Physics 3330 - Electronics for the Physical Sciences

INTRODUCTION

Modern physical measurements, communication, and computation rely on electronic hardware and instrumentation. Electronic instrumentation is used in all sub-fields of physics -- 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 experimental experience. You will be building electronic systems from scratch, and then demonstrating that you understand how they work. You are encouraged to exercise initiative in the laboratory; all of the experiments are intended to be open-ended.

ORGANIZATION

There are eight student workstations, each consisting of a set of electronic measuring instruments. You will work in groups of two, using the same workstation throughout the semester but sharing it with groups belonging to the other lab sections. Individual experiments, on the other hand, 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 complete the work.

A course calendar showing the lab and lecture plan for the semester is posted on the course web page, along other information for course (http://www.colorado.edu/physics/phys3330). 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 room 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. The building hours will be identical to those of the library on the 1st floor immediately below our lab – 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 the door open after unlocking it.

LECTURES

There will be a series of lectures on Tuesdays and Thursdays from 1:00 to 1:50 in Duane G-2B47. The material includes both theoretical background for the experiments and a discussion of practical problems you may encounter. The schedule for the lectures is posted on the web site. The Midterm Exam will cover material from the lectures and from the labs.

OFFICE HOURS

The office hours are for help with pre-lab problems and for hands-on help in the lab. You may seek help from any of the instructors. Office hours are posted on the course web site.

WEEKLY WORK SCHEDULE

Before your lab section:

- Write report on the previous week's experiment.
- Read the lab manual for the next experiment, and any other required reading. Work through the theory with a paper and pencil.
- Do the pre-lab problems.

During scheduled lab:

- Turn in the report on last week's experiment when you arrive.
- Turn in the pre-lab problems when you arrive.
- Start the experiment and go as far as you can. Analyze data as you take it whenever you can.

During open lab periods:

- Complete the experiment.

PRE-LAB PROBLEMS

The lab manual for each experiment includes problems to help you design your experiment and learn the theory. The problems are due in the lab before you begin work on the experiment. It is essential that you do the pre-lab problems and read the write-up before your lab section. Otherwise you will not be able to make good use of your time in the lab, which is your main opportunity to get help from your instructor. We recommend that you solve the pre-lab problems in your lab notebook and then hand in a copy. This way you will have your calculations available while you work on the experiment. You will work with a partner in the lab, but you should do the pre-lab problems independently. Solutions to the pre-lab problems will be posted on the web site after all lab sections have met.

LAB REPORTS

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. A typical report will be three to six pages long. 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. 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.

Data plots are one aspect of the lab report that merits 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's characteristics, think about what data you should take 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 take the data in the lab,10-30 measurements is usually sufficient for a meaningful plot. Choose data points to cover the range uniformly on the plot. Then go back and take more data where something "interesting" is happening in the circuit characteristics.

PROJECTS

The last four weeks of the semester are devoted to projects. You will use the skills you have learned to explore a topic of your choice. Pick something you are excited about! 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.

TEXTBOOK

The main textbook for the course is Horowitz and Hill, The Art of Electronics, 2nd edition, Cambridge University Press (1989). This is one textbook that you will use long after the course is over. The approach taken by the authors is highly practical, with a minimum of analysis. They teach you to think about electronics the way practicing engineers think about it. See the reading list for several other texts that are on reserve in the library. We especially recommend the two books on the reading list by Jim Williams. These are not really textbooks, but much of the material is elementary (some is not), and there is a lot of culture in these books – how scientists and engineers think about electronics and what their working conditions are like. Also, do not dismiss the three 'cookbooks' on the reading list. They were written by experts in the field.

LAB NOTEBOOKS

Whenever you work in a laboratory it is essential to keep a record of your experiments in a bound lab notebook. The purpose of your lab book is to document your experiment clearly and accurately. The usual guideline is that you record enough so that you could reproduce the experiment without too much difficulty a year later. It often happens that a result must be reproduced in the light of new information or criticism.

Your lab book will not be graded directly. Your instructor may want to see the original data in your lab book when trying to help you diagnose problems. If you are reading instruments while your partner is writing down the data, it is all right to make a photocopy of the data immediately after you leave the lab and paste or staple it permanently in your own book.

The notebook must be bound, not loose-leaf, and it should contain graph paper, rather than lined writing paper. If you ever forget to bring your notebook to the lab and use loose sheets instead, be sure to staple these into your lab book as soon as possible. Do not tuck loose sheets into the notebook. If you rely on photocopied pages from data books, pages copied from instrument manuals, or any other loose materials, staple them into your book. Make all entries in pen, not pencil, and put a single line through errors, so the text or data can still read if you later decide it was correct after all. Enter all data, text, and calculations directly into the lab book. Do not use loose sheets!

Entries in a lab notebook do not have to be neat, but they have to be readable, and some organization is very helpful. Reserve the first few pages for a table of contents, and keep it up to date. Enter the date 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 give day or a given experiment.

MIDTERM EXAM

There will be a one-hour Midterm Exam given on Tuesday, November 16, 1:00-1:50 pm (in G-2B47). This exam will primarily focus on the theoretical material covered in the lecutres as well as some practical knowledge that you are expected to have gained from the lab work.

GRADING

The grading will be based on a maximum of 700 points. Each of the 9 regular lab reports is worth 40 points (there is no report or pre-lab for the first lab). The 9 pre-lab problem sets are worth 10 points each. Your final project will be worth 150 points: 25 points for a project proposal, 50 points for your final project oral presentation, and 75 points for your final report. The one-hour midterm exam will be worth 100 points. Late work will be graded at the discretion of your instructor. There will be at least a 10 point penalty per week when a report is late. No pre-lab problems will be accepted after the solutions are posted.

LAB RULES

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, lock the door, and turn out the lights. Never prop the door open. Anyone who has authorization to use the lab should already have access. The equipment is expensive and it would be very difficult to replace.

Before you leave the lab, clean up your mess. Your bench top should be totally cleared except for the oscilloscope stand, toolbox, and multimeter. 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.

Faults or damage that occur to any instrument or non-trivial component should be reported to an instructor or to Michael Thomason (his phone number is posted in the lab). Label the offending item with a tag stating the nature of the fault to help us with repairs.

DISABILITIES

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

OBSERVANCE OF RELIGIOUS HOLIDAYS AND ABSENCES FROM CLASSES AND/OR EXAMS

Please inform your instructor, at least two weeks in advance, if any of the class activities, including the labs, lectures, exams, or final presentations, fall on a religious holiday that will preclude your attendance. Generally, it is straightforward to make-up for lab absences, but we should be aware of any reasons for absence from any particular session. If you have a conflict with the exam or final presentations, please let your instructor know as soon as possible so we can make accomodations.

HONOR CODE

The University of Colorado at Boulder Honor Code applies to all your work in this class. In the case of a lab course, in the lab exercises you will be working with a partner, with whom you will share notes and data. However, in submitting a lab report, you are asserting that you were a full participant in doing the work presented the lab, and that the data you present were taken by you and your lab partner. For the lab reports, a written honor code pledge is not necessary, but the honor code applies nevertheless. Fabrication of data, copying of data from another group, or wholesale copying of data from your lab partner when you were not a participant in the actual construction, testing, and taking of data are all honor code violations. The exam will include the honor code pledge that you must sign. The presentation and final report must represent your work, citing other sources of material appropriately.

Equipment at each Work Station

INSTRUMENTS

1	Oscilloscope, 100 MHz, 4 channel digital, Tektronix TDS 3014B
1	Power Bin for plug-in units, Tektronix TM504
1	Counter-Timer, to 100 MHz, Tektronix DC504A
1	Function Generator 15 MHz, Agilent 33120A
1	Dual DC Power Supply 30V 2A, 5 Volts, Tektronix PS280
1	Digital Multimeter - Fluke model 77

ACCESSORIES

1	pair needle nose pliers
1	pair wirecutter/stripper
1	small screwdriver
2	BNC coaxial L connector
5	BNC coaxial T connector
1	BNC coaxial 50 Ω terminator
1	BNC male to male adaptor
1	BNC female to Banana male adaptor
1	Minigripper test clips to BNC female