EE4445 Quiz 2

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Instructions. *Print* your name in the spaces above and at the top of all other pages in your quiz. Draw a box around answers. Express all answers as a decimal number. Draw a horizontal line between problems.

1 of 3. (a) If a free-field microphone is used as a vessel microphone, how would the frequency response change?

(b) What is meant by the proximity effect, and (in words) how does it vary with position between a talker and a microphone.

(c) If a ribbon microphone is rotated in front of a point source, how would the output signal from the microphone vary with the angle of the microphone?

2 of 3. An 12-inch loudspeaker driver is to be designed to have a Butterworth or B2 response in an infinite baffle. The piston radius is specified to be $a = 12\,\text{cm}$. Stock components having the following parameters are to be used for the driver diaphragm, suspension, and voice coil: mechanical mass $M_{MD} = 50\,\text{g}$, mechanical compliance $C_{MS} = 2 \times 10^{-4}\,\text{m/N}$, and voice-coil resistance $R_E = 4\,\Omega$.

(a) What is the required total quality factor Q_{TS}?

(b) If the lower cutoff frequency is specified to be $f_\ell = 40\,\text{Hz}$, what is the required resonance frequency f_S?

(c) Is an added mass load required in order to obtain the desired resonance frequency f_S? If so, what additional mass must be added to the diaphragm? Do not neglect the air-load mass.

(d) If the mechanical quality is estimated to be $Q_{MS} = 5$, what must be the electrical quality factor Q_{ES} of the driver?

(e) What is the required $B\ell$ product?

(f) What is the required volume compliance V_{AS}?

(g) What is the driver reference efficiency η_0?

3 of 3. A closed-box loudspeaker system is to be designed for a C2 alignment with $Q_{TC} = 1.2$ and an internal volume of $V_{AB} = 1.5\,\text{ft}^3 = 4.248 \times 10^{-2}\,\text{m}^3$. It can be assumed that $M_{AC} = M_{AS}$.

(a) The box is to be filled and the mechanical quality factor is estimated to be $Q_{MC} = 4$. What is the required value of the electrical quality factor Q_{EC}?

(b) The lower $-3\,\text{dB}$ cutoff frequency is specified to be $f_\ell = 45\,\text{Hz}$. Calculate the required value of the closed-box resonance frequency f_C.

(c) The compliance ratio is specified to be $\alpha = 5$. What is the required driver volume compliance V_{AS}?

(d) What is the required value of the driver resonance frequency f_S?

(e) What is the required driver electrical quality factor Q_{ES}?

(f) What is the driver reference efficiency η_0?

Problem 2

$a := 0.12$ $Q_{TS} := \frac{1}{\sqrt{2}}$ $Q_{MS} := 4$ $f_L := 40$ $M_{MD} := 0.05$ $C_{MS} := 2 \cdot 10^{-4}$

$Q_{MS} := 5$ $S_D := \pi \cdot a^2$ $M_{M1} := S_D^2 \cdot \frac{8 \cdot \rho_0}{3 \cdot \pi^2 \cdot a}$ $M_{M1} = 5.437 \cdot 10^{-3}$ $f_S := f_L$

$M_{MS} := M_{MD} + 2 \cdot M_{M1}$ $R_E := 4$ $M_{MS} \cdot 1000 = 60.875$

$M_{add} := \frac{1}{\left(2 \cdot \pi \cdot f_S\right)^2 \cdot C_{MS}} - M_{MS}$ $M_{add} \cdot 1000 = 18.282$

$Q_{ES} := \frac{Q_{MS} \cdot Q_{TS}}{Q_{MS} - Q_{TS}}$ $Q_{ES} = 0.824$

$\frac{1}{\left(2 \cdot \pi \cdot f_S\right)^2 \cdot C_{MS}} = 0.079$

$BL := \sqrt{\frac{R_E}{Q_{ES}} \cdot \sqrt{\frac{M_{MS}}{C_{MS}}}}$ $BL = 9.205$

$V_{AS} := C_{MS} \cdot S_D^2 \cdot \rho_0 \cdot c^2$ $V_{AS} = 0.057$ $V_{AS} \cdot \left(\frac{39.37}{12}\right)^3 = 2.03$

$\eta_0 := \frac{4 \cdot \pi^2}{c^3} \cdot \frac{f_S^3 \cdot V_{AS}}{Q_{ES}}$ $\eta_0 \cdot 100 = 0.429$

Problem 3

$Q_{TC} := 1.2$ $V_{ABel} := 1.5$ $V_{ABme} := V_{ABel} \cdot \left(\frac{12}{39.37}\right)^3$ $V_{ABme} \cdot 100 = 4.248$ $Q_{MC} := 4$

$Q_{EC} := \frac{Q_{MC} \cdot Q_{TC}}{Q_{MC} - Q_{TC}}$ $Q_{EC} = 1.714$ $f_L := 45$ $\alpha := 5$

$X := \frac{1}{2 \cdot Q_{TC}^2} - 1$ $f_C := \frac{f_L}{\sqrt{X^2 + \sqrt{X^2 + 1}}}$ $f_C = 35.352$

$f_S := \frac{f_C}{\sqrt{1 + \alpha}}$ $f_S = 14.432$

$V_{ASel} := V_{ABel} \cdot \alpha$ $V_{ASme} := V_{ABme} \cdot \alpha$ $V_{ASel} = 7.5$ $V_{ASme} = 0.212$

$Q_{ES} := \frac{Q_{EC}}{\sqrt{1 + \alpha}}$ $Q_{ES} = 0.7$ $\eta_0 := \frac{8 \cdot \pi^2}{c^3} \cdot \frac{f_S^3 \cdot V_{ASme}}{Q_{ES}}$ $\eta_0 \cdot 100 = 0.175$