Physics 441/841 Advanced Experimental Physics I Fall 2023

Meeting Time

Lecture: Monday 1230-1320; Laboratory: Monday 1330-1620 (Section 152) or Tuesday 1230-1520 (Section 151), JH 233.

Instructor

Timothy Gay, JH 073, 402-472-2773, tgay1@unl.edu. TJG office Hours: 16/7; appointments recommended.

Teaching Assistant

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Prerequisites

Physics 213, 223, and 231

Course Objectives

1) Develop skills needed for work in experimental physics. 2) Gain understanding of what is involved in making physical measurements, particularly with regard to error analysis. 3) Develop written and oral communication skills for the presentation of scientific work. 4) Provide hands-on experience with phenomena and principles of physics through laboratory work.

Useful Reference texts (listed in Order of Usefulness, most first)

Bevington and Robinson, *Data Reduction and Error Analysis for the Physical Sciences*
Moore, Davis, and Coplan, *Building Scientific Apparatus*
Sherz and Monk, *Practical Electronics for Inventors*
Melissinos, *Experiments in Modern Physics*
Young, *Statistical Treatment of Experimental Data*
Monk, *Light: Principles and Experiments*
Essink, *Hands-On Introduction to Labview*
The CRC Handbook of Chemistry and Physics
Saleh and Teich, *Fundamentals of Photonics* (2nd ed.)
Rosebury, *Handbook of Electron Tube and Vacuum Techniques*

There are many other useful texts and manuals in the lab room; these must remain there, except for the copying of brief excerpts.

Format

There will be a lecture period Mondays at 1230 in JH 247. Usually, the instructor will present and discuss experimental techniques, procedures, and background information for the experiments. Towards the end of the semester, however, the lectures will be replaced by final oral presentations by the students. There are two scheduled three-hour laboratory sessions (each associated with a Section Number) that are held on the Monday and Tuesday, respectively, of each week.

Each student will do four labs from the list below. The Measurement of π lab is mandatory and will be done first. Each student will work with a lab partner. From one lab to the next, students may switch partners if they wish.

On occasion, more hours in the lab can be scheduled in consultation with Prof. Gay or the TA. You may not work in the lab on weekends or without the presence of the TA and/or the instructor. These experiments will require multiple laboratory sessions to complete, and will require significantly more in-depth understanding and analysis than the typical 200-level laboratory.

The labs that available this semester are:

Measuring π (mandatory)
Atomic Spectra
Bragg Diffraction and Microwave Optics
Cavendish Measurement of Big G
Compton Scattering
Ellipsometry
Faraday Effect
Hall Effect
Interferometry and Piezoelectricity
Mechanical Resonance of a Torsional Oscillator
Millikan Oil Drop Experiment
Muon Lifetime
Radiation and the Stefan-Boltzman Law
Thin Lenses
Vacuum Technology

Grading: Overview

In addition to the mandatory first lab on the measurement of π, students are required to complete three other experiments. Lab reports are due at **11:59** pm on the days indicated on the accompanying schedule. Reports should be submitted electronically in *.pdf format. Students are encouraged to give Prof. Gay first drafts of their reports so that they can receive constructive criticism before the final report is handed in; the typical turnaround time for Prof. Gay to provide such feedback is 24 hours. You should not expect this first feedback to be extremely detailed, but it will point out the most apparent qualitative problems the report has.

During the last four weeks of the semester, each student will give a 12-minute Powerpoint presentation on one of the labs they have done during the lecture period. You and your lab partner may not both talk about the same experiment. You are encouraged to give a practice talk to Prof. Gay or the TA several days before your presentation is scheduled.

Grading will be done on an A+ (4.33) to F (0.00) scale. Individual assignments will be weighted as indicated in the Table below. The increasing value of the lab weighting is meant to reflect increased student awareness of the instructor's expectations. ***The instructor's expectations are high. Given that only four lab reports are required, these reports should be detailed and well-thought-out. They should be informative and well-written. Neatness counts.*** For a given lab report, both lab partners will receive the same grade. Final oral reports will be graded individually. ***Failure to do your share of the work in a lab partnership will be regarded as academic dishonesty and, as such, will be handled appropriately as directed by the*** **UNL Student Code of Conduct.** ***In such a situation, both lab partners will not necessarily receive the same grade for the course.*** See also the discussion below and the Lab Report Guidelines posted on Canvas.

For late reports, points will be deducted as follows. For the first three lab reports, 0.33 grade points (one-third of a letter grade) will be deducted for each day that the report has not been turned in. For example, if the second lab report (due at 2359 Sunday evening on 8 October 2023) is turned in at 0053 h (electronically, by email) on the Tuesday after it is due, and the merit grade it receives is a B- (2.67), the grade of record that it receives will be a C (2.00), which will be given a weight of 19% in the final grade determination. *If the fourth report is late it will receive no credit.* ***You are urged to submit your reports at least an hour before they are officially due.*** Remember that *.pdf documents do not always look exactly like the document from which they are produced, so check the *.pdf rendering before you submit your report.

On 11 September 2023 at the end of lecture, a take-home test on error analysis will be handed out and will be due back by 2359 on 14 September. You may work only with your lab partner on this test and cannot discuss it with anyone else. Any questions the two of you have about the test must be directed to Prof. Gay by email or in person.

Activity	Weighting Percentage
Lab # 1 (π)	14%
Error Analysis Test	9%
Lab # 2	19%
Lab # 3	21%
Lab # 4	23%
Oral Presentation	14%

Lab Reports

A written lab report will be required for each experiment completed; they are the primary output of your work. See the accompanying handout for more details on what these reports should include. For labs 2-4, they should be between 10 and 20 pages in length, including figures (all clearly labeled with captions!), tables (with captions where appropriate), and references. No specific formatting is required, but consistency, neatness and clarity of presentation count a lot. Points will be deducted for typos. The use of good English is mandatory. Your report should begin with an appropriate title and by-lines. There should then be an introduction with a discussion of the relevant physics, and a specification of the goals of your work. Following the introduction, there should be sections on the experimental apparatus you used, the data you obtained, the data analysis, and the conclusions you reached. Schematic apparatus diagrams including electrical and/or vacuum schematics should generally be included, and, where appropriate, tables of raw data. One or more properly-labelled photographs of the apparatus (that are large enough and clear enough to convey useful information!), can be very helpful to the reader. It is always good to err on the side of including too many figures rather than too few. As you write your report, always be asking yourself one question: "Would a person following this report be able to reproduce each step of the experiment we did?" If the answer is "no," include more detail in your write-up. Nothing annoys the grader of these reports more than sloppy formatting (typified by the presence of large, blank white spaces on the page), failure to thoroughly reference sources and figures, a bibliography at the end comprising only URLs, and vague philosophizing instead of hard-nosed scientific reporting. As you write your reports, budget enough time to ensure that your LaTex or Word skills are sufficient to make formatting effortless.

Lab Notebooks and Good Experimental Practice

You should use a bound laboratory notebook to record all data taken in the laboratory. One notebook should suffice for all your experiments. ***All handwriting in the notebook should be in ink. Do not record data on loose paper and copy it into your notebook later! Professor Gay has been known on occasion, in a fit of rage, to crumple up and set fire to offending single notebook pages filled with penciled notes.*** To avoid such unpleasantness, it is best to have a notebook with "graph paper" pages (to make it easier to draw plots and make tables), and remove any pencils from your person before entering the lab. In order to motivate you to do the right thing in this regard, each instance of loose-leaf note-taking in pencil detected by Prof. Gay will result in a 0.1 letter grade reduction in your report grade. A printer is available in the lab if you wish to make plots on a computer and scotch-tape or paste them into your notebook.

It is best to perform your preliminary data analysis and to make some rough plots in this notebook while you are taking your data. This practice (which should become a habit!) will allow you to see if the incoming data make sense. If they don't, you can adjust your experimental plan accordingly. Plotting data ***by hand*** as you go also gives you a better sense of the relationships between various experimental parameters, and will facilitate decisions you need to make about what to measure next. Generally speaking, it is best to first determine the range of experimental parameters you wish to explore, and to make measurements on a "course grid" first before searching for possible, more fine-grained features in the data. Throughout the data analysis you report, and especially when you are laying out your final results, proper error analysis, as discussed in *Bevington and Robinson* and in lecture, is crucial.

The Advanced Lab comprises six experimental rooms and many cabinets and shelves with a large and eclectic array of physics apparatuses, tools, and supplies. You will spend a significant fraction of your time in this course wandering through the six Advanced Lab rooms hunting for stuff you need to do your experiments. In order to make these searches more efficient, we have an inventory list that tells you the locations of various pieces of equipment, tools and supplies you may need. This inventory is best utilized by searching (Ctrl-F) for key words related to what you're looking for. Each item in the inventory is associated with a location. This inventory can be accessed at

https://uofnelincoln-my.sharepoint.com/:x:/g/personal/nstamos2_unl_edu/EZwJf9S00HpEhvW-2FGW67wBIlTO6a9B3p0Pq2c8JXyp8w?e=gz2YOi&nav=MTVfezZFNkFENjlDLUI3OEYtNEIzMi05MzhGLTAwM0I5Q0M2RkNGMX0

Talks

The talk you will give should be 12-13 minutes long. This typically means that you should prepare 11 – 14 PowerPoint slides. Practice your talk several times, so that you won't go over time. Give one of these practice talks to Prof. Gay and/or the TA. Your talk should have a title slide, followed by several slides on the physics of the experiment you did, then one or two slides about the apparatus you used. It never hurts to discuss one or two problems you encountered in taking the data, and ways that you solved (or didn't solve!) these problems. Make sure that it's clear to your audience what methods you used to take your data. Show a sample of the data, and perhaps an example of any calculations you did to analyze these data. The results with appropriate errors and conclusions come last.

Independent evaluations and grades for your talk will be given both by Prof. Gay and the TA. Grading will be based on the answers to the following questions.

Did the student give a polished presentation?

Did they speak clearly and audibly?

Were the slides neat and informative and not too "crowded"?

Did they contain appropriate illustrations, pictures, and/or drawings?

Were the basic physics principles of the experiment and the motivation for doing it clearly discussed?

Were the results clearly shown, *with appropriate error analysis*?

Did the result obtained agree with accepted physical principles or values?

Were any obvious problems with the results discussed and/or explained adequately?

Was the student able to answer questions put to them by the other students and/or the instructors?

The final grade for the talk will be within the range of grades given by the instructor and the TA. When you give your talk, don't wear a hat of any kind.

ADDITIONAL SYLLABUS INFORMATION

Academic Integrity

Academic integrity is a fundamental value of the University community. UNL students are expected to approach and complete their academic work with academic integrity. Students must read this syllabus and all other instructions carefully so that they know what is expected in terms of academic integrity. Students are expected to do their own work, to be honest in the statements they make, to refrain from harming others, to refrain from improperly helping others, and to follow the rules.

Refer to the Student Code of Conduct and Academic Integrity, which can be found at http://stuafs.unl.edu/ja/code/. The first violation of the code will result in at least a failing grade for the assignment and notification of university officials. Further action may be taken. Subsequent violations will result in failure for the course, along with notification of university officials. To avoid situations of cheating, plagiarism or academic dishonesty, contact the instructor in advance if a course-related issue is unclear.

The unauthorized use of artificial intelligence to complete coursework is a violation of the University of Nebraska Student Code of Conduct Standards of Academic Integrity. ***Use of AI resources is forbidden in PHYS 441.*** Failing to act with academic integrity violates the University of Nebraska Student Code of Conduct and will be reported to the Office of Student Conduct & Community Standards. Students who violate academic integrity standards may receive academic sanctions, up to and including receiving a grade of "F" in the course.

Students with Disabilities

Students with disabilities are encouraged to contact the instructor for a confidential discussion of their individual needs for academic accommodation. It is the policy of the University of Nebraska-Lincoln to provide flexible and individualized accommodation to students with documented disabilities that may affect their ability to fully participate in course activities or to meet course requirements. To receive accommodation services, students must be registered with the Services for Students with Disabilities (SSD) office, 132 Canfield Administration, 472-3787 voice or TTY.

For more on University Policies relating to Attendance, Academic Honesty, Services for Students with Disabilities, Mental Health/Well-Being Resources, the 15th Week of Class, Emergency Procedures on Campus, Diversity & Inclusiveness, and Sexual Misconduct, you should go to:http://go.unl.edu/coursepolicies. All students at the University of Nebraska-Lincoln are responsible for following these policies and procedures.

ACE Certification for PHYS 441 and 442

(i) the ACE Outcome(s) for which the course is certified

Student Learning Objective 10: Generate a creative or scholarly product that requires broad knowledge, appropriate technical proficiency, information collection, synthesis, interpretation, presentation, and reflection.

(ii) the opportunities the course will give students to acquire the knowledge or skills necessary to achieve the Learning Outcome(s)

The students are required to plan, execute, analyze, and report on a series of laboratory experiments that illustrate both key principles of physics and the practice of laboratory research. The creative scholarly product is the complete process from planning through reporting and is evaluated as such by the instructor(s). This process teaches the following skills. 1) Develop skills and practices needed for work in experimental physics. 2) Gain some understanding of what is involved in making measurements. 3) Develop written and oral communication skills for the presentation of scientific work. 4) Provide hands-on experience with phenomena and principles of physics through laboratory work. The process requires the development and application of broad knowledge and information collection in both the planning and reporting activities, development and demonstration of appropriate technical proficiency in the execution, and finally, interpretation, synthesis, and reflection in the analysis and reporting of results.

(iii) the graded assignments which the instructor(s) will use to assess the student' achievement of the Outcome(s)

Student achievement will be assessed from the quality of the student's preparation for and conduct of the laboratory work, four written experiment reports, and an oral presentation on one of the experiments. The students will receive timely written and or oral feedback on each graded component.