PHY 6850: Advanced Modern Physics Laboratory
Winter 2018

Instructor: Prof. W.J. Llope
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Unless otherwise noted, we will meet: Tuesday 9:00 am-12:50 pm, Room 184
Access to the lab will also be available at other times on a per-need basis by Dr. Alan Sebastian who will be assisting you in the lab

Office hours/help sessions: TBA

Class Website: Canvas (`canvas.wayne.edu`)

Course Text: *A Student's Guide to Data and Error Analysis,* by Herman J.C. Berendsen, Cambridge University Press, 2011, ISBN 978-0-521-13492-7 (paperback). Also handouts and lab manuals supplied in the course.

Course Content:
This course will introduce students to experiments and experimental methods in modern physics.

Course Objectives: Physics is an experimental science. The testing of a proposed physical theory or law or the determination of a physical quantity (mass, charge, temperature, spin, etc.) demands that an appropriate experimental test be devised and/or that a reliable measurement be made. The basic goals/aims of this course include the following: (1) to familiarize the student with some of the basic instruments and measurement techniques typically employed in experimental work in the various sub-fields (atomic, nuclear, condensed matter, etc.) within the discipline of physics; (2) to provide the student with opportunities to learn proper data recording, analysis, and reporting techniques, including the use of spreadsheets, graphical displays and curve fitting routines, the application of appropriate error analysis methodologies, and the maintenance of an accurate and complete scientist's notebook; and (3) to present the student with a chance to develop effective strategies for designing and implementing experimental solutions to problems requiring physical measurements.

Course Organization: We will use first hour most weeks for discussions of issues pertinent to the laboratory. In particular, this will be a time when students may raise questions about the physical theory underlying their experiments or about the design or plan for executing their experiments. The discussion period will also provide an opportunity to explore several other important elements related to experimental physics like the proper statistical treatment of experimental data, the correct style and format for presenting/reporting scientific results in both oral and written forms, and the accepted safety standards for laboratory work.

During the term, each student will perform four short experiments + 1 project type experiment. Generally, each structured experiment will require about two (2) weeks to complete and the project type experiment will take longer (4-6 weeks).

Attendance will be taken every session. Each missed class will deduct 1% from the attendance score. Reasons for missing a class must be submitted prior to class and documented.

Homework/Exercises: It will be expected that students be prepared for the lab sessions. Homework/Exercises will give the students opportunities to develop an understanding of the relevant theory before the lab session.

Labs: Labs could be done individually or in groups of two. It is important that all students participate in all aspects of the experiment. Make sure to alternate data recording and measuring responsibilities so everyone gets a chance to try both. Most structured labs will take 2 weeks to complete. If necessary, the lab room can be made available to finish up measurements at other than class times (Dr. Sebastian will give you access).

Lab Reports: A written report of each lab performed this term must be submitted within one (1) week following the completion of the experiment. **Each student must prepare and submit to the instructor his/her own report**, even if the experimental set-up and data taking was done in collaboration with a student colleague. Explicit guidelines for the style and format of these reports will be provided. In general, the reports must be complete enough so that another intelligent student, knowing something about experimental physics, could understand what was done in enough detail to be able to repeat your experiment successfully. In preparing your reports, it is expected that you will make use of appropriate word-processing and spreadsheet programs, and graphical analysis software. If you need assistance accessing or employing such utilities, please consult the instructor or Dr. Sebastian.

Lab Notebook: Each student keep an online notebook for the course – we will use Canvas for this. It is expected that you will record all pertinent information relating to the experiments you perform in this notebook, including equipment lists, circuit and apparatus schematics and diagrams, equation derivations, raw data, calculations, and error analyses. The pages of the notebook should be numbered consecutively, and each entry should be dated. All original data not otherwise recorded electronically and stored in computer files must be placed directly into the lab notebook preferably in a tabular style with the quantities measured and their units clearly labeled **at the time the observations/measurements are made, not afterward**. You may cross out data that later appear to be useless or wrong, but **never** erase data – they may turn out to be valuable after all. For data stored in computer files, the file names and the associated data taking set-up should be noted so that one knows where to find the data.

The instructor will evaluate lab notebooks and offer comments for improving their content, organization, structure, and style.

Oral Presentation: Each student will give a short (10 to 15 minute) oral presentation on her/his project-type experiment at the end of the semester. Guidelines for the preparation and delivery of these short talks will be provided later in the term. The presentations will be scheduled for the last lab meeting of the term and the order of the talks will be determined at random.

The **final exam** will be a GRE-type exam (3 hours long) that will be used for assessment of outgoing majors (required by the university). This will be arranged during the final exam week.

Grading:

Effort	**% of Score**		**Grade Letter**	**Score**
Attendance	5 %		A-, A	85 - 100
Technique/Lab Notebook	10 %		B-, B, B+	70 - 84
Homework/Exercises	10 %		C-, C, C+	55 - 69
Lab reports	60 %		D-, D, D+	40 - 54
Oral Presentation	5 %		F	< 40
Final Exam	10 %			

THE RULES

1. **Be prepared**: Students are expected to be prepared for each lab by reviewing the theory and experimental setup prior to starting the experiment. Oral quizzes may be given to ascertain that students are prepared.
2. **Lab reports**: Only one lab report will be dropped from the grade calculations. Lab reports are due one week after completion of the lab. For every day the report is late, 10 points (of 100 total) will be deducted from the report grade.
3. **Incompletes:** As a rule, I will not hand out any incomplete grades. Make sure to complete all necessary work during the semester, or, if that is not possible, drop the class.
4. **Grades:** Grades will be determined as detailed in this syllabus on a numerical basis only. I will not accept any special pleading at the end of the semester. You know what grade you need, so work for it!
5. **Bonus**: There will be no extra bonus beyond what is published in this syllabus.
6. **Mathematics**: This course expects that you are proficient in mathematics to the level of PHY5100.
7. **Cheating**: Any actual or attempted cheating will result in a Fail grade (F) for a report or quiz. Repeated cheating will result in an F for the entire course. *Copying items from the Internet or other sources without attribution is cheating*.

List of Experiments

There are both "short" experiments (of which you will choose 4) and "project" type experiments (of which you may choose only 1).

Short experiments (choose four):

1. Double slit interference - one photon at a time
2. Magnetic Susceptibility
3. Noise Fundamentals (measure the Boltzmann constant k_B)
4. Magnetic Torque
5. Chaos
6. Muon Counting (measure the Fermi constant G_F)
7. Gamma ray spectroscopy

8. SQUID (superconducting quantum interference device)

Project type experiments (choose one):

1. Optical Spectroscopy
2. X-ray Diffraction (XRD)
3. Atomic Force Microscopy (AFM)
4. Nuclear Magnetic Resonance (NMR) Spectroscopy
5. Modern Interferometry
6. Mossbauer Experiment