UNIV 213 Science & Engineering of Music & Sound Spring 2026

Homework Assignment #2 – due via Moodle at 6:00 pm on Tuesday, Feb. 17, 2026
[Ungraded Prob. 4 revised 2/15/26]

***Instructions, notes, and hints*:**

Provide the details of all solutions, including important intermediate steps. You will not receive credit if you do not show your work. You may make reasonable assumptions and approximations to compensate for missing information, if any.

The first set of problems will be graded and the rest will not be graded. Only the graded problems must be submitted by the deadline above. Do not submit the ungraded problems.

***Graded Problems*:**

1. When a person walks toward a certain loud 1,500 Hz noise source, the sound pressure level (SPL) rises from 25 dB to 82 dB. For this case:

   a. Find the corresponding multiplying factor by which the sound pressure increases and by which the intensity increases.
   b. Find the sound pressure expressed in pascals that corresponds to an SPL of 82 dB.
   c. Find the sound intensity expressed in W/m^2 that corresponds to an SPL of 82 dB.

2. Some radio stations like the time standard station WWV encode information using low-frequency tones that are at such a low level that listeners cannot hear them. If a station were to transmit subaudible tones at 100 Hz, find the maximum sound pressure level that the tones could have at a distance of 1 m or more from the radio and not be heard by most people.

3. Find the sound pressure level (SPL) that a 60 Hz tone must have to be perceived as loud as a 2,000 Hz tone with an SPL of 20 dB.

4. An acoustics engineer is trying to determine the source of a low-frequency rumble-like noise in a workroom that is irritating several of the employees. The engineer takes measurements in the room when no one is there and the room is completely quiet except for the rumble. The SPL measured using a sound level meter set to the A-weighting scale is 20 dB. However, the reading using the Z-weighting scale is 50 dB. What is the approximate frequency of the noise? *Hint*: Refer to the frequency weighting diagram available at the "A-Weighting" Wikipedia page.

(*continued on next page*)

***Ungraded Problems*:**

The following problems will not be graded, but you should attempt to solve them on your own and then check the solutions. Do not give up too quickly if you struggle with one or more of them. Move on to a different problem and then return to the difficult one after a few hours.

1. Suppose that a jackhammer is operating outside your building. An occupational safety official measures an SPL value of 94 dBA one meter away from the jack hammer. The jack hammer is 13 m away from the nearest wall of the building you are in, and you are right next to the same wall inside the building. The building wall attenuates outside sounds by 35 dB (i.e., sounds just outside the wall are 35 dB stronger than just inside the wall). Assuming that the decrease in sound intensity follows the ideal hemispherical behavior described in Sec. 6.2 of the textbook (Rossing, Moore, and Wheeler, 3rd. ed.) find the SPL of the jackhammer noise that you would experience.

2. Express the following power, intensity, or pressure increases or decreases in terms of the appropriate dB units:

- **a.** Power increase from 1.2 nW to 4.8 mW (increase by a factor of 4×10^6)
- **b.** Power decrease from 15 W to 300 mW (decrease by a factor of 1/50 or 0.02)
- **c.** Intensity increase from 4.4 $\mu W/m^2$ to 35.2 $\mu W/m^2$ (increase by a factor of 8)
- **d.** Pressure increase from 2.3 nPa to 12.65 μPa (increase by a factor of 5,500)
- **e.** Sound pressure level (SPL) decrease from 58.3 dB to 34.2 dB

3. Express the following absolute quantities in terms of dB units:

- **a.** For a power of 1.2 nW, find the equivalent power level (L_W).
- **b.** For an intensity of 5.4 nW/m^2, find the equivalent intensity level (L_I).
- **c.** For a sound that creates a pressure change of 0.42 mPa above or below the average air pressure, find the equivalent sound pressure level (L_p or SPL).
- **d.** For a sound that creates a pressure change of 3.7 μPa above or below the average air pressure, find the equivalent sound pressure level (L_p or SPL).

4. **[text in boldface revised 2/15/26]** Assuming that the effective area of the eardrum is 0.50 cm^2, find the average force exerted on the eardrum due to a change in air pressure of 0.01 Pa as a result of a normal conversation. Note that, in the absence of sound, the pressure is the same on both sides of the eardrum, so there is no net force pushing on one side or the other. Remember to convert all units to the MKS system (meters, kilograms, seconds, and the units derived from them, like the newton and the pascal). Assuming a **pressure** multiplying factor of 30 due to the mechanical advantage of the inner ear bones and the small diameter of the oval window on the cochlea, find the average force exerted on the oval window in the inner ear due to a normal conversation. The oval window is a thin membrane.