

Physics 238—Intermediate Physics Lab
Section 1, MFW 1:15 – 2:30 p.m.
Course Description, Spring 2025

Instructor: Andrew Dougherty
Office: HSC 031 610-330-5212
Lab: HSC 025 610-330-5212
E-mail: doughera@lafayette.edu
Web Page: <http://workbench.lafayette.edu/~doughera/>
Course Web Page: <https://moodle.lafayette.edu/course/view.php?id=29632>

Office Hours: You are not limited to the listed times. I will also normally be available on most other days during the free times indicated on my schedule. Please feel free to e-mail or call at any time and ask a question or set up an appointment. If you prefer to meet virtually, we will use the Zoom link on our Moodle page.

Classes on Snow Days and Other Emergencies: If I am unable to make it to class, I will send out a notice via email.

Web Pages: All course assignments and documents will be posted to our Moodle site.

Description: This is an experimental course featuring topics, tools, and techniques that prepare students to be independent investigators of physical phenomena. Students perform experiments in fundamental areas of physics, with particular emphasis on data analysis, experimental techniques, and effective communication of scientific findings. Uncertainty analysis is introduced in a systematic fashion. Students will troubleshoot, refine, and in some cases design experimental processes. Experiments may include mechanical and electrical oscillators, optics, and fundamental experiments in quantum physics.

Prerequisites: Phys 133 or 152, or permission of instructor.

Text: *An Introduction to Error Analysis*, by John R. Taylor. Additional material will be drawn from an introductory physics text such as the text used in Phys 132/152. Similar material is also available through the OpenStax University Physics textbooks, <https://openstax.org/details/books/university-physics-volume-1>.

Any additional resources needed will be linked from our Moodle site.

Learning Outcomes:

Physics is an experimentally-based science. Experiments have often paved the way for scientific revolution, and they remain the final arbiter among competing theories. However, experiments are rarely as straightforward as one might believe based on typical textbook descriptions, so it is important for an educated scientist to develop an understanding of, and an appreciation for, reliable, quality research. This course builds on, and extends, experimental practices introduced in the introductory Physics courses. In addition to the specific physics topics, I hope to help you learn a number of general principles and ideas that apply in many laboratory situations, such as how to determine for yourself what techniques and procedures to follow to explore a particular phenomenon, how to estimate the origin, magnitude, and importance of uncertainties in your results, how to judge whether or not to believe the results, and what to do when things go wrong. Specifically, after completing this course, you should be able to:

- Perform and analyze experiments in the areas of oscillating systems and electrical circuits;
- Design, troubleshoot, and refine appropriate experimental protocols;

- Compare experimental results to model predictions using Mathematica, python, or similar software;
- Estimate uncertainties in your measurements, and use those uncertainties properly in experimental analysis; and
- Communicate your results to an audience of peers.

Homework: Assignments will be given regularly and will ordinarily be due at the beginning of class on the dates indicated on the individual assignments.

- You are encouraged to work together on homework assignments, but collaborations must be acknowledged and should not be one-way only. You must fully understand whatever work you turn in. See the section on Academic Honesty below for more details.
- Problems will be due at the *beginning* of class. **Late homework will normally not be accepted.**
- For written homework, I expect your work to be clearly organized and easy to follow. You should include not just numbers and calculations, but also include some text to explain *what* you are doing and *why*. This can often be quite brief, but it is *your* responsibility to make your reasoning clear; it is not the reader's responsibility to try to figure out what you meant. Homework that is incomplete or difficult to understand will not get full credit. The following guidelines are intended to help *you* present your work effectively:
 1. Be sure to include your name on each page.
 2. Each problem should be clearly labeled.
 3. It is often helpful to include figures. Any figures should have clear labels.
 4. Show your work clearly, and include all non-trivial steps. Use words to explain what you are doing and why. This can often be very brief, something like "Expand for small values of x ."
 5. Allow plenty of space.
 6. Trim irrelevant details. This is especially relevant for things like *Mathematica* notebooks.
 7. Put a box around your final solution, including correct units.
- **Illegible papers will not be accepted.** If I have difficulty reading or understanding your work, I may return it to you ungraded for re-submission. You may resubmit a legible version (along with the original) by the next class meeting, but that version must not have any new content—it must simply be a legible version of the original.
- Please look at the homework problems ahead of time and ask questions about them either in or out of class. I am happy to give whatever help you need, but it is important that you eventually learn to do these problems on your own—after all, that's what you will have to do in the future.
- Homework will normally be due on Wednesdays. If you look at the problems ahead of time, I will be happy to spend class time on Mondays going over any difficulties that might arise.

Computer Work: Some of the homework assignments will involve numerical calculations or simulations. Most of these will be done in a tool such as *Mathematica* or *python*. Although I will normally use *Mathematica*, you may use whatever tool you wish. I assume

you are familiar with at least the basics of *Mathematica*, but will give explicit instructions for new, novel, or advanced features that we may use. I will post any *Mathematica* notebooks or *python* programs used in the class on the course web site. Please ask if you need further help. I want you to have time to think about the physics at hand, not get held up by syntax issues.

Academic Honesty: The fabric of science, and indeed any intellectual endeavor, is built on the integrity of all involved. Accordingly, I take academic honesty very seriously. I expect that you will abide by the “Principles of Intellectual Honesty” appearing in the Lafayette College Student Handbook.

Working with others is often a helpful way to learn physics. For this course—and indeed for most advanced courses in any discipline—I believe such collaboration to be an essential element for success. I encourage you to collaborate with each other, but unless specifically directed otherwise, all work you turn in *as* your own should *be* your own. My expectation is that everyone will be open to both giving and receiving aid from their peers.

Some students also find it useful to consult other texts, friends, and even a variety of on-line sources. In all cases, though the principles of academic honesty apply: All nontrivial collaborators and external sources must be acknowledged (apart from your textbook and instructor). You may seek help understanding a problem, but all work you turn in must be your own original work. Copying an answer from another source, such as CourseHero, Chegg, Bartleby, or a generative AI source, is a violation of the Academic Honesty Policy. Although some students believe that looking up solutions as soon as they get stuck helps their learning because they get immediate feedback, I would argue that the negatives of this approach outweigh any benefits.¹ In particular, merely looking up a solution:

- Creates a false sense of security that won’t be there during exams.
- Can replace other healthy learning behaviors, such as: reading through the text for missing concepts or similar examples; asking a friend; asking a professor; taking a break and coming back to the question later; having a “Eureka” moment when out for a walk. These are all healthy learning behaviors, and doing less of them is a negative.
- Often fails to lead to actual learning. It won’t necessarily help you the next time you encounter a somewhat similar situation.
- Can lead to a culture where it feels like everyone knows the answer all the time and being unsure of a solution feels abnormal. This is exactly backwards. Being unsure of a solution is normal.

Please read the department’s Academic Honesty policy for the rules regarding collaboration. Feel free to ask if you have any questions about this policy.

Your Responsibilities:

Ask questions. If you are confused, it is important that you stop me and try to sort it out rather than falling behind. *Please* interrupt and stop the class whenever anything isn’t clear. Remember that if you are confused, there are almost certainly many others who are confused as well, and they would welcome your question.

Keep up with assigned work. A good rule of thumb is that you should anticipate spending approximately 12 hours a week for each college course. This means you should anticipate spending an average of 9 hours per week outside of class.

¹This discussion is based on one in Prof. Boekelheide’s syllabus.

Plan ahead. Thermal physics problems are often *long* and complex. They challenge you to extend what you know to ever-more realistic and complex situations. When you are doing a problem, the answer is usually not immediately obvious. It is not always easy to tell whether you are on the right track or not—sometimes you have to work for a while to tell. I am here to help. If you start on your homework ahead of time, I will be available to help you if you get stuck. Don't wait until the night before an assignment is due before starting it.

Participate in class. Your active engagement during class can play an important part in helping you to master the material. Class time will also be used to announce changes to the syllabus. I will also post everything to our Moodle site. It is *your* responsibility to keep up.

Grades

For each experiment, you will be required to submit a typed lab report. These reports are not full journal-style articles, but instead should be clear presentations of your work and your results. Your report should normally include a brief discussion of the relevant theory, and a description of the experimental set-up. The bulk of your report will be a presentation of your data, analysis, and conclusions. In some cases, you will be responsible for designing and refining the protocols for experiments, in which case your reports should include descriptions of the procedures you followed and your reasons for following them. Your reports should not be overly long or complex, but what you do write should be clear. For one experiment, you will be required to make an oral presentation. Finally, there will also be periodic homework assignments, designed to explore specific analysis topics, or to address additional topics related to the experiments. Your final grade will be based on written reports (80%), the oral report (5%), and the homework assignments (15%).

Inclusivity: All students should feel welcome in Physics class. We all bring our own unique perspective to class, and it is my intention that all students feel included in the intellectual community of the classroom. Unfortunately, the history of science is full of exclusion, so it's important to be explicit about inclusion.

Please contact me if you feel your identity is not being honored in class, if you have a preferred name or pronouns that I am not aware of, you observe religious holidays which conflict with coursework, or if there is something else that I should address. I am still learning, too, and your feedback is important to me.

Proper Usage of Course Materials: At Lafayette College, all course materials are proprietary and for class purposes only. This includes posted recordings of lectures, examples, tests, solutions, and other course items. Such materials should not be reposted. Online discussions should also remain private and not be shared outside of the course. You must request my permission prior to creating your own recordings of class materials, and any recordings are not to be shared or posted online even when permission is granted to record. If you have any questions about proper usage of course materials feel free to ask me.

Generative AI Statement: See the general Academic Honesty section above.

Class Recordings: From time to time, it will be useful to record our classes for those unable to attend in person. I will make any such recordings available on a Google Drive shared within the class.

These recordings are for the use of this class only, and should not be shared outside of the class. If you have any concerns with being recorded during the course please let me

know.

Federal Credit Hour Statement: The student work in this course is in full compliance with the federal definition of a four credit hour course. Please see the Registrar's Office web site

<https://registrar.lafayette.edu/wp-content/uploads/sites/193/2013/04/Federal-Credit-Hour-Policy-Web-Statement.doc> for the full policy and practice statement.

| Andrew Dougherty Spring 2025 Office: Hugel Science Center 031 Lab: Hugel Science Center 025 610-330-5212 doughera@lafayette.edu | | | | | |
|--|-----------------|--------------|---------------------|---------------|-----------------|
| Time | Mon. | Tues. | Wed. | Thurs. | Fri. |
| 9:30 | Phys 151 | | Phys 151 | | Phys 151 |
| 10:20 | HSC 142 | | HSC 142 | | HSC 142 |
| 10:35 | | | | | |
| 10:45 | | | | | |
| 11:00 | | | | | |
| 11:25 | | | | | |
| 11:40 | | | | | |
| 12:15 | | | | | |
| 12:30 | | | | | |
| 12:55 | | | | | |
| 1:15 | Phys 238 | | Phys 238 | | Phys 238 |
| 1:40 | HSC 017 | | HSC 017 | | HSC 017 |
| 2:30 | | | | | |
| 2:45 | | | | | |
| 3:35 | | | | | |
| 4:00 | | | | | |
| 4:10 | | Committee | | | |
| 4:30 | | Meeting | <i>Physics Club</i> | | |
| 5:00 | Phys 151 | | | | |
| 5:30 | Lab | | | | |
| 6:00 | HSC 119 | | | | |
| 6:30 | | | | | |

ACADEMIC HONESTY GUIDELINES

Department of Physics

It is expected that each student taking courses in the Department of Physics is familiar with the statement “Principles of Intellectual Honesty” appearing in the Lafayette College Student Handbook. The following guidelines are intended to indicate how that statement pertains to your work in physics. Your instructor may have further guidelines for your specific course. We assume that students are honest; if you are not certain as to what is expected of you, consult your instructor before proceeding.

I. EXAMINATIONS:

1. Bring only those materials specifically authorized by your instructor. Frequently in the elementary courses, you will be permitted to bring in a formula sheet or you will be provided with one.
2. If you find that the seating arrangement is such that you can see someone else’s paper, don’t look! Better yet, ask if you can sit in another seat.
3. If you use a calculator, clear the answer before setting the calculator aside.
4. If you fail to hand in your paper at the end of the period you will be awarded a grade of zero for that test.

II. TAKE-HOME EXAMINATIONS: Take-home examinations are often assigned in some courses. Specific rules governing such tests will be announced by your instructor. The overriding principle, however, is that any work submitted be your own or be specifically credited to its source. There should be no discussion of the test questions with *anyone* other than the instructor.

III. HOMEWORK: You must acknowledge *all* collaborators. You are encouraged to learn from one another. You should first try to do homework problems on your own; after all you will have to do similar problems on your own in tests. However, discussion of difficult problems with others can help you to develop your own analytical skills and is encouraged, provided that, *after discussion* you write up solutions *on your own*. Do *not* borrow or lend homework papers. There is an important difference between discussing a problem with someone and copying his or her work. There have been students who have loaned papers to friends for a few minutes to “check answers”, and been horrified to find themselves charged with academic dishonesty because their “friends” copied their solutions.

Please Note: The same ethical standards of academic integrity and honesty apply to the on-line homework as to the written homework, except that there is no place for you to specifically acknowledge collaboration. However, the same general rules apply.

IV. LABORATORY: Usually two or more students will work together in performing experiments and will submit reports of their work. In some courses, a single joint report may be submitted. Specific instructions will be announced by your instructor. If the words used to describe some part of the experiment are taken from some other source (such as the lab manual), then the source should be cited. (Reference to the lab manual can usually substitute for laborious copying.) If you consult with *anyone* about the experiment (e.g. students in your lab class other than your lab partner), that consultation should be acknowledged in your report. Do *not* borrow or lend a completed lab book or any portion of one.

V. PAPERS: Refer to the statement “Principles of Intellectual Honesty” in the Student Handbook.

| Syllabus | | Phys 238 | Spring 2025 |
|-------------|-------|---|-----------------|
| Jan. | 27 | Introduction & Overview | Taylor Chs. 1–2 |
| | 29 | The Simple Pendulum | |
| | 31 | Writing reports in L ^A T _E X; Introduction to Uncertainty | Taylor Ch. 3 |
| Feb. | 3 | Statistical Analysis | Taylor Ch. 4 |
| | 5 | Normal Distribution | Taylor Ch. 5 |
| | 7 | Pendulum Report Due; Least Squares; Mathematical Tools | Taylor Ch. 5 |
| | 10 | Torsional Pendulum (Part 1) | |
| | 12 | Torsional Pendulum <i>continued</i> | |
| | 14 | HW #1; Linear fits | Taylor Ch. 8 |
| | 17 | Nonlinear fits | Taylor Ch. 8 |
| | 19 | Torsional Pendulum <i>continued</i> | |
| | 21 | Torsional (1) Report Due; Damped Oscillations | |
| | 24 | Torsional Pendulum (Part 2) | |
| | 26 | HW #2; Torsional Pendulum (2) <i>continued</i> | |
| | 28 | Numerical Modeling; Air drag | |
| Mar. | 3 | <i>continued</i> | |
| | 5 | Torsional (2) Report Due; Numerical Modeling <i>continued</i> | |
| | 7 | Resonance—Theory | |
| | 10 | Mechanical Resonance | |
| | 12 | <i>continued</i> | |
| | 14 | HW #3; Resonance <i>continued</i> | |
| | 17–21 | <i>Spring Break</i> | |
| | 24 | <i>continued</i> | |
| | 26 | Complex Impedance | |
| | 28 | Resonance Report Due; RLC Circuits—Theory | |
| | 31 | RLC Damped Oscillations—Experiment | |
| Apr. | 2 | HW #4; RLC <i>continued</i> | |
| | 4 | <i>continued</i> | |
| | 7 | RLC Report Due; RLC Resonance—Theory | |
| | 9 | RLC Resonance Experiment | |
| | 11 | <i>continued</i> | |
| | 14 | <i>continued</i> | |
| | 16 | Fourier Analysis | |
| | 18 | RLC Resonance Report due; Fourier Analysis <i>continued</i> | |
| | 21 | Fourier Analysis <i>continued</i> | |
| | 23 | HW #5; Oral Reports | |
| | 25 | Oral Reports | |
| | 28 | AC Filters | |
| May | 30 | Oral Reports | |
| | 2 | Oral Reports | |
| | 5 | AC Filters Report Due; Superconductivity | |
| | 7 | Oral Reports | |
| | 9 | HW #6 | |
| | 14 | Superconductivity Report Due | |