Physics of Sound and Music  
PHYS 152
Dr. Dean Livelybrooks (‘Dr. D.’)

Fall 2022  
TR: 10:00 - 11:50; 100 Willamette

(note: all times on this syllabus are U.S. Pacific)

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As part of the Science Literacy Program we will pay special attention to uncovering ways science is connected to larger societal issues and big ideas across and within the discipline. SLP courses include General Education courses for non-science majors and courses for science majors taught by teams of faculty, graduate fellows, and undergraduate scholars, who will include opportunities during class time for you to engage with the class topics through a variety of activities. For more information about the program scilit.uoregon.edu

For Fall term, 2022, this course is offered in-person, with lectures and assignments emphasizing active learning. To access course materials and lectures log into canvas.uoregon.edu using your DuckID to access our class. If you have questions about accessing and using Canvas, visit the Canvas support page. Canvas and Technology Support also is available by phone or live chat: 541-346-4357 | livehelp.uoregon.edu

An IMPORTANT NOTE about GRADES ON CANVAS. The information you find there showing your percentage grades is almost never correct. For example, Canvas can’t be set up to throw out lowest scores, etc. So, while individual numeric grades reported on canvas for individual assignments are correct, don’t rely on Canvas to accurately present your % (percentage) grades. You are welcome to email me for a more accurate grade estimate.

Course website (Canvas)  
https://canvas.uoregon.edu/courses/205628
**Course Description:** “What is Music?” It can be a purposeful sequence of sounds you experience, performed by live musicians, or from recorded signals played back through an electro-mechanical system (stereo, smartphone and headphones, etc.). It can be composed notes scored in sheet music, or derive improvisationally from the creative minds of, say, jazz musicians.

We will delve into the characteristics of sound (waves), how music is physically produced, what makes an instrument sound the way it does, and how that sound travels to you to be perceived by your ears, interpreted by your brain, as music. We will also discuss what music is from the point of view of how it is structured, what makes it sound like music to us. We will look briefly at scales, intervals, chords focusing on the physical basis for their arrangement. We will also look at how the human vocal and hearing systems work. Along the way, we will develop a deeper appreciation for music as listeners and performers by learning to think more analytically about how it is created and perceived through physical processes.

**Course Muse:** This fall we will focus on understanding graphical representations of music as waveforms and sonograms (upper left image). One goal is to be able to look at a sonogram—representing frequency content of sounds over time, and predict how a playback of the sonogram would sound. We won’t, however, be delving into singing dogs, sorry.

**Topics and Learning Goals:**

**Topic: Oscillations and Waves:**
- learn about oscillators (sound generators) and waves (sound propagators);
- understand what makes an oscillator and how it is controlled;
- we will pay particular attention to sound waves: properties; how they propagate; etc., and;
- what are sine waves, how are they characterized, an important concept in music.

**Topic: Resonance and Interference:**
- understand how we drive oscillators to make sounds;
- learn about resonance, including a bit of simple math, and;
- develop a conceptual understanding of sound interference.

**Topic: Mixing Sounds in Music:**
- look at musical instruments, their waveforms, sound qualities, and sonograms;
- consider how the human voice is controlled to create musical sounds;
- analyze musical sounds for their spectra (sine wave content);
- examine how instruments are constructed; how are sounds made and controlled;
- compare instrument construction and operation to analyzed waveforms—the physical basis for instrumental sounds, and;
- how (then) do we synthesize musical instrument sounds?

**Topic: Instruments, Adding Waves, Chords and Music Theory**
- what is a perfect fifth, and third: frequency ratios we do and don’t like
- notes in a chord, overtone overlap, and instrument types

**Topic: Perceiving Sounds**
- the human ear- how we sense sounds
- intensity and loudness
Topic: Recording, Reproducing Sound and Effects
- systems for recording sound
- elements for reproduction of sound
- pickups and other sound sensors (if possible)

Topic: Modern Music Technology
- Noise cancellation
- Song recognition

Recurring Topic: how do music and sound connect to other scientific research and engineering?

Prerequisite: None
Credit Hours: 4


Points Distribution:
<table>
<thead>
<tr>
<th></th>
<th>~20%</th>
<th>9 total, due approximately weekly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homeworks</td>
<td>~30%</td>
<td>in class using iClickers (17 total)</td>
</tr>
<tr>
<td>iClicker Quizzes</td>
<td>~15%</td>
<td>covers oscillators, waves, sound, resonance</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>~5%</td>
<td>there will be 2 of these to complete</td>
</tr>
<tr>
<td>Worksheets</td>
<td>~10%</td>
<td>details below, required</td>
</tr>
<tr>
<td>Term Project Proposal</td>
<td>~20%</td>
<td>details below</td>
</tr>
<tr>
<td>There is no final exam</td>
<td></td>
<td>We repeat, there is no final exam for this course.</td>
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</tbody>
</table>

Letter Grade Distribution:
- A ≥ 90%
- B < 90 and ≥ 80
- C < 80 and ≥ 70
- D < 70 and ≥ 60
- F < 60

Note that + and – beyond the letter grades will be assigned as appropriate. We reserve the right to curve grades up if we feel it is warranted.

Homework: There will be nine (9) homework assignments, roughly one every week. Feel free to discuss the questions with others, but of course, the work you submit should be your own.

Homework assignments will be submitted online, via Canvas. Solutions to all the problem sets will be posted – study these. No late homework will be accepted. Assuming you turn in all 9 assignments, your lowest scoring homework will be dropped from the overall total.

Clicker Quizzes: There will be 17 short, in-class Clicker quizzes. Each quiz will include questions about the reading assigned for that class and a question or two on material covered in the
previous lecture. iClicker quizzes will be given about half-way through class, and we’ll go over the correct answers afterwards. We’ll keep your top 14 quiz scores.

We will also give non-counting, occasional 1-question clicker quizzes during lectures, to help you develop conceptual concepts about sound, music, etc.

**Midterm Exam:** There will be one, 1-hour exam given in the course, given mid-term (**Thursday, 27-October**). It will cover fundamental physics covered mostly at the beginning of term, such as oscillators, waves, resonance, etc. A 1-hour review session will be held during the lecture preceding this (25-October.)

**In-Class Worksheets:** We will make available worksheets to be completed working in small groups (in lecture) twice later during term. These will be available on Canvas and due at the start of the next lecture.

**Term Projects:** Our goal for term projects is to have every student investigate in depth some aspect of music connected to the underlying physics. We will circulate a list of ideas to choose from. The assigned text, White & White, also gives project ideas at the end of each chapter, these are also OK. The idea of a term project is that you do a simple experiment with real equipment, make measurements, look at data (tables, plots) and make sense of it. You also relate it to things we learned in class. You doing an experiment is a requirement for your term project, we require that you include in your term project writeup a photo (ideally with a date) of you doing your experiment. We will approach these projects in 2 phases:

1) **Term Project Proposal:** due (submitted on Canvas) by 21:00 (9pm, U.S. Pacific time) on **Thursday, 20-October.** Your proposal should give information about: a) what you plan to investigate, including (b) a statement of your research question; c) background information you’ve already considered; d) your plan of work to complete the project, including any needed equipment. We will post an example Proposal on Canvas.

2) **Final Term Project:** due (submitted on Canvas) by **17:00 (5pm, U.S. Pacific time) on Tues, 6-December.** This will be your final submission for the course, and include: a) your research question, b) a background section including diagrams, equations, etc.; c) a brief outline of your work plan (now completed!); d) a ‘results’ section including data, graphs, e) a discussion of them (analysis); and (f) a conclusions section.

We will set up Discussion groups on the course Canvas site based on the type of project you propose to undertake (for example, changing the overtone content of a plucked guitar string based on where it is plucked). You will be able to use these groups to communicate ideas/thinking/tips with others doing similar projects. Our course leadership team will monitor these discussions to answer some questions. To be clear, we won’t be happy should you decide to use someone else’s data via your group (please see Academic Integrity section at end)
Course Schedule:
The course schedule (including reading assignments) will be posted and continuously updated on Canvas.

Below is a draft, subject to change as the term progresses

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
<th>Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tues. 27-Sept.</td>
<td>L1: Oscillators &amp; Periodic Motion</td>
<td>WW Chpt. 2</td>
<td>HW 1 assigned</td>
</tr>
<tr>
<td>Thurs. 29-Sept.*</td>
<td>L2: Waves</td>
<td>WW Chpts. 3, 4</td>
<td>HW1 due, HW2 assigned</td>
</tr>
<tr>
<td>Tues. 4-Oct.*</td>
<td>L3: Sound Waves</td>
<td>WW Chpt. 5</td>
<td>none</td>
</tr>
<tr>
<td>Thurs. 6-Oct.*</td>
<td>L4: Resonance, Beats &amp; Doppler</td>
<td>WW Chpt. 6</td>
<td>HW 2 due, HW 3 assigned</td>
</tr>
<tr>
<td>Tues. 11-Oct.*</td>
<td>L5: Interference &amp; Diffraction</td>
<td>WW Chpt. 7</td>
<td>none</td>
</tr>
<tr>
<td>Thurs. 13-Oct.*</td>
<td>L6: Instruments: Strings</td>
<td>WW Chpt. 11</td>
<td>HW 3 due, HW 4 assigned</td>
</tr>
<tr>
<td>Tues. 18-Oct.*</td>
<td>L7: Instruments: Winds</td>
<td>WW Chpt. 12,18</td>
<td>none</td>
</tr>
<tr>
<td>Thurs. 20-Oct.*</td>
<td>L8: Instruments: Winds &amp; Brass</td>
<td>WW Chpt. 19</td>
<td>HW 4 due, HW 5 assigned, Term Project Proposal Due</td>
</tr>
<tr>
<td>Thurs. 27-Oct.</td>
<td>L10: Human Voice &amp; time for 1 hour Exam: over Waves, Sound &amp; Resonance</td>
<td>WW Chpt. 19</td>
<td>HW 5 due, HW 6 assigned</td>
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<tr>
<td>Tues. 1-Nov.*</td>
<td>L11: Human Voice &amp; Percussion</td>
<td>WW Chpt. 13 &amp; 20</td>
<td>none</td>
</tr>
<tr>
<td>Thurs. 3-Nov.*</td>
<td>L12: Adding Waves &amp; Synthesis</td>
<td>WW Chpt. 8</td>
<td>HW 6 due, HW 7 assigned</td>
</tr>
<tr>
<td>Tues. 8-Nov.*</td>
<td>L13: Moogs &amp; Basics of Perceiving Sounds</td>
<td>WW Chpt. 9</td>
<td>none</td>
</tr>
<tr>
<td>Thurs. 10-Nov.</td>
<td>L14: Review: decibels, 1/R² sound falloff; The Human Ear</td>
<td>WW Chpt. 10</td>
<td>HW 7 due 12-Nov, HW 8 assigned</td>
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<tr>
<td>Tues. 15-Nov.*</td>
<td>L15: Music Intervals, Scales</td>
<td>WW Chpt. 14</td>
<td>Worksheet 1 done in class, due 17-Nov.</td>
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<tr>
<td>Thurs. 17-Nov.*</td>
<td>L16: Recording &amp; Reproduction</td>
<td>WW Chpt 21</td>
<td>HW 8 due, HW 9 assigned</td>
</tr>
<tr>
<td>Tues. 22-Nov.*</td>
<td>L17: Modern Music Technology: Noise Cancellation and Song Recognition</td>
<td>Reading on Canvas</td>
<td></td>
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<tr>
<td>Thurs. 24-Nov.</td>
<td>NO CLASS: U.S. THANKSGIVING</td>
<td></td>
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<tr>
<td>Tues. 29-Nov.*</td>
<td>L18: Modern Music Technology: Song Recognition and AI-generated music</td>
<td>Reading on Canvas</td>
<td>HW 9 due, Worksheet 2 done in class, due 1-Dec</td>
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<tr>
<td>Thurs. 1-Dec.*</td>
<td>L19: Final wrap-up, discussion about Term Projects</td>
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(*) these lectures include in-class Clicker Quizzes.
The Final Term Project is due Tues. 6-December by 17:00 (5pm, U.S. Pacific time). There is no final exam.

A few things to help you succeed in this course
1. Attend class every week.
2. Complete the reading assignments before class.
3. Participate and engage in every class activity.
4. When questions arise, send us an email or visit our office hours.
5. As you develop your term project, shape it for a general, non-specialist audience. This includes defining technical terms, using analogies, etc. A good term project should be comprehensible by any other student in PHYS 152, do not write it only for the physicists leading this course.

6. Keep track of all your assignments with the course calendar and transfer everything to your personal calendar throughout the term so there are no surprises.

**Academic Integrity:**
A sad reality of academic life is that some students (hopefully not you!) will resort to dishonest means to improve their grade in class (i.e., cheating). Even if you're the honest type (in which case, nice work!), you should be concerned about this: every time someone raises their grade by cheating, it devalues your grade. What do we mean by cheating? Some examples:

- **Plagiarism**, such as:
  - turning in homework solutions identical (or nearly identical) to those of another student
  - turning in homework solutions copied from the internet or anyone else
- Copying answers on exams or quizzes from other students
- Using notes, extra materials, or electronic devices (unless explicitly allowed) on exams or quizzes
- Copying and pasting someone else’s work off the web for your Term Project.
- And so on... at this point in your life you know what is okay and what isn't.

The [University Student Conduct Code](#) also defines academic misconduct, which includes unauthorized help on assignments and examinations and the use of sources without acknowledgment. Academic misconduct is prohibited at UO. We will report misconduct to the Office of Student Conduct and Community Standards—consequences can include failure of the course. In our remote class, we will ask you to certify that your exams/papers are your own work. Exams are timed and Canvas automatically varies the questions students receive. We will adjust times to support students with accommodations through the Accessible Education Center. If a technological glitch disrupts your exam, don’t panic. Take a photo to document the error message you’re receiving and then email or call one of us.

Our policy regarding plagiarism is this. If you do it once, you will receive no credit for that particular assignment. If you collude with another student and submit identical homeworks or other assignments, you will each be awarded half of the total score you achieved for that assignment. If you are determined to have plagiarized twice, you will be reported to the UO for Academic Misconduct.

**Accessibility:**
The University of Oregon is working to create inclusive learning environments. Please notify me if there are aspects of the instruction or design of this course that result in disability-related barriers to your participation. You are also encouraged to contact the Accessible Education Center at 541-346-1155 or uoaec@uoregon.edu.
Student Well-being:
University Health Services help students cope with difficult emotions and life stressors. If you need general resources on coping with stress or want to talk with another student who has been in the same place as you, visit the Duck Nest (located in the EMU on the ground floor) and get help from one of the specially trained Peer Wellness Advocates. Find out more at health.uoregon.edu/ducknest.

University Counseling Services (UCS) has a team of dedicated staff members to support you with your concerns, many of whom can provide identity-based support. All clinical services are free and confidential. Find out more at counseling.uoregon.edu or by calling 541-346-3227 (anytime UCS is closed, the After-Hours Support and Crisis Line is available by calling this same number).

Specific guidelines for best practices using Canvas Discussion:
1. Use subject lines that clearly communicate the content of your post.
2. Write clearly and concisely and be aware that humor or sarcasm often doesn’t always translate in an online environment.
3. Be supportive and considerate when replying to others’ posts.
4. Try to use correct spelling and grammar and proofread your submissions. After submitting, use the edit feature to make corrections and resubmit (don’t create a new or duplicate post that corrects your error).
5. Contribute and interact often!