EE4445 Quiz 1

September 16, 2009

Professor Leach Name_____

Instructions. Print your name in the space above and at the top of all other pages in your quiz. Express all numerical answers as a decimal number. When appropriate, draw a box around answers.

Honor Code: *I have neither given nor received help on this quiz.* Initials _____

1. (a) Briefly describe the difference between unweighted and A-weighted SPL. Which is numerically larger? A-weighted mimics the response of the ear at the 40 phon level. The unweighted is numerically larger.

   (b) There are two loudness level scales used by psychoacoustic folks. One varies approximately logarithmically with loudness and the other varies approximately linearly with loudness. Name and identify each one. The phon level varies logarithmically. The sone level varies linearly.

   (c) In simple terms, what is the basic difference between white noise and pink noise? White noise has equal power per unit bandwidth. Pink noise has equal power per octave, per decade, etc.

2. (a) An omnidirectional source of sound located against a rigid wall radiates a total acoustic power of 50 mW into a 2π steradian load. What is the SPL at a distance $r = 3$ m from the source?

$$P_{AR} = 2\cdot\pi\cdot r^2\cdot\frac{p_{rms}^2}{\rho_0\cdot c} \qquad p_{rms} := \sqrt{\frac{\rho_0\cdot c\cdot P_{AR}}{2\cdot\pi\cdot r^2}} \qquad p_{rms} = 0.6$$

$$SPL := 20\cdot\log\left(\frac{p_{rms}}{p_{ref}}\right) \qquad SPL = 89.542$$

   (b) A midrange loudspeaker having an advertised frame diameter of 4 in is to be crossed over so that it operates in a frequency range where the circumference of the diaphragm is no greater than four wavelengths. What is the highest frequency that can be applied to the midrange?

$$2\cdot\pi\cdot a = 4\cdot\frac{c}{f} \qquad f := \frac{4\cdot c}{2\cdot\pi\cdot a} \qquad f = 5.491\cdot 10^3$$

   (c) What is the peak-to-peak particle displacement in a sinusoidal 90 dB sound wave at 30 Hz?

$$p_{rms} := p_{ref}\cdot 10^{\frac{dB}{20}} \qquad p_{rms} = 0.632 \qquad u_{rms} := \frac{p_{rms}}{\rho_0\cdot c} \qquad u_{rms} = 1.554\cdot 10^{-3}$$

$$x_{rms} := \frac{u_{rms}}{2\cdot\pi\cdot f} \qquad x_{rms} = 8.242\cdot 10^{-6} \qquad x_{pp} := 2\cdot\sqrt{2}\cdot x_{rms} \qquad x_{pp} = 2.331\cdot 10^{-5}$$

3. A flat circular piston of radius $a = 5$ cm is mounted in an infinite wall. The piston vibrates sinusoidally with a peak displacement $x_p = 2$ mm at a frequency $f = 80$ Hz. The back of the piston radiates into a closed circular tube of radius $r_1 = 5$ cm and length $L_1 = 10$ cm. The

front of the piston radiates into a 2π steradian load.

(a) What is the SPL at a distance $r = 2\,\mathrm{m}$ from the front of the piston?

$$U_{rms} := \frac{2\pi \cdot f \cdot x_p}{\sqrt{2}} \cdot \pi \cdot a^2 \qquad U_{rms} = 5.583 \cdot 10^{-3} \qquad p_{rms} := 2 \cdot \pi \cdot f \cdot \rho_0 \cdot U_{rms} \cdot \frac{1}{2 \cdot \pi \cdot r}$$

$$p_{rms} = 0.264 \qquad SPL := 20 \cdot \log\left(\frac{p_{rms}}{p_{ref}}\right) \qquad SPL = 82.396$$

(b) What is the SPL inside the tube at the back of the piston?

$$V := \pi \cdot r_1^2 \cdot L_1 \qquad C_A := \frac{V}{\rho_0 \cdot c^2} \qquad C_A = 5.592 \cdot 10^{-9}$$

$$p_{rms} := \frac{U_{rms}}{2 \cdot \pi \cdot f \cdot C_A} \qquad p_{rms} = 1.986 \cdot 10^{3} \qquad SPL := 20 \cdot \log\left(\frac{p_{rms}}{p_{ref}}\right) \qquad SPL = 159.94$$

4. The impedance analogous circuit of a mechanical system is shown.

(a) Draw and label the mobility analogous circuit.

(b) Draw and label the mechanical diagram.

(c) Draw and label the mechanical system. Velocity source u_0 driving spring C_0 driving mass M_1 with friction R_1 to floor. Mass M_2 sitting on top of mass M_1 with friction R_2 between the two and spring C_2 from M_2 to wall.