PHYS 152: Physics of Sound and Music (Fall 2014)

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Office hours: M 4-5 pm, F 1-2 pm, 5-6 pm, and by appointment (best to email first)

Teaching Assistants:
- Wes Erickson (graduate teaching assistant)
- Jonathan Mackrory (graduate teaching assistant)
- Blake Parris (graduate teaching assistant)
- Richard Wagner (graduate co-teacher)
- Nathan Wilson (undergrad co-teacher)

Course page: http://atomoptics.uoregon.edu/~dsteck/teaching/14fall/phys152
This is the primary web site for this course, where news, course notes, etc. will be posted. We will not use the Blackboard system.

Schedule: MWF 3:00-3:50, 100 Willamette
Course reference number: 15071
Credits: 4
Prerequisites: no course requirements, but see below
Links: news, course notes, homework sets and keys.

Course overview
What exactly is sound? We will study fundamental concepts of harmonic motion, waves, resonance, and adding waves together, and we will apply them to many aspect of sound, including everything from producing, hearing, and recording sound to musical theory, sound effects, and sound quality (timbre).

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 EL-501XBWH 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. Any edition will work (i.e., with or without an LCD screen), as we will only use the functionality of the older clickers. 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 you use in 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-class 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 Wednesday, 1 October.

Text: The (required) textbook for this course is Berg and Stork, The Physics of Sound, 3rd ed. (Pearson Prentice Hall, 2005). This book is not cheap, but really is clear and well-written, and at an appropriate level for this course. Feel free to use earlier editions if you can find them for cheap.

Other texts you might find helpful are:
- Benade, Fundamentals of Musical Acoustics (ML3805 .B328)

These books are available at the Science Library. I highly recommend you consult them for practice problems before exams.

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 sound)—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, 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: 30%

Grades for the course will be based on quizzes, homework, two midterm exams, and a final exam. The relative weights will be as follows:
If you have a Makeup exams: ones will or won't be graded, so it's very much to your advantage to finish all the problems.

Midterm exams: there are two midterm exams, to be held in class on Friday, 24 October, and Friday, 14 November.

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 will receive a zero score for a missed exam.

Final exam: the final exam will be held from 2:45-4:45 pm on Thursday, December 11, in 100 WIL.

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.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>A</td>
<td>97-100%</td>
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<tr>
<td>A-</td>
<td>93-96.9%</td>
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<tr>
<td>B+</td>
<td>87-89.9%</td>
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<tr>
<td>B</td>
<td>80-82.9%</td>
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<tr>
<td>B-</td>
<td>77-79.9%</td>
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<tr>
<td>C+</td>
<td>73-76.9%</td>
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<tr>
<td>C</td>
<td>70-72.9%</td>
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<tr>
<td>C-</td>
<td>67-69.9%</td>
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<tr>
<td>D+</td>
<td>63-66.9%</td>
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<tr>
<td>D</td>
<td>60-62.9%</td>
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<tr>
<td>D-</td>
<td>&lt; 60%</td>
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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 out 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. Most of your learning will happen outside the classroom: this is a 4-credit class, which means you should be averaging 8-16 hours of time per week on this course between reading, homework, and studying for exams. (The low end of the range applies if you're finding the course to be easy, the high end if you're finding it to be difficult.)

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 each class 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, the quizzes will always cover a wide range of material from the assigned readings.

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 the physics of sound, 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 do 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 sound and music, 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 are responsible for making sure you complete homework on time; I will enforce homework deadlines via the web site, and since you have plenty of time (an entire week) to work on the homework, I won't accept any late homework.

Volunteering: It would be cool to have some demonstrations of the musical instruments that we'll talk about during class, played by someone who knows what they're doing. So if you play an instrument and are willing to show it to the class and play for a bit, please let me know! (Particularly you music majors in the class.)

We'll figure out an appropriate day for you to bring it in.

Learning Objectives

Beyond the basic subject matter of the physics of sound and music, the specific learning objectives in this class include:

- Practicing applying (relatively) simple math to characterizing and predicting phenomena related to sound and music, and develop related problem-solving skills.
- Understanding the behaviors of waves and their fundamental role in areas such as human hearing, sounds of musical instruments, sound recording, and auditorium acoustics.
- Practicing recognizing the physics, especially acoustics, in everyday life.
- Learning to better articulate logic and problem-solving concepts in discussions and written exercises.
- Developing "self-correction" skills in problem solving (an important habit of expert scientists is to always check your results in a calculation or problem in different ways to help detect mistakes).

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>
<th>Friday</th>
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<tbody>
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<tr>
<td>Date</td>
<td>Topic</td>
<td>Reading</td>
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<tr>
<td>29 September</td>
<td>Introduction and Welcome</td>
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<tr>
<td>6 October</td>
<td>Behavior and Addition of Waves</td>
<td>Sections 2.3-2.4 (pp. 34-50)</td>
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<tr>
<td>13 October</td>
<td>Mersenne's Laws and Longitudinal Waves</td>
<td>Sections 3.3-3.4 (pp. 77-86)</td>
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<tr>
<td>20 October</td>
<td>Fourier Analysis</td>
<td>Section 4.2 (pp. 98-104)</td>
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<tr>
<td>27 October</td>
<td>Modulation</td>
<td>Section 5.1 (pp. 120-127)</td>
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<tr>
<td>3 November</td>
<td>Characterizing Loudness</td>
<td>Section 6.4 (pp. 153-156)</td>
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<tr>
<td>10 November</td>
<td>Microphones and Speakers</td>
<td>Sections 7.3-7.4 (pp. 188-195)</td>
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<td>17 November</td>
<td>Room Acoustics</td>
<td>Sections 8.1-8.2 (pp. 216-225)</td>
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<tr>
<td>24 November</td>
<td>Wind Instruments</td>
<td>Sections 10.1-10.2 (pp. 260-272)</td>
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<tr>
<td>1 December</td>
<td>String Instruments</td>
<td>Sections 12.1-12.2 (pp. 318-325)</td>
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Other important dates:
- Last day to drop classes without a "W": 6 October
- Last day to add classes: 8 October
- Last day to withdraw from classes: 16 November