

EE4445 Quiz 2

October 21, 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. Points may be deducted if your writing is not legible or too small to read. **Honor Code:** *I have neither given nor received help on this quiz.* Initials _____

- (a) Describe the frequency response of a cavity microphone when it is used as a free-field microphone. There is a treble boost.
(b) Which of the microphone types that we covered is designed with a resonance frequency at the upper end of the audio frequency band? The condenser microphone.
(c) For a spherical wave incident on the microphone, what would be the distance from the microphone to the source at $f = 100$ Hz if the proximity effect causes 8 dB of boost?

$$8 = 20 \log \left[\sqrt{1 + \left(\frac{c}{2\pi f r} \right)^2} \right] \quad \text{yields} \quad r = 0.238 \text{ m}$$

- (a) The total mechanical mass M_{MS} of a loudspeaker diaphragm (including its air-load mass) is increased by an amount ΔM_{MS} such that the total mass is $M_{MS} + \Delta M_{MS} = k M_{MS}$, where k is a constant. In terms of k , describe the effect on the fundamental resonance frequency, the total quality factor, and the on-axis pressure sensitivity. f_S is divided by a factor of \sqrt{k} , Q_{TS} is multiplied by a factor of \sqrt{k} , and p_{sens} is divided by a factor of k .
(b) We encountered three second-order transfer functions in analyzing the infinite-baffle loudspeaker at low frequencies. These were low-pass, high-pass, and band-pass. What variable did each transfer function represent? The volume velocity is a BPF, the on-axis pressure is a HPF, and the diaphragm mechanical velocity is a LPF.
(c) The Q_{TS} of a loudspeaker driver can be increased for increased bass response near the fundamental resonance frequency in two ways without changing the mass or compliance. Both result in a reduction in efficiency. Briefly describe the methods and compare their effect on the efficiency. Increase the voice-coil resistance R_E or decrease the $B\ell$ product. The second method results in the higher efficiency.
3. A loudspeaker driver is to be designed for an acoustic suspension system having the compliance ratio $\alpha = 10$. The box volume is to be $1.2 \text{ ft}^3 = 34 \times 10^{-3} \text{ m}^3$.
 - (a) What must be the acoustic compliance C_{AS} of the driver?

$$C_{AS} = \frac{\alpha V_{AS}}{\rho_0 c^2} = 2.42 \times 10^{-6}$$

- (b) If the closed-box system resonance frequency is to be 45 Hz, calculate the required acoustic mass M_{AS} .

$$M_{AS} = \frac{1}{(2\pi f_C)^2 C_{AT}} = \frac{1 + \alpha}{(2\pi f_C)^2 C_{AS}} = 56.8$$

- (c) The total quality factor of the closed-box system is to be $Q_{TC} = 1$. The mechanical quality factor of the system is estimated to be $Q_{MC} = 3$. Calculate the required electrical quality factor Q_{ES} of the driver.

$$Q_{ES} = \frac{Q_{EC}}{\sqrt{1 + \alpha}} = \frac{1}{\sqrt{1 + \alpha}} \frac{Q_{MC} Q_{TC}}{Q_{MC} - Q_{TC}} = 0.452$$

(d) What must be the fundamental resonance frequency f_S of the driver?

$$f_S = \frac{f_C}{\sqrt{1 + \alpha}} = 13.6 \text{ Hz}$$

4. A driver has the parameters: resonance frequency $f_S = 24 \text{ Hz}$, total quality factor $Q_{TS} = 0.35$, electrical quality factor $Q_{ES} = 0.4$, and volume compliance $V_{AS} = 12 \text{ ft}^3$.

(a) Specify the volume in cubic feet of a filled closed-box for a total quality factor of $Q_{TC} = 0.9$. Assume $Q_{MC} = 4$ and that the filling increases the effective volume by 15%, i.e. $V_{AB} = 1.15V_B$.

$$Q_{EC} = \frac{Q_{MC}Q_{TC}}{Q_{MC} - Q_{TC}} = 1.161 \quad \alpha = \left(\frac{Q_{EC}}{Q_{ES}}\right)^2 - 1 = 7.43$$

$$V_{AB} = \frac{V_{AS}}{\alpha} = 1.62 \text{ ft}^3 \quad V_B = \frac{V_{AB}}{1.15} = 1.41 \text{ ft}^3$$

(b) Calculate the lower -3 dB cutoff frequency of the system.

$$f_\ell = \sqrt{1 + \alpha} f_S \left[\left(\frac{1}{2Q_{TC}^2} - 1 \right) + \sqrt{\left(\frac{1}{2Q_{TC}^2} - 1 \right) + 1} \right]^{1/2} = 57.8 \text{ Hz}$$