Phys401
Spring 2024

Course Overview

Physics 401 is a one semester course intended to give students an introduction to basic laboratory techniques in experimental physics in the context of classical mechanics and electromagnetism. In experimental physics we learn about the universe by asking it questions in a controlled way (*experiment*) and interpreting our observations quantitatively to constrain theoretical frameworks (*analysis*). In this course we will work through all aspects of this process at a level beyond that of your introductory courses:

- We will use more complex laboratory equipment than you may be used to from introductory labs: oscilloscopes, digital multimeters, signal generators, lock-in amplifiers, Hall probes, etc.
- We will focus more seriously on quantitative analysis in the presence of errors, including sources of error and noise, error propagation, basic statistics, and fitting models to data.
- Effective written communication of your results will be a key priority for this course.
- We will introduce several foundational concepts not emphasized in introductory courses, notably Fourier domain signal analysis, synchronous detection, wave propagation in transmission lines, magnetic hysteresis, etc.

The tools and techniques we will use in this course are foundational to a wide variety of endeavors in science and engineering.

Course Objectives and Prerequisites

Through their work in this course, students will:

- acquire basic concepts related to these experiments,
- become familiar with modern experimental instrumentation,
- learn how to make reliable measurements,
- understand the precision of a measurement and statistical analysis,
- learn how to do calculations with proper significant figures,
- learn how to do data and graphical analysis,
- learn how to write a laboratory report,
- learn how to approach an experiment systematically and think analytically.

Course Prerequisite

Phys325 as a prerequisite and Phys435 as a corequisite

Course Components

The course consists of an 80-minute lecture and a four-hour laboratory period each week.

1. LECTURE (Mon 3:30-4:50pm) is where we will discuss the concepts and history behind the week's experiment, outline the setup and equipment, discuss possible experimental challenges, and give tips for analysis and presentation. The lectures will provide information necessary to successfully complete the labs, as well as discuss applications of course material to current physics experiments and technology.
2. LABORATORY (Tue/Wed/Thu, 4-hour blocks) is where students will work in pairs to carry out the experiments, record the results in your lab notebook, and carry out preliminary

data analysis. Students attend one lab section each week (at your registered time). Some laboratories are completed in a single session, others require more than one week.

3. LAB REPORTS are where students describe their experimental work to the world. Students introduce relevant background, describe your experimental methods, and discuss your main results and findings. Reports must be well-organized and clearly written and are generally due one week after the lab is performed (one week after the final meeting of a multi-week lab), unless otherwise noted.

Course Topics

A. Instrumentation
- Oscilloscopes
- Digital multi-meters
- Signal generators
- Data acquisition hardware
- Lock-in amplifiers
- Power supplies

B. Data Analysis Software
- Origin (WebStore)
- Mathematica (WebStore)
- For other options, see Computing Tools.

C. Data Analysis Techniques
- Statistical error analysis
- Fitting models to data
- Time-domain analysis and transients
- Frequency-domain analysis

D. Measurement Techniques
- Measurements and modeling of systems that exhibit linear response
  - Electrical: RLC circuits
  - Mechanical: Torsional oscillator
- Synchronous detection
- Signal propagation in transmission lines
- Measurement of the electronic charge
- Studies with microwaves
- Response of magnetic materials to AC magnetic field

Class Policy

Physics 401 is a one semester course intended to give students an introduction to basic laboratory techniques in the context of classical mechanics and electromagnetism. The course consists of an 80-minute lecture and a 4-hour lab-period per week.

Before you come to the lab
- Study the laboratory handout carefully (linked from the course schedule). Your learning experience (and experimental success!) critically depends on being well-prepared prior to the laboratory sessions. Solid preparation will save a significant amount of time in carrying out the analysis and writing laboratory reports.

- You will have one lab partner for each experiment. It is suggested, but not required, that you rotate partners intermittently *for new experiments.*

Lab notebook

- Keep a laboratory notebook. Your laboratory notebook is your record of your work in the lab. It needs to contain enough information (in combination with your data files) for you to complete your report after the lab session is done. Any ruled notebook (bound or spiral) will do fine as a lab notebook, as long as you keep it neat and in one piece. Bound notebooks are more durable.
- Your lab notebook will be graded: your TA will give it a brief check for style and completeness, and this will be worth 10 points toward each report grade. Your TA will arrange their preferred method for checking your notebook.

Lab reports

- You and your partner(s) will work together to write a single lab report for seven labs and an individual report for Final Project. You are expected to share work equitably, so that everyone learns writing / analysis / plotting; please contact the course staff if this is not working out for your group.
- Lab Report Submission: Unless otherwise specified, lab reports are generally due 1 week after the final lab session for that activity, the night following your usual lab section meeting. In other words, reports from the Tuesday section are due Tuesday night (defined as ending 8am Wednesday morning). Lab reports will be uploaded through the my.physics portal.
- Late Lab Reports: It is possible to submit a lab report late for reduced credit.
    - Reports turned in within 1 week of the due date will be penalized by 5% of the assignment value.
    - Within 2 weeks, the penalty is 10% of the assignment value.
    - After two weeks, reports are not accepted without prior arrangement with the instructor, typically requiring extraordinary circumstances.
- Revise and Resubmit: You can revise one report and resubmit it for a regrade during the semester. The original report must have been a real report (fully completed, not an incomplete stub), and any late penalties carry over. Due date is the same as for the final report (which cannot be revised and resubmitted).

Attendance: Don't miss laboratories or lectures!

- Given the nature of this course, it is extremely difficult to usefully make up a missed lab activity. Please do your best to make it to lecture and lab!
- If you do miss a laboratory, consult with your laboratory instructor immediately to do the lab in another laboratory session during the same week. In some cases, it may be possible to triple-up a lab group, with permission of the instructor and the lab TA. Makeups are generally difficult to arrange, but we can sometimes staff a makeup session Friday morning during our TA office hours (if worked out in advance). We swap out lab setups on Friday afternoons, so it is generally not possible to arrange makeups after then.
- Excused absences from labs are granted only by the instructor and follow the same criteria as in Physics 10x and 21x, in accordance with the Student Code. Please contact your

instructor as soon as possible in these cases, and expect to be asked to provide documentation.

- COVID-19 introduces the possibility for absences due to isolation. This is handled similarly to other excused absences - note the campus policy on absence letters. Please contact your instructor as soon as possible in case of absences. In some cases (e.g. asymptomatic isolation during a multi-week lab activity) it may be possible to arrange Zoom participation.
- Consult with your instructors for any problems regarding your reports, laboratory schedule, etc. You may email, call and/or drop in to resolve your problems as soon as possible.

ACADEMIC AND COMMUNITY STANDARDS

Academic Integrity

The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: http://studentcode.illinois.edu/.

Academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy: https://studentcode.illinois.edu/article1/part4/1-401/. Ignorance is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

Disability-Related Accommodations

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 333-4603, e-mail disability@illinois.edu or go to https://www.disability.illinois.edu. If you are concerned you have a disability-related condition that is impacting your academic progress, there are academic screening appointments available that can help diagnosis a previously undiagnosed disability. You may access these by visiting the DRES website and selecting â€œRequest an Academic Screeningâ€ at the bottom of the page.

Family Educational Rights and Privacy Act (FERPA)

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See https://registrar.illinois.edu/academic-records/ferpa/ for more information on FERPA.

Sexual Misconduct Reporting Obligation

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: wecare.illinois.edu/resources/students/#confidential.

Other information about resources and reporting is available here: wecare.illinois.edu.

Anti-Racism and Inclusivity

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Bias Assessment and Response Team (BART) (https://bart.illinois.edu/). Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Run > Hide > Fight

Emergencies can happen anywhere and at any time, so it is important that we take a minute to prepare for a situation in which our safety could depend on our ability to react quickly. Please see this link for important safety information from the campus police.

Schedule

WEEK OF	WEEK #	EXPT #	LECTURE	LAB	DUE
January 15	1	1	*No Lecture (MLK Holiday)*	*Equipment intro lab*	
January 22	2	5	*Introduction to Physics 401 Transients and oscillations in RLC circuits*	*Transients in RLC Circuits*	*Equipment*
January 29	3		*Noise & Error*	*Report Writing Workshop*	*RLC*
February 5	4	10	*Frequency Domain Analysis*	*Frequency Domain Analysis of Linear Circuits Using Synchronous Detection*	*Error assignment*

February 12	5	11	*Pulses in Transmission Lines*	*Pulses in Transmission Lines*	*Frequency Domain Analysis*
February 19	6	100	*Counting Statistics*	*Counting Statistics*	*Transmission Lines*
February 26	7	54	*Millikan Oil Drop Experiment I*	*Millikan Oil Drop Experiment / Week #1*	*Counting*
March 4	8	54	*Millikan Oil Drop Experiment II*	*Millikan Oil Drop Experiment / Week #2*	
March 11	9		SPRING BREAK		
March 18	10	6	*Torsion Oscillator I*	*Torsion Oscillator / Week #1*	*Millikan*
March 25	11	7 & 8	*Torsion Oscillator II*	*Torsion Oscillator / Week #2*	
April 1	12	22	*Microwave*	*Microwave Cavities*	*Torsion Oscillator*
April 8	13	22D	*AC measurement of magnetic susceptibility I*	*Final Project Week #1 – AC Measurement of Magnetic Susceptibility*	
April 15	14	22D	*AC measurement of magnetic susceptibility II*	*Final Project Week #2 – AC Measurement of Magnetic Susceptibility*	*Microwave Cavities*
April 22	15	22D	*Report help session*	*Final Project Week #3 – AC Measurement of Magnetic Susceptibility*	
April 29	16		*No Lecture*	*No Lab (Reading Day)*	
May 6	17	Final Report and Resubmissions Due Wed 8May, 11:59pm			

Course Grading

Course grading will proceed in compliance with University policy, as given in Article 3, Part 1 of the Student Code. More information on standards and procedures is given on the Class Policy page.

Your final grade for Physics 401 will be based upon your total score on all of the components of the course. The central component of this course is the laboratory reports, so these constitute the bulk of your grade. Note that, due to the nature of this course, we cannot offer "free drops" of any activities. We do, however, make an allowance for two late reports by treating the course point total as 1250 (rather than 1260). Tentative point assignments are as follows:

COURSE COMPONENT	MAXIMUM POINTS
Lab Reports	*1100*
RLC Transients	100
Synchronous Detection	100

Pulses in Transmission Lines	100
Counting statistics	100
Millikan Oil Drop (2 weeks)	150
Torsional Oscillator (2 weeks)	150
Microwaves	100
Final Project AC Measurement of Magnetic Susceptibility (3 weeks)	300
Supporting assignments	*100*
Equipment intro lab	70
Problem set: Error propagation	30
Lectures	*60*
Late assignment allowance	*-10*
T O T A L	*1250*

Course Staff

Course Role	Name	Section	Office Hours	Email (@illinois)
Lecturer	Irina Burkova	**A** Mon 15:30 136 LLP	Mon 14:00 6103 ESB	burkova
Laboratory Instructor	Vishal Ganesan	**L3** Wed 13:00 6103 ESB	Wed 17:00 6103 ESB	vishalg2
Laboratory Instructor	Anthony Eugene Mirasola	**L4** Thu 08:00 6103 ESB	Thu 12:00 6103 ESB	aem8
Laboratory Manager	Todd Moore			tcmoore