PHY 335: Electronics and Instrumentation Laboratory

Fall 2015

Prerequisite: PHY 251 with lab (PHY252)

Course Description (syllabus): PHY 335 (Electronics and Instrumentation Laboratory, or Junior Lab) is a laboratory-based course covering analog electronics fundamentals as viewed by an experimental physicist. You will be designing and building basic DC and AC circuits which perform some useful function and which are used in Physics measurements. These circuits contain resistors, capacitors, transformers, diodes, transistors and operational amplifiers. You will also learn to use essential laboratory instruments such as DC and AC power supplies, digital multi-meters, and digital oscilloscope with its many features. All of the above will be taught with the reference to the laws of electricity you studied previously, these basics being reviewed and reminded at various points in the course. Ideas and tools specific to electronics, such as the principle of negative feedback, will be introduced in a context of their usefulness in performing and improving our basic circuits. An example of a difficult Physics measurement made easy with the use of electronics will be provided: we will measure diode's current-voltage characteristic over 8 orders of magnitude in current and compare the result with the theoretical (Shockley) formula. This will require understanding of the capabilities and limitations of our available instruments coupled with a number of circuit modifications dictated by the task. We will use Excel or a similar program to collect, display and fit the data.

The course consists of two three-hour laboratories per week. Each lab (or almost each lab) will start with a lecture 45 – 60 minutes long. The rest of the three-hour period will be devoted to experimental work.

Topics (Units) to be covered:

1. Lab instruments; measurements; internal resistances of a DC power supply, ammeter and voltmeter; simple DC circuits; voltage dividers; Thevenin equivalents
2. AC signals; use of an oscilloscope; AC circuits; RC filters; RC differentiators and integrators
3. Diodes and diode circuits; detailed measurement of a diode I-V characteristic over 8 orders of magnitude in current (an example of a typical physics measurement)
4. Transistors and basic transistor circuits (follower, current source, amplifier)
5. Operational Amplifiers (OpAmps) and negative feedback; OpAmp circuits (follower, two types of amplifiers, current source, OpAmp-based integrator, Op-Amp differential amplifier)

Time and place: Section 01: Tu and Th, 1:00 p.m. to 3:50 p.m., in A-127, Physics
Section 02: M and W, 1:00 p.m. to 3:50 p.m., in A-127, Physics

Instructor: Prof. Michael Gurvitch, office B-147, x 2-7298, michael.gurvitch@stonybrook.edu or avgur2001@yahoo.com

Since Prof. Gurvitch will be available each week for 12 hours in class, there will be no special office hours in addition to that; please ask your questions and raise your concerns during the scheduled hours. You will be able to speak to Professor in privacy if you so desire; in that case just ask Prof. Gurvitch to step out of the class to the corridor, or ask him to see you in his office B-147.

Teaching Assistants (TAs): TBA; teaching Assistants will be helping you in class with practical questions (and so will prof. Gurvitch), and they will also grade all of your Reports; exams are graded by the Professor.

Books and other course materials: Students are not required to buy any books for this course; essential material will be posted in the Blackboard by the Professor during the semester; students will have to download Units (each Unit contains assignments and detailed explanations) from the Blackboard.

Nonetheless, reading relevant books is encouraged. Books which are **recommended** as supplementary material (they can be found on reserve in the Physics Library) are:

1. Any basic course on E&M, for example Giancoli, *Physics for Scientists and Engineers*, 4-th Edition, Chapters 21, 23, 24 – 26.
2. Horowitz and Hill, "*The Art of Electronics*", *2-nd edition,* (Cambridge University Press, 1989); ISBN 0-521-37095-7
3. Hayes and Horowitz, "*Student manual for the Art of Electronics*" (Cambridge University Press, 1989); ISBN 0-521-37709-9
4. Curtis A. Meyer, *Basic Electronics: An Introduction to Electronics for Science Students*, Carnegie Mellon University, 2009, 2010.

Required: One laboratory *science notebook*; scientific calculator; computer, laptop or tablet to prepare reports.

Raw data and lab notes are important parts of a Report: We will ask you to attach to the typed report a copy of the lab notebook pages containing the raw data. This data can be recorded by hand, or, if you so desire, with the use of a laptop or a tablet; in latter case, we will ask you to provide us with a copy (printout) of the raw data as it has been entered into the laptop. It is essential also to sketch circuits and enter component values into your notebook, laptop, or tablet. It is also essential to indicate units of everything you are measuring. The lab notes must contain circuit diagrams, sometimes several for each measurement. You may be able to draw these circuit diagrams on paper and photograph them, or use a drawing routine directly on the computer; in any case, however you do it, we will need to see a complete record of your lab work, whether recorded by hand or with the use of a computer. The completeness and quality of the raw data, circuit diagrams and of the notes taken during the experiment contributes to your grade; a Report without reasonable lab notes and raw data will not be acceptable. So please pay attention to these issues. The lab notes need not be "neat", they are reflecting real work in progress that you have done in the lab; they may contain mistakes, corrections, markups; they may show alternative ways of doing things, hopefully with the final solution that you came up with. Nevertheless, they should be clear enough to be understandable by yourself and by your graders. Make short notes, comments and explanations to make this possible. The Report that you will eventually write is just the "crystallization" of your lab work, which therefore must come first and be clear and correct.

Reports: there will be 5 Reports in the Semester, each describing your work on one of the 5 Units. Reports should contain essential theory, circuits, essential data, and your analysis of each assignment. To better organize a Report, we ask you to include the texts of the actual assignments (taken from the Manual) as headings in your Report. Relevant theory may follow these headings; sometimes, general theory, which relates to more than one assignment, can be separated and presented in the Introduction. As we said above, Reports will also contain raw data and lab notes as separate attachments. The Report need not be excessively long: use concise, scientific rather than colloquial language when writing a Report. Try not to exceed 20-25 pages. The Report should be formatted with page numbers, assignment titles; good figures (circuit diagrams, graphs). It should be written in grammatically correct English. It should be done so that a grader will be able to understand what you have done and judge your work. Reports that lack in logic, physics and common sense will be graded accordingly.

General organization of the course:

All material is divided into *Units*, with each Unit covering internally related topics (see above). Each Unit will occupy several lab periods. Extensions of lab time may be arranged with the TA by prior mutual agreement, but should be done only under exceptional circumstances. Otherwise, no substitution of regularly scheduled lab periods is possible. After each Unit is finished, students will be expected to submit a Report on that Unit in one week's time. The Report should be done on a computer; it should be well-written (good English grammar; precise scientific language), with theoretical and experimental sections, and with good quality figures, some of which may be photographs taken by a student (using dedicated digital camera, cell-phone or laptop cameras). Pictures rather than hand-made sketches of the oscilloscope screen are encouraged.

As we said, there will be a 45 - 60 min. mini-lecture at the beginning of most labs. Students should come to class on time so as to not miss a mini-lecture. We recommend taking notes during these mini-lectures; the notes can be made in the same lab book which will be used to make calculations, sketch circuit diagrams and collect the raw data. Understanding of the material presented in the Units and in mini-lectures is essential in order to complete this course.

You will be doing the lab work in groups of 2 per setup or individually. All students should make the best effort to participate equally in the experimental part. Collaboration and consultation with your partner or anybody else in the class are encouraged. However, each student will write his or her *individual* lab report after completion of each Unit. Except for the raw data which you will take and share with your partner, the reports are expected to be different, reflecting individual work. Copying of any part of a report (except for the raw experimental data) is unacceptable and will automatically lead to zero report score, as a first warning.

The worst thing that a student may do is to *make up* data (that is, to pretend that some values were measured when actually they were just made up); if this will be discovered, the punishment may be severe. In the real world, that sort of thing (which, thankfully, is extremely rare in Physics) have cost people their jobs and careers.

Exams: There will be *First Exam* after the completion of Unit 3, and *Second Exam* in the last day of classes (after Unit 5). Careful reading of the material provided in the Units, study of the notes you will take in mini-lectures, as well as active and alert participation in experimental work will prepare you for the exams.

Note: we have a permission of the Dean to conduct the second exam in the last day of classes rather than in the Finals week.

Grading policy

All the five Units (with reports) and the two exams must be completed to pass this course. Because the number of Units is relatively small, and because all of the material in this course is essential, we will consider a missing Unit report, or a missing exam as a sufficient cause for assigning a failing grade. Additionally, if a student will receive less than 35 out of 100 in the second (cumulative) exam, irrespective of all the other scores this student will receive F for the course.

The **course grade** will be calculated as follows: ***50% Units (Report grades) + 20% 1-st exam + 30% 2-nd exam (except for the provisions stated above)***

The 2-point policy: In order to encourage your active participation, we will implement the following extra-credit policy: 2 points will be added to the Second Exam score for each professor's substantial mistake pointed by a student. Only the first one to point the mistake will be rewarded. This could be a mistake in the mini-lecture, or a mistake in the Unit write-up. By "substantial" we mean a physics-related mistake, rather than, for example, a spelling mistake. A good, interesting, substantial physics question a student may ask in class (judged as such by the Professor) will also be rewarded by 2 points. *Please do not apply pressure in order to receive these points, as it may become uncomfortable and will spoil the fun.*

ACADEMIC INTEGRITY: Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Making up experimental data is even worse. The teaching faculty is required to report any suspected instance of academic dishonesty to the Academic Judiciary. For more comprehensive information on academic integrity, including categories of academic dishonesty, please refer to the academic judiciary website at http://www.stonybrook.edu/uaa/academicjudiciary/