Phys 450 - Spring 2017 Advanced Physics Laboratory

Physics 450 Course Syllabus:

Prerequisites: Phys 234
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.

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## 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 with numbered pages

## Recommended textbooks:

• For students taking 450, it is strongly recommended that you obtain a copy of J. Schall, "Style for Students: Effective Writing in Science and Engineering".
• Optional: D. W. Preston and E. R. Dietz, "The Art of Experimental Physics", (John Wiley and Sons, New York, 1991)
• An excellent book is by W. Strunk and E. B. White, "The Elements of Style", (MacMillan, New York, 1979).
• Also consult the Physical Review Style and Notation Guide at http://publish.aps.org/STYLE/
a copy is available in the labs.

## Outline of the course:

• Students should work in pairs (if possible) 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.

• A lab notebook is required for each group of students. You should record everything about your experiment in the lab notebook. When starting the 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 three experiments (see list of experiments). There will be a presentation of the one of the experiment at the end of the semester (see the course timetable).

• Your lab reports for the experiments will be graded by the instructor

## 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.

## Rules:

• There will be no food or beverages allowed in the Lab.
• If equipment seems to be malfunctioning, see the lab instructor or teaching assistant.
You are not permitted to repair electrical equipment yourself.
• If you have to move the equipment, make sure it is unplugged.
• Lab manuals and equipment manuals may be signed-out for copying, but must be returned immediately. Ask the staff for instrument manuals.
• Damaged or lost manuals should be reported to the staff for replacement.
• If you break something, report it to the lab instructor immediately so that it may be fixed or replaced. Do not try to fix it yourself without reporting it. If you break equipment while doing something less than brilliant, do not be embarrassed to report it. You will not lose points if you break something, but you will be in big trouble if you do not report it. Reporting problems so that they can be corrected will gain you psychological points with the staff.
• 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.
• Do not use sticky tape, glue, aluminum foil, *etc*. in experiments; it never works. Use a proper, professional-level method; ask the lab instructor if you want to find the proper method.

## Lab Reports:

• The report should be typed double-spaced (12 point font), and should be about 6 - 10 pages long (excluding figures).
• While your experimental results may not be publishable, your report should be of publishable quality.
• Writing style should follow that outlined in "Style for students (and Others)" by J. Schall, or the American Physical Society (APS) standard outlined in

http://www.aip.org/pubservs/style/4thed/toc.html
and/or
Reviews of Modern Physics Style Guide

(for those who prefer LaTeX, templates can be downloaded from the Physical Reviews and Physical Reviews Letters Web-pages; any paper from these journals can be used as an example). The reports should be written in decent English, with full sentences everywhere. Although you are not writing a literary essay, you are not writing a recipe either. Be wary of typos (they will be penalized increasingly harshly as the term progresses).

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

1. Title page with
   - Title of experiment
   - Author name
   - Date submitted
2. Abstract
   with a short summary of the main results. It should be a self-contained paragraph, which interprets the findings and describes their significance. The length is about 5-10 lines.
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. References can be obtained by literature search at http://www.library.njit.edu/
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
   In this section, results are reported in Tables and Figures, and the data and error analyses you have done are described. 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 and be advised that the following will result in lost points:

- Not following Lab Report requirements (listed above)
- Typographical errors
- Figures or tables without captions
- Plots or tables without error bars
- Misreported numbers of significant figures in any x±d x (see Error Reporting)
- Miscalculated errors
- Missing or faulty units
- Egregiously bad English writing
- Undefined parameters used in equations
- Reports handed in late will be severely penalized

Class Calendar:

**Experiments and Class Organization:** List of Experiments: (zipped file)

| Teams 1st experiment Start on ~Jan 30th | Teams 2nd experiment Start on ~Feb 27th | Teams 3rd experiment Start on ~April 2nd | Experiment | |
|---|---|---|---|---|
| | | | Cavendish Experiment | Basement B11 or B4 |
| | | | Muon Lifetime | OPSE Lab |
| | | | Quantum Analog Well<br>Quantum Analog Atom | OPSE Lab |
| | | | Speed of Light | OPSE Lab |
| | | | FT-IR experiments | Basement B4 |
| | | | Fourier analysis | OPSE Lab |
| | | | Magnetic Susceptibility | OPSE Lab |
| | | | Error Reporting | |

General References:


• D. W. Preston and E. R. Dietz, "The Art of Experimental Physics", (John Wiley and Sons, New York, 1991)
• P. Horowitz and W. Hill, "The Art of Electronics", (Cambridge University Press, Cambridge, 1984)
• W. H. Press, B. P. Flannery, S. A. Teukolsky and W. T. Vetterling, "Numerical Recipes.The Art of Scientific Computing", (Cambridge University Press, Cambridge, 1992)
• A.C. Melissinos, "Experiments in Modern Physics", (Academic, New York, 1966)
• R. A. Dunlap, "Experimental Physics. Modern Methods" (New York 1988)
• J. Schall, "Style for Students: Effective Writing in Science and Engineering", (Burgess, Edina, MN, 1995)
• W. Strunk and E. B. White, "The Elements of Style", (MacMillan, New York, 1979)
• R. C. Richardson and E. N. Smith, "Experimental Techniques in Condensed Matter Physics at Low Temperatures", (Addison-Wesley, New York, 1988)


**Useful Links**

NIST: Fundamental Physical Constants
Dictionary of Units
NIST: Uncertainty of Measurement Results
Unit Converter
Periodic Table
X-ray Diffraction Calculator
http://www.metric-conversions.org/


*This page was created by Andrei Sirenko, NJIT, 2005*
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