

PRINCETON UNIVERSITY
Physics Department

Physics 104 Laboratory Manual

Spring 2004

**PRINCETON UNIVERSITY
PHYSICS 104 LAB MANUAL**

Table of Contents

Title	Page
Lab Schedule	iv
Lab Orientation	vi
Experiment #1: Build and use an electroscope	
Experiment #2: Further exploration with your electroscope	
Experiment #3: Resistors, capacitors, DC circuits, and RC circuits	
Experiment #4: Force on a moving charge in a magnetic field; force on a current-carrying conductor in a magnetic field	
Experiment #5: Make and test a motor; demonstrations with the Princeton Cyclotron magnet	
Experiment #6: Become familiar with the oscilloscope and signal generator	
Experiment #7: AC circuits, RC high-pass filter, and RLC resonant circuits	
Experiment #8: Geometric optics: optical instruments	
Experiment #9: Physical optics: interference and diffraction	
Experiment #10: Diode rectifier and transistor AC voltage amplifier	
Experiment #11: Build and signal-trace an AM radio	

DOWNLOAD THE LAB MANUALS FROM THE PH104 BLACKBOARD

LAB SCHEDULE 2004

Remember to turn in your prelab problem set at the beginning of each lab.

Date	Title	Goals	Equipment
February 2-5	#1: Build and use and electroscopes	Hands-on study of electrostatics. Build and calibrate a simple electroscopes.	Electroscopes, electrophorus.
February 9-12	#2: Further exploration with your electroscopes	Measure rates of charge leakage. Find how rates depend on size and shape of material.	Electroscopes, several weakly conducting materials.
February 16-19	#3: Resistors, capacitors, DC circuits, and RC circuits	Use breadboard. Measure resistors in series and parallel. Capacitor discharge.	Breadboard, power supply, resistors and capacitors, multimeters.
February 23-25	#4: Force on a moving charge in a B field; force on a current-carrying conductor.	Measure the electron charge/mass ratio. Measure magnetic force on a current.	Helmholtz coils, electron beam, solenoid
March 1-4	#5: Make and test a motor; Cyclotron demonstrations	Convert electromagnetic energy to mechanical. Experiment with a strong magnetic field.	Permanent magnet, coil, Cyclotron.
March 8-11	<i>No lab</i>	Midterm exams	
March 15-18	<i>No lab</i>	Midterm break	
March 22-25	#6: Oscilloscope and signal generator	Learn to use both items. Use scope to study unknown signals.	Oscilloscope, signal generator.
March 29-April 1	#7: AC circuits, RC high-pass filter, and RLC resonant circuits	Build and measure frequency response of high-pass, band pass, and notch filters.	Oscilloscope, RLC components, signal generator.

April 5-8	#8: Geometric optics	Observe refraction of light. Verify the lens equation. Use lenses to create and magnify images.	Prisms and lenses, simple cameras, magnifiers.
April 12-15	#9: Physical optics	Observe the wave-like nature of light: interference between multiple sources and diffraction from a single small source. Measure emission lines	He-Ne laser, slit-film masks, diffraction grating
April 19-22	#10: Diode rectifier and transistor AC amplifier	Rectify AC signals. Amplify AC signals.	Diode, transistor, scope and signal generator.
April 26-29	#11: Build an AM radio	Study the radio signal at each stage of the radio receiver.	Variable capacitor and inductor, transistor amplifier, diode detector.

The lab schedule runs approximately in parallel to the lecture/precept material, except that the last two weeks of lab return to electronics, while the lectures move to quantum physics.

PRINCETON UNIVERSITY
Physics Department

PHYSICS 104 LAB

LAB ORIENTATION

Welcome to Physics 104 lab! Labs begin on the first day of classes, February 2, 2004. It's important that you go to the lab section for which you signed up. It is even more important that you *go to some lab section the first week* (see Attendance, below).

How to prepare for the first lab:

- Read Experiment I in this book.
- Answer the Experiment I Prelab Problems. Remove that sheet and turn it in to your instructor when you arrive for lab.
- Bring to lab a lab notebook, the experiment description, and a scientific calculator.

Your day in Physics 104 lab:

Physics 104 lab is much like Physics 103/105 lab, except that there are more wires, fewer computers, and no final exam. For example, the principles of error analysis that you learned last semester will be your constant companions again this spring (and quite possibly for the rest of your career).

You will work in teams of two – or occasionally three. You may stay in the same group each week or not, as you choose. Please be flexible about letting others work with you or splitting up your group to make the sizes more even. Be sure that everyone gets a chance to try more or less everything, particularly the procedures that you have to repeat several times. Assembly line work may be more efficient at finishing fast, but it would hinder your learning and eliminate some of those “aha!” moments. Besides, you don't want to finish fast (see Lab Notebooks and Grading, below); you want to finish creatively. Spend some time teaching your partner(s) the things you have understood first, and spend some time learning from them the things that they understand.

From time to time, your instructor will come by your bench to ask questions about what is happening at your station. (You can prevent this by engaging the instructor with your own questions, but this serves the same purpose.) His or her job is to help you learn, which might involve asking new questions not found in the manual, answering your questions, or maybe even *not* answering your questions.

Lab Notebooks:

As in Physics 103/105, you will not turn in formal lab reports. Instead, you will be required to keep a notebook. We recommend the 5x5 Quadrille Ruled book from the U-Store, because it's inexpensive and easily available, but feel free to use any stitched or spiral bound notebook **as long as it has quad ruling** instead of plain horizontal lines.

Each week, **start on a new page and immediately write down the names of the other students on your team.** At that time, the notebook becomes your journal of what happened in lab: sketches and drawings, written observations, equations, numerical predictions and results, et cetera. Be sure you write about things that went badly or counter to your expectations, as well as the things that went smoothly. Please think of the notebook as a journal, and nothing more formal than that. Take time to write complete sentences explaining what you did and observed, and ensure that the journal is easily readable. But there's no point in visually polishing up your results when you could instead spend the time investigating the apparatus in greater detail or trying a new idea.

How much detail should you have in your notebook? Imagine that you will need to read it six months in the future as you build on the current work in a bigger, better project. (Unlikely perhaps, but it will certainly happen to you sometime during your career in science or engineering.) Or suppose that your lab instructor had to read your notes to figure out where you took a wrong turn. You can certainly assume that anyone reading your notebook (including your future self) will have access to the lab manual, so don't bother to repeat the manual in painstaking detail. Include a sentence or two saying which part of the lab you are doing, and then move on to actually doing it.

When your lab period ends, **do not take your lab notebook home with you.** It's not that kind of journal. Your instructor will expect you to leave it on the shelf in your lab room, so that he or she can grade it. This also helps you to focus on preparing for the next lab instead of prettying up your report on the previous one.

Prelab assignments:

You should read the lab manual each week before coming to lab. It is important that you think in advance about what you will be doing and observing. Otherwise, you will waste time catching up and being confused and will certainly enjoy the lab period less. If your lab partner(s) aren't preparing, they will also waste your time, so you should suggest that they start reading ahead.

To help guide your thoughts in advance of the lab, a short prelab assignment is required of you. You will find the problems at the back of each lab instruction manual. Each set is at most two pages long. Many of the questions are quantitative, aimed to help you picture what the lab will be like: what frequency you should expect, or what size screen you will need to observe a set of spectral lines, whether any other effects affect your observations, and questions of that sort. Once you've read and thought about the lab, the assignments should be rather straightforward. They are not supposed to be as challenging mathematically as the course homeworks are.

The prelab assignments are due at the start of your lab. Print your name, date, time and lab instructor's name, and rewrite and sign the Pledge.

Grading:

The focus in Ph104 lab is to give you a chance to try out many of the phenomena that you will merely discuss in precept. Watch the electrons circle through the magnetic field. Make them turn more tightly. Does it really work the way that Tipler says? How did we discover all those laws in the first place? We want you to be creative and pursue our ideas (from this manual) and your own as well. It is not critical that you finish every single item given in this manual. But if and when you do finish, try the optional experiments. If there aren't any listed, or there aren't enough, then you (with the instructor's help) should be able to think of some. Furthermore, it's not important that you get the answer you expect. If you do not, then say so, and try to figure out why. Did you do something wrong? Or perhaps you expected the wrong thing!

In other words, say what you did, and write about what you saw and why. There are penalties for not thinking, but none for getting the electron mass wrong.

Your Ph104 lab grade will make up 15-20% of your final course grade (see Professor Calaprice's syllabus for the definitive figure). The lab grade will be determined from an equal weighting of three parts:

1. Prelab problems (completeness, including short but thoughtful answers to the "word questions")
2. Lab notebooks (completeness of the record, creativity, and—if extreme—legibility)
3. Participation (in the "hands-dirty" and creative aspects of the work)

Attendance:

Your attendance is strictly required each week in Ph104 lab! There is no regularly scheduled make-up lab section. If you must miss a lab because of University-related travel or some other reasonable reason, you need to contact the Ph104 Lab Manager (Kirk McDonald, kirkmcd@princeton.edu) at least a week in advance; he can try to arrange for you to go to a different section that week.

If you are too ill to attend lab, you should contact the Ph104 Lab Manager by email as soon as possible, also to reschedule your lab for later in the week, if that is possible. If you cannot reach him in time, just show up, explain the problem to the instructor, and let us sort out the paperwork later. Illness is not an excusable absence if you do not write the Lab Manager as soon as is reasonable. Being sick on Monday and mailing him the following Thursday would not, for example, be reasonable.

If you oversleep, forget, et cetera, then you should attempt to make up the missed lab for ½ credit later in the week. As with an illness, please contact the Lab Manager to see

which labs have room for you, but at the end of the week, come to a lab even if you haven't reached him. If you forget a Thursday lab or have no free time later in the week, then you are out of luck.

In case you need to make up a lab, there will be labs Monday-Thursday afternoons at 1:30. There will also be labs Monday, Tuesday, and *probably Wednesday* nights at 7:30 (though we may cancel the latter). There will be no Thursday night lab. All 104 labs will be in McDonnell 201 or 202.

One unexcused absence from lab will be detrimental to your *course* grade, reducing it by one full letter. It will not be possible to pass Ph104 if you have more than one unexcused absence from lab.

Lab Manager:

This year's Lab Manager is Kirk McDonald. His office is 309 Jadwin Hall (office hours T/Th 2:30-4:00). Email is kirkmcd@princeton.edu, which is the best way to reach him concerning lab section changes, missed labs, and so forth.