



Altair

HyperWorks

Altair MotionView 2019 Tutorials

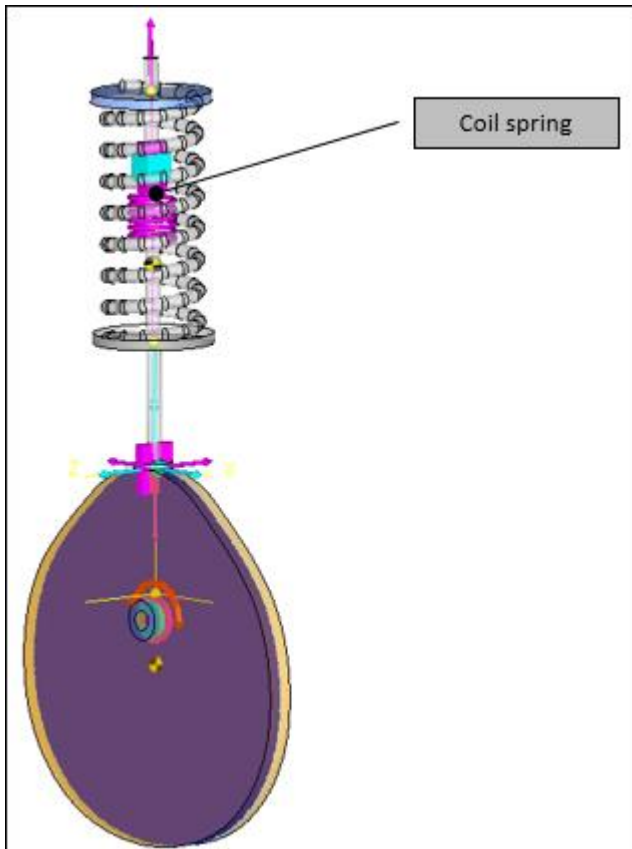
MV-2110: Using an NLFE Helical Spring in a Cam-Follower Mechanism

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In this tutorial, you will learn the following:

- Using a pre-defined NLFE Helical Spring sub-system component in a model.

This will be demonstrated by replacing the traditional coil spring in a Cam follower mechanism.



Cam Follower Mechanism

What are NLFE Components in MotionView?

You can add NLFE bodies in MotionView version 14.0 (onwards) using the traditional Body icon in toolbars or through the browser. In addition to this, ready-to-use sub-systems or Components have been provided. These are components (MotionView system definition) that can be added to the model using very few user inputs such as, for example for a Helical Spring: wire diameter, coil diameter, material properties, number of coils, etc. MotionView will automatically create the building block entities (such as points, bodies, and joints) and standard outputs needed to represent such a subsystem.

The following components are made available:

1. Helical Spring
2. Stabilizer Bar
3. Belt-Pulley

Why use an NLFE Spring?

An NLFE sub-system offers the following advantages:

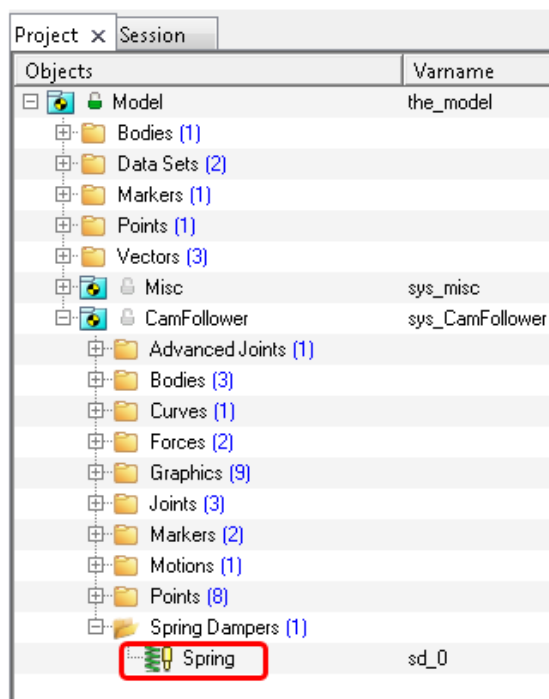
- The spring component is added as a body, which means the mass and inertia of the spring is included in the model.
- The dynamics induced by the mass of the spring can be modeled and simulated (for example, surge in springs).
- If the deformations in the model are likely to go beyond the linear assumptions, NLFE will account for it.
- Stress strain and deformation contours can be visualized.
- Coil-to-coil clash is modeled automatically.

Exercise


Copy the `CamFollower_stg1.mdl` and `CamProfile.h3d` files, located in the `mbd_modeling\nlfe\helicalspring` folder, to your <working directory>.

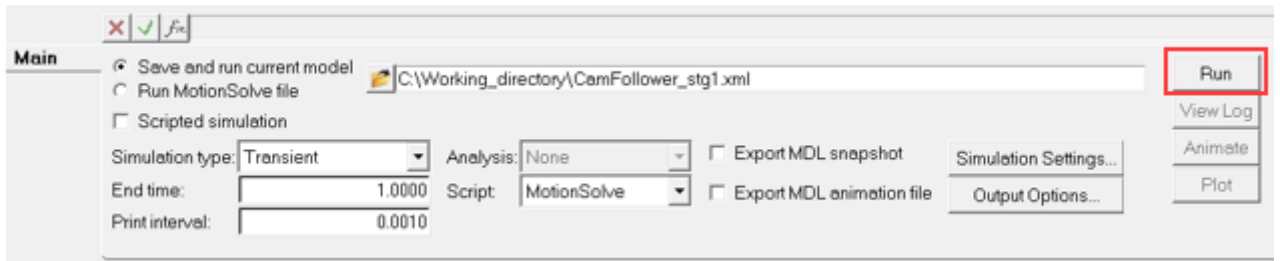
Step 1: Reviewing the Model.

1. Start a new MotionView session.
2. Load the `CamFollower_stg1.mdl` file from your working directory.
3. Review the model. From the **Project Browser** the following can be seen - the Model is organized using a **CamFollower** system which contains:
 - A Cam, Follower, Joints, Graphics, and a Spring which make the complete topology.
 - The spring with a pre-load is acting between the **Follower** and **Ground Body**.



Browser showing the model topology

- Click on the **Run Solver** toolbar icon , and **Run** the model with the settings as shown in the **Run** panel image below. This will be the initial run which will be used to compare the results with the NLFE spring model.

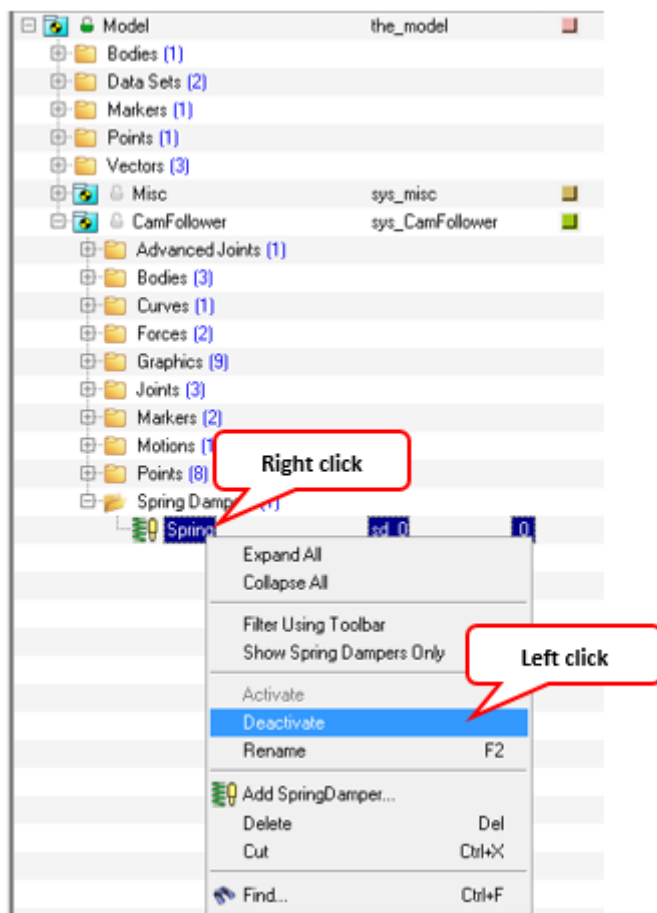


- Click **Animate** to visualize the animation.

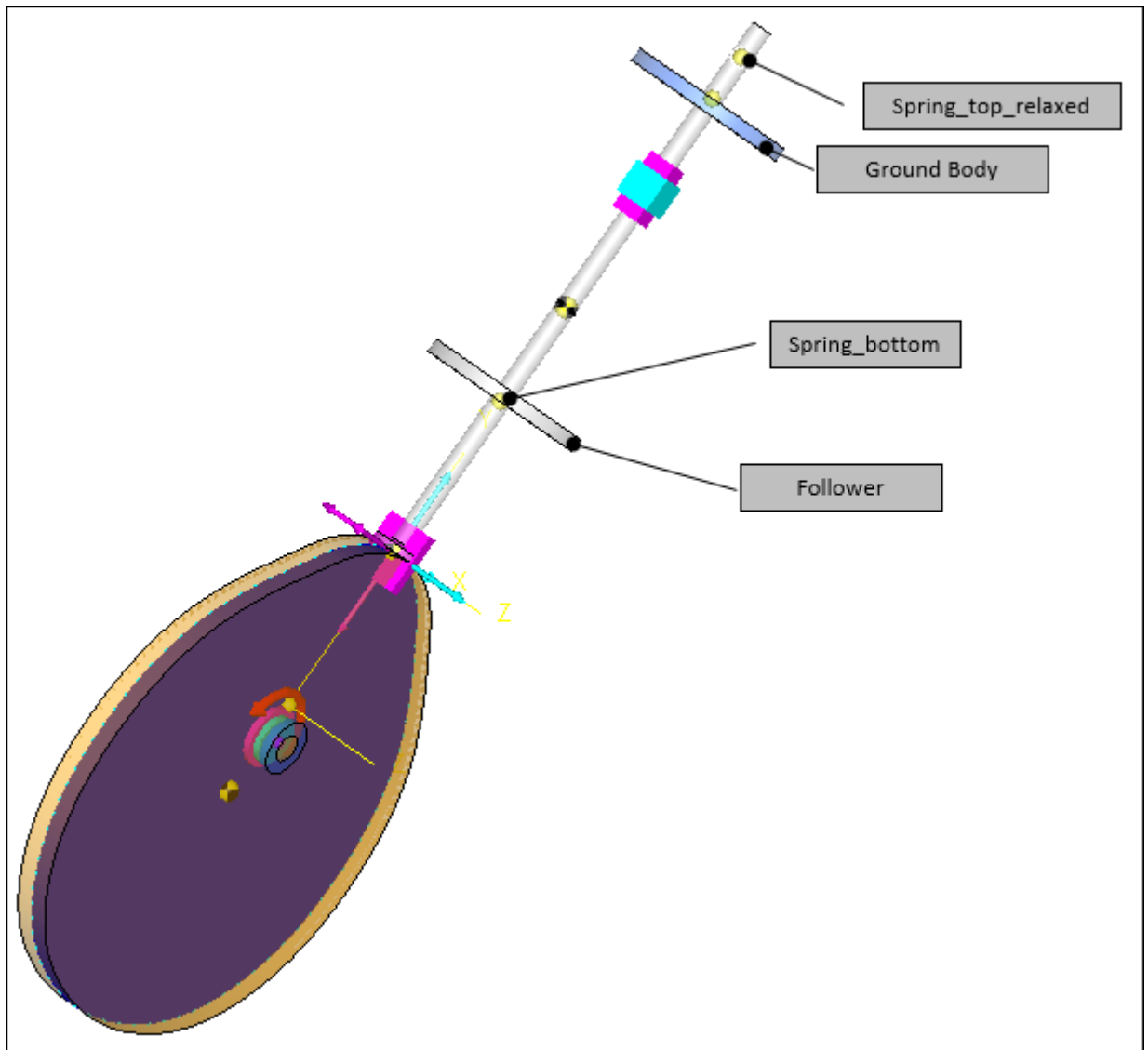
The coil spring will now be replaced with an NLFE Helical Spring component in the next section.

Step 2: Adding an NLFE Helical Spring.


- Deactivate the Coil spring in the model by right-clicking on the **Spring** and selecting the **Deactivate** option from the context menu.

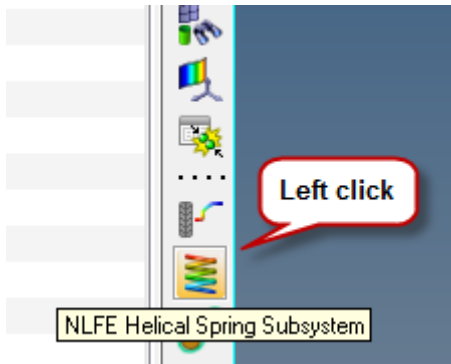


2. An NLFE spring will be added between **Ground Body** on the top and **Follower** at the bottom. The corresponding points that will be used are: **Spring_top_relaxed** and **Spring_bottom**.



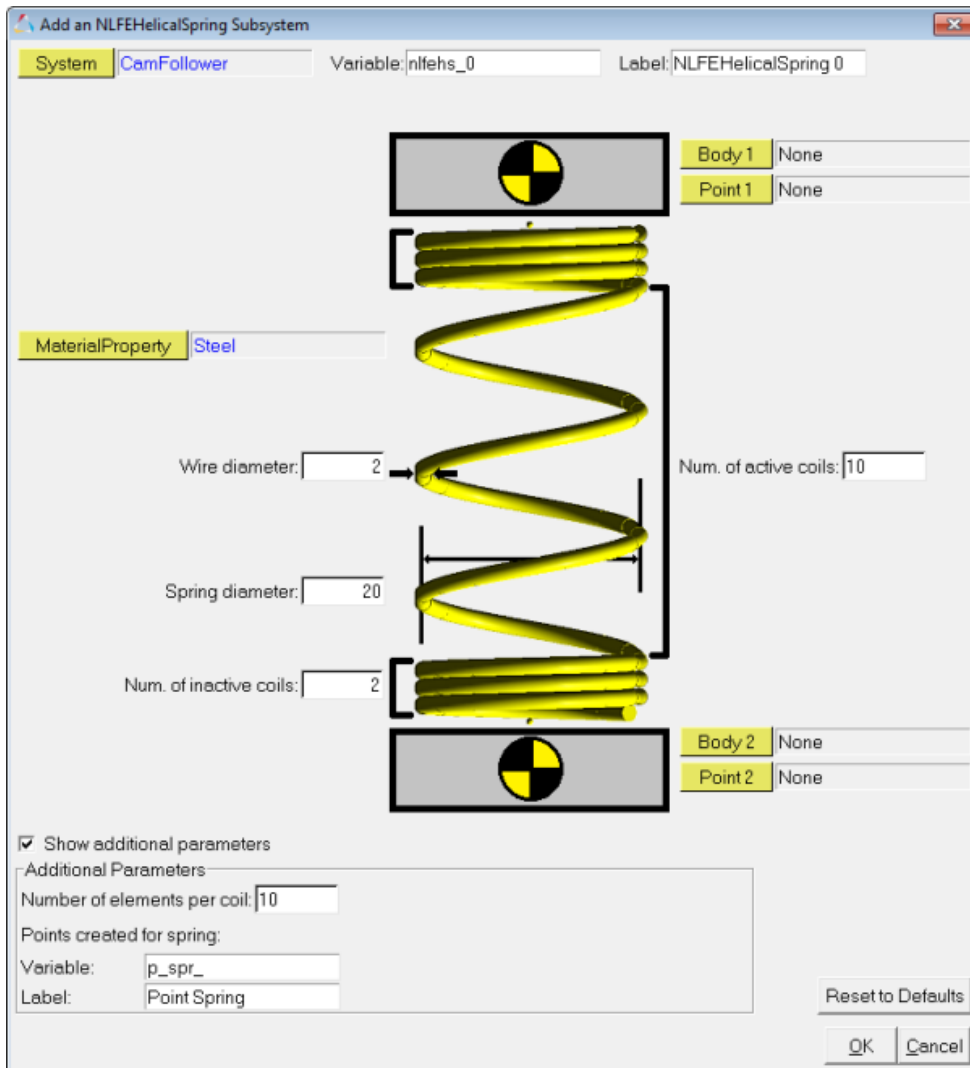
NLFE spring interface bodies and points

3. Add an NLFE Helical Spring Subsystem by clicking the **NLFE Helical Spring Subsystem** icon  in the **Subsystems** toolbar as shown:



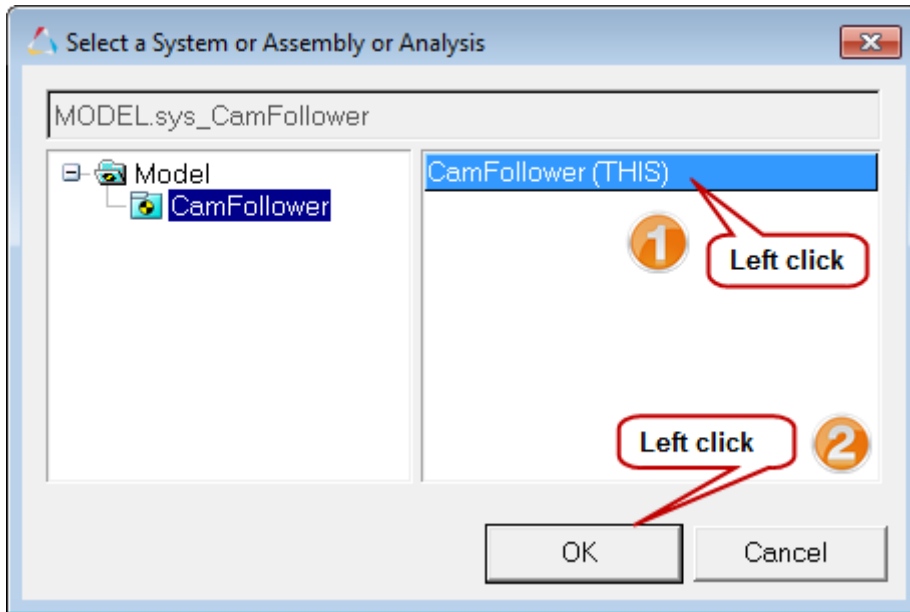
Note This toolbar may not be turned on by default. From the **View** menu, select **Toolbars > MotionView** and then click on the toolbar name to turn the display on/off.

The **Add an NLFEHelicalSpring Subsystem** dialog is displayed.



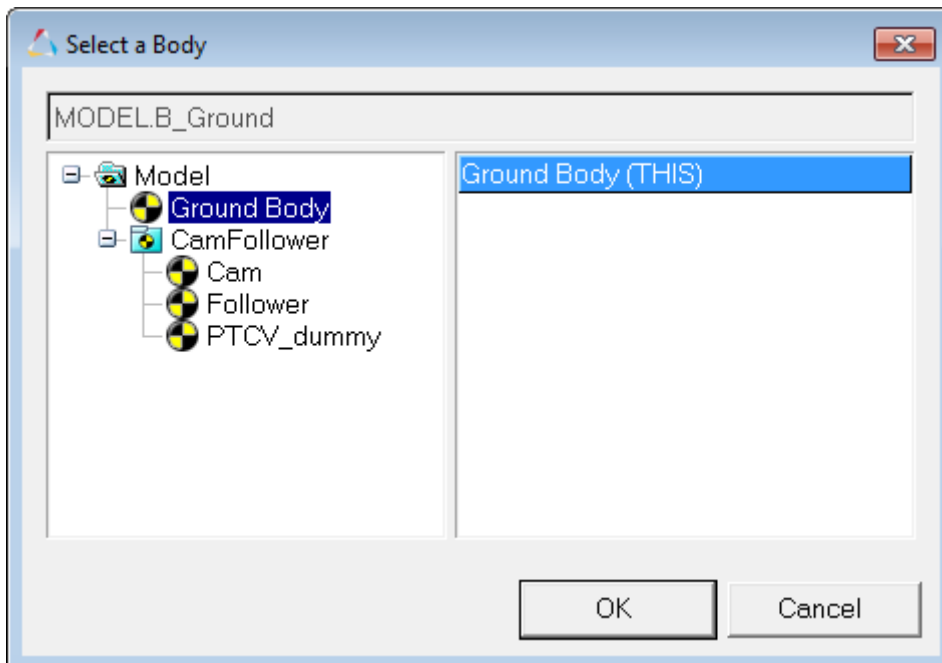
Add an NLFEHelicalSpring Subsystem dialog

4. Assign an appropriate **Label** and **Variable**.
5. Double click on the parent **System** collector to bring up the model tree. Select **CamFollower** as the parent system.

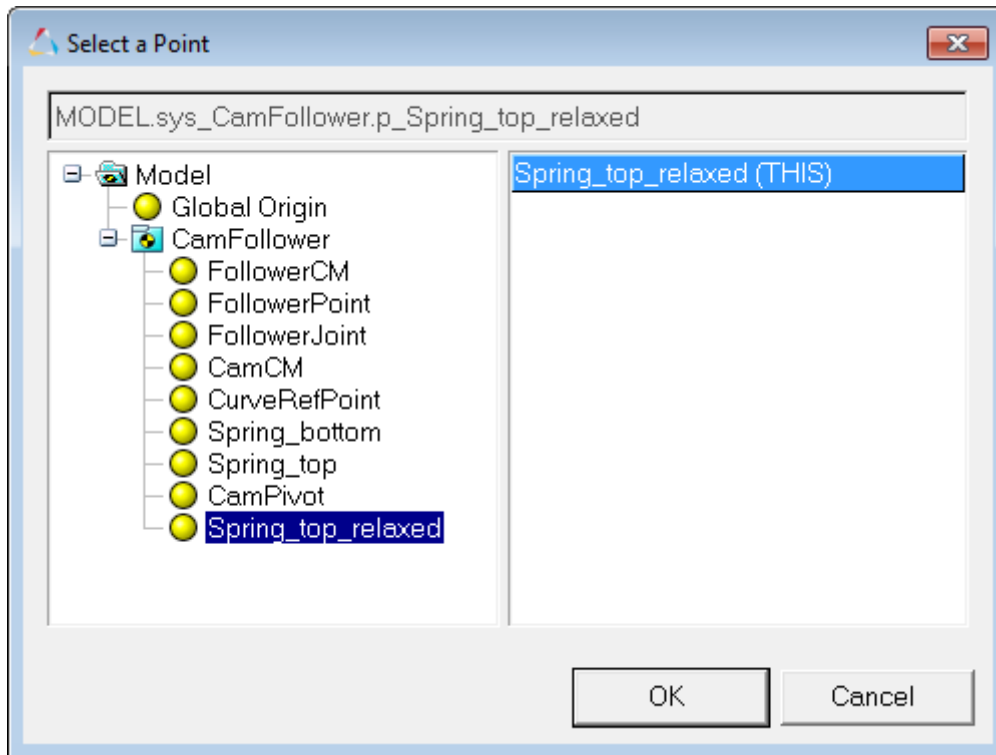


Resolving the parent System

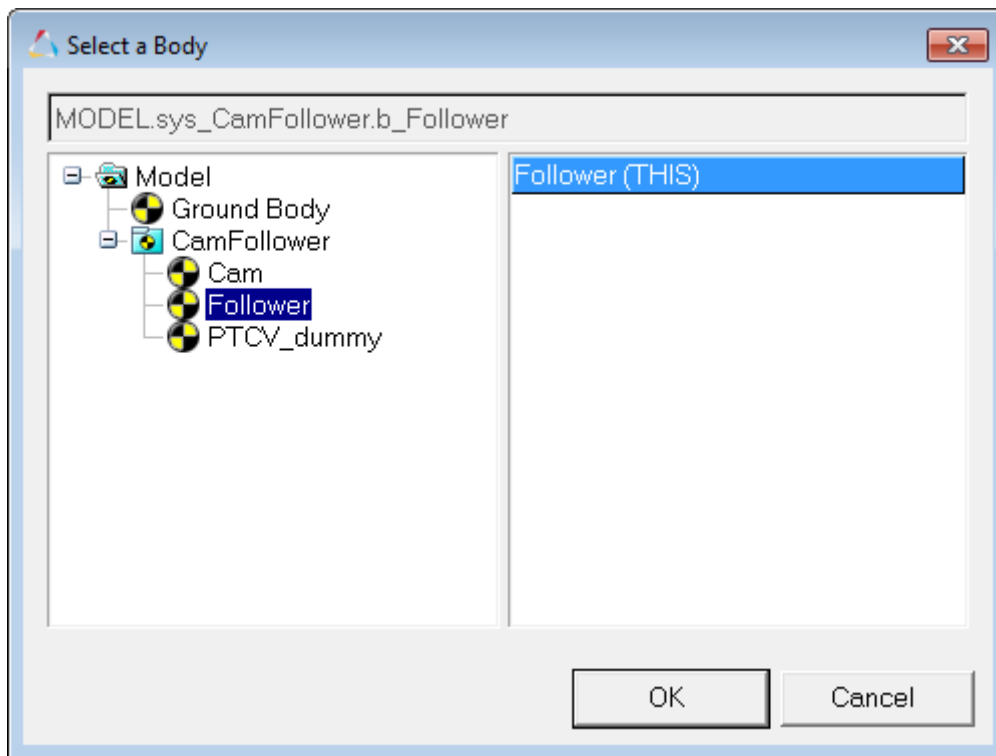
6. Resolve the other collectors for attachments as shown below:
 - **Body 1:** Resolve to **Ground Body**.



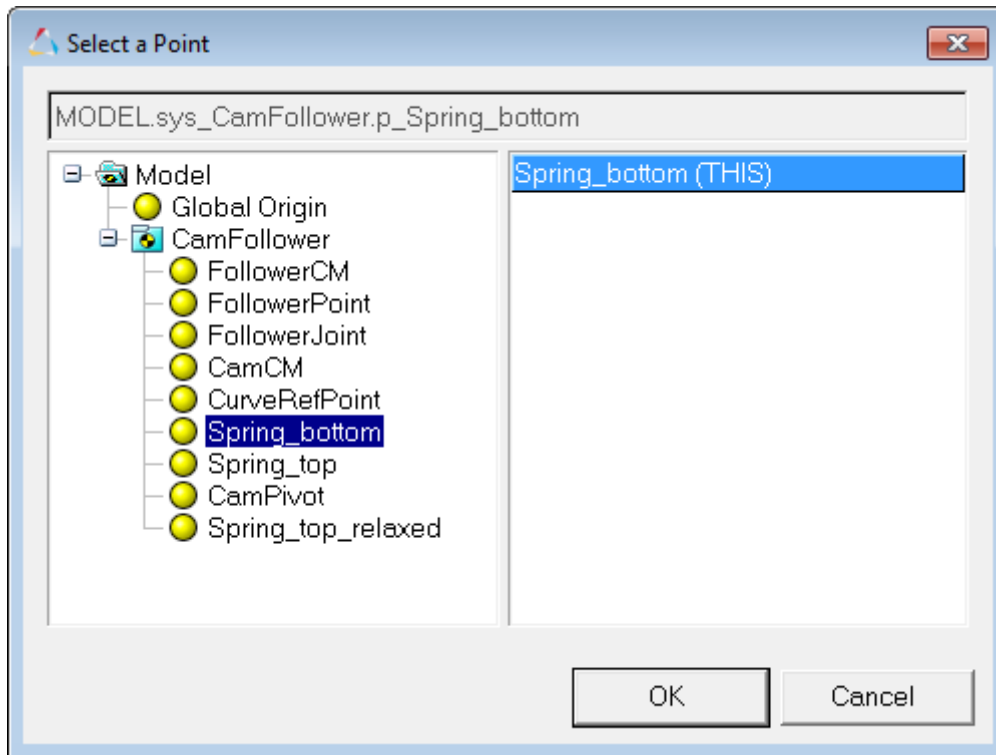
- **Point 1:** Resolve to **Spring_top_relaxed**.



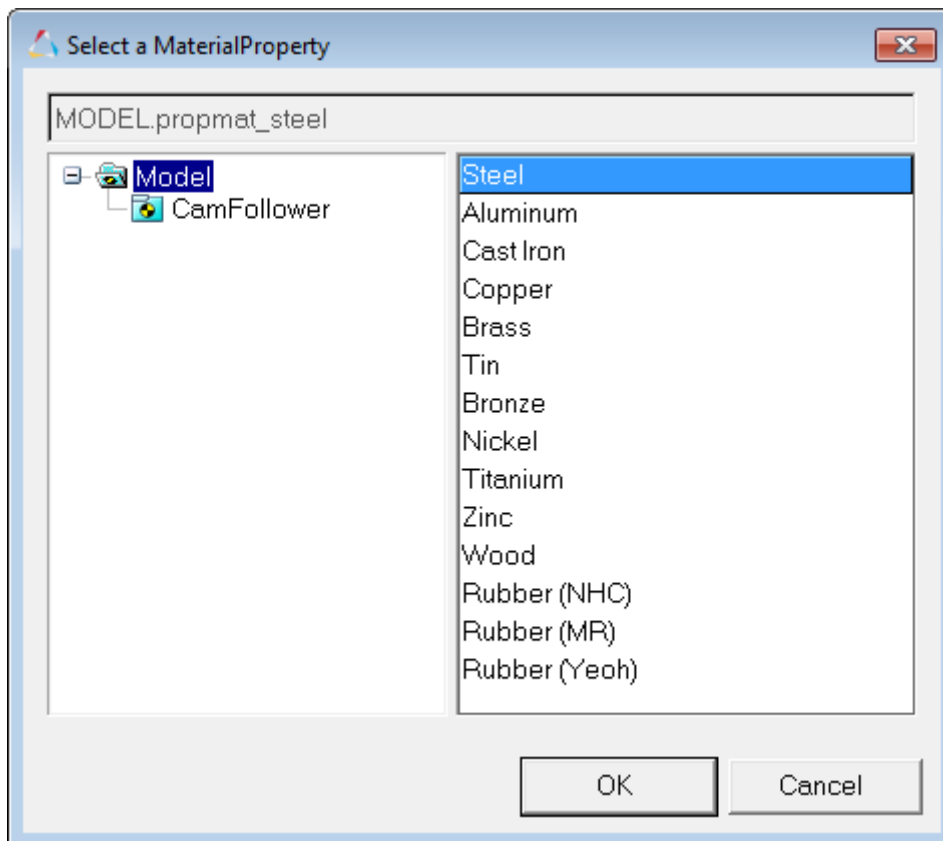
- **Body 2:** Resolve to **Follower**.



- **Point 2:** Resolve to **Spring_bottom**.



- **MaterialProperty:** Select **Steel**.



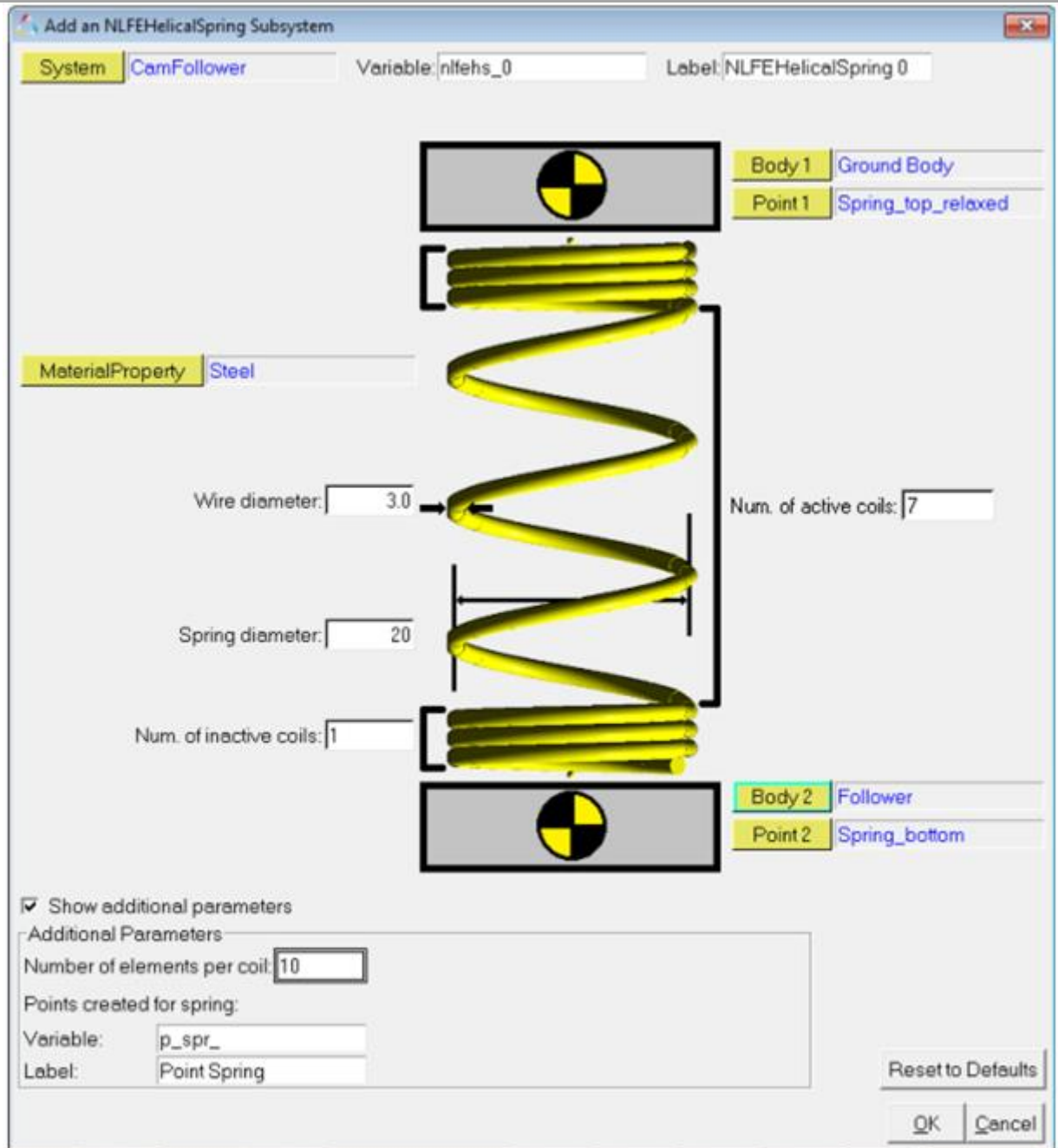
7. Fill in the spring parameters and details for label and varnames as shown below and click on **OK** in the dialog.

Spring parameters		
Wire diameter	Specify the coil spring wire diameter.	3
Spring diameter	Specify the coil mean diameter: center-to-center.	20
Num. of inactive coils	Specify the inactive/dead coils at each end.	1
Num. of active coils	Specify the active coils which contribute to spring stiffness.	7
Additional parameters		
Number of elements per coils	Specify the element density per coil.	10
Variable	Specify varname prefix for the spring profile points created.	p_spr_
Label	Specify label prefix for the spring profile points created.	Point Spring

Note These parameters have been chosen for the following reasons:

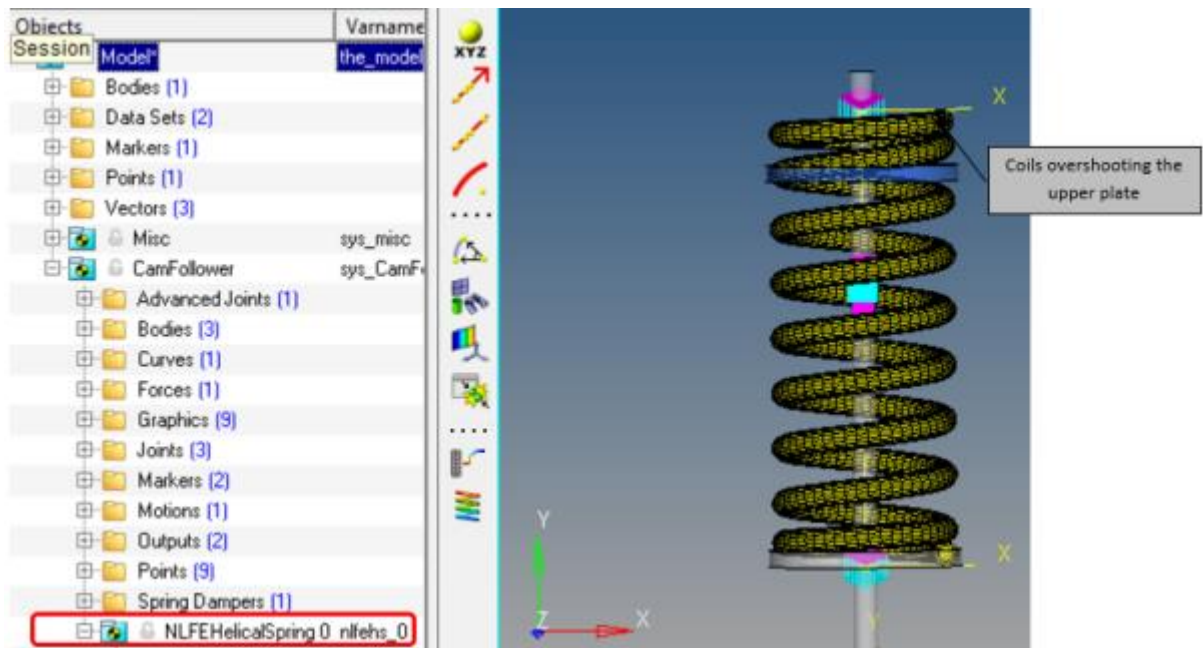
- The stiffness of the coil spring being replaced is: **14.6 N/mm**.
- The equation for the coil spring stiffness: $G.d^4/[8.n.D^3]$ (Where: G = Modulus of rigidity; d = Wire dia.; n = No. of active coils; D = Spring mean diameter).
- Substituting the values from the table above in the equation and using Steel with 80769 N/mm² for material:

$$\text{Spring stiffness } k = 80769 \times 3^4 / [8 \times 7 \times 20^3] = \mathbf{14.6 \text{ N/mm}}$$



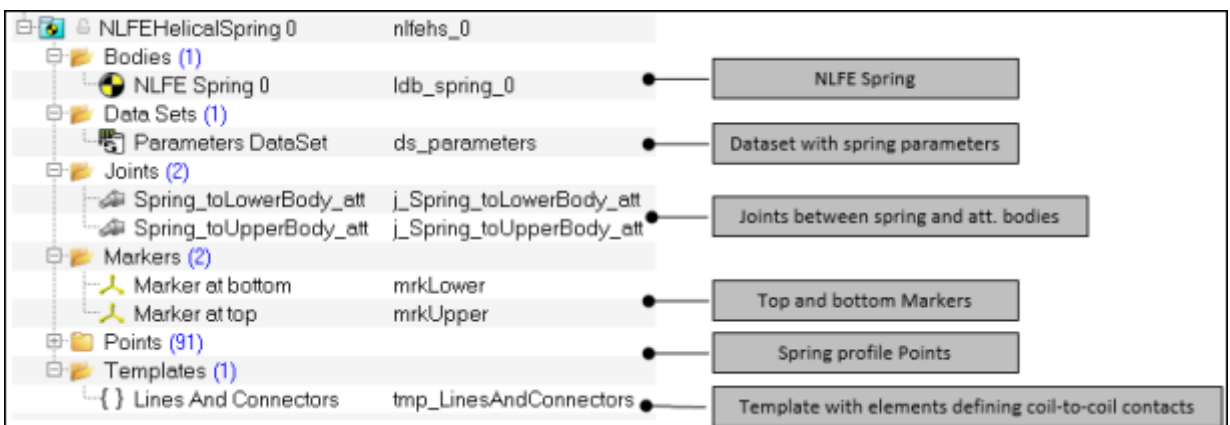
Completed dialog

- The spring will be added between the **Follower** and **Ground Body**.




The spring overshoots the upper plate as shown above. This is because the spring has been created with no pre-load on it.

- Review the NLFE Spring systems added. The following entities are available in the System:
 - An NLFE Spring.
 - DataSet with spring parameters that were used to create the spring.
 - Fixed joints connecting the spring to the suspension.
 - Markers for reference.
 - Points that define the spring profile.
 - Template with unsupported elements. These are automatically created and include elements that define **coil-to-coil contacts**.



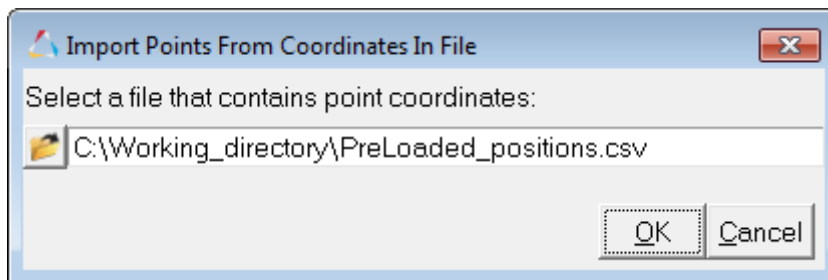
NLFE spring topology in the browser

10. Next, the pre-loaded positions for the spring will be added. To do this,
- Select the  **NLFE Spring 0** body under the subsystem.
 - Go to the **Connectivity** tab. In this tab there is a **View** drop-down menu with two options available: **No Load** and **Loaded**. The **No Load** view shows the unloaded positions of the spring.
 - Select the **Loaded** option. In this view the **Import Loaded Profile** button can be used to browse a .csv file containing the pre-loaded positions and gradients of the spring.
 - Click on the **Import Loaded Profile** button to invoke the **Import Loaded Points Information From File** dialog.



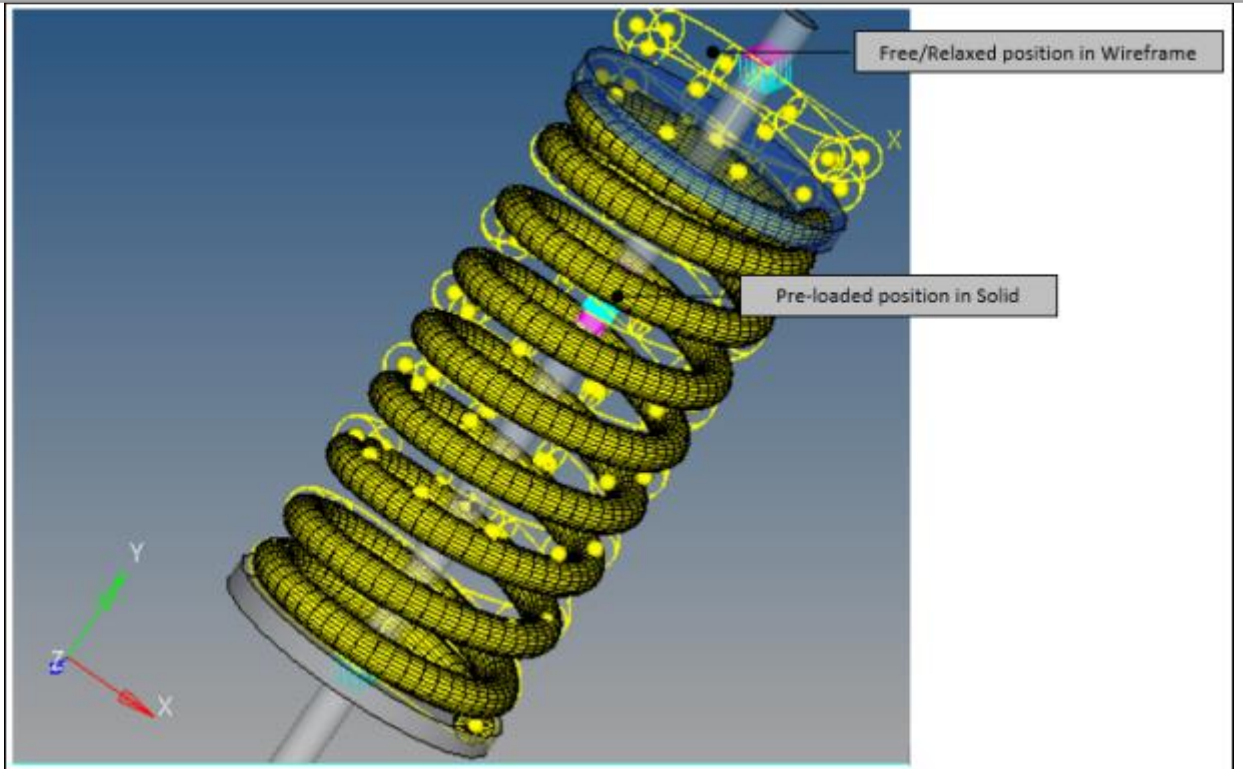
NLFE Connectivity tab - Loaded View

- Browse the file **PreLoaded_positions.csv** from the working directory and click **OK** to import the loaded positions.



The spring will be displayed in wireframe and solid. The one in wireframe is the **No Load** position (free/relaxed configuration) and the solid representation is that of pre-loaded spring.

Note Refer to the *Appendix* in the *NLFE Body Panel – Connectivity Tab* topic to learn how you can generate a preloaded position CSV file.



Free/Relaxed and Pre-loaded position of the spring

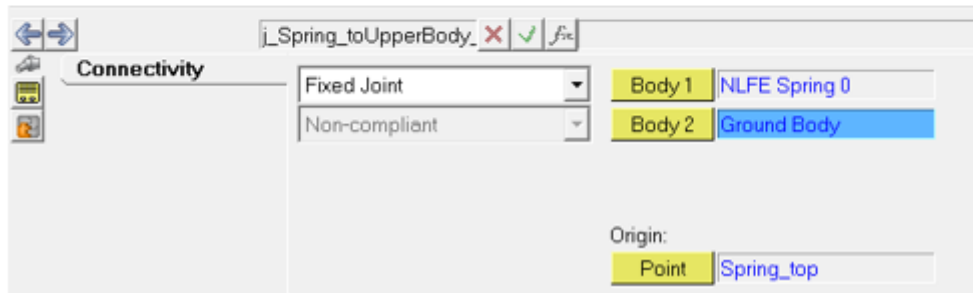
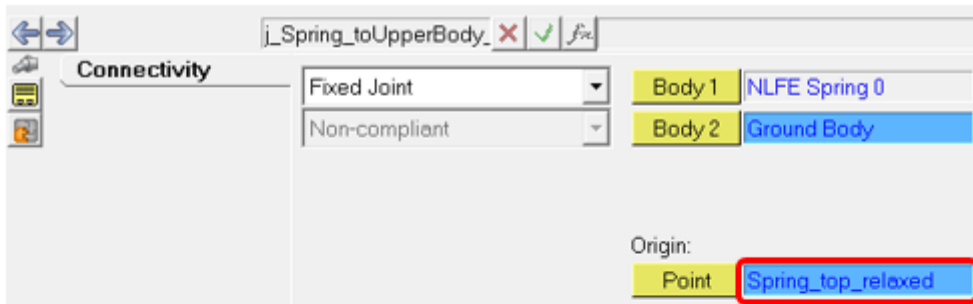
11. The pre-loaded positions can be viewed using the expansion button in the panel.

Positions	X Gradients	Y Gradients	Z Gradients
0	9.9853, 51.3189, 0.0058	-0.3071825, 0.0547869, -0.9500504	0.0399744, 0.9982208, 0.0443759
1	8.0829, 51.6551, -5.8724	-0.6349181, 0.0600532, -0.7702292	0.0242366, 0.9980535, 0.0575308
2	3.0893, 52.0638, -9.5031	-0.9315653, 0.0679594, -0.3570499	0.0354414, 0.9947116, 0.0963579
3	-3.0832, 52.4942, -9.4963	-0.9308429, 0.0670843, 0.3590596	0.1232077, 0.9829804, 0.1361625
4	-8.0687, 52.8926, -5.8535	-0.5842969, 0.0521465, 0.8098275	0.2284202, 0.9681183, 0.1026252
5	-9.9549, 53.2225, 0.0302	0.0044344, 0.0496018, 0.9987415	0.3353274, 0.9408634, -0.0480955
6	-8.0177, 53.4772, 5.9011	0.5913007, 0.0289204, 0.8059331	0.3267360, 0.9051353, -0.2720502
7	-2.9975, 53.6773, 9.5128	0.9349246, 0.0296806, 0.3535499	0.1564288, 0.8601752, -0.4855971
8	3.1876, 53.8581, 9.4863	0.9318515, 0.0292618, -0.3615580	-0.2536497, 0.7651616, -0.5919848

Pre-loaded positions and gradients imported from the .csv file

12. The fixed joints created by the **NLFEHelicalSpring Component** utility will be at the free positions. You need to move one of these to the pre-loaded positions. Inspecting the spring positions reveals that the spring is compressed at the top while the bottom position is the same in both the configurations.

- Change the origin point of the joint **Spring_toUpperBody_att** in the NLFE **Helical Spring 0** system from **Spring_top_relaxed** to **Spring_top** (in the parent **CamFollower** system).





Changing the connection to pre-loaded position

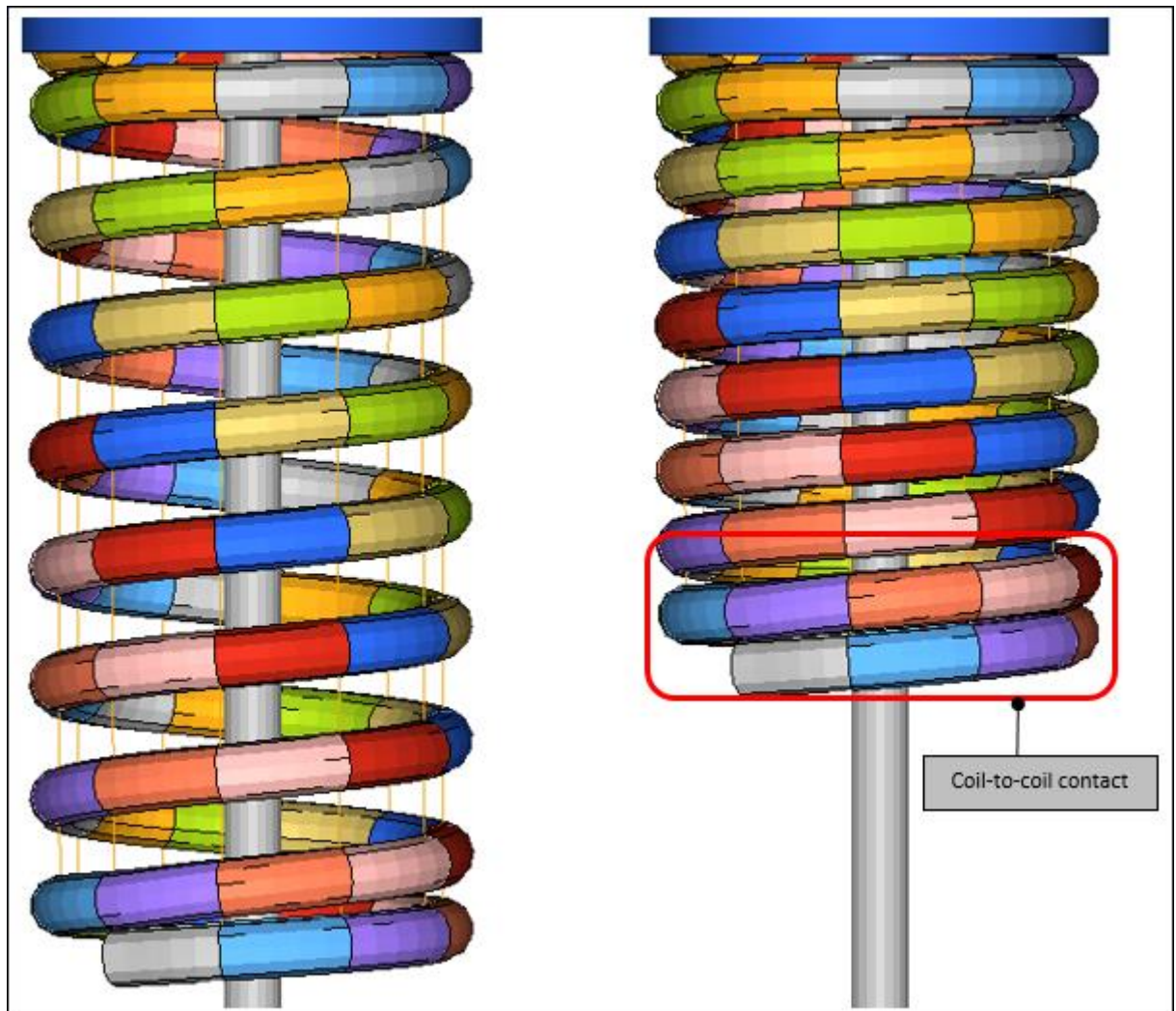
- Save  the model as `CamFollower_nlfe_spring.mdl`.

Step 3: Solving the Model and Post-processing.


The model is now complete and can be solved in MotionSolve.

- To solve the model, invoke the **Run** panel using the **Run Solver** button  in the toolbar.
- Assign a name for the `.xml` file and click on the **Run** button.
- After the simulation is completed, click on the **Animate** button to view the animation in HyperView.
- Use the **Start/Pause Animation** button  to play the animation.

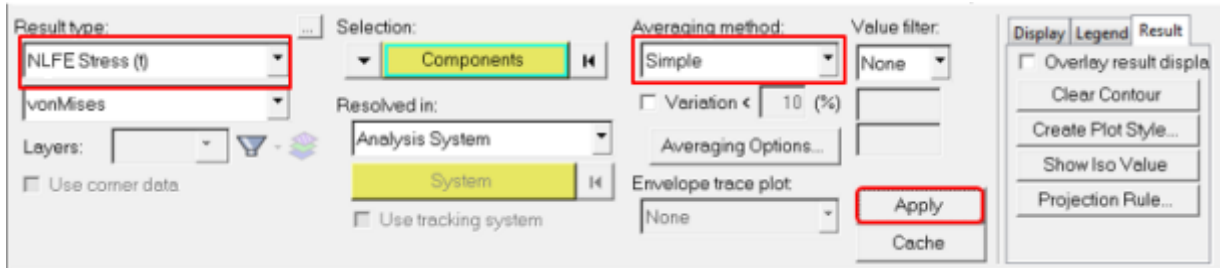
5. Coil-to-coil clash can be viewed at the bottom/top set of coils.



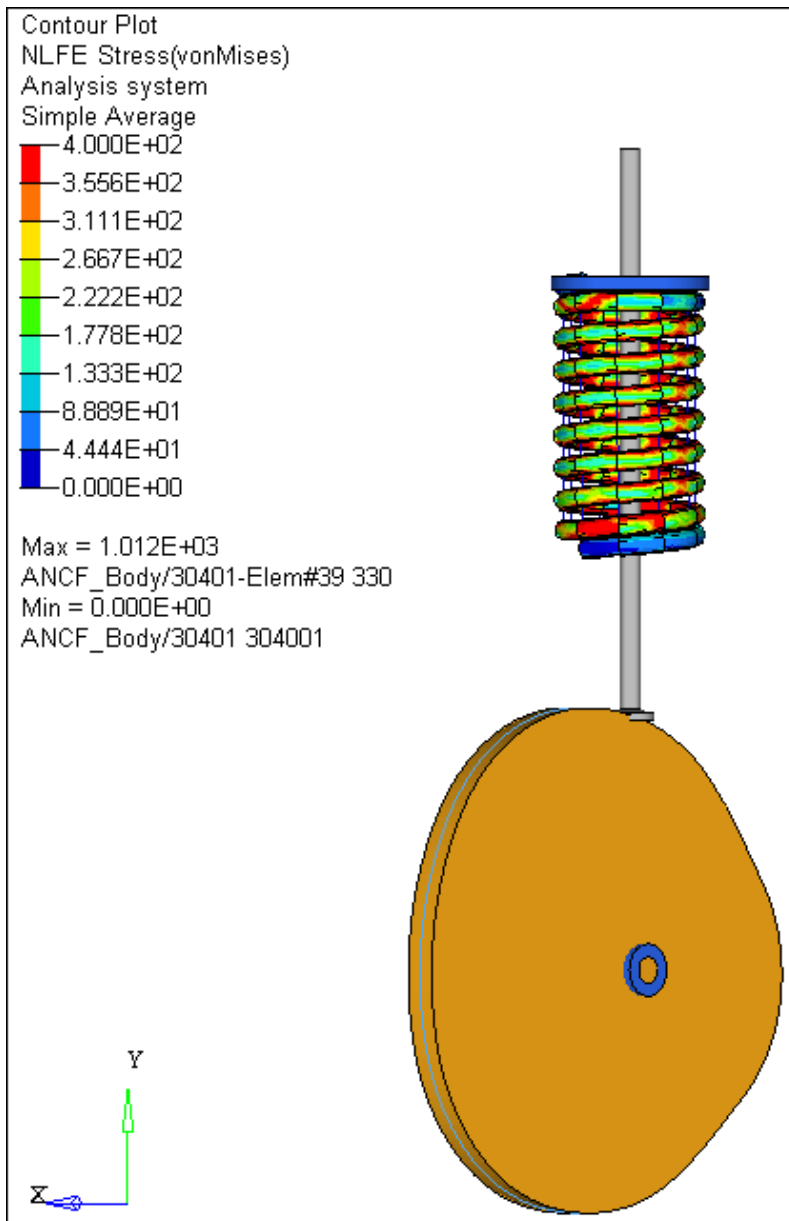
Coil-to-coil contact visualization in HyperView

6. Click the **Contour** icon  on the toolbar to activate the **Contour** panel.

- 7. Under **Result type**: select **NLFE Stress (t)**, **Averaging method**: **Simple**, and click **Apply** to view stress contours.



Viewing results in HyperView







Contours in HyperView

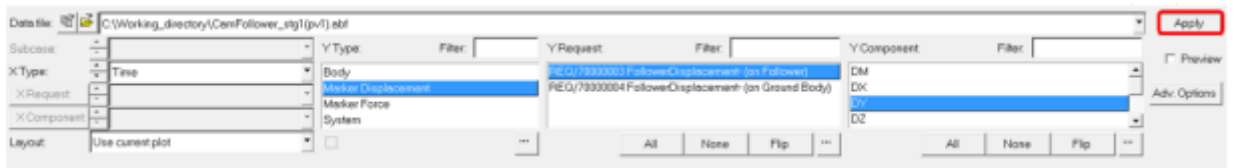
Similarly, you can view Displacement, Strain, etc. for an NLFE body in HyperView. All FE contours and types are available for an NLFE body.

Step 4: Comparing Results.

Now we will compare the results from NLFE spring and the regular spring (generated in Step 1) against each other.

1. Use the **Add Page** button, , to add a new page.
2. Change the client to **HyperGraph 2D** .
3. Split the window into two using the **Page Window Layout** button  on the toolbar.
4. In the left window  open the .abf file corresponding to the solver run with the original spring (created in Step 1), make the selections shown below and click **Apply**.

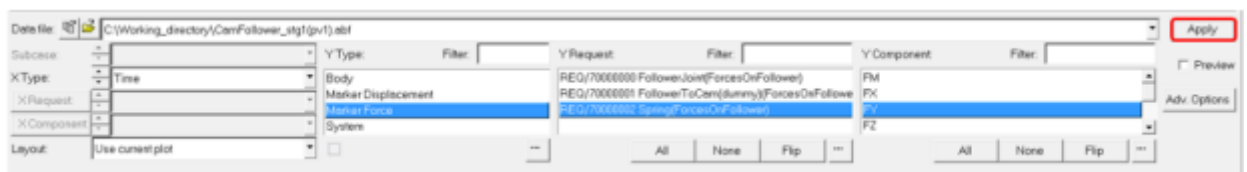
X Type	Time
Layout	Use current plot
Y Type	Marker Displacement
Y Request	REQ/70000003 FollowerDisplacement- (on Follower)
Y Component	DY



Plot selections – Follower displacement

5. Select the right window, make the following selections and click **Apply**.

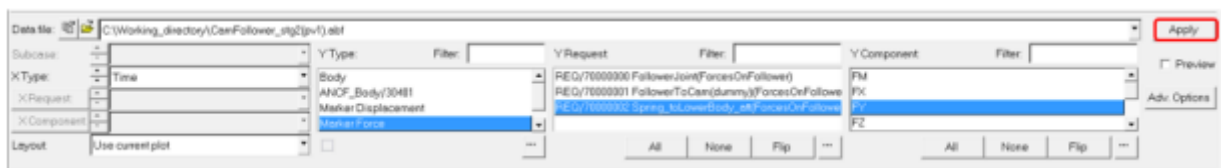
X Type	Time
Layout	Use current plot
Y Type	Marker Force
Y Request	REQ/70000002 Spring(ForcesOnFollower)
Y Component	FY



Plot selections – Spring force on follower: regular spring

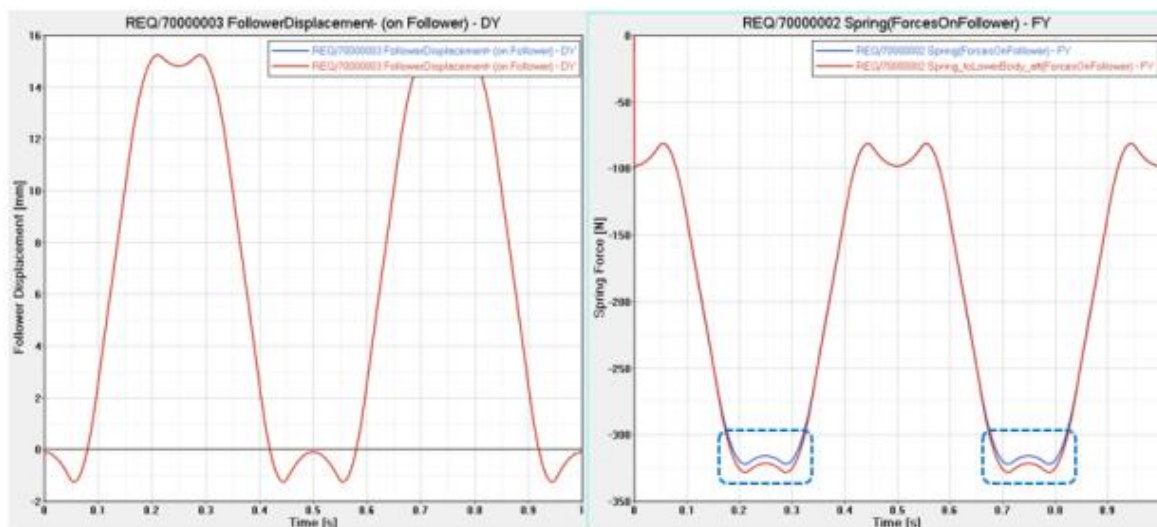
6. Select the left window, browse to the .abf file of NLFE results and plot the corresponding displacement.
7. Select the right window, make selections as shown below and click **Apply**.

X Type	Time
Layout	Use current plot
Y Type	Marker Force
Y Request	REQ/7000002 Spring_toLowerBody_att(ForcesOnFollower)
Y Component	FY



Plot selections – Spring force on follower: NLFE spring

8. Apply axis labels and formatting as appropriate. The comparison is shown below:



Result comparison: Regular spring versus NLFE spring

Upon closer inspection there are some differences in the results, especially in the Spring Forces. These could be attributed to the following reasons:

- NLFE spring has mass and inertias associated with it as it is represented as a body. A regular spring is a force entity without any mass/inertias.
- The difference in force outputs is particularly seen when the spring displacement is high. This is the point where the coil-to-coil contact happens. During this event, the effective number of coils reduces, thus increasing the spring stiffness marginally and hence the force outputs.

9. Save your work in a session file named camfollower_nlfe.mvw.