1-2014

# PHSX 444.01: Advanced Physics Lab

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# PHSX 444: Advanced Physics Lab

University of Montana
Spring, 2014
Lecture, M 3:10 PM – 5:00 PM, CHCB 012
Labs, TR 1:10 PM – 4:30 PM, CHCB 002
Website: Course materials and grades will be available on Moodle.

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**Dr. David Macaluso**
Email: david.macaluso@umontana.edu
Office: CHCB 119
Office Hours: M 1:30 PM – 3:00 PM
T 12:10 PM – 1:00 PM
R 12:10 PM – 1:00 PM

I am happy to help students and answer questions outside my normally scheduled office hours and I strongly encourage students to seek my assistance whenever necessary. If I am not in my office, I can often be found in my lab, CHCB 020, or in the machine shop, CHCB 023.

**Course Description**
This course is intended to prepare students for independent research in the experimental sciences. Students will perform experiments associated with several physics research fields, including optics, spectroscopy, lasers, atomic physics, nuclear physics, and particle physics. Data collection, data analysis, and error analysis techniques will be emphasized throughout the semester and all analysis will be performed in Python. Long-form lab write ups must be created in LaTeX (LaTeX source files will be submitted with each lab).

**Required Textbook**
*Data Reduction and Error Analysis for the Physical Sciences, 3rd Edition*
Bevington & Robinson

**Lecture**
The Monday lectures (CHCB 012) will include background theory, an introduction to the laboratory apparatus and data taking protocols, and a detailed explanation of the analysis techniques involved in each experiment. Lectures will also include weekly pre-lab quizzes and homework assignments, so attendance, while not strictly required, will be "required." Lab reports and homework assignments will be due at the beginning of lecture, and quizzes will begin promptly at 3:10 so punctuality is also "required."

**Laboratory Experiments**

- Labs will be performed on Tuesdays and Thursdays from 1:10 to 4:30 PM in CHCB 002.
- Students will work together in **assigned** pairs.
- Typically, two experiments will be running at a time.
- Each of the **seven** full labs will require a formal report (50 points each). Reports will be due by the *beginning* of lab on **Thursdays** of the following week.
- The remaining **five** lab "activities" will require simplified reports (20 points each) that will also be due by the *beginning* of lab on **Thursdays** of the following week.
- Students will maintain a **Lab Notebook** for experiment notes and hand-recorded data.
- Students are expected to arrive at lab prepared to work, having read the outline and completed any necessary research beforehand. Lectures will include pre-lab quizzes based on the preliminary work required for each experiment.
- Students will not have additional time to complete lab exercises outside of their assigned lab time, thus **efficient use of lab time is essential**.
- **No food or drinks are allowed in the lab at any time.**

**Learning Objectives**

*Students will:*

- Learn a variety of standard experimental techniques in classical and modern physics.
- Be able to set up, configure, and use a variety of laboratory equipment, including oscilloscopes, lock-in amplifiers, low-power lasers, spectrometers, scintillators, and photomultipliers.
- Be able to collect and study experimental data using LabVIEW and Python.
- Be proficient in data analysis, including propagation of error, curve fitting, and plotting.
- Be able to present experimental results to peers.
- Be better prepared for graduate-level experimental physics.

**Course Expectations**

This is an upper division course intended for physics majors. The expectations are therefore appropriate for advanced undergraduate students who are familiar with the concepts of personal responsibility, accountability, and academic honesty. For example:

*Reading Assignments*: Students are expected to read the assigned material before class. Quizzes will be given each week in lecture based on the assigned pre-lab research and reading.

*Original Work*: I strongly encourage students to work together, to use all available resources, and to seek assistance from me whenever necessary. However, written work submitted in this class must be the original work of the student. For specific information regarding the University policy on academic misconduct, please refer to the last page of this syllabus.

**Grading Policy**

Grading will be based on the traditional letter grade percentage scale. Grade breakdown:

| | |
|---|---|
| Lab Reports | **60%** |
| Homework/Lab Notebooks | **20%** |
| Quizzes | **10%** |
| Final Exam | **10%** |

Homework and Reports will be due at the beginning of class. Late assignments will be accepted at a penalty of 10% per day late except where prior arrangements have been made with me. *The first late day begins after I collect assignments at the beginning of lecture, such that one minute late = one day late.*

**Course Schedule**

| Date | | | Notes/Assignments |
|---|---|---|---|
| 1/27 | Lecture | *Syllabus, Scheduling, Lab Tour, Lab Notebooks/Reports* | |
| | Lab (Tr) | Data Analysis & Error Propagation (Activity 1) | Assignment 1 due |
| 2/03 | Lecture | *Oscilloscopes and Cable Termination* | |
| | Lab | Oscilloscopes and Cable Termination (Activity 2) | Activity 1 due |
| 2/10 | Lecture | *Introduction to Lasers* | |
| | Lab | Laser Modes (Lab 1) | Activity 2 due |
| 2/17 | Lecture | *Lasers & Lock-in Amplifiers* | |
| | Lab | Thermal Laser (Lab 2), Lock-in Amplifier (Lab 3) | Lab 1 due |
| 2/24 | Lecture | *Lasers & Lock-in Amplifiers, part 2* | |
| | Lab | Thermal Laser (Lab 2), Lock-in Amplifier (Lab 3) | |
| 3/03 | Lecture | *Introduction to LabVIEW* | |
| | Lab | LabVIEW (Activity 3) | Labs 2 & 3 due |
| 3/10 | Lecture | *Curve Fitting* | |
| | Lab | LabVIEW & Python Curve Fitting (Activity 4) | Activity 3 due |
| 3/17 | Lecture | *Muon Lifetimes & Relativity, Compton Scattering* | |
| | Lab | Muon Lifetime (Lab 4), Compton Scattering (Lab 5) | Activity 4 due |
| 3/24 | Lecture | *Muon Lifetimes & Relativity, Compton Scattering* | |
| | Lab | Muon Lifetime (Lab 4), Compton Scattering (Lab 5) | |
| 3/31 | | *Spring Break* | |
| | | *Spring Break* | |
| 4/07 | Lecture | *Spectroscopy Techniques, superconducting quantum interference* | |
| | Lab | SQUID (Activity 5) / Spectroscopy 1: Balmer, Isotopes (Lab 6) | Labs 4 & 5 due |
| 4/14 | Lecture | *Spectroscopy Techniques, superconducting quantum interference* | |
| | Lab | SQUID (Activity 5) / Spectroscopy 1: Balmer, Isotopes (Lab 6) | |
| 4/21 | Lecture | *The Zeeman Effect* | |
| | Lab | Zeeman (Lab 7) | Labs 6 & Activity 5 due |
| 4/28 | Lecture | *The Zeeman Effect* | |
| | Lab | Zeeman (Lab 7) | |
| 5/05 | Lecture | *Final Exam Prep* | |
| | Lab | | Lab 7 due |

**Final Exam: 3:20 PM – 5:20 PM, Monday May 12th (CHCB 012)**

***Academic Honesty:*** *Academic misconduct is subject to penalty by the course instructor and/or disciplinary sanction by the University. All students need to be familiar with the Student Conduct Code. The Code is available at http://life.umt.edu/vpsa/student_conduct.php.*

***Students with Disabilities:*** *Whenever possible, and in accordance with civil rights laws, The University of Montana will attempt to provide reasonable modifications to students with disabilities who request and require them. Please feel free to setup a time with me to discuss any modifications that may be necessary for this course. For more information, visit the Disability Services for Students website at http://life.umt.edu/dss/.*