

# VIBRANT MEScope Application Note 07A

## Creating a Mass-Spring-Damper Model

**NOTE:** Steps in this Application Note can be duplicated using any MEScope Package

[Click here](#) to download the MEScope Demo Project file for this App Note.

### INTRODUCTION

In this Application Note, the 3D model shown in Figure 1 will be created using the drawing tools in MEScope. In **App Note 07B**, FEA mass, spring and damper elements are added to the 3D model and its single mode of vibration is calculated and animated on the model. Also in **App Note 07B**, an FRF is synthesized from the modal model and its physical significance is examined.

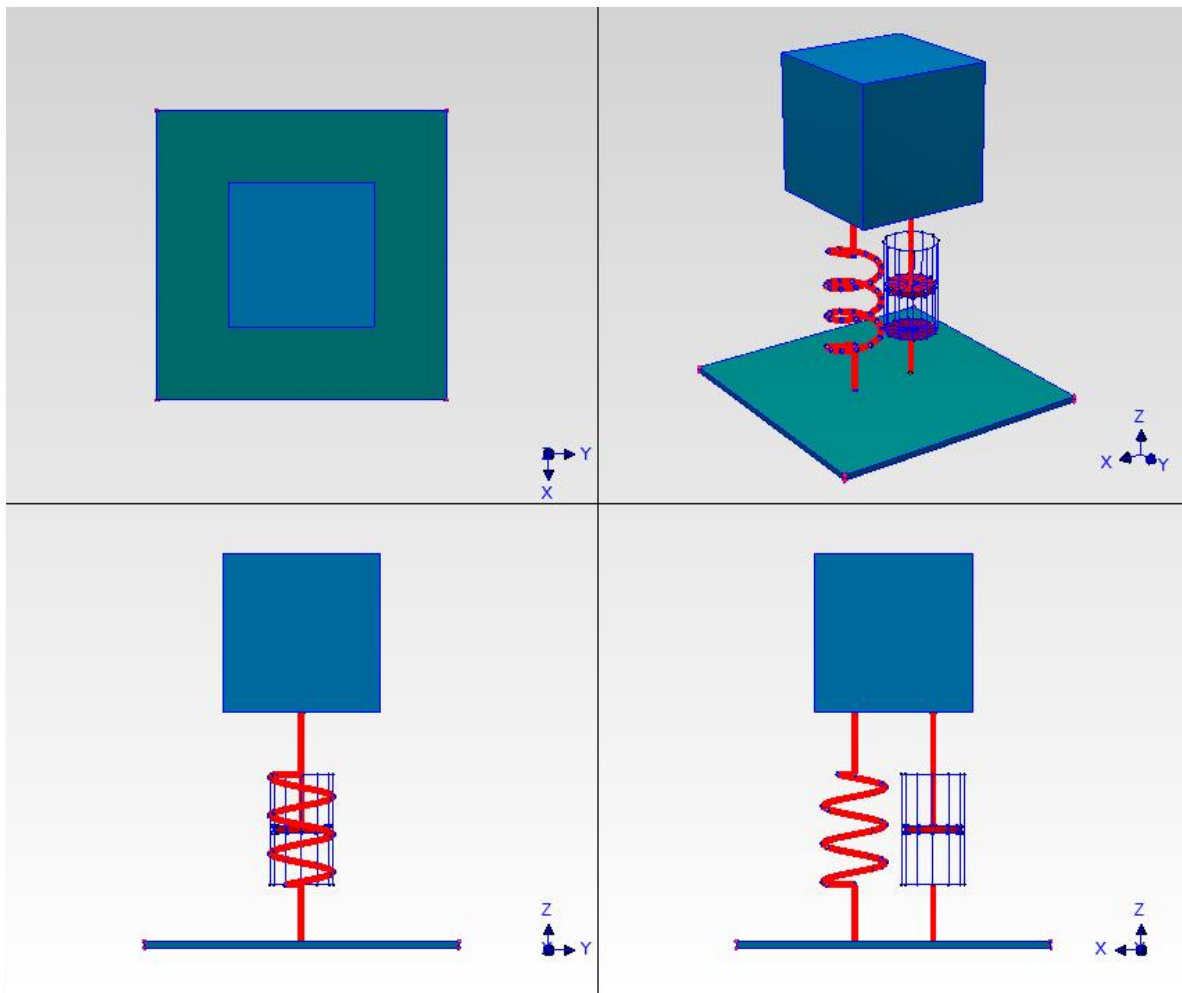


Figure 1. Quad View of the Mass-Spring-Damper Model.

### GRAPHICAL MODEL

In MEScope, a graphical 3D model is needed in order to display shapes in animation. This model can be created using the drawing tools in the Structure (STR) window. The structure 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 will be used to construct the mass-spring-damper structure shown in Figure 1 consisting of a Base Plate, Mass Cube, Damper Piston, Damper Cylinder, and Spring substructures.

Each substructure contains Lines drawn between Points to generate an outline or wire-frame model. Each substructure also contains Surfaces, either Surface Triangles or Surface Quads, Surfaces give the model a “solid” look, thus it is called a solid model. Surfaces are used for *hidden line* or *transparent* displays, and also for displaying *color contours* and *node lines* of vibration shapes, stress/strain shapes, and acoustic field shapes.

The **Drawing Assistant** in the Structure window automates creation of substructures with simple geometries. The **Drawing Assistant** will be used to help create all of the substructures of the Mass-Spring-Damper model.

## GETTING STARTED

You can either open the **AppNote07.VTprj** Demo Project file that is linked (above) to this App Note, or start with a new Project. To start a new Project,

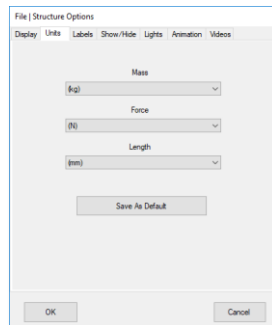
- Execute **File | New Project** in MEScope and enter “**Mass-Spring-Damper**” into the dialog box that opens

Correct dimensional units are not required in order to create a 3D model of a test article and display its shapes in animation. The proportional size of each part (or substructure) of the model is all that is necessary to display shapes realistically.

**NOTE:** Any 3D model can be re-scaled later on to the correct dimensions of the real test article

Nevertheless, it is always a good idea to create a model using the correct engineering units.

- Execute **File | New | Structure** in MEScope and enter “Base Plate Model” in the dialog box that opens
- Execute **File | Structure Options** in the STR: Base Plate Model window
- Select the Units tab in the dialog that opens, and select:
- Mass Units = Kilograms (kg)
- Force Units = Newtons (N)
- Length Units = Millimeters (mm)
- Click **Save as Default** and then **OK**

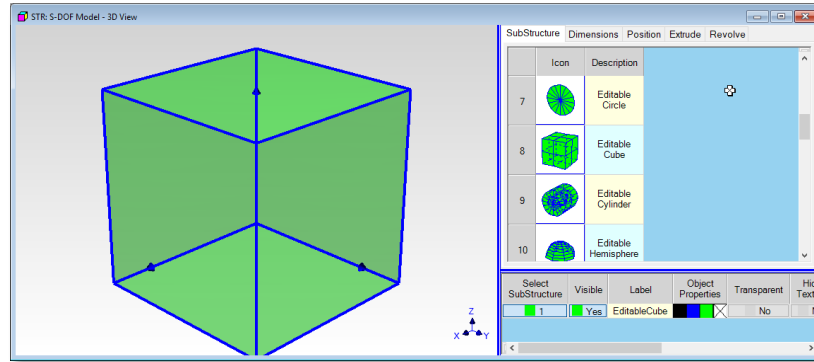


These units will be used in creation of all five of the substructures.

## CREATING THE BASE PLATE

The base substructure is a simple rectangular plate. We could draw this substructure by adding eight corner Points to the window, adding twelve Lines between adjacent corner Points, and also adding six Surface Quads between adjacent corner Points. Instead, the Drawing Assistant will be used to create this simple substructure.

- Execute **Draw | Drawing Assistant**
- Select the Substructure tab, and *double-click* on the **Editable Cube**

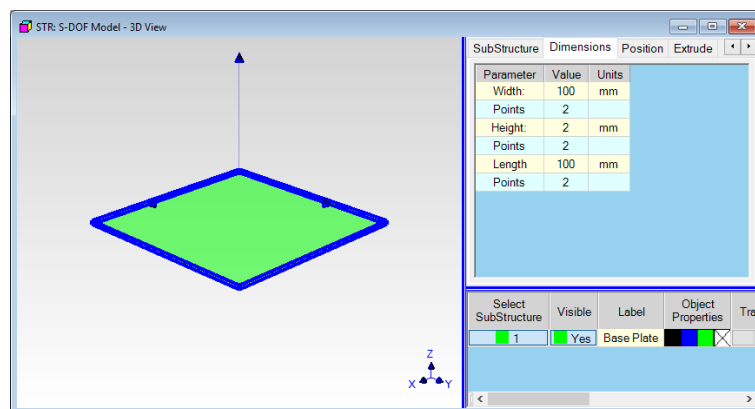


Selecting the Editable Cube Substructure

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

- Select the Dimensions tab, and enter **100 for the Width, 2 for the Height and 100 for the Length**
- Type **“Base Plate”** into the **Label** field in the Substructures spreadsheet, as shown below

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



Base Plate Dimensions.

### Base Plate Lines, Points & Surfaces

The size and color of the Points and 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,

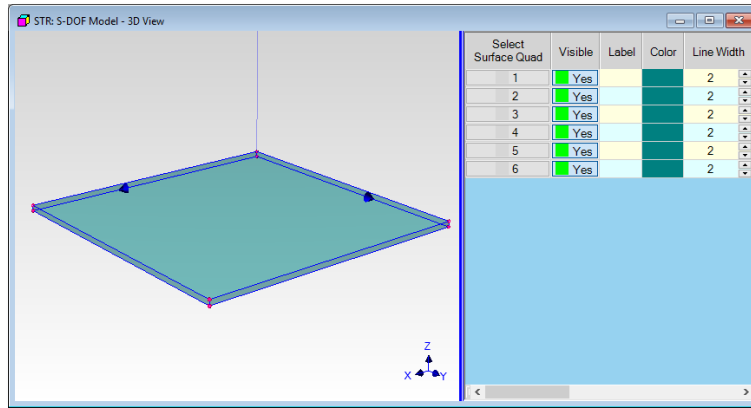
- Execute **Edit | Current Objects | Lines**
- **Double click** on the **Line Width** column heading, and enter **“1”** into the dialog box that opens

To change the Point Size and Color,

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

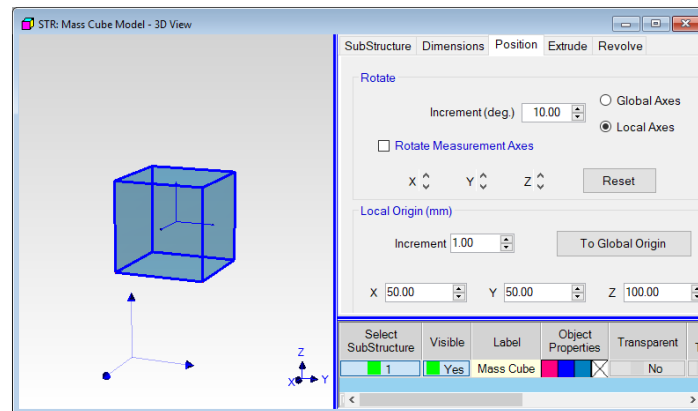


This completes the creation of the Base Plate Model.. Save this file.

### CREATING THE MASS CUBE

The Mass Cube substructure is created in exactly the same way as the Base Plate, but with using different dimensions. The Mass cube will be created in a separate Structure window. After all of the substructures have been created in their own windows, the entire model will be assembled by pasting the substructure together in one window.

- Execute **File | New | Structure** in MEScope and enter “**Mass Cube Model**” in the dialog box that opens
- Execute **Draw | Drawing Assistant** in the **STR: Mass Cube Model** window
- Select the Substructure tab, and *double-click* on the **Editable Cube**
- Select the **Dimensions** tab, and enter **50 for the Width, 50 for the Height and 50 for the Length**
- On the **Position** tab, edit the **Local Origin Position: X = 50, Y = 50, Z = 100**
- Select the **Local Axes** radio button
- Type “**Mass Cube**” into the **Label** field in the Substructures spreadsheet, as shown below



Mass Cube Position Parameters.

### Mass Cube Lines, Points & 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 | Current Objects | Lines**
- *Double click* on the **Line Width** column heading, and enter “**1**” into the dialog box that opens

To change the Point Size and Color,

- Execute **Edit | Current Objects | 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,

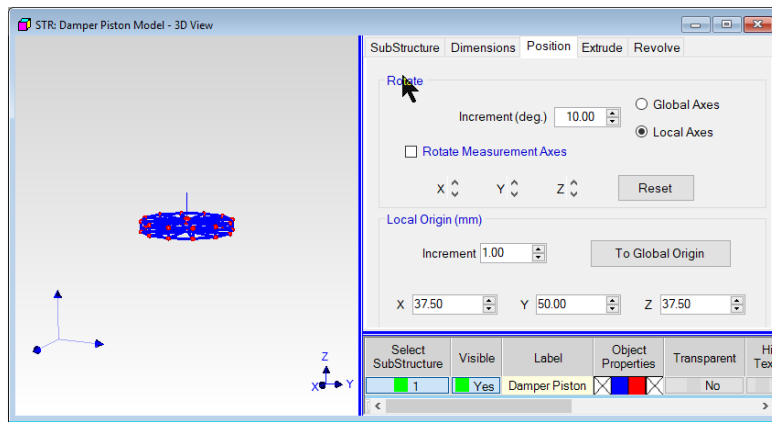
- Execute **Edit | Current Objects | Surface Quads**
- **Double click** on the **Color** column heading, and choose a **blue color** in the dialog box that opens

These parameters create a 50 mm **blue 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 Model.. Save this file.

## CREATING THE DAMPER PISTON

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

- Execute **File | New | Structure** in MEScope and enter “**Damper Piston Model**” in the dialog box that opens
- Execute **Draw | Drawing Assistant** in the **STR: Damper Piston Model** window
- Select the Substructure tab, and **double-click** on the **Editable Cylinder**
- Select the Dimensions tab, and enter **Radius End,9** and **Points 12**, as shown below
- On the **Position** tab, click on the **Y axis** in the Rotate section until the Cylinder is horizontal, as shown below
- On the Position tab, edit the **Local Origin Position: X = 37.5, Y = 50, Z = 37.5**
- Select the **Local Axes** radio button
- Type “**Damper Piston**” into the **Label** field in the Substructures spreadsheet, as shown below



Damper Piston.

## Piston 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 | Current Objects | Lines**
- **Double click** on the **Line Width** column heading, and enter “**1**” into the dialog box that opens

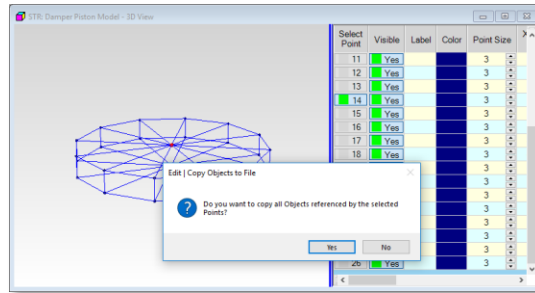
To change the Surface Color to a **red color**,

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

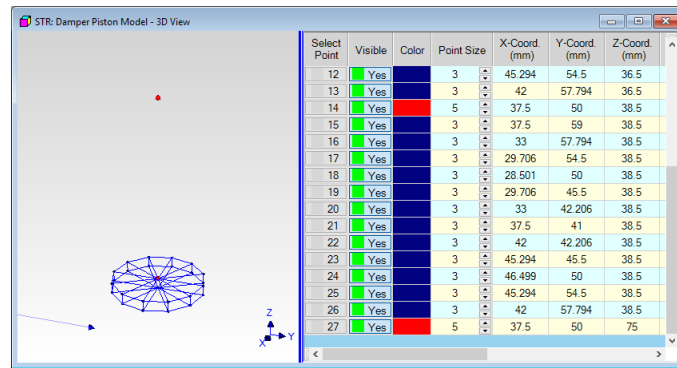
## Adding the Piston Shaft

The shaft connecting the Piston to the Mass Cube will be modeled by adding a **thick Line** between the Piston to the bottom of the Mass. Lines can only be added between two Points. The shaft Line 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 | Current Objects | Points**
- **Hold down the Ctrl key** and **click near the top center Point** of the Piston to select it
- Execute **Edit | Copy Object to File**. The dialog box shown below will open



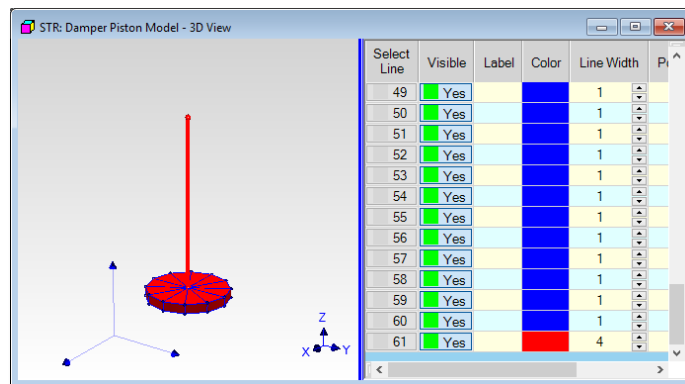
- Click on **No**, select **Damper Piston Model** in the next dialog box, and click on **Add To**. The selected center Point will be duplicated and added to the bottom of the Points spreadsheet, as shown below.



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

Now that the two end Points of the Damper shaft have been added to the Damper Piston Model

- Execute **Edit | Current Objects | 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 disable the Add Objects command
- **Color** the new Line red and change its **Line Width** to **“4”**, as shown below



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

- Execute **Edit | Current Objects | Points**
- Select **all of the Points** in the Points spreadsheet

- Execute **Draw | Substructures | Add Objects to Substructure**, and click on **Add Objects**

This completes the creation of the Damper Piston Model.. Save this file.

### CREATING 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 as with the Piston..

- Execute **File | New | Structure** in MEscape and enter “**Damper Cylinder Model**” in the dialog box that opens
- Execute **Draw | Drawing Assistant** in the **STR: Damper Cylinder Model** window

Select an **Editable Cylinder** object as a new substructure in the Drawing Assistant, and enter the following parameters on the **Dimensions** tab:

- Radius Start = 0 (mm)
- Radius End = 10 (mm)
- Points = 2
- P Angle Start = 0 (deg)
- P Angle End = 360 (deg)
- Points = 12
- Length = 40 (mm)
- Points = 2
- Label = Damper Cylinder

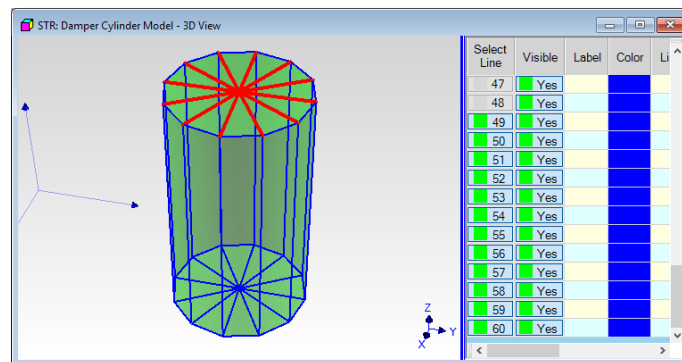
Rotate the Cylinder **90 degrees counter-clockwise** about the Global Y-axis as you did for the Damper Piston Model

Enter the **Local Origin** coordinates: on the **Position** tab

- **X = 37.5, Y = 50, Z = 12.5**

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

- Execute **Edit | Current Objects | Lines**
- **Hold down the Ctrl key and click near** each Line of the top of the cylinder to select it, as shown below
- Execute **Edit | Delete Objects**



- Repeat the steps above but instead delete the **Surface Triangles** from the **top of the cylinder**
- Repeat the steps above but instead delete the **Surface Quads** from **all sides of the cylinder**

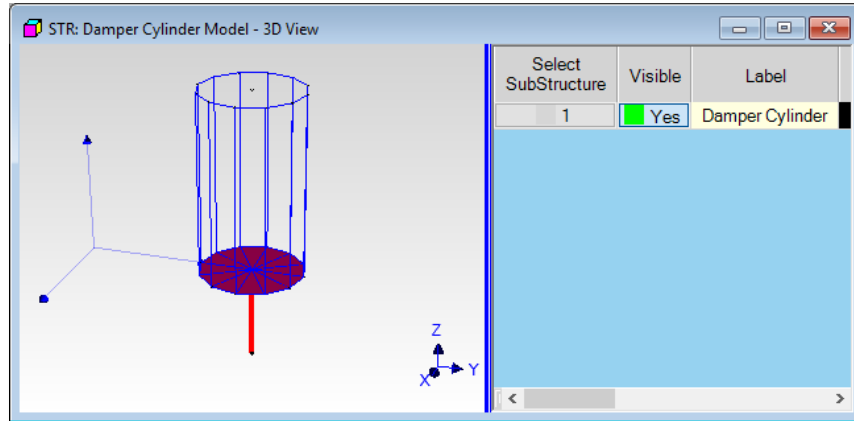
### Adding the Cylinder Shaft

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 can only be added between two Points.

- Follow the instructions above that were used to add a **shaft Line** between the **Piston** and the **Mass**

The coordinates of the new **Point in space** for the cylinder shaft should be

- **X = 12.5, Y = 50, Z = 2**



Damper Cylinder with Shaft Added Below it.

Finally, the **shaft** must be added to the Cylinder substructure.

- Execute **Edit | Current Objects | Points**
- Select *all of the Points* in the Points spreadsheet
- Execute **Draw | Substructures | Add Objects to Substructure**, and click on **Add Objects**

This completes the creation of the Damper Cylinder Model.. Save this file.

### CREATING THE SPRING

The Spring Model will also be created by using the Drawing Assistant again, and starting with an Editable Cylinder..

- Execute **File | New | Structure** in MEscape and enter “**Spring Model**” in the dialog box that opens
- Execute **Draw | Drawing Assistant** in the **STR: Spring Model** window

Select an **Editable Cylinder** as a new substructure in the Drawing Assistant, and enter the following parameters on the **Dimensions** tab:

- Radius Start = 0 mm
- Radius End = 10 mm
- Points = 2
- P Angle Start = 0 deg
- P Angle End = 360 deg
- Points = 12
- Length = 35 mm
- Points = 3
- Label = Spring

Rotate the Cylinder **90 degrees counter-clockwise** about the **Global Y-axis** as you did for the Damper Piston Model

Enter the **Local Origin** coordinates: on the **Position** tab

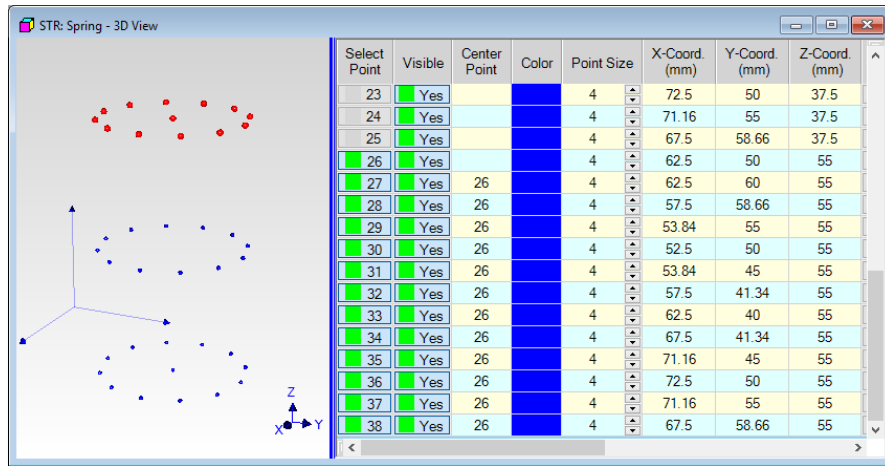
- X = 62.5 mm, Y = 50 mm, Z = 37.5 mm
- Select and Delete all of the Lines
- Select and Delete all of the Surface Triangles
- Select and Delete all of the Surface Quads
- Execute **Edit | Current Objects | Points** to display the Points spreadsheet
- Increase the **Point Size** to “4”
- **Color** the Points so they are visible

Notice that *three Point numbers* are listed in the **Center Point** column. Points number 1, 14, & 27 are Center Points. Each is referenced by 12 other Points, which are called 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 of the Points that *used to reference Point 14* no longer reference it, and also that the **Center Point at the top** of the cylinder is now referenced as **Point 26** because it *moved up one row* in the Points spreadsheet



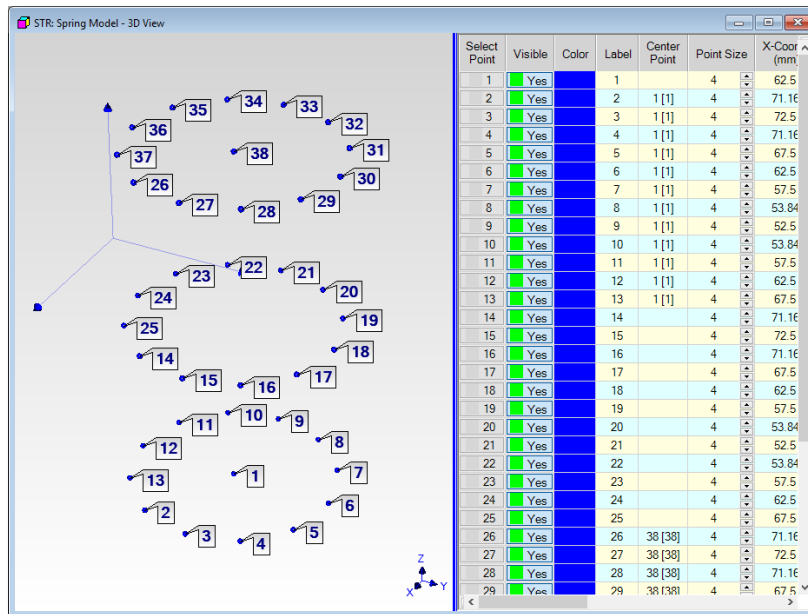
### Numbering the Points

In order 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 edited.

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

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

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

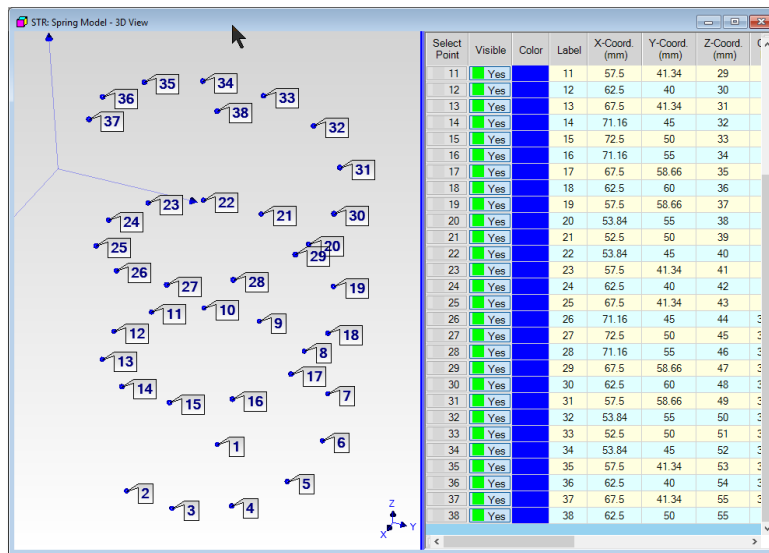


### Editing Z Coordinates

Starting at Point 3, 1 mm will be added to the **Z Coordinate** of each Point up to and including **Point 36**. This will span a total of **34 mm** between the bottom and the top of the **35 mm length** of the cylinder. To begin, the Z coordinate of all of the spiral Points will be set to 20 mm

- Select **Point 3 through Point 36**
- **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**

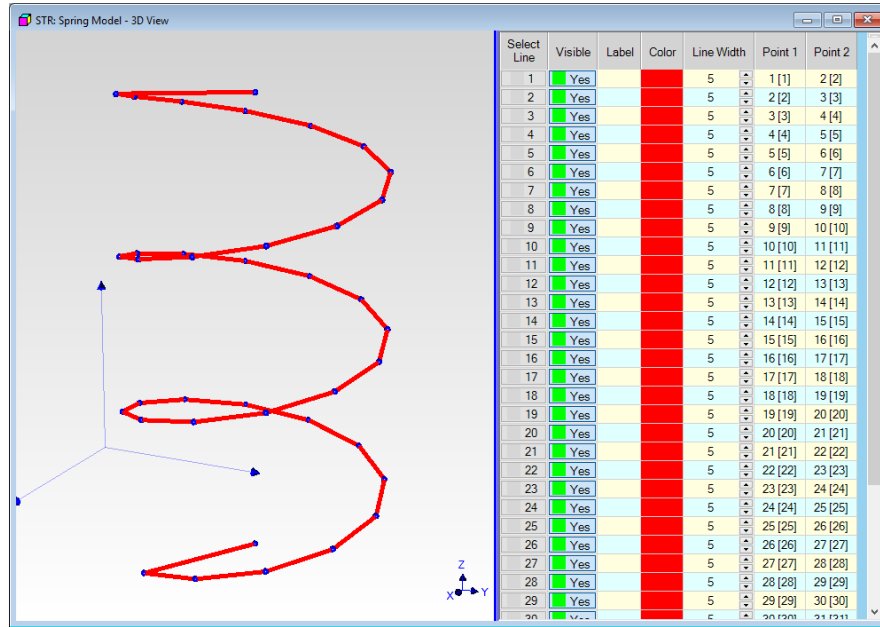
When you have finished editing, the Z Coordinate of **Point 3 should be 21 mm**, and the **Z Coordinate of Point 36 should be 54mm (20 +34mm)**, as shown below.



### Adding Lines

Next, the Points on the spring will be connected together with thick Lines.

- Execute **Edit | Current Objects | Lines**
- Execute **Edit | Add Objects**
- **Start at one end of the spring and add Lines between all of the Points in the spiral of Points, as shown below**
- After all of the Lines have been added, execute **Edit | Add Objects** again to disable the Add Objects command
- **Color the Lines red and change their Line Size to "5"**



### Adding Connection Lines

A connection Line must be added to the top of the Spring Model to connect it to the Mass, and another Line must be 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 the center Point (**Point [38]**) on the top of the spring
- Execute **Edit | Copy Objects to File** and add the selected Point to the Spring Model

A copy of **Point [38]** should be listed at the bottom of the Points spreadsheet.

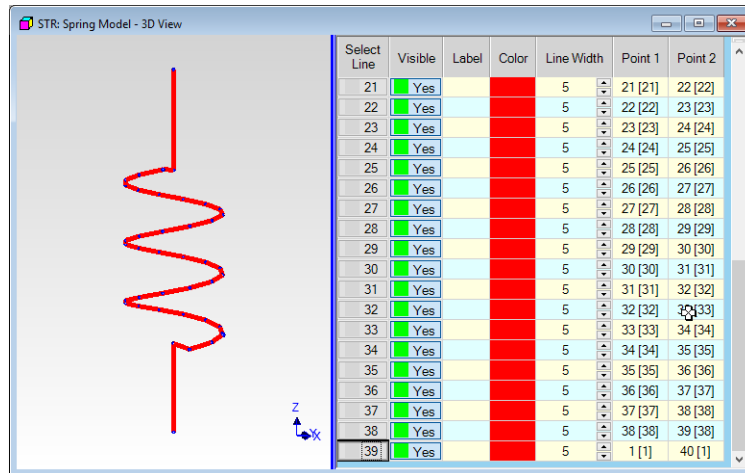
- Edit the **Z coordinate** of the new **Point [38]** to **75 mm**
- Execute **Edit | Current Objects | Lines**
- Execute **Edit | Add Objects** and add a Line between the **two Points labeled [38]**

Now, repeat the above steps to add a connection Line between the bottom of the spring and the Base Plate

- Select the center Point (**Point [1]**) on the bottom of the spring
- Execute **Edit | Copy Objects to File** and add the selected Point to the Spring Model

The copy of **Point [1]** should be listed at the bottom of the Points spreadsheet.

- Edit the **Z coordinate** of the new **Point [1]** to **2 mm**
- Execute **Edit | Current Objects | Lines**
- Execute **Edit | Add Objects** and add a Line between the **two Points labeled [1]**



Finally, the top & bottom **connection Lines** must be added to the Spring substructure.

- Execute **Edit | Current Objects | Points**
- Select *all of the Points* in the Points spreadsheet
- Execute **Draw | Substructures | Add Objects to Substructure**, and click on **Add Objects**

This completes the creation of the Spring Model.. Save this file.

### ASSEMBLING THE SUBSTRUCTURES TOGETHER

Now that all five substructures have been created, they can be pasted together to create the Mass-Spring-Damper 3D model.

- Open all five Model windows, and arrange them in MEScope, as shown below
- Execute **Edit | Copy Objects to File** in the **STR: Base Plate Model** window
- Click on **New File** and enter “**Mass-Spring-Damper**” in the next dialog box
- Execute **Edit | Paste Objects from File** in **STR: Mass-Spring-Damper**
- Select **STR: Damper Cylinder Model**, and press Paste
- Repeat the two steps above to paste the other three substructure models into **STR: Mass-Spring-Damper**

