Fall 2018

Advanced Experimental Techniques – Physics 492

Rules of the Road

(Plagiarized and adapted from the MIT Lab)

1. Usual Motivating Paragraph

The purpose of the two-semester Advanced Experimental Lab (Physics 492 – 493) is to give you hands-on experience with some experiments of modern physics and, in the process, to deepen your understanding of the relationship between experiment and theory. However, this first semester will primarily be spent honing your skills in electronics, learning how to take and organize data, and understanding how not to get hurt in the lab. By the end of this two-semester course you will have learned how to *act* like a scientist: that is, how to keep a real lab notebook, present your results to your peers, and write a clear scientific report,

2. The Basics

a) Flying solo

You will usually work by yourself; each student will have his or her own lab station. For some of the physics experiments you will pair up and work as a team.

b) Class website

Our class will use Blackboard. All the assignments as well as your pre-lab answers will be transmitted via Blackboard.

c) Textbook:

Paul Scherz and Simon Monk, "Practical Electronics for Inventors, 4th Edition"

Here's the link on Amazon: Scherz and Monk, 4th edition. The paperback edition costs about $20. DO NOT BUY THE KINDLE EDITION! This textbook has not been ordered by the USC Bookstore.

d) Preliminary questions

Each of the lab experiments and some pre-lab questions will be published on Blackboard before you perform that lab. You should read the lab description, as well as the posted pre-lab questions, and answer all those questions via Blackboard. You must post your answers on Blackboard before 7 pm on the day ***before*** of the first session of each experiment. Each student must separately work out the answers to the preparatory problems; this is not a group effort. Some of the questions are not so easy, so give yourself sufficient time.

You can write your solutions carefully and legibly by hand and then convert them to a pdf file, either with a scanner or by taking photos with your iPhone and then converting those photos in to a **single** pdf file using a scanner app. Do not simply submit photos of your answers; the contrast will be too poor. Instead you should download the free app CamScanner, and then use it to convert your crappy photos into a single, high-contrast pdf file. Alternatively, you can compose your answers in Word and then print to a pdf

file. In either case, you should create a **single pdf file** of your answers (**no Word or jpg files, please**), and post that file on Blackboard. Be sure that the pages themselves (and not just the file name) contain your name, date, and magic number.

Prof. Feinberg will read your posted pdf solutions before your lab session. When you arrive in the lab that day, bring a copy of your solutions with you. **Prof. Feinberg will discuss with each of you your solutions to the preliminary questions at the beginning of that class. If your solutions are satisfactory, then you can begin work on your experimen**t. However, if you failed to post your solutions to Prof. Feinberg the previous evening, or if your solutions are hopeless, then you will not be able to begin your experiment in the lab that day. You will be labeled as a slacker, and your grade in the course will suffer.

3. Laboratory Notebooks

A critical objective of this course is to teach you how to organize and record your thoughts and your data in a laboratory notebook. To this end, you will use only the VWR Laboratory Notebook 89005-136 provided to you. No other notebook is acceptable in this course. You will never use scratch paper for anything. Your Laboratory Notebook will record all your ideas about what you are doing, all your data, all your calculations, all your plots, all the problems you encountered, and all your frustrations with your results.

Your Laboratory Notebook must tell a story: What you are trying to do; what you did; and what results you obtained. You must write a sufficiently clear narrative so that, years later, you will be able to understand the results you obtained and not wonder what you were doing or why you did it. Notes, tables, and graphs should be neat and compact, leaving as little empty space in the lab notebook as is compatible with clarity and the logic of organization. The lined paper in your Laboratory Notebook is convenient for making tables, and for guiding line drawings and making rough plots. High-resolution plots, photos, and Xerox copies should be glued or taped in place. There should be no loose sheets or graphs floating around.

Your grade in Physics 492 will be determined primarily by the quality of your Laboratory Notebook.

Your Laboratory Notebooks will be left in the laboratory at the end of the day. You cannot take them home to work on them, so you must make time during the lab to write in them. At first it will seem bothersome to write the introductory and summarizing sentences in your Laboratory Notebook. It will seem bothersome to make clear sketches. It will seem bothersome to write neatly and carefully. Nevertheless, you will do all of this during the lab, and eventually you will be proud of the magnificent notebook you have created.

4. Ethical Behavior

The purpose of Physics 492 is to give you hands-on experience with electronics, a sense of the reality of the concepts and theories you have studied in books and lectures, and the beginning of professional skill in obtaining and recognizing reliable data and extracting

meaningful results from them. Whatever is the outcome of an experiment, you must tell exactly what you observed or measured, regardless of how "bad" the results may appear to be.

Whenever you read the report of a physics experiment in a reputable journal, you generally assume that it represents an honest effort by the authors to describe exactly what they observed. You may doubt their interpretation, or the theory they cite to explain their results. But at least you trust that if you repeat their experiments as described, you will get essentially the same results. Nature is the ultimate enforcer of truth in science. If subsequent work proves a published measurement is wrong by substantially more than the estimated error limits, a reputation shrinks. If fraud is discovered, a career is ruined. Therefore, most professional scientists are very, very careful about the records they maintain and the results they publish.

This lab is designed to provide pre-professional training in the art and science of experimental physics. What you record in your lab book and report in your written and oral presentations must be exactly what you have observed, including date, time and who did it. Sometimes you'll get things wrong because of an error in manipulation, equipment malfunction, misunderstanding, or a miscalculation. Simply cross out errors using a diagonal line in your notebook and start again. Don't erase. An example of a well-kept lab notebook will be available in the lab for you to scrutinize.

The instructor's job is to help you figure out what went wrong so you can do better next time. Fabrication or falsification of data, or using the results of another person's work without acknowledgement, are serious intellectual crimes, and are cause for dismissal from USC.

5. Lab Attendance

You are required to attend the lab session for the full three-hour period twice each week. If a medical problem forces an absence, bring a signed medical note when you return. Any exception must be approved by Professor Feinberg. Also, if high voltages are involved, a partner or instructor must always be within reach.

6. Grading Policy

Your course grade will be computed as follows:

i) Laboratory notebook = 50%
ii) Lab attendance and your effort in lab = 30%
iii) Answers to the preliminary questions = 20%

7. Safety

Since it is virtually impossible to set up a reasonably comprehensive and interesting set of experiments in modern physics without using equipment that has potential hazards, it is essential that students be aware of the hazards, and exercise appropriate cautions. Prevention of injury is a matter of being aware of and having respect for pieces of equipment that are potentially dangerous.

High Voltage

- The first rule is never to work alone. Some years ago, a student was electrocuted at MIT by a laboratory power supply. Had he not been by himself, someone might have saved him.
- All high voltage (>30 volts) supplies are dangerous. Do not poke or probe into them. Turn off the supply if you need to change cable connections. The supply may be dangerous even when turned off if internal capacitors have not yet discharged.
- Always keep one hand in your pocket when testing any circuit in which there may be high voltages present so that if you get a shock, it will not be across your chest.
- Never go barefoot in the lab.
- Remember that it is current that kills. A good (e.g. sweaty) connection of 40 volts across your body can kill you as easily as a poor connection at 600 volts. If a fellow student is frozen by an electrical shock, use momentum transfer (tackle them!) to release him or her, and then start CPR if needed and if a trained person is available.

Cryogenics
Liquid nitrogen is chemically inert, but it can cause severe frostbite. Wear gloves and protective glasses when transferring or transporting liquid nitrogen. Also, don't pour water into a vessel containing liquid nitrogen; the water can freeze on top, form an ice plug, and then explode.

Chemicals
Don't ingest them. Clean up any spills immediately. Wash your hands after using them.

Cuts and scrapes
There is a first aid kit in the lab, but please inform Prof. Feinberg as well.

Soldering irons
They get hot. Hot things burn. Be careful.

Shoes
No sandals or flip flops allowed in the lab. Human toes don't grow back.