Building your Model
Tuning forks, as you are aware, produce a sound by vibrating at a specific frequency called the Resonant Frequency. If the resonant frequency is within the audible range of 20 Hz to 20,000 Hz, we may be able to categorize that frequency into a musical note. For example, the note ‘middle-C’ is a vibration at 256 Hz whereas the note “E” is a frequency of 320 Hz.

Piano tuners and guitar players use tuning forks to tune their instruments, and you are tasked with designing the next “G” fork which resonates at 384 Hz.

Pro/MECHANICA has a special functionality to determine resonant frequencies called Modal Analyses. Note that to define a modal analysis, you simply need material definition and a constraint.

1. Apply STEEL material properties to the tuning fork part.
2. Fully constrain the “handle” of the fork (the cylindrical protrusion).

**Running your Model**

1. Call your Modal analysis fork_mode. Change Number of Modes to 1 because you are looking for only the lowest, or primary, mode.
2. Accept all other defaults.
3. Run the analysis.

**Verifying your Model**

Determine the following:

1. Total Elapsed Time _____________
2. Total CPU Time _____________
3. Working Directory Disk Usage _______________ Mb
4. Result Directory Size _______________ Mb
5. Maximum Memory Usage _______________ Mb
6. How many elements are in the model? _______________
7. What is the error of your solution? _____________
8. What is the error based on (X% error on...)

**Reviewing your Results**

In the summary file, you may find the calculated modal frequency.

What is the modal frequency? ______________Hz

You have determined that this frequency is approximately G# (G-sharp) which is close, but half a note from your desired frequency of G.

Verify the modal displacements by creating a Displacement Animation result window. Your model should be similar to the following:
Optimizing your Model

To achieve your desired note of “G”, you must redesign your tuning fork to resonate at 384 Hz. You have decided to increase the length of the fork to accomplish this task.

Assign a Design Parameter to the length of the fork using Model -> Dsgn Controls -> Design Params.

Select Create:Dimension:Select then pick the fork feature. Select the 91.24 mm dimension. What is the name of this dimension? _______
Change the range from a minimum of 90 to a maximum of 110.

Accept the form.

Define the optimization by selecting Design Studies.

Name your optimization fork_opt. Uncheck Goal: and Create a new Limit on modal frequency set equal to 384.
Accept all other defaults.

Run the optimization.

**Verify the Results of the Optimization**

Enter the total Elapsed time ____________________ secs

What is the final value of dimension d6? _______________ mm

What is the optimized modal frequency? _______________ Hz

Is this within the 1% specified in the optimization convergence?
You may also choose to review displacement animations of the optimized shape.

**Accept Optimized Dimensions**

Finally, have Pro/MECHANICA update your Pro/ENGINEER part automatically by selecting Dsgn Controls -> Optimize Hist. Enter fork_opt when prompted and answer “y” to all questions.

When you have completed this process, you will have your tuning fork for the musical note “G”.
