

SYLLABUS

Modern Physics Laboratory (Phys 1426/W1626) Spring, 2020 (1060)

Lecture: Thurs. 11-11:50 am @ 106 Allen, Lab: Thurs. 1-3:50 pm @ 318 OEH
Instructor: Vittorio Paolone

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Note: The information in this printed syllabus can also be found on the Web site maintained for this course under the CourseWeb address <http://courseweb.pitt.edu/>. This course is listed as Physics 1426 (1060 – will also include any information in regard to the writing section(1626)). Please consult this Web site regularly throughout the term for assignments, reminders, special announcements, and any future revisions of this syllabus.

Textbook:

Measurements and their uncertainties, by Ifan G. Hughes and Thomas P. A. Hase (ISBN 978–0–19–956633–4).

Scope:

This is a (2 credit) lab course normally taken by advanced physics majors; the first semester of Modern Physics (0477) and Electronics Lab (0525) are prerequisites. The subjects cover modern physics from \geq 20th century; you are expected to be familiar with the topics covered.

Objectives:

This course is designed to train students in the area of experimental physics. The course is organized so that it offers students some flexibility in selecting the projects and performing the experiments. Although the standard lab hours are from 1-4 every Thursday afternoon, students are welcome to conduct measurements in other times during the week when the laboratory is open. Students are required to do independent reading, to think about the physics behind the measurements, to analyze the data, to reach their own conclusions, and to write up a report. There is no required minimum that a student needs to accomplish for each experiment. Rather, students will be expected to demonstrate that they have researched and understood the underlying principles behind the experiments, and that they have performed meaningful experiments that probe those principles. They will also have to perform the data analysis and justify their conclusions. Some of the experimental instructions are relatively short but they could have deep implications for physics. If one just simply goes through the instructions, the experiment can be done very quickly. However, students should go beyond what is described in the instruction manual and be creative in the measurements and in the

discussion of experimental results.

Policies:

Students are expected to do 4 lab projects (3 of your choice – see experimental list, included in this syllabus) during the semester, plus the introductory project on data analysis (Numerical Methods). Two students should team up for each experiment. Students are allowed however to change partners during the semester if they are interested in different experiments. Each of the two students, at the end of every experiment, are required to submit a report. The report should be typed and submitted by e-mail either as word or a PDF document. Both students should be involved in writing the report and stand behind every word in the report. This will be tested during the presentation at the end of every experiment.

Lectures:

There will be 1 lecture per week; attendance is required. The lectures will a combination of presentations on the physics of the detectors/devices to be used during the course of the lab and possible presentations (10-15 minutes long) given by students on a completed experiment of their choice.

Lab:

Official class time is 1-4pm (lab). In practice, you should not miss lab sessions because of the work required to complete labs. The professor will generally only be available during regular class times; other students can also help with problems. However, sometimes there are conflicts with religious holidays, or other reasons that can prevent you from attending. Students who miss lab sessions have to make up for it at different times. The lab will be open Mon-Fri roughly 8am-4pm and every student is welcome to use the facilities outside class times; in fact, many students have found this additional time important. The first lab, Numerical Methods, should only take you 2 weeks to complete. The remaining 3 labs will take you 4 weeks each to complete.

Notebooks:

Each student is required to keep a lab notebook. Progress on each experiment should be documented in the notebook. You should always use pen – if you need to redo/replace an entry just cross it out - you will then have a record of what you first wrote. When each experiment is finished, a 2 page summary of findings and issues should be added. The notebook should contain all relevant steps/findings; experience will be the best guide. The goal is to write enough that a reader, e.g. the professor, can follow the key steps and understand the problems encountered along with their solution. A typical lab session should produce a few pages of notes. The report you submit at the end of each experiment should be a summary of your notes and describe your results and their interpretations.

Grade Breakdown:

Lab Reports: 80%
Presentation: 20%

Lab Reports: Each lab report counts for 20% of your total grade (4 x 20% = 80%):

10% for the lab performance
10% for the report

Regular lab reports will be graded on the basis of clarity and correctness of analysis. New ideas, extra analysis, etc. can earn bonus points. Each report should have the following sections:

- 1) Introduction: about 2 pages, which explain the physics behind the experiment.
- 2) Materials and Methods: details of all the apparatuses and materials used in the experiment. How were the measurements carried out, and how was the data analyzed.
- 3) Results: Summary of all the data acquired in the experiment and their analysis (including tables, graphs, images, etc.).
- 4) Discussion and conclusions: ~1 page summary of the main results of the experiment, and the conclusions from these results.

Presentation (20% of Grade):

Excluding the first lab (i.e. Numerical methods) you will be required to make a class presentation (10-15 minutes long) on the lab of your choice. Details of what will be required during the presentation will be presented later in the semester.

Experiment List – PHYS 1426:

Introductory – required

1. Numerical methods

Resonance Experiments (do at least one)

2. RLC circuit
3. Acoustical cavity modes
4. Acoustical gas thermometer *
5. Electron spin resonance

Quantum Mechanics origins (do at least one)

6. Single photon interference with two-slit *
7. Single photon interference with which-way (PHYS 1426) *
8. Photoelectric effect
9. Black-body radiation *

Others

10. Microwave optics
11. Fundamentals of electronic noise
12. Pulsed nuclear magnetic resonance *
13. Chaotic circuit *
14. Muon lifetime *
15. Radiation detection *
16. Ultrasound
17. RC/RL circuit and filtering
18. Mossbauer spectroscopy *
19. Scanning Tunneling Microscope *
20. Mass Spectrometer *
21. Poisson statistics with photon counting

* working in pairs most appropriate

Lab Techniques and Procedures:

In this course your own work is the emphasis. Thus, an enterprising student can go as far as he/she wishes.

- Computer analysis is an important component of many labs. The computers in Thaw 210 are available for you. You can use whatever analysis program (MATLAB, Mathematica, MathCAD, Python, ROOT) you like. My expertise is with ROOT (a product available for free from CERN: <https://root.cern.ch/>).
- The time required for each experiment should be close to 4 weeks; don't plan for slippage of more than a week because April is not far away. Depending on the circumstances, experiments can be truncated with or without penalties. You will be required to answer questions or do exercises before you can start each lab.
- Error analysis is a key part of every experiment, the best way to assess the quality of your measurement. You will be required to go through an error analysis of your results.
- For most lab periods I will be available for discussion or in my office (409 AH).
- Notebooks should always be with you during the lab, and everything you do should be recorded as you do it.

Writing option (1626):

Those of you taking this option will do more writing. You are required to prepare a more formal document for 2 of your 3 experiments (excluding Numerical Methods). You will submit a draft which will be marked up heavily so that final version will be improved. These documents must contain sections for abstract, introduction, descriptions of measurement and analysis, results, and bibliography, following the format of the American Journal of Physics, available online from the Pitt library site. These reports will be graded on style and correct journal format (references, etc.). There will be a two weeks interval between the first draft and the final draft in order to allow editorial suggestions.