PHYSICS 4L — SPRING 2010
OPTICS, ELECTRICITY, AND MAGNETISM WITH BIOMEDICAL APPLICATIONS

COURSE GOALS: Physics 4L is a one-semester introduction to the physics of light, electric charge and currents, and magnetism. We will focus on developing the basic tools needed to understand several critically important manifestations of this physics in biological and medical systems. We will lay the groundwork for these applications by beginning with simplified, idealized examples, in order to make the underlying ideas as clear as possible. We will then apply those ideas to much more complicated problems when considering biomedical applications.

In this course, we'll aim to develop a deep conceptual understanding of the core ideas as well as mastering the mathematical description. Consequently, you should place a high priority on developing and improving your skills in both rigorous qualitative reasoning and quantitative problem solving. These intellectual skills are useful in a broad variety of fields. I hope that everyone will leave this course able to explain the core ideas both in words and with mathematics.

I will do all I can to see that each one of you in this course gains the knowledge and habits of mind that will serve you well in future courses and in your profession. I will always be available to talk with you individually after class or during the evening problem session. If you would like to meet with me individually at another time, please don't hesitate to make an appointment.

CONTACT INFORMATION

Instructor: **Catherine H. Crouch**
Office: Science Center L39 (NOT L04 — that's my research lab), x8386
Email: ccrouch1@swarthmore.edu
Home: 610/328-7089 (feel free to call between 8 a.m. and 9 p.m.,)

Class hours and location: 11:20 a.m. – 12:35 p.m., TTh, Science Center 199

Evening problem sessions: Thursday, Sunday, and Monday evenings, 7:30 -9:30 p.m. in Science Center 128. I will be present at the Thursday night session. The weekly homework will be due Tuesdays in class.

The problem session will be run clinic-style; come having started the homework on your own. During the problem session, you will work with a few other students on the homework, and the SAs (Emily Hager '10, Elizabeth Mills '11, Erik Smith '10, and Ariana Strandburg-Peshkin '11) and I will be available to answer questions. we will do our best to help you figure out how to do the problems without telling you what to do.

Office hours: Mondays 11-12 and 2–3:30, and by appointment. I will also be at the Thursday night problem session, and you are encouraged to ask questions right after class; I'll stick around until all questions are answered, or until 1:00, whichever comes first! Feel free also to post questions that are of general interest on the web site forums. With 65 students in the class, it helps a lot if you post questions on the web site where others can see them! The SAs can also answer questions there if they are up later than I am. :-)

I do not generally work on Sundays, so if you post questions or send me email asking about individual matters on Sunday, most likely I'll reply as promptly as I can on Monday. If an emergency arises in the evening or on the weekend for which you need my input, you are welcome to call me at home (610/328-7089) before 9 p.m.

Finally, if you feel that you regularly need help going over the material in detail after class, I have recommended a number of tutors to Ruthanne Krauss in the Dean's Office. Please let me know if you request a tutor through the Dean's Office and also let me know if you are finding your tutor helpful.

Lab instructors: Catherine Crouch (Wednesday and Thursday)
Mary Ann Klassen (Monday and Tuesday), mklasse1@swarthmore.edu, SC L36, x8384

Lab hours and location: 1:15 – 4:15 p.m. MTWR, Science Center L03.

EDUCATIONAL STRATEGY

Active learning with ongoing feedback
Learning physics is not simply the acquisition of information; rather, it is developing rigorous ways of thinking, both qualitative and quantitative, that will serve you well in any pursuit, whatever your chosen profession. Studying for this class should never involve rote memorization. (You will have a list of equations for reference during all exams.) What you are asked to do is much harder. but much more rewarding and intellectually stimulating — to master a way of thinking about the world that will allow you to make connections and analyze new situations.

So that we can use class time to best help you develop these thinking skills, you will usually be asked to read the appropriate sections of the textbook before class. This allows us to spend more of our class time actually thinking about the material and discussing it together. I do not expect you to master the assigned reading before class; rather, I expect you to learn enough from the reading that you are familiar with the vocabulary and aware of the important issues, and ready to ask questions about what you don't understand. In class, I will give a brief explanation of the topics covered in the reading, but generally I will explain it from a different perspective; I will almost never simply reiterate what is in your book. We will spend the balance of class time on qualitative examples that you will think about and discuss, and quantitative examples (which are less conducive to small group discussion) that I solve based on suggestions from the class. Finally, most of the biological and medical examples are not included in your textbook at all, so to study those you will rely on your class notes and handouts.

Strategy for success
What counts in Physics 4L is understanding the underlying concepts and using these concepts to solve both qualitative and quantitative problems. If you complete the assignments on time and keep up with the course, you will get the most out of the course both intellectually and gradewise.

COURSE LOGISTICS

Grading: Your grade will be determined by your performance on the problem sets (25%), the labs (20%), the two midterms (15% each), and the final exam (25%).

Exams: There will be two **evening** exams during the semester, **Monday, February 22** and **Thursday, April 8**, both 7:30 – 9 p.m, in **Science Center 101.** I cannot offer alternate times except under the most important of circumstances or true emergencies. If you have a direct course conflict please speak to me no later than the end of the first week of classes. The final exam will be scheduled by the Registrar.

Textbook: The textbook for the course is Richard Wolfson, *Essential University Physics*, Volume II. Volume I was used for Physics 3; you may find it useful for reviewing relevant topics.

Course web site: http://www.seas.harvard.edu/galileo/students/?courseID=2594 will direct you to the web site. The web site is also linked directly to the physics department "courses" web page. All handouts, including solutions for problem sets and tests, will be provided on the web site. You can also ask and answer questions about the course on a discussion forum. To use the web site, you need to enroll the first time you connect, and then log in thereafter.

COMPONENTS OF PHYSICS 4

Reading

As mentioned above, you should plan to read the assigned sections of the textbook *before* coming to class. This will make it possible for us to probe into these ideas more deeply during class. You will probably want to reread the text after class, as part of preparing for lab and doing problem sets. I will announce the day-to-day reading assignments in class, and post them on the course web site.

Learning from reading is a very important skill for physicians and scientists of all kinds; you will probably find yourself needing to read differently than you do for humanities or social science classes. You must do a lot of thinking in addition to reading. The reading should introduce you to the terms and the concepts we will use, and to give you examples of how to use them.

As you read, if there are points that you find confusing, stop and try to write an explanation of the idea in your own words. Often new ideas seem confusing until you try to use them, when they begin to fall into place. However, don't feel that you need to understand the reading completely the first time, especially before you come to class. It will probably take all semester for you to feel that you completely understand the material in the course! So, if you find you can't write an explanation, try to write down a question that, if answered, would help you understand it.

Not everyone learns the same way. While most Physics 4L students find this reading strategy works well for them, if you find that the reading doesn't make sense to you before class, come talk to me and we'll discuss what might work best for you in this course.

Class meetings

During class, we'll focus on the key ideas from the reading. Sometimes we will not explicitly discuss everything from the reading; we will spend our time on the parts that are most important and difficult. In particular, I may not go through mathematical derivations in detail if they are done clearly in the textbook, as the pace at which students can effectively follow derivations varies widely, and I will rarely go through nitty-gritty details like unit conversions. If something is explained clearly and thoroughly in the textbook **do not assume that I will go over it in class in detail.** I will make it clear which parts of the reading are not required.

To help you think about the material during class, and to help me find out what you understand, class will be interspersed with questions. After everyone is given time to think about these questions, sometimes we will discuss the answers all together and sometimes in small groups of three or four. Your answers to these questions will not be recorded or graded, and the questions (with answers) will be posted on the web site.

Studying

Probably you will need to go over the material after class to solidify your understanding of it. One way you might do this: Review your notes or the book quickly, and then see if you can put the book or your notes away and write down the main points in your own words in outline form. Then add the equations that express those important ideas mathematically to your outline. Finally, start on the homework, just using your outline as a reference, or see if you can make up a problem related to those ideas and solve it. (If you prepare these outlines regularly, you will not waste time hunting through your book for equations while you're doing the problem set!)

Asking questions

It is very helpful to me in my class preparation to know what questions students have about the material. It is also very good for your own learning to formulate any questions you have into words. Because the material is usually organized into week-long chunks, I would particularly encourage you to find some time on Tuesdays to think through the material from Tuesday's class, and then if you have questions, post them on the website forums. I will look at those forums on Wednesday as I finalize plans for Thursday's class. (I'll also do this on Monday for Tuesday's class, but we may be more likely to be moving on to a new topic.) In general, posting questions on the forums also creates a record of your questions and my answers that students often find helpful when studying.

Learning equations
Don't spend your time memorizing equations; at the exams I will provide a sheet with all of the relevant equations. However, as you learn the material, you should find that if you understand the underlying principles, then you will remember that an equation exists relating certain quantities, and you will probably even remember it, with the possible exception of a proportionality constant! If you find yourself searching for an equation that relates quantities even after you have completed the homework assignment, you may not be studying and solving problems effectively; I encourage you to come talk to me about your study strategies.

Problem sets
Every week I will assign a problem set on that week's material. The problem sets will usually be due Tuesdays in class**.** On Thursdays, Sundays, and Mondays, 7:30 – 9:30 p.m., there will be help available from SAs and me (on Thursdays only). You should expect that most of the help we will provide is in the form of questions to help you focus your thinking, and ultimately figure out yourself how to approach the problems. Problem set solutions will be available on the course web site and at the end of class on Thursday.

Every member of the class may take advantage of one "free late" problem set during the semester **if arranged in advance**. To do so, **you must email me** requesting permission to use your free late no later than 9:30 p.m. on Monday night (the end of the problem session) **and you must receive an acknowledgement from me** confirming that you can do so. The "free late" permits you to turn in the problem set any time until the beginning of class on Thursday without penalty. The "free late" is intended to give you flexibility if you have an unusually busy week for any reason (you don't have to explain why—it's "free"!); you should be able to anticipate this and request permission ahead of time, and get caught up and back on the regular schedule the next week.

Otherwise, late problem sets will not be accepted except in very unusual circumstances. Please do tell me if you are seriously ill or have a family emergency.

Working in groups on the problem sets is strongly encouraged; practicing scientists and physicians do their best work in conversation and collaboration with others. Here are a few guidelines for working on the problem sets to enable each of you to learn the most you can:

1. Get started on the problem sets as far as possible in advance. Solving difficult problems is like writing; multiple drafts and revisions are an essential part of the process. You also need time to mull over different strategies.
2. Work on each one of the problems alone before working with others or talking to me. (This obviously requires getting started ahead of time.)
3. Write up your own solutions without consulting someone else's solution or notes from a group discussion. If you can't write up the solution independently, you don't understand it.

Problem set solutions that are copied from another student will not receive credit.

"Self-test" problems
Each week's problem set will include a single "self-test" problem that is included to let you assess how well you have learned the material. After you have finished the rest of the problem set, take up to 20 minutes to solve this problem completely on your own, without reference to the book or your notes, just as you would during an exam. You may use the equation sheets for the exams (posted on the web site). These problems will be graded, but the grade does not count toward your homework grade; it is solely for feedback to you. You will receive full credit for a thorough answer to the problem that shows genuine effort.

Laboratory
The Physics 4L laboratory is intended to help you understand the physics you are studying more deeply as well as to give you experience with the instruments used to study these phenomena. It is also intended to give you further experience with keeping a lab notebook and analyzing experimental data. Consequently, your grade will be based on your preparation for lab (30%) and your lab notebook (70%); the lab notebook will include records and analysis of data and written answers to questions designed to help you think about an interpret your results. More details are provided in the lab manual.

WEEKLY SCHEDULE OF CLASSES & LABS

This week-by-week schedule is intended to give you an overview for the semester as a whole. The daily breakdown of reading assignments will be announced in class and posted on the course web site.

Week	Topic	Wolfson	Lab/Tutorials
Jan. 18	Geometric optics: reflection, refraction, lenses, mirrors		none
Jan. 25	Geometric optics: imaging with lenses		Reflection and refraction
Feb. 1	Electrostatic interactions and fields		Optical instruments
Feb. 8	Electric potential, work, and energy		Electric fields and potential
Feb. 15	Dielectrics and capacitors		Mapping electric fields
Feb. 22	Voltage, current, and resistance		No lab (midterm this week)
March 1	Nerve and membrane potentials		Electrocardiography
March 15	Magnetic forces on charges		Voltage, current, and resistance
March 22	Magnetic fields of currents		Discharging capacitors
March 29	Magnetic flux, changing magnetic fields		Magnetic forces on moving charges
April 5	Electromagnetic induction		Magnetic flux workshop (short)
April 12	Electromagnetic waves		Magnetic induction
April 19	Polarization and interference of electromagnetic waves		Polarization
April 26	Diffraction and optical imaging, limits of resolution		Interference and diffraction

MIDTERM 1: Monday, Feb. 22, 7:30 – 9 p.m., Science Center 101, covers material discussed in class from Tuesday, Jan. 19 to Tuesday, Feb. 16 (first 4.5 weeks).
MIDTERM 2: Thursday, April 8, 7:30 – 9 p.m., Science Center 101, covers from where previous exam left off to Thursday, April 1
FINAL EXAM: will be scheduled by the Registrar, half will focus on the remainder of the semester and half will be cumulative.