Physics of Sound and Music

PHYS 152

Dr. Dean Livelybrooks ('Dr. D.')

Fall 2018

TR: 14:00 - 15:50 (2:00-3:50pm); 100 Willamette Hall

SCIENCE LITERACY PROGRAM

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

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Office hours: Mon. 14:30-15:30, Thurs. 09:00-10:00,
and by appointment

SLP Fellow: Kara Merfeld **Office:** 315 Willamette Hall
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TA: Philippe Nguyen **Office:** 315 Willamette Hall
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TA: James Sartor **Office:** 373 Willamette Hall
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Office hours: Thurs. 13:00, Mon. 16:00 Drop-in, & by appointment

Course website (Canvas): https://canvas.uoregon.edu/courses/117591/sections/112817

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. We will look at scales, intervals, chords, and the physical bases 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.

Topics and Learning Goals:

Topic: Oscillations and Waves

- learn what are oscillators and waves;
- 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
- develop a conceptual understanding of interference

Topic: Mixing Sounds in Music

- look at waveforms from musical instruments
- 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
- effects (reverb, delay, etc.)

Topic: Acoustics

- basic elements of acoustics and design

Prerequisite: None
Credit Hours: 4

Required Text: Physics and Music: The Science of Musical Sound, Dover Edition Authors: Harvey E. White and Donald H. White: ISBN-13: 978-0486779348 (available as eTextBook)

Required: i>Clicker or equivalent, calculator (your cell phone calculator will probably be good enough)

Supplementary Text (not required): The Physics of Sound, 3nd Edition Authors: Richard Berg and David Stork: ISBN-13: 978-0131457898

Points Distribution:

Homeworks	20%	9 total, due approximately weekly
Quizzes	20%	first 10 minutes of each lecture, on assigned reading
Exam	15%	held during last lecture, covers oscillators, waves, sound, resonance
Term Project Proposal	10%	details below, required
Term Project Draft	15%	details below
Final Term Project	20%	details below

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*. Assignments will be submitted online, via Canvas. Solutions to all the problem sets will be posted – study these. **No late homework will be accepted.** Your lowest scoring homework will be dropped from the overall total.

Quizzes: There will be a short ($\leq$10 minute) iClicker quiz at the beginning of each class. Each quiz will include questions about the reading assigned for that class, and may include a question or two on material covered in the previous lecture. We'll throw out the bottom 3 quiz scores.

Exam: There will be one, 1-hour exam given in the course, on the last day of class (**Thursday, 29-November**). It will cover fundamental physics covered mostly at the beginning of term, such as oscillators, waves, resonance, etc. A review session will be held during the lecture preceding this (27-Nov.)

Term Projects: Our goal for term projects is to have every student investigate in depth some aspect of music connected to the underlying physics. The assigned text, White & White, gives project ideas at the end of each chapter. However, you are welcome to come up with your own, for example the difference in how microphone and piezoelectric pickups work and produce electronic signals from instrument sounds. We will approach these projects in 3 phases:

1) Term Project Proposal: due (submitted on Canvas) by 17:00 (5pm) on Tuesday, 16-October. Your proposal should give information about: what you plan to investigate, including a statement of your research question; background information you've already considered; your plan of work

to complete the project, including any needed equipment. We will post an example Proposal on Canvas.

2) Term Project Draft: due (submitted on Canvas) by 17:00 (5pm) on Tuesday, 13-November. For your draft, we expect to see: your (possibly restated) research question; a draft background section, including diagrams, etc.; a statement of progress on your plan of work (what you've done, what you will do); some analysis of results (to date; and preliminary conclusions section

3) Final Term Project: due (submitted on Canvas) by 17:00 (5pm) on Weds, 5-December. This will be your final submission for the course, and include: your research question, a background section including diagrams, equations, etc.; a brief outline of your work plan (now completed!); a 'results' section including data, graphs, and a discussion of them (analysis); and a conclusions section.

Course Schedule:

The course schedule (including reading assignments) will be posted and continuously updated on Canvas.

There is a short iClicker quiz at the beginning of each lecture. I will drop the 3 lowest scores from the total Quiz score.

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

Date	Topic	Reading	Assignments
Tues. 25-Sept.	Oscillators & Periodic Motion	WW Chpt. 2	HW 1 assigned
Thurs. 27-Sept.	Waves	WW Chpts. 3, 4	**HW1 due**, HW2 assigned
Tues. 2-Oct.	Sound Waves	WW Chpt. 5	none
Thurs. 4-Oct.	Resonance, Beats & Doppler	WW Chpt. 6	**HW 2 due**, HW 3 assigned
Tues. 9-Oct.	Interference & Diffraction	WW Chpt. 7	none
Thurs. 11-Oct.	Instruments: Strings	WW Chpt. 11	**HW 3 due**, HW 4 assigned
Tues. 16-Oct.	Instruments: Winds	WW Chpt. 12,18	**Term Project Proposal Due**
Thurs. 18-Oct.	Instruments: Brass & Voice	WW Chpt. 19	**HW 4 due**, HW 5 assigned
Tues. 23-Oct	Instruments: Percussion	WW Chpt. 13	none
Thurs. 25-Oct.	Adding Waves & Synthesis	WW. Chpt. 8	**HW 5 due,** HW 6 assigned
Tues. 30-Oct	Basics of Perceiving Sounds	WW Chpt. 9	none
Thurs. 1-Nov.	The Human Ear	WW Chpt. 10	**HW 6 due**, HW 7 assigned
Tues. 6-Nov.	Musical Intervals & Scales	WW Chpt. 14	none
Thurs. 8-Nov.	Music Theory & Chords	WW Chpt. 15.5-8	**HW 7 due**, HW 8 assigned
Tues. 13-Nov.	Topic: Recording & Reproduction	TBA	**Term Project Draft Due**
Thurs. 15-Nov.	Topic: Effects	TBA	**HW 8 due,** HW 9 assigned
Tues. 20-Nov.	Topic: Acoustics	WW Chpt. 26	none
Thurs. 22-Nov.	NO CLASS: THANKSGIVING		
Tues. 27-Nov.	REVIEW		**HW 9 due**
Thurs. 29-Nov.	**Exam:** Waves, Sound & Reson.		

The Final Term Project is due Weds. 5-December by 17:00 (5pm).

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 comprehendible 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 I 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 multiple clickers in class
- Using notes, extra materials, or electronic devices (unless explicitly allowed) on exams or quizzes
- And so on... at this point in your life you **know** what is okay and what isn't.

Doing any of these will send your grade straight to the dustbin (i.e., you will **automatically fail the course**), so **don't do it**.

In case you need more information about acceptable academic conduct, please consult the Student Conduct Code.