PHYS 155: The Physics Behind the Internet (Winter 2009)

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Course home page: http://atomoptics.uoregon.edu/~dsteck/teaching/09winter/phys155

This is the primary web site for this course, where news, course notes, etc. will be posted. We will also use the Blackboard system, but only for grades and online surveys.

Schedule: MWF 12:00-12:50, 110 Willamette  
Course reference number: 24279  
Credits: 4  
Prerequisites: no course requirements, but see below

Links: news, course notes, homework sets and keys.

Course overview

The internet is an incredibly vast network, letting people on opposite sides of the Earth communicate in real time and linking them to an enormous quantity of information. But when you type out your favorite emotion in a chatroom, what exactly happens so that someone else far away gets this? By studying fundamental concepts of waves, energy, light, and atoms, we will gain deeper insight into the technology that links the world, with a particular emphasis on communication technologies, rather than the technologies of individual computers. Along the way, we will study everything from radio to lasers to wireless networks to fiber optics.

Required Materials

Calculator: You will need a scientific calculator for this course, and you should plan to bring it to all classes and exams. At minimum, it should be able to calculate sin, cos, exp, and log functions, and of course handle basic arithmetic. Anything satisfying these criteria will do, but for example the Sharp EL531WB BK will work if you want a really cheap one, while the HP 50g will satisfy any cravings your inner nerd might have. There are plenty of choices at the UO bookstore.

i>clicker: You will also need to purchase an i>clicker from the UO bookstore. You will also need to register your clicker on the web at http://www.iclicker.com/registration/ (use your Blackboard user name, the same as your UO Duck ID, and the ID number on the back of the clicker when you register). Contact me immediately if you have problems registering your clicker. You will use this to respond to class polls and to take in-cass quizzes (see the grades section below). You should bring your clicker to every class, and I will expect you to obtain and register one prior to 12 January.

Text: The (required) textbook for this course is Michael G. Raymer, The Silicon Web (to be published by Taylor and Francis, 2009). This book is not available at the UO bookstore, since it has not yet been published. You can purchase a copy from Lulu.com at http://www.lulu.com/content/1043708. The cost is $22.18 plus shipping (about $10.41, depending on the method), which turns out to
be cheaper than UO printing services. So that you can use cheaper (slower) shipping, you should order this book as soon as possible (taking into account the 3-5 day printing time, you should plan to have the book arrive by the end of the second week of class).

I will also post notes for the course (the slides I show in class) on this course web site. Check the news page for updates on when new notes are posted. In general, these notes will be available after the corresponding material is covered in class; so you should still plan to take your own notes during class (the simple act of writing information down will give you a good head start on learning it).

Mathematical Background

This is a physics class. Physics is the discipline of understanding how relatively simple things work. By “simple” I mean things ranging from atoms to lasers to airplanes to the universe (not to mention the internet)—things we have some hope of understanding precisely and in depth.

One of the main aspects of physics that makes it an especially precise and useful discipline is that you can use mathematics to understand how things work. For example, after studying sound waves, you will know that if you yell at the edge of a canyon, you will hear an echo (duh). But armed with a simple formula and a couple of numbers, you can tell how long it will take before you hear the echo, if you know how wide the canyon is. Or, if you want to get fancy, you can measure how long it takes the echo to come back, and calculate how wide the canyon is from your measurement.

As such, you will need to employ some basic math skills—skills you already needed to master to graduate from high school, like: simple algebra (solve 2x+5=0), basic trigonometry (how are sin and cos defined), roots, logarithms, exponents, and how to draw and interpret charts and graphs.

So why bother with all this annoying math? These are the same skills you need to have to balance your checkbook, figure out whether or not it’s worth it to refinance your mortgage, figure out how much raw material you need to buy to build a nice wooden cabinet, or to see whether your investments are soaring or crashing. Further, mastering these skills will develop your problem-solving abilities, as well as your ability to think critically and deeply about just about anything. In other words these are the skills you need to be a functional, self-sufficient adult. Not only will you do poorly in this class if you don’t master math at this level, but you will do poorly in life—so make sure to get help if you need it.

This doesn’t mean that you have to be a math whiz. We’ll review the more “advanced” math concepts as we need them in the course, and we won’t go anywhere near the kind of math you need in an upper-level physics class. However, you’re gonna have to get to know your way around a calculator, and if you’re math-phobic, you’re gonna have to be a bit less math-phobic.

Grades

Grades for the course will be based on quizzes, homework, two midterm exams, and a final exam. The relative weights will be as follows:

- Quizzes: 10%
- Homework: 25%
- Midterm exam 1: 20%
- Midterm exam 2: 20%
- Final exam: 25%

Quizzes: about 2/3 of the classes (chosen randomly) will begin with a short quiz, where you submit your answers using your clicker. The point of the quizzes is to add incentive to do your assigned reading before class, and the questions are designed to be easy if you’ve done the reading (i.e., they won’t test understanding or mastery of the material). In some cases I will post the actual quiz questions here on the web site before class; if I do so, I will post them at least 24 hours before class (monitor the news page for announcements when questions are posted). Also, 25% of your quiz score is based on whether or not you answer at least two clicker questions in class (you get full credit just for answering, whether or not your answers are correct; you
get none for not answering). The point of this is to give you incentive to participate in class. I understand you may need to miss an occasional class; therefore I will drop your lowest 3 quiz scores in computing your final grade (missed quizzes and forgotten clickers count as zero scores).

**Homework:** weekly homework sets will be assigned by paper and on the course web site. Homework is due each Monday at the beginning of class (except where noted), and must be completed before the deadline. I will not accept late homework, so if you’re not done by the deadline then turn in what you have. Each problem set will be assigned at least one week before it is due. Your lowest homework score will be dropped in computing your final grade, so you can bomb or miss one assignment without affecting your grade (whew).

**Midterm exams:** there are two midterm exams, to be held in class on Wednesday, 28 January, and Friday, 20 February.

**Makeup exams:** the exams are scheduled before the beginning of the term so you can avoid scheduling conflicts. Thus, there will be no makeup exams for this course. If you have a serious and documented reason for missing an exam (death in the family, serious illness), your final-exam score will count in place of the exam score. That is, your final-exam score will account for almost double what it would otherwise. Otherwise, you’ll receive a zero score for a missed exam.

**Final exam:** the final exam will be held from 10:15 am-12:15 pm on Wednesday, March 18.

**Pass/fail grading option:** a passing grade requires the equivalent of a C- grade on all course work (quizzes, homework, exams, and final).

**Grading scale:** the nominal grading scale for this course is below. If the final class average is excessively low, I may apply a curve for a higher average final grade. However, you are guaranteed at least the grade listed below on your final average; you are not repeating the others in the class for your grade.

- 97-100=A+, 93-96.9=A, 90-93.9=A-, 87-89.9=B+, 83-86.9=B, 80-82.9=B-, 77-79.9=C+, 73-76.9=C, 70-72.9=C-, 67-69.9=D+, 63-66.7=D, 60-62.9=D-, <60=F

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### Your Responsibilities in this Class

Physics is not a spectator sport. It is an often challenging discipline that requires active engagement on your part—both in and outside of the classroom—for you to learn and do well in this class. If you were learning to play the violin, you wouldn’t get much out of a lesson where you didn’t actually touch your instrument, but just sat and watched your instructor play. Similarly, you aren’t going to learn any physics if I just pontificate for the whole class with you staring at me in a half-asleep daze, drool dripping from your chin.

**Reading:** You need to read the assigned material before each class. This is crucial to your getting any benefit from attending class. Again, we are taking an active approach to learning in this class, and this does not include me reading the book to you in class. (That would be a waste of time, no?) You wouldn’t show up to a literature class without reading the novel to discuss beforehand, and this class is no different. To credit you for reading the material in advance, we will have brief, easy (if you did the reading) quizzes at the start of most classes using your clicker. Note that in class, we won’t necessarily cover everything that’s in the assigned reading—while the exams will concentrate mostly on topics I emphasize in class, anything from the assigned reading is fair game for an exam question. In class, I will review the more difficult and important concepts in class, answer any questions you have, show you demonstrations to illustrate the concepts and help you build a mental model for understanding physics, and finally to test your understanding and help you confront any misconceptions through class polls, which brings me to...

**Participation:** As an active learner, you will obviously need to participate regularly in class. The main way for you to participate will be in the form of “clicker questions,” where the whole class will answer a multiple-choice question designed to uncover common misconceptions about physics, and then we will discuss the question after seeing what the answers are. Remember, you get credit in the form of free quiz points (25% of the total) just for answering at least a couple of poll questions (even incorrectly!) in each class. The responses are anonymous, so you don’t have to worry about anyone making fun of your wrong answer. In fact, if you get the wrong answer after thinking about the question, this is in some sense good: this means you have the chance to learn something! The point is, I don’t expect you to have mastered the material by the time we discuss it in class. But of course, you should master it by exam-time!

I will also be thrilled if you ask questions in class or during office hours. This tells me you’re actually making an effort to learn something. Assuming the in-class questions are actually related to physics and the Internet, just interrupt me anytime. Also, feel free to email me before class if you find something in the reading...
especially confusing. This helps me know what you want to spend class time understanding, and I’d be happy to adjust my lectures, demonstrations, etc. appropriately.

**Attendance:** You will need to show up promptly at the beginning of each class to take (and get credit for) each quiz, and to participate in class. Some of your lowest scores are dropped as I mentioned above in computing your final grade, so this allows you to miss a few classes without penalty if necessary. I won’t distinguish between excused and unexcused absences. I have scheduled the exams at the beginning of the term so you can plan around them; there are no make-up exams for this course. You need to make sure you complete homework on time; since you have plenty of time (an entire week) to work on the homework, I won’t accept any late homework.

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**Syllabus**

This is the schedule of topics we will cover in this course, with reading assignments for you to complete before each class.

<table>
<thead>
<tr>
<th>Monday</th>
<th>Wednesday</th>
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| 5 January  
Introduction and Welcome | 7 January  
Science and Research  
Reading: Chapter 1 (pp. 1-1 to 1-18) | 9 January  
Speed, Acceleration, and Force  
Reading: Sections 3.1-3.2 (pp. 3-1 to 3-13) |
| 12 January  
Newton’s Laws and Energy  
Reading: Section 3.3 (pp. 3-14 to 3-20)  
Homework 1 due | 14 January  
Thermal Energy and Power  
Reading: Section 3.4 (pp. 3-20 to 3-36) | 16 January  
Electric Charge and Electric Fields  
Reading: Sections 5.1-5.4 (pp. 5-1 to 5-14) |
| 19 January  
No Class: MLK Day | 21 January  
Electrical Current and Energy  
Reading: Sections 5.5-5.6 (pp. 5-15 to 5-27)  
Homework 2 due | 23 January  
Ohm’s Law  
Reading: Sections 5.7-5.8 (pp. 5-27 to 5-31) |
| 26 January  
Magnetism and Electromagnetism  
Reading: Sections 5.9-5.10.1 (pp. 5-31 to 5-38)  
Homework 3 due | 28 January  
23 January  
Midterm Exam 1 | 30 January  
Electric and Magnetic Induction  
Reading: Sections 5.10.2-5.10.3 (pp. 5-38 to 5-49) |
| 2 February  
Harmonic Motion  
Reading: Sections 7.1-7.4 (pp. 7-1 to 7-12)  
Homework 4 due | 4 February  
Waves  
Reading: Sections 7.5-7.7 (pp. 7-12 to 7-26) | 6 February  
Sound and Radio Waves  
Reading: Sections 7.8-7.9 (pp. 7-26 to 7-42) |
| 9 February  
Light Waves  
Reading: Sections 7.10-7.11 (pp. 7-42 to 7-52)  
Homework 5 due | 11 February  
Analog and Digital Radio  
Reading: Sections 8.1-0.3 (pp. 8-1 to 8-15) | 13 February  
Transmission of Data and Bandwidth  
Reading: Sections 8.4-8.6 (pp. 8-15 to 8-28) |
| 16 February  
Atoms  
Reading: Sections 9.1-9.6 (pp. 9-1 to 9-23)  
Homework 6 due | 18 February  
Photons  
Reading: Sections 12.1-12.5 (pp. 12-1 to 12-23) | 20 February  
Midterm Exam 2 |
| 23 February  
Lasers  
Reading: Sections 14.1-14.6 (pp. 14-1 to 14-18)  
Homework 7 due | 25 February  
Quantum Description of Lasers  
Reading: Section 14.9 (pp. 14-20 to 14-28) | 27 February  
Optical Communication: Propagation of Light  
Reading: Sections 13.1-13.6 (pp. 13-1 to 13-15) |
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<tr>
<td>2 March</td>
<td>Optical Communication: Guiding Light in Optic Fibers</td>
<td><em>Sections 13.7-13.12</em> (pp. 13-15 to 13-29)</td>
<td>4 March</td>
<td>Optical Communication: Light Modulation</td>
<td><em>Sections 15.1-15.4</em> (pp. 15-1 to 15-13), <em>Sections 11.1-11.2</em> (pp. 297-308)</td>
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<td>9 March</td>
<td>Communication Networks and the Internet</td>
<td><em>Sections 16.1-16.5</em> (pp. 16-1 to 16-15)</td>
<td>11 March</td>
<td>Wireless Networks</td>
<td><em>Sections 16.6-16.8</em> (pp. 16-15 to 16-28)</td>
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<td>Homework 8 due</td>
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<td>Review</td>
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**Other important dates:**
- Last day to drop classes without a "W": 12 January
- Last day to add/drop classes: 14 January
- Last day to withdraw from classes: 22 February