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Reference information

Instructor: Prof. Britton Plourde, bplourde<at>syr.edu.
Office: 219 Physics Bldg., 315-443-8967. Contact by email to make an appointment for any necessary
discussions outside of the usual class meeting times.

Graduate assistant: Francis Toriello, 3-5995, fetoriel<at>syr.edu
Jiahan Zhang, jzhang31<at>syr.edu.


Final examination: none.
Credits: 4. Prerequisites: 2 semesters of calculus-based elementary physics with laboratory (PHY 211/221 & 212/222 at Syracuse University) and PHY344.

Blackboard: Required course information can be accessed at http://blackboard.syr.edu/.

Notebook: You are required to purchase a laboratory notebook similar to National Brand 43-648, which is presently available at the Syracuse University bookstore. The key element is that the notebook be permanently bound (no spiral-bound notebooks), and that the pages be sequentially numbered. Entries in a laboratory notebook are never erased or deleted; pages should never be torn out. Your instructors prefer quadrille ruled notebooks so you can make rough graphs easily by hand.

Textbook: John R. Taylor, An Introduction to Error Analysis, Second Edition (University Science Books, 1997), which is available at the bookstore. A copy is available in the laboratory. There is homework based on this book.

Learning outcomes
The general learning outcomes expected from this course are similar to those for the first course on Experimental Physics, PHY344, but you will work on experiments that give you more options and you will have less guidance from the manuals and instructors.

Here is the present listing of learning outcomes from Experimental Physics I: in this course you will perform several experiments in different areas of physics. In addition to studying the underlying physics for each measurement, you will learn fundamental experimental techniques and how to record and report your results and analysis. These skills are crucial for anyone who would like to investigate our natural world! All students completing this course should be able to

1. set up advanced equipment, using the necessary resources (manuals, etc.),
2. troubleshoot and solve equipment setup problems,
3. acquire and analyze data in the manner best addressing an experimental question,
4. take accurate notes of their actions and observations during an experiment,
5. estimate and propagate uncertainties associated with laboratory measurements in order to draw accurate conclusions,
6. manage their time and work constructively with others,
7. write scientific reports and make oral presentations with appropriate display of data and analysis leading to conclusions.

Assignments & grading
1. 70% for four assigned experiments. Your grade for each experiment is based on the chronological notebook record you keep. The procedures are described separately.
2. 10%: Error analysis experiment (grade based on notebook entries) and homework assignment.
3. 10%: Two formal laboratory reports based on any two of the four experiments that you were assigned.
4. 10%: attendance – no student is expected to attend all 9 hours of class each week, but you must be working in the lab for 50% of the class time each week, as monitored by the sign-up sheets.
Unexcused late work will be accepted, but only up until the next deadline in the calendar (for example, submitting Notebook 2 on the due date for Notebook 3) and you will lose one grade as a penalty (A becomes B, etc.). No unexcused late work will be accepted after the last day of class (April 27).

**Calendar**

Each student will do four projects this semester, each involving a different experiment. Generally you will work alone, although you are free to discuss the experiments with other students in the class. The schedule assigning students to experiments for each project will be posted separately.

<table>
<thead>
<tr>
<th>Week</th>
<th>Project</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/20</td>
<td>1/error</td>
<td>1/20 is the first day of class</td>
</tr>
<tr>
<td>1/25</td>
<td>1/error</td>
<td>Homework due Friday, 1/29.</td>
</tr>
<tr>
<td>2/1</td>
<td>1/error</td>
<td></td>
</tr>
<tr>
<td>2/8</td>
<td>1/error</td>
<td></td>
</tr>
<tr>
<td>2/15</td>
<td>1/2/error</td>
<td>Notebook due 2/17; both Lab 1 and the Error Lab are due.</td>
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<tr>
<td>2/22</td>
<td>2</td>
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<tr>
<td>2/29</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3/7</td>
<td>2</td>
<td>Notebook (Lab 2) due 3/11.</td>
</tr>
<tr>
<td>3/14</td>
<td>2</td>
<td>Spring Break – lab closed</td>
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<tr>
<td>3/28</td>
<td>3</td>
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<tr>
<td>4/4</td>
<td>3</td>
<td>Notebook (Lab 3) due 4/8.</td>
</tr>
<tr>
<td>4/11</td>
<td>4</td>
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<tr>
<td>4/18</td>
<td>4</td>
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<td>4/25</td>
<td>4</td>
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<tr>
<td>5/2</td>
<td>4</td>
<td>Last day of class is Monday, 5/2. Notebook (Lab 4) and formal lab report (#2) due 5/2.</td>
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</table>

**The experiments**

You will work on the following four experiments:

- Nuclear magnetic resonance
- Modern interferometry
- Single-photon two-slit interference
- Diode laser spectroscopy

In addition, there is a “Random Errors” experiment that all students will do at the beginning of the semester.

The instructions for these experiments are posted in Blackboard under the Experiments tab.
Lab safety

The first priority for laboratory work is safety, both for you and for others using the laboratory. Any laboratory has some dangers; our laboratory is safe, but it is not fool-proof. It is possible to receive an electrical shock. Ultraviolet lamps can cause sunburn. Heavy objects can be dropped.

The most reliable safety device in the laboratory is your understanding of the apparatus.

- **Read** the various manuals and references in the lab until you understand whether or not the equipment has any risks.
- **Ask** the graduate assistant or instructor about apparatus before your turn it on. Do not turn on equipment until your wiring and other setup has been checked. This rule protects both the equipment and you.
- **Describe** any safety issues in your notebook, including the precautions for preventing an accident.

Also, do not work on live experiments if you are alone in the laboratory. If an accident occurs, there needs to be someone to get help.

Lab etiquette

- In wet laboratories, eating and drinking aren’t allowed at all for safety reasons. We discourage it in this laboratory because of the damage that a spilled drink can cause to some of the equipment. If you bring a drink into the lab, please make sure it cannot be spilled onto the apparatus, even by someone else.
- Please do not text or use the cell phone while you’re working on an experiment.
- When you are finished with an experiment, please restore it to its original condition (or better).

Lab partners

On most of the experiments, you will work alone, although you are free to discuss the experiments with other students in the class.
Additional information and notices

Academic integrity

Syracuse University’s Academic Integrity Policy holds students accountable for the integrity of the work they submit. Students should be familiar with the policy and know that it is their responsibility to learn about course-specific expectations, as well as about university policy. The university policy governs appropriate citation and use of sources, the integrity of work submitted in exams and assignments, and the veracity of signatures on attendance sheets and other verification of participation in class activities. The policy also prohibits students from submitting the same written work in more than one class without receiving written authorization in advance from both instructors. The presumptive penalty for a first offense by an undergraduate student is course failure, accompanied by a transcript notation indicating that the failure resulted from a violation of Academic Integrity Policy. The standard sanction for a first offense by a graduate student is suspension or expulsion.

For more information and the complete policy, see http://academicintegrity.syr.edu/academic-integrity-policy/

As with any assignment, your work must be original. Any sources (even online resources) that you quote or paraphrase in your reports, presentations, or lab notebooks, must be properly cited.

Disability-Related Accommodations

If you believe that you need accommodations for a disability, please contact the Office of Disability Services (ODS), http://disabilityservices.syr.edu, located in Room 309 of 804 University Avenue, or call (315) 443-4498, TDD: (315) 443-1371 for an appointment to discuss your needs and the process for requesting accommodations. ODS is responsible for coordinating disability-related accommodations and will issue students with documented Disabilities Accommodation Authorization Letters, as appropriate. Since accommodations may require early planning and generally are not provided retroactively, please contact ODS as soon as possible.

Religious Observances Policy

SU religious observances policy, found at http://supolicies.syr.edu/emp_ben/religious_observance.htm, recognizes the diversity of faiths represented among the campus community and protects the rights of students, faculty, and staff to observe religious holidays according to their tradition. Under the policy, students are provided an opportunity to make up any examination, study, or work requirements that may be missed due to a religious observance provided they notify their instructors before the end of the second week of classes. For fall and spring semesters, an online notification process is available through MySlice/StudentServices/Enrollment/MyReligiousObservances from the first day of class until the end of the second week of class.

Religious observance is an acceptable reason for handing in homework or other assignments late; please just indicate this when you turn in the assignment. If there is a conflict between your presentation date and a religious holiday, please contact the instructor directly.
Procedures for Physics Experiments

Your work in this course needs to be recorded in a laboratory notebook. Such a book is used by all experimental scientists. It is where grand concepts and minute details of experiments are written down. You should think of your notebook as a guide for another scientist to understand how you performed your experiment and interpreted the results that you obtained, with sufficient detail so that he/she could repeat your measurements and obtain the same results. A sample set of notebook pages has been posted to Blackboard; the experiment measured the volume change of water when it freezes.

Your notebook entries will describe four aspects of each experiment:

1. The design of the experiment
2. Testing of the experimental apparatus
3. The detailed measurements you perform with the apparatus
4. Analysis of the measurements and discussion of them

1. Experimental Design

You are not responsible for the basic experimental design and apparatus for most of the experiments you will perform; however, you are responsible for completely understanding this design and documenting your understanding.

1. Please include enough diagrams, notes and references to explain the apparatus and its use. Sketches of different aspects of your experiment with some well-chosen labels are extremely helpful.
2. Major components of the apparatus such as power supplies or measuring instruments should be clearly identified.
3. If there are any safety issues, it is important that you describe the issue and discuss how to manage it.
4. If calculations are required for the experiment these should be done here.
5. You may use printouts from manuals, books, etc. to illustrate the design. Just tape these in your notebook, and annotate to indicate the source, etc..

2. Testing of Apparatus

It is possible to destroy many instruments by improper connections between components or improper settings of the apparatus. Carefully record the initial arrangements you have made before starting any experiments, explaining how you determined them. Have a staff member sign off before you turn on the power of any equipment.

1. You should include a log of the procedures you use to verify that the apparatus is functioning.
2. Include a log of any calibration measurements you performed.
3. You may wish to include notes about any problems you encounter or about proposed improvements to the apparatus.

3. Measurement Log

Having verified that the apparatus is functioning properly, you will normally perform a series of measurements. These should be carefully recorded.
1. Use tables to record your measurements whenever possible. Always record the actual values you measure, not calculations based upon them.

2. You should occasionally check that measurements you performed early can be produced later on, as the apparatus or specimen may change during the measurement. In addition, by repeating a measurement you will gain an indication of the errors involved.

3. Be careful to specify the uncertainty for any measurement you make and include a brief explanation of how you estimate the uncertainty.

4. Prepare rough graphs of the results of your measurements as you are taking them; measurements very often give unexpected or unreliable results which only become obvious when they are graphed. Graph printouts from a computer can be taped into your notebook.

5. Include notes and diagrams to illustrate any unexpected occurrences or accidents during the measurement.

6. Record computer filenames, etc., as needed.

4. Analysis and discussion
When you think that a set of measurements is finished, you will normally “turn off” the apparatus and do further analysis of your results. This analysis may include “data reduction” (i.e. calculations based on the measurements), error estimates and comparison with theoretical predictions. In the analysis section of your write up you should include:

1. Calculational procedures: formulae, computer programs, etc.
2. Numerical results of calculations.
3. Calculation of uncertainties in final quantities.
4. Graphs of the calculations.
5. Discussion of the results.
6. Discussion of any possible sources of systematic error and methods to reduce them in a future experiment.

More notebook notes
Entries in your notebook should be dated and in some cases the hour should be noted as well.

Do not erase early entries in a notebook, nor remove the pages. You can annotate your earlier entries to indicate later work that affects their interpretation. Note that lab notebooks are often used in industry as legal evidence. Any tampering or editing of a lab notebook is a problem.

Save a page or two at the front of the notebook for a Table of Contents or other general notes that aren’t associated with a particular experiment.

Students often make the error of thinking their notebook should contain only polished material since it is to be turned in for grading. Rather, your lab notebook should include all your notes and observations on your experiments – it is a detailed diary to allow you or others to recreate everything you did. Try to keep it orderly and neat, but it must by nature be the first (and only) draft recording your work.