# Physics 9, Fall 2018, Homework #4.
Due at start of class on Friday, October 12, 2018

Problems marked with (*) must include your own drawing or graph representing the problem and at least one complete sentence describing your reasoning.

Problems for Giancoli Chapter 12 (Sound)

1*. How will the air temperature in a room affect the pitch of organ pipes? (A complete answer probably requires two or three short sentences and an equation. Assume that the temperature of the air within the organ pipes equals the room temperature.)

2*. Why are the frets on a guitar spaced more closely together as you move up the fingerboard toward the bridge? Hint: adjacent frets differ in pitch by one semitone.
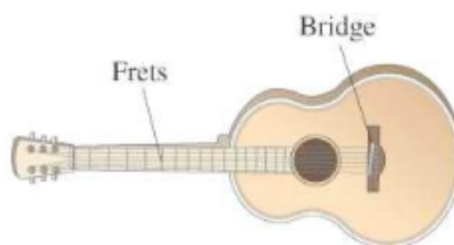
3. An organ pipe is 1.20 m long. What are the fundamental and the first three audible overtones if the pipe is (a) closed at one end, or (b) open at both ends? (Be careful: the pattern for part (a) is not as simple as for a guitar string.)

4*. Two loudspeakers are 2.5 m apart. A person stands 3.0 m from one speaker and 3.5 m from the other. (a) What is the lowest frequency at which destructive interference will occur at this point? (b) Give the next two frequencies that would also result in destructive interference at this point.

5. Approximately how many octaves are there in the human audible range of frequencies?

6. At the Indianapolis 500, you can measure the speed of cars just by listening to the difference in pitch of the engine noise between approaching and receding cars. Suppose the sound of a certain car drops by a full octave as it goes by on the straightaway. How fast is it going?

7. The frequency of a locomotive whistle as it approaches you is 532 Hz (as measured by you, a stationary observer). After it passes you, its frequency is measured as 490 Hz. How fast was the train moving (assume constant velocity)?

8. In audio and communications systems (for example, the amplifier for a sound system or for a home stereo), the gain, β, in decibels is defined as $\beta = 10 \log_{10}(P_{\text{out}}/P_{\text{in}})$, where P_{in} is

the power input to the system and P_{out} is the power output. A particular stereo amplifier puts out 32 W of power for an input of 1 mW (that's 0.001 W). What is its gain in dB?

Problems for Giancoli Chapter 23 (Geometric optics)

9*. When you look at the Moon's reflection from a ripply (i.e. not smooth) sea, it appears elongated, as shown in the figure at right. Explain (with a diagram and a short sentence or two).
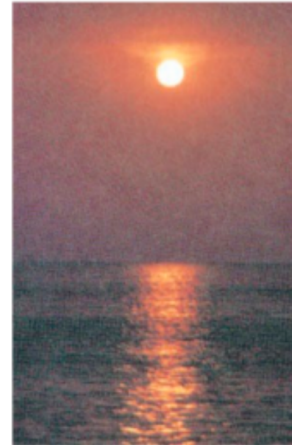
10*. Although a plane mirror reverses left and right, it doesn't reverse up and down. Explain.

One Architectural Acoustics problem

11. A box-shaped classroom has a $10\,\text{m} \times 10\,\text{m}$ floor (that's $100\,\text{m}^2$ floor area) and ceiling height $3\,\text{m}$. (a) What is the volume of the room? (b) What is are the area of each of the four walls? Initially the floor material is vinyl tile on concrete (absorption coefficient $\alpha = 0.03$), and the wall and ceiling material are gypsum drywall ($\alpha = 0.05$). (c) Using Sabine's (rule-of-thumb) formula for Reverberation Time,

$$RT \approx \frac{(0.161\,\text{s/m})\ V}{\alpha_1 A_1 + \alpha_2 A_2 + \cdots + \alpha_6 A_6}$$

where V is volume (in m^3), each A is area (in m^2), and each α is a unitless absorption coefficient, calculate the (estimated) Reverberation Time in seconds. (d) Now cover the floor with carpet-on-foam ($\alpha = 0.57$), cover the ceiling with acoustic ceiling tiles ($\alpha = 0.72$), and cover the walls with wood paneling ($\alpha = 0.17$). What is your updated estimate for the Reverberation Time? (e) Which conditions would be more comfortable for listening to a spoken lecture?

Remember **online response** at `positron.hep.upenn.edu/wja/jitt/?date=2018-09-12`

XC1*. Optional/extra-credit. A source of sound waves (wavelength λ) is a distance ℓ from a detector. Sound reaches the detector directly, and also by reflecting off of an obstacle, as shown in the left figure below. The obstacle is equidistant from source and detector. When the obstacle is a distance d to the right of the line of sight between source and detector, as shown, the two waves arrive in phase. How much farther to the right must the obstacle be moved if the two waves are to be out of phase by $\frac{1}{2}$ wavelength, so that destructive interference occurs? (Assume $\lambda \ll \ell, d$.) (This problem is fine as originally stated. Please disregard my comment about rewording it.)
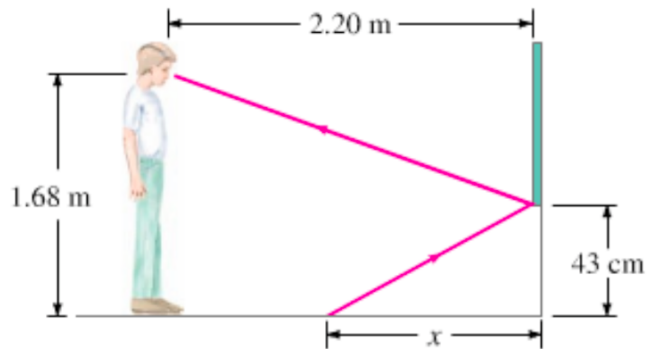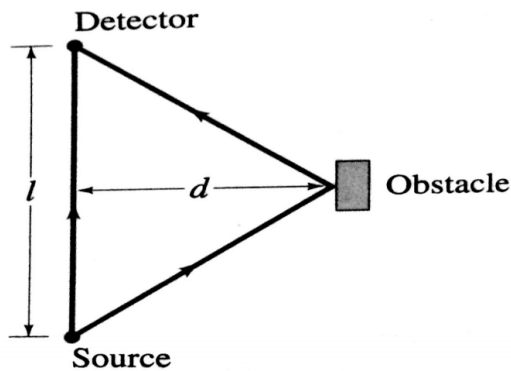
XC2*. Optional/extra-credit. A person whose eyes are 1.68 m above the floor stands 2.20 m in front of a vertical plane mirror whose bottom edge is 0.43 m above the floor, as shown in the right figure above. What is the horizontal distance x to the base of the wall supporting the mirror of the nearest point on the floor that can be seen reflected in the mirror?

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