PHYS 0520 Syllabus (Fall 2015)

September 16, 2015

Introduction

Instructors

Lectures are not the primary component of this course. The instructor:

Prof. Brian D'Urso
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will help conduct the experiments and provide advice on analysis. When appropriate, occasional lectures will be given. Guidance in the lab will also be provided by:

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who is in charge of equipment for this lab. He is responsible for all advanced teaching labs in the department of Physics and Astronomy.

Scope

This is a lab course normally taken by sophomore honors students in either physics or engineering physics programs. It carries 3 credits. The subjects both look back to topics from the introductory physics sequence and look forward to courses taken later in the undergraduate experience.

Skills

The only prerequisite is the introductory physics sequence, either 0174-0175 (calculus based) or 0475-0476 (honors). Previous 'experimental' experience of many types is useful. The main purpose of the course is to get you thinking like a physicist in the lab.

Textbook

There is unfortunately no complete textbook for all the material in this course, but we require the following text for data analysis:

- Measurements and their Uncertainties, Ifan G. Hughes and Thomas P. A. Hase

The instructor can give advice on background material at the appropriate level for many topics. The handouts (all in CourseWeb) are mostly self-contained but definitely not complete. Some reading from other sources will be required.

Attendance

Official class time is Tuesday and Thursday, 1:00-3:50 p.m. Like all college classes, the assumption is that the student has the maturity to decide about attendance. In practice, it is dangerous to miss lab sessions because of the work required to complete labs. The instructor will generally only be available during regular class times; other students can also help with problems. Sometimes, there are conflicts with religious holidays; in the past, these students have to make extra effort but it always worked out. The lab will be open Mon-Fri roughly 8:30 a.m.-5:00 p.m. and every student is welcome to use the facilities outside class times; in fact, many students have found this time important to keep up the pace required.

Grades

Your grade for the course will be based on the work on the experiments (80%) and on the final paper (20%). Each experiment will provide a grade based on the notebook. The course is small and the emphasis is on your work, so the instructor will know each student well. Approximately 7 labs (2 required, 5 optional) will be required for the course. There will be no exams.

Writing Option

This course can be used to satisfy your Writing Option requirement. Since you already have to do some writing for the course, this is a good option. That course requires 3 formal documents. They will be significantly expanded versions of your notebook. This course has a separate lecture; the first lecture will be TBD.

Surveys

With your help, I am hoping to improve this course and the available experiments. For that purpose, I will give you a survey at the beginning and end of the course, as well as a few questions to answer with each lab experiment. Please answer the surveys thoughtfully, as your feedback will help improve the course.

Lab Experiments

This course is unusual because lectures are secondary and your own work is the emphasis. Thus, an enterprising student can go as far as he/she wishes.

Students choose experiments with advice of the instructor as requested. All experiments beyond the 2 required must be approved in advance by the instructor. That way, the equipment will be ready. For some experiments, you will need to choose a partner. For those experiments, you will have to agree on experiments you do together. You must submit an ordered list of 7 experiments you would like to complete, including the name of a partner when recommended, by the end of the second week of classes. We will return a tentative schedule of your labs to you by the end of the third week of classes. Keep in mind that you schedule may have to be modified as the semester progresses due to equipment problems, scheduling changes, etc.

The time required for each experiment is not fixed; the instructor will help you make choices to finish advantageously. The balance will be between finishing in reasonable time and a deep enough understanding of the material. Any experiment taking more than 2 weeks can be a problem.

The quality of the equipment and the lab manual varies considerably. Weve been recently adding 2 new experiments per year, so improvement is always under way. The instructor is always available during class period for discussion. Sometimes, you will be learning about a new experiment with less than perfect lab manual. Your notes will then contribute to the upcoming version of the lab manual.

Notebooks

Notebooks (2 of them) are required. Typically, you will be writing in one notebook while a lab report in the other the other is being graded. Progress on each experiment is documented in the notebook. You bring the notebook every day to class and regularly write down your measurements and comments. The comments include thoughts on how the measurement is done and what it means. The goal is to write enough that a reader, e.g. the instructor, 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.

Lab Reports

Lab reports can be completed in your lab notebook, which will be turned in after each experiment. If you prefer, you may type up your report and include it in your lab notebook, but all your notes and results while running the experiment must be recorded directly in your lab notebook. Your lab reports must contain the following sections; incomplete notebooks will be returned for improvement.

A. In-Class: These are typically completed directly in your notebook during class time. The order of these is not important.

   1. Diagrams: Every distinct part of the experiment must have a good quality diagram of the apparatus; it is best to make this picture at the beginning to help you understand the pieces then again at the end when you need to explain what you really did. Make sure everything is labeled. You may copy diagrams from the lab handouts if they accurately reflect the setup you used.
   2. Procedure: A description of the steps that you followed. This may be copied directly from the lab write-up, but you may find you need to add extra steps or make changes to solve problems you encounter.
   3. Results: Report your data with uncertainties.
   4. Data Analysis: Show data in plots with error bars, axis labels, and legends. Include fits to model functions, fit parameters (with uncertainties), and final results. You should attempt to propagate and report uncertainties in every result you report. You are encouraged to complete as much of the data analysis as you can during class time, since you may find that you want to take more data.

B. Summary (1-2 pages): Give an overview of the purpose of the experiment, what you did, your results, and your conclusions. Your conclusions should be supported by the data and uncertainties in your results.

C. Survey Questions: Write an approximately one paragraph response to each of the following questions:

   1. What about the lab experiment did you find most useful for your learning?
   2. What aspects of the lab experiment were most challenging?
   3. What about the lab experiment could be improved?

Final Papers

The paper will be based on a Nobel Prize physics experiment. You will describe their work in a short paper which emphasizes the measurement and physics aspects of the topic studied. It should have an introduction and a conclusion with some theoretical discussion. This paper is due December 11 (last day of classes), the only formal due date in the course.

Examples from past papers include Cerenkov, CP violation, Cosmic background radiation, neutrino properties (many), discovery of the neutron or antiproton. My field of research is condensed matter and atomic physics, so I would tend to steer you towards those areas. Here is good web site where they have the talk each Nobel prize winner gave and often some reference material:

`http://www.nobelprize.org`

Since it's a little annoying to negotiate, here's a specific example of what you can get - a copy of the speech of Georges Charpak and other resources.

`http://www.nobelprize.org/nobel_prizes/physics/laureates/1992/`

There is almost always the acceptance speech and a biography. Some of the speeches have footnotes to other resources. Sometimes, there is also an "other resources" link for that scientist.

Some have asked a good question about eras. Modern experiments tend to be too complicated for this course. Early experiments tend to be simpler and have interesting concepts; sometimes, results are too narrow and simple for our modern tastes. e.g Franck-Hertz is fairly simple so needs to have other material drawn in. Someone did it once and wrote a fine paper. The period from roughly 1940-70 seems to have interesting subjects that you can understand.

The required length is 5-6 single spaced or 10-12 double spaced pages. I consider that a minimum, so don't make a large effort to make it shorter unless it is also an effort to also make it clearer. Diagrams and figures almost always improve your discussion, so please include them if you see an advantage. Need for text is independent of figures; therefore, my guidance of page count does not include figures.

A possibility for organization:

- Why did they do the experiment (not always for the result that earned a Nobel Prize)?
- Difficulties they had getting experiment built and working
- Calibration - how were they sure the effect was real?
- The signal
- Convincing the world it was right
- Impact on our view of the world

You must provide a bibliography of materials you used in your study. Quotes in the paper should also be included in the bibliography. Giving proper credit to sources is important, but it's a tough balance between clarity and completeness. If it's a widely held thought, e.g. that the earth is round then you don't need to reference it. However, a novel idea or opinion such as how neutrino oscillations in the sun affect what we see on earth should be referenced. If in doubt, it is better to reference than not. I am happy to answer questions.

Experiment List

The first 2 experiments are Test Measurements and Numerical Methods; each is required for all students. Handouts for all experiments are in CourseWeb.

Introductory - required

1. Test Measurements
2. Numerical Methods

Resonance Experiments (do at least 1)

3. RLC Circuit
4. Acoustical Cavity Modes
5. Acoustical Gas Thermometer *
6. Electron Spin Resonance (ESR)

Quantum Mechanics Origins (do at least 1)

7. Single Photon Interference *
8. Electron Diffraction
9. Photoelectric Effect
10. Black-Body Radiation *

Others

11. Microwave Optics
12. Bandwidth Measurement with Electrical Noise
13. Nuclear Magnetic Resonance (NMR) *
14. Chaotic Circuit *
15. Muon Lifetime *
16. Radiation Detection *
17. Scanning Tunneling Microscope (STM) *
18. Mössbauer Spectroscopy
19. Ultrasound

* working in pairs most appropriate