other course work undertaken by students. The Honor Pledge is implied, whether or not it is stated: "On my honor, as a student, I have neither given nor received unauthorized aid on this academic work." A grade of XF can result from a breach of academic honesty. The F indicates failure in the course; the X indicates the reason is an Honor Pledge violation.

**Statement Defining Expectations for Classroom Conduct:** All student activities in the University, including this course, are governed by the Student Judicial Conduct Code as outlined in the Student Governing Association By Laws, Article V, Section 3, number 2. Students who engage in behavior that disrupts the learning environment may be asked to leave the class.

**Academic Freedom Statement:** Kansas State University is a community of students, faculty, and staff who work together to discover new knowledge, create new ideas, and share the results of their scholarly inquiry with the wider public. Although new ideas or research results may be controversial or challenge established views, the health and growth of any society requires frank intellectual exchange. Academic freedom protects this type of free exchange and is thus essential to any university's mission.

Moreover, academic freedom supports collaborative work in the pursuit of truth and the dissemination of knowledge in an environment of inquiry, respectful debate, and professionalism. Academic freedom is not limited to the classroom or to scientific and scholarly research, but extends to the life of the university as well as to larger social and political questions. It is the right and responsibility of the university community to engage with such issues.

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