Physics 3330: Electronics for the Physical Sciences -Fall 2013

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Course Webpage: http://www.colorado.edu/physics/phys3330

Introduction: Modern physical measurements, communication, and computation rely on electronic hardware and instrumentation. Electronic instrumentation is used in all sub-fields of physics, including condensed matter, elementary particles, nuclear physics, and atomic/molecular/optical physics. Electronic measurements are no less common in the other physical sciences, and are essential in many modern interdisciplinary areas such as satellite-based environmental monitoring, the experimental study of chaos, nanotechnology, and the search for extraterrestrial life.

Electronics for the Physical Sciences provides an introduction to electronic design through hands-on experimentation. You will be building electronic systems from scratch, then debugging them and demonstrating that you understand how they work.

Organization: There are ten student workstations in the lab, each equipped with a set of electronic measuring instruments. You will work in pairs, using the same workstation throughout the semester but sharing it with students belonging to the other lab sections. Individual experiments are built up on circuit boards that your team keeps for the entire semester. This allows you to continue to work on your circuit for as long as you need to.

During the semester, announcements will be posted on the course web page and, if needed, sent to you by e-mail. In accordance with University policy, you are required to maintain and regularly check an e-mail account. You are also encouraged to use e-mail to communicate with the instructors.

Lab Sessions: Each section has one 3-hour instructional lab per week in Duane G-230, supervised by your lab instructor. You must attend your scheduled lab. The course will go much more smoothly for you if you are well prepared for each lab session so you can get most of the work done while your instructor is there to help. The lab is open for unsupervised work any time the building wing is open, and when no other section is meeting. Access will be via the eastern stairwell. These times are available for you to complete unfinished experiments or to explore your own ideas. Your Buff OneCard will open the lab door. Please do not prop open the lab door or the hallway barrier door. Doing so will result in a warning and then loss of card access to the lab.

Lectures: There will be a series of lectures on Tuesdays and Thursdays from 1:00 to 1:50 pm in Duane G-125. We will be using iClicker remote transmitters for the class, available in the CU bookstore. The material includes theoretical background that you will need to solve the pre-lab homework problems and to do the experiments. A schedule for the lectures is posted on the web site. The midterm exam will cover material from the lectures and from the labs.

Textbook: There is no required textbook. Two useful references which you will likely consult at different times in the semester are The Art of Electronics, 2nd Edition by Horowitz and Hill and The Electronics Companion by A.C. Fischer-Cripps (IOP Press). Copies of these references are available in the lab.

Midterm Exam: There will be a midterm evening exam given about Week 10. We will provide the exact date and time later in the semester. This exam will primarily focus on the theoretical material covered in the lectures as well as some practical knowledge that you are expected to have gained from the lab work.

Pre-Labs: The lab manual for each experiment includes problems to help you design your experiment and learn the theory. Pre-labs are due at the beginning of your lab section. They are worth 20% of your lab grade (10 out of 50). Since they are intended to prepare you for the lab session, late submissions will not be accepted. Solve the Pre-Lab problems in your lab notebook, then scan a copy and hand it in to the D2L dropbox. You should solve the Pre-Labs in your notebook since the calculations are useful for the lab itself.

Lab Partners: You may perform the experiments either individually or with a partner. Groups larger than two are not permitted. If you work with a lab partner you should analyze the data separately and turn in separate Pre-Lab problems and Lab Reports.

Lab Notebook: Our goal is for you to develop lab notebook skills that align with professional practice in research labs.

1. A lab notebook will provided at the beginning of the course. You should bring the notebook to every lab including the times you work on your final project. Do not use loose sheets. If you ever forget to bring your notebook to the lab and have to use loose sheets instead, be sure

to tape or glue these into your lab book as soon as possible.

2. Reserve the first few pages for a table of contents. Thereafter, don't skip pages. Write in ink and don't erase mistakes. Rather, put a line through them and give a short explanation.

3. Enter the date, time and the name of your partner in your notebook when you start to work each day. Use a consistent format so it is easy to find the work that was done on a given day or a given experiment. Noting the time in your lab book for the start of specific experiments is also useful. Use your notebook in the same way when you are working outside of your scheduled lab session.

4. Keep a record of your data as well as of the experimental procedure, describing what you tried, what worked and what did not work.

5. Your lab notebook is a conversation with your future self, so include enough detail so you can understand clearly what you did a month ago. Be sure to include schematic diagrams for the circuits you are building. Write some descriptive text as you proceed through the experiment, for example, "…needed a 4.5 kΩ resistor, but settled for a series circuit of two 2 ks and a 500 Ω…". If you measure something and are confused, say so in your notebook.

6. Your lab notebook will be graded during each lab by your instructor. This is worth 20% (10 points) of your lab grade. You will not get this credit if you miss the lab section. Your instructor will grade, initial and date your lab notebook each week before you leave the lab. You will also hand in to the D2L dropbox a scanned copy of the relevant pages of your lab notebook with your lab report each week.

<u>Lab Reports:</u>

1. Your reports should give a brief and clear account of what you observed in the lab, and what conclusions you can draw from your measurements. The report should be of a quality and style comparable to what you might imagine sending to a supervisor or project coworkers if you were working in a lab in a local high-tech company.

2. You report will be worth of 60% your lab grade (30 points).

3. A typical report will be typed, and three to six pages long, including the figures. It will contain an introduction which describes the experiment in a few sentences, one or more figures depicting the circuit or other apparatus, a summary of the data or other observations, analysis of the data, and conclusions. It should be self-contained in that one should not have to be a student or instructor in this course to understand it.

4. If the overall goal of an experiment is to measure some quantity, then an account of the important random and systematic errors will be necessary. Always strive to make simple estimates of errors, to avoid wasting time estimating errors that will not contribute to the final result, and to avoid elaborate propagation-of-errors calculations unless they are really necessary.

5. Data plots are an aspect of the lab report that merit special attention. Each plot should be of a size and quality to enable a clear understanding of the data, and provided with appropriate axis labels and units. Before you take data on a particular circuit characteristic, think about what data you need to make an informative plot. For example, if you are measuring

characteristics of a low-pass filter, it has an expected roll off frequency that you can calculate, or find experimentally. The characteristics of a low-pass filter are best illustrated using a logarithmic scale, so choose your x-axis as logarithmic with the roll-off frequency near the center of the x-axis scale. When you collect data in the lab, 10-30 measurements is usually sufficient for a meaningful plot.

6. Your lab reports are due at the beginning of the following week's lab section and should be handed in to the D2L dropbox.

Final Project: The last four weeks of the semester are devoted to projects. Final projects may be done by individuals or teams of two. You will use the skills you have learned to explore a topic of your choice. A list of projects from previous years is posted on the web site, just to give you some ideas. If you have an idea for a project at any time during the semester, by all means discuss it with your instructor and begin reading and collecting the materials you will need. This course is mostly about analog rather than digital electronics, because a good knowledge of analog is more important for laboratory scientists. We will discourage projects that are all or mostly digital. The final project topic should be something you can build that involves what you learned during the semester. Your final project is worth 200 points total and will be graded by 4 different parts:

1. Project Proposal (25 pts) of 1 to 2 pages is due in the D2L dropbox at the beginning of your lab section in Week 9 (Oct. 22 or 24). You must talk to your lab instructor to get preliminary approval of your plans during Week 8 (Oct. 14-18) or sooner. Teams prepare a single proposal, but each member should turn in a copy.

2. Progress Report (25 pts) due in the D2L dropbox at the beginning of the lab in Week 13. (Nov. 19 or 21). It should be a 1-3 pages describing your progress so far. It should include essentially complete circuit diagrams for your project. Teams prepare a single Progress Report but each member should turn in a copy.

3. Oral Presentations (75 pts) will be on Tuesday and Thursday of the final week of the course (Dec. 10 and 12). Talks will be scheduled from 9 am to 4 pm. You should plan to give a computer-based presentation (PowerPoint, Keynote etc.). The quality of your presentation will be graded in addition to the details of the project. A working demonstration of your project should be the part of the presentation whenever possible. Both members of a team must contribute to the oral presentation approximately equally.

4. Project Reports (75 pts) due in the D2L dropbox by 5 pm on Dec. 13, the last day of classes. You must submit fully polished, typed documents with complete figures, diagram and data. Teams prepare a single Project Report but each member should turn in a copy. Include in the report a section where you described the contributions of each member to both the lab work and the report. The quality of writing will be graded in addition to the details of project.

Grading: The grading will be based on a maximum of 850 points. Clicker questions during lecture will be counted total 50 points. Each of the 10 regular lab reports is worth 30 points. The 10 pre-lab problem sets are worth 10 points each and your lab notebook grade 10 points each week. Your final project will be worth 200 points: 25 points for a project proposal, 25 points for the progress report, 75 points for your final project oral presentation, and 75 points for your final

written report. The midterm exam will be worth 100 points.

Late Pre-Lab problems will not be accepted. Lab reports are due in the D2L dropbox at the beginning of the next lab section. 25% will deducted from your grade from labs that are less than 1 day late. From 1 day to 1 week late, 50% will be deducted. Lab reports will not be accepted more than 1 week late.

Weekly Work Schedule:

1. Before your lab section: 1) Write report on the previous week's experiment. Deposit the report in the appropriate D2L dropbox. 2) Read the lab manual for the next lab. 3) Work through the theory with a paper and pencil. 4) Do the pre-lab problems in your notebook, scan the pages, and turn them in to the appropriate D2L dropbox by the beginning of the lab. If you prefer solving the pre-lab with Mathematica, then turn in the Mathematica notebook to the appropriate D2L dropbox and tape or glue a copy of the pre-lab solutions into your lab notebook. You will want the pre-lab solutions at hand during the lab.
2. During scheduled lab: Go as far as you can and analyze data as you take it whenever you can.
3. During open lab periods: Complete the experiments

Important Lab Rules:

1. If you are the last to leave the lab, first be sure to turn off all equipment, especially soldering irons and hot plates. Then close all windows and turn out the lights. Never prop the door open. Anyone who has authorization to use the lab will have access. The equipment is expensive and it would be very difficult to replace.
2. Before you leave the lab, clean up your mess. Your bench top should be totally clear except for the test equipment and the toolbox. Your own circuit boards and other equipment should be left on your labeled shelf in one of the storage cabinets. Communal equipment, including meters, stop watches, tools from the bench, cables, etc. should be returned to their storage locations.
3. Faults or damage that may occur to any instrument or non-trivial component should be reported to an instructor or to Michael Thomason, the lab coordinator. Label the offending item with a tag stating the nature of the fault to help us with repairs.

Equipment at each workstation

Instruments

1 Oscilloscope, 100 MHz, 4 channel digital, Tektronix TDS 3014B
1 Function Generator, Agilent 33120A
1 Dual DC power supply 30V 2A, 5V, Tektronix PS280
1 Digital Multimeter, Fluke-77

Accessories:
1 pair needle nose plier
1 pair wire cutter/stripper
1 small screwdriver
2 BNC coaxial L connector
5 BNC coaxial T connector
1 BNC coaxial 50Ω terminator
1 BNC male to male adapter
1 BNC female to Banana male adapter
1 Minigripper test clip to BNC female
1 black and 1 red alligator clip

Other policies set by the University

Disability issues: If you qualify for accommodations because of a disability, please submit a letter from Disability Services in a timely manner so that your needs may be addressed. Disability Services determines accommodations based on documented disabilities. Contact: 303-492-8671, Willard 322, and http://www.colorado.edu/disabilityservices.

Religious observances: Campus policy regarding religious observances requires that faculty make every effort to reasonably and fairly deal with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. See full details at http://www.colorado.edu/policies/fac relig.html. Please contact us if you will miss a lecture or laboratory session due to a religious observance to arrange an appropriate remedy.

Classroom behavior: Students and faculty each have responsibility for maintaining an appropriate learning environment. Students who fail to adhere to such behavioral standards may be subject to discipline. Faculty have the professional responsibility to treat all students with understanding, dignity and respect, to guide classroom discussion and to set reasonable limits on the manner in which they and their students express opinions. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, culture, religion, politics, sexual orientation, gender variance, and nationalities. Class rosters are provided to the instructor with the student's legal name. We will gladly honor your request to address you by an alternate name or gender pronoun. Please advise of this preference early in the semester so that we may make appropriate changes to my records. See polices at http://www.colorado.edu/policies/classbehavior.html and http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#studentcode.

Honor code: All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution. Violations of this policy may include: cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. All incidents of academic misconduct shall be reported to the Honor Code Council (honor@colorado.edu;303-725-2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). Other information on the Honor Code can be found at http://www.colorado.edu/policies/honor.html and http://www.colorado.edu/academics/honorcode.

Discrimination & sexual harassment: The University of Colorado at Boulder policy on Discrimination andHarassmenthttp://www.colorado.edu/policies/discrimination.html, the University of Colorado policy on Sexual Harassment and the University of Colorado policy on Amorous Relationships applies to all students, staff and faculty. Any student, staff or faculty member who believes s/he has been the subject of discrimination or harassment based upon race, color, national origin, sex, age, disability, religion, sexual orientation, or veteran status should contact the Office of Discrimination and Harassment(ODH) at303-492-2127 or the Office of Judicial Affairs at303-492-5550. Information about the ODH and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at http://www.colorado.edu/odh.