



Altair

HyperWorks

Altair MotionView 2019 Tutorials

MV-1020 Modeling 2D Rigid to Rigid Contact Simulation

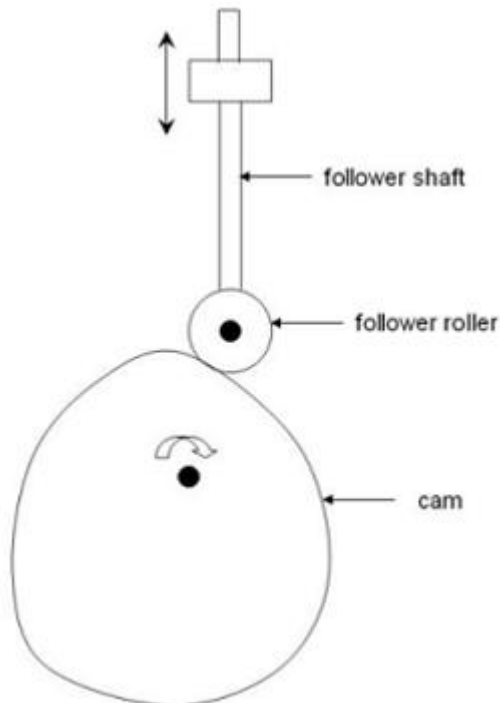
MV-1020 Modeling 2D Rigid to Rigid Contact Simulation

In this tutorial, you will learn how to:

- Create Curve Entities using File, Math and Values options
- Create Curve Graphics using Marker and Body/Point option
- Use macro to create Curve Entity and Curve Graphics simultaneously
- Setup 2D rigid curve to curve contact

Introduction

This tutorial will guide you through the new 2D rigid body contact capabilities in MotionSolve which can be used when contact occurs in a plane. In this tutorial, we will model a roller type cam-follower mechanism with the help of 2D rigid to rigid contact as there are no out-of-plane contact forces that are expected.




Exercise

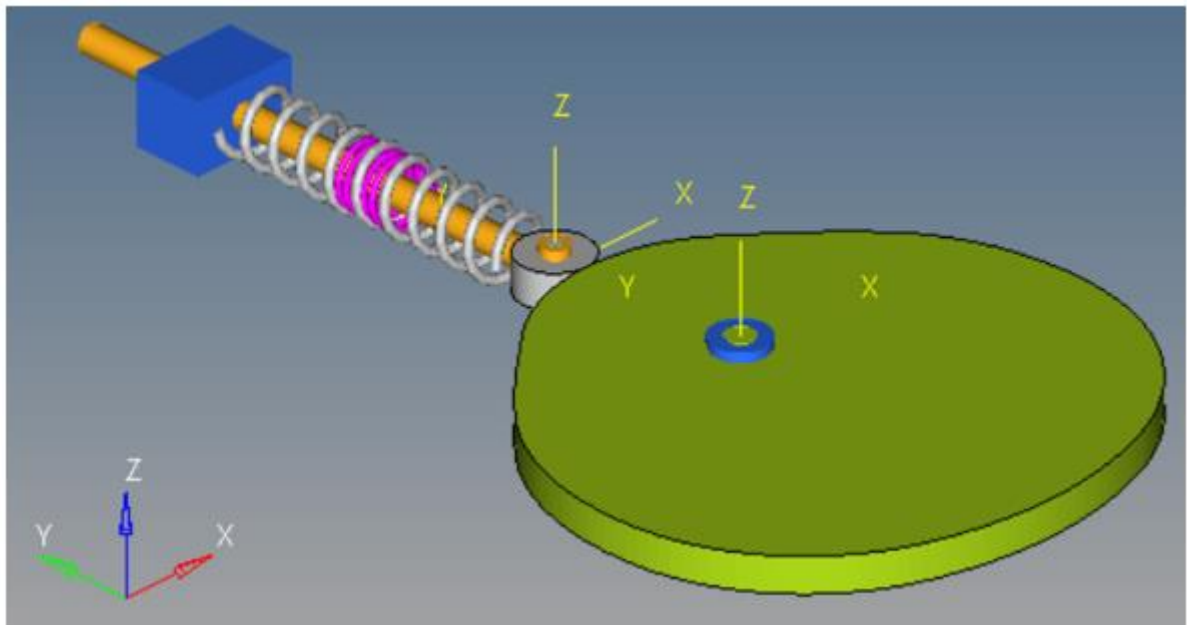
Copy the files `Cam_Follower_Input.mdl`, `CamProfile.h3d`, `Cam_Fixed.csv` and `Cam_Variable.csv` from the location `<installation_directory>\tutorials\mv_hv_hg\mbd_modeling\interactive\` to your `<Working directory>`.


Step 1: Review the partially setup model.

A partially setup model is available for you to open in MotionView. Except the 2D contact, everything else has been setup. Let us review the same by running the model using MotionSolve.

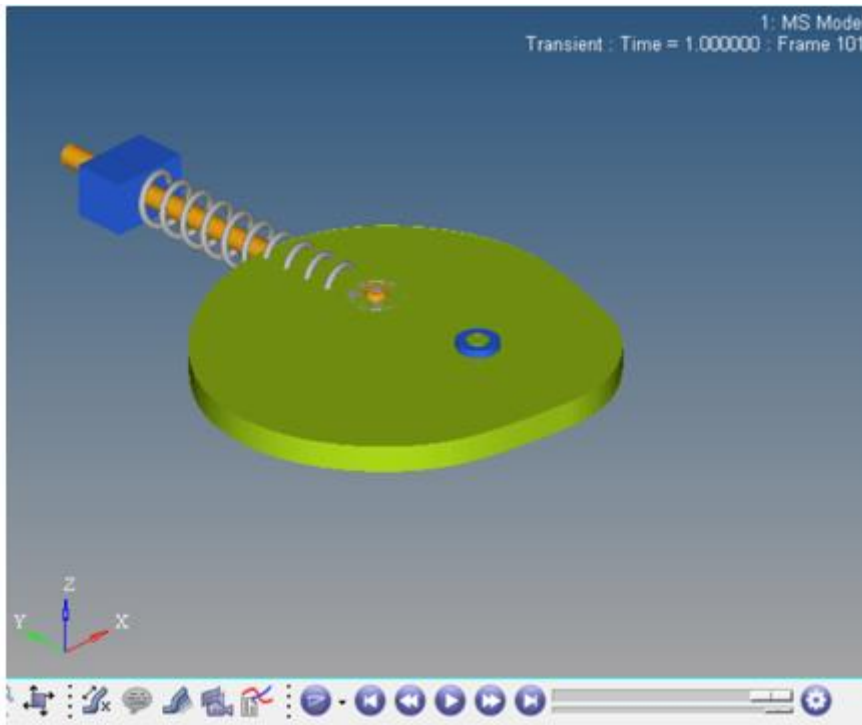
1. Launch MotionView.
2. From the HyperWorks-**Standard** toolbar, click the **Open Model** icon, .
Or
– Open the model by selecting **File > Open > Model**.
3. From the **Open** model dialog, select the file **Cam_Follower_Input.mdl** from your working directory and click **Open**.

Once the model is loaded it will look as it does below. Review the model for its bodies, graphics, markers, joints and motion.

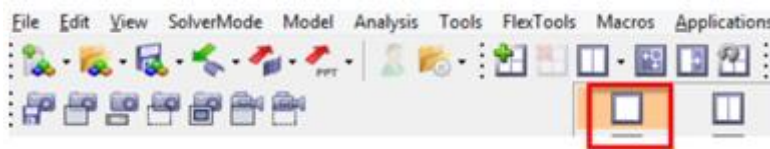


4. In the **Run** panel , click the **Save and run current model** browser button
5. Click the **Run** button. Once the simulation is completed, close the solver window and the **Message Log**.

- From the **Run** panel, review the results animation by clicking on **Animate** button.
Notice that the FollowerRoller is not in contact with the Cam since there is no contact defined in the model.




- Return to MotionView window using the **Page Window Layout** button located on the HyperWorks **Page Controls** toolbar as shown below.



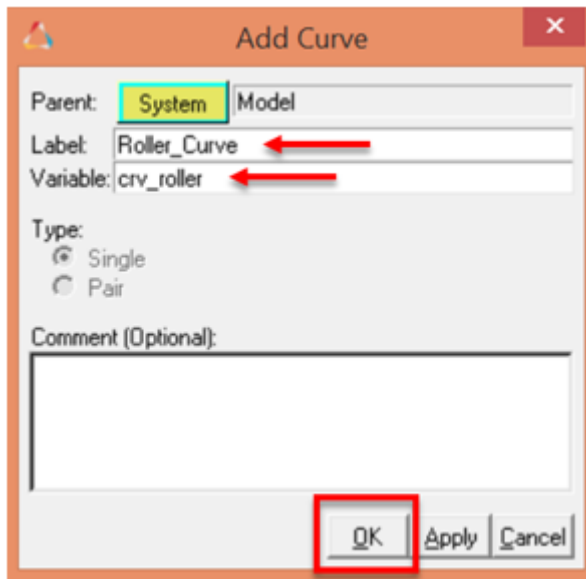
Step 2: Create Curve Entity and Curve Graphics for FollowerRoller.

Since the FollowerRoller profile is circular - it can be easily defined using mathematical expressions. First, we will create a closed circular Curve Entity (using the **Math** option). Then, we will create Curve Graphics to associate this Curve Entity with FollowerRoller body so that it can be later used in setup the 2D Contact.

- From the **Project** browser right-click on **Model** and select **Add Reference Entity > Curve** (or right-click the **Curves** icon  on the **MotionView-Reference Entity** toolbar).

The **Add Curve** dialog is displayed.

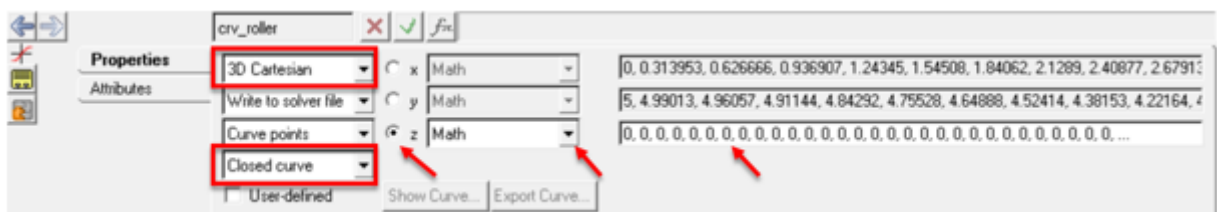
- For **Label**, enter `Roller_Curve`. For **Variable**, enter `crv_roller` and click **OK** (as shown in the image below).




- From the **Properties** tab, use the first drop-down menu to change the curve from **2D Cartesian** to **3D Cartesian**.

Note Only 3D Cartesian types of Curve Entities are supported for the Curve Graphics.

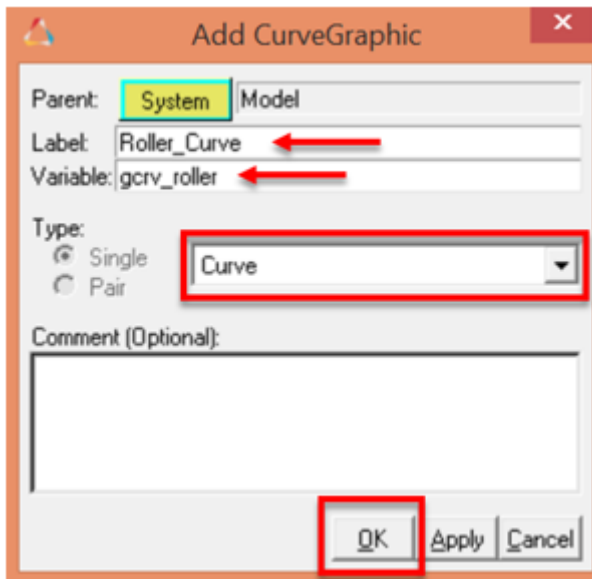
- Use the fourth drop-down menu to change the curve from **Open Curve** to **Closed Curve**.
- From the **Properties** tab, click on the **x** radio button. Select **Math** from the second drop-down menu on the left. Enter $5 * \sin(2 * \pi * (0 : 1 : 0.01))$ in the **Expression Builder** and hit **Enter** on the keyboard.
- Similarly enter $5 * \cos(2 * \pi * (0 : 1 : 0.01))$ and $0.0 * (0 : 1 : 0.01)$ as **Math** expressions for **y** and **z** coordinates of the curve respectively. The panel should now look as shown in the image below.



Note Now having created the Curve Entity, let us create a Curve Graphics to graphically represent the FollowerRoller body on the screen and later use it to define 2D Contact.

- From the **Project** browser right-click on **Model** and select **Add Reference Entity > Graphic** (or right-click the **Graphic** icon  on the **MotionView-Reference Entity** toolbar).
- Choose **Curve** from the drop-down menu.

- For **Label**, enter `Roller_Curve`. For **Variable**, enter `gcrv_roller` and click **OK** (as shown in the image below).



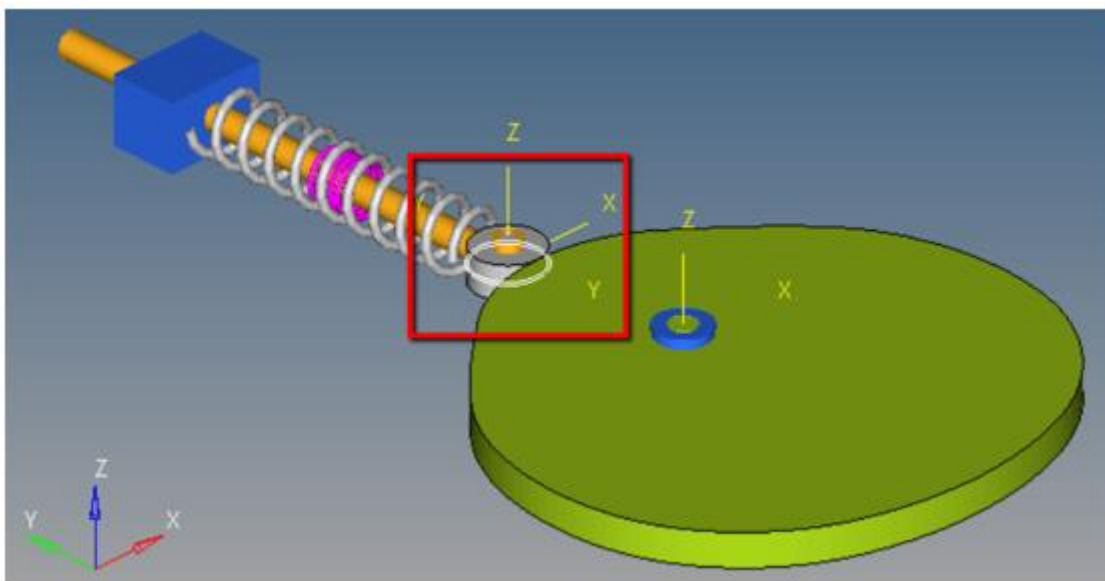
Note The **Body/Point** option (Parent type) has been selected by default on the **Connectivity** tab.

- From the **Connectivity** tab, double-click on the **Body** collector Body.
The **Select a Body** dialog is displayed.
 - Select **FollowerRoller** from the tree.
- Now the **Point** collector is highlighted by default Point, click once on the same.
The **Select a Point** dialog is displayed.
 - Select **FollowerRevJoint** from the tree.

12. Similarly choose **Roller_Curve** using the **Curve** collector Curve. Leave the rest of the options on the panel as default. The panel should look as shown in the image below.

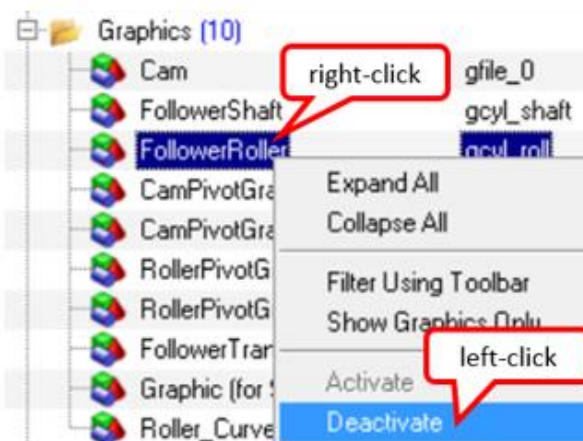


Note Curve Graphics representing the FollowerRoller should now be graphically visible as shown in the image below.



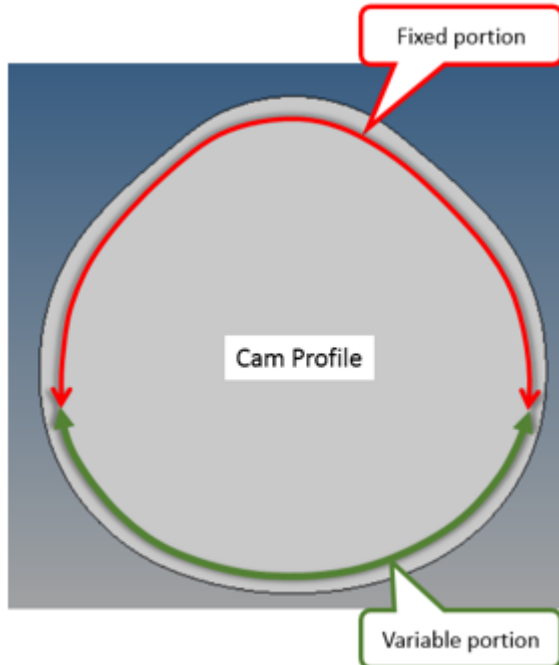
Note At this point we can deactivate (or delete) the original cylinder graphics used to represent FollowerRoller.

13. To deactivate the **FollowerRoller** graphics from the **Project** browser; right-click on **FollowerRoller > Deactivate** as shown in the image below.



Step 3: Create Curve Entity and Curve Graphics for Cam.



In the process of designing a cam, designers often like to determine the best shape of the cam in order to achieve a specific displacement profile of the follower. To allow this, let us divide the cam profile into two portions: Fixed and Variable, as show in the image below.



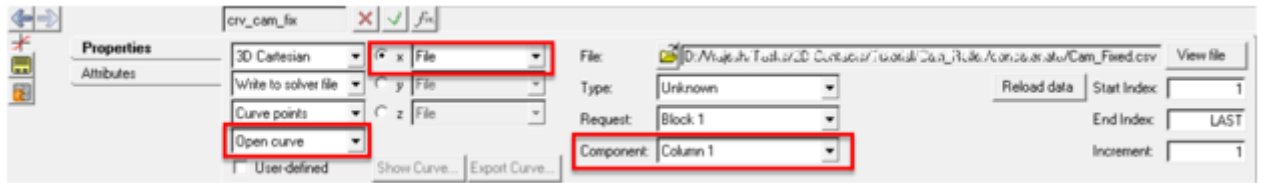
The variable portion of cam will be controlled by the coordinates of some points in our model.

Step 3a: Create fixed portion of Cam profile.

In this step we will learn how to use .csv File containing x,y and z coordinates of points to create a Curve Entity.

1. Right-click the **Curves** icon  to insert a new Curve Entity and provide `Cam_Fixed_Curve` for the **Label** and `crv_cam_fix` for the **Variable**.
2. From the **Properties** tab, use the first drop-down menu to change the curve from **2D Cartesian** to **3D Cartesian**.
3. Retain the default selection for the fourth drop-down menu to **Open Curve**.
4. From the **Properties** tab, click on the **x** radio button. Retain the default **File** option in the second drop-down menu on the left.
5. Click on the file browser icon  and select **Cam_Fixed.csv** from the working directory. Click **Open**.

6. Select **Column 1** for the **Component**. Retain all other options on the panel to its default values. The panel should look like the image below:

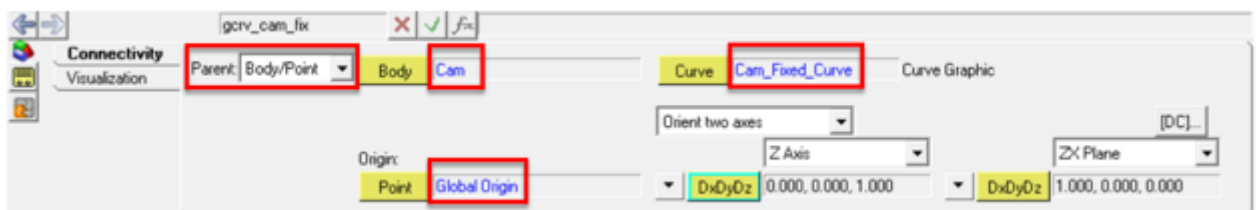


7. Similarly click on the **y** radio button, the same file should be selected by default. This time, select **Column 2** for the **Component**.
8. Click on the **z** radio button, the same file should be selected by default. This time, select **Column 3** for the **Component**.

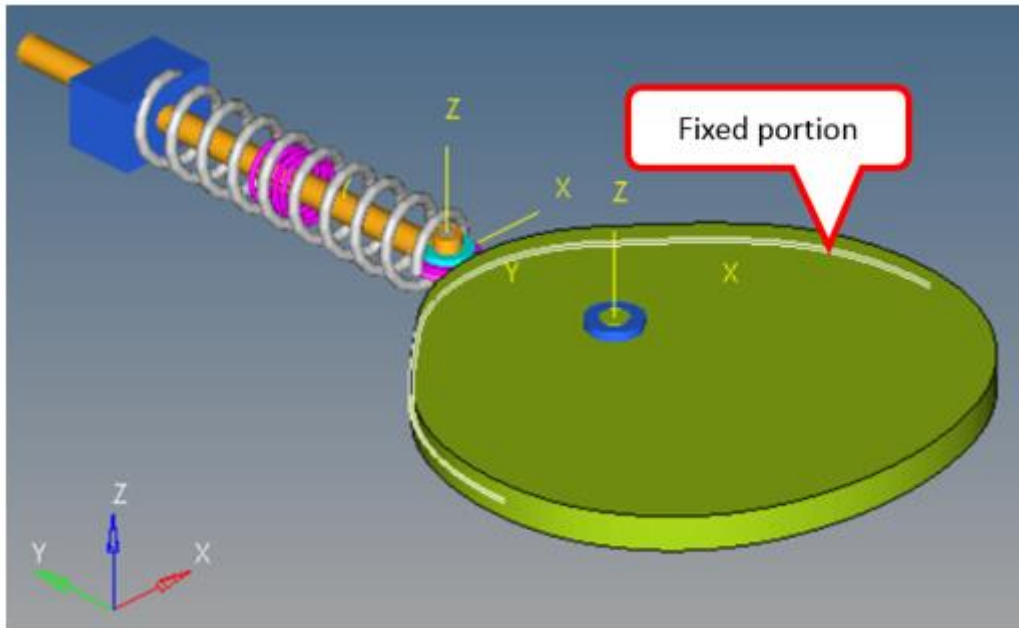
Note Now, having created the Curve Entity, let us create a Curve Graphics to just graphically visualize and make sure that the imported data is located as per our requirement.

9. Insert a new Curve Graphic by following *Steps 7 - 13 of Step 2* of this tutorial with input details as listed in the table below:

Variable	Value
Label:	Cam_Fixed_Curve
Variable:	gcrv_cam_fix
Body:	Cam
Origin Point:	Global Origin
Curve:	Cam_Fixed_Curve



Note Curve Graphics representing the fixed portion of Cam should now be graphically visible as shown in the image below.

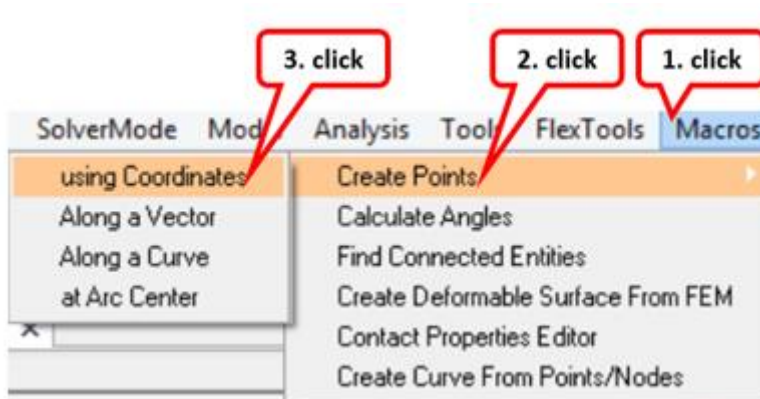


Step 3b: Create variable portion of Cam profile.


In this step we will learn how to use a macro to automatically create both Curve Entity and Curve Graphics using existing points in the model.

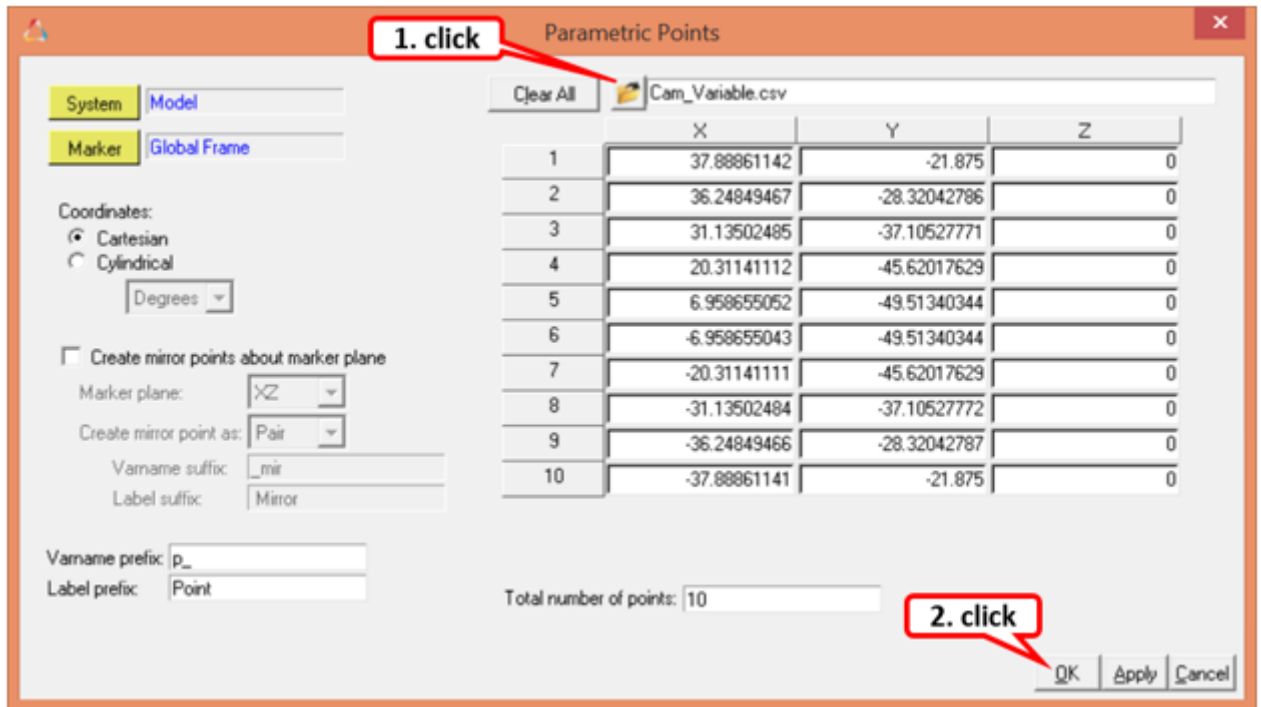
Firstly, let us create some points in the model using Menu > Macros > Create Points > using Coordinates.

1. From **Main** menu, click **Macros > Create Points > using Coordinates** (or click **Create Points using Coordinates**  button from the **MotionView Toolbar > Point Macros** toolbar).

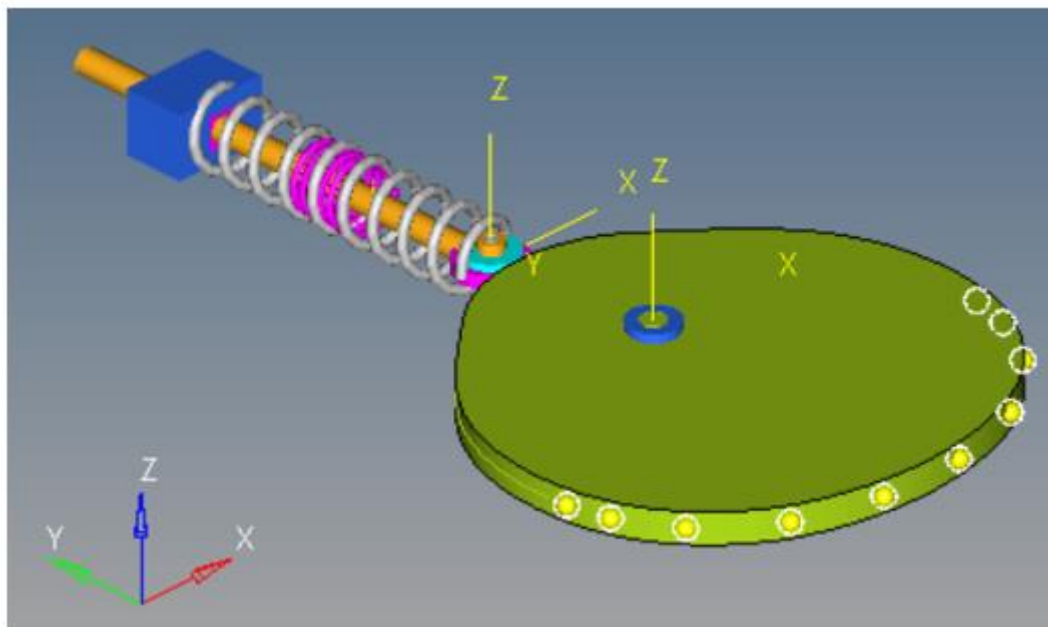


The **Parametric Points** dialog box opens.

- Click on the file browser icon  and select **Cam_Variable.csv** from the working directory. Click **Open**. Click **OK** to create 10 points (Point 0 to Point 9).

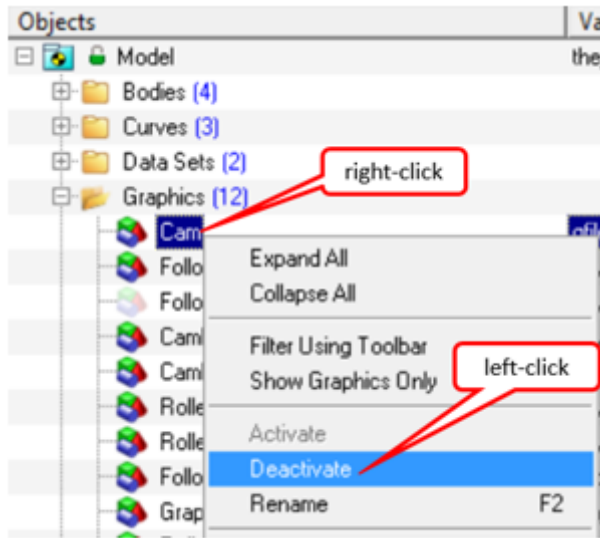


Note The image below shows the newly created points.




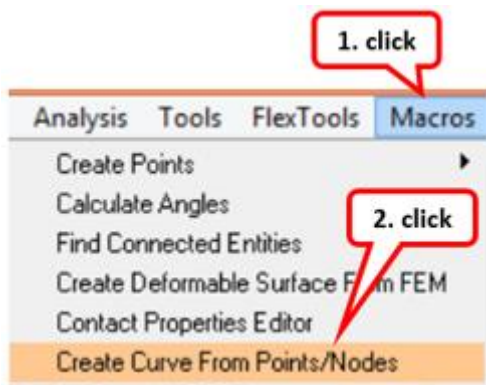
Note Now that we have fixed portion Curve Graphics representing Cam, we can deactivate (or delete) the original H3D file graphics used to represent Cam.

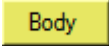
- 3. To deactivate the Cam graphics, from the **Project** browser; right-click on **Cam** > **Deactivate** as shown in the image below.




Now let us use the newly created points to create the variable portion of the cam profile using the **Create Curve from Points/Nodes** macro.

- 4. From the **Main** menu, click **Macros** > **Create Curve from Points/Nodes** (or click the **Create Curve from Points/Nodes** macro button  from the **MotionView toolbar** > **Point Macros toolbar**).



- 5. Double-click the **Body** collector  and select the **Cam** body.
- 6. Edit the **Labels** prefix for the new Curve Entity as well as the Curve Graphics to be created to `Cam_Variable_Curve`.

7. Now, the **Point/Node** collector will be highlighted by default .

You can graphically pick **Point 0** from the screen

OR

Click once on the **Point/Node** collector.

The **Select a Point** dialog is displayed.

– Double-click on **Point 0** from the filtered list of points.

Note The selected **Point 0** is highlighted in the graphics screen and also listed in the panel.

8. Now repeat the above step to pick all the points from Point 1 to Point 9.

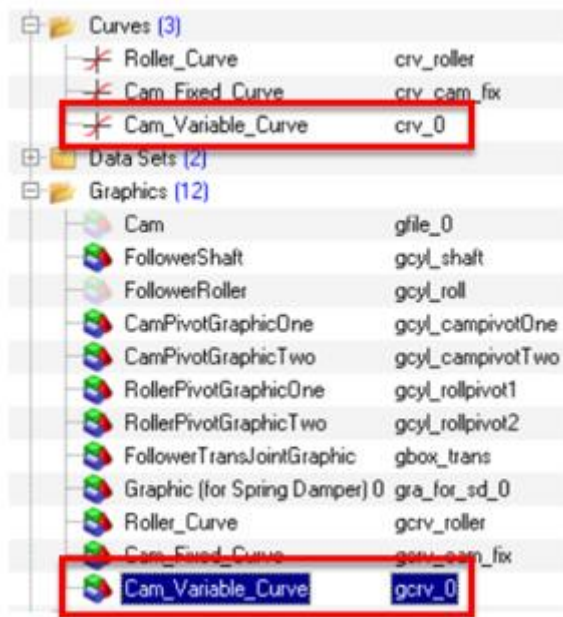
The panel should look like the image shown below.



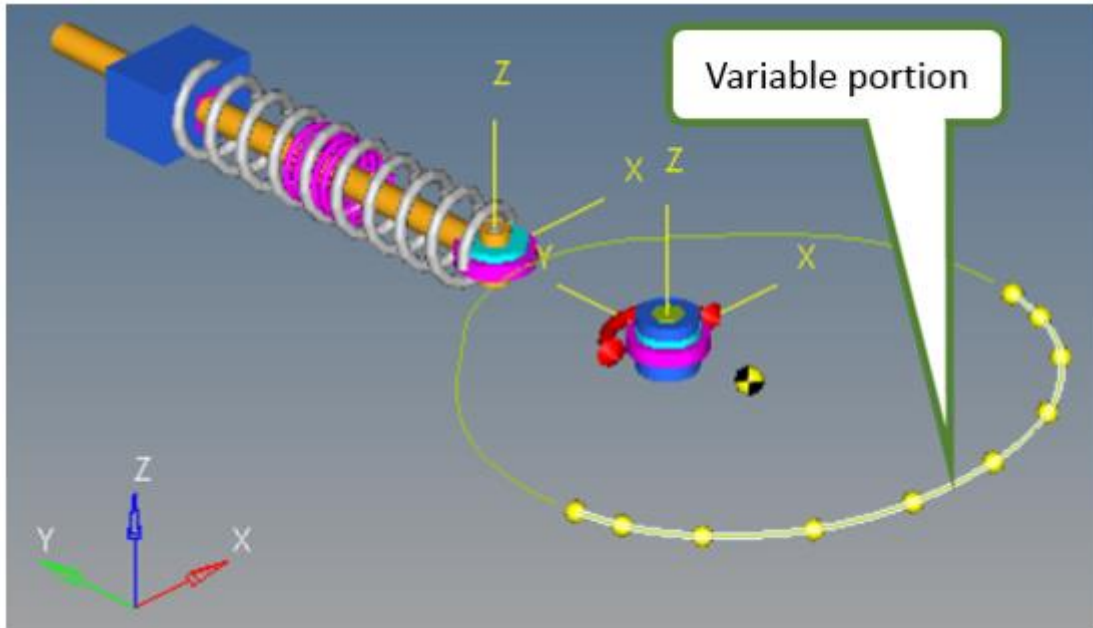
Note A node associated with File graphic H3D can also be picked. However, the curve created would not be parametrically linked with the node. Picking a point retains the parametric relation between the point and the curve.

9. Click the **Create** button.

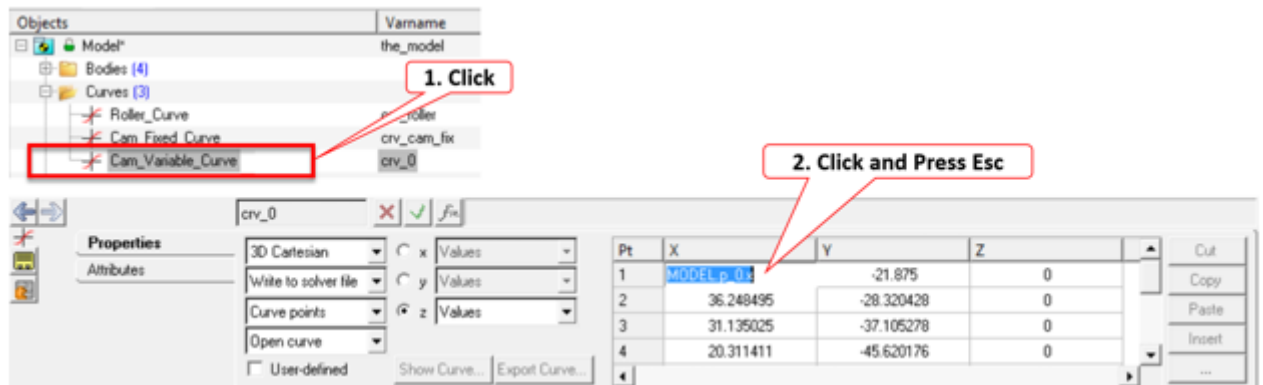
A new Curve Entity and a new Curve Graphics (`Cam_Variable_Curve`) has been added to the model as shown in the image below.



Note The newly created Curve Graphics representing the variable portion of Cam should now be graphically visible as shown below.



Note Review the newly created Curve Entity by selecting it from the model tree as shown in the image below. Notice (by clicking as shown in the image below) how the X, Y and Z values in the panel are parametrically pointing to the points selected while using the macro. Thus, by changing the coordinates of these Points in the model, the curve can be modified.



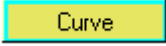
Step 3c: Create merged curve of Cam profile for 2D Contact.

The fixed and variable Curve Graphics of Cam generated in Step 3a and Step 3b cannot be used in setting up contact since they are using open Curve Entities. We generated these in order to verify if the curve data is in the correct location. For a continuous contact between FollowerRoller and Cam, we need closed curves. Thus, in this step we will merge both fixed and variable portions of Cam and create a new closed curve to setup the 2D Contact. In the process, we will learn how to use a mathematical function (CAT) to concatenate two Curve Entities.

- 8. Now, double-click on the **Marker** collector.

The **Select a Marker** dialog is displayed.

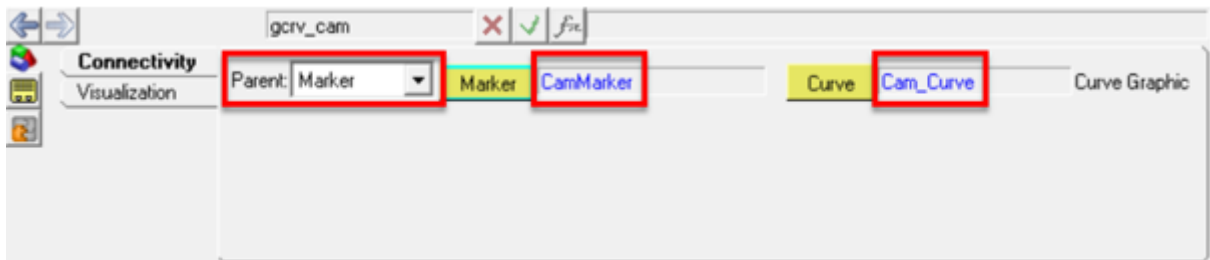
- Select **CamMarker** from the tree and click **OK**.

- 9. Now the **Curve** collector  is highlighted by default, click once on the same.

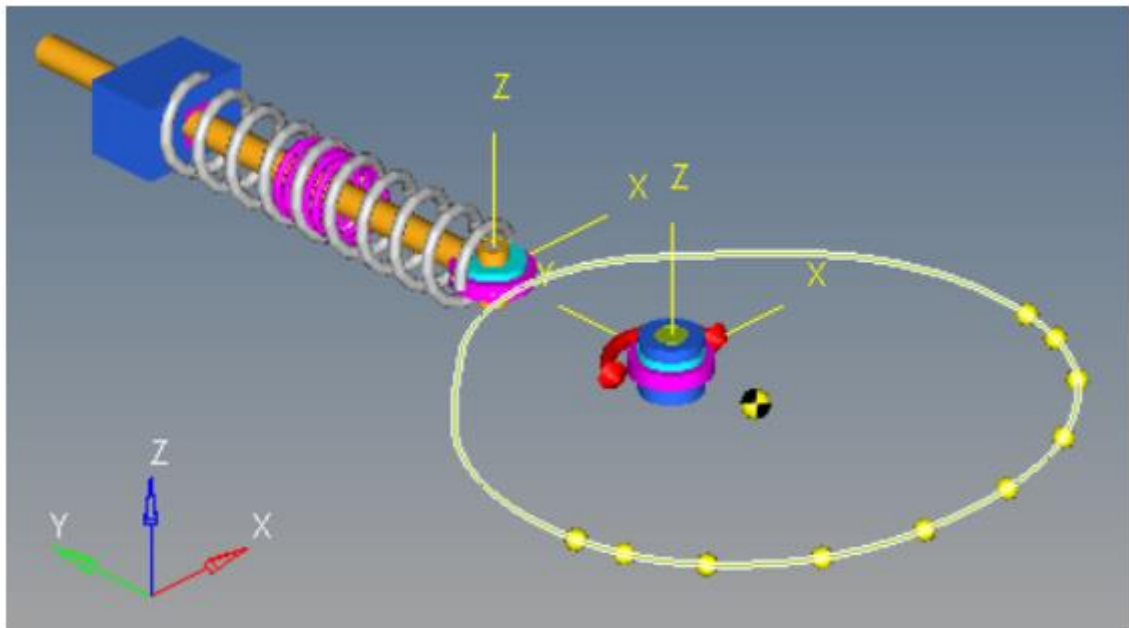
The **Select a Curve** dialog is displayed.

- Double-click on **Cam_Curve** from the list of filtered curves.

Note The panel should now look like shown in the image below.



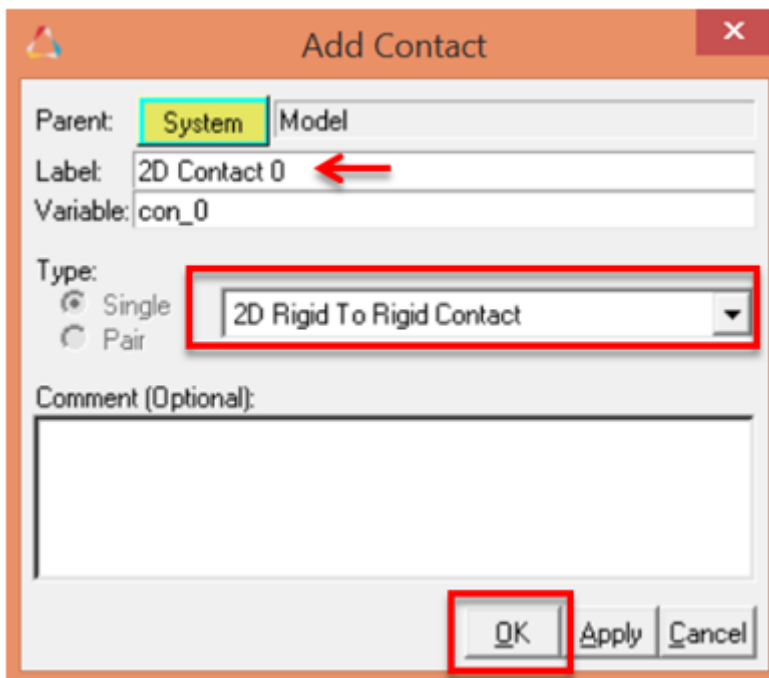
Note Curve Graphics representing the Cam should now be graphically visible on screen as shown in the image below.



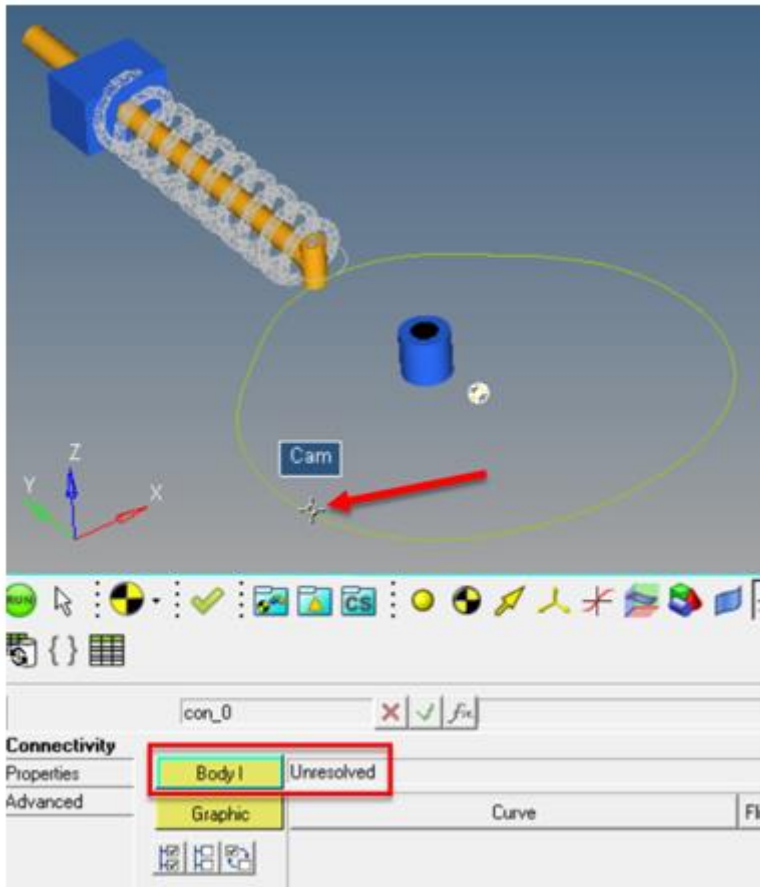
Step 4: Set up 2D Contact.

In this step we will define a contact between Cam and FollowerRoller using their respective Curve Graphics.

1. Right-click on the **Contact** button  in the **Force Entity** toolbar.
The **Add Contact** dialog is displayed.
2. For **Label**, enter 2D Contact 0 and retain the default **Variable**.
3. Change the contact **Type** to **2D Rigid to Rigid** and click **OK**.

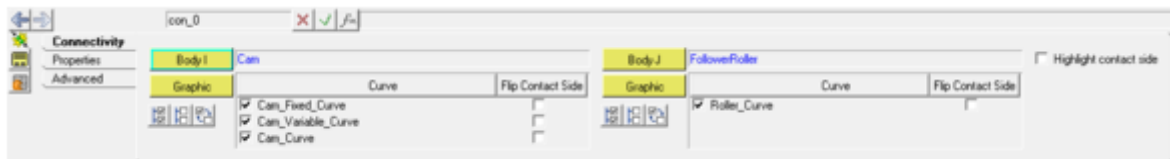


- From the **Connectivity** tab, click the **Body I** collector once to activate it and then select the **Cam** body from the screen by picking its Curve Graphics as shown in the image below.



- Next, the **Body J** collector will be highlighted automatically. Click once and select the **FollowerRoller** body from the **Select a Body** dialog box.

Note The **Contact** panel should be displayed as shown below.



Note Fixed and Variable Curve Graphics are selected by default since they are associated with Cam body. Let us remove the same from the contact definition as they are not required.

- Uncheck (or deselect) **Cam_Fixed_Curve** and **Cam_Variable_Curve** from the list of **Curves** under **Body I**.

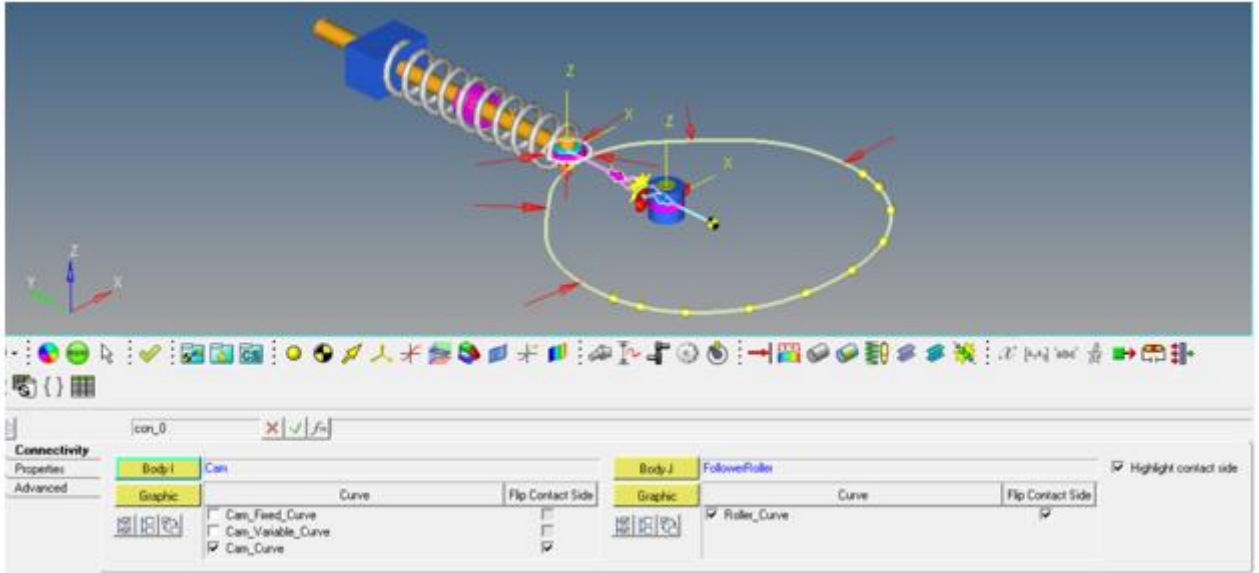
Now, let us review the side of selected curves that will be in contact.

- 7. Click the **Highlight contact side** check box.

Note The arrow display indicates the inside of Cam and FollowerRoller as contacting side. This needs to be corrected.

- 8. Click the **Flip Contact Side** check box for both **Body I** and **Body J** curves.

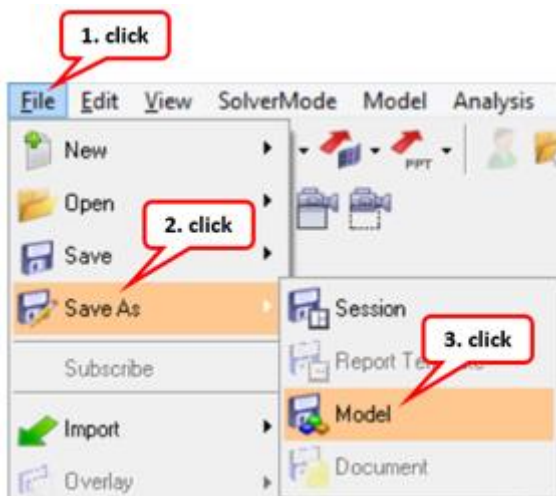
Note The highlighted contact side for both the bodies should now be as shown in the image below.



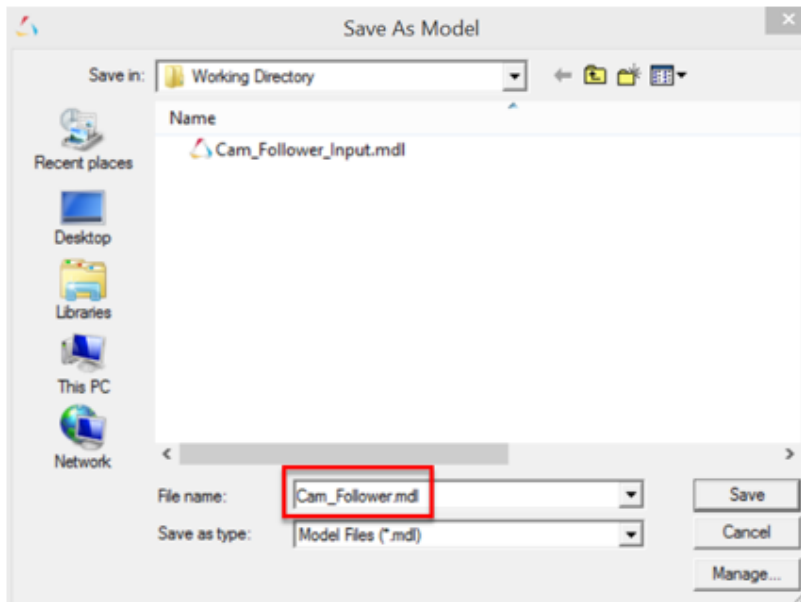
- 9. Review the **Properties** tab, the default selections are fine for the model.
- 10. Review the **Advanced** tab, turn on the **Find precise contact event** and **Change simulation max step size options** with its default values.

Step 5: Save and Run the model.

- 1. Click **Save As > Model** using the option located in the **File** menu.



- From the **Save As Model** dialog, browse to your working directory and specify the **File name:** as `Cam_Follower.mdl`.



At this point, you are ready to run your model. We expect a lot quicker run using 2D curve contact as compared to an equivalent model using 3D contact where the solver has to work harder to determine contact for a 3D tessellated geometry.

- Navigate to the **Run** panel by clicking on the **Run** button in the toolbar .

Note To obtain accurate results, a smaller step size and a finer print interval have been selected in this model. You can review the same by checking **Simulation Settings...** button.

- Specify a new name for your results by clicking on file browser icon  `Cam_Follower.xml` and click the **Save** button as shown in the image below.



- Click the **Run** button.

Step 6: Post-processing the results

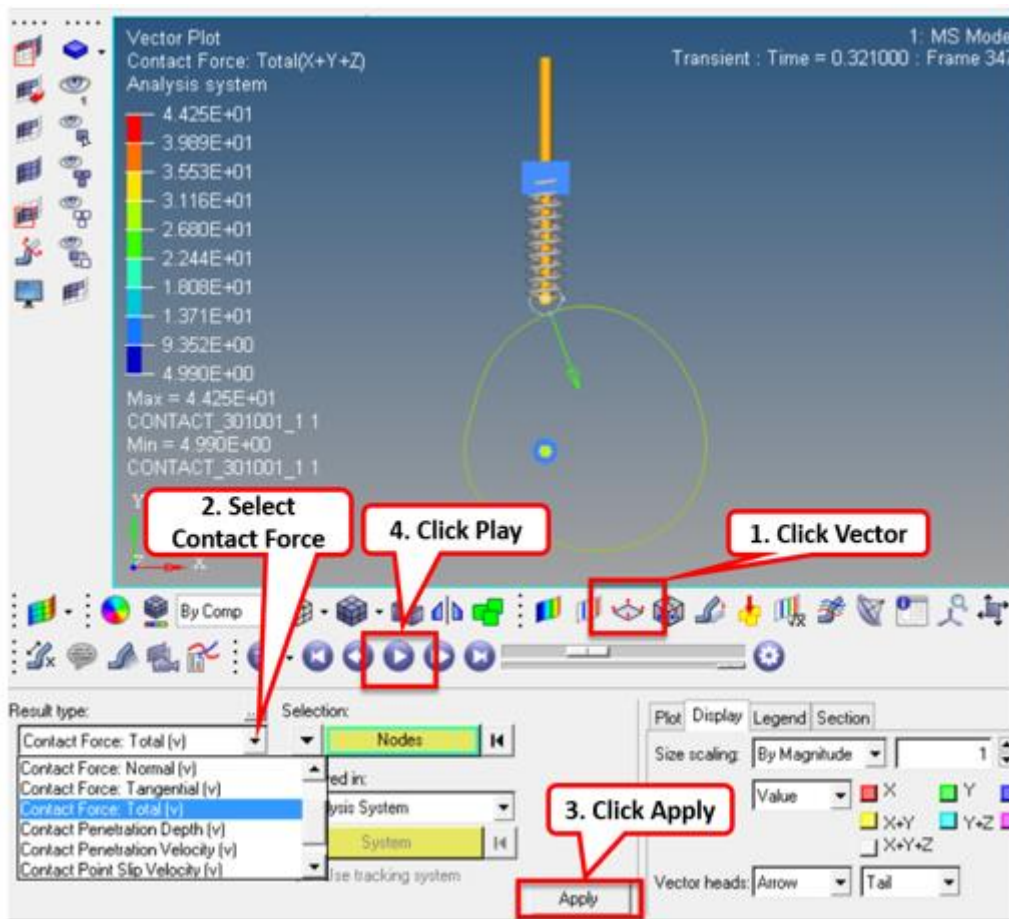
After the simulation is complete, MotionSolve prints out a summary table like for 3D contact (both on screen-solver view window and in the log file generated) that lists the contact pairs ordered by maximum penetration depth and by maximum contact force for this simulation. The image below is an illustration of the same.

Contact Graphics


```

90003 "Cam_Curve" "Model-Cam_Curve"
90007 "Roller_Curve" "Model-Roller_Curve"
Contact Overview (sorted by MAX_PD / MAX_FORCE)
-----
CONTACT      I_GRAPHIC  J_GRAPHIC  MAX_PD      (TIME)      MAX_FORCE  (TIME)
-----
301001      90003      90007      2.600E-01  (7.242E-01)  1.327E+02 (7.242E-01)
    
```

1. Click on the **Animate** button to review the graphical animation in HyperView.
2. Review contact force graphically in HyperView by selecting **Vector** plot, then choosing the **Result type** to be **Contact Force**, click **Apply** and **Start** as shown in the image below.



Note You can even plot the graph of FollowerShaft vertical displacement during the entire simulation using HyperGraph. To do the same, follow the steps mentioned below.

- 3. In the MotionView window, from the **Run** panel  click the **Plot** button.

Note This should open .abf file in HyperGraph.

- 4. Use the **Build Plot**  tool and for **Y Type** (Axis) select **Body, FollowerShaft, Y** , and click **Apply** as shown in the image below.



Further Optional Exercise

Edit the coordinates of any/all points (Point 0 to Point 9) to get updated Cam profile and re-run the model to investigate its effect on Contact Force on Cam or FollowerShaft Displacement.