Electronics for Scientists   Phys320L

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Text: Basic Electronics for Scientists and Engineers, Dennis Eggleson

1 Academic Integrity

1.1 Official Paragraph

By enrolling in this course, each student assumes the responsibilities of an active participant in UMBC's scholarly community in which everyone's academic work and behavior are held to the highest standards of honesty. Cheating, fabrication, plagiarism, and helping others to commit these acts are all forms of academic dishonesty, and they are wrong. Academic misconduct could result in disciplinary action that may include, but is not limited to, suspension or dismissal. To read the full Student Academic Conduct Policy, consult the UMBC Student Handbook, the Faculty Handbook, or the UMBC Policies section of the UMBC Directory.

1.2 Electronics 320L Rules

In this course, I encourage collaboration to help clarify difficult concepts. There are lines that can't be crossed however:

- Under no circumstances are you to copy or paraphrase answers from another student's assignments
- Do not use previous year's assignments in any way.
- Falsifying lab data will not be tolerated.
- No collaboration of any kind can occur during quizzes or exams.

There are still many ways in which collaboration can be very helpful:

- Ask other students to explain concepts rather than answers. One particularly useful way to explain concepts is to share an example problem with a slightly different configuration than the assigned problem.
- Ask other students clarifying questions about the interpretation of a problem or a laboratory procedure.
- If you gain insights to a problem or a section of a lab from another student, give a short credit (for example, "John Doe helped by explaining…").

Also, I understand that there are many answers that can be found on the internet, or in the libraries on campus. Please use these sources wisely. If you find answers or get help from other sources, please reference that source.

2 Philosophy

This is one of the first laboratory courses that you take that is not a straightforward "cookbook" variety. Although each lab has a set of steps that you are to follow, many times things will not seem to work out correctly on the first attempt. At times, you may feel as if you are not sure what to do next. First, you need to carefully read through the lab ahead of time and answered some of the questions before you get started. In some instances, there will be a quiz prior to a lab to ensure you have done your pre-lab work. It is great to know where you are headed before you start down the road. Please take your time and think through what you are trying to accomplish, usually by sketching what it is you plan to do. Remember, there is a reason why the lab class time is four hours, so you have the time to work through your difficulties.

Something that you will find very useful is one of many free or inexpensive circuit simulators that are available on the internet. They can be used to check your homework solutions and to understand what may happen when you build your circuit correctly in the lab. In many instances, I will be asking to see some simulations performed before the lab class, to ensure you have adequately prepared for the lab. For this course, I would like you to use CircuitLab, which is available at (surprise) http://www.CircuitLab.com. It is very easy to use, and it is either free or cost $12. If you need any basic help using it you can contact me, but I believe that you will be able to handle it on your own. If you buy a student version, you should set up an account there so you will be able to save and print your circuit's simulations.

This course serves to introduce you to the principles of electronics, primarily from the standpoint of a user. You will be introduced to a number of standard electronic instruments and techniques and gain enough background to design simple circuitry of your own. If you do work in experimental science, it is likely that some part of your research will involve instruments that turn real-world physical quantities (temperature, pressure, acceleration, light intensity) into electrical signals that can be measured, recorded, or maybe used in some sort of process control (e.g. turning on and off a laser or a vacuum pump). While many labs use commercial electronics modules for data collection, you may still need to bias a detector and amplify or filter its signal before connecting it to a commercial data-acquisition module. Or perhaps your lab's existing commercial module has a spare output that can be switched on or off under computer control, but you need to amplify that output with a circuit that can provide enough current to drive the stepper motor that moves your experiment back and forth on the tabletop. Understanding the building blocks of electronics can give you more flexibility in how you carry out experiments in your own research.

The overriding goals of this course are to make you comfortable working with electronic circuitry and familiar with various electrical measuring devices. You will learn the basic skills necessary to troubleshoot more complicated circuitry. Basically, electronics is problem solving. Generally, the more organized you are in your layout of circuits (including color-coding wires, etc.) the less trouble you will have both in the initial setup of your circuit and any necessary troubleshooting. It is best to be methodical in your approach. You can get shocked by some of the circuits we will build. But thus far, no one has been severely damaged by any laboratory mishaps, and I plan to keep it that way. Some electrical components can get hot and overloaded integrated circuits (IC's) have been known to fail catastrophically. Be sure you know what you are doing before you turn on the power to your circuit or ASK FOR HELP. You are encouraged to experiment in this lab. The fun thing about electronics is you can go into the lab and test out any circuit you can dream up. Although there is an awful lot of microscopic theory behind the operation of each component, in the end, you can go into lab and use macroscopic devices to test any circuit's operation. I also encourage you to provide any relevant feedback regarding lectures, quizzes, homework, labs, etc. The course is under constant revision to make things more clear and to improve your understanding. I'm always learning, too, and appreciate your comments.

3 Class Structure

- One-hour lectures are scheduled every Tuesday and Thursday
- A four-hour laboratory will be held Tuesday afternoon
- Regular problem sets and laboratory reports will be due, as noted
- Quizzes will be held in either the lecture or the lab
- A standard written mid-term and a laboratory practical final exam

We will not always be able to keep the class work in sync with the labs, but I will make every effort to do so. If not, you will have to read ahead to keep up. It is your responsibility to have read the relevant Chapters and Labs each week so you are prepared for the lectures. There is always the possibility for a quiz to ensure you are prepared. The labs are posted on the Blackboard website, with the homework assignments. The lectures will be posted on the website within a week after the lecture.

4 Grading

On each assignment, quiz, and exam, I determine the points necessary for a specific letter grade. These points will be translated into a scale where 90, 80, 70, 60 correspond to A, B, C, D respectively. Then final grade is assigned as A: 90, B: 80, C: 70, D: 60, F: <60.
The apportionment of the grade for the class is:

Homework: 15%
Mid-Term (March 15): 15%
Class Work (quizzes, etc.): 5%
Final Lab Exam: 15%
Lab Reports: 50%

Students have a period of one week to dispute any grading mistakes on returned work. After one week, grades on an assignment are final.

5 Introduction

The vast majority of laboratory measurements are based on electrical measurements. Somehow a physical variable is transformed into a current, voltage, resistance, etc. An example measurement that is not electrical would be the recording of a visible spectrum on photographic film. Most spectroscopy was originally done this way. But today, you can perform far more sensitive spectroscopic measurements with CCD's, photomultipliers, etc! You will learn how to use basic instruments including:

- Voltmeter/Ammeter
- Oscilloscope – analog and digital
- Function Generator
- Power Supplies and how to understand the role of discrete components in circuits, such as
    - Resistors/Capacitors
    - Diodes
    - Transistors

You will then "graduate" to more "black box" components such as

- Op Amps
- 555 Timers
- Multivibrators, etc.
- Digital gates (NAND, flip-flops, counters . . .)
- Medium level integrated circuits

You will have one lab that introduces you to LabView, one of the most popular instrument control systems. In this lab, you will repeat some previous work using the lab computer as a function generator and as an oscilloscope, and controlling the experiments with the lab computer. Subsequent labs will make use of LabView to supply signals, extract data, and control the equipment. Also, we the last lab will encompass building a bias supply/preamplifier circuit for a semiconductor photodiode and measuring the systems characteristics.

6 Homework

Homework assignments can be found on the course Blackboard website under the *Assignments* tab. These are due at Thursday at the beginning of class, unless otherwise noted. All problems are from Eggleston, <u>Basic Electronics for Scientists and Engineers</u>, unless otherwise noted. No late homework assignments will be accepted.

7 Labs

Lab sections will be held each Tuesday afternoon, unless otherwise noted on the course website. Never be alone in the lab – this is dangerous and will result in a zero for your most recently graded lab report! The lab report is due one week after the lab is performed, at the beginning of the lecture on Tuesday before the next lab class.

Bring a copy of the lab you are doing that week to the lab, with notes you have made on the lab. These can include simulation results and in the later labs, circuits that you have designed.

Data and other work that you do during the lab should be written onto these lab sheets in ink, and any changes should be made by crossing out the incorrect data and entering in the new data. Each person should have his or her own lab sheets.

When you hand in the lab (the next Tuesday at the beginning of the 11:30 lecture) you should have the newly typed, neat lab on the top, and the original hand written work on the bottom, with all of it stapled together.