Subject: ACS 547, Noise Control Applications - Module 2 Assignment

Date: February 20, 2025 (Submitted)

Problem 1 - Modal Behaviour of a Cylindrical Room

The Matlab code for this problem is listed in Appendix **??**.

Problem 1a

The lowest cut-on frequency for a rectangular duct with air flow is given by equation,

$$\mathrm{f_{cut-on}} = 0.5 \cdot \frac{\mathrm{c}}{\mathrm{L}} \tag{1}$$

where c is the speed of sound in air, 343 $\frac{\mathrm{m}}{\mathrm{s}}$, and L is the largest side of the rectangular cross-section.

With cross-sectional dimensions of $\mathrm{L_x}$ = 12 cm and $\mathrm{L_y}$ = 20 cm, the lowest cut-on frequency for this rectangular duct is,

$$\mathrm{f_{cut-on}} = 0.5 \cdot \frac{343\ \frac{\mathrm{m}}{\mathrm{s}}}{0.20\ \mathrm{m}} = \mathbf{857.5\ Hz}$$

Problem 1b

The lowest cut-on frequency for a circular duct with air flow with the same cross-sectional area as the rectangular duct in part (a.) can be calculated using equation,

$$\mathrm{f_{cut-on}} = 0.568 \cdot \frac{\mathrm{c}}{\mathrm{d}} \tag{2}$$

where c is the speed of sound in air, 343 $\frac{\mathrm{m}}{\mathrm{s}}$, and d is diameter of the circular duct.

The cross-sectional area of the rectangular duct is,

$$\mathrm{Area}_{\ \mathrm{rectangular\ duct}} = 0.12\ \mathrm{m}\ \ \cdot 0.20\ \mathrm{m} = 0.024\ \mathrm{m}$$

The corresponding diameter for this area is,

$$\mathrm{diameter} = \sqrt{\frac{0.24\ \mathrm{m}^2}{\pi}} \cdot 2 = 0.17\ \mathrm{m}$$

Using Eq. 2, the lowest cut-on frequency for this circular duct with air flow is,

$$\mathrm{f_{cut-on}} = 0.568 \cdot \frac{1,500\ \frac{\mathrm{m}}{\mathrm{s}}}{0.17\ \mathrm{m}} = \mathbf{1,114.5\ Hz}$$

Problem 1c

The lowest cut-on frequency for this circular duct with water flow can be calculated using Eq. 2,

$$f_{\mathrm{cut-on}} = 0.568 \cdot \frac{1,500\ \frac{\mathrm{m}}{\mathrm{s}}}{0.17\ \mathrm{m}} = \mathbf{4,873.9\ Hz}$$

The lowest cut-on frequency for water is considerable larger than it is for air flow.

Problem 2 - Sabine Room

The Matlab code for this problem is listed in Appendix **??**.

For these muffler comparisons, the following assumptions were made:

- There is no flow.
- There are no resistive terms.
- The load impedance was not included because the transmission loss does not require it.

Problem 2a

Figure **??** shows the transmission loss profiles for a simple expansion chamber, a double-tuned expansion chamber, and a cascaded double-tuned expansion chamber muffler.

The peaks for the simple expansion chamber (red, dashed line) are approximately 22 dB and occur at frequencies with a wavelength that is a quarter of the length of the expansion chamber. Minimal loss occurs at half wavelength multiples.

The addition of the extension tube inside the muffler produces a quarter wavelength resonator. The side branch of Ji (2005; Slide 11, Lecture 3 notes) was used to calculate L_o. For the cascaded double-tuned expansion chamber, the extension tubes produce a secondary quarter wavelength resonator.

As noted in office hours, there is no damping which produces artificially high resonances.

Problem 2b

Figure **??** shows the transmission loss profiles for a cascaded double-tuned expansion chamber and a modified version of this muffler.

Two modifications were made to the original muffler:

1. The left 3" extension tube in the left chamber was shortened to 2" inches, making the respective muffler section 1" longer.

2. The left 3" extension tube in the right chamber was lengthened to 4", making the respective muffler section 1" shorter.

These modifications change the symmetry of the cascaded system, and allow the resonate frequencies to be changed independently.

Problem 3 - Transmission Loss Measurement

The Matlab code for this problem is listed in Appendix **??**.

Table 1 lists the length of the pipe section and the mouthpiece.

Item	**Length [mm]**
Pipe	145
Mouthpiece	90

Table 1: Calculated length of the pipe and length of the mouthpiece.

Problem 4 - Panel Transmission Loss

The Matlab code for this problem is listed in Appendix ??.

Problem 4a

Table 2 lists the Mach numbers for each pipe section. The flow rate is 0.017462 $\frac{\text{m}^3}{\text{s}}$.

Pipe	Area [m^2]	Mach Number [unitless]
Inlet	0.000507	-0.10047
Outlet	0.00811	-0.0062795

Table 2: Calculated Mach numbers.

Problem 4b

Figure ?? shows the transmission loss profiles.

The addition of flow to the intake system introduces a slight phase delay, a lower overall level of loss (approximately 22 dB), and greater loss at the dips. The phase delay is easier to see at respective dips in the loss profile.

i - Critical Frequency and Coincidence Frequency at 75°

ph

ii - Transmission Loss at Angle of Incidence of 75°

ph

iii - Transmission Loss for Angles of Incidence between 0-90°

ph

iv - Diffuse Transmission Loss

ph

Problem 4c

Problem 4d

i - Critical Frequency and Coincidence Frequency at 75°

ph

ii - Transmission Loss at Angle of Incidence of 75°

ph

vspace0.25cm

iii - Transmission Loss for Angles of Incidence between 0-90°

ph

iv - Diffuse Transmission Loss

Problem 5 - Large Enclosure Design

The Matlab code for this problem is listed in Appendix **??**.

ph

Problem 6 - Close-fitting Enclosure Design

The Matlab code for this problem is listed in Appendix **??**.

ph