Physics 321 – Electronics Laboratory – Fall 2018

Lecture:	Tuesday & Thursday, 1:00 – ∼2:15 AM, Crow 206
Lab:	Tuesday & Thursday, ∼2:20 – 5:00, Crow 302
URL:	http://physics.wustl.edu/ClassInfo/321/

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Textbook (optional): Robert E. Simpson, *Introductory Electronics for Scientists and Engineers*, 2nd edition, 1987 (Prentice Hall) and in class notes.

Other useful references:

- Horowitz and Hill, *Art of Electronic*, 2nd edition, 1989 (Cambridge)
- Sedra and Smith, *Microelectronic Circuits* 5th edition, 2004 (Oxford University Press)

This course will cover the practical application of analog, digital, radio frequency and mixed signal electronics to experiment in the physical sciences.

The topics to be covered include:

- Passive circuit elements: resistors, capacitors and inductors.
- Voltage dividers, input impedances, output impedances and Thevenin equivalent circuits.
- Basic circuit analysis.
- The operational amplifiers as a useful black box: opamps as amplifiers, integrators, summers, buffers, and oscillators.

- Complex impedances, passive and active filters, Fourier transforms, power.
- Circuit design and simulation using Multisim.
- Diodes as rectifiers, mixers and building blocks of DC power supplies.
- Radio transmitters and receivers, mixers, and detectors.
- Electro-optical devices.
- Electromechanical drivers, interfaces.
- Transistors as amplifiers, buffers, switches, voltage controlled current sources and voltage controlled resistors.
- Oscillators, monostable circuits, one-shots, and flip-flops.
- Counters, timers, pulse width modulation and fun with the 555 counter.
- Digital to analog conversion and analog to digital conversion.
- Digital electronics and computers.
- Transmission lines, waveguides and antennas.
- Electronic music, low-noise amplifiers for biomedical applications, microcontrollers, and other fun projects!

It is impossible to teach both a lecture course and lab course covering all of electronics in a one semester course, but I'll try anyway! This means that it will be important for you to attend all of the lectures and take good notes, in addition to doing the lab work. Rather than boring you with detailed models of components and mind-numbing measurements of transistor curves, I'll attempt to help you to learn some practical debugging and design skills and some useful mathematics to understand circuit theory. The core of the course will consist of completing a series of assigned labs for which you are expected to keep notes and summarize results in a lab notebook. *For you to learn from these labs, you will need to complete reading assignments prior to the lab.* After you complete the assigned labs, you will work on a final project. You may choose to undertake your own independent project or to join with other students in a group design project, but you will be required to turn in your own final lab writeup. Throughout the semester, you will also be given a number of short in-class exercises (like open-book homework or quizzes) to make sure you have been keeping up with reading and are making an effort to understand the material presented in class.

Grading:

You are required to keep a well organized laboratory notebook describing the work you have done for each lab. Notebooks will be collected on Fridays following the completion of a lab, and returned at the beginning of class the following Tuesday. If you need information from your lab notebook during the weekend, you should make photocopies of the relevant sections of your notebook. You are expected to take good notes during the lectures, and should

keep a separate notebook for this purpose. This notebook and your textbook can be used to assist you in solving any in-class exercises. I also encourage you to discuss your work on these exercises (or on the labs in general) with your class-mates, but ultimately the work you turn in must be your own. Your grade will be based 40% on your lab notebook grade, 20% on your performance in the lab and on *attendance*, 10% on in class exercises and 30% on your final project.

Lab Notebook: I recommend that you obtain a "computation notebook" (with brown cardboard covers, and numbered graph-paper pages). While somewhat expensive, these are particularly useful since they have pages slightly larger than 8 1/2×11 allowing you to cut and paste pages into your notebook (e.g., data sheets, figures, etc.). While the entries of a lab notebook are more free-form than a final report or paper, you should format your notebook according to the following guidelines (and will be graded accordingly):

Final Project: For your final project, you will be required to turn in a formal write-up (in the style of a short journal paper) by the end of reading period. Details about the format of this writeup will be distributed in class in the latter part of the semester.

Your entries in your lab notebook should have the following sections:

1. *Introduction:* Each lab should start with an introduction with the lab number, title and a brief description of the experiment. It is usually a good idea to either cut and paste the circuit drawing from the lab handout into your notebook, or redraw the circuit with labeled components, for reference later in your notebook. You should begin writing this introduction before you start since it will help you to collect your thoughts and get organized (15 pts).

2. *Data:* Record all raw data as it is taken, without being overly concerned with anything other than a chronological organization of this information until later. Here you should include data in all forms that you think appropriate (include sketches of the lab setup, sketches of oscilloscope traces, tables, plots, computer print outs etc.) Throughout the notebook you should date your entries, and include the initials of your lab partner (or others) who worked with you on that particular day. In this section, you should make drawings of parts of the circuit and keep a record of any modifications you make along the way, or any circuit analysis that is done even scratch calculations (e.g., calculating RC time constants, performing a network analysis) (40 pts).

3. *Results:* Summarize key data in neat tables and graphs and key calculations done as part of the circuit analysis. If you are performing a circuit analysis, please show your work including a definition of the symbols used in your calculations, a justification of any approximations used, and intermediate steps in your calculation. If you try different methods along the way to getting the correct answer, it is important that you restate the final, correct methods and calculations in this section. Make sure that you provide answers to any explicit questions in your lab writeup (15 pts)

4. *Conclusions:* When you have completed all of the lab work, finish your lab notebook entry with a summary including a qualitative and/or quantitative analysis of the circuit describing in words and equations how the circuit worked (or didn't work), what you learned and what you might have tried if you had more time. Most importantly, you

are expected to do some form of circuit analysis even if you are not explicitly asked. Think of this section as notes to your future self, when you look at your notebook years later and try to understand what you had done (25 pts)

5. Neatness = success in the lab. I can't overemphasize how significant the correlation is between neat circuits, neat lab benches, neat notebooks and successful results. Points will be deducted for messy lab notebooks (5 pts)

Note: Each student is responsible for returning all electronic components and equipment to their proper drawers and cabinets before they start the next lab experiment. Points will be deducted from your grade if you don't!