Course syllabus

Experimental Physics III: Electromagnetic Waves, Optics, and Modern Physics

PHYS 375
Spring 2023

Overview

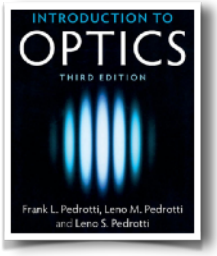
The primary objective of this course consists of learning experimental physics through the study of optics. You will become familiar with the fundamentals of lab work, namely careful experimental set up and measurements, proper documentation, and analysis of the measurement uncertainties. This class is one of a few offered in our undergraduate curriculum where you will have the opportunity to develop experimental procedures, and not simply carry out prewritten instructions. You will learn how to carefully take data, analyze it, understand the origins and propagation of errors, and devise experimental protocols.

You will also learn how to use modern programming languages (MATLAB or Python). Learning programmatic data acquisition and analysis is one of the key aspects of this course, so we will not accept Excel "code." Data acquisition will be in MATLAB and analysis in either MATLAB or Python.

Course organization

Lectures will be Mondays 2 pm - 2:50 pm. With the exception of lab 2, all of the labs will each take place over a two-week period, and you will have two lab sessions to complete the experiments.

Textbooks



Recommended textbook
Introduction to Optics
F. Pedrotti, L. M. Pedrotti, and L. S. Pedrotti
Cambridge University Press, 3rd edition (2017)
ISBN: 978-1108428262

Additionally, "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurement" by John Taylor will be helpful for error analysis. Also, a nice reference for MATLAB is "MATLAB For Beginners: A Gentle Approach" by Peter Kattan, and a good quick primer on statistics is "A Practical Guide to Data Analysis" by Louis Lyons.

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Lectures
Mondays 2:00pm – 2:50pm
PHYS 1204

Office hours
Thursdays 3:00pm-6:00pm
PHY #3115 (Toll bldg.)

Labs
0101 - Mon 3:00pm - 5:50pm
0201 - Tue 3:00pm - 5:50pm
0301 - Wed 3:00pm - 5:50pm
0401 - Thur 3:00pm - 5:50pm
PHY #3115 (Toll bldg.)

Prerequisites
PHYS 273, PHYS 276

Grades

The final grade will be based on the following:

- **Pre-lab code (5%):** due ~biweekly (at 2 pm, the day of the lab session)
- **Lab Notebooks (40%)**: due ~biweekly (see schedule below)
- **Formal Lab Reports (35%):** associated with the labs on Refraction (10%) and Diffraction (25%)
- **Homework (20%)**: due every 2-3 weeks, see schedule below, lowest score is dropped

Pre-lab: prior to coming to the lab, you should read through the lab manual, prepare an initial draft of all scripts that you think you will need for the lab, and answer any prelab questions. Place all your scripts and answers in a single zipped folder. Pre-labs are **due by 2pm**, the day of your laboratory session. No late submissions will be accepted.

Lab Notebooks and Lab reports: For all experiments, you will be required to submit a **notebook** with the written record of everything you do in the lab: set up, measurements, results, as well as all your code. They should allow you to repeat the experiment a long time from now. For two of the labs, you will need to submit a **formal lab report**. This is a formal document, modeled on a journal article, consisting of an introduction, a brief description of the experiment, the results, and conclusions. More details on these items can be found in the "Course specifics" section below.

Lab notebooks and reports are to be submitted in .pdf files via ELMS.

➡ **Lab notebooks** are **due at noon**, typically one week after the experiment is finished (e.g. notebooks for a Monday lab section are due the following Monday at noon; see "Schedule").

➡ The **formal lab reports** are **due at noon**, 14 days after the experiment is finished.

A document submitted after the deadline will receive a **late penalty** unless you have prior approval from your instructor. *The late penalty is 5% for a delayed submission on the same day, 2.5% for each additional day's delay, with a maximum penalty of 40%.* **You must submit a notebook for all experiments to pass the course.**

No late notebooks or reports will be accepted after Monday May 15th.

Homework: Homework will be assigned on ELMS and submitted as .pdf files via ELMS. Homework are **due Mondays at 1 pm.** Solutions will be posted shortly after the deadline, and n***o late homework will be accepted,*** but the lowest score will be dropped. Only a subset of the problems, announced after submission, will be graded.

Tip: After uploading a file to ELMS, **you should make sure that it is the correct file and is readable by previewing it in the system.** You can do this by clicking on "Submission Details" and then on "View Feedback".

Course schedule

Note: This is a tentative schedule, and subject to change as necessary – monitor the course ELMS page for current deadlines. **Homework (HW)** is due **Mondays at 2pm**. **Lab notebooks (LN)** are **due at noon 7 days after the lab is taken**. The **formal lab reports (LR) are due at noon 14 days after you took the lab**. Pre-labs are due at 2pm before the corresponding lab.

Week of	Lecture	Lab experiment	Work due	
Jan 23	No lecture or lab			
Jan 30	1 - Intro/Analysis I	Lab 1 - Advanced Data Analysis		
Feb 6	2 - Analysis II			
Feb 13	3 - Refraction	Lab 2 - Introduction to DAQ Setup		LN #1
Feb 20	4 - Lenses I	Lab 3 - Refraction [REPORT #1]	HW #1	LN #2
Feb 27	5 - Lenses II			
Mar 6	6 - Polarization I	Lab 4 - Lenses	HW #2	LN #3
Mar 13	7 - Polarization II			LR #1
Mar 20	Spring Break			
Mar 27	8 - Waves	Lab 5 - Polarization	HW #3	LN #4
Apr 3	9 - Diffraction I			
Apr 10	10 - Diffraction II	Lab 6 - Diffraction [REPORT #2]		LN #5
Apr 17	11 - Interferometry I		HW #4	
Apr 24	12 - Interferometry II	Lab 7 - Interferometry		LN #6
May 1	13 - Spectroscopy		HW #5	LR #2
May 8	No lecture or lab			LN #7

Labs may be missed only for valid reasons as specified by the University rules book. **If you should miss a lab for any reason, contact your instructor as soon as possible** to make arrangements for a makeup. If it is not possible to arrange sufficient lab makeups, alternative assessments based on oral or written remote exams will be employed.

Course specifics

Lab policies

- **No food or liquids (including water) are allowed in the laboratory.**
- **Closed-toe shoes are required in the laboratory, no open toe shoes (sandals, flip-flops, etc) will be allowed.**
- **Check the University COVID-19 policies.**

Lectures

The material covered in the lectures is instrumental to the understanding of the experiments and will be tested in the homework. Slides and notes for the lectures will be posted after each lecture.

Lab notebooks

Keeping a meticulous, detailed record of your experiments as you go is important in this course, and in experimental science in general. The notebook does not need to be written like a formal paper, but it does need to contain all the information you would need to recreate the experiment a long time later.

You must upload to ELMS the following **as two separate files**

- **A .pdf file** broken into sections clearly labeled using **section headers that correspond to the various parts of the lab** (Part A.1, Part A.2, etc). When answering questions, please include a copy of the question you are answering. This file should include:
    - Your name, the experiment number, and the date.
    - Brief description of the experiment and apparatus including photographs of the set up.
    - All measurements taken. For simple measurements (done for example with a ruler), include them in this document. For scans, please include the plot and the name of the file containing the raw scan data.
    - All requested plots, and answers to all questions, in the appropriate section (not at the end of the document!) including any requested derivations of formulae (photos taken with your phone of a derivation done on paper are acceptable).
    - Description of any intermediate steps between questions.
    - If you needed to do propagation of uncertainties, please include the formulae you derived.
- **A .zip file** with **all the code/scripts** you used and the **raw data** from all useful scans.

Include your name in the filename of the Notebook and the Zipped file**.**

The grading rubric will be adjusted according the specific lab, but the rubric below can serve as a general guideline:

- Code (analysis and acquisition): 10%
- Presentation of Experiment, Data, and Analysis: 15%
    - Figures are neat, well labeled, appropriate, properly incorporated
    - Document has been neatly and clearly laid out
    - etc.
- Description and diagrams/photographs (quality and thoroughness): 15%
- Questions and intermediate steps (data acquisition, plots, interpretations): 25%
- Data quality: 10%
- Analysis and uncertainties: 25%

You will be expected to adhere to the following style guidelines.

1. Write in a **proper text editor** (Word, Pages, LaTex, etc.) Do not simply turn in raw code files with comments.

2. **Figures** should appear **in the notebook** where they are described and should have **clear labels**. Do not simply include a collection of figures at the end of the pdf. Figures that are included only in the zip file and not in the pdf will not receive full credit.
3. Clearly **label all sections, questions,** and **figures/tables**.

General rule of thumb: the TA is a person. Make it as easy as possible for them to see your work.

Formal lab reports

As discussed in the previous sections, you will submit formal lab reports for experiments #3 and #6. The format of these lab reports should be modeled after that of a journal paper. You should aim at around 8 pages, and no more than 15. Include the following sections:

- **Title Page:** name of the experiment, abstract (a brief summary of what was done and the results), your name, section number, and date.
- **Introduction:** a brief description of the experiment and its motivation, relevant theory and equations, as well as the analysis used to arrive at your conclusions.
- **Methods and measurements**: a brief description of your actual experimental setup and approach, without copying what the manual told you to use or do.
  - Schematics and diagrams of equipment and experimental setup.
  - Description of the experimental procedures.
  - Synthesized raw data (most important plots and tables with units, putting several plots on same canvas when possible).
- **Experimental results and analysis**: plots and tables of analyzed data, including your attempts and failures. All tables and figures must be numbered in order and have captions explaining their content.
  - Include a clear description of the uncertainties and sources of errors; the actual analysis/error propagation and approaches used (programs, etc.) belong in your notebooks.
  - Present the final results with uncertainties.
- **Discussion of results**: comparison of your results to expected/known/previous results.
  - Include a critical discussion of how well your measurements fit the theory or model.
  - Discuss ways to improve measurement and other possible measurements that could be made.
- **Conclusions**: short summary of what you discovered and presented in the report.

These reports constitute the midterm and final papers for PHYS 375 and each student should work individually. The grading rubric will be adjusted according the specific lab, but the rubric below can serve as a general guideline:

- ➡ Overall structure: 5%
- ➡ Title page: 10%
  - ➡ Title: 2%
  - ➡ Name/section/date: 2%
  - ➡ Abstract: 6%
- ➡ Introduction: 10%
- ➡ Methods and measurements: 20%
  - ➡ Description of setup/approach: 7%
  - ➡ Experimental procedure: 7%
  - ➡ Raw data with figures and tables: 10%
- ➡ Experimental results and analysis: 30%
  - ➡ Sources of uncertainties: 8%
  - ➡ Error propagation: 7%
  - ➡ Final results with uncertainties: 15%
- ➡ Discussion of results: 20%
  - ➡ Fit, comparison with expectations from theory: 15%
  - ➡ Possible improvements: 5%
- ➡ Conclusions: 5%

Programming Languages

The official programming language for this course is MATLAB. All data acquisition must be done in this language, and the course instructors are available to answer questions about how to write data acquisition and analysis code in this language.

If you have prior experience using Python and wish to do so, data analysis may be carried out in Python, rather than MATLAB. However, we cannot guarantee software support for this language. Students who are new to coding or to Python should plan to work in MATLAB.

We will not accept code written in any other languages. MATLAB and Python syntax are close enough for assignments in these two languages to be graded simultaneously. It is unfair to expect the TA to be versed in all possible languages, so we will not be able to accept code written in any other languages (e.g. Java, C, C++…)

Lastly, Excel is not a programming language, and we will not accept "code" in Excel. Learning to carry out programatic data acquisition and analysis is one of the central objectives of this course. Once mastered, this skill will allow you to go **far** beyond what is possible in Excel. While it is technically possible to do some of the data analysis required for this course in Excel, this will not help you build the advanced data analysis skills required for the latter parts of 375, 405, and independent research.

Tips for Doing Well

- Read the lab instructions carefully before you go to the lab and attempt an experiment. Make sure to complete the code pre-lab.
- Prepare tables in your notebook to enter data.
- During class, keep a neat, well-organized and complete record in your lab notebook of the experiment including diagrams of measurement configurations actually used to obtain data, your results, and the analysis used to obtain the results
- When something in the lab is not making sense or working properly talk to your TA or instructor as soon as possible – do not hesitate to ask what you think might be a trivial questions if you are not sure!
- Do not leave class unless you have finished your data collection and are reasonably sure about how to handle the analysis. It is often a good idea to discuss your results with your instructor or TA before leaving as well.
- Do basic data analysis while taking data to confirm that the apparatus is working properly. You want to catch any software or hardware bugs early.
- **Analyze the data that you take on the first week of the lab before the second week so that you can revise your data-taking procedure if necessary.**
- Do the assigned homework diligently.

Course collaboration policy

Physics is a community effort. You are welcome to work together on and talk to your fellow students about most aspects of this class (i.e., experiments, homework, prelabs, and notebooks). You are also encouraged to consult your TA and instructor in and out of class.

Supplying another student with copies of your completed (or nearly completed) work for them to work off of directly *is not allowed and will be considered a direct violation of the UMD academic honesty regulations*. Receiving and making use of such material is also a violation.

Collaboration with other students is not allowed on the formal reports. These are the midterm and final papers for PHYS 375 and each student should work individually.

Other campus policies

It is our **shared responsibility** to **know and abide by the University of Maryland's policies** that relate to all courses, which include topics like:

- **Accessibility and accommodations**: we in UMD are committed to providing appropriate accommodations for students with disabilities. Students with a documented disability should inform me within the add/drop period if academic accommodations are needed.
- **Academic integrity**: the UMD Honor Code prohibits students from cheating, fabricating information, facilitating academic dishonesty, and plagiarism in any course. Consequences of academic dishonesty are severe if caught, and, in most cases, even if not caught right away or ever.
- **Student and instructor conduct**: students are responsible for upholding UMD's standards of conduct, and we the instructors are responsible for meeting the expectations for faculty providing undergraduate courses, such as providing a complete syllabus promptly, evaluating and sharing the student's performance throughout the course, or being reasonably available.

Please visit www.ugst.umd.edu/courserelatedpolicies.html for the Office of Undergraduate Studies' full list of campus-wide policies and follow up with me if you have questions.