EE4445 Quiz 1
February 4, 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 answers as a decimal number, i.e. do not give an answer that involves fractions, square roots, symbols such as π, etc. Draw a box around answers. Draw a horizontal line between problems.
Honor Code: *I have neither given nor received help on this quiz.* Initials _____

1. (a) A sinusoidal acoustic wave at a frequency of 100 Hz has an SPL of 100 dB. Calculate the peak-to-peak particle velocity.
   (b) Describe one application for pink noise.
   (c) A graphic equalizer is to be designed to cover the full audio band. If the bandwidth of each filter in the equalizer is 1/6 an octave, how many filter bands would be required?

2. (a) The SPL of an acoustic wave is 86 dB. With a second acoustic wave added to the first, the SPL increases to 96 dB. What is the SPL of the second acoustic wave?
   (b) At a distance $r = 3$ m, the SPL radiated by a simple source into 4π steradians is 80 dB. What is the total acoustic power radiated?
   (c) A loudspeaker with an advertised frame diameter of 15 in is mounted in an infinite baffle. The diaphragm vibrates sinusoidally. What is the highest frequency at which it radiates a simple wave into 2π space?

3. A loudspeaker in an infinite baffle (2π steradian load) radiates an SPL of 90 dB at a distance $r = 2$ m. The loudspeaker diaphragm has the piston radius $a = 10$ cm. The frequency is $f = 60$ Hz.

   (a) What is the rms volume velocity emitted by the loudspeaker diaphragm?

   (b) What is the rms mechanical velocity of the diaphragm?

   (c) What is the rms mechanical displacement of the diaphragm?

4. (a) A piston in the end of an infinitely long tube having a diameter of 8 cm radiates an average acoustic power of 2 mW into the tube. Calculate the SPL in the tube.
   (b) The tube is terminated with a rigid cap a distance of 15 cm from the piston. Calculate the SPL in the tube if the peak piston displacement is 1.5 mm and the frequency is 80 Hz.
   (c) Calculate the SPL in the 15 cm tube if the end cap is removed.

Over for solutions.

$\rho_0 := 1.18$ $c := 345$ $p_{ref} := 2 \cdot 10^{-5}$ $R_p(x, y) := \frac{x \cdot y}{x + y}$

Problem 1

Part (a)

$SPL := 100$ $f := 100$ $p_{rms} := p_{ref} \cdot 10^{\frac{SPL}{20}}$ $p_{rms} = 2$ $u_{rms} := \frac{p_{rms}}{\rho_0 \cdot c}$

$x_{rms} := \frac{u_{rms}}{2 \cdot \pi \cdot f}$ $x_{pp} := 2 \cdot \sqrt{2} \cdot x_{rms}$ $x_{pp} = 2.212 \cdot 10^{-5}$

Part (b)

measuring loudspeaker frequency response

setting up graphic equalizers in rooms and auditoriums

Part (c)

$f_1 := 20$ $f_2 := 20000$ $n := \frac{6}{\log(2)} \cdot \log\left(\frac{f_2}{f_1}\right)$ $n = 59.795$

Problem 2

Part (a)

$SPL_1 := 86$ $SPL_{sum} := 96$ $p_1 := p_{ref} \cdot 10^{\frac{SPL_1}{20}}$ $p_{sum} := p_{ref} \cdot 10^{\frac{SPL_{sum}}{20}}$ $p_{sum} = 1.262$

$p_2 := \sqrt{p_{sum}^2 - p_1^2}$ $SPL_2 := 20 \cdot \log\left(\frac{p_2}{p_{ref}}\right)$ $SPL_2 = 95.542$

Part (b)

$r := 3$ $SPL := 80$ $p_{rms} := p_{ref} \cdot 10^{\frac{SPL}{20}}$ $I := \frac{p_{rms}^2}{\rho_0 \cdot c}$ $I = 9.826 \cdot 10^{-5}$

$P_{AR} := 4 \cdot \pi \cdot r^2 \cdot I$ $P_{AR} = 0.011$

Part (c)

$a := 0.15$ $f := \frac{c}{2 \cdot \pi \cdot a}$ $f = 366.056$

Problem 3

$SPL := 90 \qquad r := 2 \qquad a := 0.1 \qquad f := 60$

Part (a)

$p_{rms} := p_{ref} \cdot 10^{\frac{SPL}{20}} \qquad p_{rms} = 0.632 \qquad U_{rms} := 2 \cdot \pi \cdot r^2 \cdot \frac{p_{rms}}{2 \cdot \pi \cdot f \cdot \rho_0} \qquad U_{rms} = 0.036$

Part (b)

$u_{rms} := \frac{U_{rms}}{\pi \cdot a^2} \qquad u_{rms} = 1.137$

Part (c)

$x_{rms} := \frac{u_{rms}}{2 \cdot \pi \cdot f} \qquad x_{rms} = 3.017 \cdot 10^{-3}$

Problem 4

Part (a)

$D := 0.08 \qquad a := \frac{D}{2} \qquad P_{AR} := 0.002 \qquad R_A := \frac{\rho_0 \cdot c}{\pi \cdot a^2} \qquad R_A = 8.099 \cdot 10^4$

$p_{rms} := \sqrt{P_{AR} \cdot R_A} \qquad p_{rms} = 12.727 \qquad SPL := 20 \cdot \log\left(\frac{p_{rms}}{p_{ref}}\right) \qquad SPL = 116.074$

Part (b)

$L := 0.15 \qquad f := 80 \qquad x_p := 0.0015 \qquad C_A := \frac{\pi \cdot a^2 \cdot L}{\rho_0 \cdot c^2} \qquad C_A = 5.368 \cdot 10^{-9}$

$U_{rms} := \frac{1}{\sqrt{2}} \cdot \pi \cdot a^2 \cdot 2 \cdot \pi \cdot f \cdot x_p \qquad U_{rms} = 2.68 \cdot 10^{-3} \qquad p_{rms} := \frac{U_{rms}}{2 \cdot \pi \cdot f \cdot C_A} \qquad p_{rms} = 993.128$

$SPL := 20 \cdot \log\left(\frac{p_{rms}}{p_{ref}}\right) \qquad SPL = 153.92$

Part (c)

$M_A := \frac{\rho_0 \cdot L}{\pi \cdot a^2} \qquad M_A = 35.213 \qquad p_{rms} := U_{rms} \cdot 2 \cdot \pi \cdot f \cdot M_A \qquad p_{rms} = 47.434$

$SPL := 20 \cdot \log\left(\frac{p_{rms}}{p_{ref}}\right) \qquad SPL = 127.501$