Physics 3461 Laboratory Modern Physics

Fall 2019

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Office Hours: MTWF 9a-9:30a; MWF 9:30a-11a; WR 1:30p-2p, and by appointment

The laboratory activities are listed below. Students will work in groups of two to complete all activities during the semester. A rotating schedule for each group will be posted on blackboard after the semester starts.

**Lab Activities:**
1. The Millikan oil drop experiment to measure the value of $e$.
2. Measurement of $e/m$ of the electron.
3. Wave diffraction of the electron to determine the DeBroglie wavelength of the electron.
4. Optical line spectra measurements with a diffraction spectrometer to determine the Rydberg constant.
5. The photoelectric effect to determine Planck's constant, $h$.
6. The Franck Hertz experiment to measure atomic energy levels.
7. Measure the half-life of Ba-137 to demonstrate nuclear decay.

**Laboratory Procedures:**

(1) **GENERAL INFORMATION:**

Experiments must be performed during supervised laboratory sessions, which are provided on Wednesdays, from 2-5 p.m. when the professor will be available. You may visit the laboratory any day of the week, including mornings and days when no supervised sessions are scheduled to freely utilize the laboratory reference material and the computer facilities. See the instructor to have the laboratory opened.

Students are to work in teams two, with an independent and complete notebook produced by each. Tables of data and plots may be photocopied, but all narrative material, calculations, and analysis must be performed independently. Consult freely with your partner (or anyone else) in analyzing your data, but do not simply copy another person's results.

Descriptions for each experiment are provided in the lab. Most of these descriptions have been recently revised to reflect the current state of the experiments. While informative, these descriptions do not contain all of the information you will need. It is vital that you study other references for each topic.

(2) **REQUIREMENTS:**

You and your partner will have at least one session of 3 hours in the Laboratory each week in order to complete the data collection for each required activity. All experimental work must be performed only during supervised hours when teaching staff is available. After completion of an experiment at the bench, you should devote sufficient time to completion of the notebook entries, consulting with the professor.

Most of the experiments have limited directions. You will be responsible for reviewing additional materials as needed including appropriate portions of the textbook. The labs will not be synchronized with the lectures so it will be necessary for you to assume responsibility for obtaining relevant background material for each laboratory.
A laboratory notebook is a record (a journal) of your activities in the laboratory. The entries should contain enough information and narrative to allow anyone with a background in either theoretical or experimental physics to understand the goal of the experiment, the experimental methods used, and the results obtained. This means logging and acknowledging errors as well as correct procedures. It should be possible for the reader to successfully reproduce the experiment from only the material that has been entered in the notebook. All entries must be dated and permanent (WRITTEN IN INK). Any deletions should be made with a single line striking through the deleted entries. Each partner will keep an independent notebook. Photocopies of spreadsheets, graphs, etc. are acceptable. Consult with the instructor about copying facilities available through the laboratory.

EVERY LABORATORY NOTEBOOK SHOULD CONTAIN AT LEAST THE FOLLOWING:

Ask the general question when considering what to write in the notebook, "If I pick up this notebook in a year or two, is there enough information in it for me to reproduce the experiment and understand the results?"

1. The first entry MUST be a detailed TABLE OF CONTENTS containing the experiment title, dates of activity and completion, partner’s name, page numbers, and any other entries that you feel will be useful to the reader (and yourself at a later date). Leave several pages blank at the beginning of the notebook for this.

2. Write the date, partner, page number, and initial in the upper right corner of each page.

3. State a general purpose for the experiment in two or three sentences. Throughout the experiment indicate the purpose of each new set of measurements.

4. Sketch the apparatus, free hand, but with the parts labeled. Clearly indicate any measured values with symbols to match data tables and where on the apparatus measurements were taken.

5. Include a brief description of the actual procedures followed in the laboratory, including vital parameters such as instrument used, settings, distances, times, temperatures, etc. THIS INFORMATION SHOULD BE WRITTEN INTO THE NOTEBOOK WHILE THE EXPERIMENT IS BEING PERFORMED, NOT AT SOME LATER TIME. DO NOT SIMPLY COPY THE HANDOUT. Each page is to be dated and signed.

6. All raw data, with the exception of computer acquired files, should be entered in clearly labeled tables, with realistic estimates of all of the uncertainties from all sources of random and systematic errors. The exception of computer file listing is one of convenience and clarity since, of course, error analysis is expected for all data regardless of how it was obtained. An estimate of uncertainties is an integral part of all data. Cross out any data that appears useless or wrong, but do not erase them. Include a brief note and initials for any cross-outs.

7. Show the "ball park" calculations used to immediately test the validity of data. Always perform these before altering a setup, or leaving the lab. Describe all of these preliminary calculations clearly.

8. Tables of results should be clearly labeled and set off for the convenience of the reader, supplemented by graphs of data where appropriate. Graphs should have titles and captions, labels on the axes (with units), with all interesting features identified. Provide detailed descriptions of all calculations performed. Use of computer generated graphs using Excel, etc. is encouraged.

9. A brief discussion of your results, with a comparison with theory and previously published experimental values is essential, i.e., a "Conclusion". Tell briefly what you did and how it came out. If you find inadequacies, or errors, in the experiment, or descriptions, discuss them constructively. Suggestions for improving existing experiments or proposals for new ones are eagerly solicited.
Some extra pages should be left after the experiment for subsequent notes, etc.

(4) GRADING PROCEDURES:

An experiment is successfully completed if you can demonstrate a thorough understanding of the physics and have familiarity with the apparatus. Grades are recorded based 70% on the NOTEBOOK, and 30% on polished reports. These other report types include A PHYS REV. LETTER format report, A SCIENTIFIC POSTER, and a 10 minute group PRESENTATION.

1. NOTEBOOK: Entries for the experiment, organized to present a brief introduction, experimental procedures and data produced, analysis of the data, and conclusions (as outlined in the previous section on NOTEBOOKS) should be completed for presentation to the Instructor. These notebook entries will be graded. You will have two notebooks and alternate between them in completing the labs. These notebook entries must be submitted within one (1) week from the conclusion of the experiment. All NOTEBOOKS must be turned in by the lab period during dead week. Failure to meet this schedule will result in a reduction of the notebook grade by one letter grade per day late. The notebook grade reflects the pre-lab preparation and performance in the laboratory, the validity of experimental procedures, and the quality and completeness of notebook entries. Grades will be available from your Instructor expeditiously after the End-Of-Experiment notebook grading.

You may revise, or supplement, any (or all) notebook entries (and are encouraged to do so in another color ink) before submitting the notebook for its final grading at the end of the experiment. Be sure that all revisions are dated and clearly labeled as such.

2. POSTER, PHYS. REV. LET., PRESENTATION

The contents of each media are to reflect the learning that you have achieved and are formal descriptions of the experiment you have performed. Although the experimental work is done with a laboratory partner (or partners), each person is expected to write his or her own report of the experimental work. One purpose of such formal reports is to emphasize the importance of the process of communicating your experimental results to other people. It is just as important to be able to communicate the results as to obtain the results in the first place.

The reports will be graded on form, grammar, punctuation, and spelling as well as its scientific content. The report should have a neat, well-organized style and be written in good, standard English. It is generally accepted practice to use passive voice in scientific reports. For example, instead of writing "we passed a proton beam through a gas target", one should write instead “a proton beam was passed through a gas target.” Please pay attention to always writing in the passive voice. It is expected that the reports will reflect work of a quality commensurate with a junior level course. The lab reports are a formal presentation of the information contained in your notebook. If the notebook is done well then the report is not a difficult task.