Physics 323 Electronics

Sept. 2012

The following laboratory exercises have been designed to illustrate and enhance the class material and to familiarize you with simple lab equipment and lab practice. As far as possible, the material covered in the lab exercises will have already been presented to you in class, i.e. the labs and lectures are in step but some things which are basically a review we will cover in lab before lecture. All principles presented, circuits demonstrated etc. in the laboratory are considered examinable material.

LAB EXERCISES (and the expected schedule)

Sept. 11 *Lab (1) Introduction to Laboratory Equipment*

Goal: To re-familiarize yourself with the lab equipment: Power supply, oscilloscope (CRO), digital multimeter (DMM), breadboard.

Sept. 18 *Lab (2) RC Circuits (filters)*

Goal: To re-familiarize yourself with frequency dependent circuits that rely on the capacitor.

Sept. 25 *Lab (3) Operational Amplifiers I (Negative Feedback)*

Goal: To demonstrate the very important concept of negative feedback using the 741 operational amplifier. To examine amplifying, integrating and differentiating circuits.

Oct. 2 *Lab (4) Operational Amplifiers II (Positive Feedback)*

Goal: To demonstrate the behaviour of a comparator, Schmitt trigger, and a Wien-bridge oscillator which employ positive feedback.

Oct. 9 *Lab (5) Semiconductor Diodes*

Goal: To measure the forward and reverse characteristic of a semiconductor diode and to demonstrate circuits that use diodes.

Oct. 16 No lab; midterm on Oct. 17.

Oct. 23 *Lab (6) Characteristics of a Bipolar Junction Transistor*

Goal: To measure the input and output characteristics of a transistor to be used in the design of a small signal audio amplifier.

Oct. 30 *Lab (7) Transistor Biasing*

Goal: To design and test different DC bias circuits using the characteristics of the particular transistor examined in lab (6).

Nov. 6 *Lab (8) Small Signal Amplifier*

Goal: Using the results of the two previous lab sessions, to design and test a small signal amplifier satisfying certain criteria.

Nov. 13 No lab; midterm on Nov. 14.

Nov. 20 *Lab (9) FET Characteristics and Circuits*

Goal: To measure the characteristics of a Junction Field Effect Transistor (JFET) and to demonstrate its properties through examination of several circuits.

Nov. 27 *Lab (10) Digital Circuits*

Goal: To design and test simple combinational and sequential logic circuits.

LAB PROCEDURE

Lab Protocols

You will perform all lab exercises on your own - there will be no lab partners. All your preparations for the lab (the prelab) and the actual work done in the lab must be recorded IN PEN in a laboratory notebook. Data, together with error estimates, should be recorded in table form. You should practice and form the habit of recording observations in your lab notebook in

a reasonable, logical and neat manner. If you make a mistake you should cross it out with a single line and as appropriate indicate why you have crossed it out. Your lab notebook should be a complete record; another person should be able to repeat your experiment without having to refer to any other source of information other than the lab handouts. In the 'real world' (i.e. industry, graduate school etc) your lab notebook is a legal document; it may be used for patent applications, proving 'who did it first' etc. If you plot a graph on a separate sheet of graph paper, you must securely attach it to a page in your lab notebook. Separate loose sheets of paper will not be tolerated and will not be considered part of your lab record, i.e. you will not receive any marks for information recorded or presented on unattached sheets of paper. In light of this, it is preferable, but not absolutely essential, that you use a notebook which contains graph paper.

Lab Clean-up

This term the electronics lab 1079 will be used multiple times per week! It is essential that you leave your lab area when finished as clean as when you found it (the exception is labs 6-8 where you *need* to keep the same transistor each week). Please try and put the resistors and jump wires back in the correct trays.

Lab Preparation

Solid preparation for each lab session is absolutely ESSENTIAL. The minimum preparation required is the completion of the Prelab exercises which are due at the beginning of the scheduled lab period. Show the Prelab work to the lab supervisor/professor when you come into the lab session. It is impossible to complete the lab exercises in the allotted time if you are not prepared.

Lab Sessions

The lab period is three hours long and starts promptly at 2:15 pm. You should be able to complete the lab in that time period if you are well-prepared. Under no circumstances will the lab be open beyond 6:00 pm. Only under exceptional circumstances and with permission of the professor

will you be allowed to complete a lab exercise at a time outside the scheduled lab period. You will only receive credit for those parts of a lab exercise that you have completed.

You may expect that your lab notebooks, which will be handed in Thursday morning, will be graded and available for pick-up on Monday. If you are concerned about privacy I can give them back to you individually but otherwise I will leave them on the shelf outside my office.

Helpful Hints (for getting the labs done on time)

Study the lab description carefully and try to UNDERSTAND it as soon as possible. Do not leave preparation for the lab session to the hour before. Early preparation gives you an opportunity to ask questions in class and in visits to the professor's office. The more you understand before you do the lab exercises the more you will learn from them. You often get a deeper understanding of a lab exercise if you analyze your mistakes and try to figure out why things turned out to be different in the lab from what you originally assumed.

Formal Lab Report

The lab exercises on the Bipolar Junction Transistor [Labs (6)-(8)] will form the basis of a formal lab report which is due Nov. 19. These three labs will be written up in one coherent lab report, including all graphs, calculations, etc. from the three sessions. It will be written up in the style of an article submitted to a physics journal. The basic format of such a report is: Abstract, Introduction, Theory, Experiment, Results, Discussion, Conclusions.

Lab Grading

Your formal report will constitute 30% of your lab grade. Labs (6)-(8) will not be marked in your book. Each of the remaining 7 lab exercises will be given equal weight and account for the other 70% of your mark. In each lab one-third will be assigned to the prelab exercises and two-thirds to the lab record in your lab notebook.

The total grade for the laboratory component of this course will account for 35% of your overall course grade. It is necessary for each student to pass the lab component of this course in order to receive a passing grade for the course.

Concise, clear answers to the questions in the prelab and lab exercises will be emphasized in grading. For maximum credit a brief justification of your answer should be included. We are interested in why an answer is correct in addition to the correct answer.

Academic Honesty

You are expected to write up your prelabs, lab record and formal report on your own. Students who cut corners will be severely penalized. It will become apparent during a lab session which students have prepared for a lab session properly, i.e. have at least completed the Prelab exercises on their own. The regulations on cheating and plagiarism (Academic Calendar, Section 3.8) cover assignments as well as examinations and quizzes. These regulations will be enforced for all aspects of this course including the lab component.

LAB SAFETY

I admit that there are very few things in the lab that will be directly hazardous to you (unless you stick a screwdriver in the wall but I assume you learned that already!) We will not be dealing with any voltages over 30 V so there won't be any shock hazards to you. *However* various components and instruments are susceptible to fire, explosion (!), melting, and just breaking. I try to highlight that in the individual lab descriptions but here a couple of things to always keep in mind:

1. *Avoid short circuits* (this is when stuff melts, smokes, gets really hot)
    a. Don't carelessly plug stuff in.
    b. Remember the extra "grounds" that come from oscilloscopes and function generators.
    c. Think before plugging in the AC transformers!

d. Diodes (including LEDs) have a very low forward-bias resistance. There should be a resistive load in series to prevent currents over 100 mA.
e. Op-amps have a "virtual ground" at one of their inputs when the other input is grounded. Again use a safety resistor. The output of a comparator can also go to ground; make sure a power supply isn't directly connected!
f. Remember an ammeter (a digital multimeter measuring current) is essentially a short circuit.
g. There are voltage and current limits given in the component data sheets.
h. Very quickly disconnect/turn off the power supply if you suspect a short circuit.
i. If you suspect something is hot resist the temptation to grab it. You will just burn yourself! (can you imagine how annoying this lab would be with burned finger tips?). See item h.

2. *Respect the polarity of electrolytic capacitors:* the negative terminal is marked and should always be kept at a lower potential than the positive terminal. Otherwise they explode! (A redox reaction destroys the insulating layer.) The electrolytic capacitors are the ones that look like little cans.

3. *Some of the integrated circuits are susceptible to static electricity:* I haven't had too many problems with this since we don't use a lot of CMOS (complementary metal-oxide- semiconductor field effect transistor) circuits. If you ever do see CMOS gates they will usually be mounted in some kind of conductive foam and you will need to make sure you are discharged and all of the pins are connected to something.

4. *Don't worry: stuff breaks!* I am more concerned about you and your education. All of these things wear out. If something is broken either throw it away or let me know. *But* do take a few seconds to think about *why* something broke or you may break several things in the exact same way.