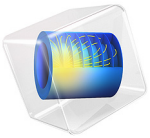

Model created in COMSOL Multiphysics 6.4

Optimization of a Tuning Fork

Introduction

This model extends the model *Tuning Fork* in the COMSOL Multiphysics Application Library by adding a second study, in which the Parametric Sweep is replaced by an Optimization study node. The prong length $L_p = L + \pi R_b/2$, where L is the straight cylindrical part and R_b is the prong base radius, is determined by minimizing the objective function $(f - 440\ \text{Hz})^2$, where f is the fundamental frequency of the fork. The result agrees with that found in the original model version. For a detailed description of the model geometry and setup, see *Tuning Fork* in the COMSOL Multiphysics Application Library.

Application Library path: `Optimization_Module/Design_Optimization/tuning_fork_optimization`

Modeling Instructions

ROOT

In this model version you determine the prong length by using an **Optimization** study node.

APPLICATION LIBRARIES

1. From the **File** menu, choose **Application Libraries**.
2. In the **Application Libraries** window, select **COMSOL Multiphysics** > **Structural Mechanics** > **tuning_fork** in the tree.
3. Click **Open**.

To keep the results of the parametric study, add a second study with an **Eigenfrequency** step set up the same way as before.

ADD STUDY

1. In the **Home** toolbar, click **Add Study** to open the **Add Study** window.
2. Go to the **Add Study** window.
3. Find the **Studies** subsection. In the **Select Study** tree, select **General Studies** > **Eigenfrequency**.
4. Click the **Add Study** button in the window toolbar.
5. In the **Home** toolbar, click **Add Study** to close the **Add Study** window.

STUDY 2

Step 1: Eigenfrequency

1 In the **Settings** window for **Eigenfrequency**, locate the **Study Settings** section.

2 Select the **Desired number of eigenfrequencies** checkbox. In the associated text field, type `1`.

3 In the **Search for eigenfrequencies around shift** text field, type `440`.

STUDY 1: SWEEP

1 In the **Model Builder** window, click **Study 1**.

2 In the **Settings** window for **Study**, type `Study 1: Sweep` in the **Label** text field.

Now, add optimization. The **BOBYQA** solver is generally the fastest of the derivative-free solvers when the objective function is smooth.

STUDY 2: OPTIMIZATION

1 In the **Model Builder** window, click **Study 2**.

2 In the **Settings** window for **Study**, type `Study 2: Optimization` in the **Label** text field.

Parameter Optimization

1 In the **Study** toolbar, click **Optimization** and choose **Parameter Optimization**.

2 In the **Settings** window for **Parameter Optimization**, locate the **Objective Function** section.

3 In the table, enter the following settings:

Expression	Description	Evaluate for
`(freq-440[Hz])^2`		Eigenfrequency

Next, add the control parameter. You can choose between the global parameters defined in your model. In this case, use the prong length.

4 Locate the **Control Parameters** section. Click **Add**.

Specify a length scale and suitable bounds.

5 In the table, enter the following settings:

Parameter	Initial value	Lower bound	Upper bound	Unit
L (Cylinder length)	`7.8[cm]`	`7[cm]`	`9[cm]`	m

The setup is now complete.

6 In the **Study** toolbar, click **Compute**.

RESULTS

Mode Shape (solid) 1

1 Click the  **Zoom Extents** button in the **Graphics** toolbar.

The default plot shows the eigenmode that corresponds to the optimized value of the cylinder length `L`.

Objective Table 3

The optimized value of the cylinder length can be seen in the Objective Table:

The resulting cylinder length is close to 7.91 cm, which agrees with the value determined using a parametric sweep.

Mode Shape (solid) 1

1 Click the  **Zoom Extents** button in the **Graphics** toolbar.

2 In the **Model Builder** window, expand the **Results** > **Tables** node.

Eigenfrequencies (Study 1), Mode Shape (solid)

1 In the **Model Builder** window, under **Results**, Ctrl-click to select **Mode Shape (solid)** and **Eigenfrequencies (Study 1)**.

2 Right-click and choose **Group**.

Sweep

In the **Settings** window for **Group**, type `Sweep` in the **Label** text field.

Eigenfrequencies (Study 2: Optimization), Mode Shape (solid) 1

1 In the **Model Builder** window, under **Results**, Ctrl-click to select **Mode Shape (solid) 1** and **Eigenfrequencies (Study 2: Optimization)**.

2 Right-click and choose **Group**.

Optimization

In the **Settings** window for **Group**, type `Optimization` in the **Label** text field.

Length vs. Frequency

1 In the **Results** toolbar, click  **1D Plot Group**.

2 In the **Settings** window for **1D Plot Group**, type `Length vs. Frequency` in the **Label** text field.

3 Locate the **Data** section. From the **Dataset** list, choose **Study 1: Sweep/ Parametric Solutions 1 (sol2)**.

Global 1

1 Right-click **Length vs. Frequency** and choose **Global**.

2 In the **Settings** window for **Global**, locate the **y-Axis Data** section.

3 In the table, enter the following settings:

Expression	Unit	Description
`freq`	`Hz`	`Sweep`

4 Locate the **x-Axis Data** section. From the **Axis source data** list, choose **Outer solutions**.

5 Click to expand the **Legends** section. Find the **Include** subsection. Clear the **Solution** checkbox.

Global 2

1 Right-click **Global 1** and choose **Duplicate**.

2 In the **Settings** window for **Global**, locate the **Data** section.

3 From the **Dataset** list, choose **Study 2: Optimization/Solution 19 (sol19)**.

4 Locate the **y-Axis Data** section. In the table, enter the following settings:

Expression	Unit	Description
`freq`	`Hz`	`Optimization`

5 Locate the **x-Axis Data** section. From the **Parameter** list, choose **Expression**.

6 In the **Expression** text field, type `L`.

7 Click to expand the **Coloring and Style** section. Find the **Line markers** subsection. From the **Marker** list, choose **Circle**.

8 In the **Length vs. Frequency** toolbar, click **Plot**.

9 Click the **Zoom Extents** button in the **Graphics** toolbar.