

# PHY4803L Syllabus

## Fall 2018

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*University of Florida Department of Physics*  
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### Contact Information

See the course homepage at <http://www.phys.ufl.edu/courses/phy4803L/> for instructor contact information and office hours.

### Students with Disabilities

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, [www.dso.ufl.edu/drc](http://www.dso.ufl.edu/drc)) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

### Academic Honesty

UF students are bound by The Honor Pledge which states:

We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code.

On all work submitted for credit by students at the University of Florida, the following pledge is implied:

On my honor, I have neither given nor received unauthorized aid in doing this assignment.

The Honor Code (<http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the course instructors.

### Course Evaluations

Students are expected to provide feedback on the quality of instruction in this course by completing on-

line evaluations at <https://evaluations.ufl.edu>. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at <https://evaluations.ufl.edu/results>.

### Lab Fees

A \$7 materials and supplies fee is for consumables such as chemicals, glassware, and printing supplies. A \$90 equipment use fee is for replacing whole experiments or a component such as a meter or data-acquisition computer.

### Lab Attendance Policy

Students are only allowed access to the laboratory during the lab access hours. It is very important that you attend at these times and that you use your time with the equipment wisely. Attendance will be taken via sign-in sheets posted in the lab. In addition, faculty will note individual absences on the experiments. Attendance will affect your grade as described below.

### Course Objectives

For each experiment you perform in this laboratory you will be expected to demonstrate an understanding of the underlying physics, the experimental apparatus, the measurement techniques, and the data analysis. You should reach a level of mastery sufficient to suggest and explore such experimental refinements as improving the quality or quantity of the data, expanding the analysis, or widening the scope of the measurements beyond what is suggested in the handouts.

During your time in and out of the lab, you will:

- Learn physics regarding the systems explored in the experiments.
- Use modern instrumentation and data acquisition computers to collect data on those systems.
- Learn about measurement uncertainty and systematic error and use statistical analysis pro-

cedures to determine experimental parameters and their uncertainties.

- Learn how to keep a lab notebook and how to communicate experimental results in a variety of formats.
- Learn the various concepts involved in designing a physics experiment.

### General Instructions

Work will be performed in groups of two students. There will be seven sessions to finish each experiment with a total of four experiments to be completed during the semester. The fourteen available experiments are classified into four groups: (1) Particle Physics, (2) Condensed Matter Physics, (3) Spectroscopy, and (4) Other Topics. Instructors will assign the experiments you will perform based on preferences you will be asked to supply while avoiding more than two experiments from any one group.

**Attendance factor:** Your presence at the experiment station is also monitored. Late arrivals, leaving the lab early, being absent from the workstation for extended time during the lab, will be noted by the faculty on the sign-in sheet. Missing more than 5 hours of lab sessions without excuses (*for the whole semester*) will result in a specified deduction in the total score:

missing 6 - 9 hrs	10% deduction
missing 10 - 12 hrs	20% deduction
missing 13 - 15 hrs	30% deduction
missing more than 15 hrs	<b>FAIL</b>

Several experiments have unusual data taking conditions which require additional access to the equipment. The additional/extended access will be arranged between the students performing the experiment and the instructors. The additional access hours *will not count to offset absences during normal lab hours*.

**Special Circumstances:** Excusing absences after-the-fact requires providing a letter from the dean of student affairs office. Planned absences can be excused ahead of time, but require consultation with the faculty and the lab partner.

### Preparation

It is important to get up to speed quickly on each experiment. The first day of an experimental rotation should be spent working with the apparatus and getting a start on the experimental procedures (not reading the write-up for the first time). To prepare for the next experiment and complete the exercises on time, be sure to download the write-up at least

one full week (two sessions) ahead. Read it and try out the exercises before the first day that you will be working on the new experiment.

### Grading

Please refer to the Course Schedule provided for a list of assignments and due dates. Information on current UF grading policies for assigning grade points can be found at <https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>.

#### Composition of Grade

3 Lab Reports	37.5%
4 Exercises	20%
4 Performance	20%
1 Presentation	12.5%
3 Stat HW's	10%
Total	100%

#### Grade Scale

85	80	75	70	65	60	55	50	45	40	35
A	A-	B+	B	B-	C+	C	C-	D+	D	D-

**Late Assignments:** The submission time for assignments is indicated in the *Course Schedule* provided. Assignments turned in late will be given only partial credit. The partial credit factor will decrease by 20% per day that the assignment is late. If the assignment is late between 1 minute and 24 hrs, it will yield partial credit corresponding to 80% of its value had it been turned in on time. Assignments turned in more than four days late will receive no credit.

Waiving overdue assignment penalties requires providing a letter from the dean of student affairs office. Overdue assignments can be excused of penalties in exceptional circumstances with *prior* approval of the instructors.

### Lab Conduct

You are expected to show maturity in the following areas:

**Safety:** We have tried to minimize hazards but there are always possibilities for injury. Follow all safety procedures for handling lasers, x-ray machine, radioactive materials and high voltage sources. Students are not allowed to work alone in the laboratory in any circumstances (*two-body rule*).

**Care:** Take care of the equipment. Know how to use it. Do not make connections unless you understand what you're doing. Read the equipment manuals.

**Courtesy:** Keep your area clean. Return tools, equipment, etc., to their proper place. Do not remove equipment from other experiments without asking first.

In-class *Performance* will be evaluated based on your level of preparation and participation during the lab sessions. You will demonstrate preparation and progress during notebook inspections and discussions, which will be conducted informally more or less every session. You should always be prepared to answer the following questions. What are you doing or about to do? Why are you doing it? What do you think will happen?

**Do not wait until you are writing your report before you begin graphing and analyzing data.** Mistakes are common in laboratory work and can often be discovered as the data come in by graphing and/or analysis. Graphs and analysis should be displayed in your lab notebook. Instructors will be looking specifically for them during discussions and notebook inspections. In addition, a “checkpoint” has been included in each experimental write-up containing benchmarks that should be achieved by the end of the fourth session of an experiment. Checking data as it comes in and meeting the benchmarks on time will be a significant part of your in-class performance score.

By the end of the sixth session, data acquisition and data analysis should be complete, as should be your understanding of all aspects of the experiment. You will be individually debriefed during that period where you will be expected to show your data and analysis. The seventh session is to clean up any remaining details, work on the report and prepare for the next experiment.

### Notebook/Flash drive

Please refer to the [Laboratory Notebook Guidelines](#) for details on maintaining a laboratory notebook. *Both partners in an experiment must keep their own complete notebook.* Bring your notebook to every lab session. Failure to do so will result in a grade penalty.

Bring a flash drive to each lab session for storing your data and other files for an experiment. Use a separate directory for each experiment and subdirectories within it when appropriate. Do not assume your data will be on the computer from one day to another. Backup your flash drive files to your personal computer after each session in case your flash drive is lost or damaged.

### Reports

Although two students work as a team on an experiment, each student must write their own report. Feel free to discuss any questions you might have with instructors, your partner, or anyone else, but the report should be your own independent work. Turn in a printed version on the scheduled due date and email a PDF version as well. The late submission policy applies to lab reports.

Please read the handout [Writing Scientific Reports Using L<sup>A</sup>T<sub>E</sub>X](#) for additional information on writing lab reports. Whereas the notebook is written chronologically and is a complete record of what occurred in the lab, the report components can be placed in a more reader friendly order and can be more selective in content. Also keep in mind, many of the notebook guidelines apply to the report as well.

The report should be limited to four pages maximum (excluding appendices as discussed below) and written in the style of a scientific publication. It should show that you understand the physical system under study, the apparatus, and the experimental results. The sections listed below should be included. The points associated with each section are a rough guideline and not binding.

*Abstract:* (10%)

The abstract should briefly summarize the motivation, the method and most importantly, the quantitative results with errors. Based on those, a conclusion may be drawn.

*Introduction and Theory:* (20%)

This section should succinctly report the motivation, purpose and relevant background to the experiment. It should define all the major variables involved and provide equations and assumptions.

*Apparatus and Experiment:* (10%)

This section should provide schematics of the apparatus and discuss how the raw data are generated. It should also include an assessment of their random and systematic errors.

*Analysis and Results:* (40%)

This section should explain the data analysis and how it leads to the results, including random uncertainties and possible systematic effects.

*Conclusions:* (20%)

Summarize and discuss the findings of the experiment including quantitative comparisons between your results and theoretical expectations or other experimental values. Suggestions for experimental improvements and possible future studies are also appropriate here.

*Appendices:*

Here you may include any additional information and/or figures that do not fit into the four page limit. It should not be necessary to read this section in order to understand the main results and conclusions presented in the body of the paper.

**Homework and Prelab Exercises**

All assignments should be submitted separately by both students at the beginning of the scheduled class. Although the due date for each Prelab Exercise is on the 3rd session of each rotation, you are strongly encouraged to work on them as early as possible. The late submission policy also applies to homework and exercises.

**Presentations**

For the last rotation, you and your lab partner will deliver a conference-style oral presentation of your work. A written report for this last rotation is not required. In order to keep all of the talks within the time allotted for our lab meeting, strict time constraints will be enforced. Each group has 17 minutes to talk plus 3 minutes to answer questions from the instructors or other students. The 17 minutes should be divided roughly equally between the two members of a group, who should prepare the talk cooperatively and should agree before-hand how the presentation will be divided.

You should utilize visual slides that help to present your results and organize the flow of your presentation. Each group's slides should be in the form a single PDF or PowerPoint file. The file should be sent to the instructor by 11:59 pm on the evening prior to the day of the presentations. This is necessary so that we can efficiently transition from one presentation to the next without delays. Other file formats—such as Keynote—are not acceptable.

We strongly recommend that you do several practice talks before delivering your presentation in class. Given the short time allotted, you will need this practice in order to make sure that you can deliver all of the necessary information clearly and concisely. The breakdown of topics covered in your presentation should roughly follow the breakdown listed for the written reports, minus the abstract. "Appendix" slides at the end of your PDF file can be included that are not presented during the main body of your presentation, but may be shown in order to help answer questions from the audience.

In any scientific presentation it is important to tailor what you cover to the specific audience. For

this presentation you need to provide enough background information that students that haven't performed your experiment can learn something. At the same time, you should provide enough detail that the instructors and other students that have performed your experiment can gauge your results and any technical issues you may have run into. Some useful information on scientific speaking can be found here: <http://physics.illinois.edu/people/celia/ScienceTalks.pdf>

**Experiments**

Our experiments range from simple to sophisticated on several levels. To help you decide which experiments to request, we have assigned scores from 1 (relatively easy) to 3 (relatively difficult) in the following three categories:

**Physics**—the sophistication of the theory of the system under study.

**Experimental technique**—the sophistication of the apparatus and techniques used to make the measurements.

**Analysis**—the complexity of the data analysis required.

Brief descriptions of each experiment are given below along with their **PEA** scores based on the judgment of several instructors.

**ACS** *ac Susceptibility Measurements in High- $T_c$  Superconductors*: **231** A magnetic susceptometer is used to observe the superconducting transition in a high temperature superconductor.

**CP** *Chaotic Pendulum*: **323** A driven pendulum-spring apparatus is used to study deterministic chaos in nonlinear dynamical systems. Special graphing and analysis techniques are used to display the data and determine invariants such as fractal dimensions and Lyapunov exponents.

**CRM** *Cosmic-Ray Muons and the Muon Lifetime*: **222** Four scintillation detectors and coincidence techniques are used to determine the flux and angular distribution of muons created in collisions of cosmic rays with atoms in the upper atmosphere. The muon lifetime is measured using rare events where, after passage of a muon into the system is detected, its decay is also detected. Statistical techniques for low counting rate experiments are employed.

**GGC** *Gamma-Gamma Correlation*: **222** Two NaI detectors, and various nuclear instrumentation modules are used to observe the coincident emission of two photons arising from the annihilation of positrons emitted by a  $^{22}\text{Na}$  source.

- GRS** *Gamma Ray Spectroscopy: 122* A NaI scintillation detector and pulse height analyzer are used to analyze gamma rays from a variety of radioactive isotopes. The metastable  $^{137}\text{Ba}$  isotope is extracted from a  $^{137}\text{Cs}$  source and the exponential decay of its radioactivity is measured and used to determine the nuclear half-life.
- IRS** *Rotation Vibrational Spectrum of the HCl Molecule: 312* The absorption spectrum of the diatomic HCl molecule is measured using a Fourier transform infrared spectrometer. The spectrum shows a characteristic shape that can be understood based on the quantum mechanics of the non-rigid rotator, and analysis of the spectrum provides information about the molecular bond, such as bond length and strength.
- LTT** *Low Temperature Transport: 122* Temperature has dramatic effects on the transport properties of metals and semiconductors. The electrical resistance of pure metals can decrease by several orders of magnitude as temperature is reduced from room temperature to cryogenic temperatures. The junction voltage of a  $p$ - $n$  junction increases in a characteristic way as temperature is lowered, allowing the Si diode to be used as a thermometer. A cryostat capable of reaching extremely low temperatures is used for studies of these properties at temperatures between about 10 and 350 K.
- NMR** *Pulsed Nuclear Magnetic Resonance: 232* The nuclear magnetization of a sample immersed in a strong magnetic field is manipulated using a pulse of resonant radio frequency radiation. Time-resolved measurements of the sample magnetization after the pulse are used to determine the time constants associated with the magnetization's return to equilibrium.
- SAS** *Saturated Absorption Spectroscopy: 332* Properties of laser absorption in a rubidium vapor are measured. Single beam, Doppler broadened absorption and sub-Doppler saturated absorption using counterpropagating beams are observed and measured.
- TFH** *Quartz Crystal Tuning Fork in Superfluid Helium: 233* The resonance behavior of a tiny quartz tuning fork is measured to investigate the hydrodynamic properties of the medium in which it is immersed. The tuning fork is immersed in helium gas at various pressures and in liquid helium at temperatures around the superfluid transition in a study of the changing density and viscosity of the medium. Lock-in impedance measurements and cryogenic techniques are involved.
- VIS** *Visible Spectrometer: 122* A transmission grating spectrometer is calibrated by measuring the spectrum from a mercury and/or helium discharge lamp and using their known wavelengths compiled in reference tables. The spectrometer is then used to obtain wavelengths of the Balmer series observed with a hydrogen discharge. A comparison with the Rydberg formula is made and the hydrogen Rydberg constant is obtained.
- XDA** *Xray Diffraction and Absorption: 222* An xray spectrometer is used to observe diffraction from single crystals and determine the emission spectrum of the xray tube. Diffraction spectra from powdered crystals are obtained and analyzed to determine the crystal structure and interatomic spacings. Xray absorption through a variety of metal foils is measured to observe absorption edges and determine their dependence on atomic number.
- OT** *Optical Tweezers: 232* A laser beam is focused through a microscope objective to a micron-sized spot. A microscope slide is prepared containing spherical micron-sized silica beads dispersed in water. When a bead is placed near the laser beam, it is drawn toward the focus with a Hooke's law restoring force that arises from the laser light scattered by the bead. The microscope slide is mounted on a piezoelectric stage that can be put into small amplitude oscillations. The bead is also constantly subjected to the random impulsive forces responsible for Brownian motion. The scattered light is collected on a quadrant photodiode and used to determine the bead motion which is Fourier analyzed to obtain the force constant and other system parameters. These parameters are studied as the laser intensity, bead size, and other conditions are varied. Micro-organisms can also be manipulated and studied.
- FCS** *Fluorescence Correlation Spectroscopy: 332* A laser beam is brought through a microscope objective to a diffraction limited focal spot inside a fluid-filled microscope slide containing fluorescent dye molecules. As the dye-containing particles or molecules diffuse into the laser spot their fluorescence is collected by the objective and brought to a focus in the objective's image plane where a pinhole is positioned to overlap with the fluorescing image. A photomultiplier placed just beyond the pinhole records individual photon arrivals on a nanosecond time scale, which are used to determine their autocorrelation function (ACF). The ACF is checked against model predictions and fit to obtain model parameters such as diffusion constants and reaction rates.