Spring 2021

PHYS 450-002: Advanced Physics Lab

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Spring 2021: PHYS 450
ADVANCED PHYSICS LAB

Formal Course Catalog Entry: Introduction to electrical measurements; instrumentation; theoretical and applied electronics, solid state electronic devices, digital circuitry; computer design; experiments in modern physics.

In the advanced Physics Laboratory students will learn about physical phenomena by performing quantitative measurements of fundamental physical constants, like the speed of light and gravitational constant. Students will also gain experience with experimental techniques, such as Raman spectroscopy and x-ray diffraction, which are common in physics laboratories in academia and industry. This course focuses on solving problems, which occur in experimental measurements and offers basics of data acquisition, data analysis, data storage, and professional data presentation.

Learning Goals:
• Learn about physical phenomena by performing quantitative measurements
• Gain experience with techniques and instrumentation used in modern physics laboratories in academia and industry
• Gain experience in solving problems, which occur in experimental measurements
• Learn basics of data acquisition, data analysis, data storage, and data presentation

Materials:
• For this course you will need a lab notebook that can be handed in for a grade, and various supplies found from a hobby/craft store and a local convenient store for LAB 1.

Recommended References:
• For students taking 450, it is strongly recommended that you obtain a copy of:
- Strunk and White, "The Elements of Style", (MacMillan, New York, 1979)
- Bevington and Robinson, “Data Reduction and Error Analysis for the Physical Sciences”, 3rd Edition, (McGraw-Hill Education, 2002)

Instructor(s):
Hyomin Kim, Assistant Professor
104 Tiernan Hall, hmkim@njit.edu, https://web.njit.edu/~hmkim/
Office hour: Tuesdays 2:30 - 4:30 pm (in person or virtual), other times by appointment

Andrew Gerrard, Professor, Director; Center for Solar Terrestrial Research, Chair, Dept. of Physics
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Outline of the Course:
- OTHER THAN LAB 1, students should work in pairs or triples and divide the work between them evenly. While the data will be shared, each student will write his/her own lab report. A goal of this course is to help students enhance their ability to solve experimental problems. You should try to work out problems for yourself, but the lab instructor and teaching assistant will be glad to make suggestions when necessary.

- Students should show up in the lab during the period assigned to them and expect to spend the full three hours working on the experiment. Students who complete the course requirement before the end of the semester are encouraged to work on additional experiments for extra credit, but only during their regular lab hours. Exceptions should be discussed with staff.

- Each student must attend the lab at the beginning of each period; report to the staff if you will be leaving to do

library or computer work on that day. Occasionally there may be short lectures on computers, instrumentation, experimental techniques, etc. at the beginning of the lab class.

- Attendance on Friday at 12:30 PM is mandatory, however that "class" should only last 1 hour.

- A lab notebook is required for each student. You should record everything about your experiment in the lab notebook. When starting an experiment, you should write down a description of the experiment and appropriate references, plus any notes you take from references, etc. Include sample calculations and detailed sketches of experimental apparatus. Note relevant settings on instruments (e.g., amplifier gain, etc.).

- All data should be recorded directly into the lab book. Do not use scraps of paper for recording data. If the data are acquired using a computer, then a hard copy of the data should be pasted into the lab notebook. Staff will be checking your book periodically and at the end of the course.

- Each team will do one initial MANDATORY Experiment and then two experiments of their choice (see list of experiments). There will be a presentation of the one of the experiments at the end of the semester (see the course timetable).

- Your lab reports must be submitted on or before the deadline. The experiments will be graded by the instructor.

Possible Labs:

Cavendish Experiment
Quantum Analog Well
Quantum Analog Atom
Muon Lifetime
FT-IR experiments
Fourier analysis
Magnetic Susceptibility
Photoelectric Effect Hall Effect
THz Imaging and Spectroscopy
OTHER: Magnetometers
OTHER: Software Defined Radio (SDR) experiment
OTHER: ???

Grading:

Your final grade will be based on the total points obtained using the following schemes. Maximum values are shown in this Table. Late lab reports will be severely penalized. Careful experimental technique and Physical-Review-quality lab reports are necessary for a good grade.

Random Lab Notebook Check	20
Experimental Results	10x3
Experimental Report	10x3
Presentation	20

General Lab Rules:

- There will be no food, chewing gum, or beverages allowed in the Lab
- If equipment seems to be malfunctioning, work with the lab instructor to address the issue
- Lab manuals and equipment manuals may be signed-out for copying, but must be returned immediately
- Damaged or lost manuals should be reported for replacement
- If you break something, report it immediately
- Clean up after your lab session; leave the apparatus and work area in good condition for the next group
- Return tools, support stands, rods, brackets, etc. to proper place. If you don't know the proper place, ask
- When you need a tool from a set (e.g. set of wrenches), take the whole set, then return it whole. It is easier to locate a whole set than one missing piece

Lab Reports

- The report should be a typed, double-spaced (10 point font), Times font, in a DRAFT mode.
- While your experimental results may not be publishable, your report should be of publishable quality
- Writing style should follow that outlined in the Reviews of Modern Physics Style Guide: https://web.njit.edu/~sirenko/Phys450/style/style.pdf

(For those who prefer LaTeX, templates can be downloaded from the Physical Reviews and Physical Reviews Letters Web-pages; https://journals.aps.org/authors/web-submission-guidelines-physical-review, and any paper from these journals can be used as an example). The reports should be written in decent English, with full sentences everywhere.

- **The Lab Report should include the following sections:**

1. Introductory material, with:
    - Title of experiment
    - Author name
    - Author affiliation

2. Abstract- A short summary of the experiment and the main results. It should be a self-contained paragraph, which interprets the findings and describes their significance.

3. Introduction- 2 or 3 paragraphs with description of the point of the experiment, historical overview, and a few references to recent scientific papers on the related subject.

4. Theory- This should describe the theory and other background information relevant to your experiment, including all relevant equations and derivations where necessary.

5. Experimental Procedure- This section should by a general description of the method you have followed, and should be complete and relatively detailed. It may include schematics of the experimental setup. However, it should not be an excruciating list of every small adjustment you made. This section can be a summary of the procedures described in the various manuals you will be consulting, but it should not be a literal transcription! Just for future reference for this lab, put detailed procedures in an appendix to your paper.

6. Experimental Results- Results are reported in Tables and Figures, and the data and error analyses you have done are described. Graphs for figures should be properly generated by a visualization software (e.g., IDL, Matlab, Python, etc.). Note that Figures and Tables need to be numbered, to have captions, and to be introduced in the text (e.g. "In Figure 4 and Table 2 the measured voltage as a function of applied external magnetic field is presented."). Data in Figures and Tables should not duplicate each other.

7. Discussion- This is where you bring it all together. You can restate your salient final results. You can comment on sources of error, difficulties encountered, and suggest ways to improve the measurements in the future.

8. Conclusions- Should not repeat the Abstract

9. References- Follow the APS style when citing references

- Please proofread your reports thoroughly and check your calculations carefully before handing them in. Where appropriate (but only where appropriate), perform fits to your data and report the fit parameters with errors. Be as quantitative as possible in your analysis and discussion. Please read what you write.

Class Schedule for Spring 2021

WEEK	ACTIVITY
Week 1 (Jan 17):	PASS
Week 2 (Jan 24) : Introduction and Settling In	Review of Syllabus, **START LAB 1**
Week 3 (Jan 31):	Lab Reports, Papers, Figures, LaTeX
Week 4 (Feb 7):	Research Funding: Where does the money come from? **START LAB 2**
Week 5 (Feb 14):	**LAB 1 DUE**
Week 6 (Feb 21):	**LAB 1 FEEDBACK SESSION**
Week 7 (Feb 28):	
Week 8 (Mar 7):	**LAB 2 DUE** **START LAB 3**
Week X (Mar 14):	**Spring Break**
Week 9 (Mar 21):	**LAB 2 FEEDBACK SESSION**
Week 10 (Mar 28):	No Friday Classes at NJIT due to Good Friday
Week 11 (Apr 4):	Scientific Presentations 101
Week 12 (Apr 11):	
Week 13 (Apr 18):	**LAB 3 DUE**
Week 14 (Apr 25):	**PRESENTATIONS**
Week 15 (May 2)	Friday classes at NJIT run on Tuesday (May 6)