Exercise 1. Loudness

For a sound wave whose pressure is given by $P(x,t) = P_0 + A\cos(kx - \omega t)$, which coefficient determines loudness?

(a) y_0
(b) A
(c) k
(d) ω

Exercise 2. Pitch

For a sound wave whose pressure is given by $P(x,t) = P_0 + A\cos(kx - \omega t)$, which coefficient determines pitch?

(a) y_0
(b) A
(c) k
(d) ω

Exercise 3. Liquid Helium

Assuming that the velocity of a wave in an elastic medium is $v = \sqrt{F/\mu}$, one may show that $v = \sqrt{B/\rho}$. Assuming $B = 5 \times 10^7$ [Pa], and $\rho = 0.125$ [g/cm^3], calculate the speed of sound in liquid helium.

(a) 20000 [m/s]
(b) 9480 [m/s]
(c) 632 [m/s]
(d) 343 [m/s]

Exercise 4. High Temperature

Air pressure goes up at higher temperatures. Assuming that B and P are constant, is the speed of sound at 35 [°C] higher or lower than at 0 [°C]? Hint: $n = PV/RT$, and $\rho = M/V$ where $M = mn$ where m is the molar mass.

(a) slower at high temperature
(b) faster at high temperature

Exercise 5. Speed of Sound

Rank the following from slowest speed of sound to highest: solid water (ice), liquid water, gaseous water (steam).

(a) SLG
(b) SGL
(c) LSG
(d) LGS
(e) GSL
(f) GLS

Exercise 6. Open Pipe

Consider an open pipe, of diameter $d = 2$ [cm], length $L = 0.3$ [m]. Assuming that the speed of sound is 343 [m/s], find the frequency of the second harmonic. Hint: $f_n = nv/2L$, for $n \in \{1, 2, 3, 4, \dots\}$. How does mode number relate to harmonic?

Exercise 7. Stopped Pipe

Consider an pipe, stopped at one end, of diameter $d = 2$ [cm], length $L = 0.3$ [m]. Assuming that the speed of sound is 343 [m/s], find the frequency of the second overtone. Hint: $f_n = nv/4L$, for $n \in \{1, 3, 5, 7, \dots\}$.

Exercise 8. Interference I

Suppose you stand at the midpoint between two speakers that are separated by 5 [m] and create a standing wave. If the speed of sound is 343 [m/s], and the speakers play a tone at 1372 [Hz], do you hear anything? Hint: $\lambda = v/f$.

Exercise 9. Interference II

Now, suppose that you take a one meter step forward. Do you hear anything now?

Exercise 10. Intensity I

Find the intensity as a function of time for a wave given by $y(x,t) = A\cos(kx - \omega t)$. Hint: $I = p(x,t)v_y(x,t)$, where $p(x,t) = -B\partial_x y(x,t)$ and $v_y(x,t) = \partial_t y(x,t)$.

Exercise 11. Intensity II

Find the average intensity in [W/m^2] of a wave given by $y(x,t) = A\cos(kx - \omega t)$, with $A = 0.2$ [mm], $k = 8.33$ [1/m], and $\omega = 60$ [rad/s]. Assume that the bulk modulus of air is 10^5 [Pa]. Hint: $\int_0^{n\pi} d\theta \ \sin^2(\theta)/n\pi = 1/2$.

(a) 1 [W/m^2]

(b) 10 [W/m^2]

(c) 100 [W/m^2]

(d) 1000 [W/m^2]

Exercise 12. Intensity III

How many decibels is this? Hint: $\beta = 10\log_{10}(I/I_0)$ [dB], where $I_0 = 10^{-12}$ [W/m^2].

(a) 0 dB

(b) 30 dB

(c) 60 dB

(d) 120 dB

Exercise 13. Beats

Can humans detect the changing loudness of beats frequency of two musicians, one who plays C = 261.63 Hz and one who plays A = 440.00 Hz? Hint: assume that at above 20 [Hz], humans hear beats as a new frequency, while below 20 [Hz], beats like an oscillation of loudness.

(a) No, the beats frequency is 701.63 [Hz]

(b) No, the beats frequency is 178.37 [Hz]

(c) Yes, the beats frequency is 1.6818 [Hz]

(d) Yes, the beats frequency is 0.5946 [Hz]

Exercise 14. Doppler I

A cargo ship sees a sailboat directly ahead and plays its foghorn at $f = 150$ [Hz] to alert the sailboat. It the cargo ship is headed east at 15 [m/s] and the sailboat is headed west at 5 [m/s], at what frequency does the sailboat hear the foghorn? Hint: $v_{\text{sound}} = 343$ [m/s].

(a) 141.6 [Hz]

(b) 145.8 [Hz]

(c) 154.6 [Hz]

(d) 159.1 [Hz]

Exercise 15. Doppler II

Now, suppose that the sailboat sees the cargo ship and plays an airhorn at 300 [Hz], at what frequency does the cargo ship hear the airhorn?

(a) 282.8 [Hz]

(b) 291.1 [Hz]

(c) 308.6 [Hz]

(d) 317.8 [Hz]