



MEscope Application Note 07

Creating a Mass-Spring-Damper Model

The steps in this Application Note can be carried out using any MEscope package. The steps in this App Note are also carried out using the **AppNote07** project file. These steps might also require MEscope software with a *more recent release date*.

APP NOTE 07 PROJECT FILE

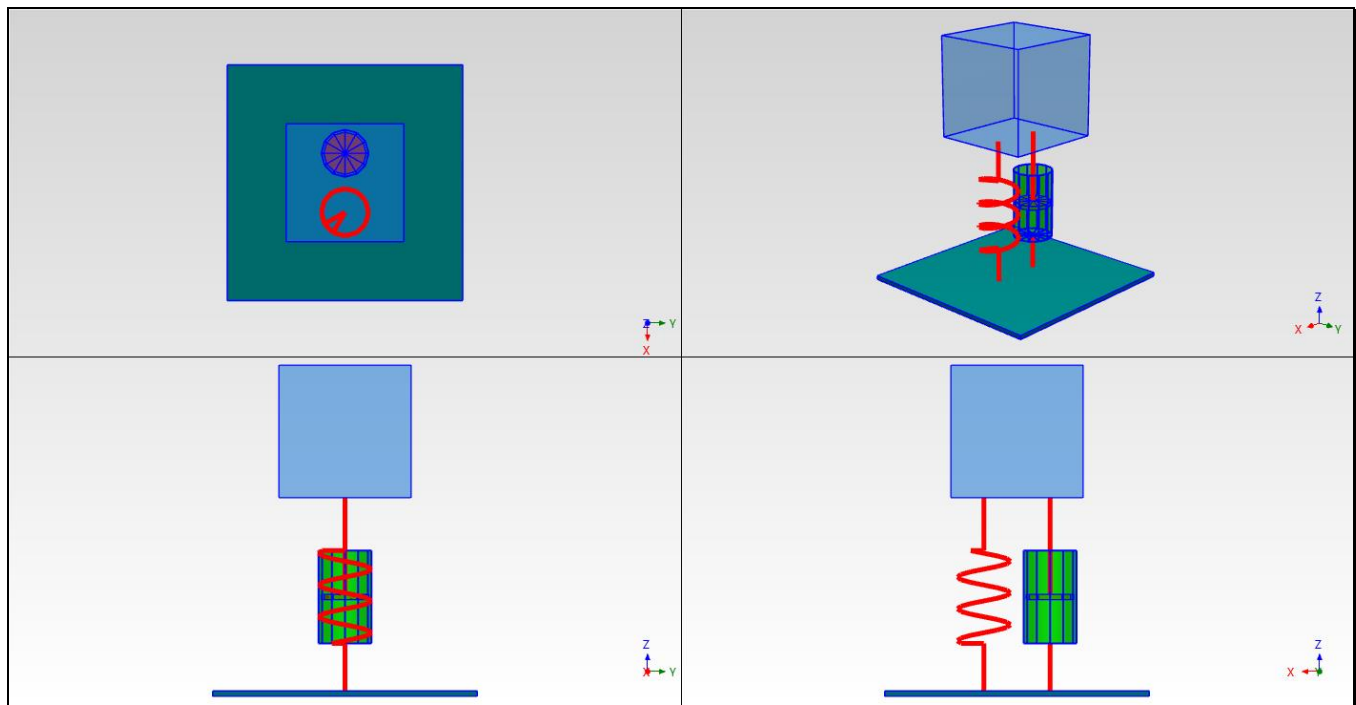
- To retrieve the Project for this App Note, [click here](#) to download **AppNote07.zip**

This Project file contains *numbered Hotkeys & Scripts* for carrying out the steps of this App Note.

- Hold down the Ctrl key and click on a Hotkey* to display its Script window

INTRODUCTION

In this Application Note, the 3D model shown in the figure below is created using the drawing tools in MEscope. In **App Note 17**, FEA mass, spring and damper elements are added to the 3D model and its single mode of vibration is calculated and displayed in animation on the model. An FRF is also synthesized from this modal model in **App Note 17**, and its physical significance is examined.



Quad View of the Mass-Spring-Damper Model.

GRAPHICAL MODEL

In MEscope, a graphical 3D model is needed to display Operating Deflection Shapes (ODS's) and mode shapes in animation. A model can be created using the drawing tools in the Structure (**STR**) window, or by importing a model from a graphics, solid modeling, or finite element analysis file.

- A 3D model is usually much easier to construct *by using several substructures*, each substructure representing a portion of the structure

In this App Note, five substructures are used to construct the mass-spring-damper structure model shown above. The five substructures are,

- A **Base Plate**, a **Mass Cube**, a **Damper Piston**, a **Damper Cylinder**, and a **Spring** substructure
- Each substructure contains **Lines** drawn between Points to generate a *wire-frame* model
- Each substructure also contains **Surfaces** which give the *surface model* a more realistic *solid look*

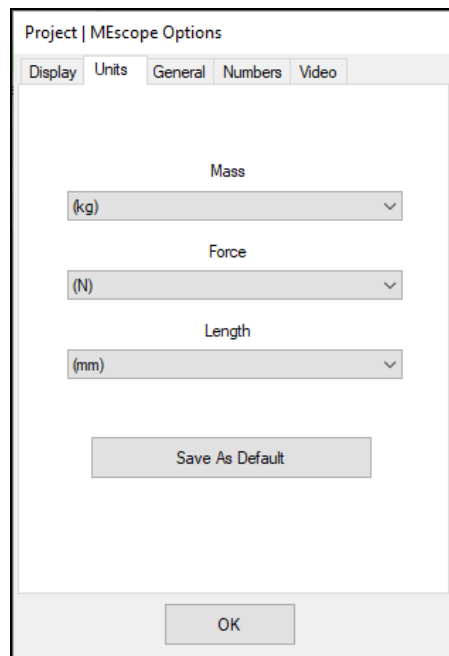
Surfaces are also displayed with *hidden lines* or as *transparent* surface. They are also used to display *color contours* and *node lines*. *Node lines* enhance the display of ODS's and mode shapes. *Color contours* enhance the display of stress/strain and acoustic field data.

The **Drawing Assistant** in the Structure (**STR**) window automates the creation of substructures with simple geometries. The **Drawing Assistant** is used in this App Note to create all the substructures of the Mass-Spring-Damper model. After all the substructures have been drawn in their own windows, the complete model is assembled by pasting the substructures together in one (**STR**) window.

ENGINEERING UNITS

- To create a 3D model of a test article and display its ODS's or mode shapes in animation, *correct dimensions in engineering units are not required* in MEscope
- But if finite elements are added to a 3D model to create an FEA model of the test article, *correct dimensions in engineering units are required*
- Any 3D model can be re-scaled later in MEscope to the dimensions of the actual test article
- Nevertheless, it is always better to create a 3D model using dimensions in correct engineering units

Engineering Units for all models created in an open Project in MEscope are chosen on the **Units** tab in the **Project | MEscope Options** box



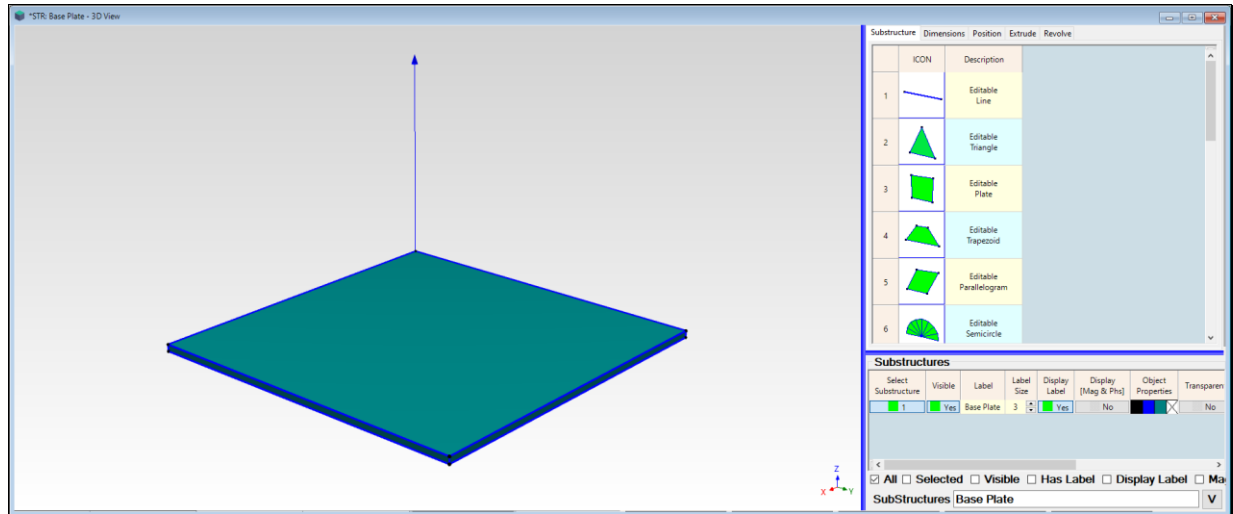
STEP 1 - DRAWING THE BASE PLATE SUBSTRUCTURE

The base substructure is a simple rectangular plate. The **Drawing Assistant** is used to create this simple substructure.

- **Press Hotkey 1 Base Plate**

The **STR: Base Plate** window will open with the Base Plate already in it, and the **Drawing Assistant** tabs displayed *on the right side*.

You can re-draw the Base Plate substructure, or move on to the next step.

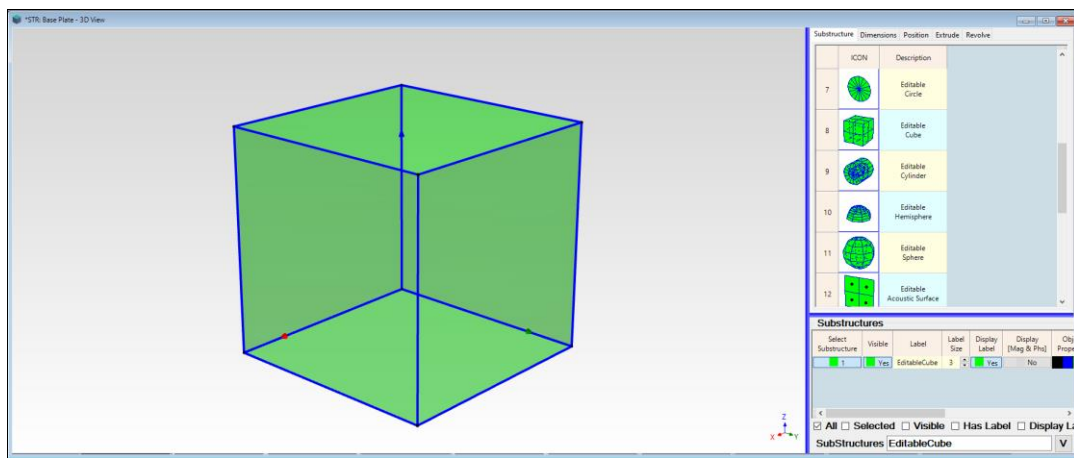


STR: Base Plate Window Showing the Base Plate Substructure and Drawing Assistant Tabs

RE-DRAWING THE BASE PLATE

To re-draw the Base Plate substructure,

- Execute **Edit | Delete Objects** to delete the selected Base Plate
- Select the **Substructure** tab, and *double-click* on the **Editable Cube**

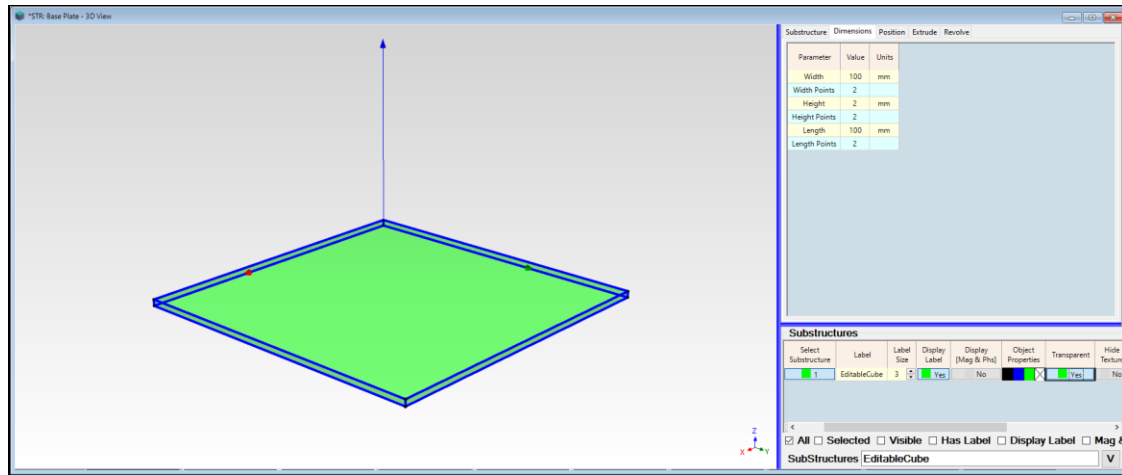


Selecting the Editable Cube Substructure

The default Cube (above) is displayed in the graphics area of the window. The dimensions of the Cube can now be changed to the dimensions of a base plate (**100 mm on each side and 2 mm thick**).

- Select the **Dimensions** tab, and *enter the numbers shown in the figure below*
- Type **“Base Plate”** into the Label field in the **Substructures** spreadsheet, as shown below

The global coordinate axes are also displayed with the base plate. The origin (0, 0, 0) is located at the bottom left-rear corner of the substructure.



Base Plate After Its Dimensions are Entered.

BASE PLATE POINTS, LINES, & SURFACES

The size & color of the Points & Lines, and the color of the Surfaces, are easily changed by editing these properties in each of the drawing Object spreadsheets.

To change the Line width

- Execute **Edit | Lines**
- **Double click** on the **Line Width** column heading, and **enter “1”** into the dialog box that opens

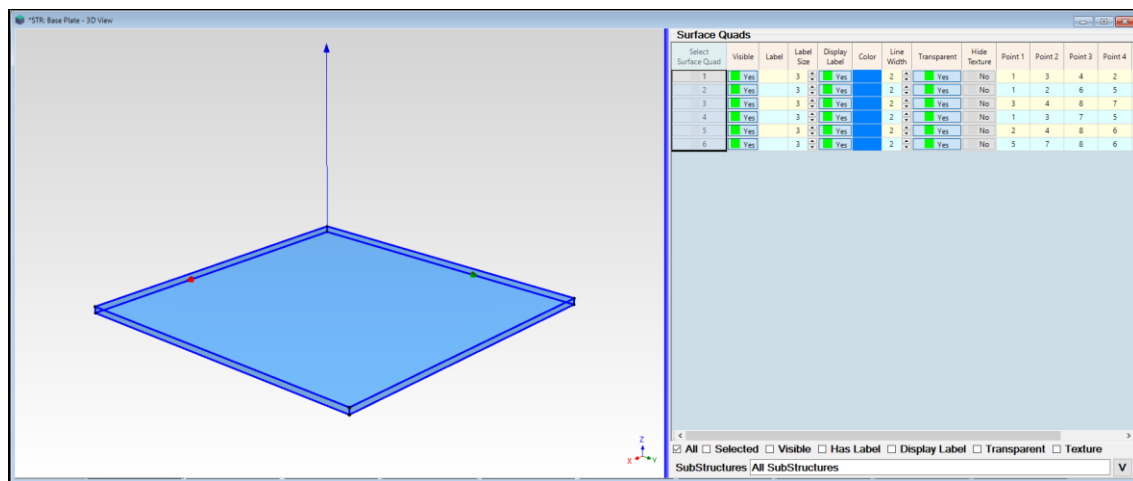
To change the Point Size & Color,

- Execute **Edit | Points**
- **Double click** on the **Point Size** column heading, and **enter “3”** into the dialog box that opens
- **Double click** on the **Color** column heading, and **choose any color** in the dialog box that opens

To change the Surface Color,

- Execute **Edit | Surface Quads**
- **Double click** on the **Color** column heading, and **choose any color** in the dialog box that opens

This completes the creation of the Base Plate.



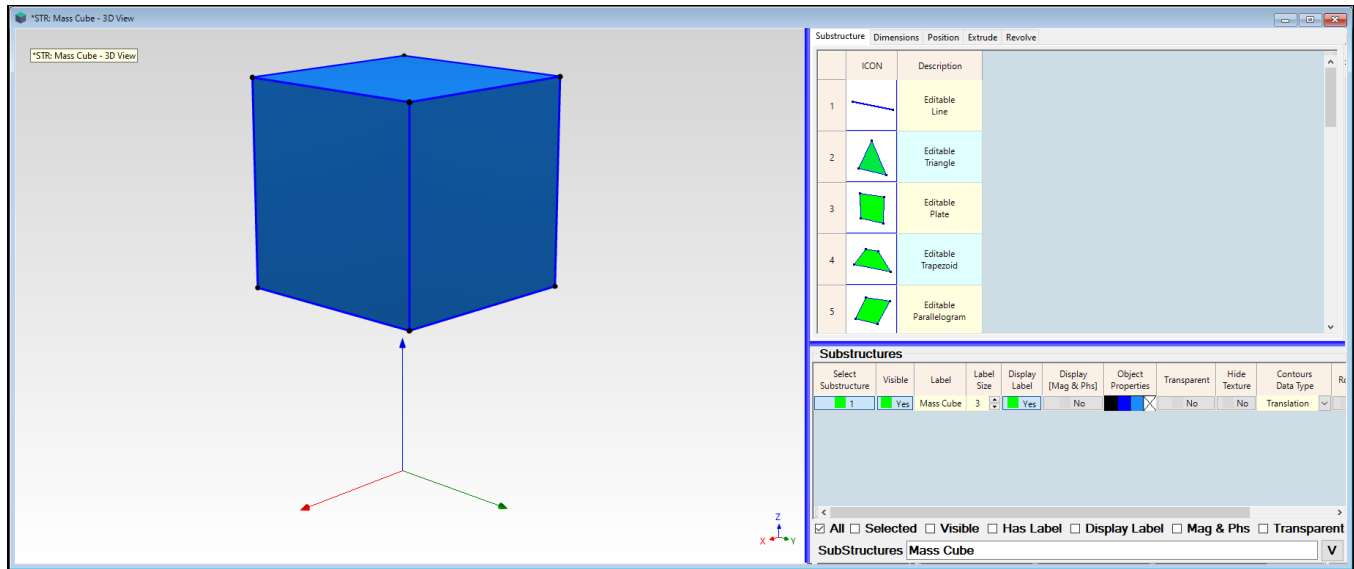
Finished Base Plate Substructure.

STEP 2 - DRAWING THE MASS CUBE SUBSTRUCTURE

- **Press Hotkey 2 Mass Cube**

The **STR: Mass Cube** window will open with the Mass Cube already in it, and the **Drawing Assistant** tabs displayed on the right side.

You can re-draw the Mass Cube substructure or move on to the next step.

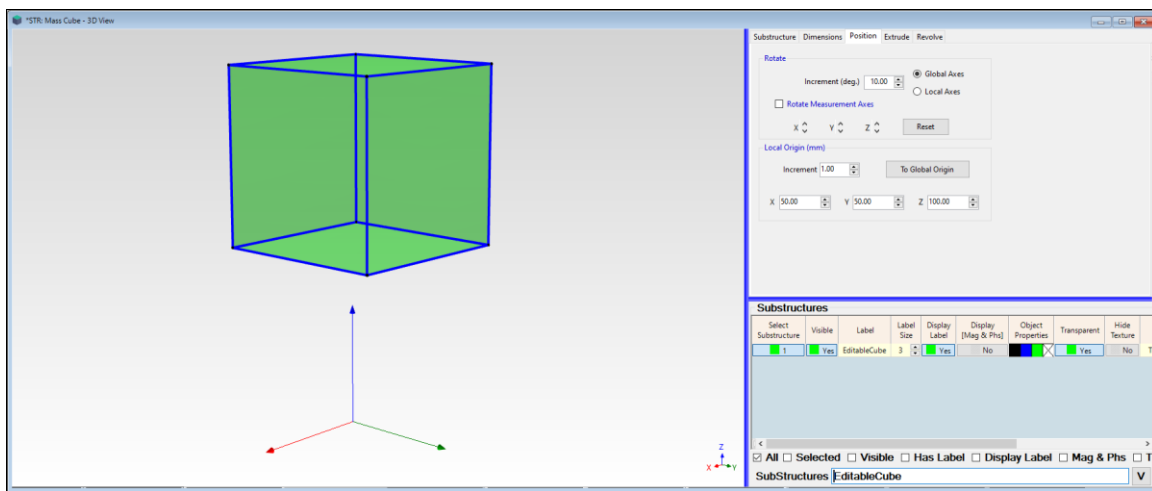


STR: Mass Cube Window Showing the Mass Cube Substructure and Drawing Assistant Tabs

RE-DRAWING THE MASS CUBE

The Mass Cube substructure is created in the same way as the Base Plate, but with different dimensions. To re-draw the Mass Cube,

- Execute **Edit | Delete Objects** to delete the selected Mass Cube
- Select the **Substructure** tab, and **double-click** on the **Editable Cube**
- Select the **Dimensions** tab, and enter **Width → 50 mm, Height → 50 mm, Length → 50 mm**
- On the **Position** tab, edit the **Local Origin: X → 50 mm, Y → 50 mm, Z → 100 mm**
- Type **“Mass Cube”** into the **Label** field in the Substructures spreadsheet, as shown below



Drawing Assistant Showing Position Parameters

MASS CUBE POINTS, LINES, & SURFACES

The size and color of the Points and Lines, and the color of the Surfaces, are easily changed by editing these properties in the drawing Object spreadsheets.

To change the Line Width,

- Execute **Edit | Lines**
- **Double click** on the **Line Width** column heading, and **enter “1”** into the dialog box that opens

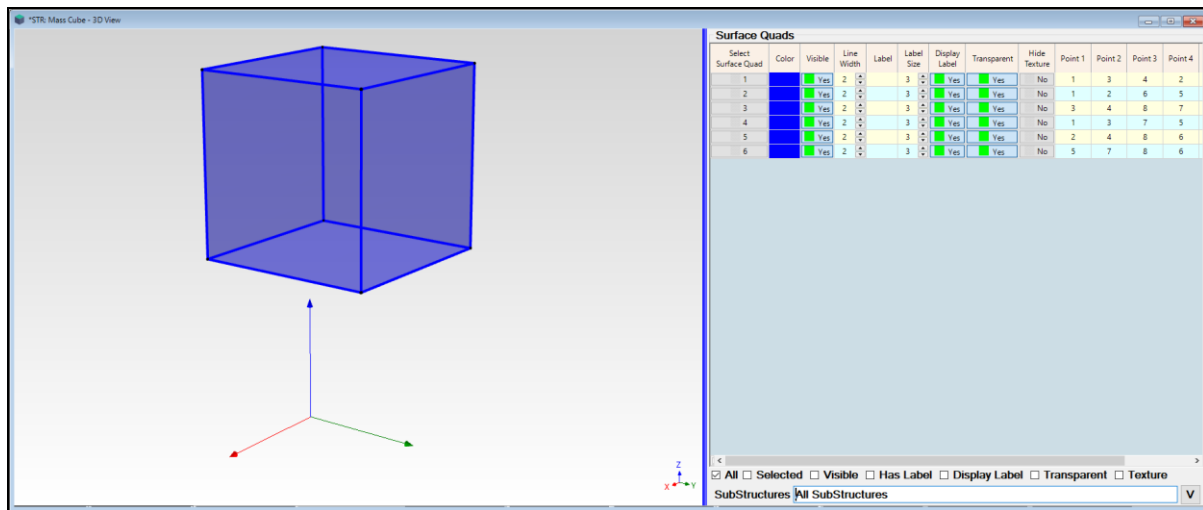
To change the Point Size & Color,

- Execute **Edit | Points**
- **Double click** on the **Point Size** column heading, and **enter “3”** into the dialog box that opens
- **Double click** on the **Color** column heading, and **choose any color** in the dialog box that opens

To change the Surface Color to blue,

- Execute **Edit | Surface Quads**
- **Double click** on the **Color** column heading, and **choose any color** in the dialog box that opens

These parameters create a 50 mm **Mass Cube** substructure with its **local origin at 100 mm** above the center of the Base Plate. This completes the creation of the Mass Cube.



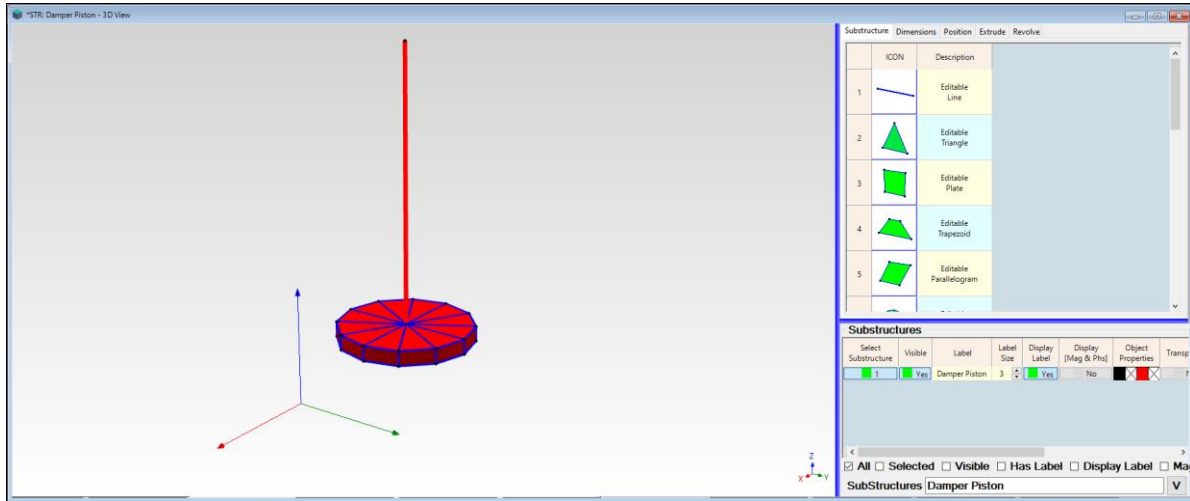
Finished Mass Cube Substructure.

STEP 3 - DRAWING THE DAMPER PISTON SUBSTRUCTURE

- **Press Hotkey 3 Damper Piston**

The **STR: Damper Piston** window will open with the Damper Piston already in it, and the **Drawing Assistant** tabs displayed *on the right side*.

You can re-draw the Damper Piston substructure, or move on to the next step.



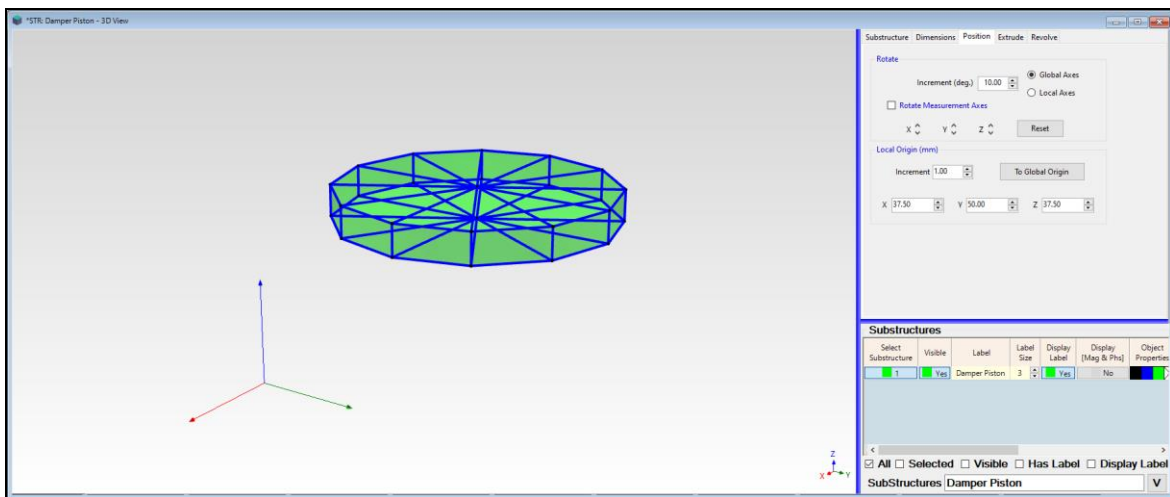
STR: Damper Piston Window Showing the Damper Piston Substructure and Drawing Assistant Tabs

RE-DRAWING THE DAMPER PISTON

The damper piston is created by using the Drawing Assistant again, but this time starting with an Editable Cylinder.

To re-draw the Damper Piston,

- Execute **Edit | Delete Objects** to delete the selected Damper Piston
- Select the **Substructure** tab, and **double-click** on the **Editable Cylinder**
- Select the **Dimensions** tab, and enter **Radius End** → 9 mm and **T Angle Points** → 12, as shown below
- On the **Position** tab, **click** on the **Y axis** in the **Rotate** section until the Cylinder is **vertical**, as shown below
- On the **Position** tab, edit the **Local Origin**: **X** → 37.5 mm, **Y** → 50 mm, **Z** → 37.5 mm
- Type "**Damper Piston**" into the **Label** field in the Substructures spreadsheet, as shown below



Damper Piston Substructure.

PISTON POINTS, LINES, & SURFACES

The size & color of the Points & Lines, and the color of the Surfaces, are easily changed by editing these properties in the drawing Object spreadsheets.

To change the Line Width,

- Execute **Edit | Lines**
- **Double click** on the **Line Width** column heading, and **enter “1”** into the dialog box that opens

To change the Surface Color to **red**,

- Execute **Edit | Surface Quads**
- **Double click** on the **Color** column heading, and **choose a red color** in the dialog box that opens
- Execute **Edit | Surface Triangles**
- **Double click** on the **Color** column heading, and **choose a red color** in the dialog box that opens

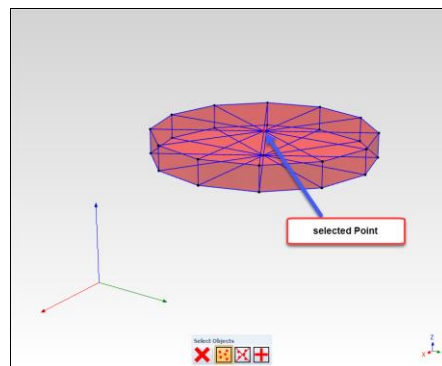
ADDING THE PISTON SHAFT

The shaft connecting the Piston to the Mass Cube is modeled by **adding a thick Line** between the Piston and the bottom of the Mass.

- Lines are added **between two Points**

The Line to model the shaft will be added between the center Point on the top of the Piston and a **new Point in space** that will coincide with the bottom of the Mass Cube. To add the new **Point in space**,

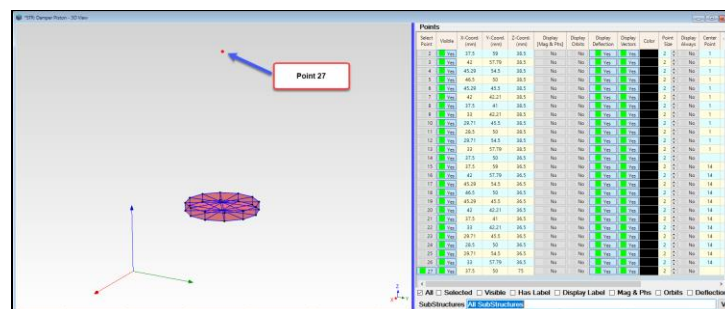
- Execute **Edit | Points**
- Execute **Edit | Select Objects | Interactive**
- **Select** the top center point of the cylinder



- Execute **Edit | Copy Object to File**
- **Click** on **No** in the dialog that opens, select **STR: Damper Piston** in the next dialog box, and **click on Add To**

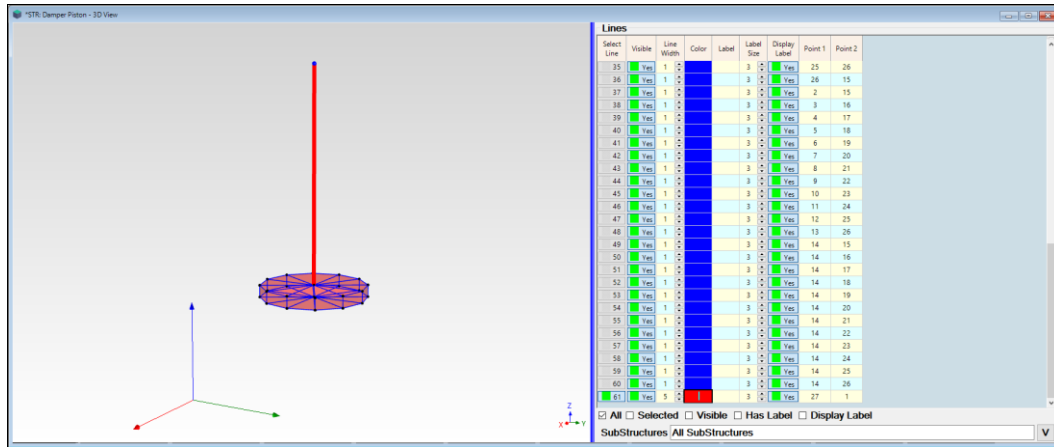
The selected center Point was duplicated and added to the bottom of the **Points** spreadsheet as **Point 27**.

- Change the **Z Coord** of **Point 27** in the **Points** spreadsheet to **75 mm**



Now a Shaft Line can added between the two end Points of the Damper shaft.

- Execute **Edit | Lines**
- Execute **Edit | Add Objects**
- **Click near** each of the two end Points to add a new Line between them
- Color the **new Line red** and change its **Line Width** → 5, as shown below
- Execute **Edit | Add Objects again** to disable the **Add Objects** command



Finally, the **shaft Line** must be added to the Damper Piston substructure.

- Make sure that **Line 41** is *selected*
- Execute **Draw | Substructures | Add Objects to Substructure**, select **Damper Piston**, and *click on* **Add Objects**

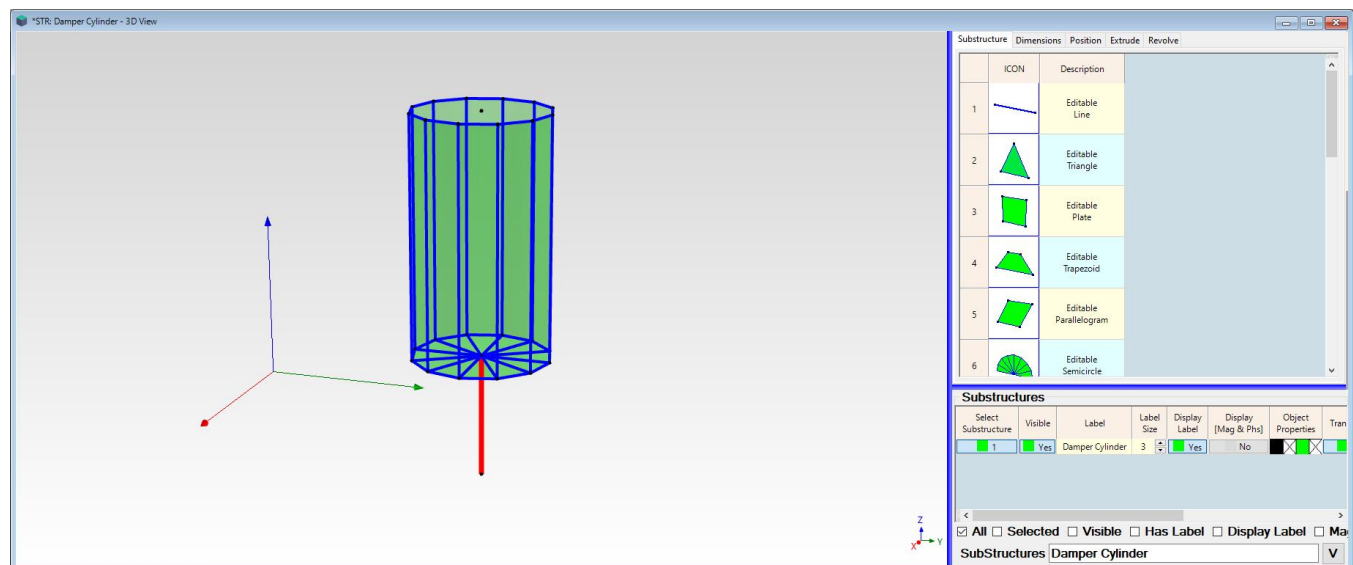
This completes the creation of the Damper Piston.

STEP 4 - DRAWING THE DAMPER CYLINDER

- **Press Hotkey 4 Damper Cylinder**

The **STR: Damper Cylinder** window will open with the Damper Cylinder already in it, and the Drawing Assistant tabs displayed on the right side.

You can re-draw the Damper Cylinder substructure, or move on to the next step.



STR: Damper Cylinder Window Showing the Damper Cylinder Substructure and Drawing Assistant Tabs

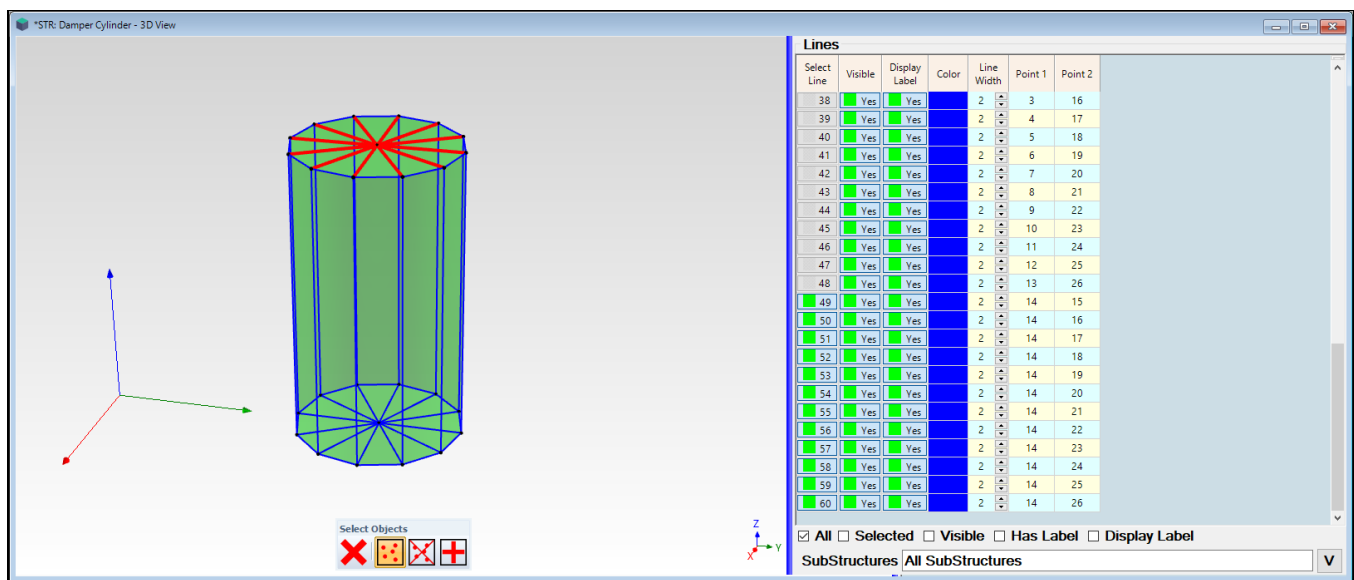
RE-DRAWING THE DAMPER CYLINDER

The second part of the Damper, the Damper Cylinder is created by using the Drawing Assistant again, starting with an Editable Cylinder.

- Execute **Edit | Delete Objects** to delete the selected Damper Cylinder
- Select the **Substructure** tab, and **double-click** on the **Editable Cylinder**
- Select the **Dimensions** tab, and enter **Radius End** ➔ **10**, **T Angle Points** ➔ **12**, **Length** ➔ **35**
- On the **Position** tab, **click** on the **Y axis** in the **Rotate** section until the Cylinder is **vertical**, as shown below
- On the **Position** tab, edit the **Local Origin: X** ➔ **37.5 mm**, **Y** ➔ **50 mm**, **Z** ➔ **40 mm**
- Type **“Damper Cylinder”** into the **Label** field in the Substructures spreadsheet, as shown below

To delete the Lines and Surface Triangles from the Top of the Cylinder,

- Execute **Edit | Lines**
- Execute **Edit | Select Object | Interactive**
- Click **near the center** of each Line on the top of the Cylinder **to select it**, as shown below
- Execute **Edit | Select Object | Interactive again** to terminate Interactive selection
- Execute **Edit | Delete Objects**



Lines Selected on the Top of the Cylinder

- Execute **Edit | Surface Triangles** and select & delete the **Surface Triangles** from *the top of the cylinder*
- Execute **Edit | Surface Quads** and select & delete the **Surface Quads** from *the sides of the cylinder*

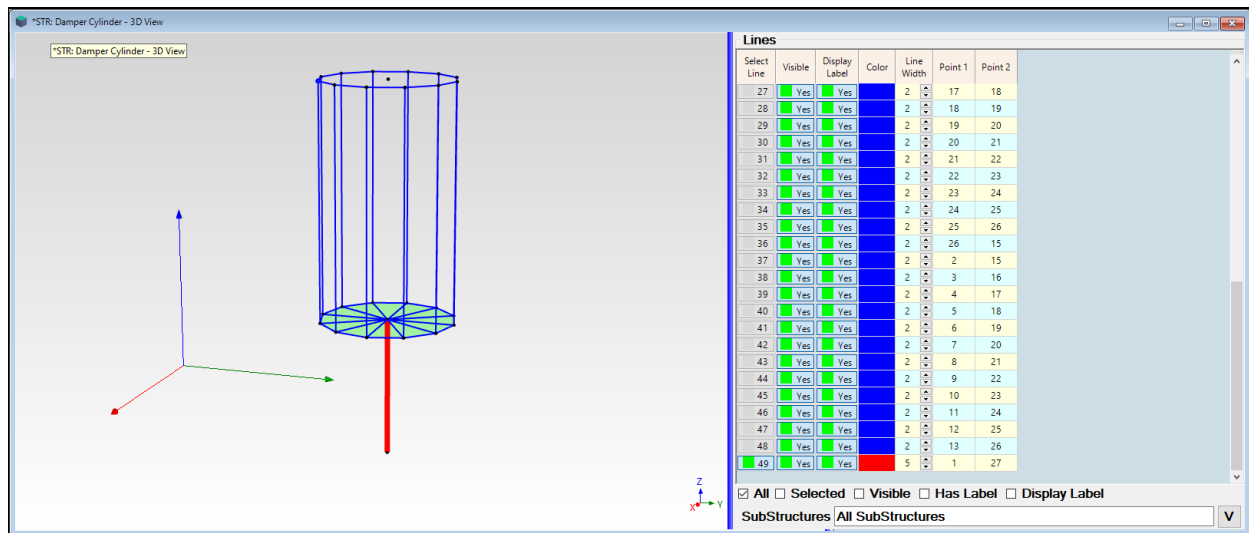
ADDING A CYLINDER SHAFT

The shaft connecting the Damper Cylinder to the Base Plate will be modeled by adding **a thick Line** between the bottom of the cylinder and the top surface of the Base Plate. Lines are added between two Points.

- Follow the instructions above that were used to add a **shaft Line** to the **Damper Piston**
- The coordinates of the **new end Point** of the cylinder shaft should be **X Coord** ➔ **37.5 mm**, **Y Coord** ➔ **50 mm**, **Z Coord** ➔ **2 mm**

Finally, to add the **thick shaft Line** to the Damper Cylinder substructure.

- Execute **Edit | Lines**
- Execute **Edit | Add Objects**
- **Click near** each of the two end Points to add a new Line between them
- Execute **Edit | Add Objects again** to terminate the **Add Objects** command
- Color the **new Line red** and change its **Line Width** ➔ **5**, as shown below
- Execute **Draw | Substructures | Add Objects**, select **Damper Cylinder**, and **click on Add Objects**



Damper Cylinder with Shaft Added Below it.

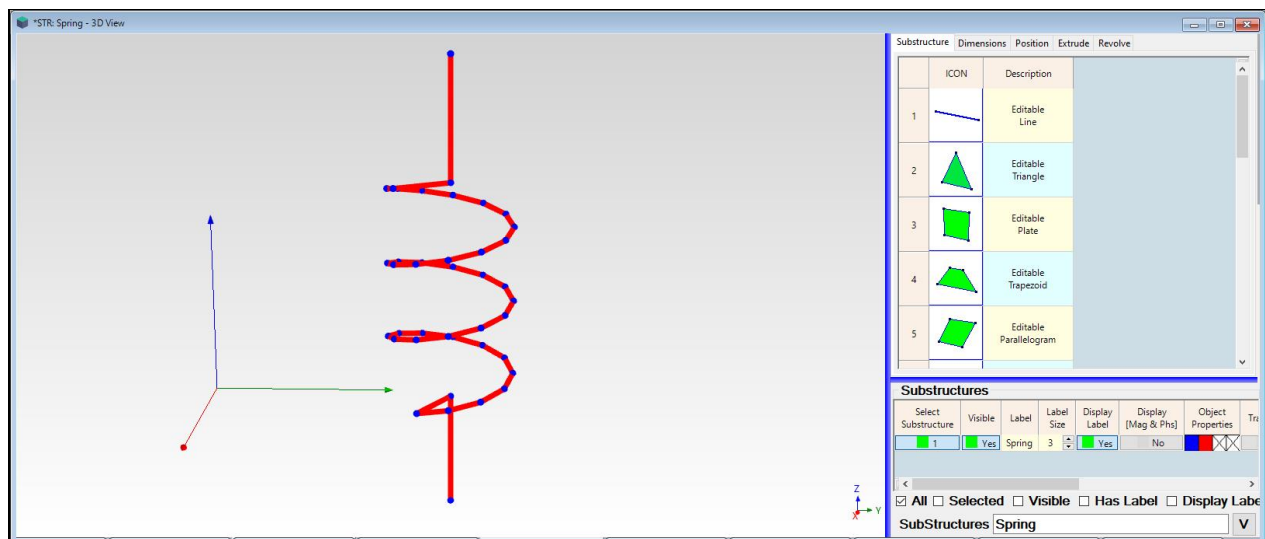
This completes the creation of the Damper Cylinder. Save **STR: Damper Cylinder**.

STEP 5 - DRAWING THE SPRING SUBSTRUCTURE

- **Press Hotkey 5 Spring**

The **STR: Spring** window will open with the Spring substructure already in it, and the **Drawing Assistant** tabs displayed **on the right side**.

You can re-draw the Spring substructure, or move on to the next step.



STR: Spring Window Showing the Spring Substructure and Drawing Assistant Tabs

RE-DRAWING THE SPRING

The Spring is created using the **Drawing Assistant** and starting with an **Editable Cylinder**.

- Execute **Edit | Delete Objects** to delete the selected Spring
- Select the **Substructure** tab, and *double-click* on the **Editable Cylinder**
- Select the **Dimensions** tab, and enter **Radius End** → 10 mm, **T Angle Points** → 12, **Length** → 35 mm, **Length Points** → 3
- On the **Position** tab, *click* on the **Y axis** in the **Rotate** section until the Cylinder is *vertical*, as shown below
- On the **Position** tab, edit the **Local Origin: X** → 62.5 mm, **Y** → 50 mm, **Z** → 37.5 mm
- Type “**Spring**” into the **Label** field in the Substructures spreadsheet, as shown below
- Select and *delete all Lines* in the **Lines** spreadsheet
- Select and *delete all Surface Triangles* in the **Surface Triangles** spreadsheet
- Select and *delete all Surface Quads* in the **Surface Triangles** spreadsheet
- Execute **Edit | Points**
- On the **Points** spreadsheet increase the **Point Size** → 4
- **Color** the Points so they are visible

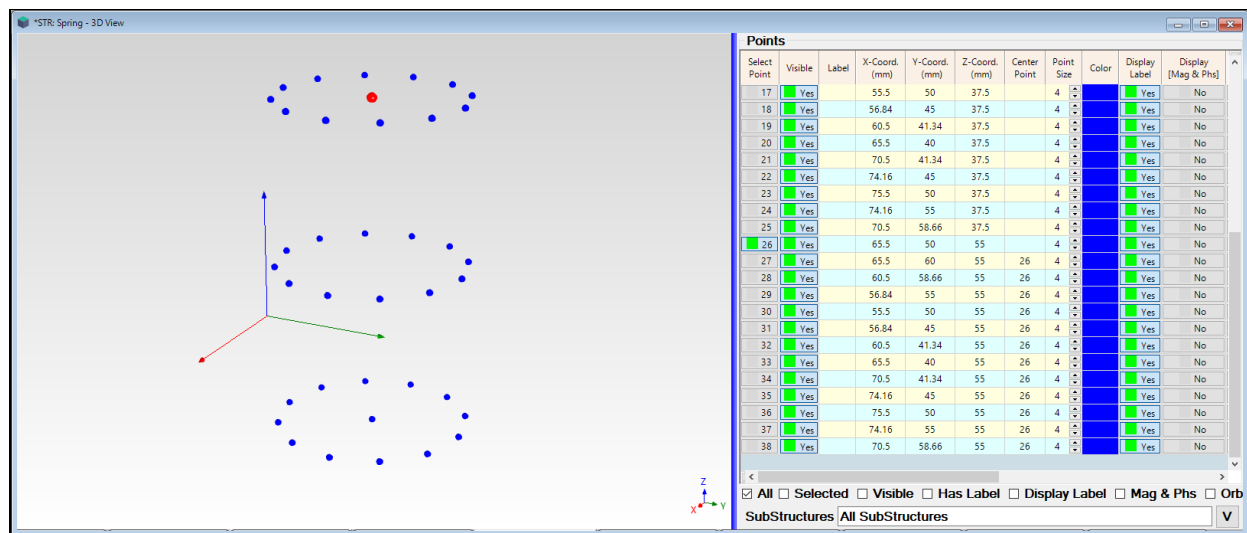
Three Point numbers are listed in the **Center Point** column in the **Points** spreadsheet.

- Point numbers **1, 14, & 27** are **Center Points**
- Each of these Points is **referenced by 12 other Radial Points**

The three groups of Radial Points are the *three circles of .points* on the cylinder.

- *Select and delete Point 14*

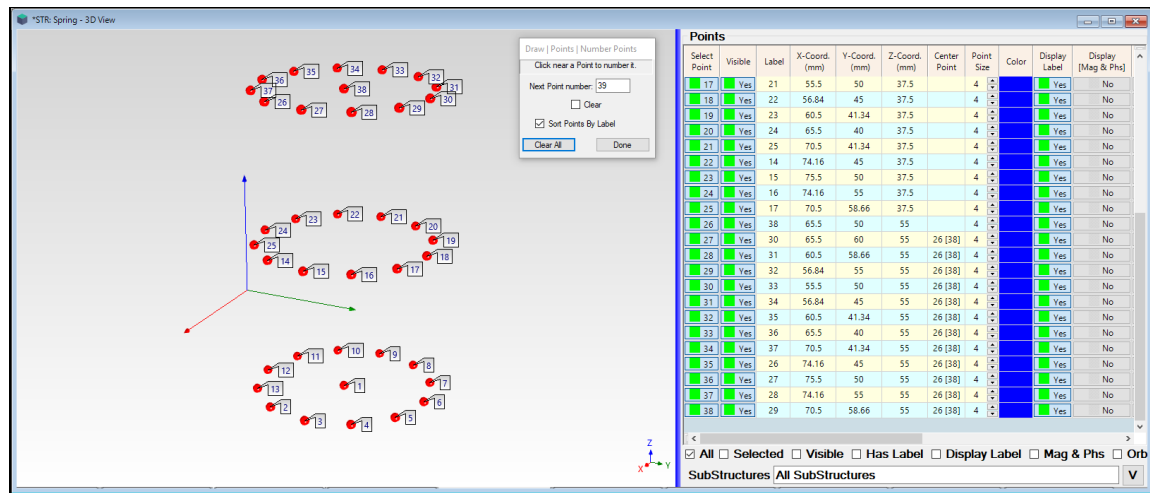
Notice that *all the Radial Points that referenced Point 14* no longer reference it, and that the **Center Point at the top** of the cylinder is now referenced as **Point 26** instead of **Point 27** because it *moved up one row* in the Points spreadsheet



NUMBERING THE POINTS

To form *the spiraling points* of the spring, the Z Coordinate of each Point in the spring will be numbered in order from bottom to top of the cylinder. Then the Points will be re-ordered in the Points spreadsheet according to their Point number. Then, working from top to bottom in the spreadsheet, the **Z Coordinate of each spiral Point** of the spring will be changed.

- Execute **Draw | Points | Number Points**. The Point numbering dialog box will open
- Number the Points *from bottom to top* in the order shown below



Spring Points Numbered From Bottom to Top

When all the Points have been numbered in the order shown below,

- Execute **Edit | Sort Objects by Label**

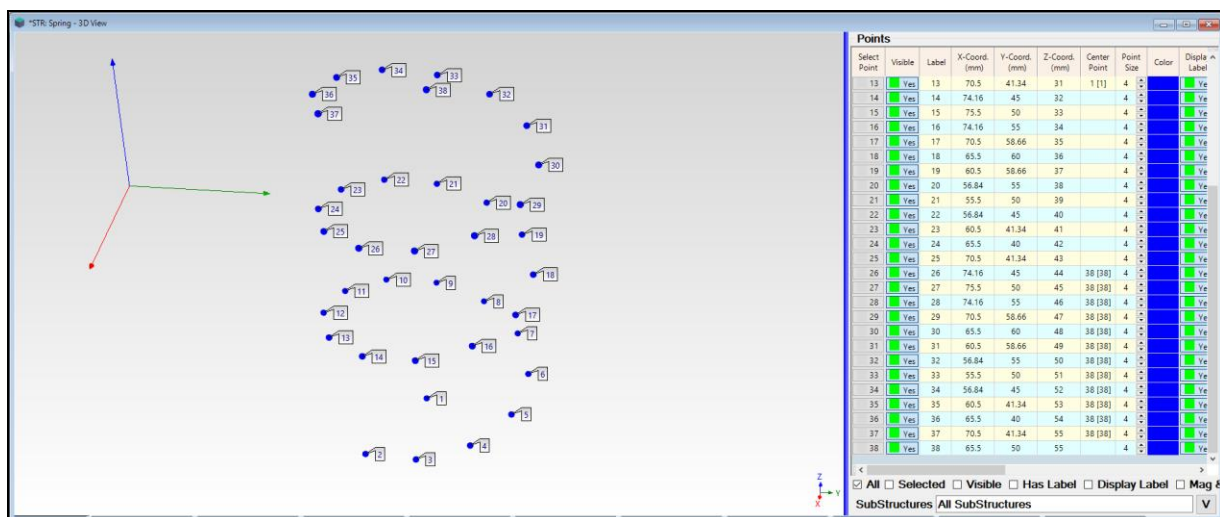
EDITING THE Z - COORDINATES

- **Starting a Point 3, 1 mm** will be added to the **Z Coordinate** of each Point up to and including **Point 36**

To begin, the Z coordinate of the spiral Points will be **set equal to 20 mm**

- **Select Point 3 through Point 36** in the Points spreadsheet
- **Double click** on the **Z Coord** column heading, and enter **Replace with 20** into the dialog box that opens
- Begin at **Point 3** and **increment the Z Coord of each Point by 1 mm** as you move down the Points spreadsheet
- **Stop** editing Z Coordinates at **Point 36**

When you have finished editing, the Z Coordinate of **Point 3 should be 21 mm**, and the Z Coordinate of **Point 36 should be 54 mm** as shown below.

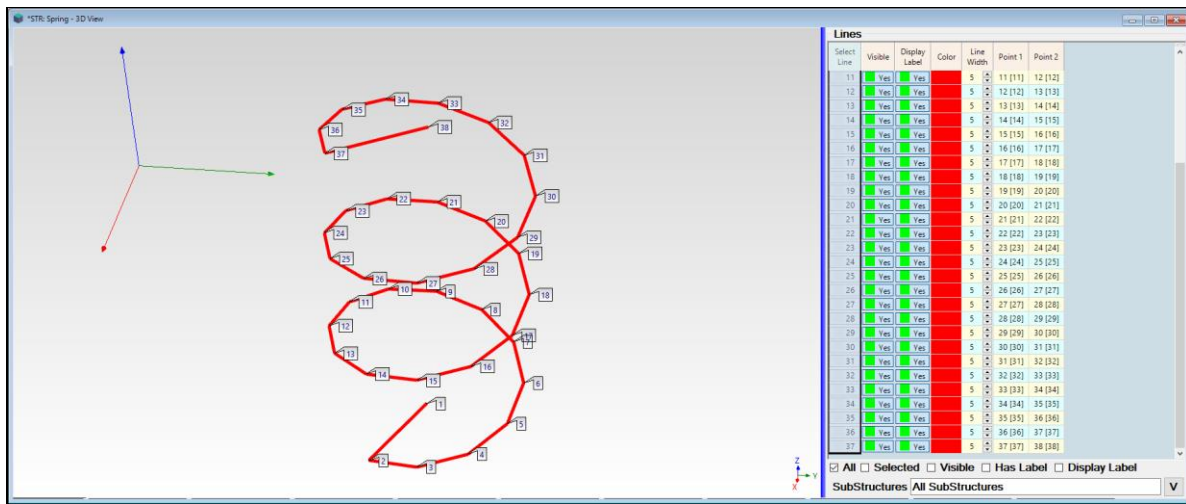


Spring Point Z-Coords Incremented by 1 mm to Create Points Spiral

ADDING LINES

Next, **thick Lines** are added between the Points on the Spring substructure.

- Execute **Edit | Lines**
- Execute **Edit | Add Objects**
- **Start at one a top or bottom Point** and add Lines between pairs of Points in the spiral of Points, as shown below
- After all the Lines have been added, execute **Edit | Add Objects** to terminate the **Add Objects** command
- Color the Lines **red** and change their **Line Width** → **5**



Spring Substructure With Thick Lines Added Between Points.

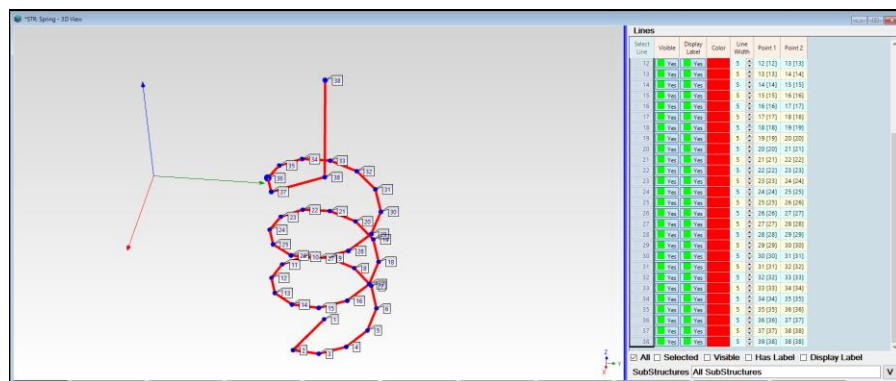
ADDING CONNECTION LINES

A connection Line will be added to the top of the Spring to connect it to the Mass Cube, and another Line added to bottom to connect it to the Base Plate. This can be done in the same way that the shaft Lines were added to the Damper Piston and Cylinder.

- Select **Point 38** in the Points spreadsheet
- Execute **Edit | Copy Objects to File** and add the *selected Point* to the **STR: Spring**

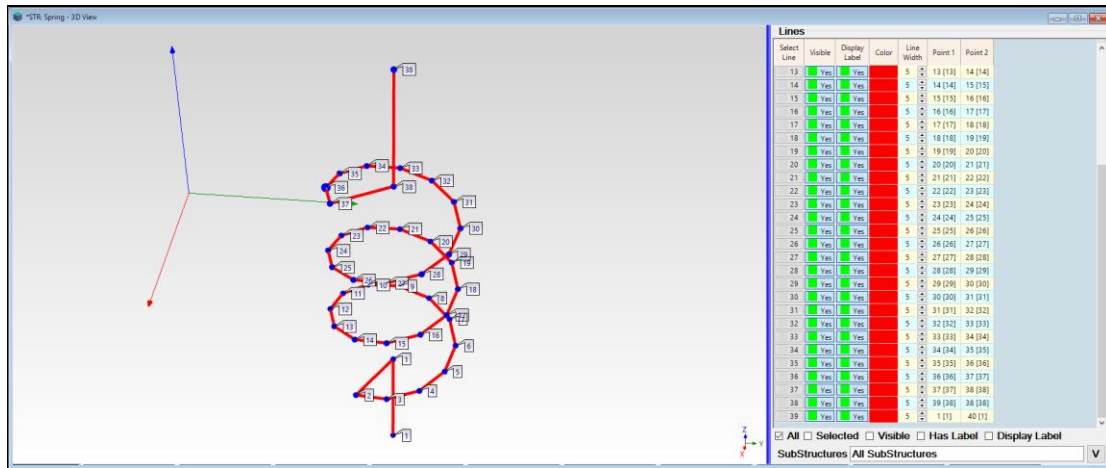
A copy of **Point 38** should be listed at the bottom of the Points spreadsheet as **Point 39**.

- Change the **Z Coord** of the **Point 39** → **75 mm**
- Execute **Edit Lines**
- Execute **Edit | Add Objects** and add a Line between the **Points 38 & 39**
- Change the **Line color to red**, and the **Line Width** → **5**



To add a connection Line between the bottom of the Spring and the Base Plate

- Select **Point 1** in the **Points** spreadsheet
- Execute **Edit | Copy Objects to File** and add the *selected* Point to the **STR: Spring**
- Change the **Z Coord** of the **Point 40** → **2 mm**
- Execute **Edit Lines**
- Execute **Edit | Add Objects** and add a Line between the **Points 1 & 40**
- Change the **Line color to red**, and the **Line Width** → **5**



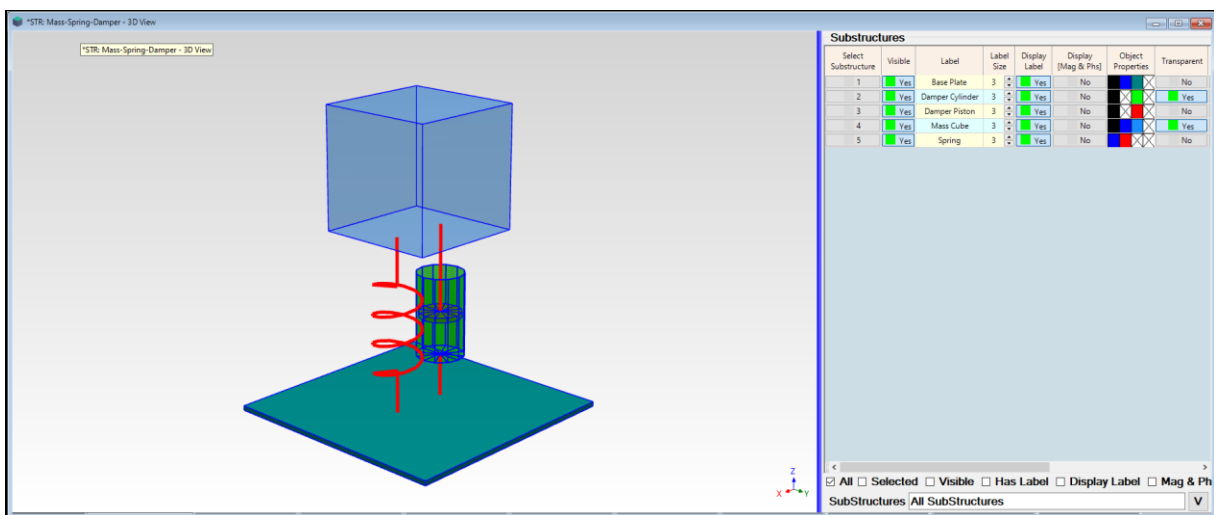
Spring Substructure With Top & Bottom Connection Lines Added.

STEP 6 - ASSEMBLING THE SUBSTRUCTURES TOGETHER

Now that all five substructures of the Mass-Spring-Damper have been created, when **Hotkey 6** is *pressed*, they are pasted together to create the Mass-Spring-Damper 3D model.

- **Press Hotkey 6** Mass-Spring-Damper

The five Substructure windows plus the Mass-Spring-Damper are opened together as shown below



Five Mass-Spring-Damper Substructures Pasted Together in One Window.

STEP 7 - REVIEW

To review the steps of this App Note,

- **Press Hotkey 7** Review Steps