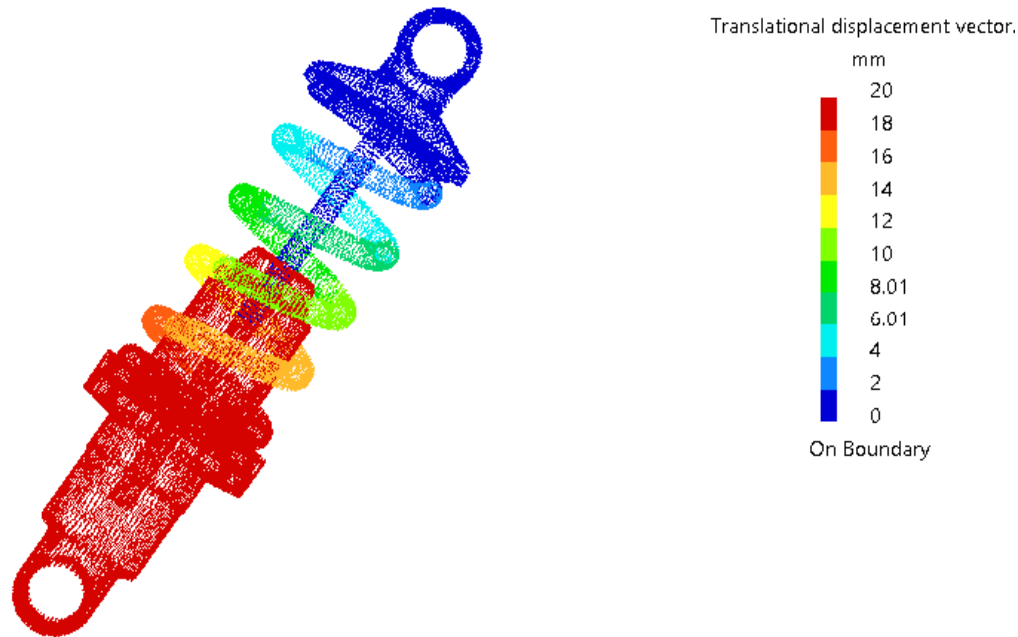
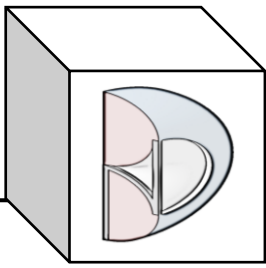
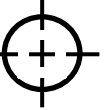


Shock Absorber Preload Analysis using CATIA Generative Structural Analysis (FEA)

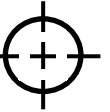




- The following licenses are required to create the Shock Absorber Preload Simulation:
 - Generative Shape Design
 - Mechanical Part Design
 - Generative Structural Analysis



- Issues to prove with this coil over shock absorber FEA analysis:
 1. The spring rate will be linear when the spring has a consistent (evenly spaced) pitch and a constant diameter.
 2. Preloading the spring on the coil over assembly will NOT change the rate of the spring.
 3. Preloading the spring on the coil over assembly WILL affect the deflection at load (length at load) of the shock absorber.



1.1) Calculate the spring values.

From CATIA				C3 Project Front Spring Calculation													
Material	Young's Modulus (E) [modulus of elasticity]		Poisson's ratio (ν) [transverse contraction]	Modulus of Rigidity (G)		Wire Diameter [d]			Spring Mean Diameter [D]			Free Length [L _f]			Total coils [N _t]	Active coils [N _a]	Select End Types:
	(psi x 10 ⁶)	(MPa x 10 ³)		(psi x 10 ⁶)	(MPa x 10 ³)	inch	m	mm	inch	m	mm	inch	m	mm	value	value	Choice
	Chrome Silicon	30.0	207.0	0.305	11.5	79.3	0.500	0.0127	12.7	3.000	0.0762	76.2	10.000	0.254	254	8.650	6.650


$$k = \frac{d^4 G}{8 D^3 N_a}$$

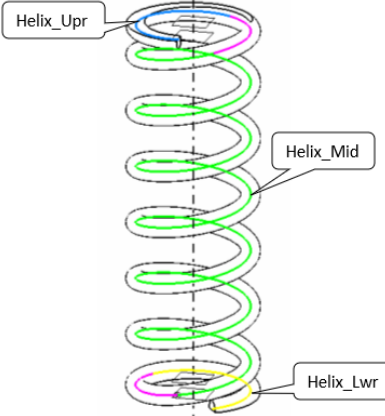
$$\nu = \frac{E}{G \cdot 2} - 1$$

$$G = E / (2 \cdot (1 + \nu))$$

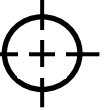
Spring Results (FEA)			
Mean Dia.	Force	defl	Rate
mm	N	δ (mm)	(k) N/mm
76.2	876.4	10	87.6

in	lb	in	lb/in
3.000	197.03	0.394	500.4



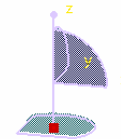
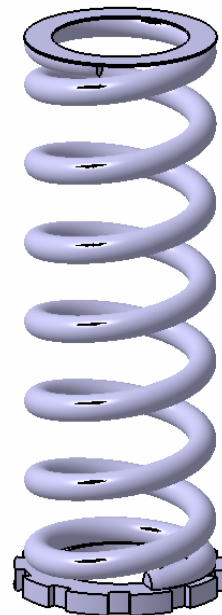
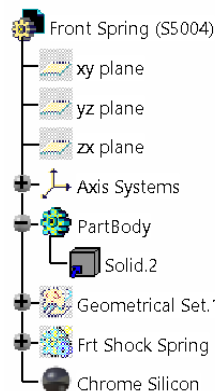


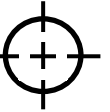
Adjusted for CATIA FEA	
38.195	= Pitch in Helix_Mid
2.55	= Factor for Coils in Helix_Mid
6.10	= Coils in Helix_Mid
232.992	= Height in Helix_Mid
21.01	= Δ Free Length to Helix_Mid Ht.
10.504	= Height of Helix_Mid Start Plane
0.77	= Factor for Pitch in Helix_Upr&Lwr
0.50	= Factor for Height in Helix_Upr&Lwr
8.088	= Pitch in Helix_Upr&Lwr
5.252	= Height in Helix_Upr&Lwr



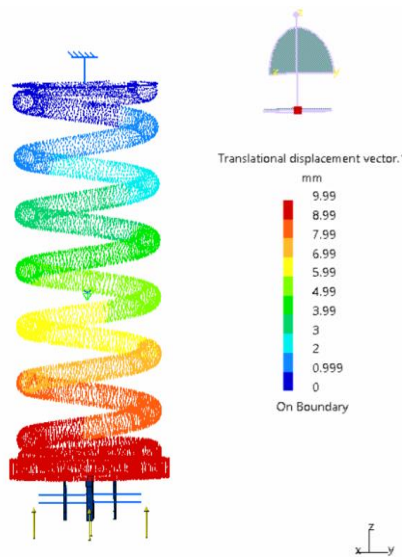
1.2) Create a CATIA Part model of the Spring.

- Since this is an FEA simulation analysis of a coil over shock absorber assembly, we will assume the user has created all the parts within the assembly.

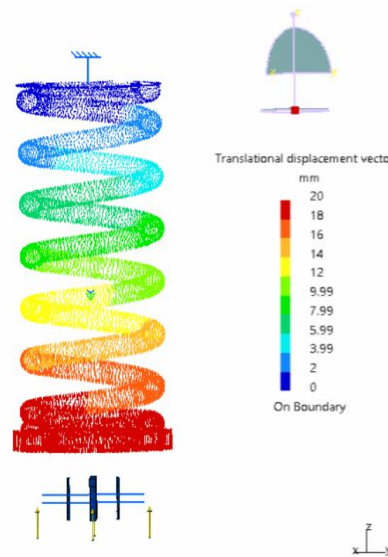




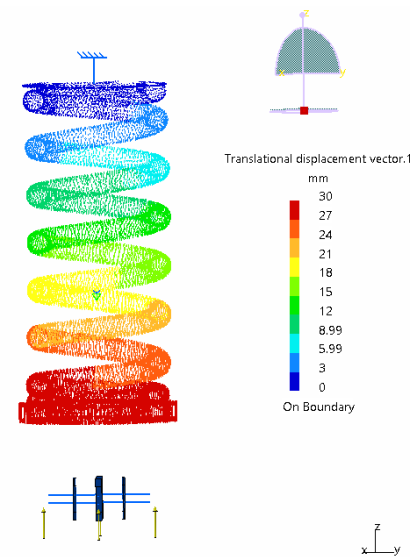
1.3) Create an FEA analysis of the Spring which correlates the Spring Rate of the CATIA Part model and proves the rate to be Linear.



Load = 10X
the Spring
Rate →
10mm Defl.



Load = 20X
the Spring
Rate →
20mm Defl.



Load = 30X
the Spring
Rate →
30mm Defl.

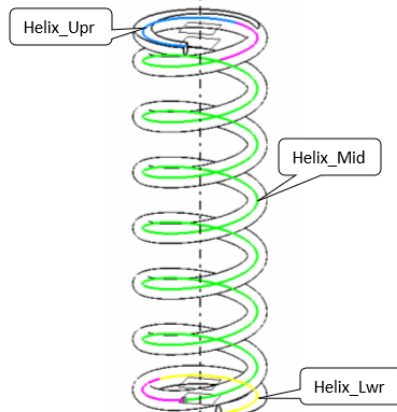



2.1) Change the Free Length of the Spring on the Calculation sheet to remove the deflection caused by the Preload value.

From CATIA			C3 Project Front Spring Calculation														
Material	Young's Modulus (E) [modulus of elasticity]		Poisson's ratio (v) [transverse contraction]	Modulus of Rigidity (G)		Wire Diameter [d]			Spring Mean Diameter [D]			Free Length [L _f]		Total coils [N _t]	Active coils [N _a]	Select End Types:	
	(psi x 10 ⁶)	(MPa x 10 ³)		(psi x 10 ⁶)	(MPa x 10 ³)	inch	m	mm	inch	m	mm	inch	m	mm	value	value	Choice
Chrome Silicon	30.0	207.0	0.305	11.5	79.3	0.500	0.0127	12.7	3.000	0.0762	76.2	9.606	0.244	244	8.650	6.650	Squared or closed (Ground)
				11501494	79300000000												
$k = \frac{d^4 G}{8 D^3 N_a}$ $v = \frac{E}{G \cdot 2} - 1$ $G = E / (2 * (1 + v))$						Calculated Pitch [P]			Spring Outer Diameter [OD]			Spring Inner Diameter [ID]			Spring rate [k]		
						inch	m	mm	inch	m	mm	inch	m	mm	lb/in	N/mm	
						1.411	0.0358	35.836	3.500	0.0889	88.9	2.500	0.0635	63.5	500.45	87.64	

Spring Results (FEA)			
Mean Dia.	Force	defl	Rate
mm	N	δ (mm)	(k) N/mm
76.2	876.4	10	87.6

in	lb	in	lb/in
3.000	197.03	0.394	500.4

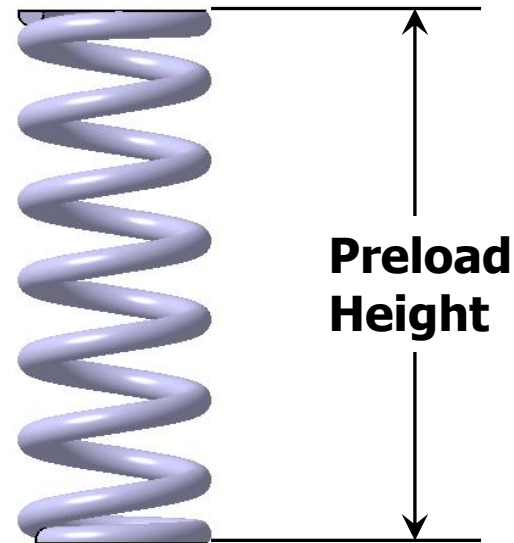


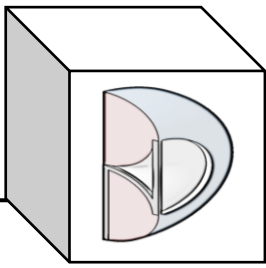
Adjusted for CATIA FEA	
36.692	= Pitch in Helix_Mid
2.55	= Factor for Coils in Helix_Mid
6.10	= Coils in Helix_Mid
223.820	= Height in Helix_Mid
20.18	= Δ Free Length to Helix_Mid Ht.
10.090	= Height of Helix_Mid Start Plane
0.77	= Factor for Pitch in Helix_Upr&Lwr
0.50	= Factor for Height in Helix_Upr&Lwr
7.769	= Pitch in Helix_Upr&Lwr
5.045	= Height in Helix_Upr&Lwr



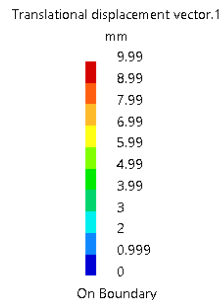
2.2) Update the CATIA Part for the Spring using the new values from the calculations sheet.

Adjusted for CATIA FEA
36.692 = Pitch in Helix_Mid
2.55 = Factor for Coils in Helix_Mid
6.10 = Coils in Helix_Mid
223.820 = Height in Helix_Mid
20.18 = Δ Free Length to Helix_Mid Ht.
10.090 = Height of Helix_Mid Start Plane
0.77 = Factor for Pitch in Helix_Upr&Lwr
0.50 = Factor for Height in Helix_Upr&Lwr
7.769 = Pitch in Helix_Upr&Lwr
5.045 = Height in Helix_Upr&Lwr

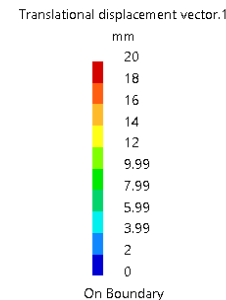
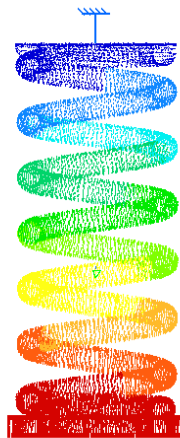




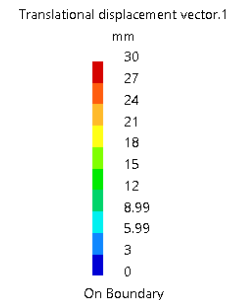
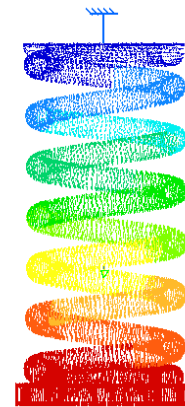
2.3) Create an FEA analysis of the Preloaded Spring to correlate the Spring Rate from the CATIA Part model and prove the rate remains Linear.



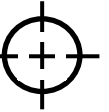
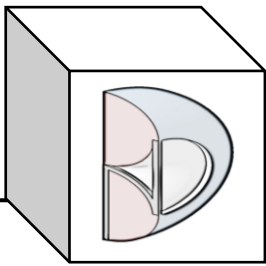
Load = 20X the
Spring Rate –
the Preload →
10mm Defl.



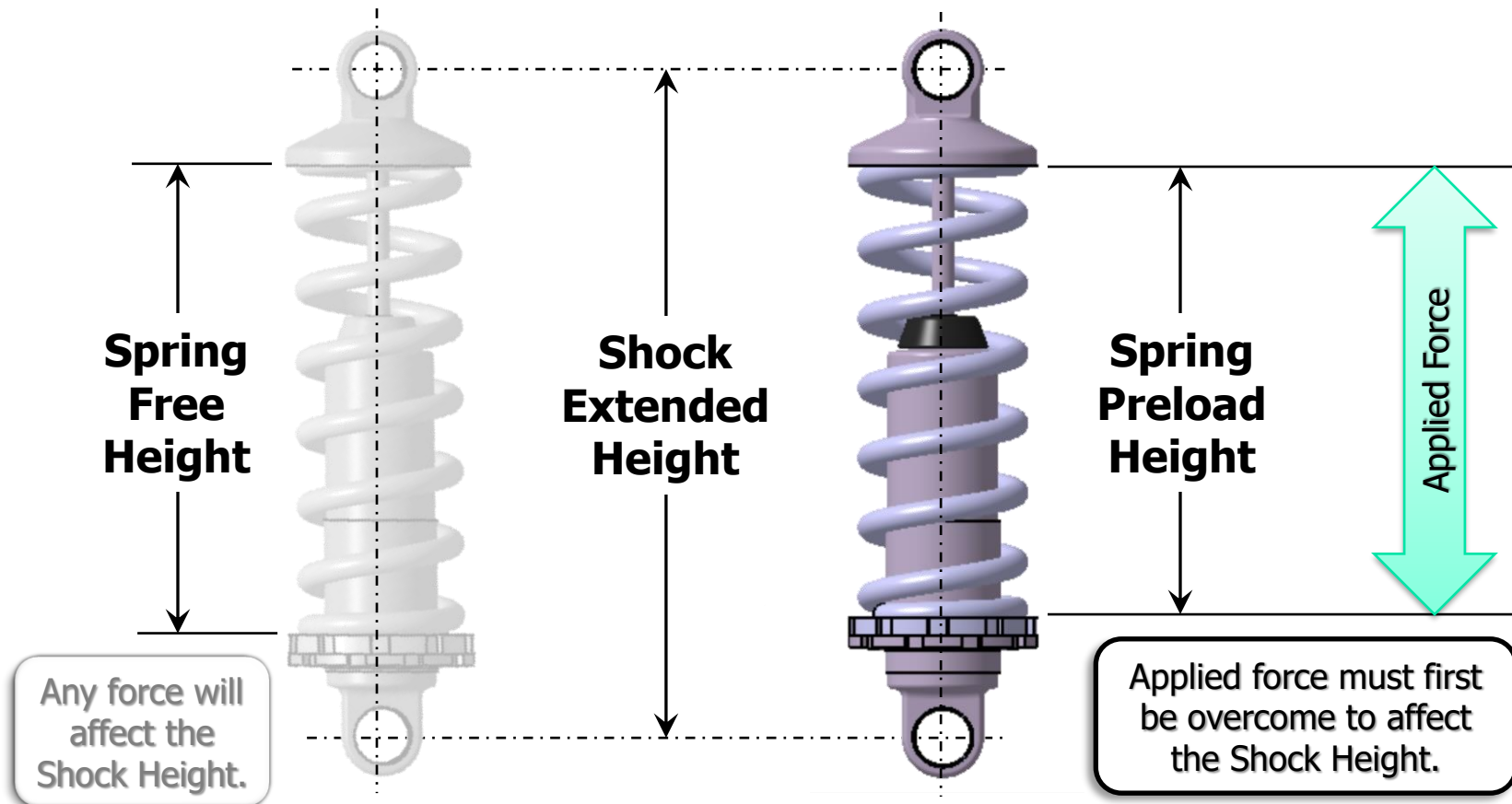
Load = 30X the
Spring Rate –
the Preload →
20mm Defl.

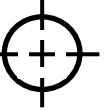
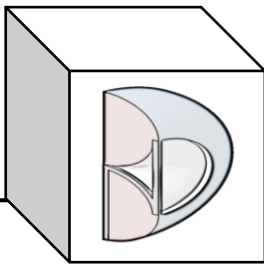


Load = 40X the
Spring Rate –
the Preload →
30mm Defl.



3.1) Create a CATIA Product model of the Coil Over Shock Absorber Assembly in the Preloaded condition.

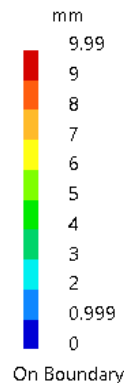




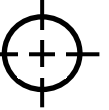
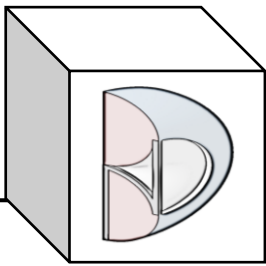
3.2) Create an FEA analysis (Static Case.Preload) of the Coil Over Assembly applying the proper restraints and loads.
(10x rate = 10mm deflection)



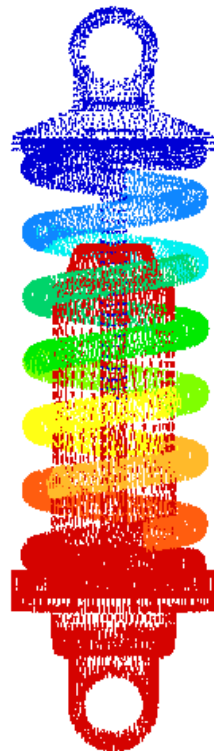
Translational displacement vector.1



Static Case.Preload
will be used as the
Preload for this
simulation.

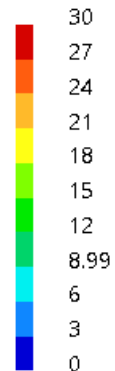


3.3) Create an FEA analysis (Static Case.Shock Load) of the Coil Over Assembly applying the proper restraints and loads.
(30x rate = 30mm deflection)



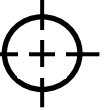
Translational displacement vector.2

mm

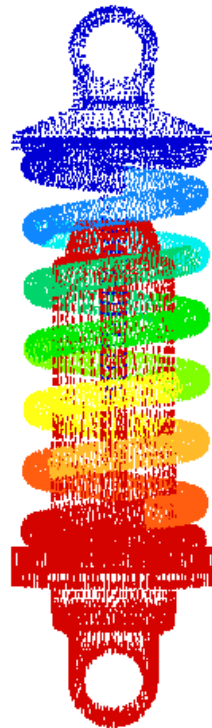


On Boundary

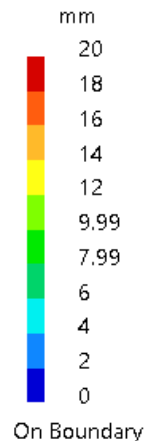
Static Case. Shock Load will be used as the **Shock Load** for this simulation.



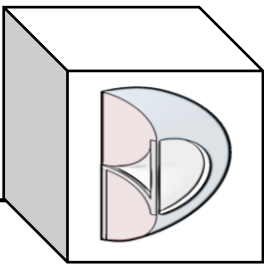
3.4) Create an FEA analysis (Combined Case.Shock Load) of the Coil Over Assembly applying the proper restraints and loads.
(Shock Load – Preload = Resultant Shock Load → Shock Deflection)



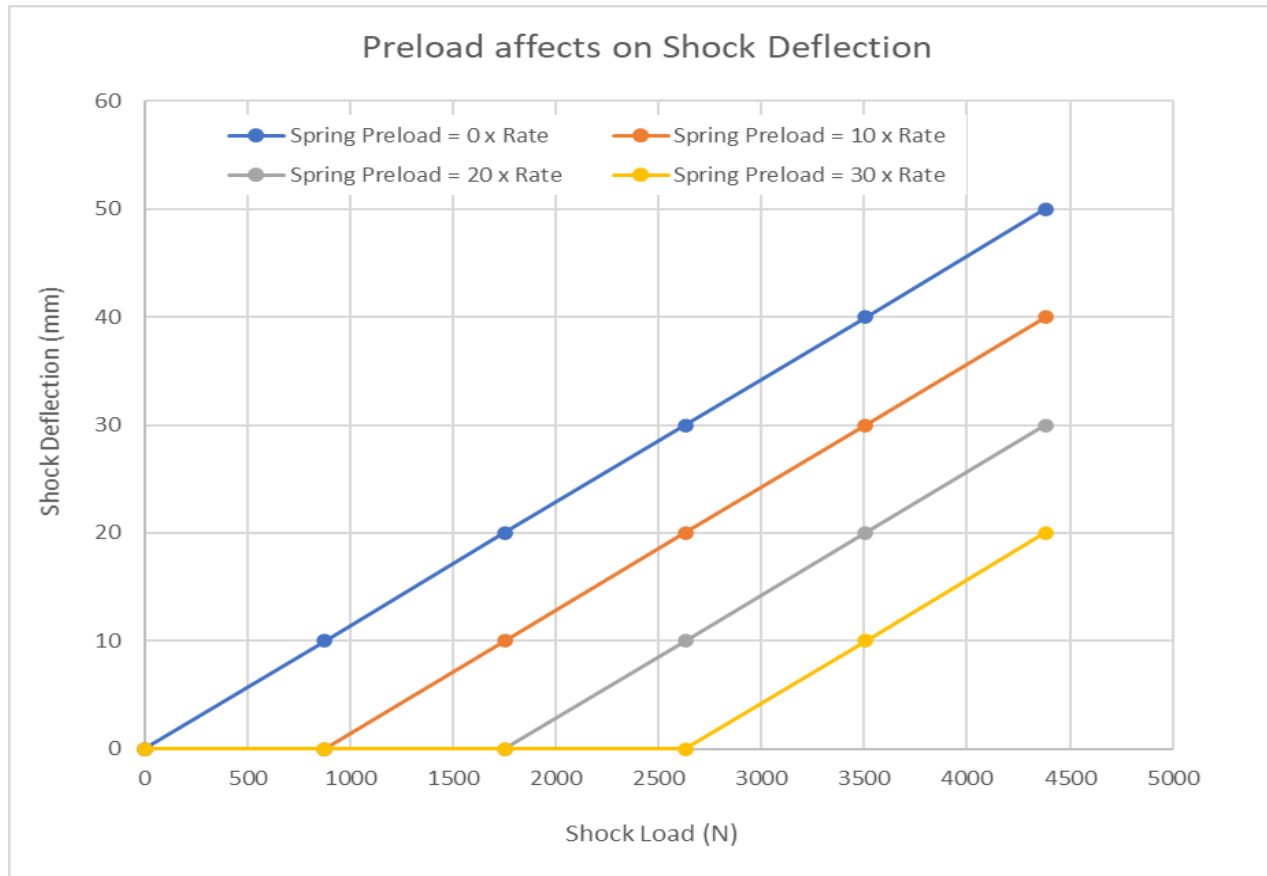
Translational displacement vector.3

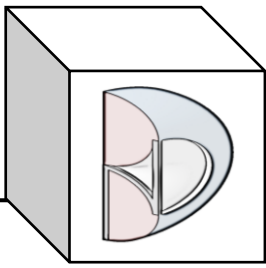


Combined Case.
Shock Load will be
used as the
**Resultant Shock
Load** for this
simulation.



3.5) Graph below shows the Shock Deflection based on Shock Load at various Preload conditions.





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Create the Free Length Spring FEA



BND TechSource




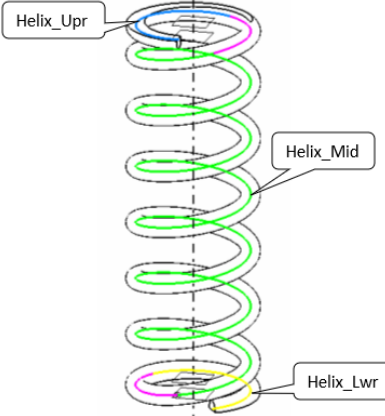
- Create an Excel spreadsheet to calculate the spring values.

From CATIA				C3 Project Front Spring Calculation																																														
Material	Young's Modulus (E) [modulus of elasticity]		Poisson's ratio (v) [transverse contraction]	Modulus of Rigidity (G)		Wire Diameter [d]			Spring Mean Diameter [D]			Free Length [L _f]			Total coils [N _t]	Active coils [N _a]	Select End Types:																																	
	(psi x 10 ⁶)	(MPa x 10 ³)		(psi x 10 ⁶)	(MPa x 10 ³)	inch	m	mm	inch	m	mm	inch	m	mm	value	value	Choice																																	
Chrome Silicon	30.0	207.0	0.305	11.5	79.3	0.500	0.0127	12.7	3.000	0.0762	76.2	10.000	0.254	254	8.650	6.650	Squared or closed (Ground)																																	
				11501494	79300000000																																													
				<div><div>$k = \frac{d^4 G}{8 D^3 N_a}$$\nu = \frac{E}{G \cdot 2} - 1$$G = E / (2*(1+\nu))$</div><div><table><tr><th colspan="3">Calculated Pitch [P]</th><th colspan="3">Spring Outer Diameter [OD]</th><th colspan="3">Spring Inner Diameter [ID]</th><th colspan="2">Spring rate [k]</th></tr><tr><th>inch</th><th>m</th><th>mm</th><th>inch</th><th>m</th><th>mm</th><th>inch</th><th>m</th><th>mm</th><th>lb/in</th><th>N/mm</th></tr><tr><td>1.475</td><td>0.0375</td><td>37.475</td><td>3.500</td><td>0.0889</td><td>88.9</td><td>2.500</td><td>0.0635</td><td>63.5</td><td>500.45</td><td>87.64</td></tr></table></div></div>														Calculated Pitch [P]			Spring Outer Diameter [OD]			Spring Inner Diameter [ID]			Spring rate [k]		inch	m	mm	inch	m	mm	inch	m	mm	lb/in	N/mm	1.475	0.0375	37.475	3.500	0.0889	88.9	2.500	0.0635	63.5	500.45	87.64
Calculated Pitch [P]			Spring Outer Diameter [OD]			Spring Inner Diameter [ID]			Spring rate [k]																																									
inch	m	mm	inch	m	mm	inch	m	mm	lb/in	N/mm																																								
1.475	0.0375	37.475	3.500	0.0889	88.9	2.500	0.0635	63.5	500.45	87.64																																								

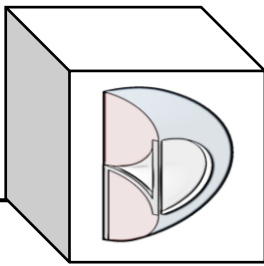
Spring Results (FEA)			
Mean Dia.	Force	defl	Rate
mm	N	δ (mm)	(k) N/mm
76.2	876.4	10	87.6

in	lb	in	lb/in
3.000	197.03	0.394	500.4

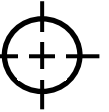




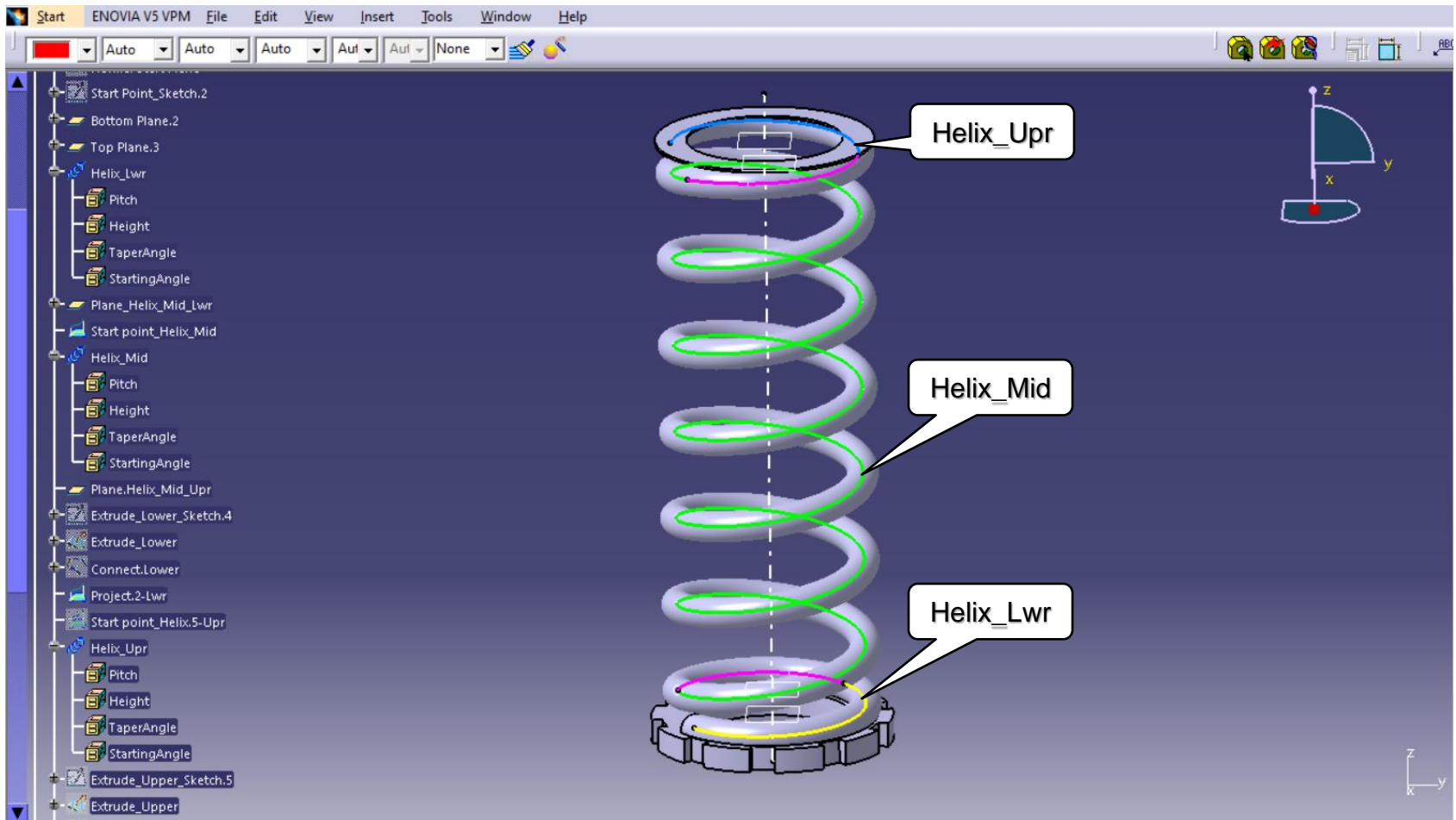
Adjusted for CATIA FEA	
38.195	= Pitch in Helix_Mid
2.55	= Factor for Coils in Helix_Mid
6.10	= Coils in Helix_Mid
232.992	= Height in Helix_Mid
21.01	= Δ Free Length to Helix_Mid Ht.
10.504	= Height of Helix_Mid Start Plane
0.77	= Factor for Pitch in Helix_Upr&Lwr
0.50	= Factor for Height in Helix_Upr&Lwr
8.088	= Pitch in Helix_Upr&Lwr
5.252	= Height in Helix_Upr&Lwr

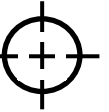
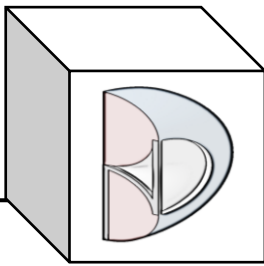


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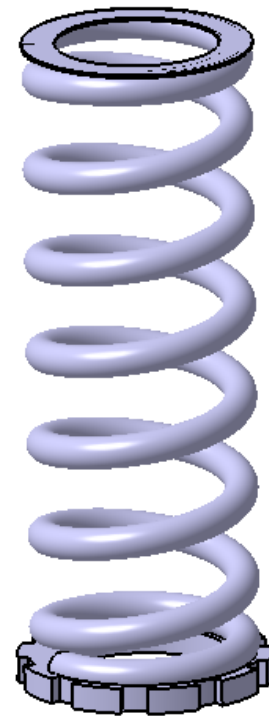


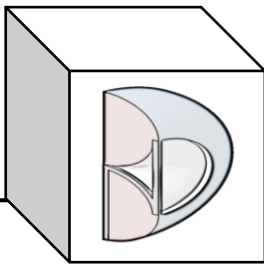
- Create the Spring based on calculated the spring values.





- Generative Structural Analysis only works with the geometry inside the PartBody!

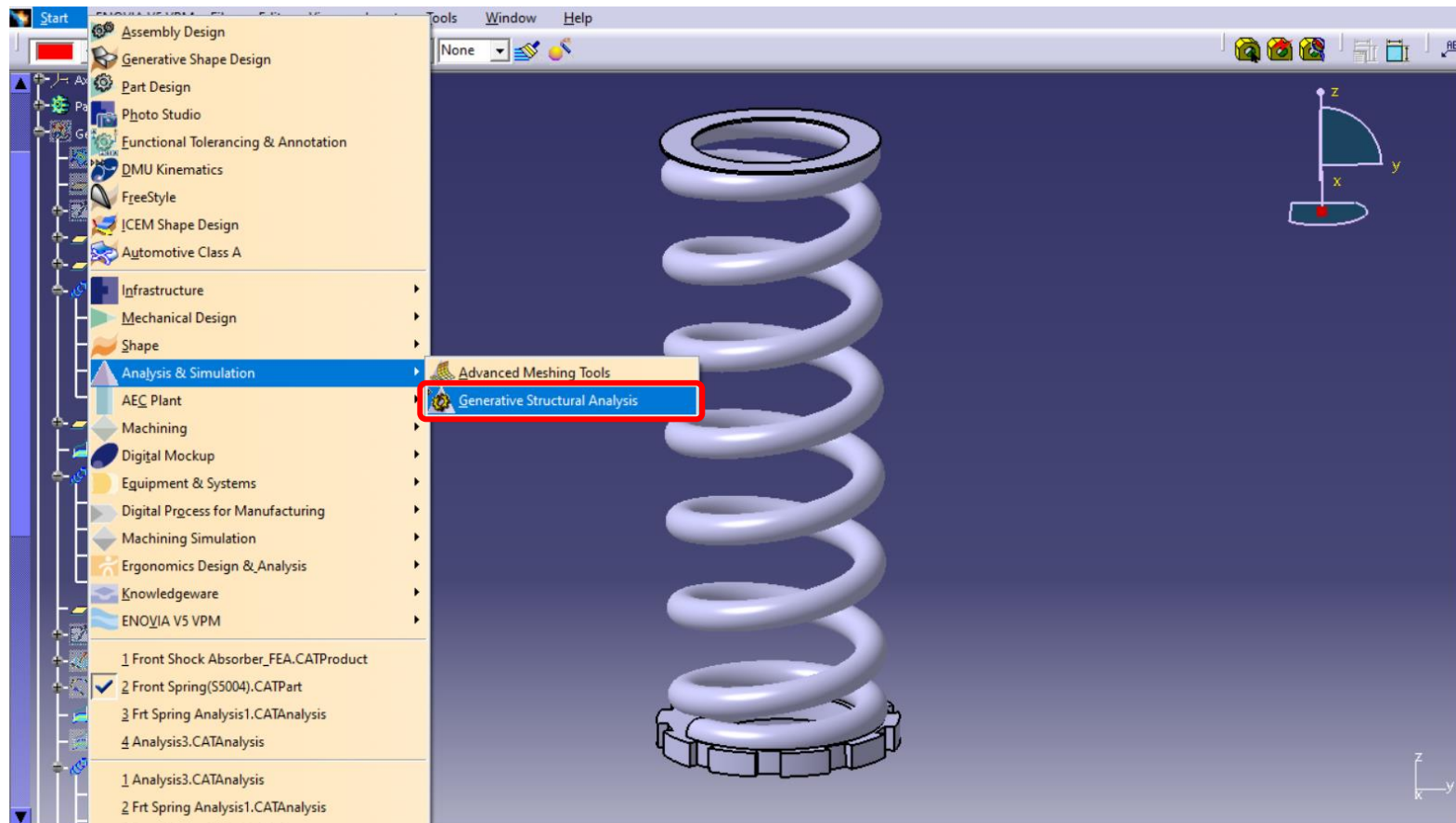


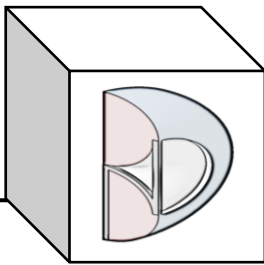


BND TechSource

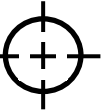


- While inside the CatPart, call the Generative Structural Analysis workbench.

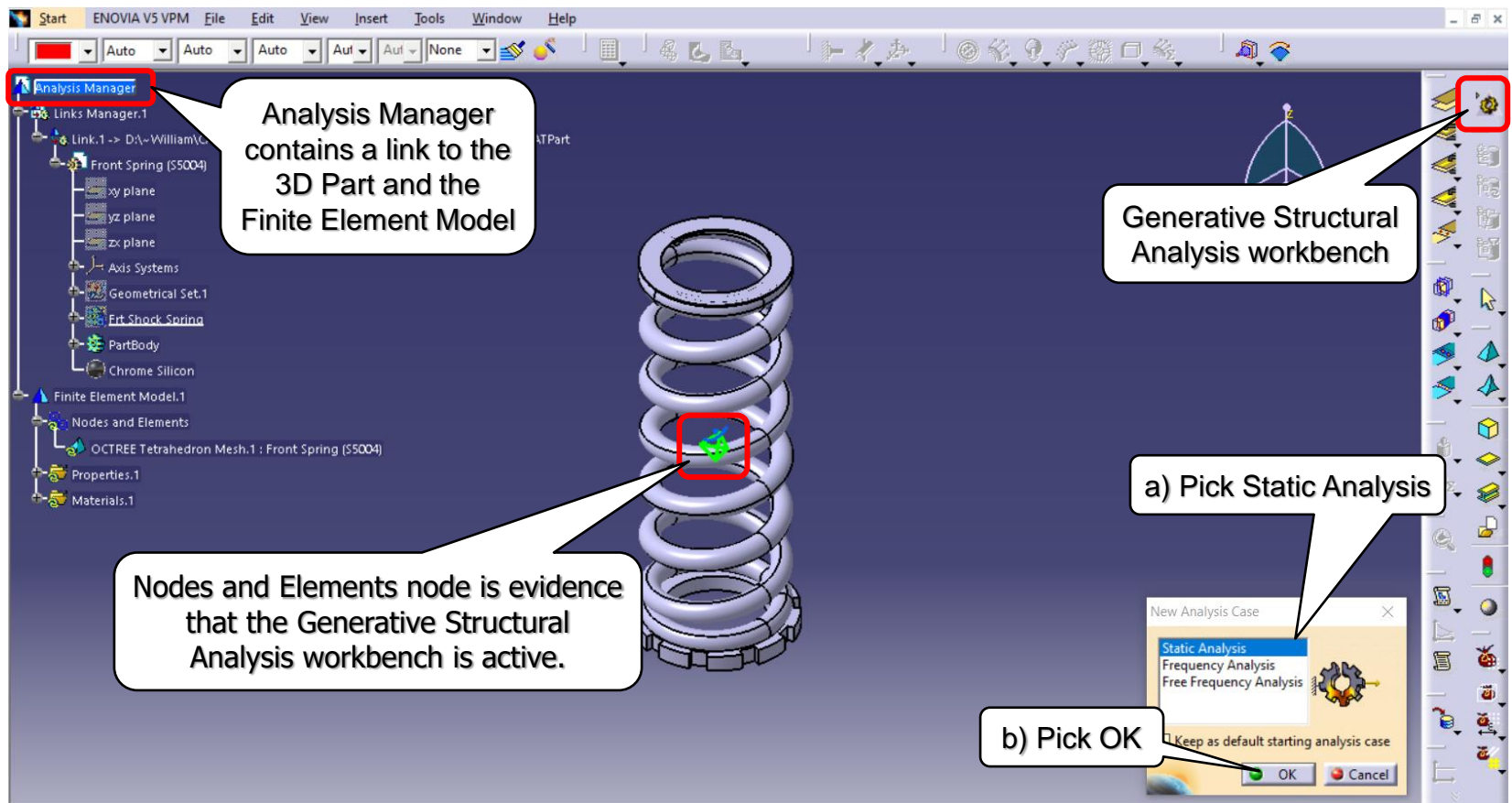




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- Generative Structural Analysis workbench creates the Analysis Manager.





- Optimize the Mesh for the Spring.

a) Double-pick the Octree Tetrahedron Mesh

b) Change the Size to 5mm

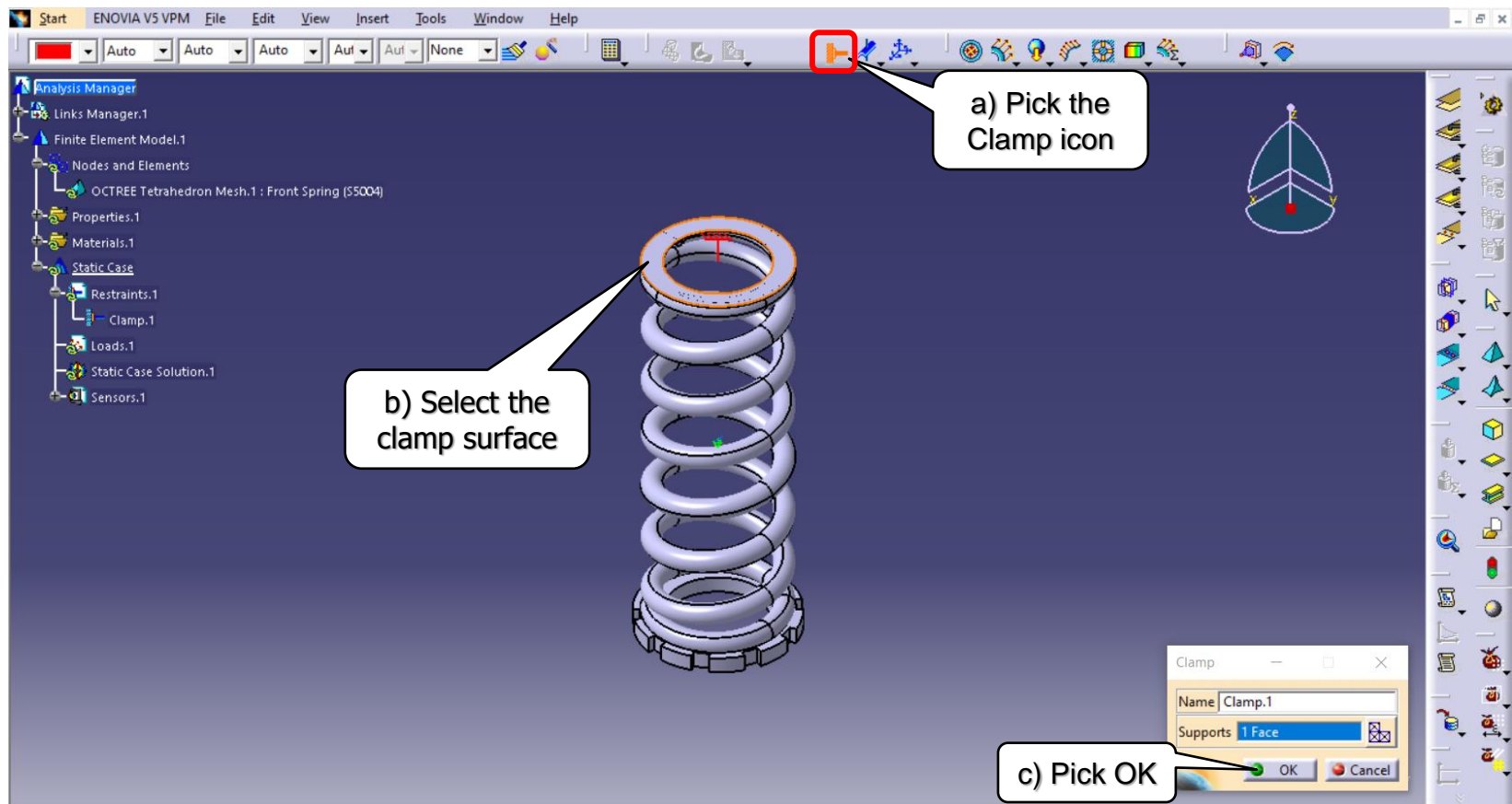
c) Pick Absolute sag (1mm)

d) Pick Parabolic

e) Pick OK

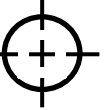


- Create the Clamp Restraint.

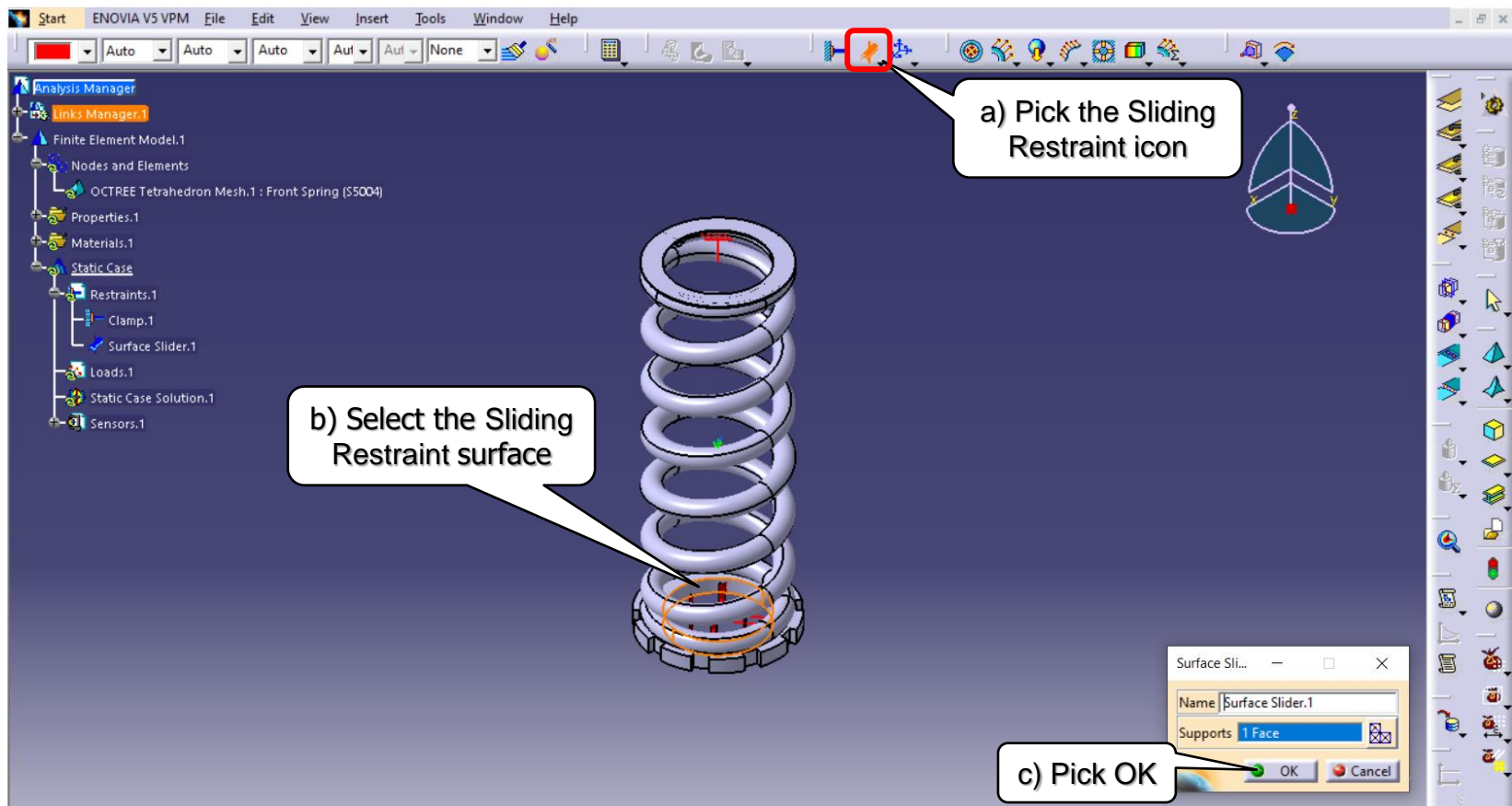




BND TechSource

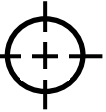


- Create the Sliding Restraint.

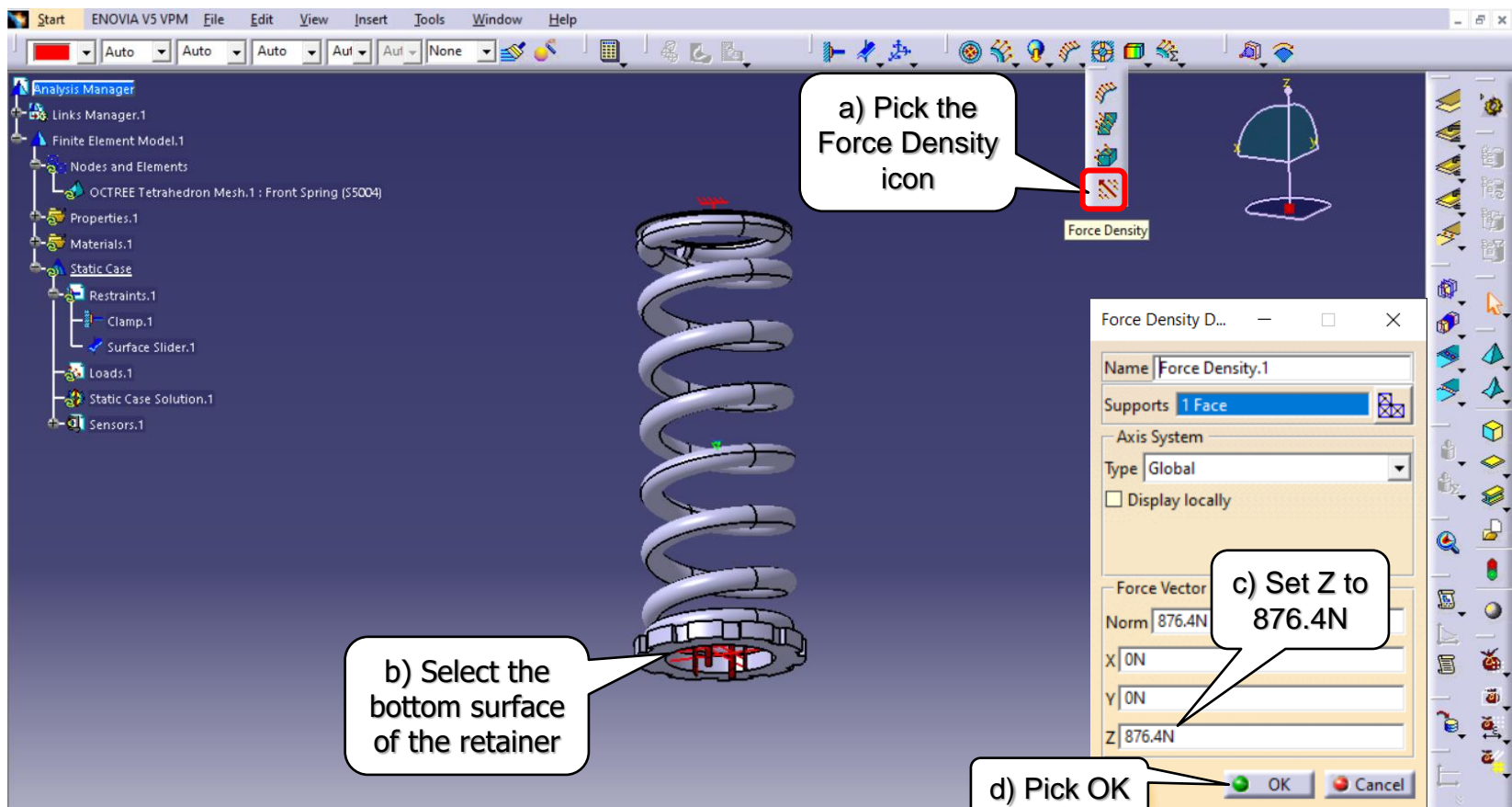


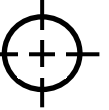
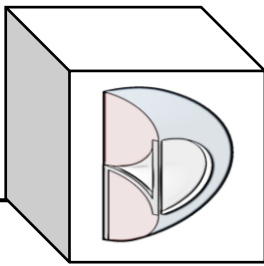


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- Create the Load (10 x rate \rightarrow 876.4N).



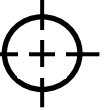


- Compute the analysis of the Free Length Spring.

The screenshot shows the ENOVIA V5 VPM software interface. The main window displays a 3D model of a spring. The left-hand 'Analysis Manager' tree is expanded, showing the hierarchy: Links Manager.1, Finite Element Model.1, Nodes and Elements, OCTREE Tetrahedron Mesh.1 : Front Spring (S5004), Properties.1, Materials.1, Static Case, Restraints.1 (containing Clamp.1 and Surface Slider.1), Loads.1 (containing Force Density.1), Static Case Solution.1 (highlighted in orange), and Sensors.1. A red box highlights the 'Compute' icon (a calculator symbol) in the top toolbar. A callout 'a) Pick the Compute icon' points to this icon. Another callout 'c) Pick the Static Case Solution' points to 'Static Case Solution.1' in the tree. A third callout 'b) Select the Analysis Case Solution selection' points to the 'Analysis Case Solution Selection' dropdown in a 'Comp...' dialog box. A fourth callout 'd) Pick OK' points to the 'OK' button in the same dialog box. The dialog box also shows 'Solution(s) to Be Computed' as 'Static Case Solution.1' and has a 'Preview' checkbox.



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- Compute the analysis of the Free Length Spring.

The screenshot shows the ENOVIA V5 VPM software interface. The main window displays a 3D model of a spring. The left sidebar shows the Analysis Manager tree with the following structure:

- Analysis Manager
 - Links Manager.1
 - Finite Element Model.1
 - Nodes and Elements
 - OCTREE Tetrahedron Mesh.1 : Front Spring (S5004)
 - Properties.1
 - Materials.1
 - Static Case
 - Restraints.1
 - Clamp.1
 - Surface Slider.1
 - Loads.1
 - Force Density.1
 - Static Case Solution.1
 - Sensors.1

Two dialog boxes are open:

Computation Resources Estimation

3 s of CPU
2.27e+004 kilo-bytes of memory
1.46e+005 kilo-bytes of disk

Do you want to continue the computation?

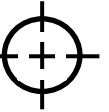
Computation Status

Operation Name	Elapsed Time
Total computing time	0:00:06
Meshing execution	0:00:04
Structure computation	0:00:01
Stiffness Computation	0:00:00
Singularity computation	0:00:01
Constraint Computation	0:00:00

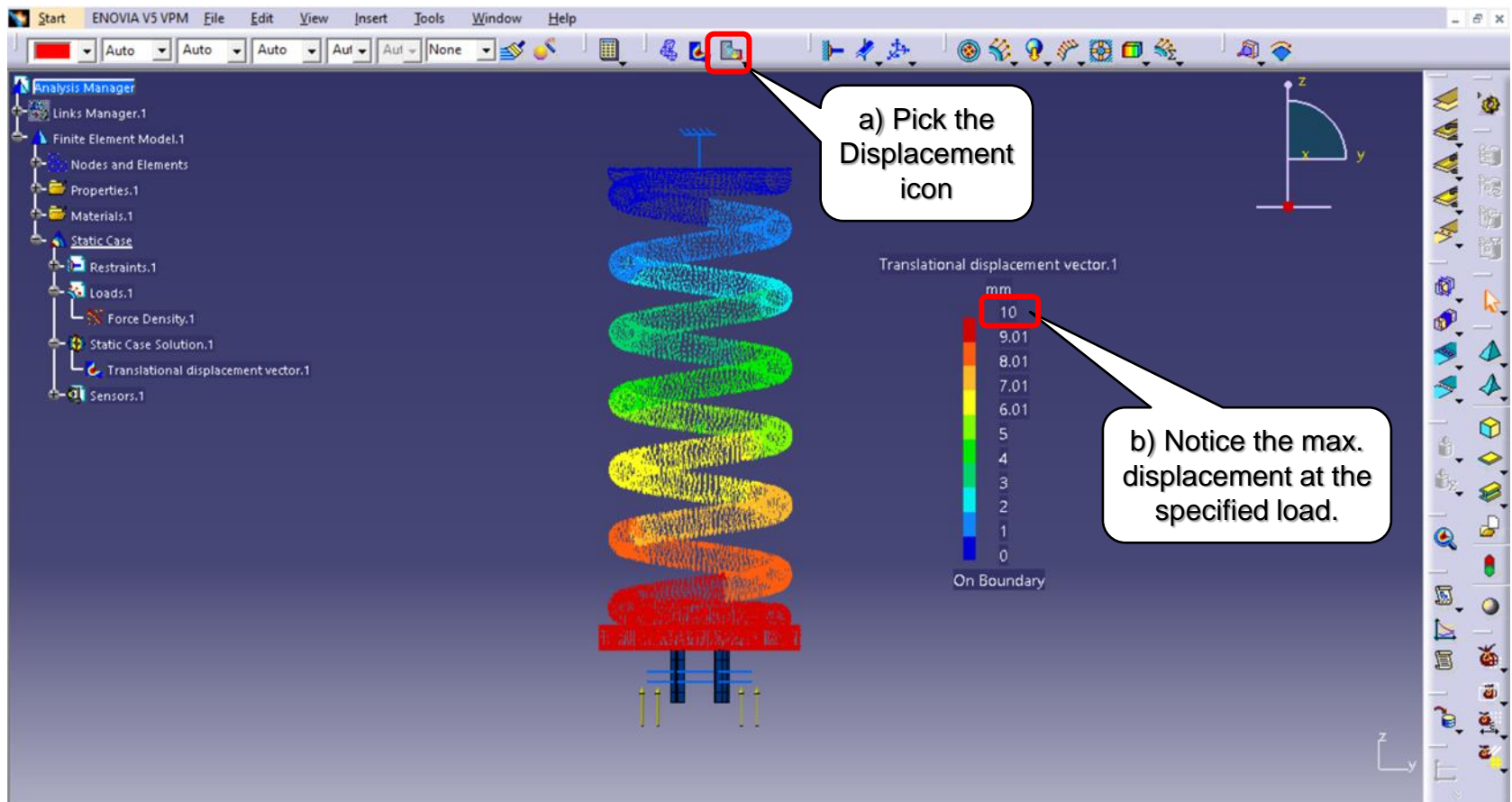
e) Pick Yes and wait for the computation to run.



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- Show results of the analysis.





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- Adjust Factors to “dial in” the FEA correlation if required.

From CATIA			C3 Project Front Spring Calculation															
Material	Young's Modulus (E) [modulus of elasticity]		Poisson's ratio (ν) [transverse contraction]	Modulus of Rigidity (G)		Wire Diameter [d]			Spring Mean Diameter [D]			Free Length [L _f]			Total coils [N _t]	Active coils [N _a]	Select End Types:	
	(psi x 10 ⁶)	(MPa x 10 ³)		(psi x 10 ⁶)	(MPa x 10 ³)	inch	m	mm	inch	m	mm	inch	m	mm	value	value	Choice	
Chrome Silicon	30.0	207.0	0.305	11.5	79.3	0.500	0.0127	12.7	3.000	0.0762	76.2	10.000	0.254	254	8.650	6.650	Squared or closed (Ground)	
				11501494	79300000000													

$$k = \frac{d^4 G}{8 D^3 N_a}$$

$$\nu = \frac{E}{G \cdot 2} - 1$$

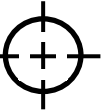
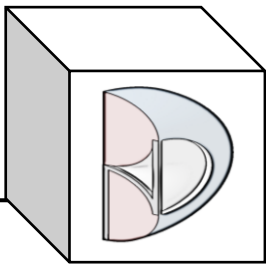
$$G = E / (2 * (1 + \nu))$$

Calculated Pitch [P]			Spring Outer Diameter [OD]			Spring Inner Diameter [ID]			Spring rate [k]	
inch	m	mm	inch	m	mm	inch	m	mm	lb/in	N/mm
1.475	0.0375	37.475	3.500	0.0889	88.9	2.500	0.0635	63.5	500.45	87.64

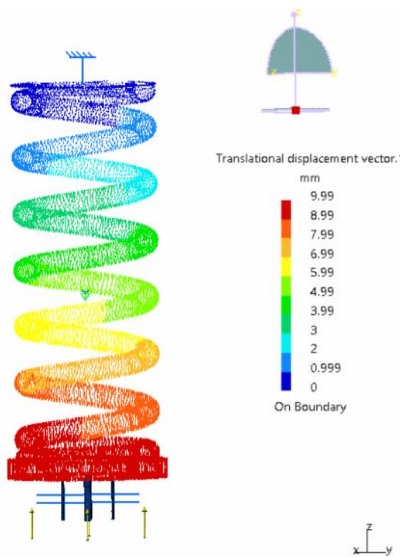
Mean Dia.	Force	defl	Rate
mm	N	δ (mm)	(k) N/mm
76.2	876.4	10	87.6

in	lb	in	lb/in
3.000	197.03	0.394	500.4

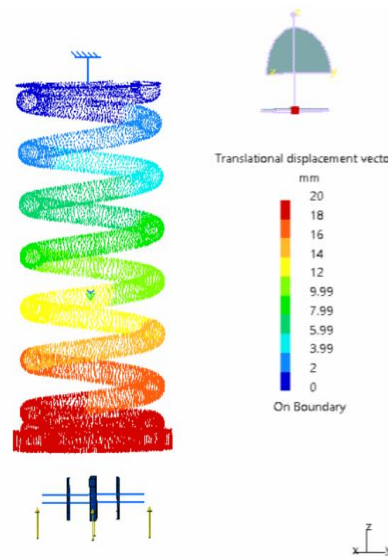
38.195 = Pitch in Helix_Mid
2.55 = Factor for Coils in Helix_Mid
6.10 = Coils in Helix_Mid
232.992 = Height in Helix_Mid
21.01 = Δ Free Length to Helix_Mid Ht.
10.504 = Height of Helix_Mid Start Plane
0.77 = Factor for Pitch in Helix_Upr&Lwr
0.50 = Factor for Height in Helix_Upr&Lwr
8.088 = Pitch in Helix_Upr&Lwr
5.252 = Height in Helix_Upr&Lwr



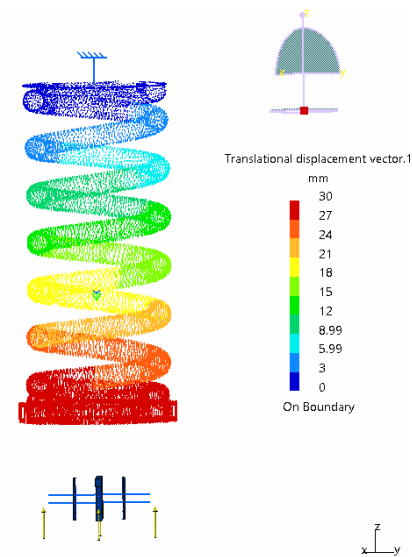
- The FEA analysis of the Free Length Spring correlates with the Spring Rate of the CATIA Part model and proves the rate to be Linear.



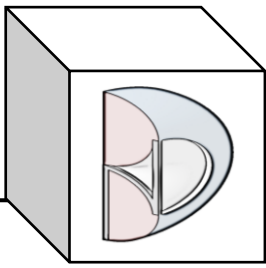
Load = 10X
the Spring
Rate →
10mm Defl.



Load = 20X
the Spring
Rate →
20mm Defl.



Load = 30X
the Spring
Rate →
30mm Defl.



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Create the Preload Length Spring FEA

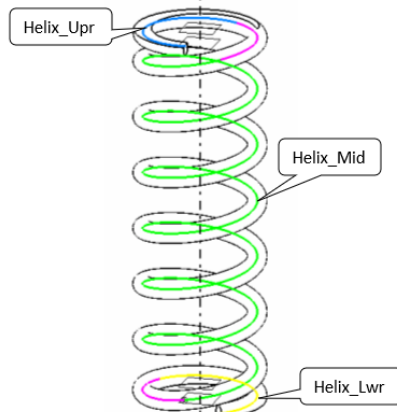



- Change the Free Length of the Spring on the Calculation sheet to remove the deflection caused by the Preload value.

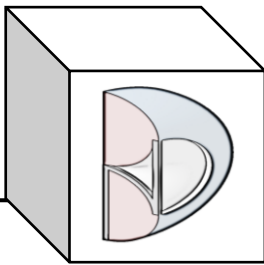
From CATIA				C3 Project Front Spring Calculation													
Material	Young's Modulus (E) [modulus of elasticity]		Poisson's ratio (v) [transverse contraction]	Modulus of Rigidity (G)		Wire Diameter [d]			Spring Mean Diameter [D]			Free Length [L _f]		Total coils [N _t]	Active coils [N _a]	Select End Types:	
	(psi x 10 ⁶)	(MPa x 10 ³)		(psi x 10 ⁶)	(MPa x 10 ³)	inch	m	mm	inch	m	mm	inch	m	mm	value	value	Choice
Chrome Silicon	30.0	207.0	0.305	11.5	79.3	0.500	0.0127	12.7	3.000	0.0762	76.2	9.606	0.244	244	8.650	6.650	Squared or closed (Ground)
				11501494	79300000000												
$k = \frac{d^4 G}{8 D^3 N_a}$ $\nu = \frac{E}{G \cdot 2} - 1$ $G = E / (2 * (1 + \nu))$						Calculated Pitch [P]			Spring Outer Diameter [OD]			Spring Inner Diameter [ID]			Spring rate [k]		
						inch	m	mm	inch	m	mm	inch	m	mm	lb/in	N/mm	
						1.411	0.0358	35.836	3.500	0.0889	88.9	2.500	0.0635	63.5	500.45	87.64	

Spring Results (FEA)			
Mean Dia.	Force	defl	Rate
mm	N	δ (mm)	(k) N/mm
76.2	876.4	10	87.6

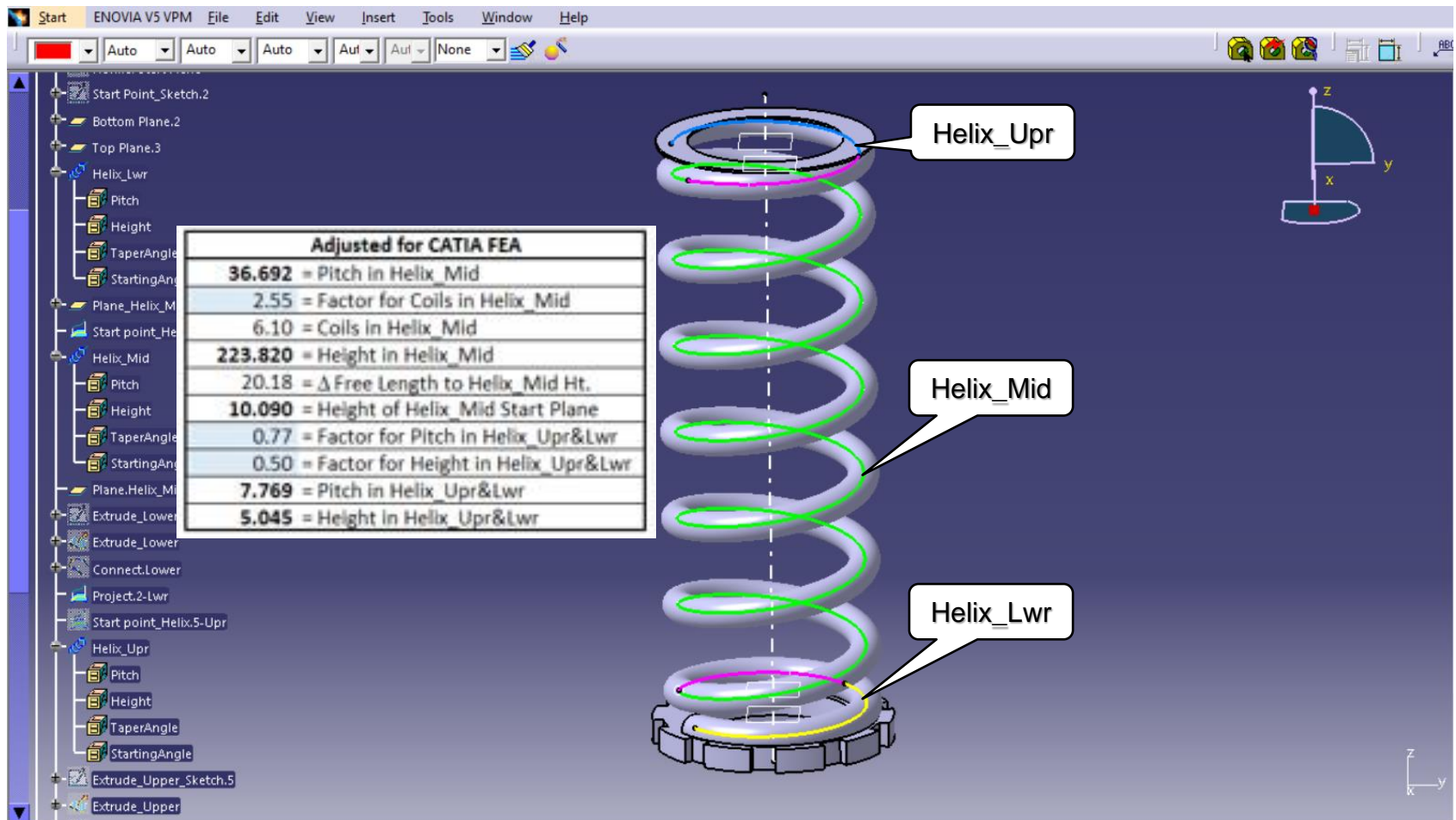
in	lb	in	lb/in
3.000	197.03	0.394	500.4

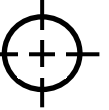
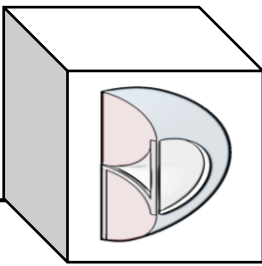


Adjusted for CATIA FEA	
36.692	= Pitch in Helix_Mid
2.55	= Factor for Coils in Helix_Mid
6.10	= Coils in Helix_Mid
223.820	= Height in Helix_Mid
20.18	= Δ Free Length to Helix_Mid Ht.
10.090	= Height of Helix_Mid Start Plane
0.77	= Factor for Pitch in Helix_Upr&Lwr
0.50	= Factor for Height in Helix_Upr&Lwr
7.769	= Pitch in Helix_Upr&Lwr
5.045	= Height in Helix_Upr&Lwr



- Adjust the Spring based on Preload calculated the spring values.





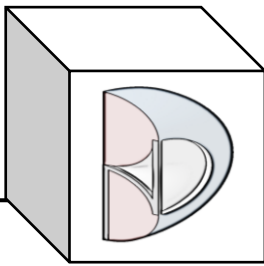
- Compute the analysis of the Preloaded Spring.

a) Pick the Compute icon

c) Pick the Static Case Solution

b) Select the Analysis Case Solution selection

d) Pick OK



- Compute the analysis of the Preloaded Spring.

The screenshot shows the ENOVIA V5 VPM software interface. The main window displays a 3D model of a spring. The left sidebar shows the 'Analysis Manager' tree with the following structure:

- Links Manager.1
 - Finite Element Model.1
 - Nodes and Elements
 - OCTREE Tetrahedron Mesh.1 : Front Spring (S5004)
 - Properties.1
 - Materials.1
 - Static Case
 - Restraints.1
 - Clamp.1
 - Surface Slider.1
 - Loads.1
 - Force Density.1
 - Static Case Solution.1
 - Sensors.1

The 'Computation Resources Estimation' dialog box is open, showing the following information:

- 3 s of CPU
- 2.27e+004 kilo-bytes of memory
- 1.46e+005 kilo-bytes of disk

Below the information, it asks: 'Do you want to continue the computation?' with 'Yes' and 'No' buttons. A speech bubble points to the 'Yes' button with the text: 'e) Pick Yes and wait for the computation to run.'

The 'Computation Status' dialog box is also open, showing the following table:

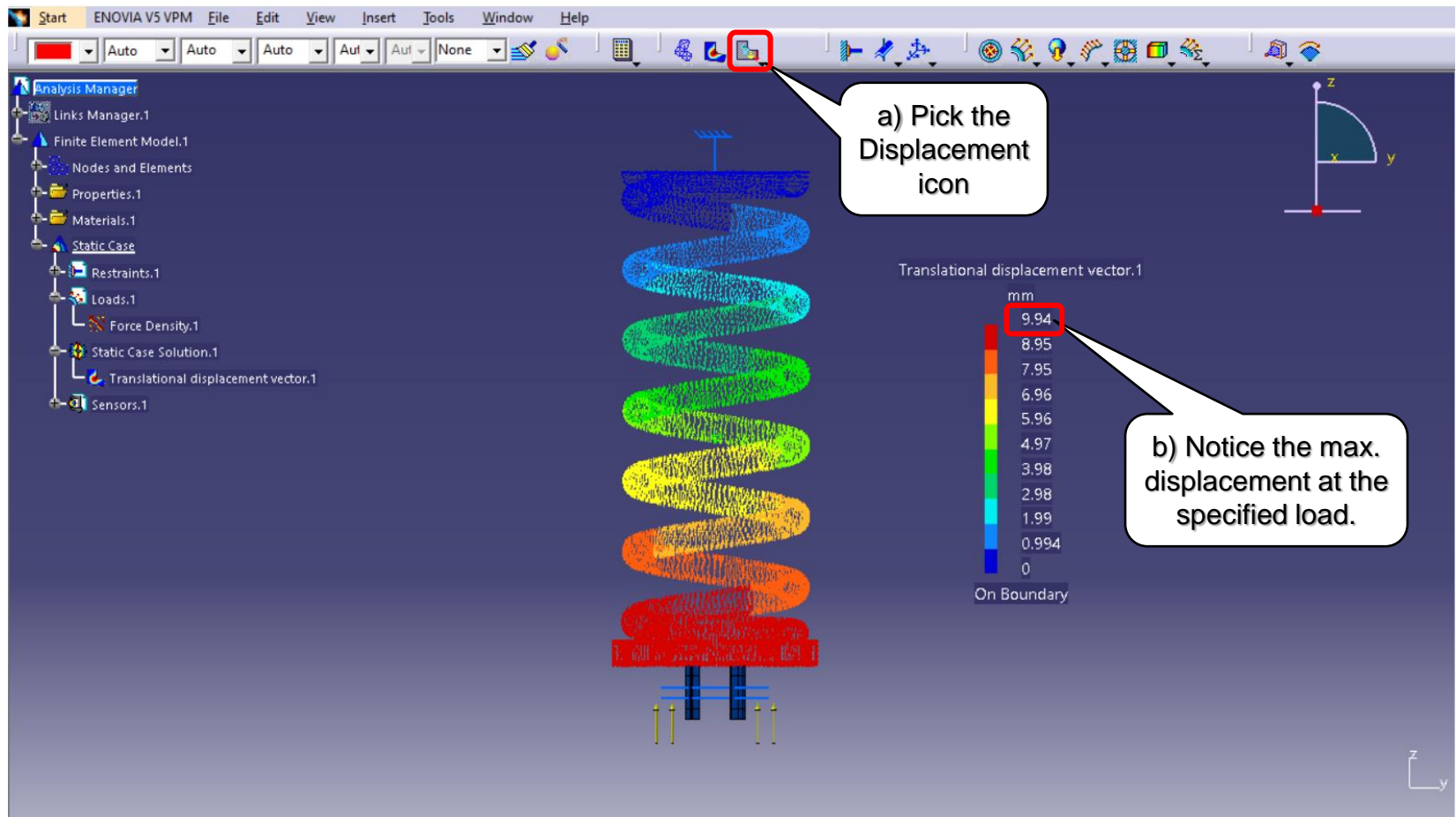
Operation Name	Elapsed Time
Total computing time	0:00:06
Meshing execution	0:00:04
Structure computation	0:00:01
Stiffness Computation	0:00:00
Singularity computation	0:00:01
Constraint Computation	0:00:00



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- Show results of the analysis.





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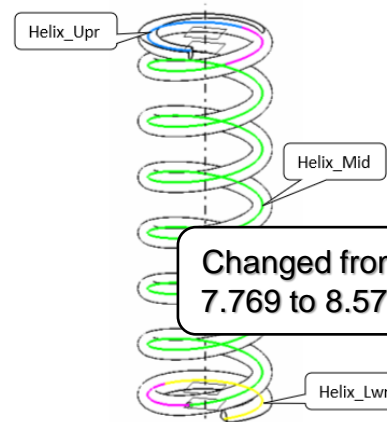
- Adjust Factors to “dial in” the FEA correlation if required.

From CATIA			C3 Project Front Spring Calculation														
Material	Young's Modulus (E) [modulus of elasticity]		Poisson's ratio (ν) [transverse contraction]	Modulus of Rigidity (G)		Wire Diameter [d]			Spring Mean Diameter [D]			Free Length [L _f]			Total coils [N _t]	Active coils [N _a]	Select End Types:
	(psi x 10 ⁶)	(MPa x 10 ³)		(psi x 10 ⁶)	(MPa x 10 ³)	inch	m	mm	inch	m	mm	inch	m	mm	value	value	Choice
Chrome Silicon	30.0	207.0	0.305	11.5	79.3	0.500	0.0127	12.7	3.000	0.0762	76.2	9.606	0.244	244	8.650	6.650	Squared or closed (Ground)

$$k = \frac{d^4 G}{8 D^3 N_a} \quad \nu = \frac{E}{G \cdot 2} - 1 \quad G = E / (2 * (1 + \nu))$$

Calculated Pitch [P]			Spring Outer Diameter [OD]			Spring Inner Diameter [ID]			Spring rate [k]	
inch	m	mm	inch	m	mm	inch	m	mm	lb/in	N/mm
1.411	0.0358	35.836	3.500	0.0889	88.9	2.500	0.0635	63.5	500.45	87.64

Spring Results (FEA)			
Mean Dia.	Force	defl	Rate
mm	N	δ (mm)	(k) N/mm
76.2	876.4	10	87.6
in	lb	in	lb/in
3.000	197.03	0.394	500.4



Adjusted for CATIA FEA	
36.692	= Pitch in Helix_Mid
2.55	= Factor for Coils in Helix_Mid
6.10	= Coils in Helix_Mid
223.820	= Height in Helix_Mid
20.18	= Δ Free Length to Helix_Mid Ht.
10.090	= Height of Helix_Mid Start Plane
0.85	= Factor for Pitch in Helix_Upr&Lwr
0.50	= Factor for Height in Helix_Upr&Lwr
8.577	= Pitch in Helix_Upr&Lwr
5.045	= Height in Helix_Upr&Lwr

Changed from
0.77 to 0.85



- Re-compute the analysis of the Preloaded Spring.

The screenshot displays the ENOVIA V5 VPM software interface. The main window shows a 3D model of a spring. The left-hand 'Analysis Manager' tree is expanded to show the 'Static Case Solution.1' item, which is highlighted in orange. A red box highlights the 'Compute' icon (a grid with a plus sign) in the top toolbar. A dialog box titled 'Comp...' is open in the bottom right, showing 'Analysis Case Solution Select' and 'Solution(s) to Be Computed' with 'Static Case Solution.1' selected. The 'OK' button is highlighted.

a) Pick the Compute icon

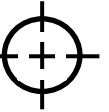
b) Select the Analysis Case Solution selection

c) Pick the Static Case Solution

d) Pick OK



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- Re-compute the analysis of the Preloaded Spring.

The screenshot shows the ENOVIA V5 VPM software interface. The main window displays a 3D model of a spring. The left sidebar shows the Analysis Manager tree with the following structure:

- Analysis Manager
 - Links Manager.1
 - Finite Element Model.1
 - Nodes and Elements
 - OCTREE Tetrahedron Mesh.1 : Front Spring (S5004)
 - Properties.1
 - Materials.1
 - Static Case
 - Restraints.1
 - Clamp.1
 - Surface Slider.1
 - Loads.1
 - Force Density.1
 - Static Case Solution.1
 - Sensors.1

Two dialog boxes are open:

Computation Resources Estimation

3 s of CPU
2.27e+004 kilo-bytes of memory
1.46e+005 kilo-bytes of disk

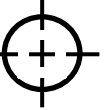
Do you want to continue the computation?

Yes No

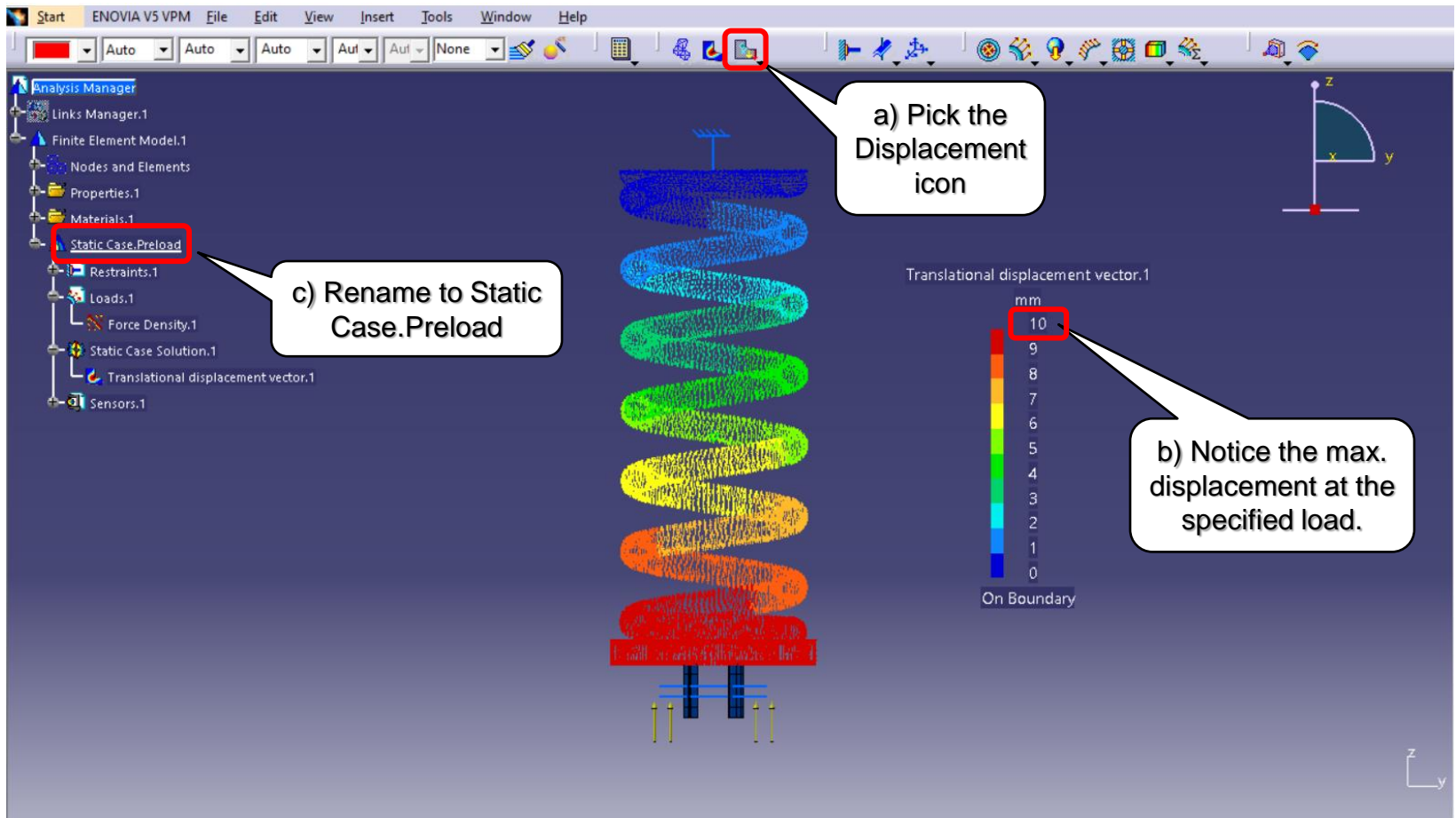
Computation Status

Operation Name	Elapsed Time
Total computing time	0:00:06
Meshing execution	0:00:04
Structure computation	0:00:01
Stiffness Computation	0:00:00
Singularity computation	0:00:01
Constraint Computation	0:00:00

e) Pick Yes and wait for the computation to run.



- Show results of the Preload analysis.



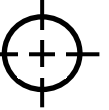
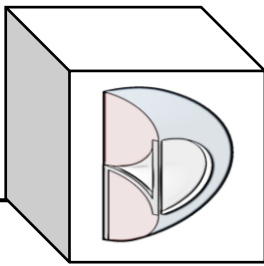


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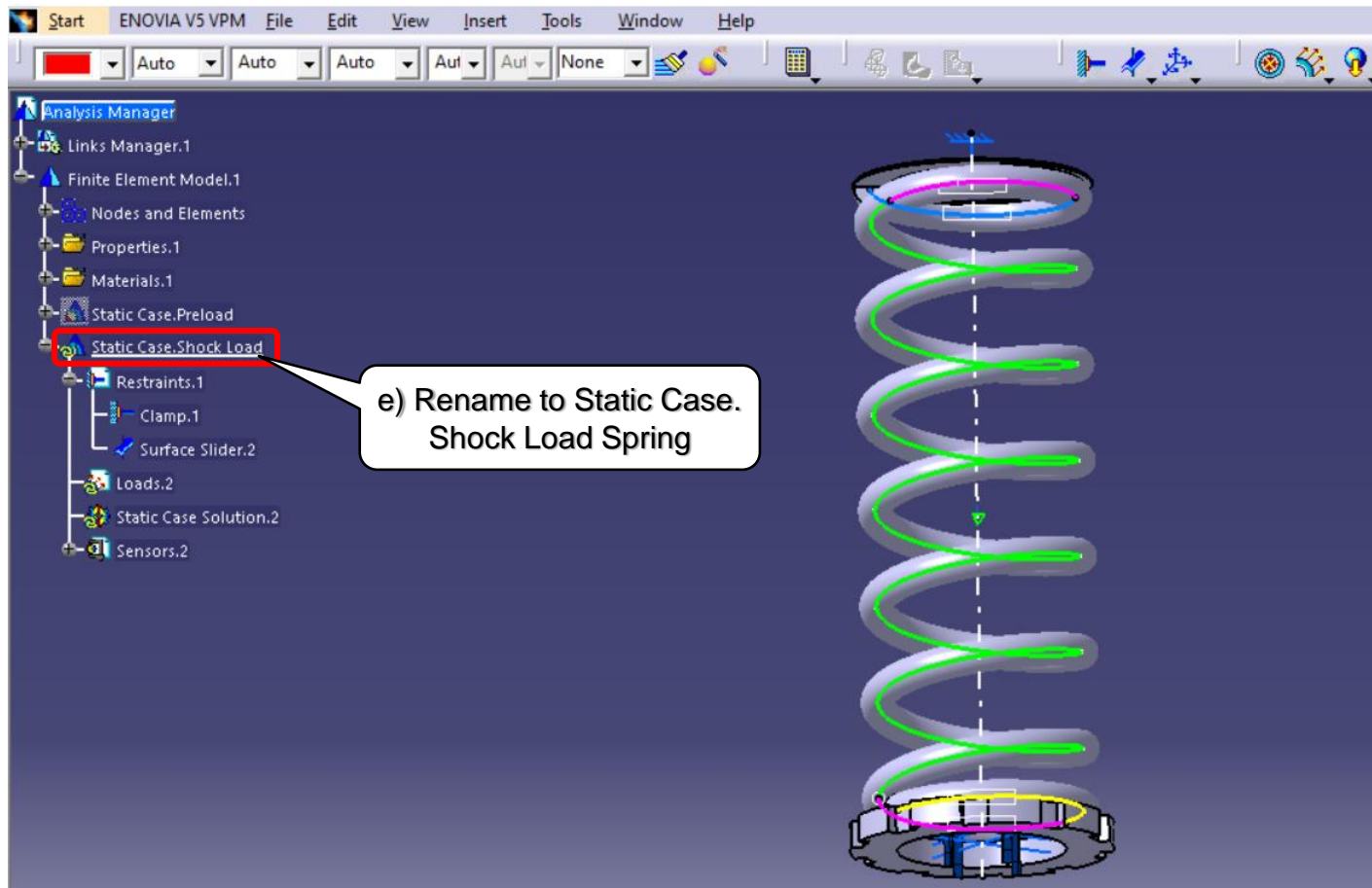


- Create a new Static Case.Shock Load Spring.

The screenshot shows the ENOVIA V5 VPM software interface. The 'Insert' menu is open, and the 'Static Case' option is highlighted. A callout box labeled 'a) Pick Insert + Static Case' points to this option. In the left-hand tree view, 'Restrains.1' is highlighted under the 'Static Case.Preload' folder. A callout box labeled 'c) Pick Restrains.1 from Static Case.Preload' points to this item. The 'Static Case' dialog box is open, showing the 'Restrains' section with the 'Reference' radio button selected and 'Restrains.1' entered in the text field. A callout box labeled 'b) Pick Restrains + Reference' points to the 'Reference' radio button. The 'OK' button is highlighted with a callout box labeled 'd) Pick OK'. The background shows a 3D model of a spring with a color gradient from blue to red, and a coordinate system (x, y, z) is visible in the top right corner.



- Create a new Static Case.Shock Load Spring.





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- Create the new Shock Spring Load (30 x rate → 2629.2N).

a) Pick the Force Density icon

b) Select the bottom surface of the retainer

c) Set Z to 2629.2N

d) Pick OK

Force Density D...

Name Force Density.2

Supports 1 Face

Axis System

Type Global

☐ Display locally

Force Vector

Norm 2629.2N

X 0N

Y 0N

Z 2629.2N

OK Cancel



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- Compute the analysis of the Shock Load Spring.

The screenshot shows the ENOVIA VS VPM software interface. The main window displays a 3D model of a shock load spring. The left sidebar shows the Analysis Manager tree with the following structure:

- Links Manager.1
- Finite Element Model.1
 - Nodes and Elements
 - Properties.1
 - Materials.1
 - Static Case.Preload
 - Static Case.Shock Load
 - Restraints.1
 - Loads.2
 - Force Density.2
 - Static Case Solution.2
 - Sensors.2

Callouts and actions:

- a) Pick the Compute icon: A red box highlights the Compute icon (a grid with a play button) in the top toolbar.
- b) Select the Analysis Case Solution selection: A callout points to the 'Static Case Solution.2' entry in the Analysis Manager tree.
- c) Pick the Static Case Solution: A callout points to the 'Static Case Solution.2' entry in the Analysis Manager tree.
- d) Pick OK: A callout points to the 'OK' button in the 'Comp...' dialog box.

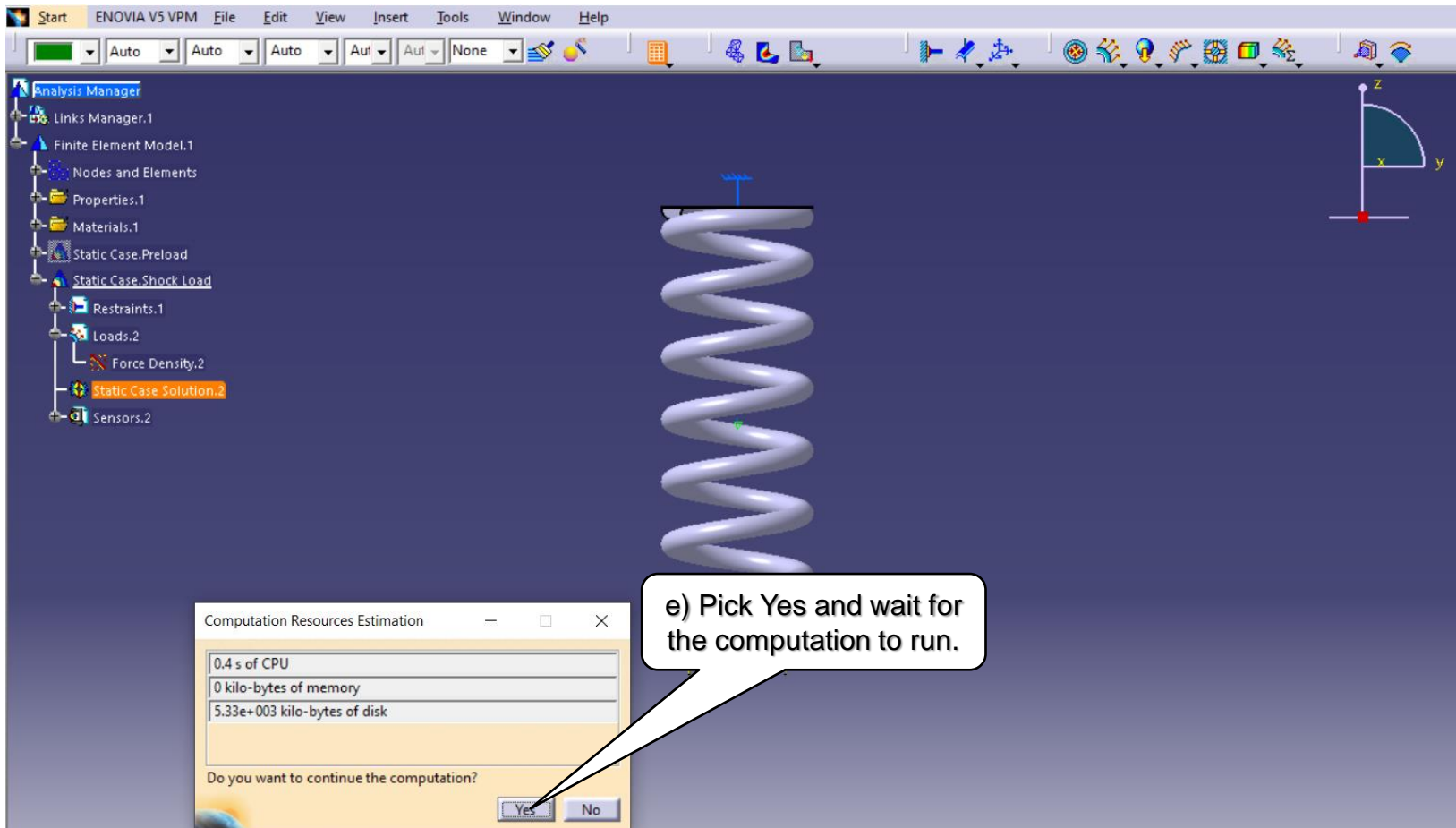
The 'Comp...' dialog box is open, showing the 'Analysis Case Solution Selection' dropdown set to 'Static Case Solution.2'. The 'Solution(s) to Be Computed' list also shows 'Static Case Solution.2'. The 'Preview' checkbox is checked. The 'OK' and 'Cancel' buttons are at the bottom.



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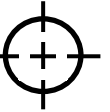


- Compute the analysis of the Shock Load Spring.

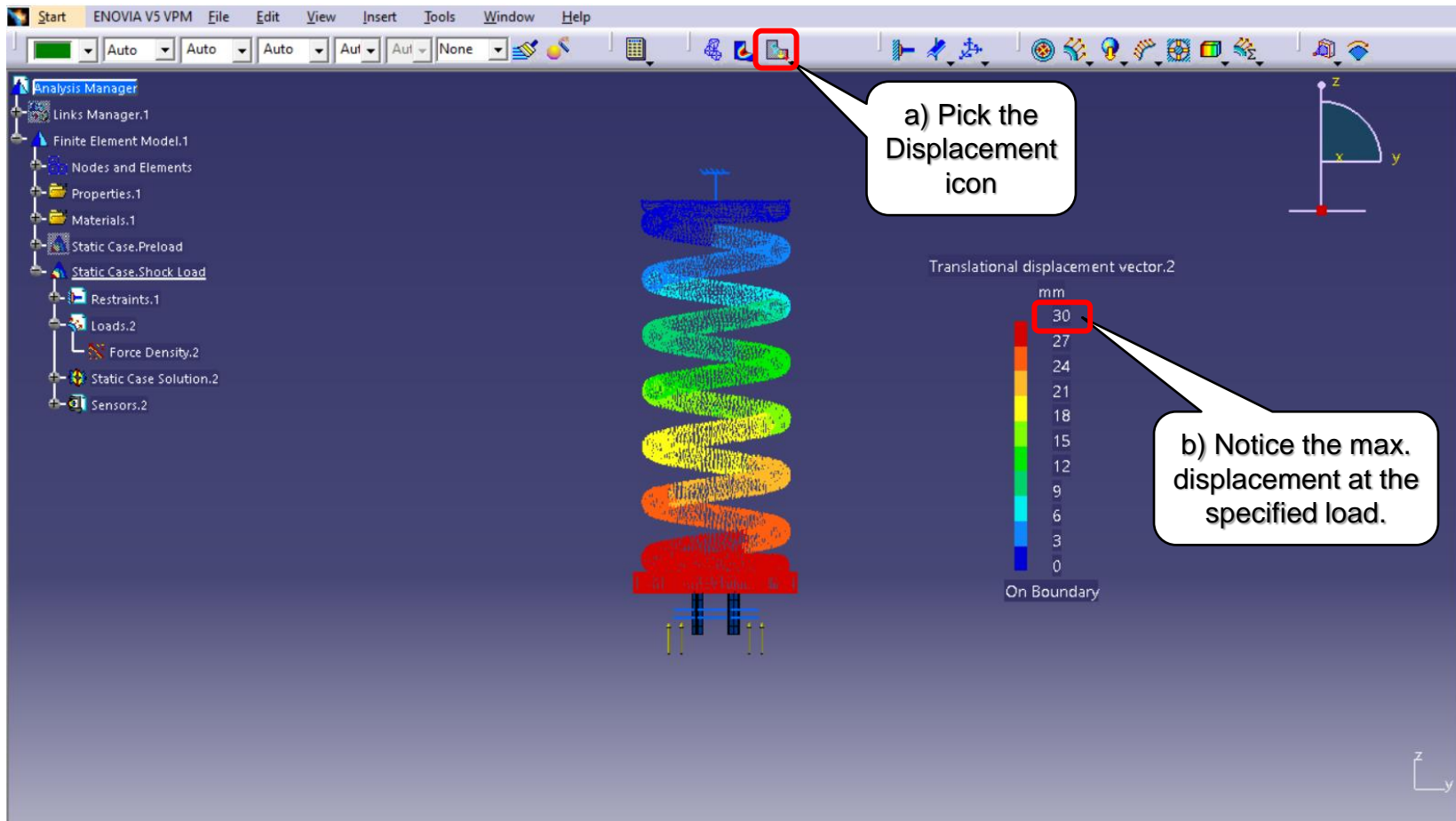




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- Show results of the Shock Load Spring analysis.





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- Create a new Combined Case.Shock Spring Deflection.

a) Pick Insert + Combined Case

b) Double-pick Combined Static Case Solution.1

c) Pick Combined Static Case Solution.1 to add to the index

d) Pick Combined Static Case Solution.2 to add to the index

e) Right-click the coefficient to edit

f) Set the first coefficient to -1

g) Set the second coefficient to 1

h) Pick OK

Index	Selected Solution	Coefficient	Occurrence	Path
1	Static Case Sol...	1	Not applicable	St...
2	Static Case Sol...	0	Not applicable	St...

Combined Solution

Param...

Coefficient -1

OK Cancel



- Compute the analysis of the Combined Static Case Solution.1

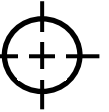
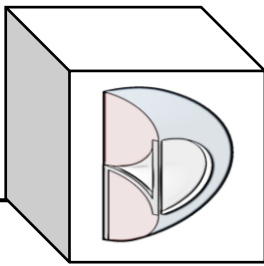
The screenshot shows the ENOVIA V5 VPM software interface. The Analysis Manager tree on the left lists the following items: Links Manager.1, Finite Element Model.1, Nodes and Elements, Properties.1, Materials.1, Static Case.Preload, Static Case.Shock Load, Combined Case, Combined Static Case Solution.1 (highlighted), and Sensors.3. A 3D model of a spring is displayed in the center. A callout 'a) Pick the Compute icon' points to the Compute icon in the top toolbar. A callout 'b) Select the Analysis Case Solution selection' points to the 'Analysis Case Solution Selection' dropdown in the 'Comp...' dialog box. A callout 'c) Pick the Combined Static Case Solution.1' points to the 'Combined Static Case Solution.1' item in the Analysis Manager tree. A callout 'd) Pick OK' points to the 'OK' button in the 'Comp...' dialog box.

a) Pick the Compute icon

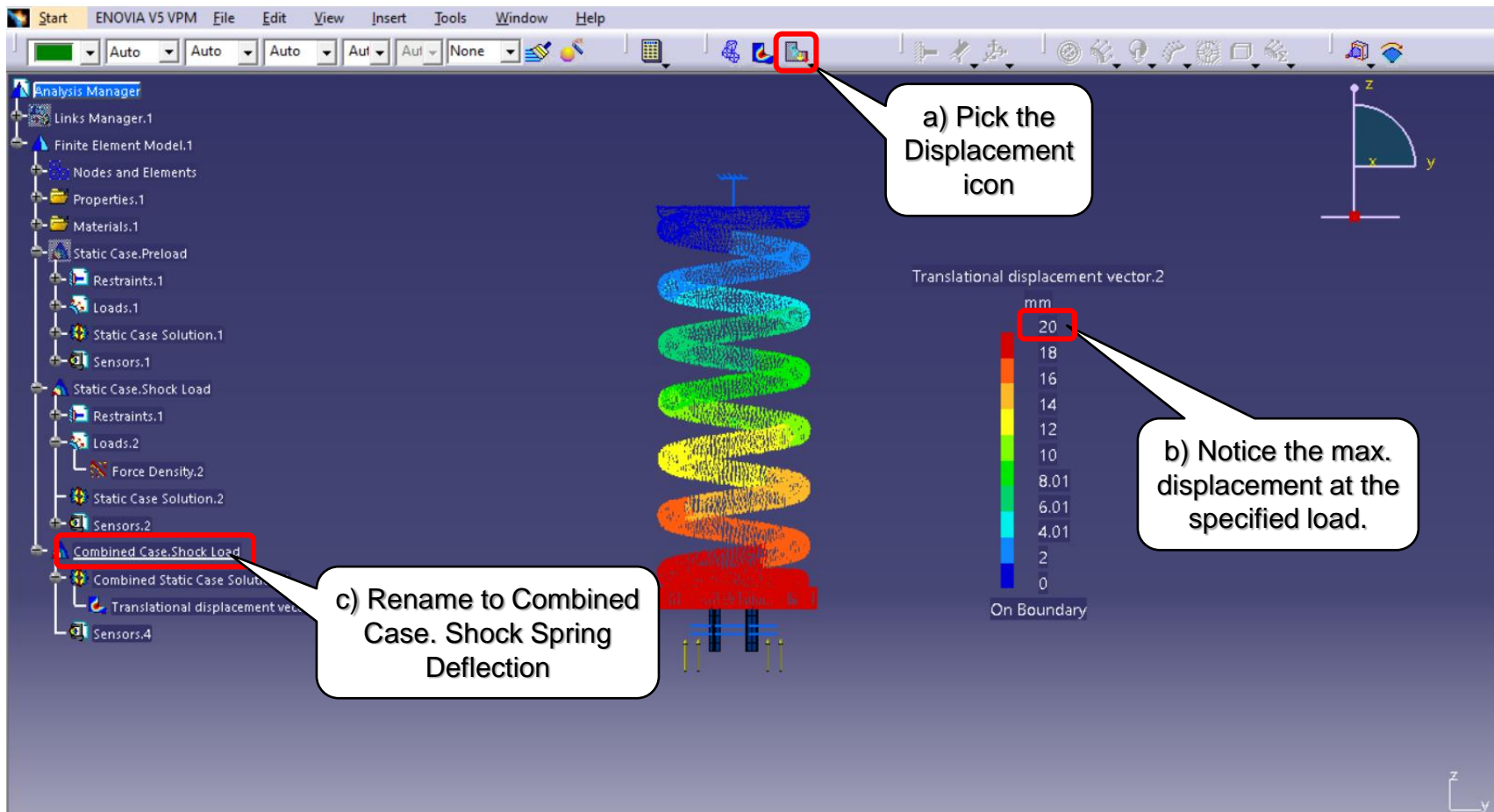
b) Select the Analysis Case Solution selection

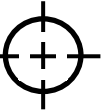
c) Pick the Combined Static Case Solution.1

d) Pick OK

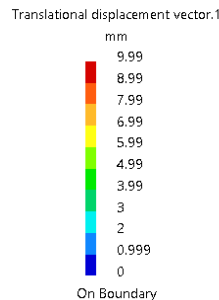


- Show analysis results of the Combined Case.Shock Spring Deflection.

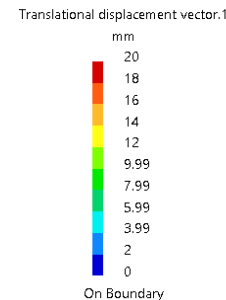
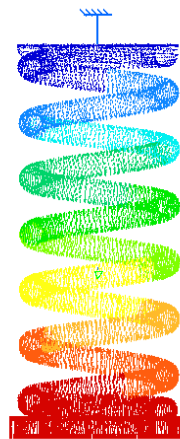




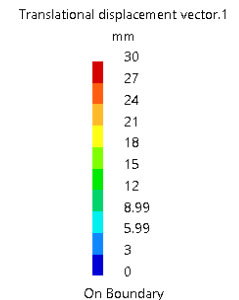
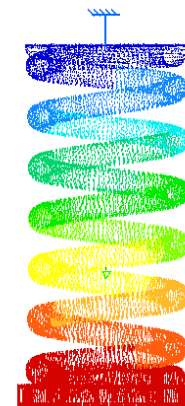
- The FEA analysis of the Preloaded Spring correlates with the Spring Rate from the CATIA Part model and proves the rate remains Linear.



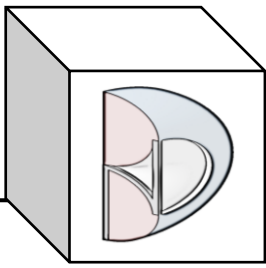
Load = 20X the
Spring Rate –
the Preload →
10mm Defl.



Load = 30X the
Spring Rate –
the Preload →
20mm Defl.



Load = 40X the
Spring Rate –
the Preload →
30mm Defl.



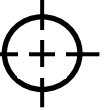
BND TechSource



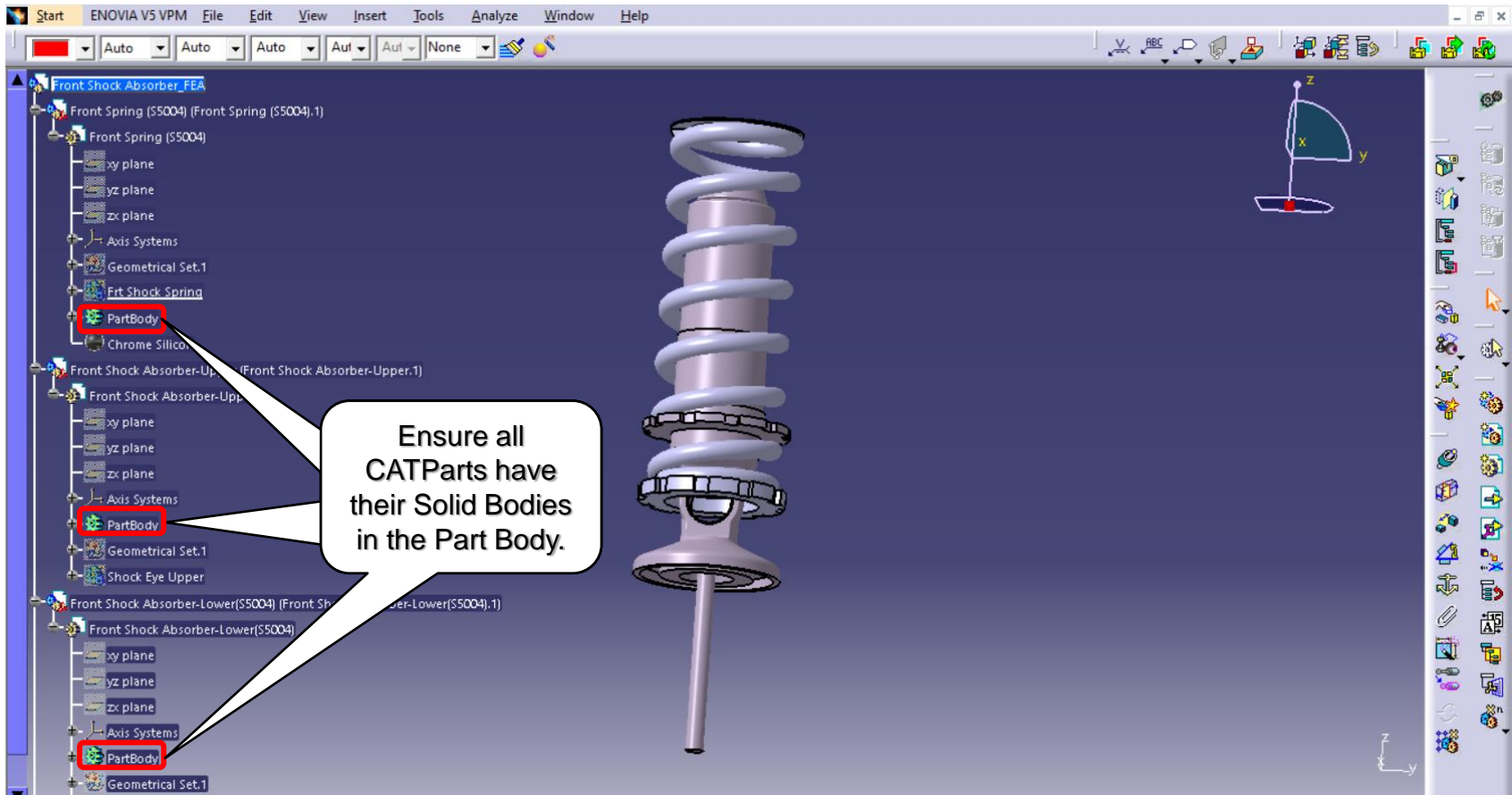
Create the Preloaded Coil-over Shock Assembly FEA



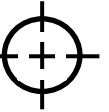
BND TechSource



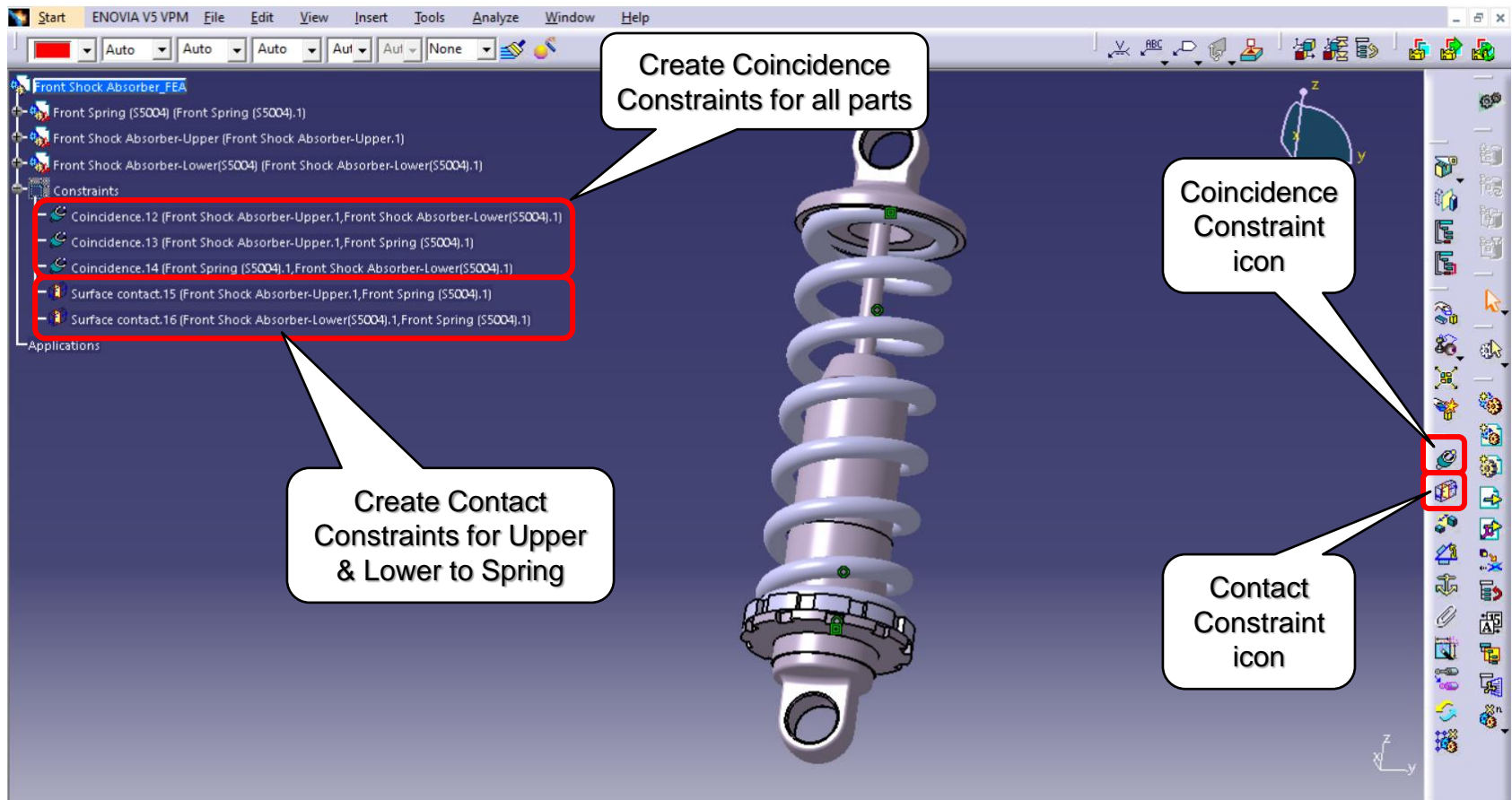
- Create a CATProduct for the Coil-over Shock Assy.



Ensure all
CATParts have
their Solid Bodies
in the Part Body.

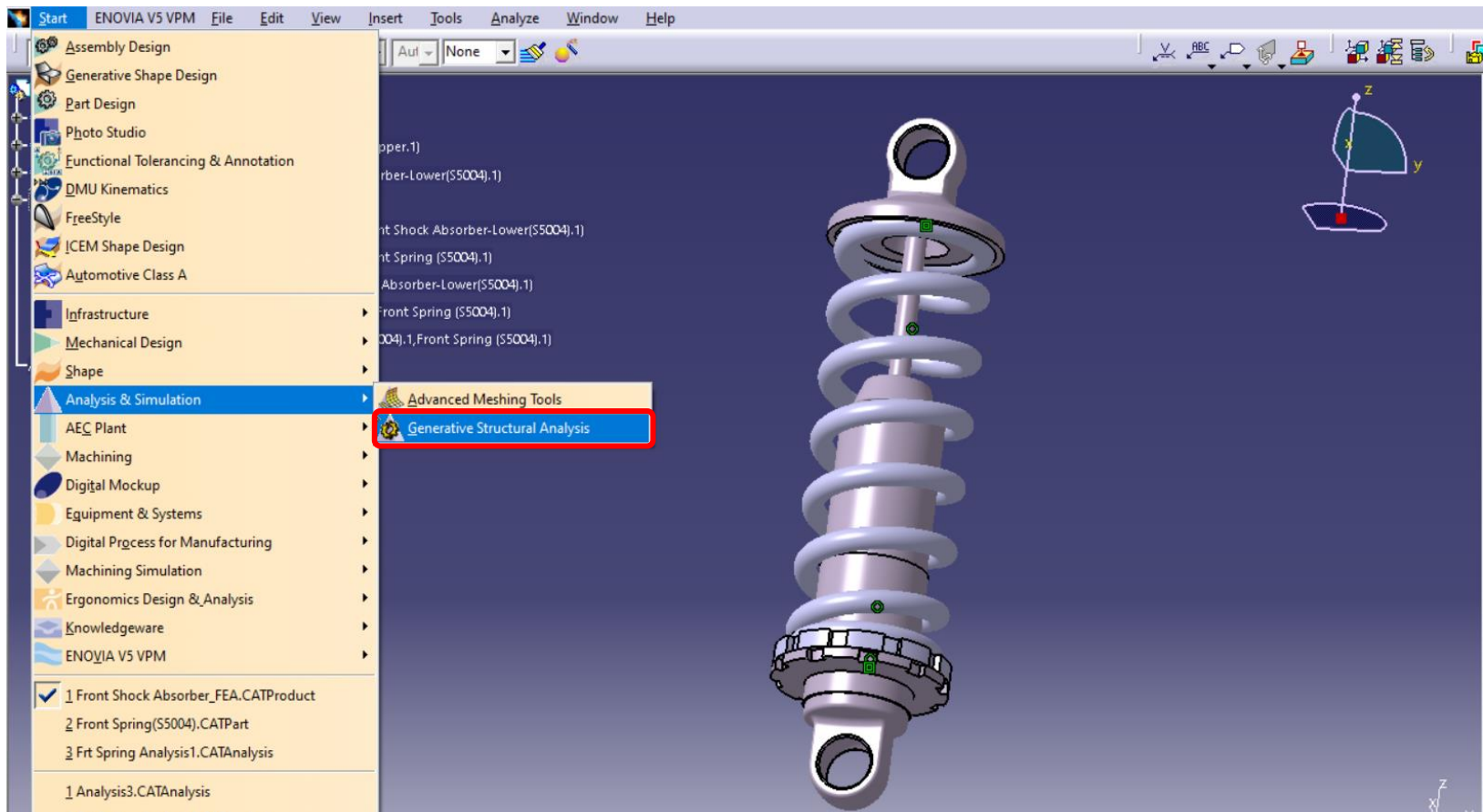


- Create Constraints for all parts within the Coil-over Shock Assy.





- While inside the CatPart, call the Generative Structural Analysis workbench.

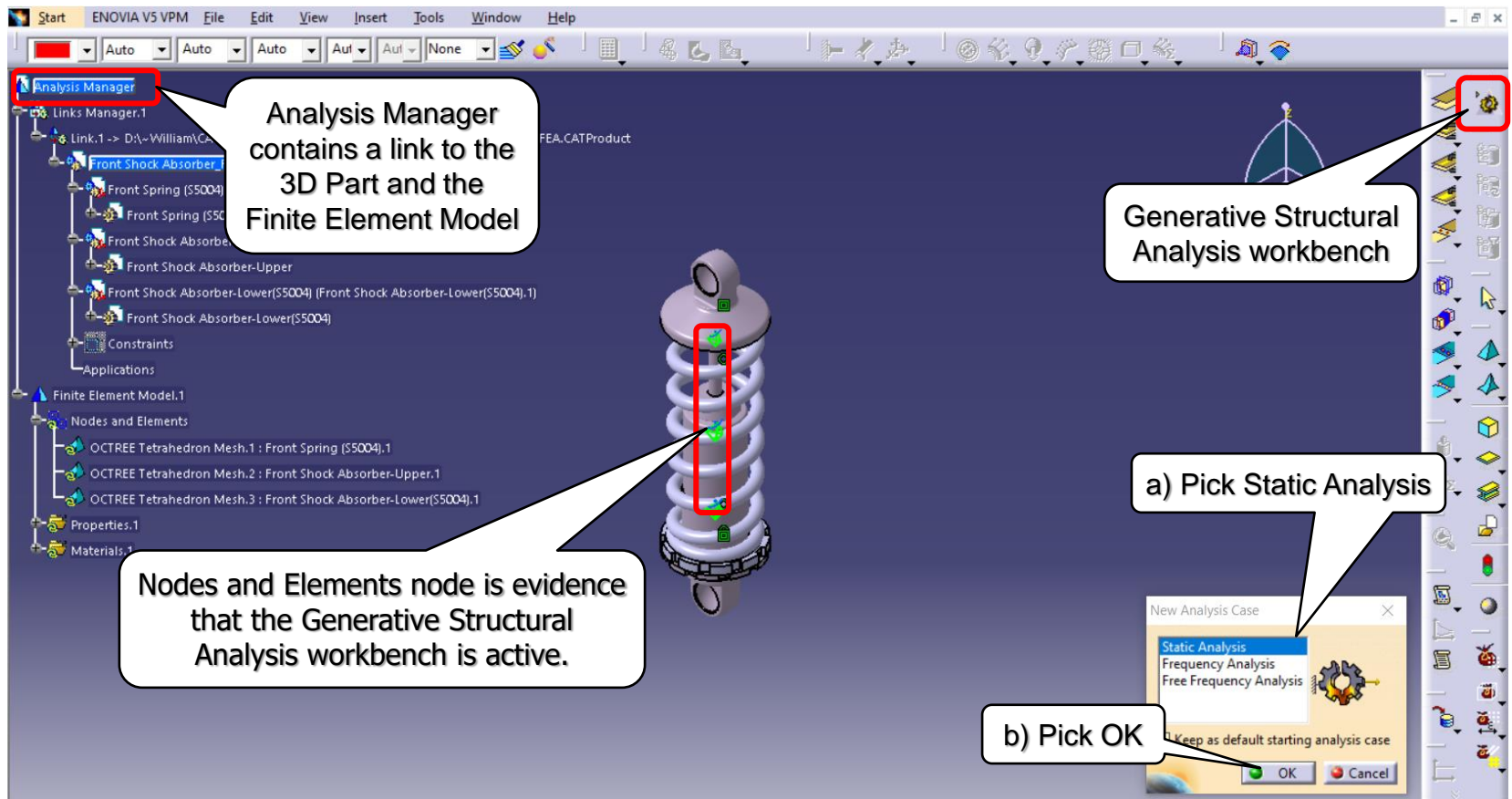


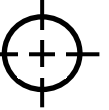
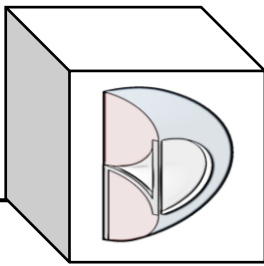


BND TechSource



- Generative Structural Analysis workbench creates the Analysis Manager.





- Optimize the Mesh for the Spring.

The screenshot shows the ENOVIA V5 VPM software interface. The main window displays a 3D model of a spring. The left-hand 'Analysis Manager' tree shows the following structure:

- Analysis Manager
 - Links Manager.1
 - Finite Element Model.1
 - Nodes and Elements
 - OCTREE Tetrahedron Mesh.1 : Front Spring (S5004).1** (highlighted with a red box)
 - OCTREE Tetrahedron Mesh.2 : Front Shock Absorber-Upper.1
 - OCTREE Tetrahedron Mesh.3 : Front Shock Absorber-Lower(S5004).1
 - Properties.1
 - Materials.1

Five callout boxes provide instructions for optimizing the mesh:

- a) Double-pick the OCTREE Tetrahedron Mesh.1 : Front Spring (S5004).1
- b) Change the Size to 5mm
- c) Pick Absolute sag (1mm)
- d) Pick Parabolic
- e) Pick OK

The 'OCTREE Tetrahedron Mesh' dialog box is open, showing the following settings:

- Global | Local | **Quality** | Others
- Size: 5mm
- ☒ Absolute sag: 1
- ☐ Proportional sag: 0.2
- Element type:
 - ☐ Linear
 - ☒ **Parabolic**
 - ☐ Cubic
- Buttons: OK, Cancel



- Optimize the Mesh for the Upper Shock.

The screenshot displays the ENOVIA V5 VPM software interface. The main window shows a 3D model of a shock absorber. The left-hand 'Analysis Manager' tree is expanded to 'Nodes and Elements', where 'OCTREE Tetrahedron Mesh.2 : Front Shock Absorber-Upper.1' is highlighted with a red box. A callout 'a) Double-pick the OCTREE Tetrahedron Mesh.2 : Front Shock Absorber-Upper.1' points to this item. The 'OCTREE Tetrahedron Mesh' dialog box is open, showing the 'Quality' tab. Callout 'b) Change the Size to 10mm' points to the 'Size' field, which is set to '10mm'. Callout 'c) Pick Absolute sag (2mm)' points to the 'Absolute sag' field, which is set to '2mm'. Callout 'd) Pick Parabolic' points to the 'Parabolic' radio button under 'Element type'. Callout 'e) Pick OK' points to the 'OK' button at the bottom of the dialog box. The background shows a 3D model of a shock absorber with a mesh applied to the upper part.

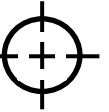
a) Double-pick the OCTREE Tetrahedron Mesh.2 : Front Shock Absorber-Upper.1

b) Change the Size to 10mm

c) Pick Absolute sag (2mm)

d) Pick Parabolic

e) Pick OK



- Optimize the Mesh for the Lower Shock.

The screenshot displays the ENOVIA V5 VPM software interface. The main window shows a 3D model of a shock absorber. The left-hand 'Analysis Manager' tree is expanded to 'Nodes and Elements', where 'OCTREE Tetrahedron Mesh.3 : Front Shock Absorber-Lower(S5004).1' is highlighted with a red box. A callout bubble 'a)' points to this selection. The 'OCTREE Tetrahedron Mesh' dialog box is open, showing the 'Quality' tab. Callout bubble 'b)' points to the 'Size' field set to '10mm'. Callout bubble 'c)' points to the 'Absolute sag' field set to '2mm'. Callout bubble 'd)' points to the 'Parabolic' radio button under 'Element type'. Callout bubble 'e)' points to the 'OK' button at the bottom right of the dialog. The background shows the 3D model of the shock absorber with a green arrow indicating the direction of the lower shock.

a) Double-pick the OCTREE Tetrahedron Mesh.3 : Front Shock Absorber-Lower(S5004).1

b) Change the Size to 10mm

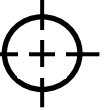
c) Pick Absolute sag (2mm)

d) Pick Parabolic

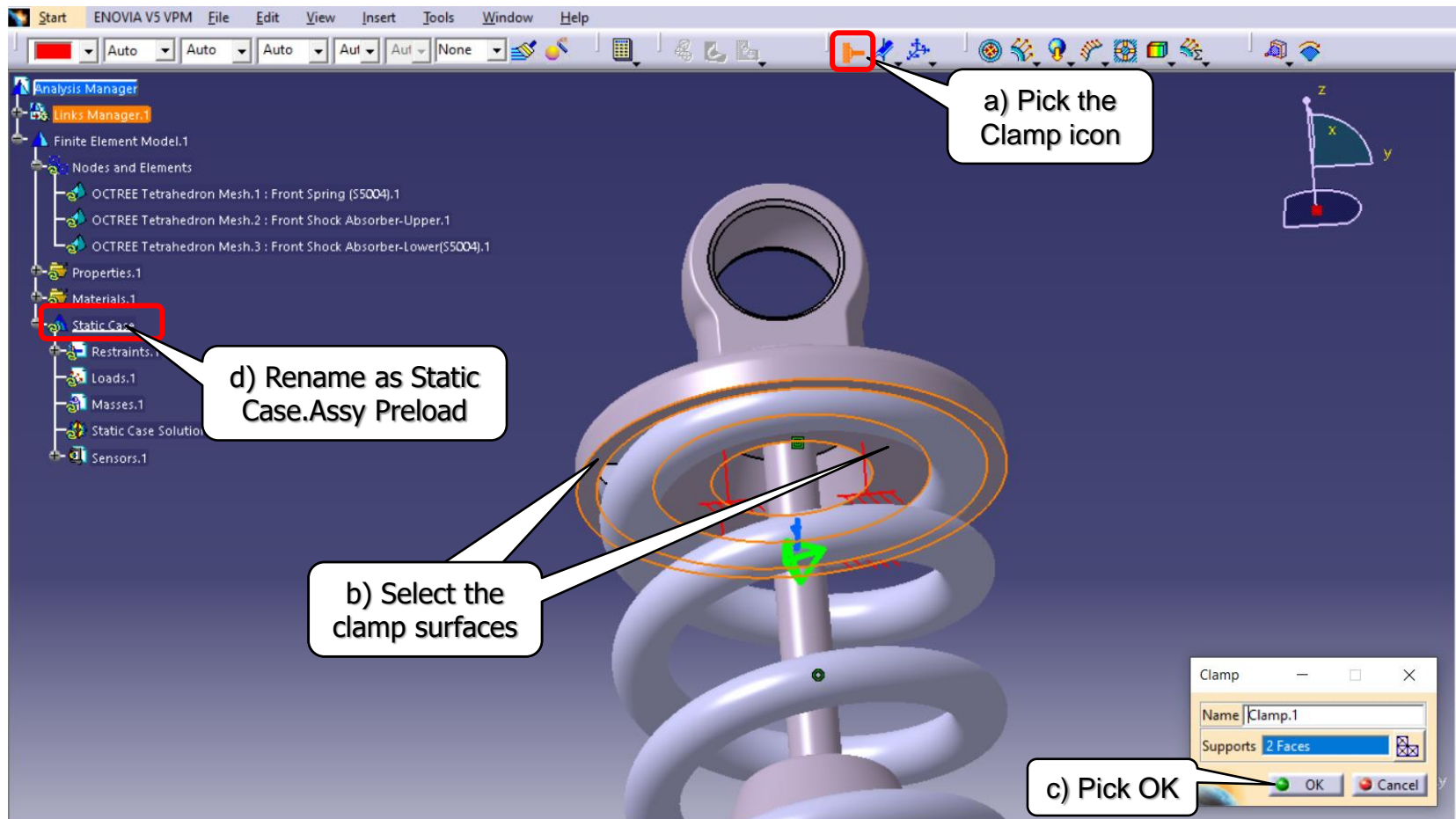
e) Pick OK



BND TechSource

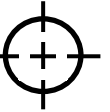


- Create the Clamp Restraint and rename Static Case.





BND TechSource



- Create the Sliding Restraint.

Start ENOVIA V5 VPM File Edit View Insert Tools Window Help

Analysis Manager

Links Manager.1

Finite Element Model.1

Nodes and Elements

OCTREE Tetrahedron Mesh.1 : Front Spring (S5004).1

OCTREE Tetrahedron Mesh.2 : Front Shock Absorber-Upper.1

OCTREE Tetrahedron Mesh.3 : Front Shock Absorber-Lower(S5004).1

Properties.1

Materials.1

Static Case Preload

Restraints.1

Clamp.1

Surface Slider.1

Loads.1

Masses.1

Static Case Solution.1

Sensors.1

a) Pick the Sliding Restraint icon

b) Select the Sliding Restraint surfaces (10)

c) Pick OK

Surface Slider.1

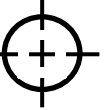
Name Surface Slider.1

Supports 10 Faces

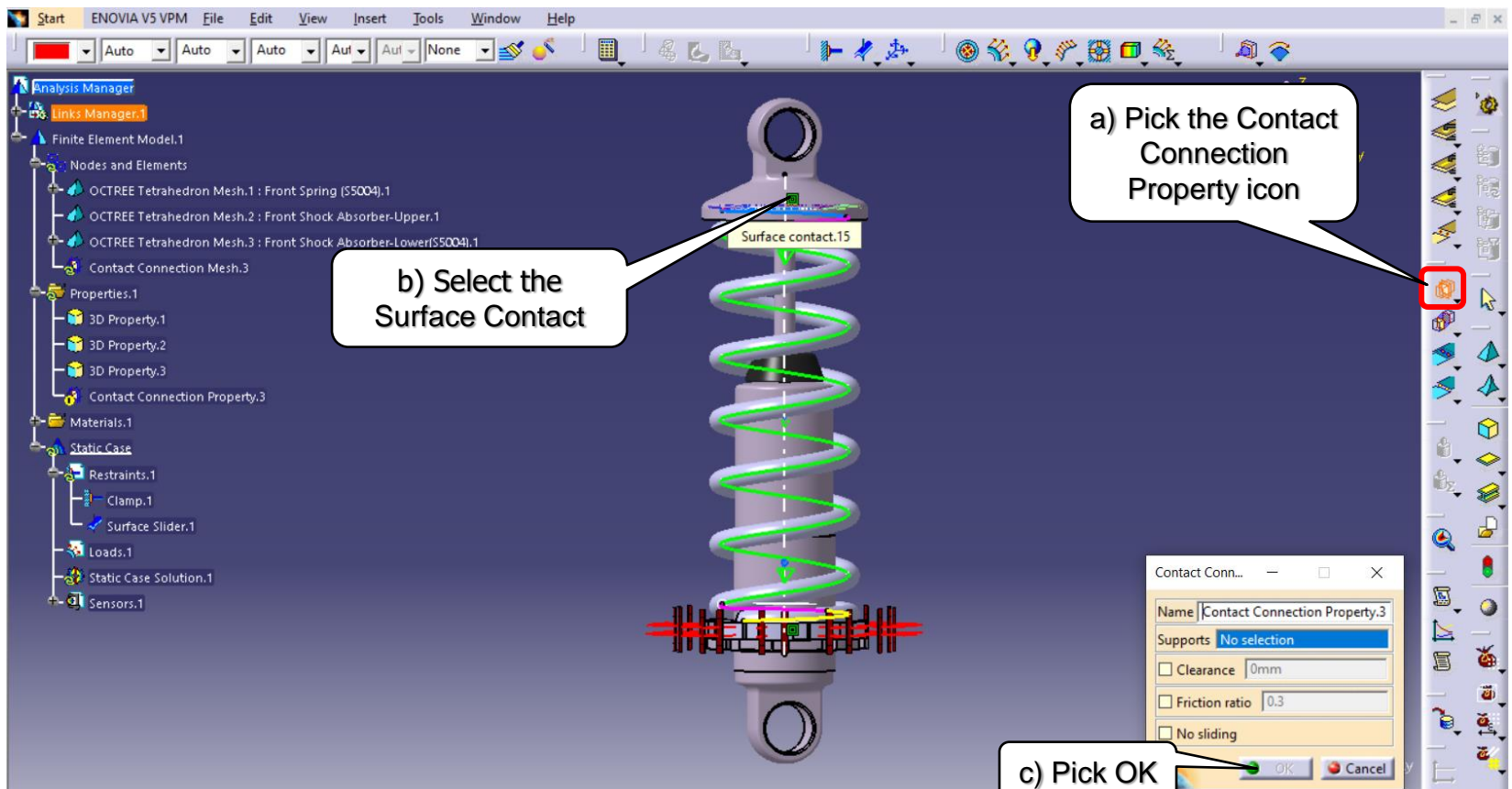
OK Cancel

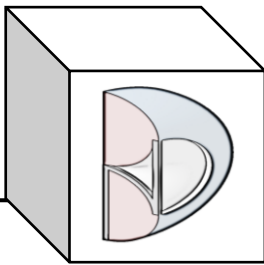


BND TechSource



- Create the Contact Connection Property.1

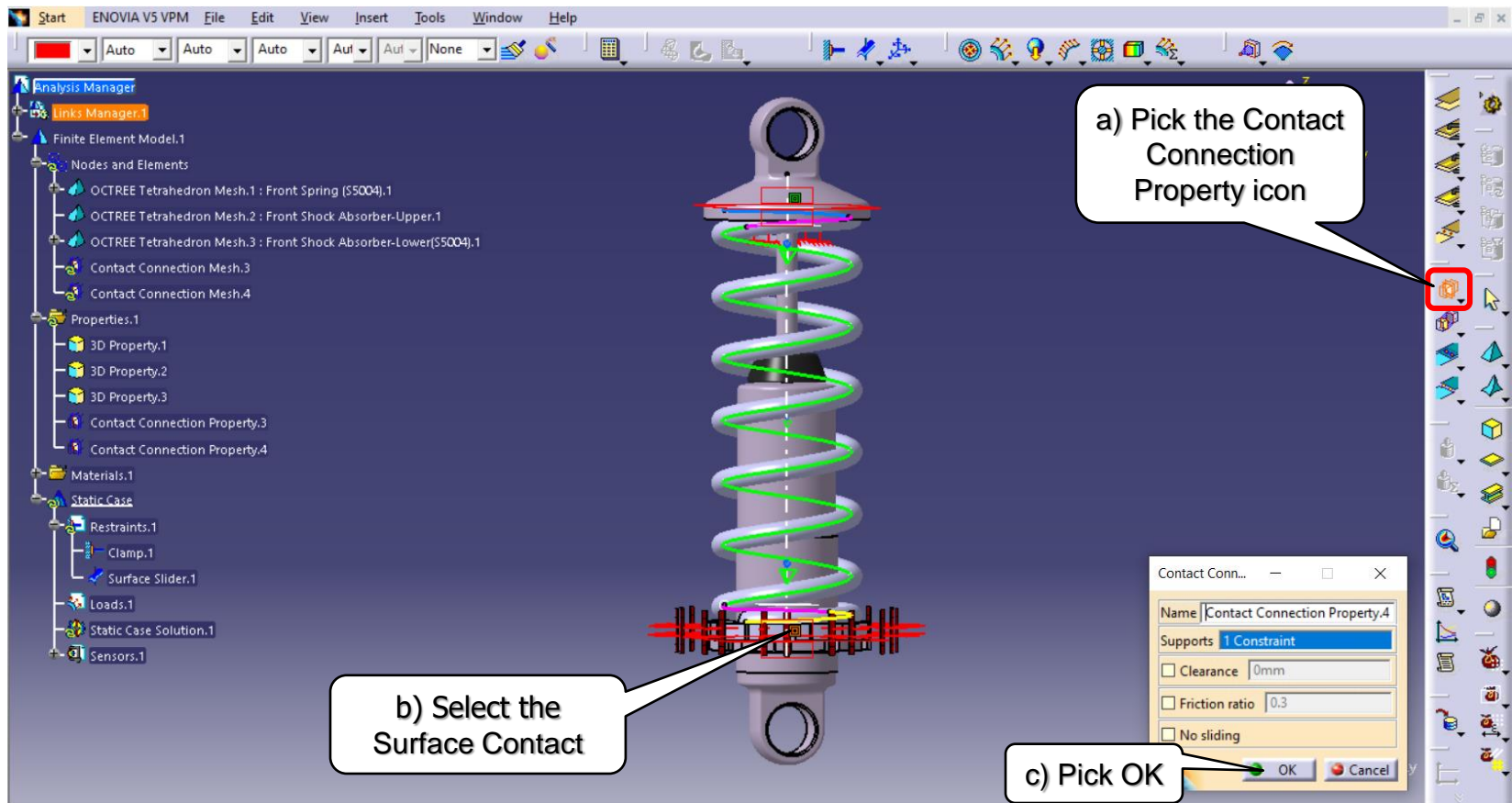


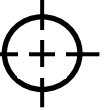


BND TechSource

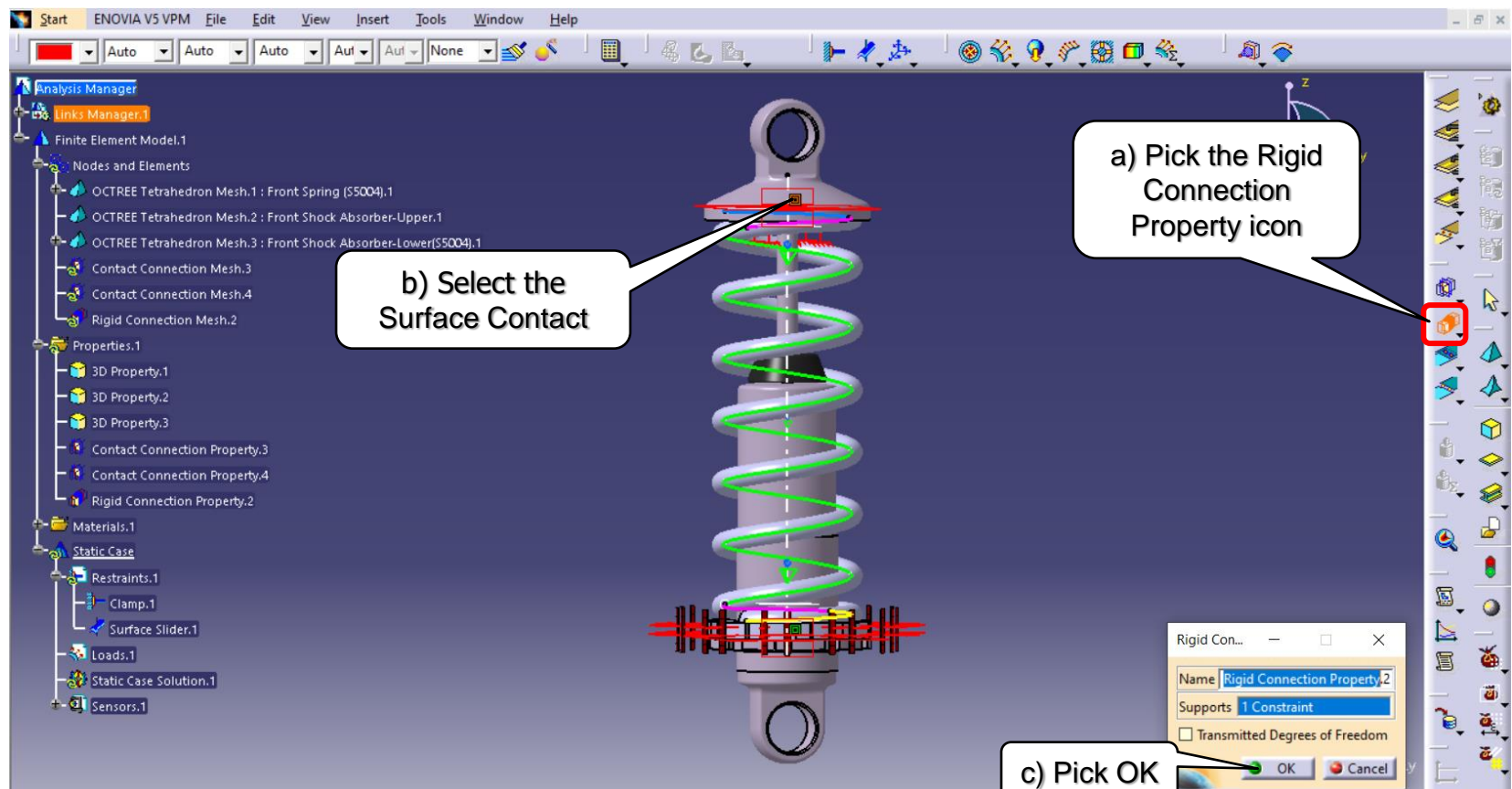


- Create the Contact Connection Property.2





- Create the Rigid Connection Property.

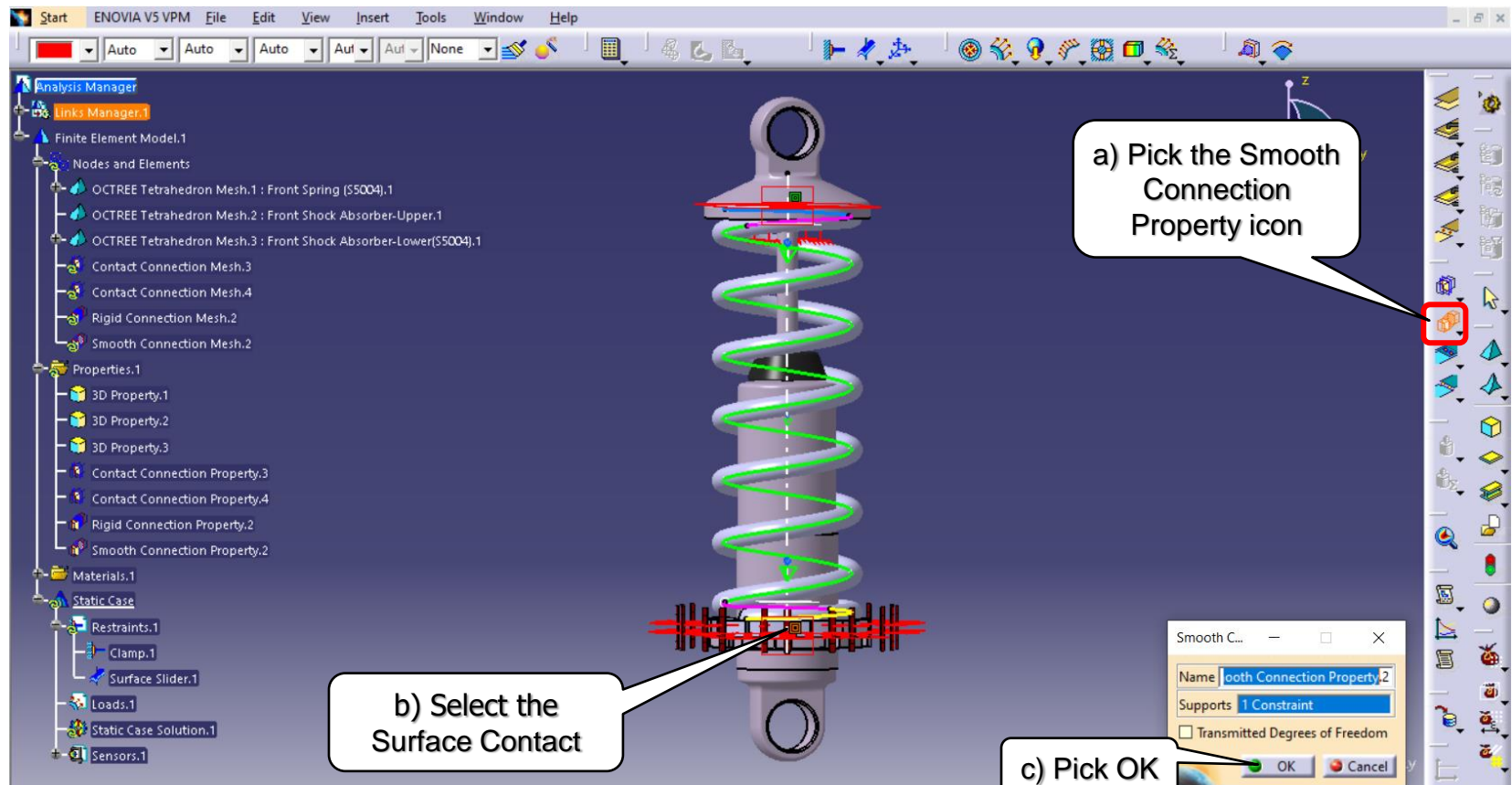




BND TechSource



- Create the Smooth Connection Property.

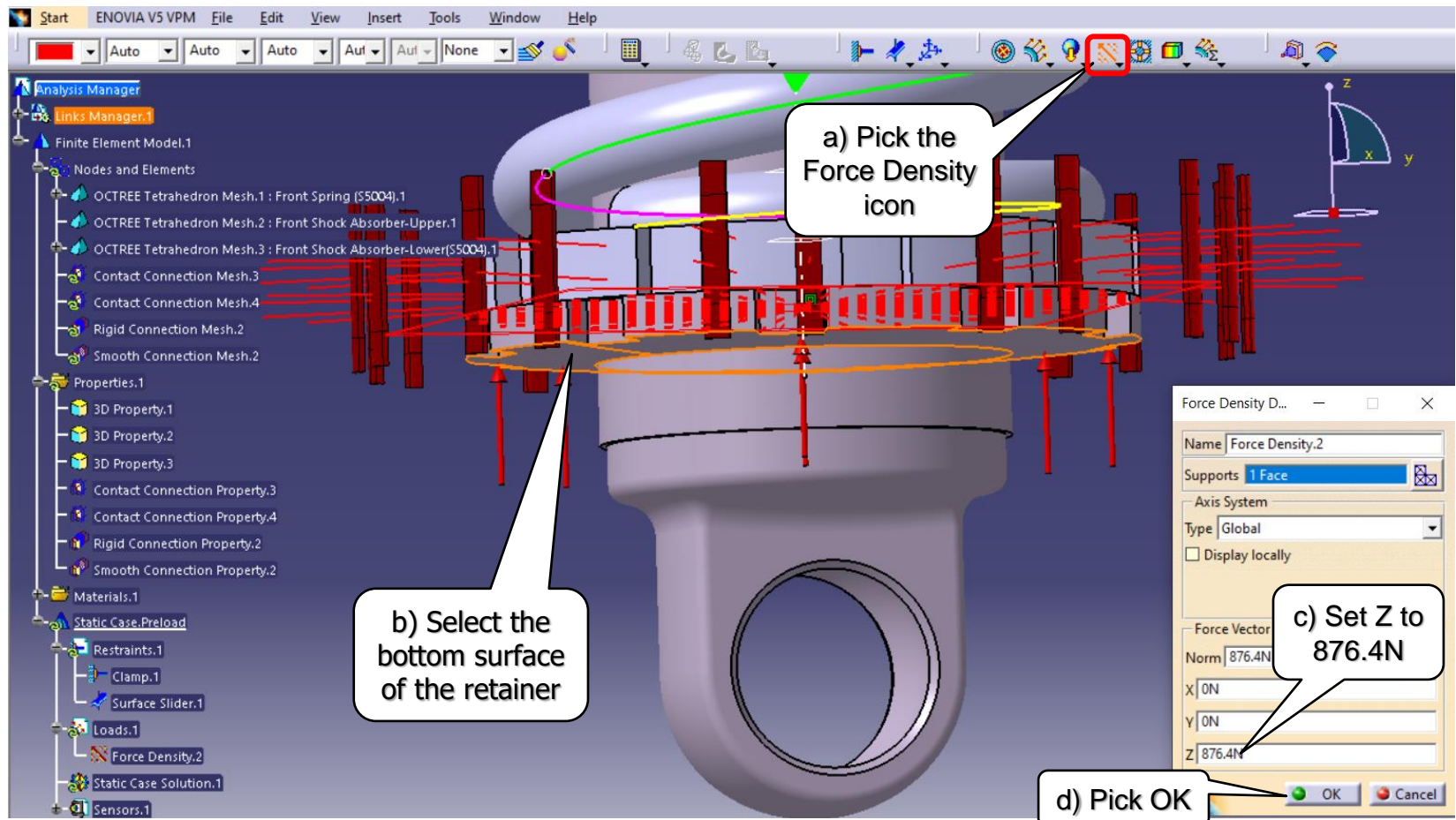


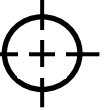


BND TechSource



- Create the Preload (10 x rate \rightarrow 876.4N).





- Compute the Assy Preload analysis.

The screenshot displays the ENOVIA V5 VPM software interface. The main window shows a 3D model of a mechanical assembly, specifically a spring-loaded component. The left-hand 'Analysis Manager' tree is expanded to show the 'Static Case.Preload' analysis. The 'Static Case Solution.1' item is highlighted in orange. A red box highlights the 'Compute' icon (a grid of squares) in the top toolbar. A callout bubble points to this icon with the text 'a) Pick the Compute icon'. Another callout bubble points to the 'Static Case Solution.1' item in the tree with the text 'c) Pick the Static Case Solution'. A third callout bubble points to the 'Analysis Case Solution Selection' dialog box, which is open in the bottom right corner. This dialog box has a dropdown menu set to 'Static Case Solution.1' and an 'OK' button. A callout bubble points to the 'OK' button with the text 'd) Pick OK'. A fourth callout bubble points to the 'Analysis Case Solution Selection' dropdown menu with the text 'b) Select the Analysis Case Solution selection'. The background of the main window is dark blue, and the 3D model is rendered in a light gray color.

a) Pick the Compute icon

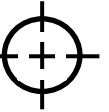
b) Select the Analysis Case Solution selection

c) Pick the Static Case Solution

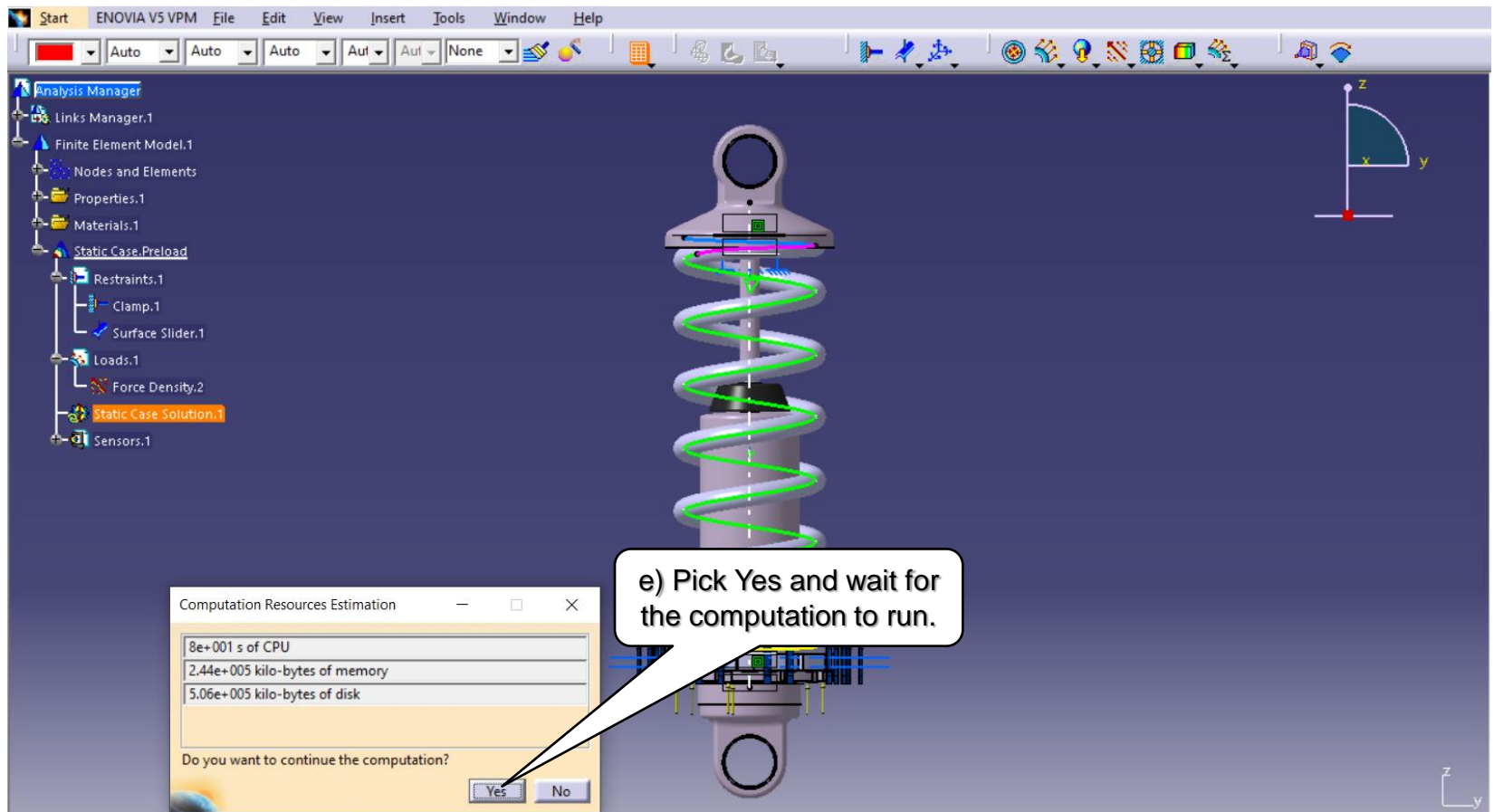
d) Pick OK



BND TechSource

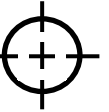


- Compute the Assy Preload analysis.

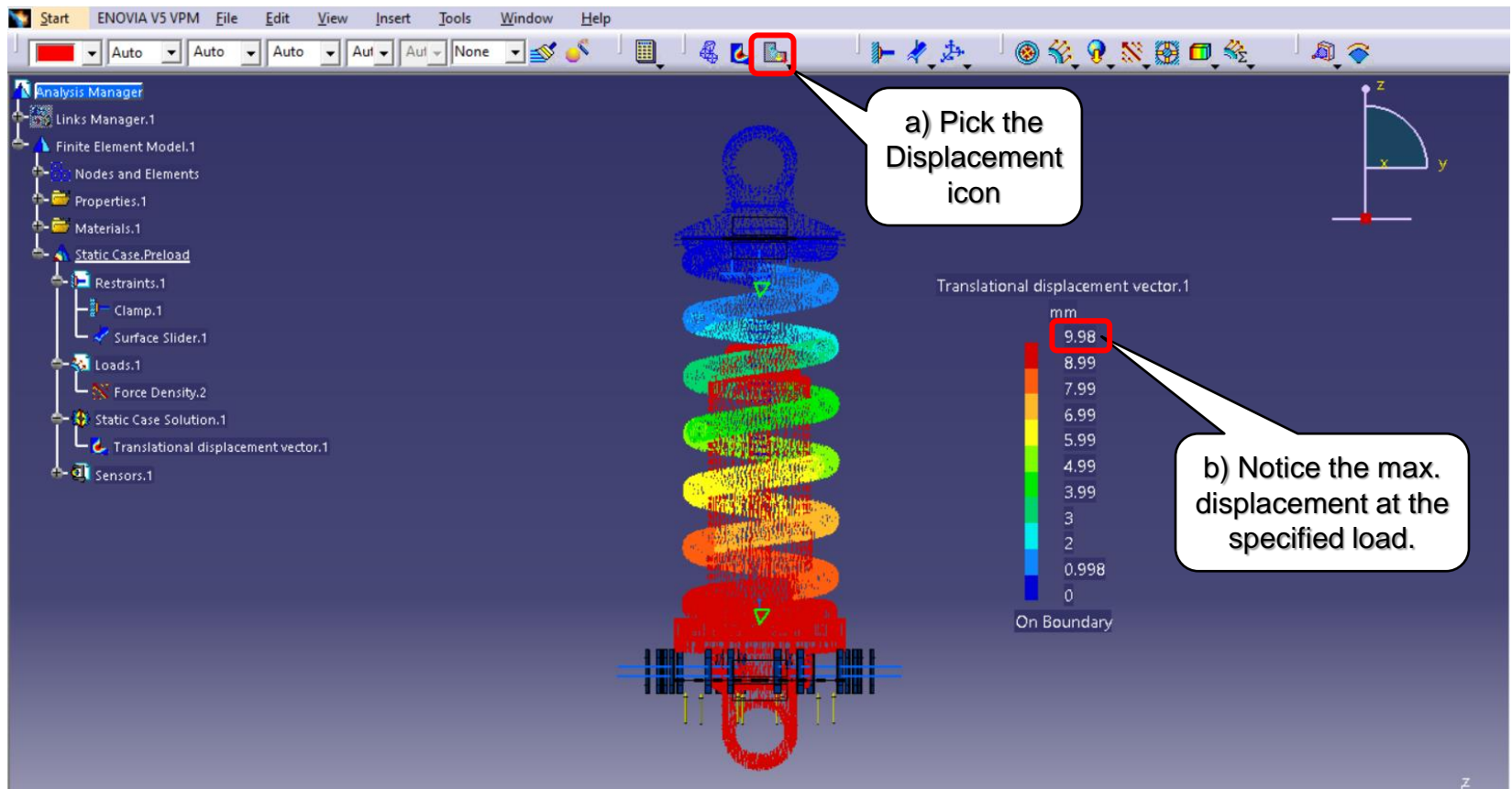




BND TechSource

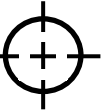


- Show results of the Assy Preload analysis.





BND TechSource



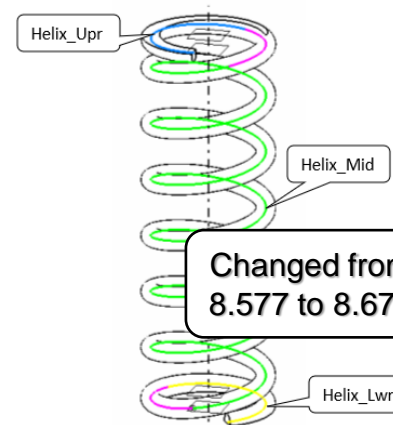
- Adjust Factors to “dial in” the FEA correlation if required.

From CATIA				C3 Project Front Spring Calculation													
Material	Young's Modulus (E) [modulus of elasticity]		Poisson's ratio (v) [transverse contraction]	Modulus of Rigidity (G)		Wire Diameter [d]			Spring Mean Diameter [D]			Free Length [L]			Total coils [N _t]	Active coils [N _a]	Select End Types:
	(psi x 10 ⁶)	(MPa x 10 ³)		(psi x 10 ⁶)	(MPa x 10 ³)	inch	m	mm	inch	m	mm	inch	m	mm	value	value	Choice
Chrome Silicon	30.0	207.0	0.305	11.5	79.3	0.500	0.0127	12.7	3.000	0.0762	76.2	9.606	0.244	244	8.650	6.650	Squared or closed (Ground)
				11501494	79300000000												

$$k = \frac{d^4 G}{8 D^3 N_a} \quad v = \frac{E}{G \cdot 2} - 1 \quad G = E / (2 * (1 + v))$$

Calculated Pitch [P]			Spring Outer Diameter [OD]			Spring Inner Diameter [ID]			Spring rate [k]	
inch	m	mm	inch	m	mm	inch	m	mm	lb/in	N/mm
1.411	0.0358	35.836	3.500	0.0889	88.9	2.500	0.0635	63.5	500.45	87.64

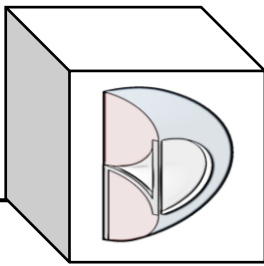
Spring Results (FEA)			
Mean Dia.	Force	defl	Rate
mm	N	δ (mm)	(k) N/mm
76.2	876.4	10	87.6
in	lb	in	lb/in
3.000	197.03	0.394	500.4



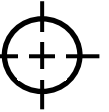
Adjusted for CATIA FEA	
36.692	= Pitch in Helix_Mid
2.55	= Factor for Coils in Helix_Mid
6.10	= Coils in Helix_Mid
223.820	= Height in Helix_Mid
20.18	= Δ Free Length to Helix_Mid Ht.
10.09	= Height of Helix_Mid Start Plane
0.86	= Factor for Pitch in Helix_Upr&Lwr
0.50	= Factor for Height in Helix_Upr&Lwr
8.68	= Pitch in Helix_Upr&Lwr
5.05	= Height in Helix_Upr&Lwr

Changed from
8.577 to 8.678

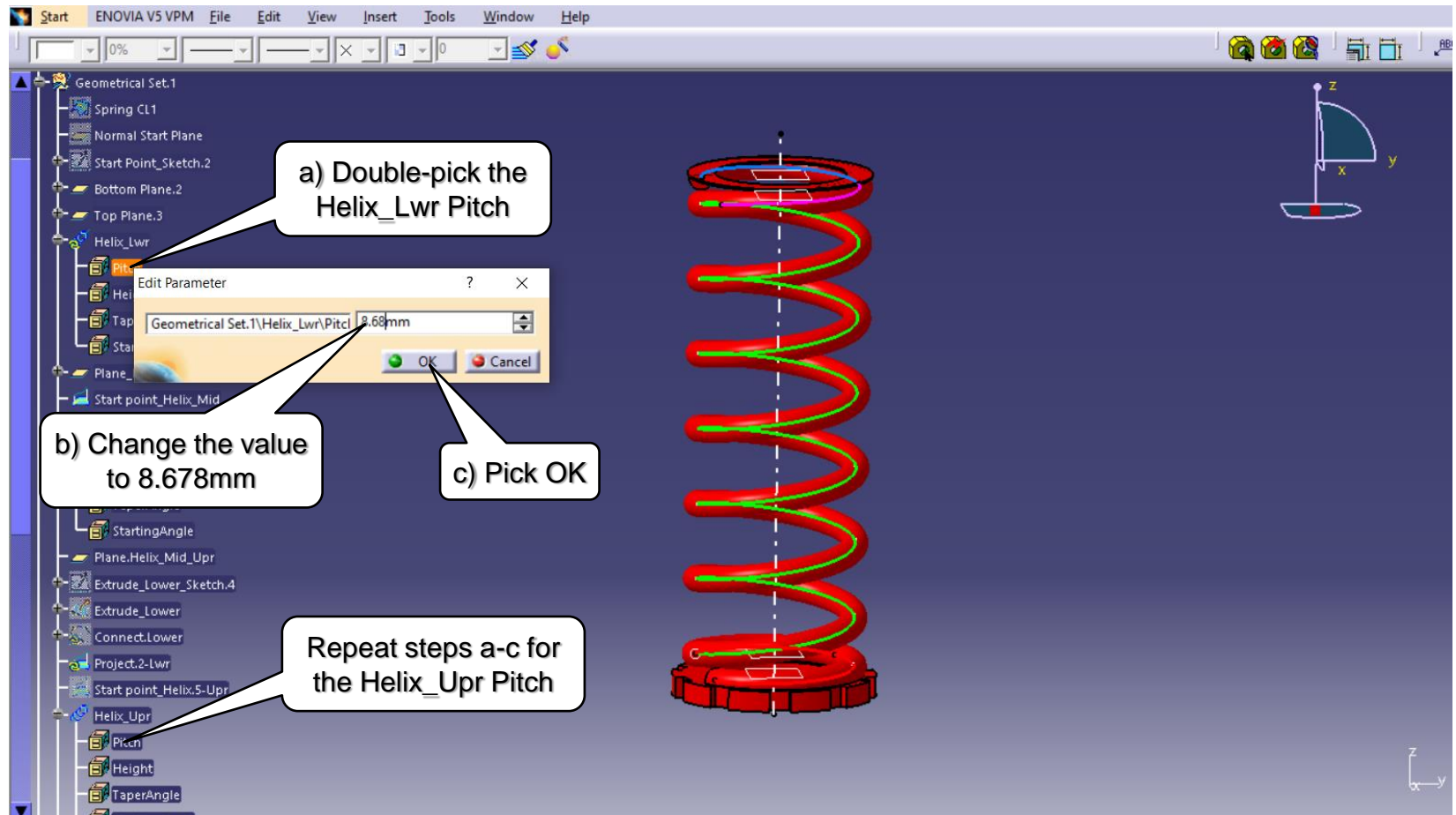
Changed from
0.85 to 0.86

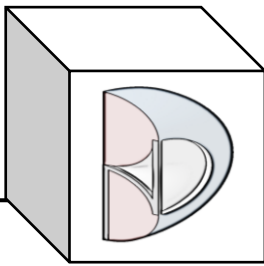


BND TechSource

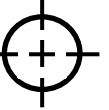


- Adjust the Spring CATPart Up & Lwr Helix.





BND TechSource



- Re-compute the Assy Preload analysis.

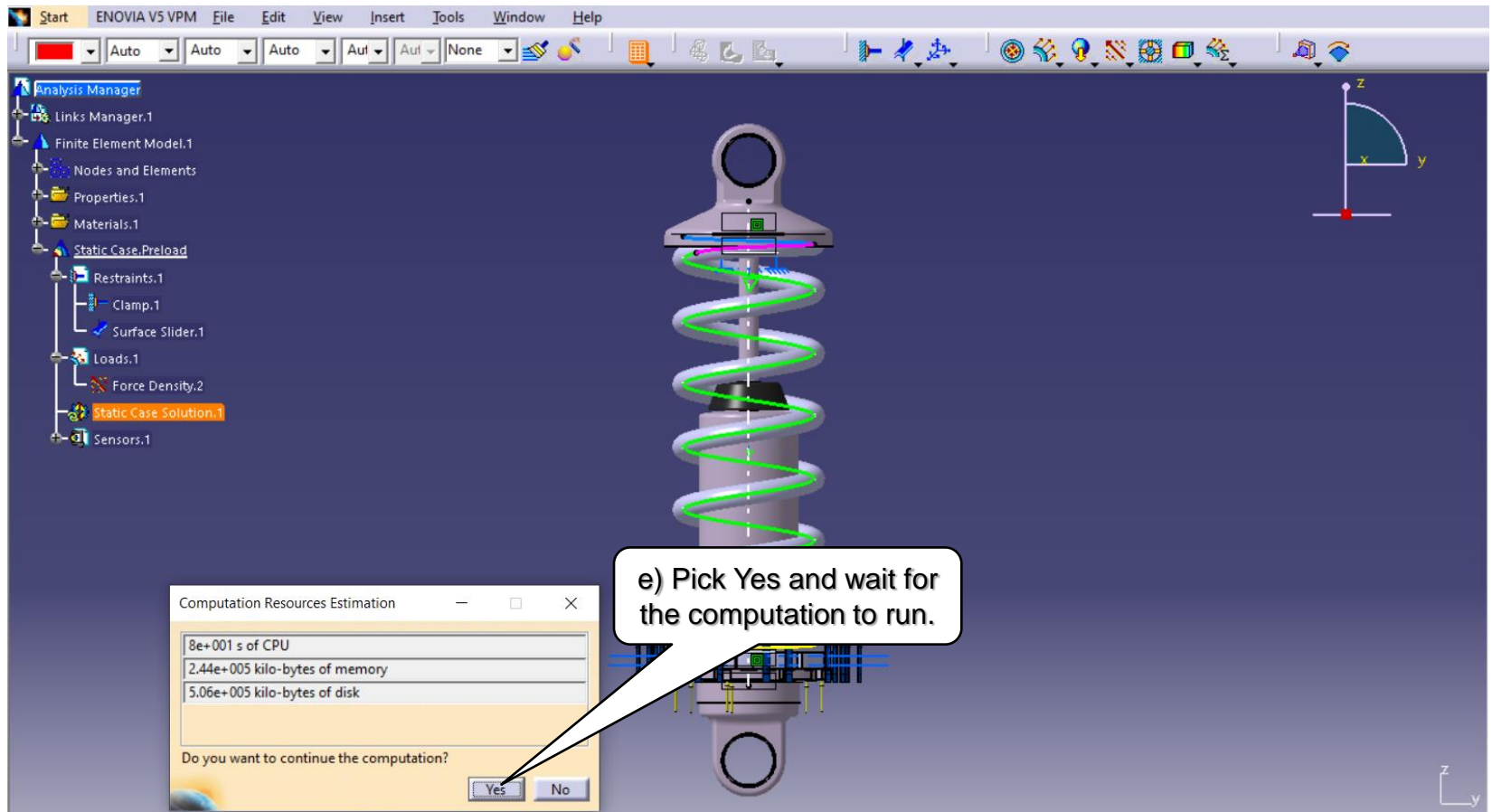
The screenshot displays the ENOVIA V5 VPM software interface. The top menu bar includes Start, ENOVIA V5 VPM, File, Edit, View, Insert, Tools, Window, and Help. The toolbar contains various icons, with the 'Compute' icon (a grid) highlighted by a red box and labeled 'a) Pick the Compute icon'. The left-hand 'Analysis Manager' tree shows a hierarchy: Links Manager.1, Finite Element Model.1, Nodes and Elements, Properties.1, Materials.1, Static Case:Preload, Restraints.1 (containing Clamp.1 and Surface Slider.1), Loads.1 (containing Force Density.2), Static Case Solution.1 (highlighted in orange and labeled 'c) Pick the Static Case Solution'), and Sensors.1. The central 3D model shows a vertical spring assembly with green helical springs and blue/purple components. A coordinate system (x, y, z) is visible in the top right. A 'Comp...' dialog box is open in the bottom right, with 'Analysis Case Solution Selection' as the title. It contains a dropdown menu set to 'Static Case Solution.1' and a 'Preview' checkbox. The 'OK' button is highlighted by a red box and labeled 'd) Pick OK'. A callout 'b) Select the Analysis Case Solution selection' points to the dropdown menu.

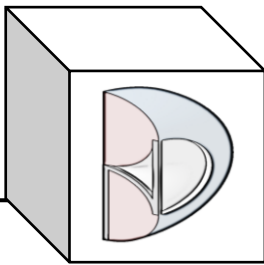


BND TechSource

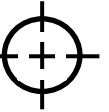


- Re-compute the Assy Preload analysis.

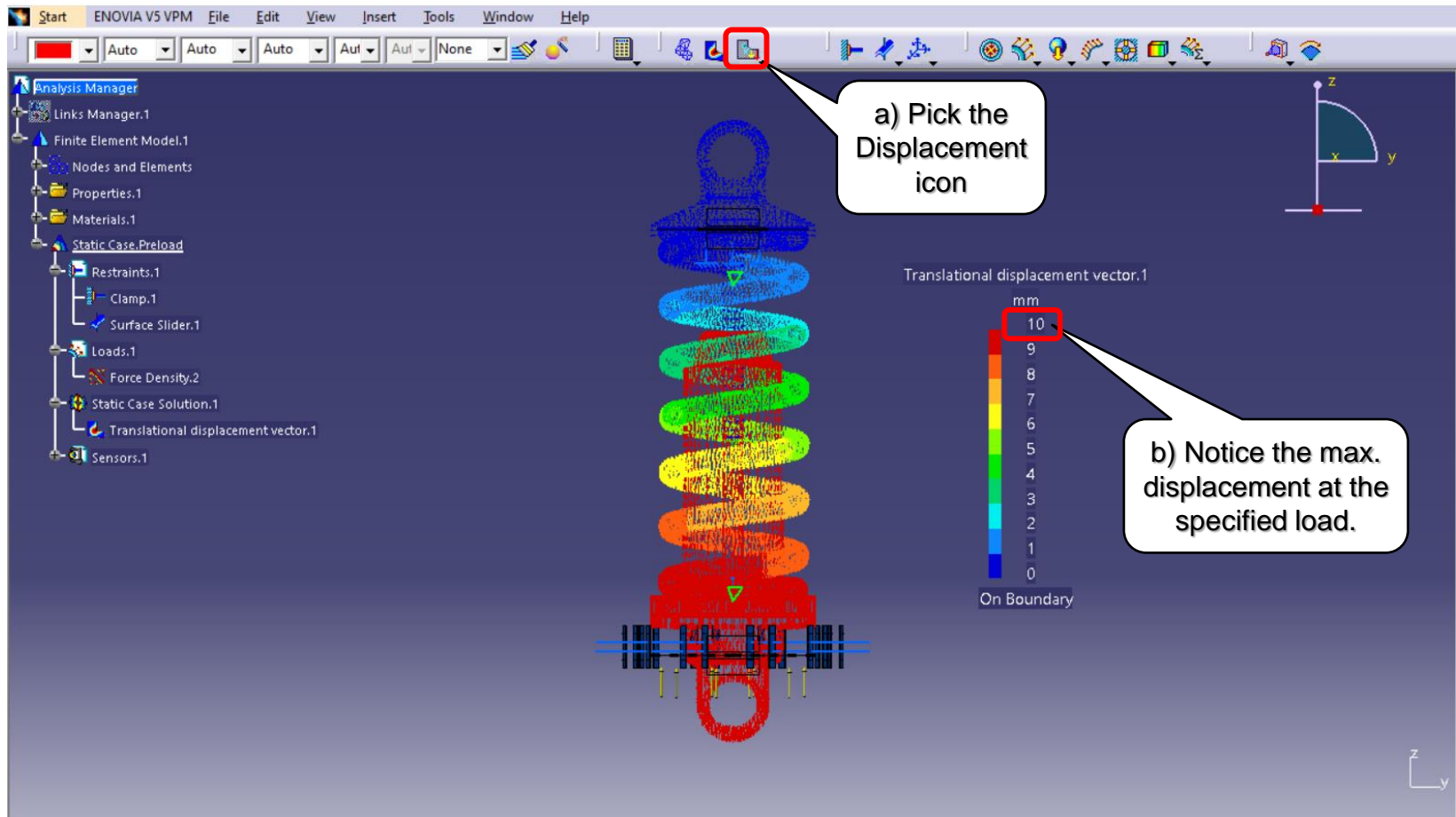


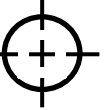


BND TechSource



- Show results of the Assy Preload analysis.





- Create a new Static Case. Assy Shock Deflection.

The screenshot illustrates the steps to create a new Static Case in the ENOVIA VS VPM software:

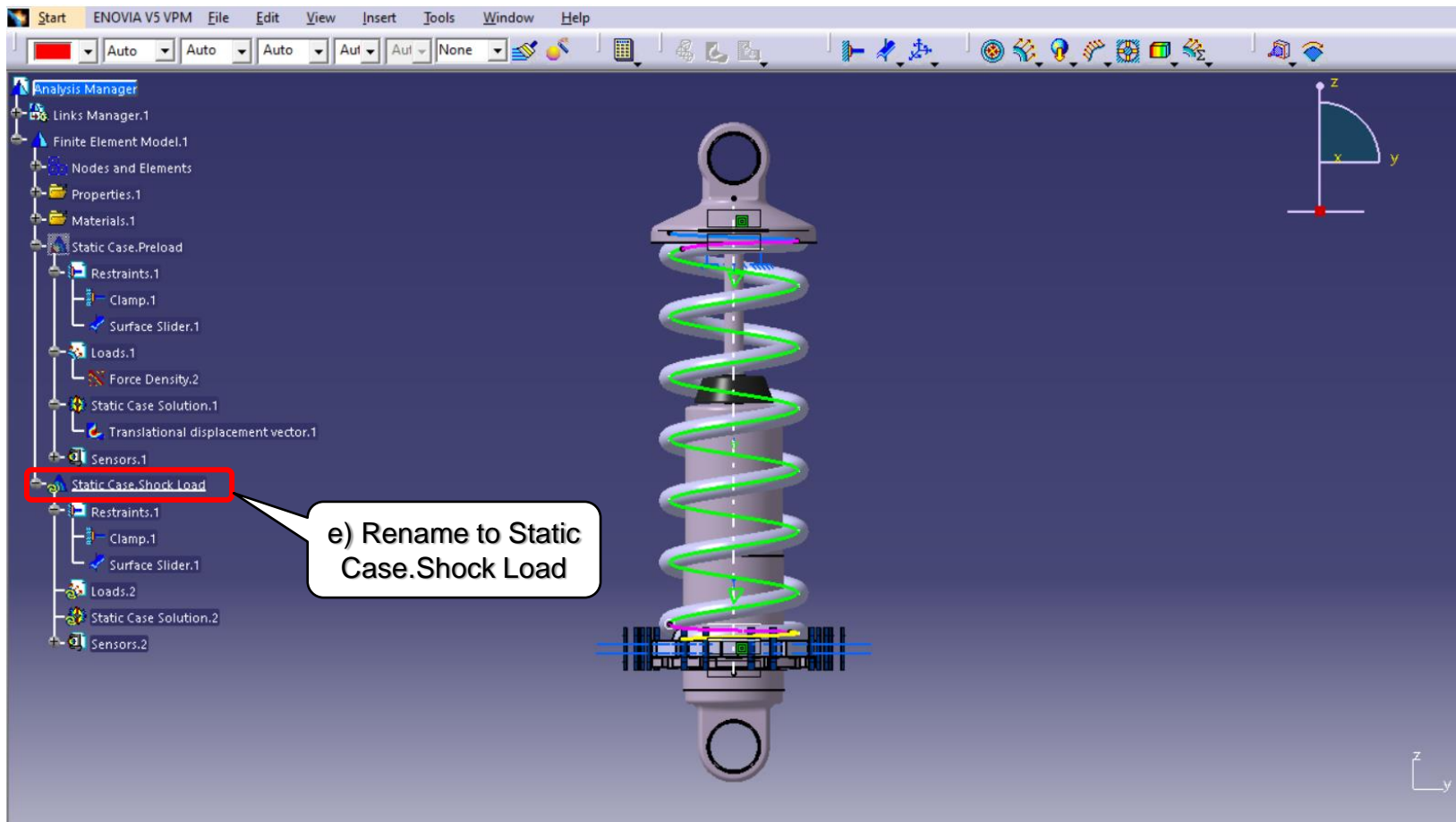
- a) Pick Insert + Static Case**: The 'Insert' menu is highlighted, and the 'Static Case' option is selected from the 'Object' dropdown.
- b) Pick Restraints + Reference**: The 'Static Case' dialog box is open, and the 'Reference' radio button is selected under the 'Restraints' section.
- c) Pick Restraints.1 from Static Case.Preload**: The 'Restraints.1' option is selected from the 'Static Case.Preload' folder in the Analysis Manager tree.
- d) Pick OK**: The 'OK' button is clicked to confirm the selection.



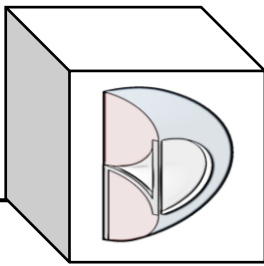
BND TechSource



- Create a new Static Case.Assy Shock Deflection.



e) Rename to Static Case.Shock Load



BND TechSource



- Create the new Shock Load (30 x rate \rightarrow 2629.2N).

a) Pick the Force Density icon

b) Select the bottom surface of the retainer

c) Set Z to 2629.2N

d) Pick OK

Force Density D...

Name: Force Density.2

Supports: 1 Face

Axis System

Type: Global

☐ Display locally

Force Vector

Norm: 2629.2N

X: 0N

Y: 0N

Z: 2629.2N

OK Cancel



BND TechSource



- Create a new Combined Case.Assy Shock Deflection.

a) Pick Insert + Combined Case

b) Double-pick Combined Static Case.1

c) Pick Combined Static Case Solution.1 to add to the index

d) Pick Combined Static Case Solution.2 to add to the index

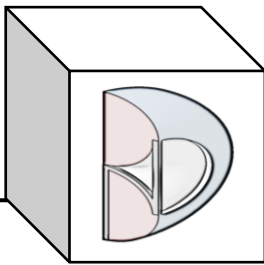
e) Right-click the coefficient to edit

f) Set the first coefficient to -1

g) Set the second coefficient to 1

h) Pick OK

Index	Selected Solution	Coefficient	Occurrence	Path
1	Static Case Sol...	-1	Not applicable	St...
2	Static Case Sol...		Not applicable	St...



BND TechSource

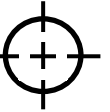


- Compute the analysis for the Combined Case.

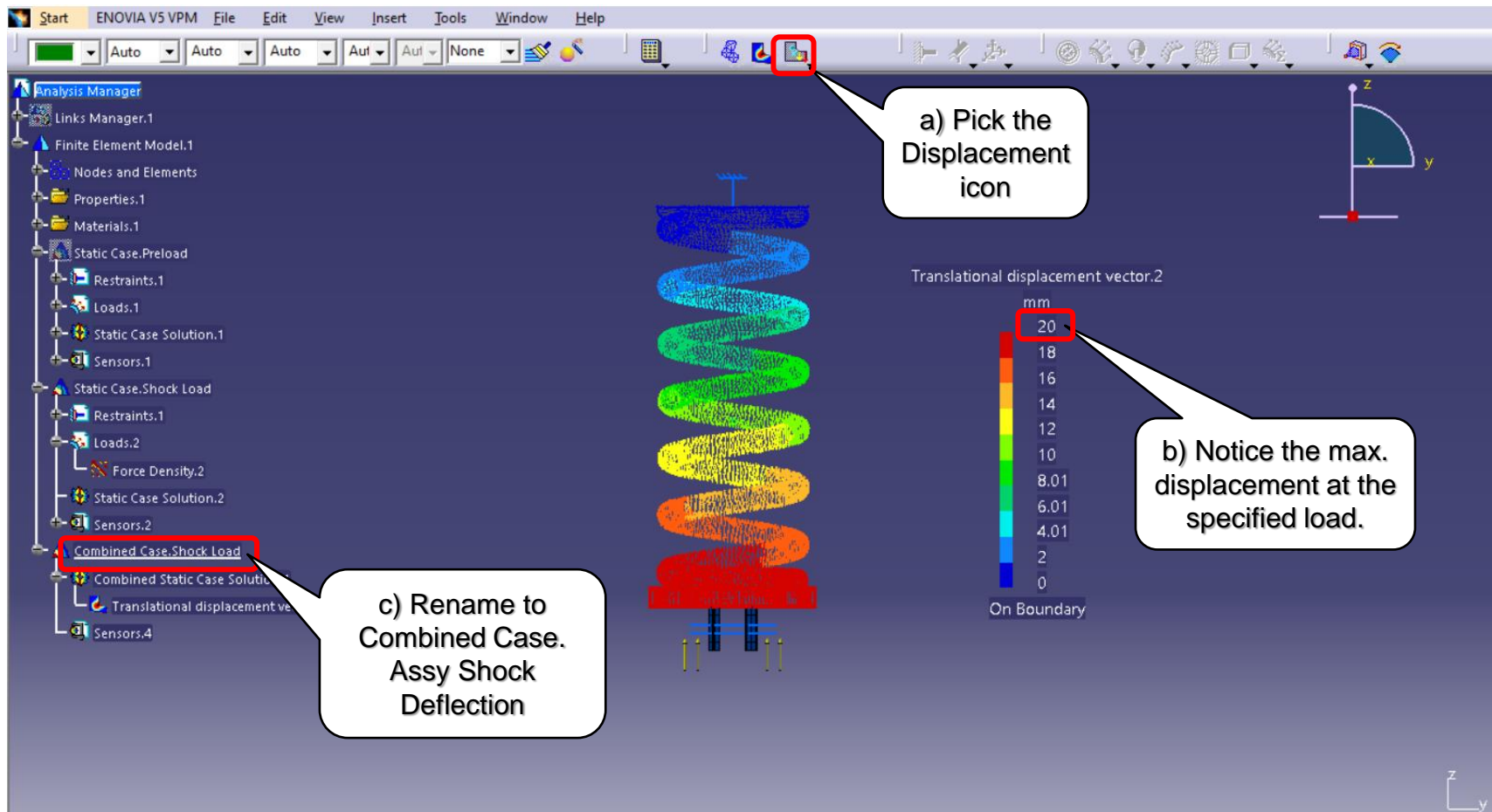
The screenshot displays the ENOVIA V5 VPM software interface. The top menu bar includes 'Start', 'ENOVIA V5 VPM', 'File', 'Edit', 'View', 'Insert', 'Tools', 'Window', and 'Help'. Below the menu is a toolbar with various icons. The left sidebar shows the 'Analysis Manager' tree with the following structure:

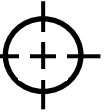
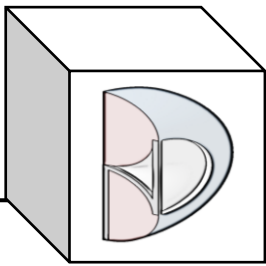
- Links Manager.1
- Finite Element Model.1
 - Nodes and Elements
 - Properties.1
 - Materials.1
 - Static Case.Preload
 - Restraints.1
 - Loads.1
 - Static Case Solution.1
 - Sensors.1
 - Static Case.Shock Load
 - Restraints.1
 - Loads.2
 - Static Case Solution.2
 - Sensors.2
 - Combined Case
 - Combined Static Case Solution.1
 - Sensors.3

The central 3D model shows a purple shock absorber. A red box highlights the 'Compute' icon in the toolbar, with a callout 'a) Pick the Compute icon'. The 'Combined Static Case Solution.1' item in the tree is highlighted in orange, with a callout 'c) Pick the Combined Case Solution.1'. The 'Compute' dialog box is open in the bottom right, showing 'Analysis Case Solution Selection' and 'Solution(s) to Be Computed' with 'Combined Static Case Solution.1' selected. A callout 'b) Select the Analysis Case Solution selection' points to the selection area. The 'OK' button is highlighted with a callout 'd) Pick OK'.

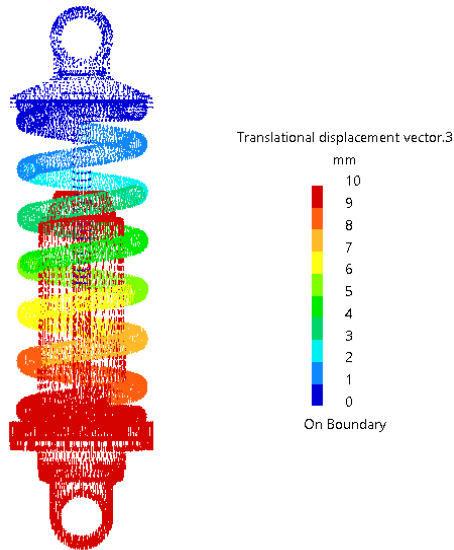


- Show results of the analysis of the Combined Case.Assy Shock Deflection.

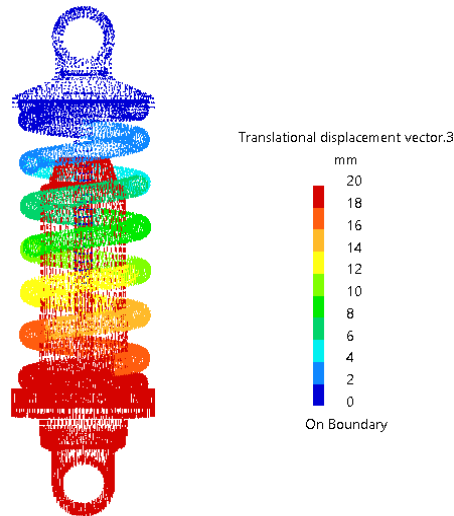




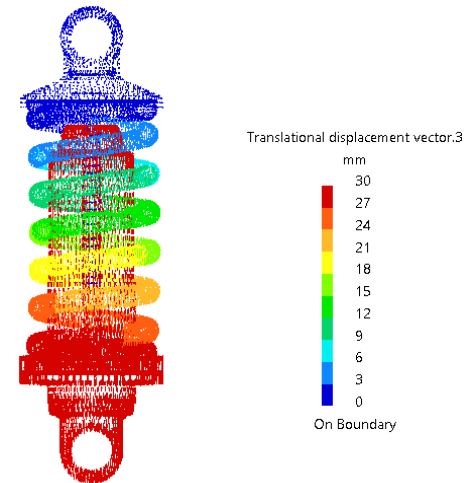
- The FEA analysis of the Preloaded Shock Assy correlates with the Spring Rate from the CATIA Part model and proves the rate remains Linear.



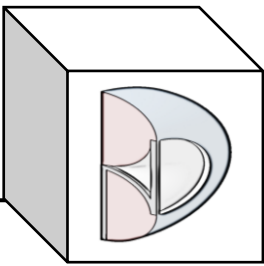
Load = 20X the
Spring Rate –
the Preload →
10mm Defl.



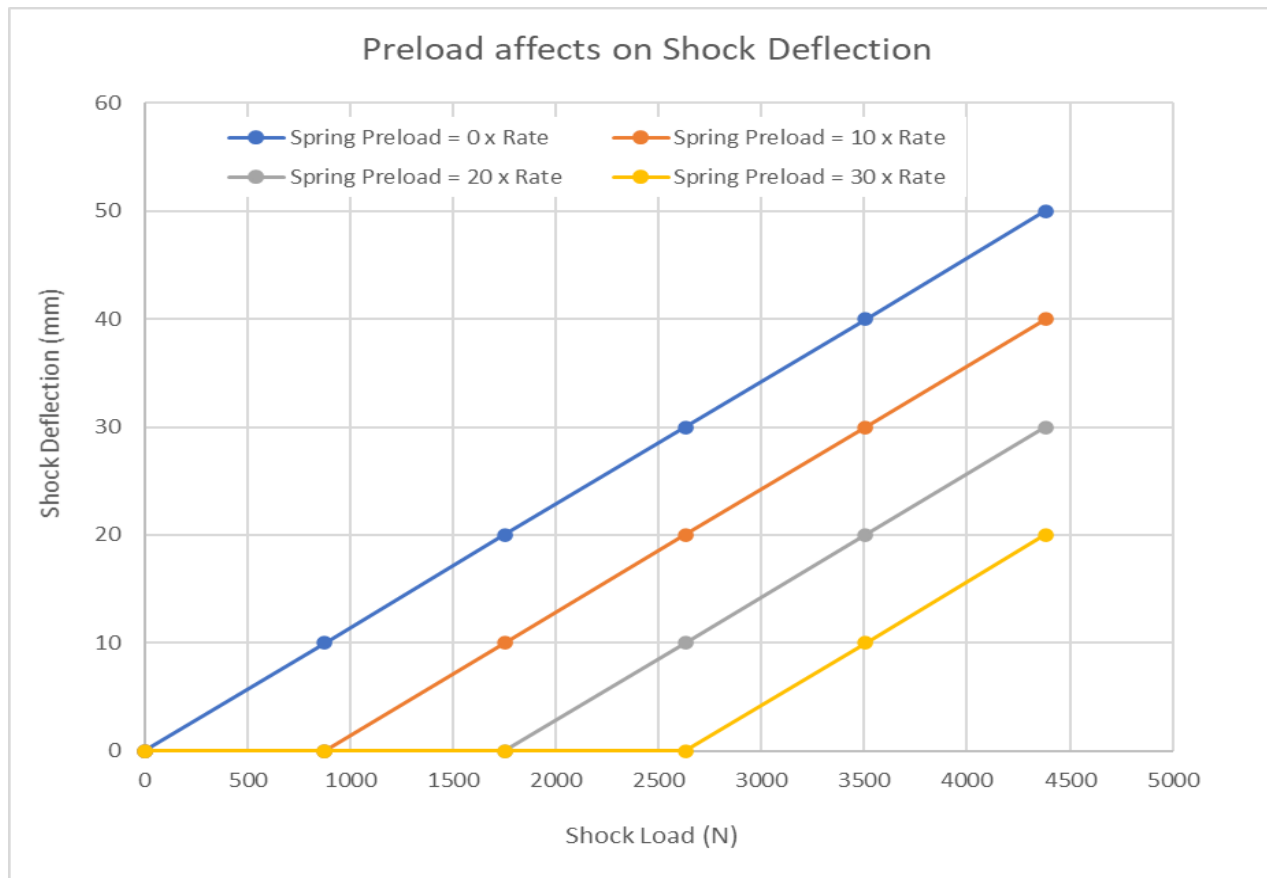
Load = 30X the
Spring Rate –
the Preload →
20mm Defl.

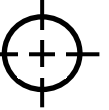
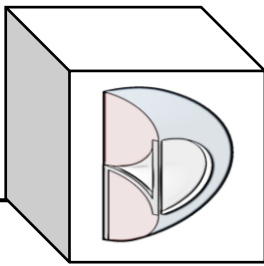


Load = 40X the
Spring Rate –
the Preload →
30mm Defl.

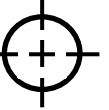
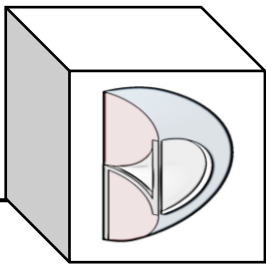


- Graph below shows the Shock Deflection based on Shock Load at various Preload conditions.





- In this Shock Absorber Preload Analysis, we have proven the following:
 1. The spring rate will be linear when the spring has a consistent (evenly spaced) pitch and a constant diameter.
 2. Preloading the spring on the coil over assembly will NOT change the rate of the spring.
 3. Preloading the spring on the coil over assembly WILL affect the deflection at load (length at load) of the shock absorber.



- Conclusion:

This is an example of how to use CATIA Generative Structural Analysis to prove the affects of Preload within the coil over shock absorber.

We hope this analysis proves useful for those who need to show a Torsion Bar Analysis.

As always, we are open to any discussions this may bring.

Please ***subscribe*** to our YouTube channel!

