Course syllabus

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

PHYS 375
Spring 2021

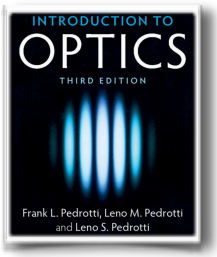
Overview

The primary objective of this course consists of learning physics through experimental investigation and becoming 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 can learn key aspects of geometrical (ray) and physical (wave) optics, polarization, interference and diffraction. You will learn how to carefully take data, analyze it, understand the origins and propagation of errors, and better appreciate the subtleties of experimental physics. You will also learn how to make useful written presentations of scientific results.

Course organization

Each section will be divided into halves (pod A and pod B) and will carry out each experiment during one lab class of 3 hours, on alternating weeks. A preparatory Lab 0.5 will be conducted the week of Feb. 8, with the class time split between the two pods. A series of videos posted on ELMS will provide the theoretical underpinnings for the experimental work. Data analysis will be done in MATLAB. The 2 pm - 2:50 pm slots on Mondays will be used as office hours to discuss the lectures, experiments, and homework (due right before these sessions).

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.

Prof. Alicia Kollar
2112, PSC Building
akollar@umd.edu

Prof. Arpita Upadhyaya
1151, PSC Building
arpitau@umd.edu

Teaching assistants
Edward Broadberry
edbroad@umd.edu
Srivatsa Tata
stata@umd.edu

Lectures
Released as videos in ELMS, discussed during office hours

Office hours
Mondays 2:00pm – 2:50pm
https://umd.zoom.us/j/92523706317
You can also contact us via email and we'll find a time that is convenient for everyone involved.

Labs (Kollar)
0101 - Mon 3:00pm - 5:50pm
0104 - Thu 3:00pm - 5:50pm
PHY #3115 (Toll bldg.)

Labs (Upadhyaya)
0102 - Tue 3:00pm - 5:50pm
0103 - Wed 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 (10%):** due biweekly (at 12 noon, the day of the lab session)
- **Lab Notebooks (40%)**: due biweekly (see schedule below)
- **Formal Lab Report (15%):** due week of Mar 1 (pod A) and Mar 8 (pod B)
- **Homework (20%)**: due biweekly, lowest score is dropped
- **Presentation (15%):** due on May 10

Pre-lab code: prior to coming to the lab, you should read through the lab manual and prepare an initial draft of all scripts that you will need for the lab. Place all your scripts in a single zipped folder. Pre-lab codes are **due by 12 noon**, the day of your laboratory session.

Lab Notebooks and Lab Report: For all labs, you will be required to submit a **notebook** containing notes taken while performing the lab, along with accompanying files detailed in the lab. The **lab notebooks** are the written record of everything you do in the lab: set up, measurements, results. They should allow you to repeat the experiment a long time from now. For one of the labs, you will need to submit a **formal lab report**. This is a formal document, modeled as a scientific research 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 report are to be submitted in .pdf files via ELMS. Please see ELMS for the exact due date of these reports. Lab Notebooks are typically due at 10 pm, 6 days after the experiment is finished (e.g. notebooks for a Monday lab section are due the following Sunday at 10 pm; except the notebook for Lab 2 which is due 13 days after the lab, to account for Spring Break; see "Schedule"). The formal Lab Report for Lab 1 is due at 10 pm, 13 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.**

Details on the grading rubrics for the notebook and files, and the formal lab report, can be found in the "Files" section of ELMS. Please read the grading rubrics carefully so you will know what is required. You may not receive a good grade if you do not check the requirements first.

Homework: Homework will be assigned on ELMS and submitted as .pdf files via ELMS. After uploading the file, **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". Homework are **due Mondays at 1 pm**, and a **penalty of 20% for all late HWs, with an additional 20% per day late** will be applied. Solutions will be posted by Friday at 1 pm, and **no homework will be accepted after that time**. Only a subset of the problems, announced after submission, will be graded. The homework grade will be a weighted average of the completion grade (40% weight) and the grade from a subset of the problems that will be graded (60% weight).

Presentation: You will make a presentation based on a paper that you will read on experimental techniques and results related to optics (you will be provided with a set of papers to choose from). A detailed rubric and instructions will be provided later on in the semester.

COVID-19 situation and policies

COVID-19 is a **very serious disease** that not only affects populations at risk. It also kills or permanently/long-term damages the organs of young and healthy individuals with a frequency yet to be measured, but possibly fairly high. The virus transmits primarily via droplets and aerosols emitted via mouth and nose while breathing, talking, coughing, or sneezing, and possibly through surfaces as well. **Droplets fall to ground** quickly and close to the emitter, so their risks are mitigated by **social distancing, masks,** and **face shields**. **Aerosols float** in the air and can accumulate in indoor places, so their risks are mitigated by **decreased person density** and **ventilation**. The virus is **transmitted most effectively by infected people** displaying symptoms, but, insidiously, it also spreads **via asymptomatic carriers**. Thus, the following measures will be in place to avoid spread during the lab sessions

- **Stay at home** and notify the instructors **if any COVID-19 symptoms are experienced** (fever, cough, new loss of taste or smell, and others).
- **Masks** covering nose, mouth, and chin **are compulsory**. Face shields are recommended.
- Maintain a **distance of at least 6 feet** apart from others without a face shield.
- To ensure social distancing and low density, **only 7 students will be allowed in the lab at a time**, so the sections will be divided into halves alphabetically by last name (**Pod A** and **Pod B**). Depending on the experiment, each half will come either in alternating weeks for 3h, or 1.5h each week. In the latter case, 10 minutes would be devoted to cleaning the set up before the next half comes into the lab. The University will thoroughly clean the labs between sessions.
- Ventilation will be maximized by leaving the **doors open** and having a fan to move the air around.

Students that do not follow these measures will not be allowed to enter the lab.

Course schedule

Note: This is a tentative schedule, and subject to change as necessary – monitor the course ELMS page for current deadlines. **Lab notebooks** are **due six days after the lab is taken**, the **night before** the next session. The **formal lab report for Lab 1 is due the night before your lab session one week later (13 days after the lab)**.

WEEK OF	LAB	POD	TOPICS	HW DUE	
Jan 25	0	A,B	ONLINE asynchronous: Introduction to MATLAB and the experimental set up		
Feb 1					
Feb 8	0.5	A,B	Optics Basics	HW #1	Mon 1pm
Feb 15	1	A	Refraction and reflection of light [REPORT #1]		
Feb 22	1	B		HW #2	Mon 1pm
Mar 1	2	A	Refraction of light through curved surfaces: Lenses		
Mar 8	2	B		HW #3	Mon 1pm
Mar 15			Spring Break		
Mar 22	3	A,B	Online data analysis lab		
Mar 29	3	A,B		HW #4	Mon 1pm
Apr 5	4	A	The polarization of light		
Apr 12	4	B		HW #5	Mon 1pm
Apr 19	5	A	Diffraction		
Apr 26	5	B		HW #6	Mon 1pm
May 3			Makeup week		

Due dates for Lab Notebooks and Lab Report:

All due at 10 pm	Pod A				Pod B			
	0101	0103	0102	0104	0101	0103	0102	0104
Notebook #0	Feb 7	Feb 8	Feb 9	Feb 10	Feb 7	Feb 8	Feb 9	Feb 10
Notebook #0.5	Feb 14	Feb 15	Feb 16	Feb 17	Feb 14	Feb 15	Feb 16	Feb 17
Notebook #1	Feb 21	Feb 22	Feb 23	Feb 24	Feb 28	Mar 1	Mar 2	Mar 3
Report #1	Feb 28	Mar 1	Mar 2	Mar 3	Mar 7	Mar 8	Mar 9	Mar 10
Notebook #2	Mar 14	Mar 15	Mar 16	Mar 17	Mar 21	Mar 22	Mar 23	Mar 24
Notebook #3	Apr 4	Apr 5	Apr 6	Apr 7	Apr 4	Apr 5	Apr 6	Apr 7
Notebook #4	Apr 11	Apr 12	Apr 13	Apr 14	Apr 18	Apr 19	Apr 20	Apr 21
Notebook #5	Apr 25	Apr 26	Apr 27	Apr 28	May 2	May 3	May 4	May 5

If you should miss a lab for any reason, contact your instructor as soon as possible to make arrangements for a makeup. Labs may be missed only for valid reasons as specified by the University rules book. 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 COVID-19 policies (stay home if sick, bring a mask, maintain social distancing).**

Lab notebooks

Keeping a meticulous, detailed record of your experiments is important in this course, and in experimental science in general. You must have a written record of everything you do in the lab; do not rely on your memory.
Your notebook grade will be based on how well you document the experiment you performed and the details of your analysis. Your notebook should show all the steps you took to perform the experiment: distances with uncertainties, step sizes, scan speeds, etc. You should describe how measurements were made, what went into the calculations you performed, computer programs you wrote and/or used, etc. You should be able to use only your notes to repeat the experiment five years from now. From your notes you will write your formal lab report. Thus, it should be possible to find the raw data used for the results you present in your reports. If your analysis relies on outside results, include references to those.

Lab report

Experiment #1 will also require a formal lab report. The goal of this report is to learn how to produce formal and clear scientific documents with proper formatting. Make sure you include appropriate captions for all tables and figures, and reference external results. A detailed rubric is available in ELMS.

The lab report should have around 8 pages (no more than 15) and include the following:

- **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, the sources of errors and relevant analysis.
    - 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.

Lectures

Slides for the lectures will be posted together with each video.

Tips for Doing Well

- Read the lab instructions carefully before you go to the lab and attempt an experiment. Make sure to complete the pre-lab assignment.
- 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 the assigned homework diligently.
- 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 and homework); the only exception are all components of the exam, which must be done individually. You are also encouraged to your TA and instructor in and out of class.

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.