

 <b>POLITECNICO</b> MILANO 1863	051483 Musical Acoustics Module 2: Modeling of musical instruments Academic Year 2021/2022	Homework 5 Design of a piano
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## Design of a piano

### Soundboard characterization

Consider a rectangular plate of dimensions 1m x 1.4 m, to be used as a soundboard. The plate is assumed to be simply supported (i.e. the analytical form of the displacement can be computed). The thickness of the soundboard is 1cm, and the material is assumed to be homogeneous and isotropic (approximation!).

The mechanical parameters of the soundboard to be used are those of the longitudinal direction of the Sitka spruce.

- Compute the input impedance of the soundboard as a function of the position  $(x, y)$  and of the frequency  $f$ . Assume the reference frame to be centered in the lower left corner of the soundboard. The student is not required to use Finite Element Analysis for this question, but he could do so if he prefers.

### String pairing

Consider pairs of strings (approximation wrt reality!) mounted on the soundboard. The pairs are deputed to produce the notes F2 ( $f_0 = 349.23$  Hz) A4 ( $f_0 = 440$  Hz), C5 ( $f_0 = 523.25$  Hz), E5 ( $f_0 = 659.25$  Hz), G5 ( $f_0 = 783.99$  Hz).

- Design the shape of the bridge for producing the above notes, so that the input impedance at the force application points is not at a maximum. In the design, assume that the bridge transfer energy to the soundboard at the point where the string is mounted.
- For all the strings assume that the weight per unit length is 10.8g/m. One of the strings in the pair is tuned to produce  $f_0$  (i.e.  $\omega_1 = 2\pi f_0$ ), while the second is detuned and  $\omega_1 = 2\pi f_0(1 + 2\epsilon)$ . Compute the eigenfrequencies of the two strings in the pairs.
- Compute the decay times for the two eigenfrequencies for all the pairs.

### Notes & suggestions:

- Answer concisely;
- Describe – concisely - the procedure used to obtain the results: if an error is present, I cannot identify the reason – numerical or conceptual - if the procedure is not described: in grading I will be forced to use the worst-case option.
- Upload the report by December 9<sup>th</sup>.
- All students must upload the report.**
- In the PDF file and possibly in the filename, specify the name, surname and ID of all the students participating to the HW, if more than one student worked on it.