

Physics 446 - Advanced Laboratory

Syllabus - Spring 2022

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Please check my webpage for the latest info.

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[**COVID-19 NOTICE:** The Spring 2022 semester is (still) taking place in the middle of a global pandemic. We have experienced our society turned upside down and inside out. In the Spring 2020 semester Truman (and everywhere else) shifted to online instruction due to the pandemic. During the Fall 2020, Spring 2021, and Fall 2021 semesters Truman managed to hold classes on campus and online in a variety of delivery formats including completely in person. We will try to do that again this semester. This class is scheduled to meet in person for the entire semester. There is a possibility that some of us will need to quarantine or isolate during the semester. I will contact you if that is the case for me. If I have to quarantine I will teach via Zoom during the quarantine. If I have to isolate it means I have the virus. What happens then depends on the severity of my reaction to it. I'll try to let you know what is going on in that case. I am fully vaccinated and boosted so there is a significantly reduced probability that I will have a severe reaction if I get covid. Please let me know if you have to quarantine or isolate so we can work out how best to keep you on track.

In terms of the number of cases and deaths, the US is worse off now than we were Spring 2020 when the pandemic began. But we have learned a lot more about the virus. We have a better understanding of how it spreads and how to minimize that spread. We just can't let our guard down. Especially now that there is a vaccine. You should already be aware of the special rules for holding classes that are in place. You will be required to wear a face covering that completely covers your nose and mouth. You will be expected to keep the covering on at all times while we are meeting. In the event you arrive to class without a face covering, I will ask you to leave until you are able to obtain one and return. Thank you for your help in containing this virus and helping to protect your peers.

If we need to pivot to online instruction again we will substitute the in person labs planned for the semester with the online labs developed by the textbook's editor and co-authors. You are, of course, free to explore those labs. Bear in mind that the course for which the textbook was developed is different from Truman's course. Not all of the textbook's labs translate to a Truman lab and vice versa.]

Now to the actual syllabus...

Syllabus Begins Here

“... in theory there is no difference between theory and practice, while in practice there is.”

-Benjamin Brewster (1892) [<https://quoteinvestigator.com/2018/04/14/theory/>]

Required Books:

- *Experimental Physics: Principles and Practice for the Laboratory* Edited by Walter Fox Smith and material on the accompanying website (email the editor for access, Prof. Walter Smith at wsmith@haverford.edu)
- A bound lab notebook. (You may use the one you used in Electronics or Intermediate Lab, if you have one.)

From the Catalog: A selection of experiments in light, heat, electricity and magnetism, and modern physics are performed at an advanced level. Reports of “near-publication quality” are written for each experiment. Proper analysis and presentation of data with its uncertainties are covered as well as software used in the acquisition and analysis of data.

Prerequisite: PHYS 196 - Physics II with a grade of “C” or higher.

Corequisite: PHYS 250 - Modern Physics I.

General Information: This may be your first formal exposure at Truman to experimental physics at an advanced level. The experiments you did in your introductory sequence are not as involved as the experiments in this course. Some of you may have taken Electronics, which is a lab class and teaches you about an area of knowledge that is very useful to the experimenter, but it does not teach you experimental *physics*. Some of the skills you develop in Electronics are useful so I hope you still have them. I will assume you learned *something* in Intermediate Lab. You may also be (or have been) exposed to experimental methods during research projects but the exposure is informal and will vary greatly from project to project. The purpose of Advanced Lab is to give you a common background in various aspects of experimental physics. Some of these aspects are:

- experimental design
- data collection, e.g. extracting a signal from noise
- data analysis with uncertainty
- expressing your results in writing, including appropriate use of diagrams and graphs
- the use of scientific software

Course Objectives: At the end of the this course the student shall be able to

- design experiments to make measurements of a variety of physical phenomena.
- keep careful and detailed notes of experiments.
- analyze data using basic statistical models.
- use a spreadsheet to analyze data.
- use Octave and/or Python to analyze data.
- write simple Labview virtual instruments (programs)
- write publishable quality scientific reports of experimental results using LaTeX.

“People who write obscurely are either unskilled in writing or up to mischief.”
-Sir Peter Medawar, “Science and Literature” in *Plato’s Republic* (1984)

This is a writing enhanced course. By the end of the course you will be expected to be able to write near-publication-quality manuscripts. Furthermore, you will be able to do it using L^AT_EX. Regardless of what you do after Truman, learning to write technical documents well will be an important outcome of this course. Judging from comments made by previous students, it is also the part that takes the most time and is the least satisfying *in the beginning*. Many students, however, are pleased, and maybe a bit surprised, by the quality of their writing at the end of the course. Please be aware, however, that good writing is a necessary but not a sufficient condition for success in this course. The quality of your experiments will be a more important factor in achieving a good grade.

This course is also designed to promote a professional attitude in you. Much of the work in this course is self-motivated. You are responsible for working without direct supervision and for meeting course deadlines. I will not explain how to do each lab it is up to you to interpret the pre-lab and perform the experiment. I will, of course, help you to understand and set up the experiment, but only after you have demonstrated due diligence in figuring it out on your own. As preparation for the working world, including graduate school, all work is due when specified. If it is late, it will cost one letter grade per day overdue including Saturday and Sunday. In addition, all labs must be turned in to pass the class. **If you fail to turn in one lab you will fail the class.** (Failing to complete a report can be grounds for termination in the working world.)

Course Structure: The course is divided into a recitation time and a lab time. The recitation time is when formal teaching will occur and probably should be called a lecture period. I will use the recitation time to explain how to use L^AT_EX, Inkscape, and other software, keeping a lab notebook, some basics on writing, etc. We will also work through the text book. There will be homework associated with the recitation, e.g. problems and skill-building labs from the textbook, example programs for analyzing or plotting data, etc. I think it is now safe to assume that everyone has taken Intermediate Lab, so we will be able to do more interesting things.

The lab period is a time reserved for you to work on your experiments and receive help from me. I encourage you to use this time to work on your experiments, but you are also encouraged to work on the experiments outside of the formally scheduled times. You are expected to leave your equipment set up during the two weeks you have to complete an experiment. You may also ask for help from me at times outside the regularly scheduled time, but be aware that I will not always be available to provide it. Also take note that I will be less inclined to ignore my other work to help you if a) you have not been working during the lab time without a good reason (e.g. interference from someone else’s experiment prevents you from working on yours) and b) it is the day before the lab is due and you are still *setting things up*. **You** are responsible for finishing the lab on time.

You will be expected to do five labs, one every two weeks or so, and work through a tutorial on LabVIEW. I will assign the labs and LabVIEW tutorial as the semester progresses.

Experiments: Each experiment has a pre-lab associated with it that describes the general idea behind the experiment and some rough experimental design considerations. You will be required to fill in the theory behind the experiment and flesh out the details of the experimental design. This process will require you to consult outside references including your textbooks from previous classes, library books, journal articles, and the internet. You must cite these references appropriately in your report. I realize the internet is a convenient source but it is not always the most reliable. Additionally, there is information that is more easily obtained from other sources. Try to use some non-internet sources. *Once you understand the theory* and have an experimental design you will then collect and analyze the data. Finally, you will interpret the data in the context of the theory. All of this will be written in two places: your lab report and your lab notebook.

Your lab report is designed to be read by someone unfamiliar with the details of your experiment. Great care must be taken to write clearly and concisely. It is a synthesis of the most relevant aspects and most relevant results of your experiment. Your lab notebook, on the other hand, is a record of all your work in the lab. It should also be clear but is less formal and not as concise. In your notebook you should write everything of importance that you do in lab: ideas for the design, rough sketches of the setup, a neat drawing of the final design, and, yes, even your data. If you take your data using a computer, you should

indicate in your lab notebook where the data is located including the computer identification, e.g. “Ima Student’s laptop”, and the file name. The results of analysis of the data should be taped, pasted, or stapled in your notebook, preferably taped. Likewise any graphs you make using your data should also go into your notebook, even if they are also in your report. In fact, almost everything in your report should have originated in your notebook. It is a good idea to get in the habit of keeping a good notebook now. To encourage this, you will turn in photocopies of your notebook pages when you turn in your lab report. The notebook pages will be graded on completeness and how well they corroborate what is in the report. Note: This does not mean that you should include every little thing from your notebook in your final report. Your lab notebook may have notes on ideas that did not work. There is no need to include such detours in the final report unless something useful can be learned from them. I will discuss these ideas in more detail in class.

Resist the temptation to start setting up your experiment before you read through and understand the theory. There is a good chance that you will only take bad data. You will then have to retake your data. One of the biggest sources of poor performance in this course is not bothering to gain a thorough understanding of the physics of the experiment. The pre-labs alone will not give you that understanding. You must read outside material.

But, do not wait too long to set up your equipment. Make sure you understand how it all works. This means understanding how each piece of equipment works and also how the different pieces of equipment interface to each other to give you the measurement you seek. You should be prepared to take rough sets of data to make sure everything is working as expected. This data will probably not be used in your report but will ensure you are not overlooking something and guide you to producing better data for the report.

Grades: You will be graded as follows:

- first two lab write-ups (6% each)
- second two lab write-ups (14% each)
- your fifth lab write-up (18%)
- your LabVIEW assignment (12%)
- the quality of your lab notebook (15%)
- homework (15%).

Attendance: I expect you to come to each recitation and the beginning of *each* lab period. After we finish any group business you are free to go about your business. I encourage you to stay and work but I recognize that may not always be possible or desirable. For example, your experiment may be sensitive to vibration and you will get better data at night, when the building is empty. Do not put off working on the lab. It will take longer than you think. Note: While you have a certain amount of freedom in allocating your time you are still obligated to be in class if I deem it necessary. Do not schedule anything else during class time.

Students with sanctioned absences will not be penalized for being absent, but will be expected to make up any missed work within a reasonable length of time. The professor reserves the right to deem additional absences as unsanctioned once a student has missed 6.67% of class time for sanctioned absences. A list of sanctioned absences can be found in the General Catalog. Sanctioned absences include serving as a representative of the University at intercollegiate athletic events, professional conferences, academic competitions, and field trips for courses, interviews for graduate school or careers, health-related absences (with documentation), and absences covered by Truman’s non-discrimination policy. For an absence to be sanctioned, students must notify the professor of scheduled absences during the free add/drop period and as soon as possible for any other absences. Students should also provide the faculty member with written notification of the absence. Arrangements for making up prior work should be made prior to the absence. If the absence is unexpected, the student should arrange to make up the missed work as soon as possible. An appeal of a faculty member’s attendance policy can be made through the University Grade Appeals process (see the General Catalog for details).

Substantive Interaction: Truman policy and federal regulations require that students demonstrate that they are academically engaged in the courses they take. You must meet this requirement within the first calendar week of the semester, beginning at 12:00 am on Monday, 10 January 2022, and ending 11:59 pm Saturday, 15 January 2022. Failure to do so, or to provide an explanation of an extenuating circumstance by that date and time will result in your removal from the course. Under certain circumstances, removal could impact your scholarship eligibility or financial aid. For the purposes of this class, establishing academic engagement requires, at a minimum, attending class and engaging in your labs.

Credit Hour Justification: The *minimum* investment of time by the average Truman student necessary to achieve the learning goals in this course are approximately one “hour” of more or less formal instruction and approximately four “hours” (240 minutes) of work in the laboratory under the instructor’s tutelage and a minimum of four hours of out-of-class student work each week for the two credit hours awarded. The outside work consists of writing lab reports, readings and problem sets from the textbook, and learning the underlying theory for the laboratory work and troubleshooting difficulties encountered doing the labs. In many ways the teaching model is similar to what is now called a “flipped” classroom. This average time per week for an average student may have weekly variations.

Students with Disabilities: I am committed to working with students with disabilities in conjunction with Truman’s Office of Disability Services to fulfill any needs of those students, in alignment with the American’s with Disabilities Act (ADA) of 1990. Please let me know early if you have special needs.

Academic Honesty: Obviously, you are to do your own work in this class. In addition, you must learn to properly cite the work of others in your lab reports. It is part of scientific writing to cite the work of authors who have preceded your work in a field and whose work directly influences your work. If you have questions about proper citation please ask me before you turn in the report. Plagiarism is using the work of others and claiming it as your own. Plagiarism will be grounds for disciplinary action that may include expulsion from school. Changing your data is scientific misconduct and will not be tolerated. I will discuss these issues in more depth during class.

Office Hours: Office hours are not the only times I am available for help. My listed office hours just indicate the times I guarantee I will be in or near my office (MG 3002) or my lab (MG 3147). I encourage you to come and ask questions when you need help. If you cannot make it during the regular office hours, then please schedule a time to meet with me. My standard weekly schedule is posted on my door and on the web. Please check the web for the latest version.

Standard University Policies

Please see the accompanying document with that title.