ERASMUS MUNDUS MASTER WAVES

Computational Modelling

2024/2025

PRACTICAL WORK 2

To be prepared in groups of 2 students

NOTE: A1 and B1 are the last digits of the student identification number of students A and B

(for example: Student A - SID 1234567 -> A1=7; Student B - 13425821 -> B1=1)

Consider a 2D practical acoustic problem, in the frequency domain, in which it is intended to compute the transmission loss (TL) provided by an acoustic attenuator, depicted in the figures presented in the appendix (note that the figure to be considered will depend on A1).

In all the given figures, L=0.6+(A1+B1)/100.0.

Consider that the acoustic wave propagating problem is governed by the Helmholtz equation $\nabla^2 p + \left(\frac{\omega}{c}\right)^2 p = 0$, in which p is the acoustic pressure, c the sound propagation velocity and ω the angular frequency, and that there is no air flow inside this device. In addition, consider that all surfaces can be assumed to be locally reactive (thus absorption conditions can be approximated from surface impedance Z=p/v=$\rho c \frac{1+\sqrt{1-\alpha}}{1-\sqrt{1-\alpha}}$).

The internal surfaces are rigid (Neumann condition with v_n=0), except:

- at the internal heterogeneities (black) for which the following sound absorption curve should be considered (valid from 100 Hz to 2500 Hz):

$$\alpha = \frac{0.002f + 0.04\log(f) - (0.0008f)^2}{2\sqrt{A1+1}}$$

- at the left side (input), where a normal velocity of 1.0mm/s should be considered;
- at the right side (output), where a perfect absorption should be considered.

QUESTIONS:

Establish a Finite Element Model for this problem using Matlab's pdeModeler application.

a) Considering an excitation frequency of 500+A1*10+B1 (Hz):

a1) parametrize (and explain the different parameters you use) pdeModeler to solve the given problem (including PDE and boundary conditions).

a2) define a uniform mesh that you consider to be adequate (justify) to solve this problem for the given frequency.

a3) compute the sound pressure distribution in this system, and present plots for its real, imaginary and absolute values, as well as for the Sound Pressure Level (ref 2E-5Pa).

a4) starting from a coarser mesh (with elements 3 time larger than in the previous mesh), and then using iterative refinement, with 5 refinement steps, compute the pressure distribution, and compare its absolute value with the one computed before. Discuss the results, also considering the total number of elements and their distribution.

b) Consider now the octave frequency bands of 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz. For each band, estimate the Transmission Loss and the Insertion Loss of the system. For this calculation, consider 3 frequencies for each band, given by $f_c/2$^(1/3), f_c and $f_{c*}2$^(1/3), and use the average (energy) sound pressure level at a central point in the "input" and "output" extreme boundaries. Use the same mesh for all frequencies, defined so as to obtain adequate results for the higher calculated frequency.

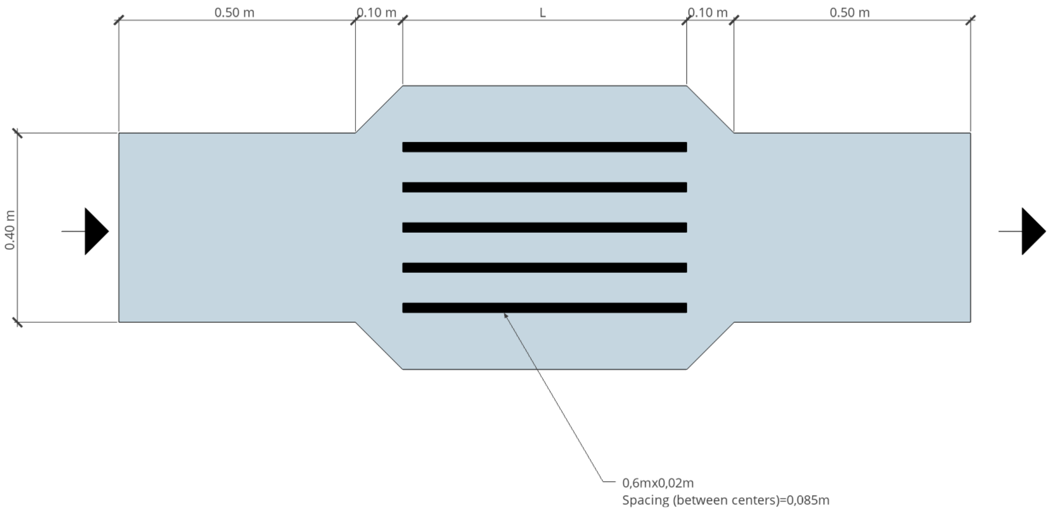
NOTE: $TL=SPL_{(input,\ with\ attenuator)} - SPL_{(output,\ with\ attenuator)}$

$IL=SPL_{(output,\ without\ attenuator)} - SPL_{(output,\ with\ attenuator)}$

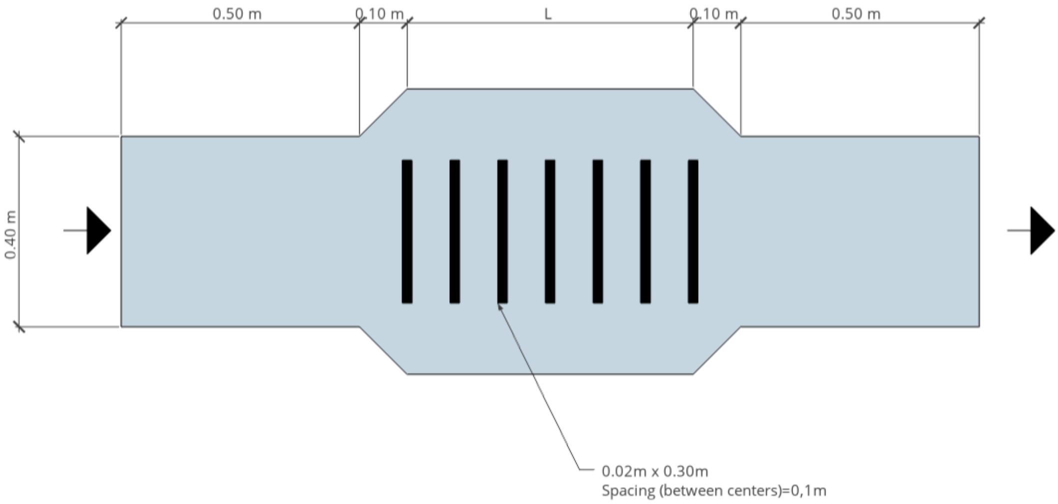
APPENDIX

Geometry of the problem

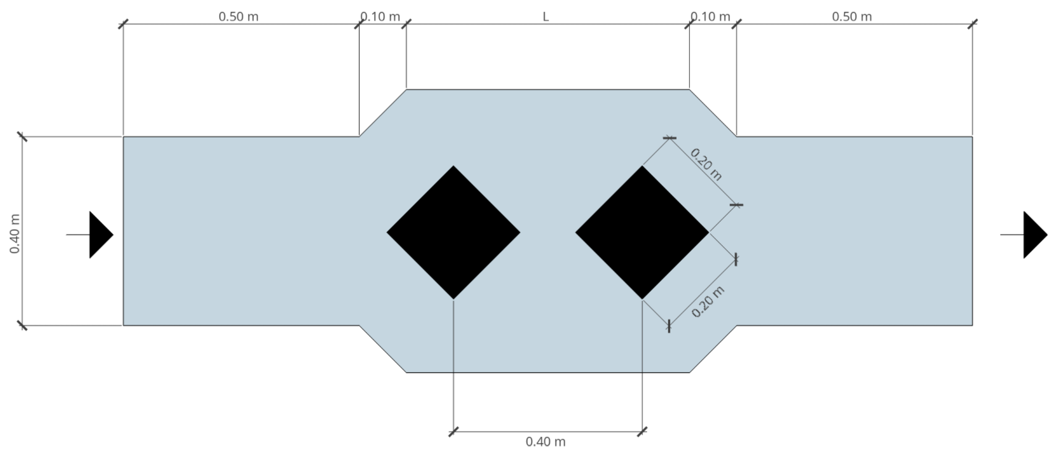
a) For A1=0, A1=1 or A1=2



b) For A1=3, A1=4 or A1=5



c) For A1=6 or A1=7



d) For A1=8 or A1=9