POLITECNICO
MILANO 1863

MSc. Music and Acoustic Engineering

Musical Acoustics - A.Y. 2020/2021

H7 - Eigenfrequency Study of a Marimba Bar

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1 Constructing the mesh

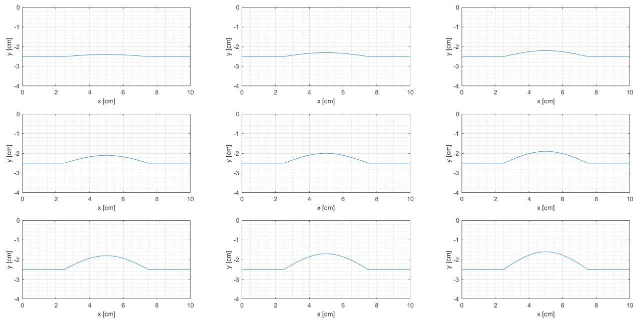

Figure 1: Profiles of the lower surface of a marimba bar with the depth of the arching varying from 1 to 9 mm.

Our aim in this homework is to study the dependency of the modes of a marimba bar on the depth a of the arching. Fig. 1 shows how we modelled the profiles: the cutaway is sinusoidal in shape and varies from 1 to 9 mm in depth in steps of 1 mm. The model for the bar was implemented in Comsol with a length of 10 cm, a height of 2.5 cm and a width of 2.5 cm. The depth a was defined as a global parameter in order to perform a parametric study of the eigenfrequencies. The values of the Young moduli, shear moduli and Poisson coefficients were taken from [1], considering Honduran mahogany as our material of choice. Ideally, the most sought after instruments of this kind are made of rosewood; however, for this material, it is harder to find measurements of all of the nine relevant parameters that are needed to completely characterize it. Fig. 2 shows the profiles of the generated meshes.

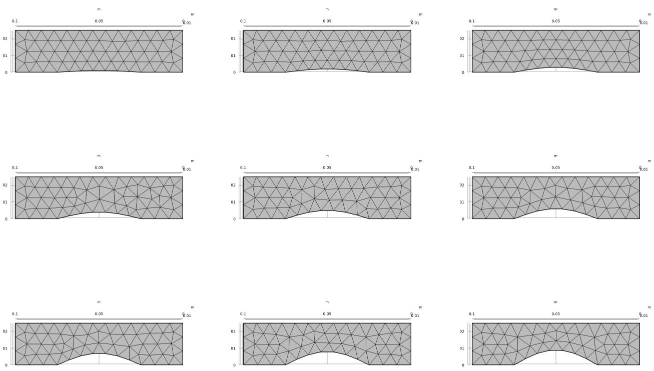

Figure 2: Profiles of the Comsol mesh for all values of a used in the parametric study.

2 Eigenfrequencies

As mentioned in the previous section, a parametric eigenfrequency study was performed, with the values we already reported for a and with free boundary conditions. The first five eigenfrequencies obtained from this study for each value of a are reported in Tab. 1. They are also reported as functions of a in Fig. 3.

a [cm]	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
f_1[kHz]	5.9071	5.7717	5.6294	5.4788	5.3202	5.1534	4.9770	4.7969	4.6076
f_2[kHz]	8.1063	8.0827	7.8760	7.5803	7.2655	6.9319	6.5852	6.2287	5.8557
f_3[kHz]	8.4015	8.1523	8.0464	8.0000	7.9430	7.8755	7.7968	7.7086	7.6096
f_4[kHz]	12.2164	12.3037	12.3886	12.4762	12.5592	12.6413	12.7214	12.7876	12.5428
f_5[kHz]	14.0013	13.8828	13.7447	13.5885	13.4160	13.2263	13.0134	12.7992	12.8797

Table 1: First five eigenfrequencies of the bar for each value of a.

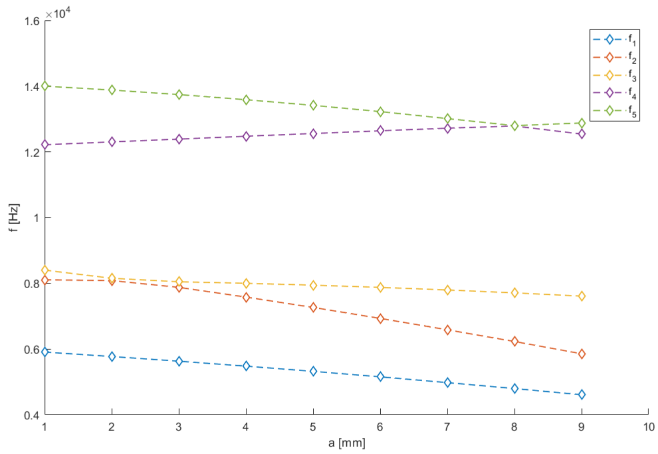

Figure 3: The five lowest eigenfrequencies plotted as functions of a.

3 Inharmonicity

Lastly, we compute the inharmonicity of the sets of eigenfrequencies obtained before. The inharmonicity is a descriptor defined as:

$$I = \sum_{n=2}^{N} \left| \frac{f_n}{f_{n-1}} - m_n \right| ,$$
$$m_n = \arg\min_m |f_n - m f_{n-1}| \, , \; m \in \mathbb{N}^+,$$

where $N = 5$ in our case. The values of I we computed are reported in Fig. 4.

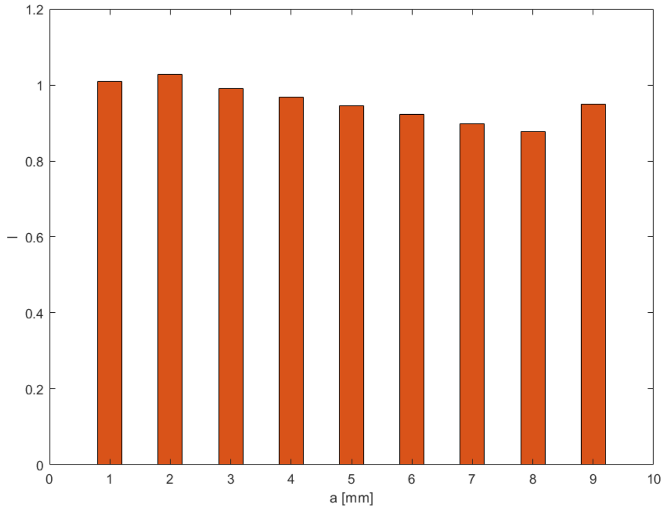

Figure 4: Inharmonicity as a function of a.

4 A better shape of the bar

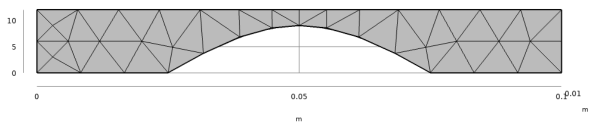

Figure 5: Profile of the alternate mesh (with $a = 9$ mm).

Looking at the values we obtained from the eigenfrequency study, a problem seems to arise. While we expect the values of the ratios between the frequencies of the first two bending modes is ~ 4, the actual ratio is much lower. We tried therefore to alter the shape of the bar to see if we could obtain better results. We ran a parametric eigenfrequency study like before, but with an height of 1.2 cm. The new shape of the bar can be seen in Fig. 5.