1. Your favorite band, Green Day, has their amplifiers really cranked up to produce a sound intensity level, $SIL = 110$ dB at a distance of 20 m.

(a) (2 pts) What is the intensity of this sound at this same distance of 20 m?

(b) (3 pts) You are standing at a distance of 20 m. What is the total force due to this sound pressure acting on your eardrum if it can be considered a circle of radius $r = 0.5$ cm (area of a circle, $A = \pi r^2$)? (don't need to know this one)

(c) (3 pts) Bad electronic feedback occurs giving a high-pitched "shriek" at a frequency of 5000 Hz with the same sound pressure level of 110 dB. The loudness of this sound is approximately ________ phons (see attached graph of equal-loudness curves).

(d) (2 pts) At the same sound pressure level, for what frequency would this horrendous sound be perceived as even louder? ___________ Hz.
(d) Conditions are such that sound pressure level is equal to sound intensity level, i.e., \( L_I = L_p \). If this is true,

(i) (3 pts) total sound power in being cranked out by the band is \( \ldots \) watts, and

(ii) (3 pts) the sound intensity level, \( SIL_p \), at a distance of 80 m is \( \ldots \) dB.

(e) (3 pts) Your friend, who isn't so into Green Day, is wearing earplugs that reduces the sound intensity outside his ears compared to that inside his ears by 25 dB. What is the ratio of sound intensity inside his ear compared to outside his ear? i.e., find \( I_{\text{inside}} / I_{\text{outside}} \).

2. (3 pts) Three trombones from a small school marching band are measured at some distance to have a sound intensity level of \( L_I = 60 \) dB. The trombone section of the huge UCLA marching band consisting of 96 trombones walks by at the same distance. Find the sound intensity level, \( L_I \), of these 96 trombones (added as incoherent sources, i.e., non-interfering).
3. (3 pts) during summer vacation, you are swimming underwater and your ear canal of length \( L = 3.0 \) cm is filled with water. It can be treated as a column of fluid open at one end and closed at the other (eardrum). Given that the velocity of sound in water is \( v_{\text{water}} = 1435 \) m/s, at what lowest frequency will your ear be most sensitive due to resonance in your ear canal? (This is one of the reasons that what you hear underwater seems very different).

(A) 480 Hz  
(B) 2,620 Hz  
(C) 3,990 Hz  
(D) 11,960 Hz  
(E) 15,650 Hz

4. Two tones of frequency 600 Hz and 1000 Hz of equal amplitude are played together.

(a) (2 pts) Which tone will excite the Basilar membrane of your inner ear closer to the oval window?

(b) (3 pts) What property of the Basilar membrane explains this, and what is the theory called describing the response of the membrane to different frequencies at different distances from the oval window?

(c) (3 pts) If these frequencies are instead \( f_A = 400 \) Hz and \( f_B = 450 \) Hz, using the concept of critical bandwidth, describe what you would hear (i.e., two separate tones or one fused tone, and if one fused tone, what frequency? Would you hear beats?)
(d) (2 pts) Give two roles of the middle ear in the hearing process.

(e) (2 pts) If your hearing is fine in both ears, is it easier to determine the direction of sounds for high frequency sounds or low frequency sounds, and why?

5. (a) (1 pt) What frequency is 2 octaves above a frequency of \( f = 6000 \) Hz? \( \text{______} \) Hz

(b) (1 pt) Is this new frequency beyond the normal frequency response of a typical adult? Yes No (circle one)

(c) (1.5 pts) What frequency is one semitone below a frequency of \( f = 6000 \) Hz? \( \text{______} \) Hz.

(d) (1.5 pts) At this frequency of 6000 Hz, the just noticeable difference, jnd, of frequency is \( \text{______} \) Hz.

6. (4 pts) Sketch below the standing wave pattern of pressure variations for the third harmonic, i.e., \( f_3 \) in each of the tubes (a) open on both ends; and (b) open on one end, closed on other.

(a)  

(b)  

(c) (3 pts) For the pattern on the left (tube open on both ends), if the length of the tube is \( L = 0.25 \) m, what is the wavelength and frequency of the sound in the tube? (take velocity of sound as 343 m/s).
(c) (2 pts) If the quality factor or $Q$-factor of the resonance in the tube is determined to be 500, what is the linewidth, $\Delta f$, of the resonance? Sketch what that means qualitatively in a plot below: (don’t need to know this one)

\begin{center}
\includegraphics[width=0.5\textwidth]{amplitude-frequency_plot.png}
\end{center}

(d) (2 pts) What would be the fundamental frequency for the tube on the left?

(e) (2 pts) What would the new fundamental frequency be if the temperature was increased to $T = 30^\circ C$?

7. (6 pts) Fill in the blanks in the table below:

<table>
<thead>
<tr>
<th>&quot;Physics&quot; Quantity</th>
<th>Perceived (by ear &amp; brain) Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Loudness</td>
</tr>
<tr>
<td></td>
<td>Timbre</td>
</tr>
</tbody>
</table>

Remember that the lecture on Friday (tomorrow) is cancelled. Also your next CALM homework will be due next Thursday, not Tuesday. Have a good weekend!