

Topics of this homework: Basic Acoustics and units, dB, Intensity calculations, the Helmholtz resonator

1. The speed of sound:
 - (a) What is the formula for the speed of sound?
 - (b) Identify the variables: Names, units, and values of consonants.
 - (c) What is the meaning of ηP_0 ?
 - (d) Does P_0 depend on temperature? Explain?
 - (e) Does ρ_0 depend on temperature or P_0 ? Explain.
 - (f) What is the form of the dependence of the speed of sound on temperature? Namely give the formula for $c(T)$, and explain the dependence.
2. Basic equations of sound propagation:
 - (a) Write out the 2x2 matrix equation that describes the propagation of 1 dimensional sound waves in a tube having area A :
 - (b) Rewrite these equations as a second order equation in terms of the pressure P , and thereby find the formula for the speed of sound in terms of Z and Y :
3. Assume that a flash bulb puts out 50 Joules when it is triggered, and it lasts for 20 μ s. How much power is delivered while the flash is present, assuming the illumination is constant during the interval?
4. What is the displacement magnitude (RMS) of air particle in pm, of a pure-tone plane wave, having a pressure of 0 dB-SPL at 1 kHz.
5. Compare and discuss this movement with respect to the radius of a single Hydrogen atom.
6. A person is speaking at an intensity of I_0 66 dB-SPL, as measured with a sound level meter at 1 meter.
 - (a) Find the total power in the voice assuming that the level is uniform around the head.
 - (b) Find the total power assuming that the intensity varies as

$$I(\theta, \phi) = I_0 \cos(\theta/2) \cos(\phi/2) \quad (1)$$

where θ is the angle in the horizontal plane and ϕ in the vertical plane. where $\theta = 0, \phi = 0$ corresponds to "straight ahead."

7. Bels
 - (a) How many millibels [mB] in 1 bel [B]?
 - (b) Give the formula for the intensity in mB units.
 - (c) Give the formula for the sound pressure level in cB (centibel) units.
8. Demonstrate that $P_{ref} \equiv 20 \mu\text{Pa}$ is the same as $I_{ref} \equiv 10^{-12} [\text{W}/\text{m}^2]$.

9. A bottle has a neck diameter of 1 [cm] and is $l = 1$ cm long. It is connected to the body of the bottle “barrel” which is 5 cm in diameter and $L = 10$ cm long. Treat the barrel as a short piece of transmission line, closed at one end, which looks like a compliance $C = V_{barrel}/\eta P_0$, and the neck which look like a mass $M = \rho_0 l/A_{neck}$. These two impedances are in series, since they both see the same volume velocity (flow).
- Find the resonant frequency of the bottle. Hint: set the impedance to zero and solve for the resonant frequency in terms of M and C .
 - write out the formula for the resonant frequency in terms of the dimensions of the bottle.
 - calculate the resonant frequency in Hz for the dimensions given.
 - Blow into a bottle and measure the resonant frequency by recording the tone, and taking the FFT of the resulting waveform, and finding the frequency (Extra credit).