Physics of Sound and Music
PHYS 152

Dr. Dean Livelybrooks (‘Dr. D.’)
Dr. Zoheyr Doctor (‘Dr. Doctor’)

Fall 2020
TR: 12:15 - 13:45* (12:15-1:45pm); On-Line

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

Email: dlivelyb@uoregon.edu  Office: 225 Willamette Hall
Office hours: Weds: 21:00 (9pm) & Thursday: 08:30 (U.S. Pacific)
and by appointment

Email: zoheyr.doctor@gmail.com  Office: N/A
Office hours: Mon. 13:00 (1pm), Weds: 13:00 (1pm) and by appointment

TA: Valerie Beale  Office: meeting remotely
Email: vbeale@uoregon.edu
Office hours: Mon. 14:00 (2pm), Weds. 14:00

TA: Aileen Carroll-Godfrey  Office: meeting remotely
Email: aileeng@uoregon.edu
Office hours: Monday, 13:00 (1pm)

TA: Isabelle Kloc  Office: meeting remotely
Email: ikloc@uoregon.edu
Office hours: Weds. 10:00, Thurs: 15:30 (3:30pm)

(*) This course is offered on-line (‘00 REMOTE’) with lectures, in-class activities emphasizing active learning and demonstrations presented live or in short, pre-recorded video segments during the scheduled class days/times listed above. All students will be assigned Between-Class Quizzes (BCQs). Those attending on-line during scheduled times (‘synchronous students’) will be asked to take ungraded, short polls or surveys indicating their thinking on topics during class. Those taking the course asynchronously—meaning they aren’t able to regularly during the schedule times—will see some of these poll questions show up as on the BCQs, so all will have an opportunity to answer these questions for credit. Other coursework will also be assigned to all.

To access course materials and lectures (live or recorded) 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

Course website (Canvas): https://canvas.uoregon.edu/courses/165575
**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 discuss 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 and 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 at scales, intervals, chords focusing on the physical basis for their arrangement. 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 the physics behind how to make ‘bent notes’ on all the instruments (and voice) we discuss. What is a ‘bent note?’ Listen to the end of the rising note the clarinet plays in the beginning of an orchestral version of Rhapsody in Blue.

**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.
- what are sine waves, how are they characterized; important in music

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

**Topic: Mixing Sounds in Music**
- look at musical instruments, their waveforms, sound qualities, bent notes
- 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
- 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
- AI generated music

**Recurring Topic: how do music and sound connect to other scientific topics?**

**Prerequisite:** None  
**Credit Hours:** 4


**Points Distribution:**

<table>
<thead>
<tr>
<th>Points Distribution</th>
<th>Percentage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homeworks</td>
<td>~20%</td>
<td>9 total, due approximately weekly</td>
</tr>
<tr>
<td>Quizzes</td>
<td>~30%</td>
<td>to be completed between lectures (17 total)</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>~15%</td>
<td>covers oscillators, waves, sound, resonance</td>
</tr>
<tr>
<td>Worksheets</td>
<td>~5%</td>
<td>there will be 2 of these to complete</td>
</tr>
<tr>
<td>Term Project Proposal</td>
<td>~10%</td>
<td>details below, required</td>
</tr>
<tr>
<td>Final Term Project</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>
</tr>
</tbody>
</table>

**Letter Grade Distribution:**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>≥ 90%</td>
</tr>
<tr>
<td>B</td>
<td>&lt; 90 and ≥ 80</td>
</tr>
<tr>
<td>C</td>
<td>&lt; 80 and ≥ 70</td>
</tr>
<tr>
<td>D</td>
<td>&lt; 70 and ≥ 60</td>
</tr>
<tr>
<td>F</td>
<td>&lt; 60</td>
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</table>

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.*  
**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.
**Quizzes:** There will be 17 short on-line ‘Between Class Quizzes’ (BCQs). These will be made available on Canvas at the end of the preceding lecture and due at the start of the next lecture. Each quiz will include questions about the reading assigned for that class and a question or two on material covered in the previous lecture. There will also be a few questions that were given as zoom polls during the previous lecture. We’ll keep your **top 15** quiz scores.

**Midterm Exam:** There will be one, 1-hour exam given in the course, given mid-term (**Thursday, 29-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 (27-October.)

**In-Class Worksheets:** We will make available worksheets to be completed working in small groups (in lecture or asynchronously) twice 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 (not virtual), 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, 22-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, 8-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. 29-Sept.</td>
<td>L1: Oscillators &amp; Periodic Motion</td>
<td>WW Chpt. 2</td>
<td>HW 1 assigned</td>
</tr>
<tr>
<td>Thurs. 1-Oct.</td>
<td>L2: Waves</td>
<td>WW Chpts. 3, 4</td>
<td>HW1 due, HW2 assigned</td>
</tr>
<tr>
<td>Tues. 6-Oct.</td>
<td>L3: Sound Waves</td>
<td>WW Chpt. 5</td>
<td>none</td>
</tr>
<tr>
<td>Thurs. 8-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. 13-Oct.</td>
<td>L5: Interference &amp; Diffraction</td>
<td>WW Chpt. 7</td>
<td>none</td>
</tr>
<tr>
<td>Thurs. 15-Oct.</td>
<td>L6: Instruments: Strings</td>
<td>WW Chpt. 11</td>
<td>HW 3 due, HW 4 assigned</td>
</tr>
<tr>
<td>Thurs. 22-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. 29-Oct.</td>
<td>L10: Human Voice &amp; time for 1 hour Exam: over Waves, Sound &amp; Resonance (available later on Canvas for asynchronous students, due 30-Oct by 17:00 Pacific Time for asynch. students)</td>
<td>none</td>
<td>HW 5 due, HW 6 assigned</td>
</tr>
<tr>
<td>Tues. 3-Nov.</td>
<td>L11: Human Voice &amp; Percussion</td>
<td>WW Chpt. 13 &amp; 20</td>
<td>none</td>
</tr>
<tr>
<td>Thurs. 5-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. 10-Nov.</td>
<td>L13: Moogs &amp; Basics of Perceiving Sounds</td>
<td>WW Chpt. 9</td>
<td>none</td>
</tr>
<tr>
<td>Thurs. 12-Nov.</td>
<td>L14: The Human Ear</td>
<td>WW Chpt. 10</td>
<td>HW 7 due, HW 8 assigned</td>
</tr>
<tr>
<td>Tues. 17-Nov.</td>
<td>L15: Music Intervals &amp; Scales</td>
<td>WW Chpt. 14</td>
<td>none</td>
</tr>
<tr>
<td>Thurs. 19-Nov.</td>
<td>L16: Music Chords / Pickups/sensors</td>
<td>WW Chpt. 15.5-8 / 24</td>
<td>HW 8 due, HW 9 assigned</td>
</tr>
<tr>
<td>Tues. 24-Nov.</td>
<td>L17: Recording &amp; Reproduction</td>
<td>WW Chpt 21</td>
<td>none</td>
</tr>
<tr>
<td>Thurs. 26-Nov.</td>
<td>NO CLASS: U.S. THANKSGIVING</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Tues. 1-Dec.</td>
<td>L18: Modern Music Technology: Noise Cancellation and Song Recognition</td>
<td>Reading on Canvas</td>
<td>HW 9 due</td>
</tr>
<tr>
<td>Thurs. 3-Dec.</td>
<td>L19: Modern Music Technology: Song Recognition and AI-generated music</td>
<td>Reading on Canvas</td>
<td>none</td>
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</table>
4. When questions arise, send us an email or visit (virtually) 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).

Guidelines for Remote Participation:
1. **Participate and Contribute**: Students are expected to participate by sharing ideas and contributing to the collective learning environment. This entails preparing, following instructions, and engaging respectfully and thoughtfully with others.
2. **Use Proper Netiquette**: Please use “good net etiquette”: identify yourself with your real name and use a subject line that clearly relates to your contribution. Respect the privacy of your classmates and what they share in class. Understand that we may disagree and that exposure to other people’s opinions is part of the learning experience. “Good netiquette” also means using humor or sarcasm carefully. In addition, your language should be appropriate for an academic context, and exhibit interest in and courtesy for others’ contributions.
3. **Interact Professionally**: Our learning environment provides an opportunity to practice being professional and rigorous in our contributions. As much as possible, use correct spelling, grammar, and style for academic and professional work. Moreover, seize the chance to learn from others and develop your interpersonal skills, such as mindful listening and awareness of one’s own tendencies (e.g. Do I contribute too much? Too little?).
4. **Expect and Respect Diversity**: All classes at the University of Oregon welcome and respect diverse experiences, perspectives, and approaches. We will value differences and communicate disagreements with respect.
5. **Help Everyone Learn**: As we move forward learning during this challenging time, it is important that we work together and build on our strengths. We need to be patient with each other, identify ways we can assist others, and be open-minded to receiving help and advice from others. No one should hesitate to contact us to for assistance or offer suggestions that might help us learn better.

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!

Specific guidelines for best practices using Zoom:
1. Please test your video and audio prior to joining a live class session. You can learn more about testing your audio and video by visiting the UO Service Portal.
2. Try to be on time. It can be distracting to have participants join late.
3. All of us occasionally need to hide video, but we value video on when possible.
4. That said, please be mindful that others can see you and your surroundings if your video is on.
5. Use a microphone or speak closely to your computer microphone so that others can hear you. If you have video on, try to look at your camera when you are contributing.
6. Mute your audio when you are not actively contributing.
7. Use chat to pose questions or offer insights “on the side” while others are contributing. Remember, the chat can be read by all.
8. For help and troubleshooting with Zoom, visit the UO Service Portal.