POLITECNICO
MILANO 1863

Musical Acoustics Module I: Modeling of Musical Instruments

HL1 - Practice Session Homework I – Comsol Multiphysics

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Instructions

- Homeworks can be done in groups of up to 3 people

- You must upload on the HL1 beep folder the Comsol files and a report describing the work you have done.

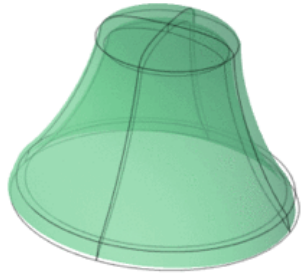
- You will have one month from the day when the exercises were published.
  (23:59 – 26/11/2020)

- Each Exercise and sub-exercise corresponds to different points
  - Exercise 1 (0.75 points)
  - Exercise 2 (0.25 points)

- N.B. please include your student ID in the report

Exercise 1 – Church Bell – 3D model (0.75 points)

- ❑ Create a **3D model** for computing the eigenfrequencies of a Church Bell



- ❑ Model Design can be inspired by the following Church Bell example

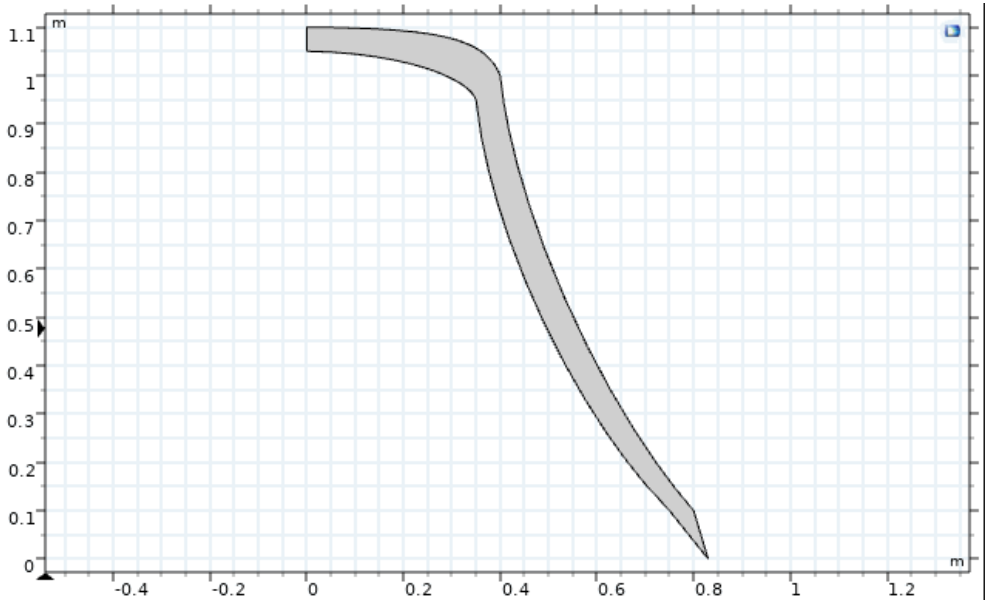
http://www.apps.vib.mw.tum.de/app-lib#0

1. **(0.25 points)** Build the 3D model of the Church Bell, you can do it both using fixed values or parameters that can modify the shape design.
2. **(0.10 points)** Perform the eigenfrequency simulation for the bell with no boundary conditions (free model). What do the first eigenfrequency represent? Export some videos related to the eigenfrequencies motion.
3. **(0.25 points)** Add a boundary load on the edge and on the side of the church bell (you can also try other excitation points), then perform:
   a) **(0.05 points)** Time domain study
   b) **(0.05 points)** Frequency Domain Study
   c) **(0.05 points)** Frequency Domain modal study

In all cases comment your results in the report.

Exercise 1 – Church Bell – 3D model - Hints

❑Model shape must be defined through **bezier polygon**



❑**Hints:**

- ❑Define geometry in Work plane
- ❑Use Revolve to obtain 3D geometry

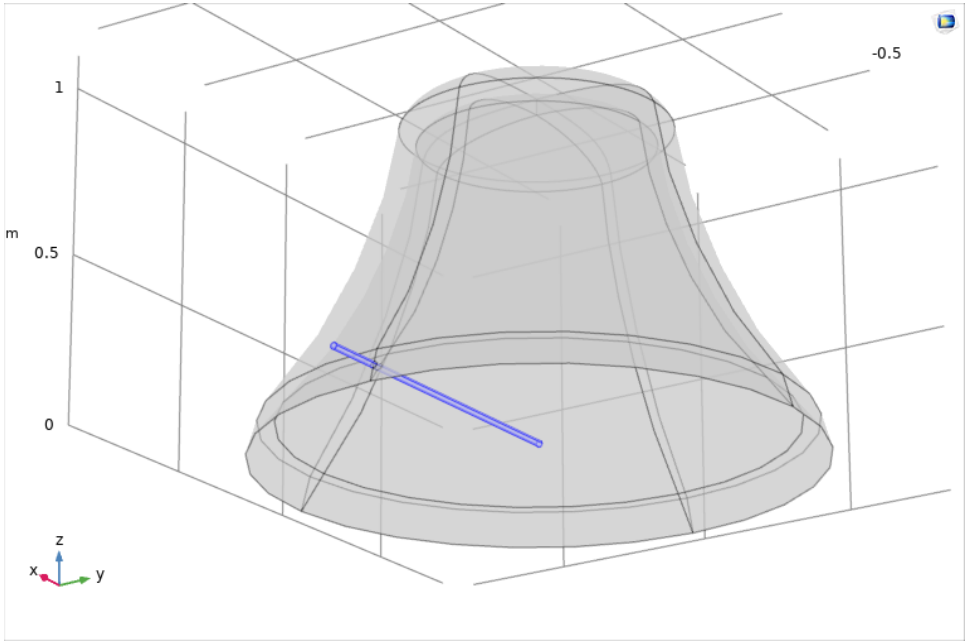
https://www.comsol.it/learning-center/how-to-build-3d-objects-from-2d-geometries-in-comsol-multiphysics

- More hints about bezier polygons contained in the appendix

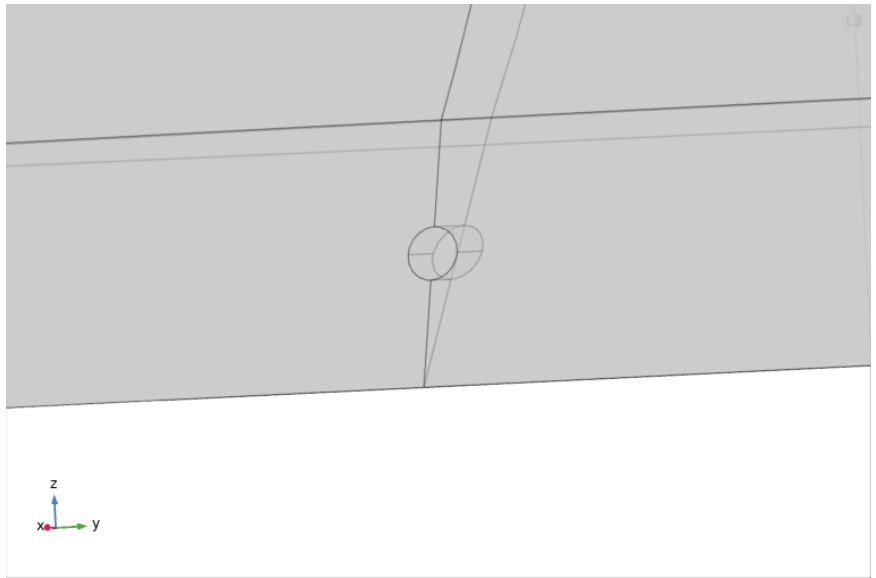
Exercise 1 – Church Bell – 3D model - Hints

❑ Boundary Load: with non-planar geometries

1. Add a *Cylinder* node in the geometry node
2. Add a *Intersection* node and compute the intersection between bell and cylinder
3. Use *Delete Entities* to delete the unnecessary part of the cylinder

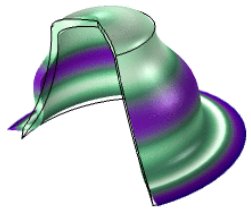


If the boundary of the intersection includes undesired edges, use the *Ignore Edges* node and select the edges to delete.



Exercise 2 – Church Bell – 2D Axysimmetric (0.25 points)

- Model the church bell using an ***axysimmetric model***



1. **(0.15 points)** Model the church bell geometry using an axysimmetric model
2. **(0.05 points)** Compute the eigenfrequency study considering no boundaries (free model)
3. **(0.05 points)** Are you able to obtain the same results of the first model? Why?

Appendix – Bezier Polygon

Bézier Polygon

A Bézier polygon consists of a sequence of connected line segments, quadratic Bézier curves (for example circular arcs), and cubic Bézier curves. To create a Bézier polygon, right-click a 2D **Geometry** node and select **Bézier Polygon** () or right-click a 3D **Geometry** node and select **More Primitives>Bézier Polygon**. Then enter the properties of the Bézier polygon.

GENERAL

From the **Type** list, select **Solid**, **Closed curve**, or **Open curve** to specify if the Bézier polygon is a solid object (only available in 2D) or a closed or open curve object. If you choose **Solid** or **Closed curve**, the software automatically adds a line segment if needed to close the polygon.

POLYGON SEGMENTS

Define the Bézier polygon by adding curve segments to the list of segments. Choose from linear segments, quadratic segments, and cubic segments. Delete segments by selecting them and clicking **Delete**. To edit a segment, select it in the list. When editing the last segment, click **Close Curve** to make the last control point coincide with the first control point of the first segment.

Appendix – Bezier Polygon

Linear Segments

To add a linear segment, click **Add Linear**. Specify the start of the linear segment on the first row of coordinates under **Control points**. Specify the end of the linear segment on the second row of coordinates.

Quadratic Segments

To add a quadratic segment, click **Add Quadratic**. Specify the coordinates of the three control points on rows under **Control points**. Add the weights of the control points under **Weights**. The default weights—1, $1/(\sqrt{2})$, and 1—correspond to a circular arc if the control points are three corners of a square.

Cubic Segments

To add a cubic segment, click **Add Cubic**. Specify the coordinates of the four control points on each row under **Control points**. Add the weights of the four control points under **Weights**. Cubic segments with self-intersections might look correct when displayed but are not handled correctly by other geometry and meshing operations.

SELECTIONS OF RESULTING ENTITIES

Select the **Create selections** check box to create predefined selections for all entities (boundaries and points) that the Bézier polygon consists of. These selections are available in all applicable **Selection** lists but do not appear as separate selection nodes in the Model Tree.