PTC® PRODUCT & SERVICE ADVANTAGE

Simulation-News in Creo 1.0 & 2.0 & 3.0

Weighted Links: "Tips & Tricks"

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- Focused on PTC-simulation products
- Presales, Training, Consulting, …
- 25+ years simulation-experience (17 years with PTC)

Agenda

- What's New: - PTC Creo Simulate 1.0
  - PTC Creo Simulate 2.0
- What's Next: - PTC Creo Simulate 3.0
- Weighted Links: "Tips & Tricks"
- Live-Demos: - Mechanism-Connections
  - Connections with Stiffness (e.g. Roller-Bearing)
- Questions

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WHAT'S NEW
WHAT'S NEXT

What's New: PTC Creo Simulate 1.0

http://www.ptc.com/appserver/wcms/relnotes

Pro/MECHANICA → creo® simulate

PTC Creo Simulate 1.0: User Experience

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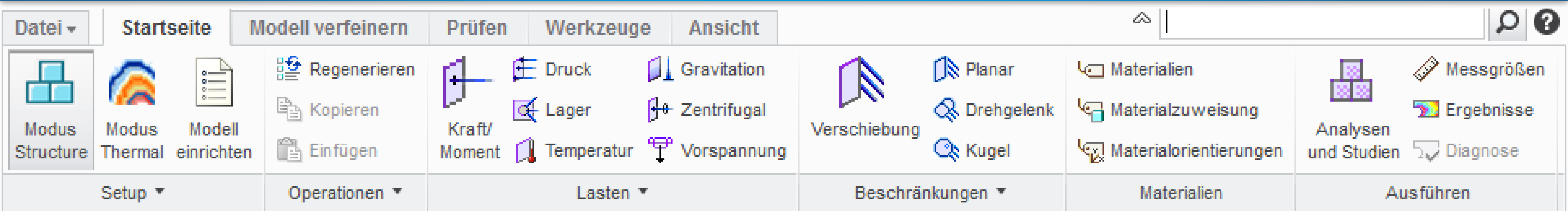


> PTC Creo Simulate Standalone

> Ribbon UI

> Unit Support on all dialogs / Results

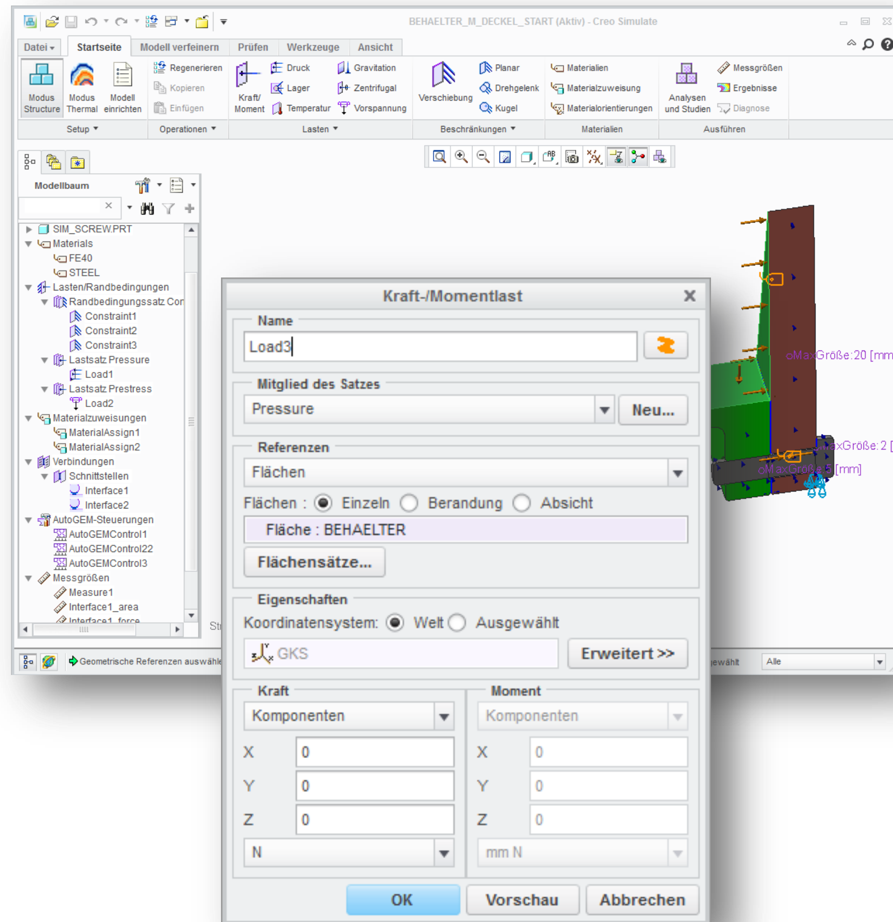
> Moments/Rotations active when valid

> Distributed Batch Support

> Process Guide Template editor

> 3D icons for loads, constraints

> Mesh display in exploded view



PTC Creo Simulate 1.0: Engineering Functionality

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> General Large Displacement Analysis:
- Contacts
- Plasticity
- Hyper-Elasticity

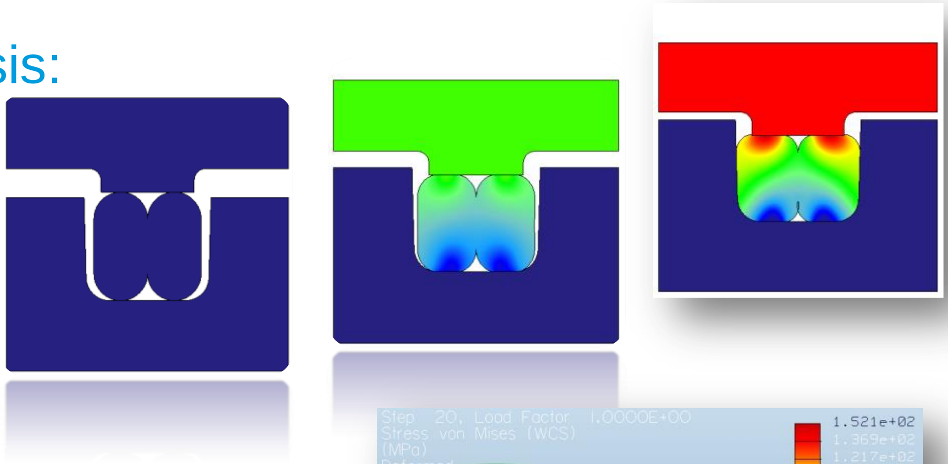
> Nonlinear Thermal Analysis:
- Temperature Dependent Conductivity
- Generalized Convection Conditions
- Radiation Conditions

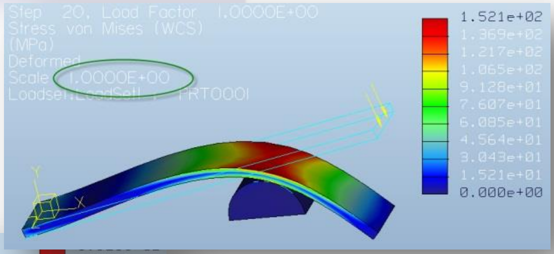
> Modeling of nonlinear springs

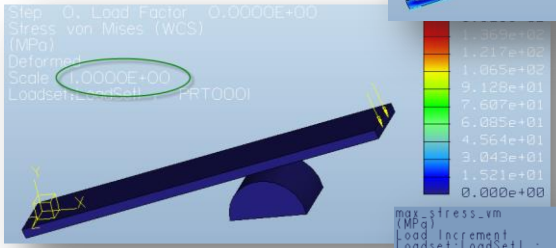
> Ordering of nonlinear loads

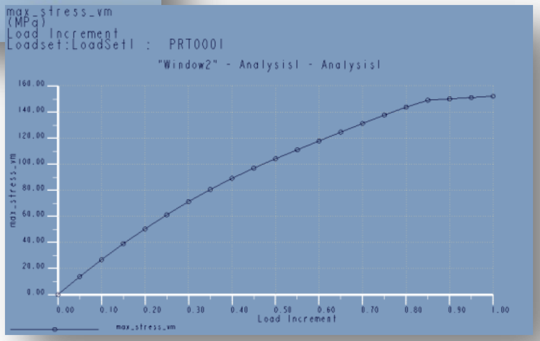
> 2D axi-symmetric LDA

> Modeling of UCS constraints in LDA

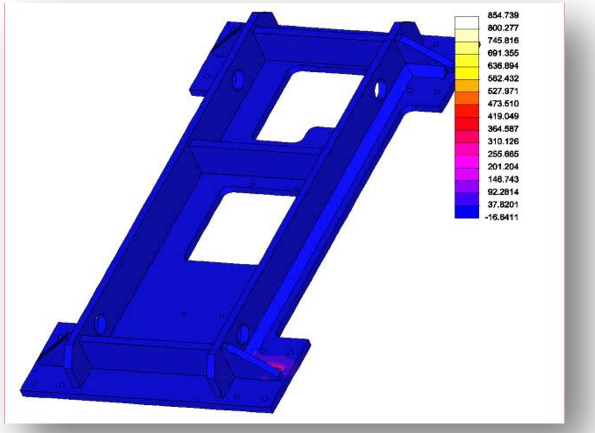








PTC Creo Simulate 1.0: Engineering Functionality



> Moving Heat Loads:

- Heat loads as combined functions of time and space
- Heat loads on composite curves
- Heat Loads as functions of arc length

> Generalized modeling of Total Volume Heat Load

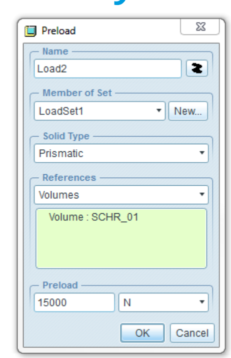
> Base Excitation Enhancements:

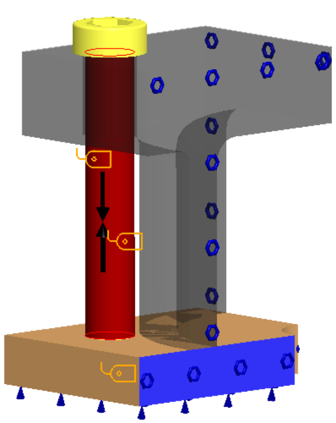
- Different histories in different directions
- Linear and rotational motion of the supports
- Support G^2/Hz units of PSDs

> Calculation of von Mises stress results in Random Analyses

> Preload on bolts modeled as solids

> Modeling of variable thickness shells





PTC Creo Simulate 1.0: Results

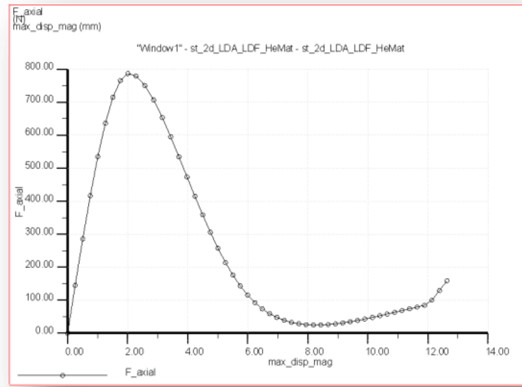
> Animation of Dynamic Frequency results

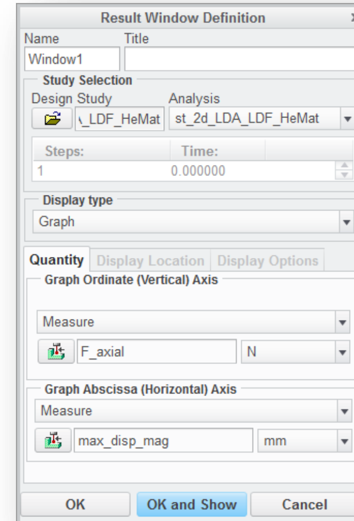
> Measure vs. Measure graphs

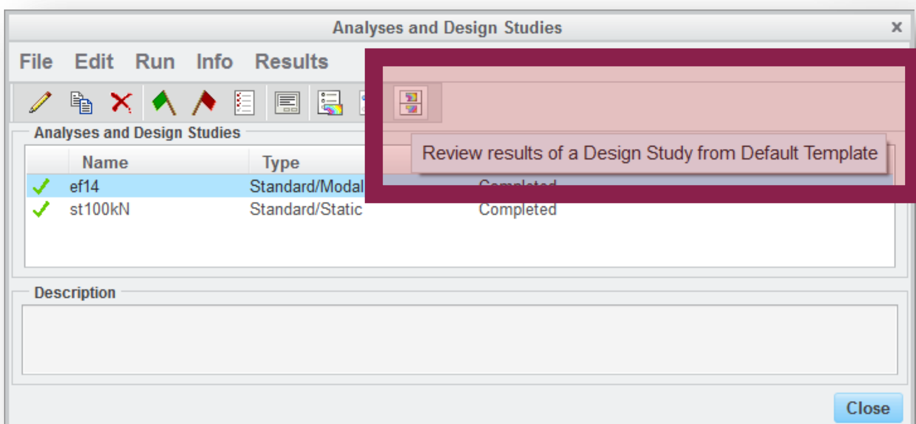
> Animation on cutting planes

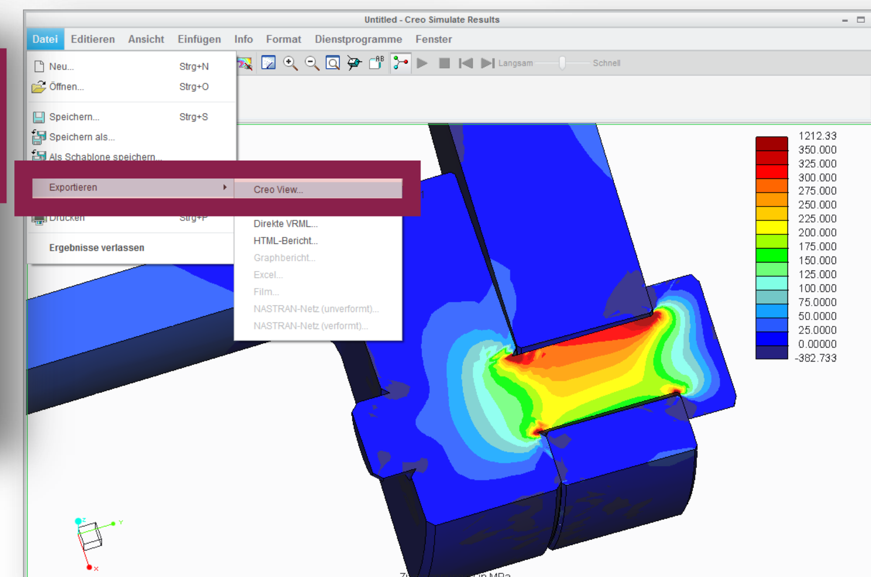
> Default Result templates

> Output to PTC Creo View

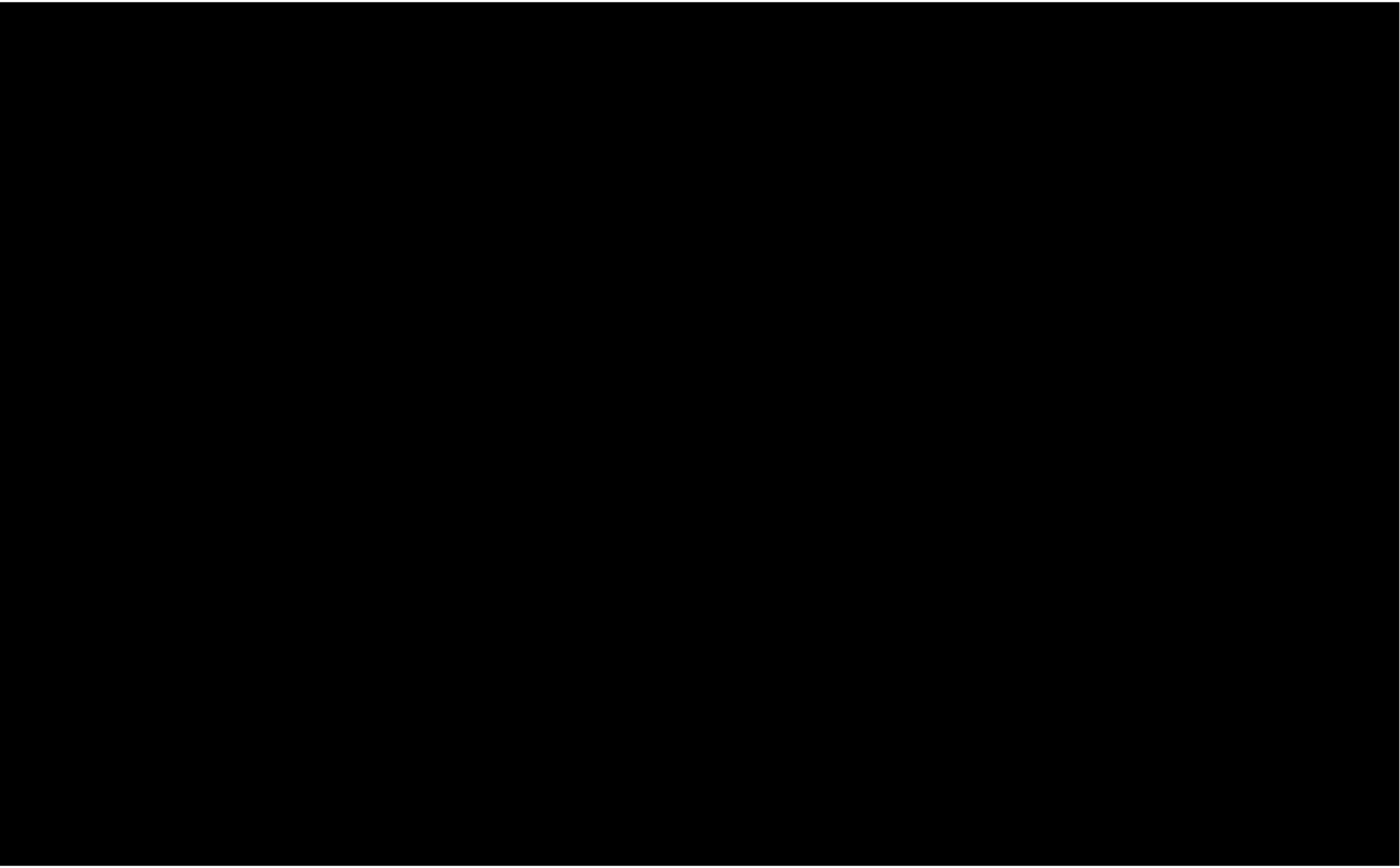








PTC Creo Simulate 1.0: Output to PTC Creo View



PTC Creo Simulate 1.0: Robustness

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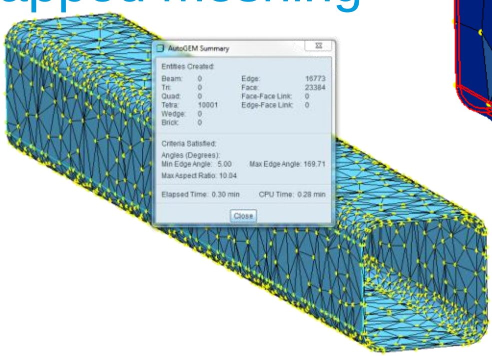
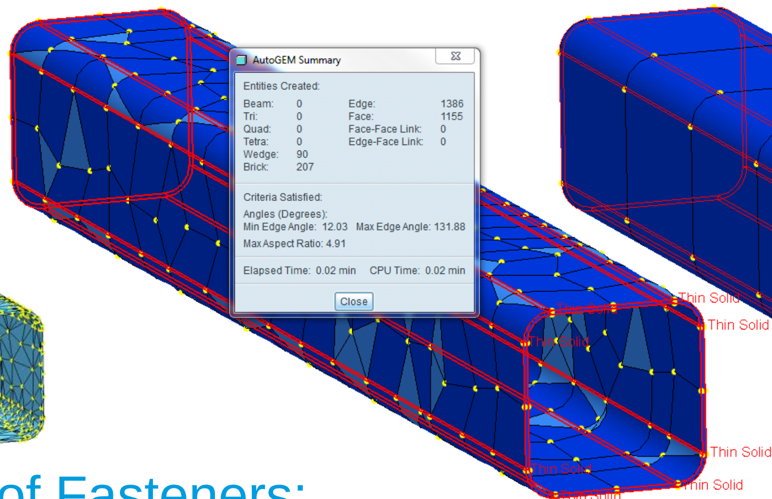
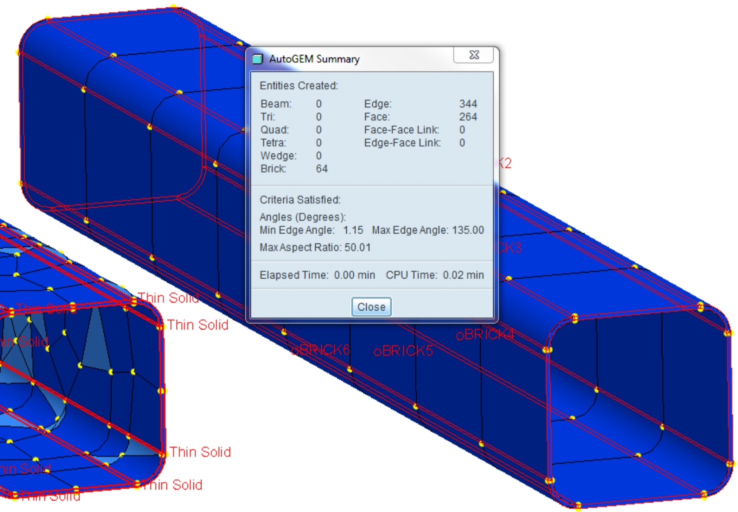
> Ability to mesh thin regions with bricks and wedges

> Ability to mesh prismatic regions with bricks and wedges

> Mapped meshing

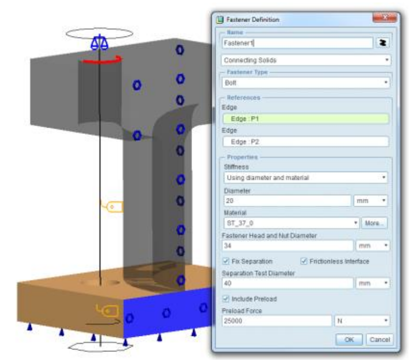






> Enhanced modeling of Fasteners:

- More accurate modeling of interface between bolted components
- Modeling of bending and torsion effects
- New measure calculations



> Filtering of negative Buckling Factors

> Increased solver memory

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WHAT'S NEW
WHAT'S NEXT

What's New: PTC Creo Simulate 2.0

PTC Creo Simulate 2.0: Engineering Functionality

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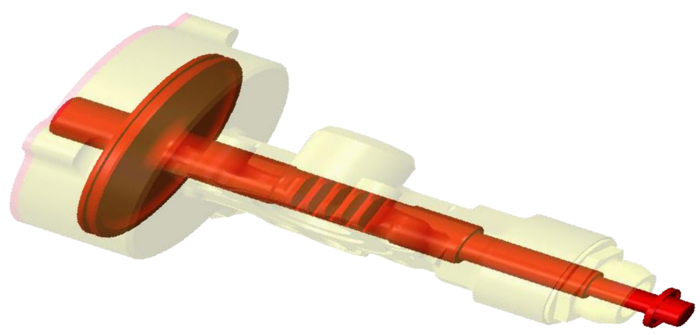
> Temperature History as Load of Nonlinear Static Analysis

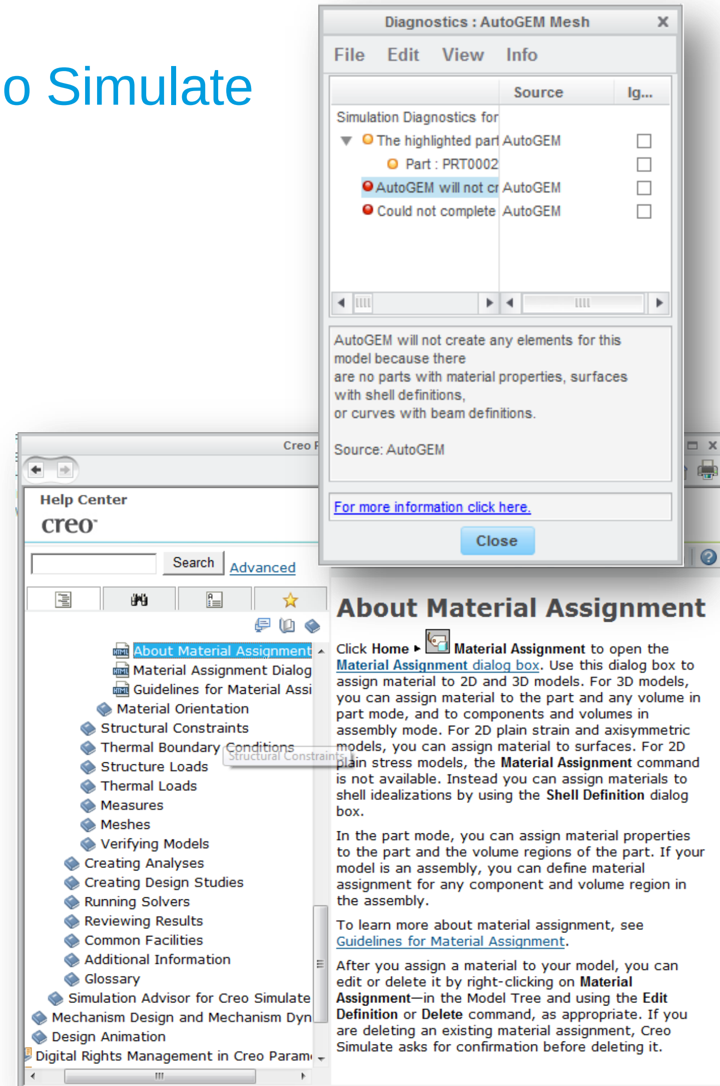
> Lightweight Assembly Representations in Creo Simulate

> Online Help Links in Diagnostics

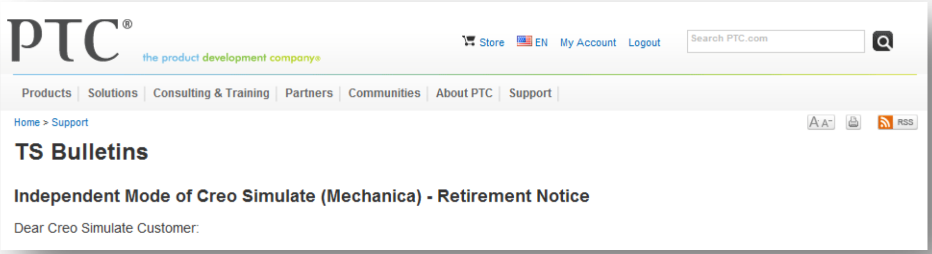
> Speedup of Dynamic Analysis Calculations

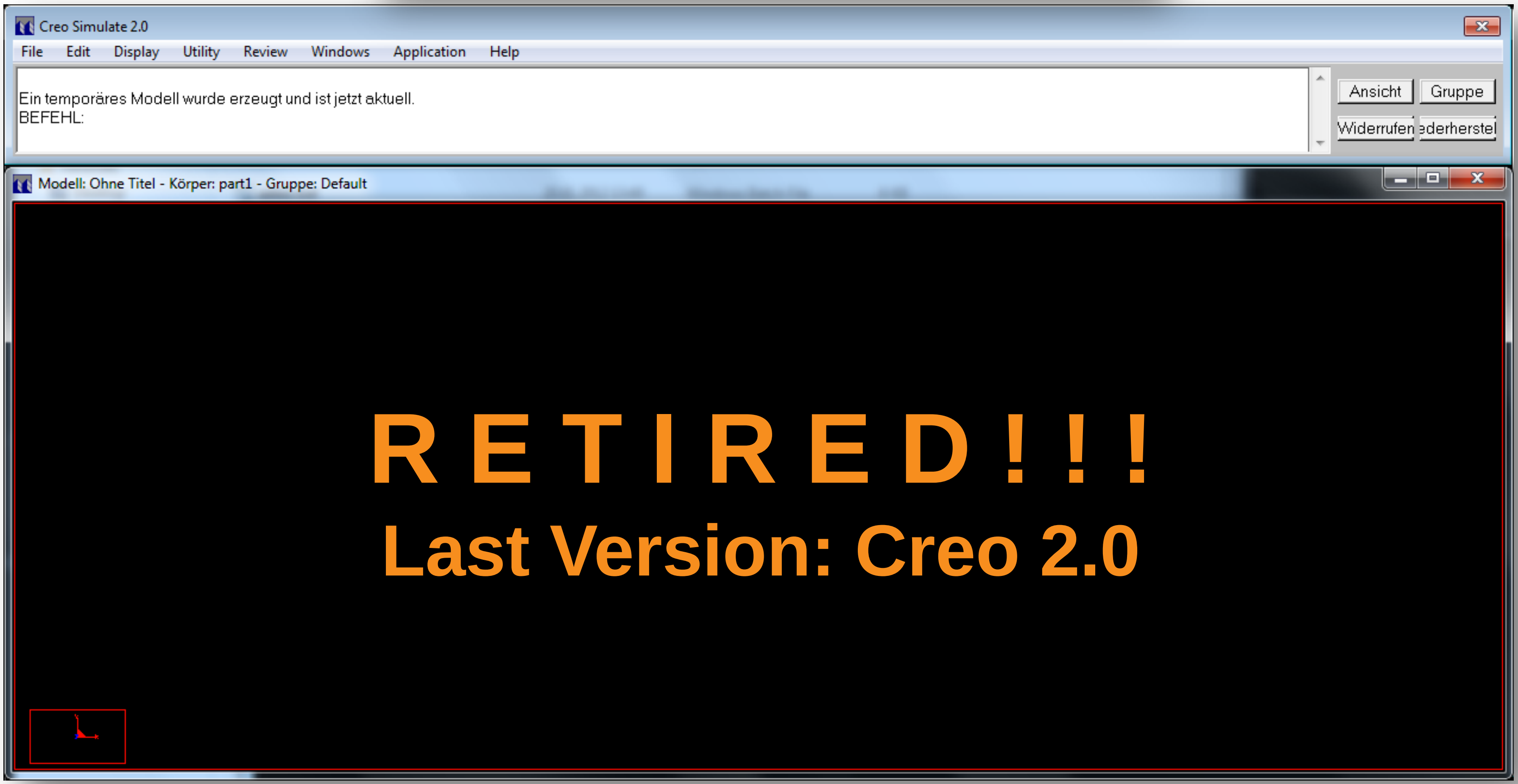
> General Performance Tuning





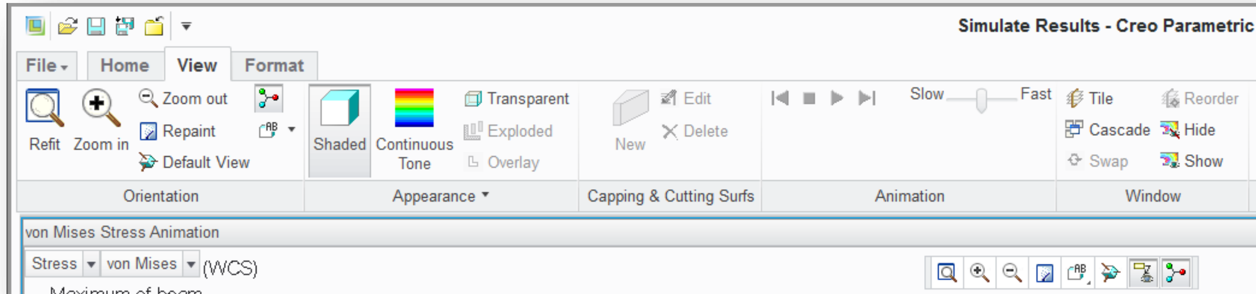
Independent Mode → Retirement



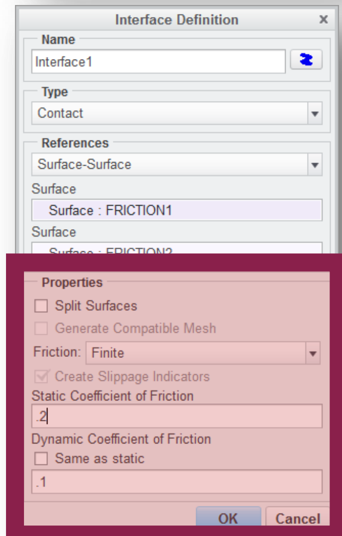


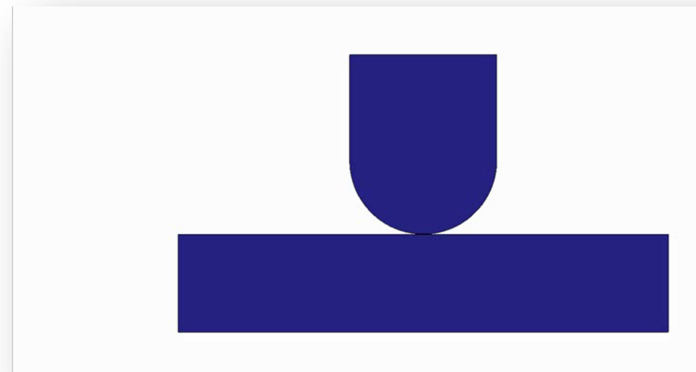
What's Next: PTC Creo Simulate 3.0

> New Ribbon-based UI for Results

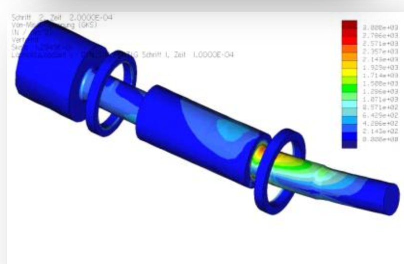


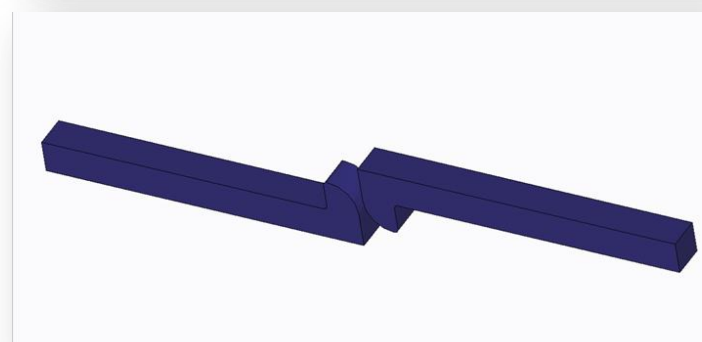
> Contact with sliding finite friction





> Faster dynamic analyses





Future Plans PTC Creo Simulate 3.0: User Experience

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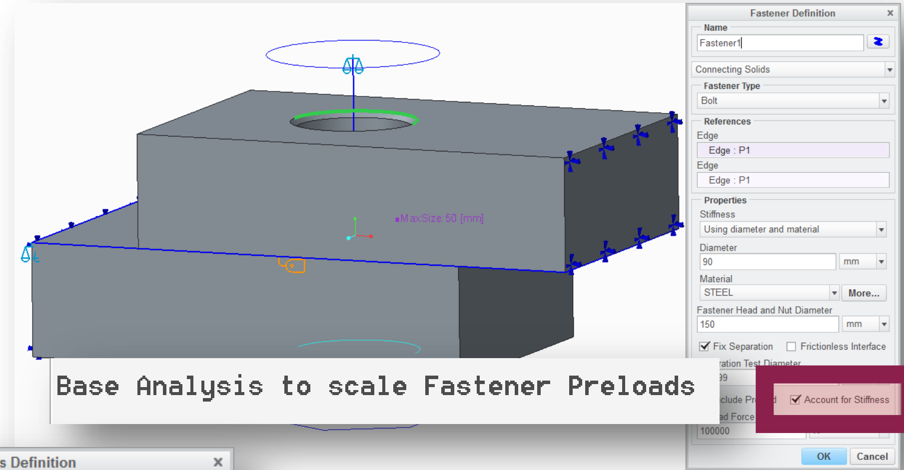
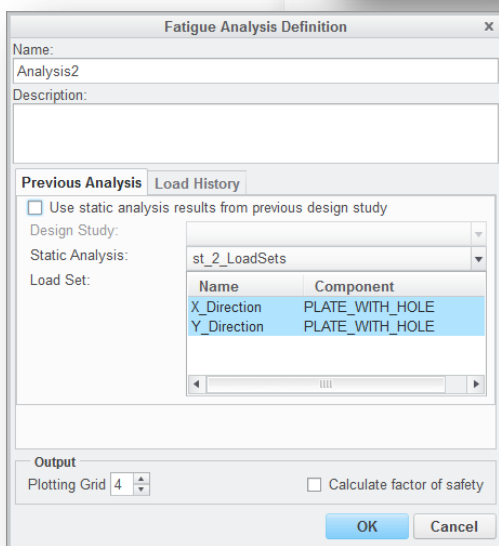
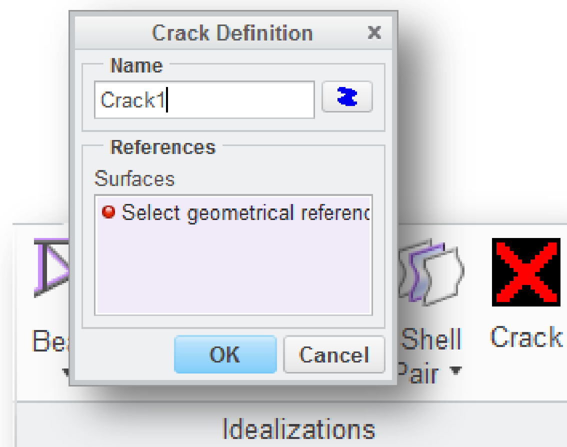
> Automatic preloads for fasteners



> Fatigue Analysis with Multiple Load Sets



> Stress intensity factor measures for cracks



Future Plans PTC Creo Simulate 3.0: User Experience

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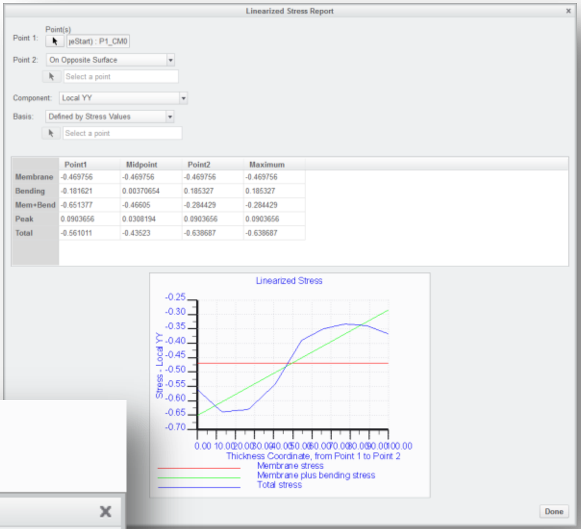
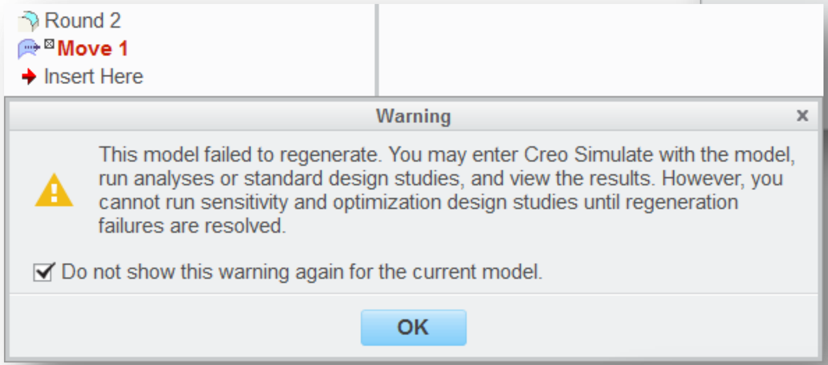
- Improved UI for linearized stresses



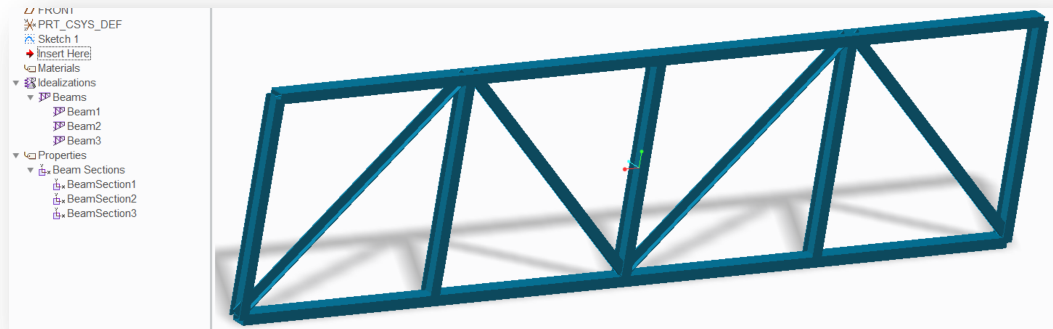
- Can enter Simulate with failed features



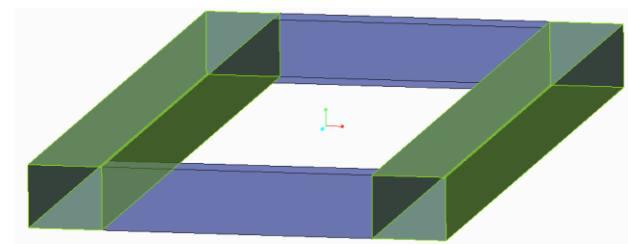
- Faster entrance into Simulate from Creo Parametric & Creo Direct

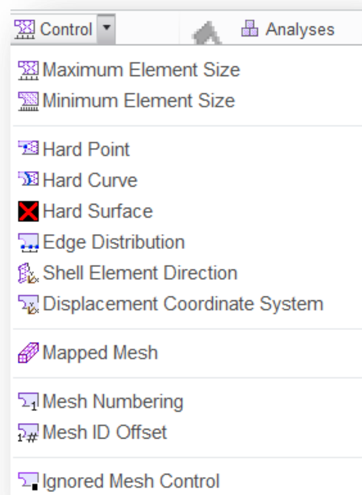
Future Plans PTC Creo Simulate 3.0: User Experience

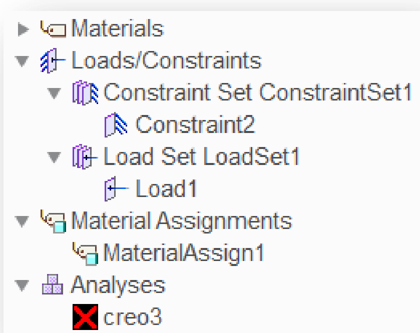
> Beams, shells, fasteners displayed as solid geometry

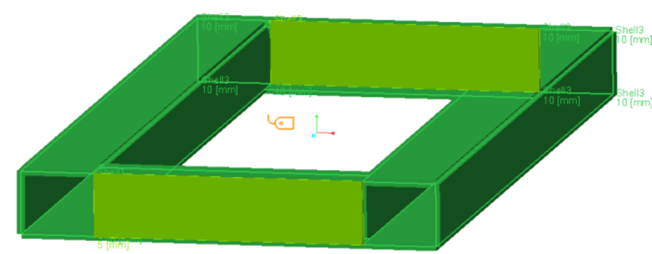


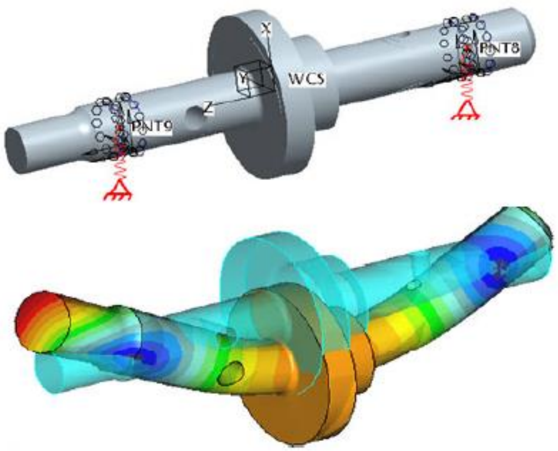
> In addition there are many other small, less impactful features added to Creo 3.0

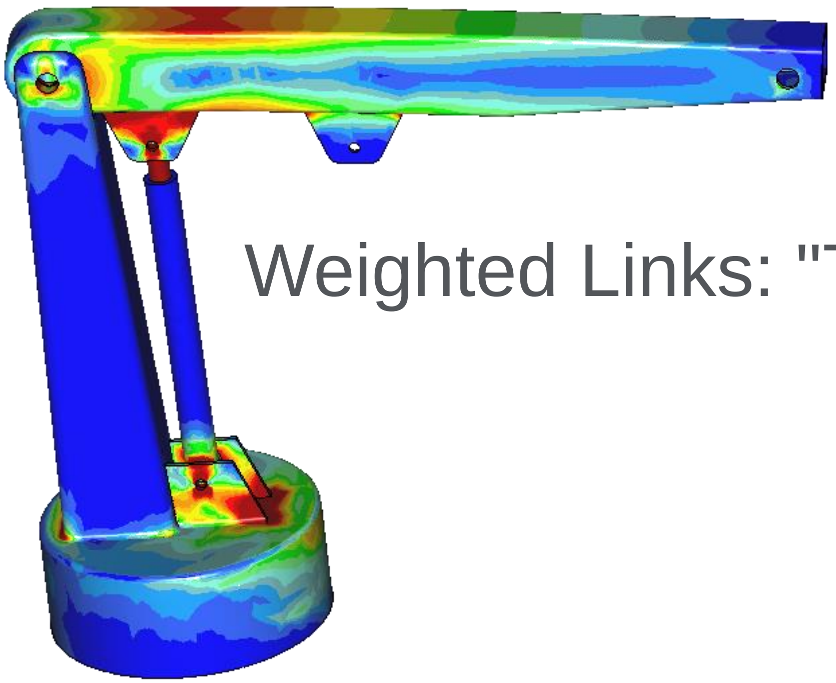












Weighted Links: "Tips & Tricks"

Functionality: Weighted Links

Theoretical Background:

- Weighted Links allow to transfer the displacements of so called independent references (points, edges/curves or surfaces) to one dependent point.
- A special technique is used to weight (average) and transfer them to the dependent point.
- The dependent point may also rotate if the independent references enforce a rotation by their displacements; however, a pure local rotation of an independent reference (e.g. of a shell or beam) is not taken into account for the dependent point rotation.
- In opposite to rigid links the selected references do not become a rigid body; they stay flexible.

Use-Cases: Weighted Links

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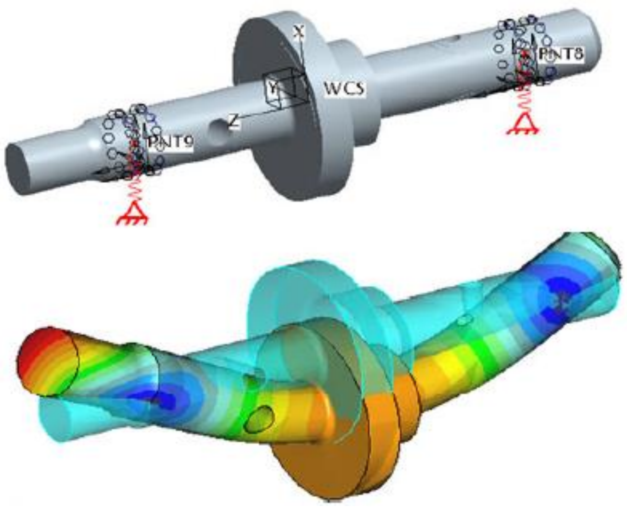
Functionality Purpose:

- It is not easy to understand how weighted links work; in case of doubts try it out on a simple model.
- Real structures, who are idealized with help of rigid or weighted links, often behave somehow in between: They are neither infinite stiff nor do not add any stiffness.
- A big advantage of weighted links compared to rigid links is that there are no stiffness jumps at the edges of their referenced surfaces, the surfaces can still deform.
- So, a weighted link is a good idealization e.g. to built cylindrical joints: Connect a beam end point (the beam represents the axis) as dependent point to the bearing hole surface (=independent surface).

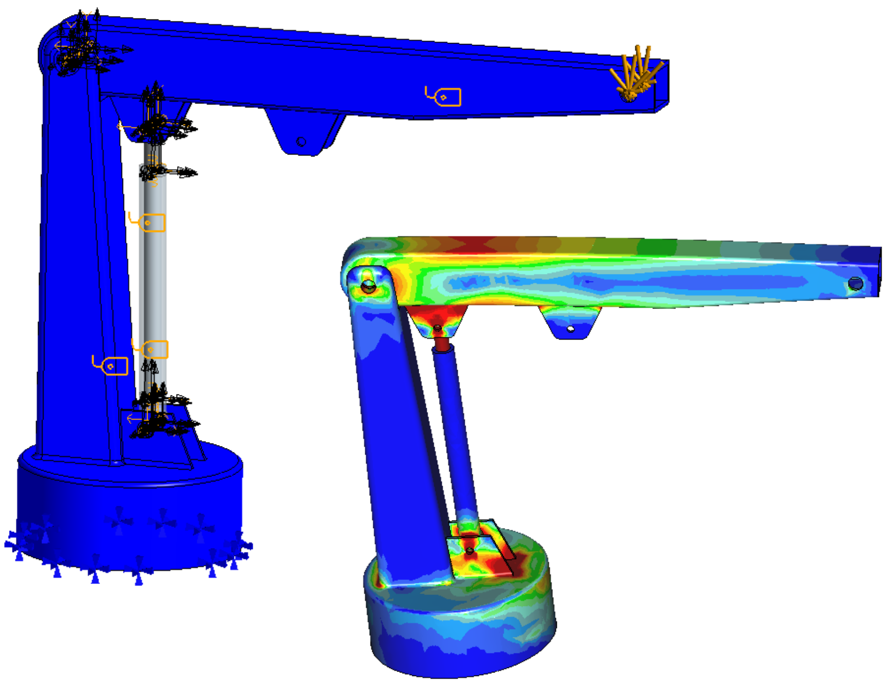
Functionality Purpose:

- Idealized connection of references from one or more parts or simulation elements to obtain a certain structural behavior



Simply supported shaft under bending and torque

Mechanism-Connections



Use-Cases: Weighted Links

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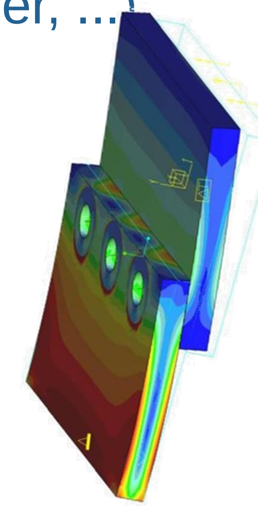
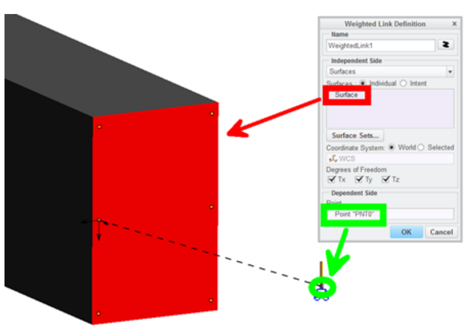
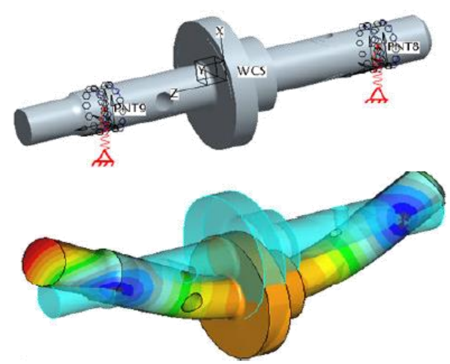
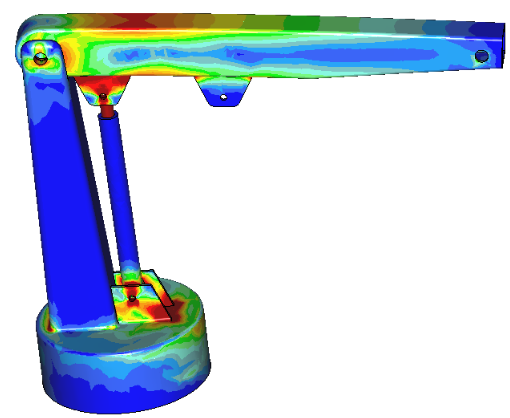
Wide application spectrum:

- Modeling Connections with Stiffness (e.g. Roller-Bearing)
- Modeling Mechanism-Connections (e.g. Pin, Cylinder, Ball, Slider, ...)
- Modelling Prestressed Screw (with Beams/Shells)
- Total Load Applied at Point: Measuring the Point-Deflection
- Applying a Moment-Free Enforced Dispacement
- Connecting Mass Elements
- Avoid Singularities
- ...









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Modeling Connections with Stiffness (e.g. Roller-Bearing)

We want to study displacements and stress of a traction sheave shaft. From the belt drive, the shaft is loaded in bending and torque. From limp belt theory, we have derived the equations shown below for a wrap angle of 180° . Note it is assumed that a belt tensioning pulley holds the belt force B_1 constant. We are interested in the components of the shaft loading (1. pressure from belt pretension, 2. torque equilibrium, 3. additional belt pressure from the transferred torque). We want to transfer a nominal torque of 50 Nm.

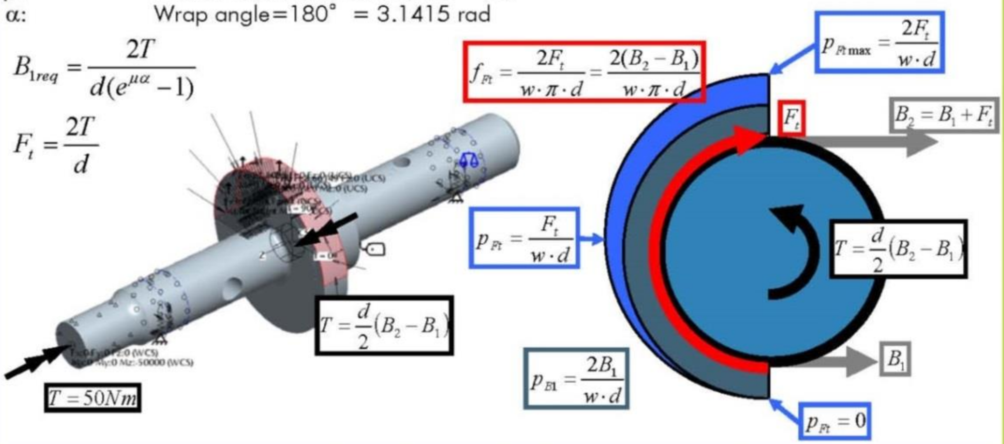
1. Open the part *"traction_sheave_shaft"*
2. Study the components of belt loading shown right and think about which components belong into which load set regarding the three points listed above.
3. Create the simulation model and run an SPA analysis with load sets for each of the three components of loading listed above. For details, see cards II-IV.

A belt drive with 180° wrap angle:

T:	Torque to be transferred = 50 Nm
B_{1req}:	Minimum required belt pretension force to transfer torque = 1824.1 N
B_1:	Selected belt pretension (force in the loose side of the belt) = 2500 N
B_2:	Tensile force in the loaded side of the belt = 5357.14 N
F_t:	Tangential force (transfers the torque) = 2857.14 N
d:	Traction sheave diameter = 35 mm
w:	Belt width = 6 mm
p_{B1}:	Belt pressure from selected belt pretension = 23.8095 MPa
p_{FTmax}:	Maximum additional belt pressure from tangential force = 27.2109 MPa
f_{Ft}:	Belt tangential traction from tangential force = 8.6615 MPa
μ:	Friction coefficient belt-sheave = 0.3
α:	Wrap angle=180° = 3.1415 rad

$$B_{1req} = \frac{2T}{d(e^{\mu\alpha} - 1)}$$

$$F_t = \frac{2T}{d}$$



Exercise Purpose:
- Using multiple load sets
- Creating bearing constraints for simple support of a shaft (tilting moment free fixed and floating bearing)
- Creating interpolated forces with points
- Defining forces in cylindrical coordinates

Prerequisites:
- Outline: Loads
- Outline: Constraints
- Outline: Analysis Definition – Linear Static Analysis

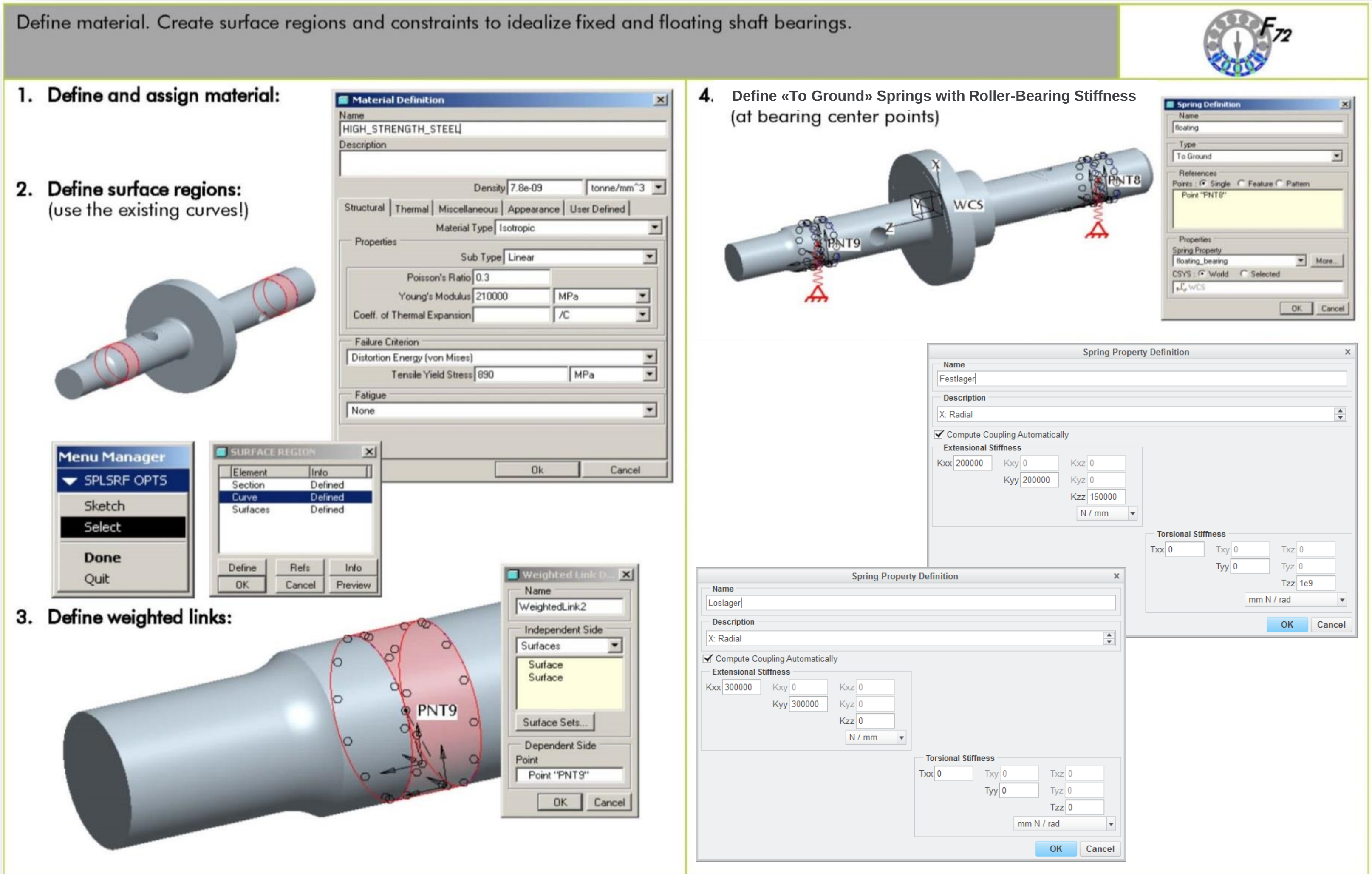
Context Information:
- Functionality: Rigid and Weighted Links
- Functionality: Springs (see the workshop booklet "Mechanica Fundamentals II")

The steps shown left and on the following slides just describe the most important basics. Use the cards listed under "Prerequisites" as a minimum for more details. Check your work with help of →Techniques: Assuring Result Quality.
The example results for comparing with your own analysis results are shown hereafter.

Workshop "Mechanica Fundamentals II" for Wildfire 4 by Dr.-Ing. Roland Jakel

Use-Cases: Weighted Links

Modeling Connections with Stiffness (e.g. Roller-Bearing)

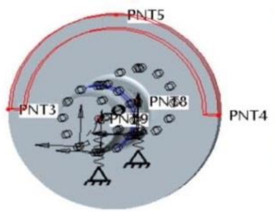


Use-Cases: Weighted Links

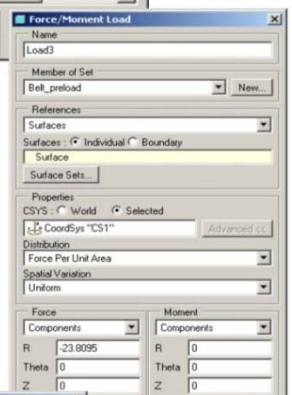
Modeling Connections with Stiffness (e.g. Roller-Bearing)

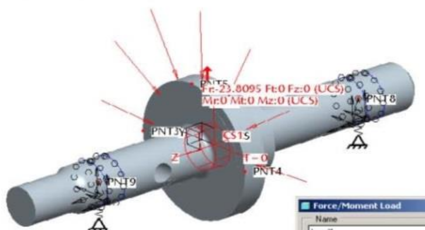
Create Volume regions and loads. Finally, create the analysis using all three load sets.

6. **Create the volume region:**

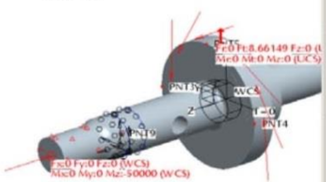


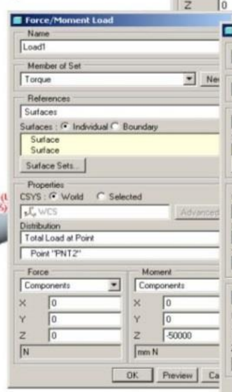
7. **Create the load set "Belt_preload" and define the according force** (use cyl. CS):

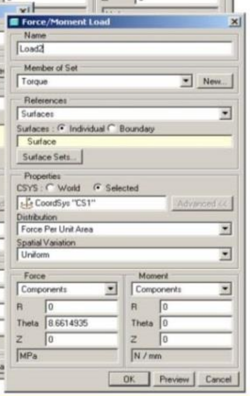




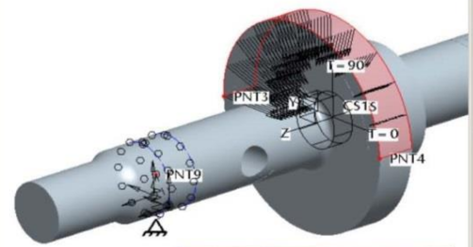
8. **Create load set "Torque" and define according loads:**

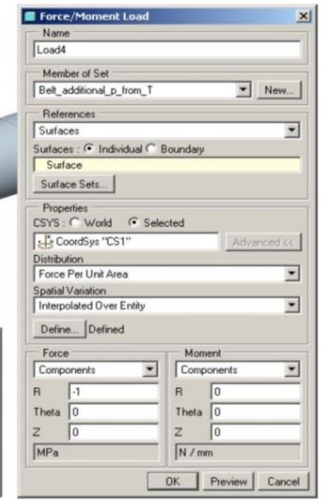


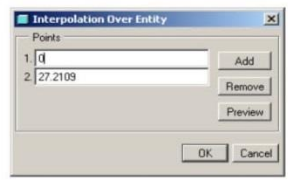




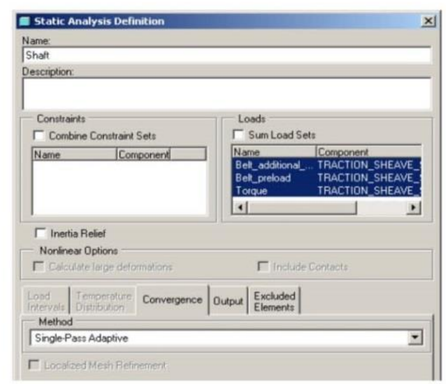
9. **Create load set "Belt_additional_p_from_T" and define the last acting load:**







10. **Create the analysis:**



Use-Cases: Weighted Links

Modeling Connections with Stiffness (e.g. Roller-Bearing)

These images show the results you should obtain when you performed all steps correctly.

Report file:

Examine the single load sets results also in the result window and combine them. Note that load set "Torque" and "Belt_additional_p_from_T" in reality just appear simultaneously!

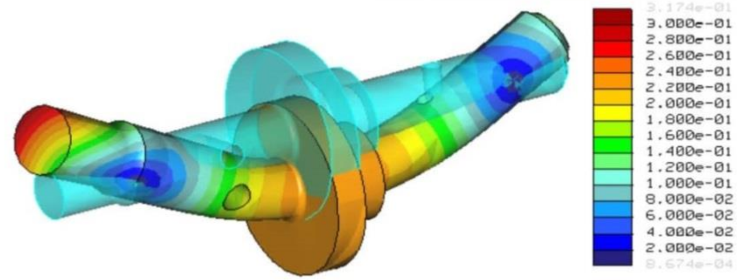
```
Run Status (Shaft.rpt) Not Running

Number of Load Sets: 3

Load Set: Belt_preload: TRACTION_SHEAVE_SHAFT

   Resultant Load on Model:
      in global X direction: -4.999995e+03
      in global Y direction:  1.721589e-07
      in global Z direction: -2.906497e-10

   Measures:

   max_beam_bending:    0.000000e+00
   max_beam_tensile:    0.000000e+00
   max_beam_torsion:    0.000000e+00
   max_beam_total:      0.000000e+00
   max_disp_mag:        1.479440e-01
   max_disp_x:         -1.450780e-01
   max_disp_y:         -1.992267e-03
   max_disp_z:         -3.854885e-02
   max_prin_mag:       -9.889004e+02
   max_rot_mag:         6.430981e-03
   max_rot_x:          -5.767832e-06
   max_rot_y:           6.430978e-03
   max_rot_z:          -4.280631e-07
   max_stress_prin:     9.784337e+02
   max_stress_vm:       8.546405e+02
   max_stress_xx:      -3.615445e+02
   max_stress_xy:      -9.712982e+01
   max_stress_xz:       3.716960e+02
   max_stress_yy:      -2.774719e+02
   max_stress_yz:      -1.850252e+02
   max_stress_zz:      -8.698128e+02
   min_stress_prin:    -9.889004e+02
   strain_energy:       3.620268e+02
   Free_Torque:         1.337759e-02

Detailed Summary                                    Close
```

```
Run Status (Shaft.rpt) Not Running

Load Set: Torque: TRACTION_SHEAVE_SHAFT

   Resultant Load on Model:
      in global X direction: -5.830746e-06
      in global Y direction:  1.818914e+03
      in global Z direction: -7.101530e-11

   Measures:

   max_beam_bending:    0.000000e+00
   max_beam_tensile:    0.000000e+00
   max_beam_torsion:    0.000000e+00
   max_beam_total:      0.000000e+00
   max_disp_mag:        1.565136e-01
   max_disp_x:         -9.048446e-02
   max_disp_y:         -1.565136e-01
   max_disp_z:          1.908022e-02
   max_prin_mag:       -9.312366e+02
   max_rot_mag:         1.089860e-02
   max_rot_x:           2.946589e-03
   max_rot_y:          -2.172233e-06
   max_rot_z:          -1.049272e-02
   max_stress_prin:     9.108250e+02
   max_stress_vm:       9.116679e+02
   max_stress_xx:       3.476493e+02
   max_stress_xy:      -1.389552e+02
   max_stress_xz:       3.776612e+02
   max_stress_yy:      -2.071215e+02
   max_stress_yz:      -3.188921e+02
   max_stress_zz:      -7.696146e+02
   min_stress_prin:    -9.312366e+02
   strain_energy:       4.731537e+02
   Free_Torque:         5.214767e+00

Load Set: Belt_additional_p_from_T: TRACTION_SI

   Resultant Load on Model:
      in global X direction: -2.857144e+03
      in global Y direction: -1.818915e+03
      in global Z direction: -5.623459e-11

   Measures:

   max_beam_bending:    0.000000e+00
   max_beam_tensile:    0.000000e+00
   max_beam_torsion:    0.000000e+00
   max_beam_total:      0.000000e+00
   max_disp_mag:        1.082773e-01
   max_disp_x:         -8.305130e-02
   max_disp_y:          6.605002e-02
   max_disp_z:         -2.819167e-02
   max_prin_mag:       -6.429641e+02
   max_rot_mag:         4.707753e-03
   max_rot_x:          -2.940055e-03
   max_rot_y:           3.676821e-03
   max_rot_z:           5.040890e-07
   max_stress_prin:     6.161163e+02
   max_stress_vm:       5.424970e+02
   max_stress_xx:      -2.570338e+02
   max_stress_xy:      -8.348640e+01
   max_stress_xz:       2.254984e+02
   max_stress_yy:      -1.910106e+02
   max_stress_yz:       1.915335e+02
   max_stress_zz:      -5.465380e+02
   min_stress_prin:    -6.429641e+02
   strain_energy:       1.697927e+02
   Free_Torque:        -1.063801e+00

Detailed Summary                                    Close
```

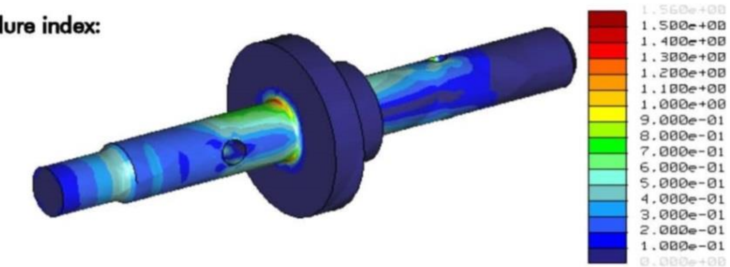
All loadcases combined:

Include	Load Set	Component	Scaling
☑	Belt_preload	TRACTION_SH...	1
☑	Torque	TRACTION_SH...	1
☑	Belt_additional_p_from_T	TRACTION_SH...	1

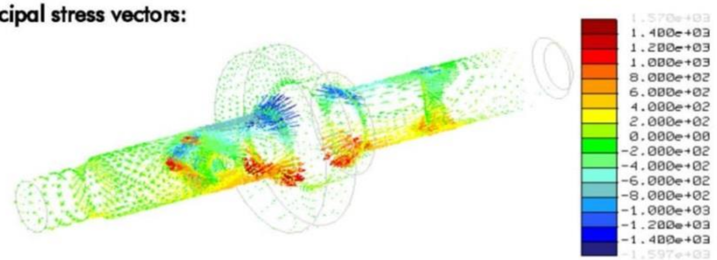
Displacement magnitude:
(Scale factor 50 absolute)



Failure index:

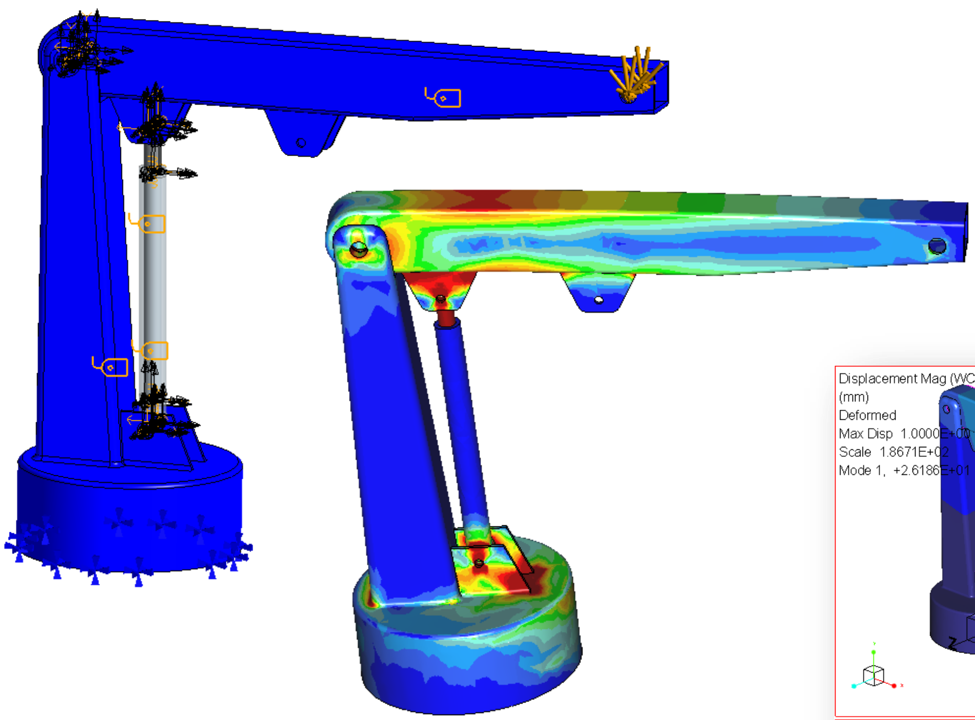


Principal stress vectors:



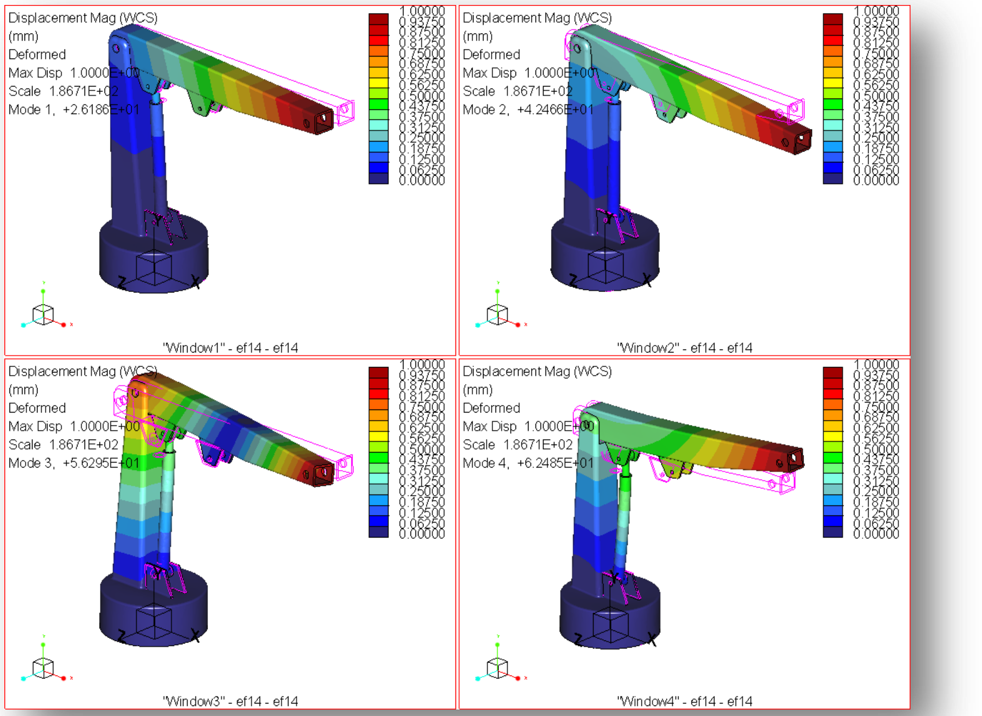
Use-Cases: Weighted Links

Modeling Mechanism-Connections (e.g. Pin, Cylinder, Ball, Slider, ...)



Static Analysis

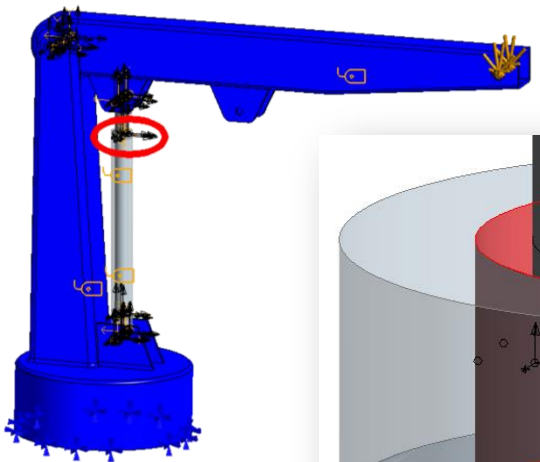
Modal Analysis

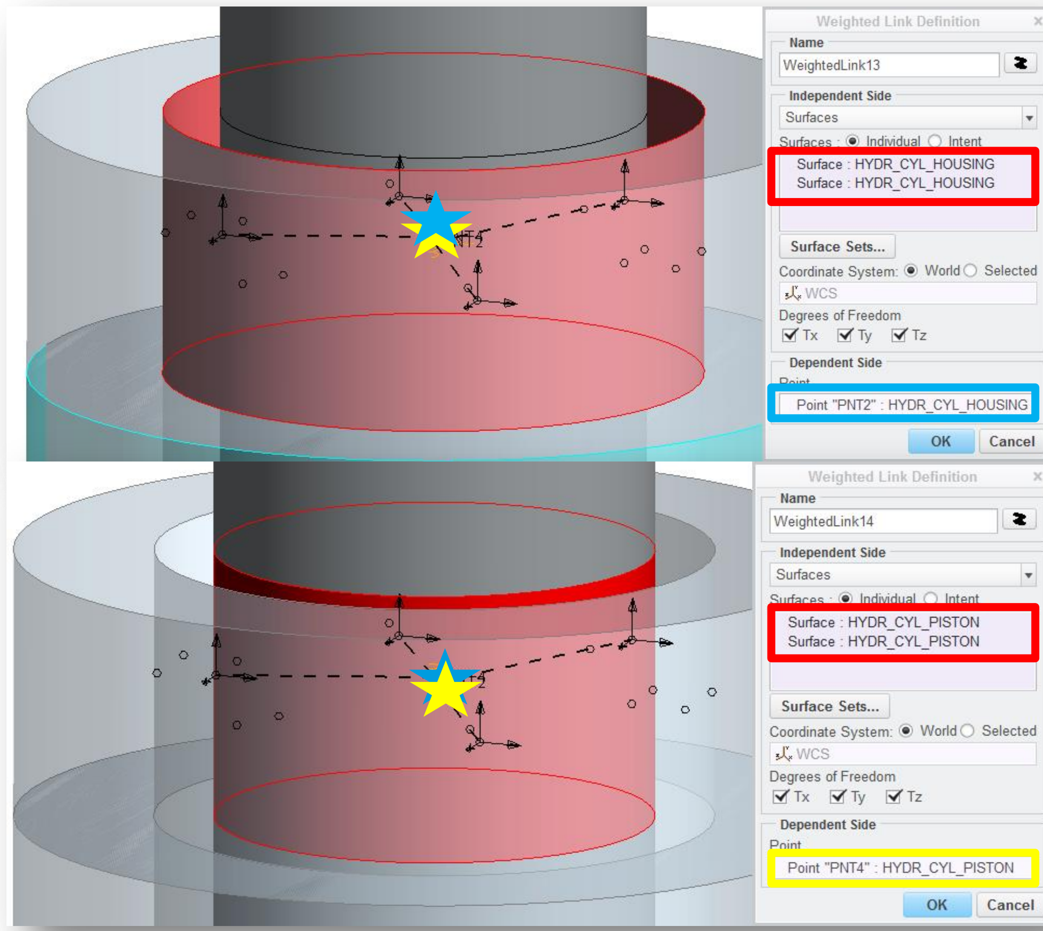


Use-Cases: Weighted Links

Modeling Mechanism-Connections (e.g. Pin, Cylinder, Ball, Slider, ...)

- Idealizations
  - Springs
    - Spring1
    - Spring2
    - Spring7
    - Spring8
    - Spring3
    - Spring4
    - Spring5
    - Spring6
- Connections
  - Weighted Links
    - WeightedLink1
    - WeightedLink3
    - WeightedLink5
    - WeightedLink6
    - WeightedLink7
    - WeightedLink8
    - WeightedLink9
    - WeightedLink11
    - WeightedLink13
    - WeightedLink14
    - WeightedLink15
    - WeightedLink16
    - WeightedLink17
    - WeightedLink18
    - WeightedLink19
    - WeightedLink20





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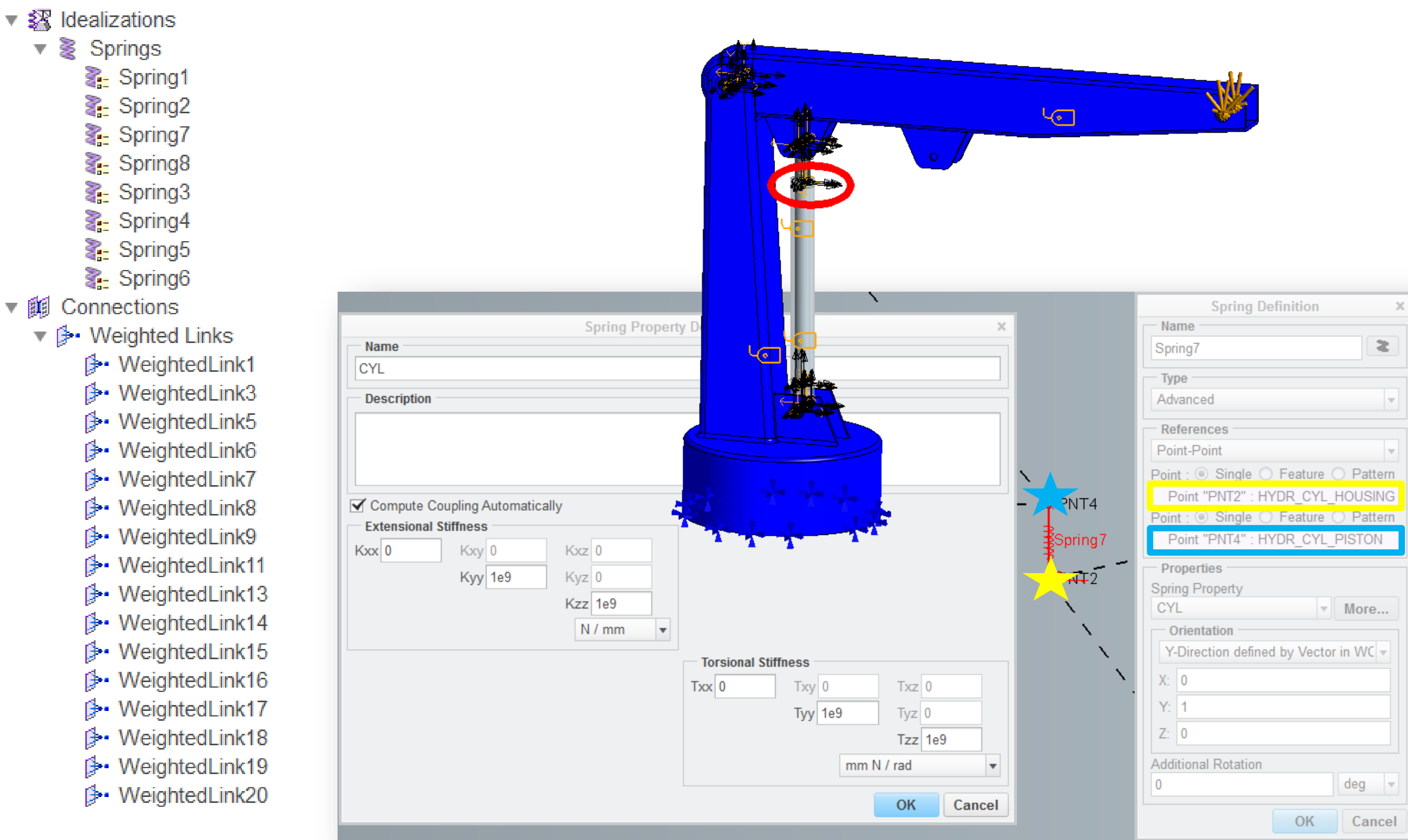
Modeling Mechanism-Connections (e.g. Pin, Cylinder, Ball, Slider, ...)



Use-Cases: Weighted Links

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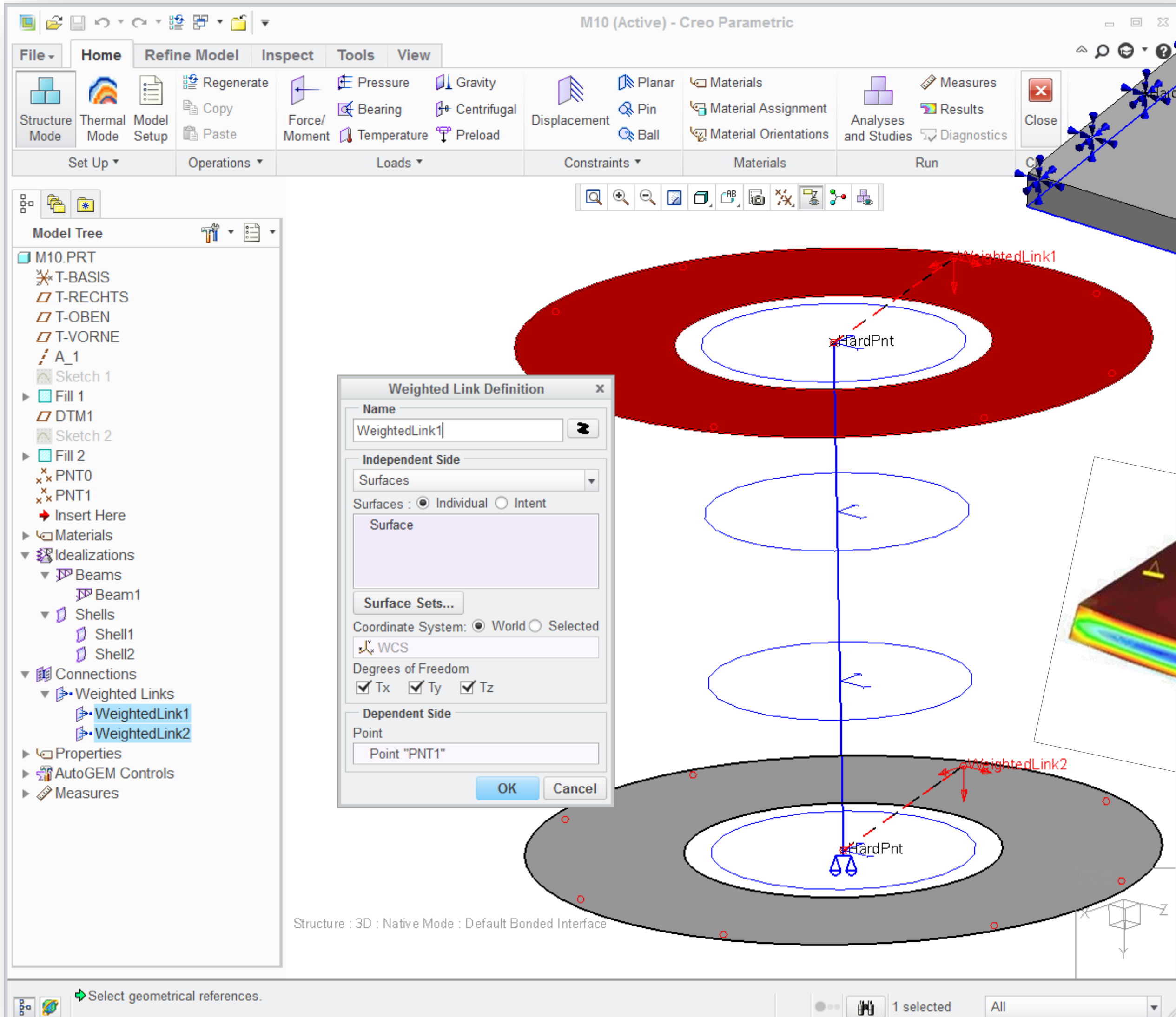
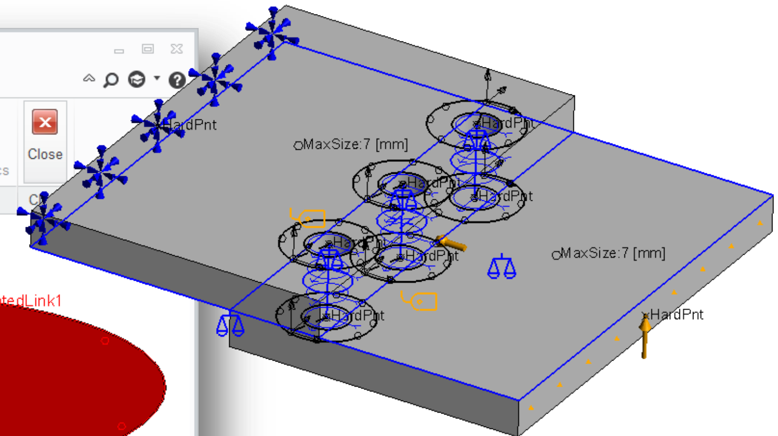
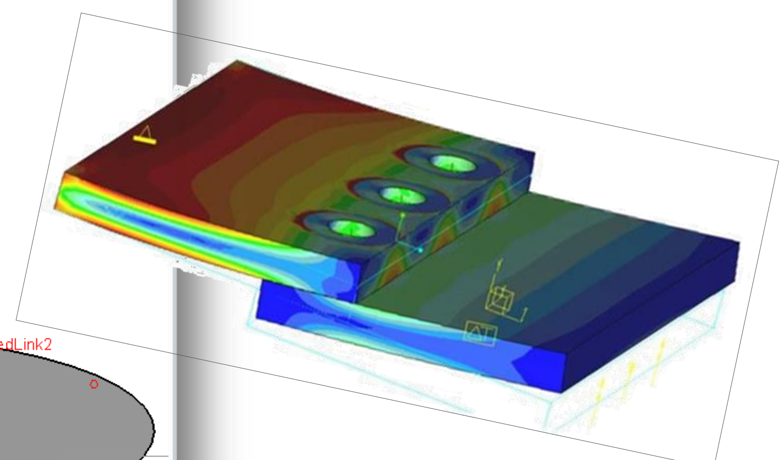
Modelling Prestressed Screw (with Beams/Shells)

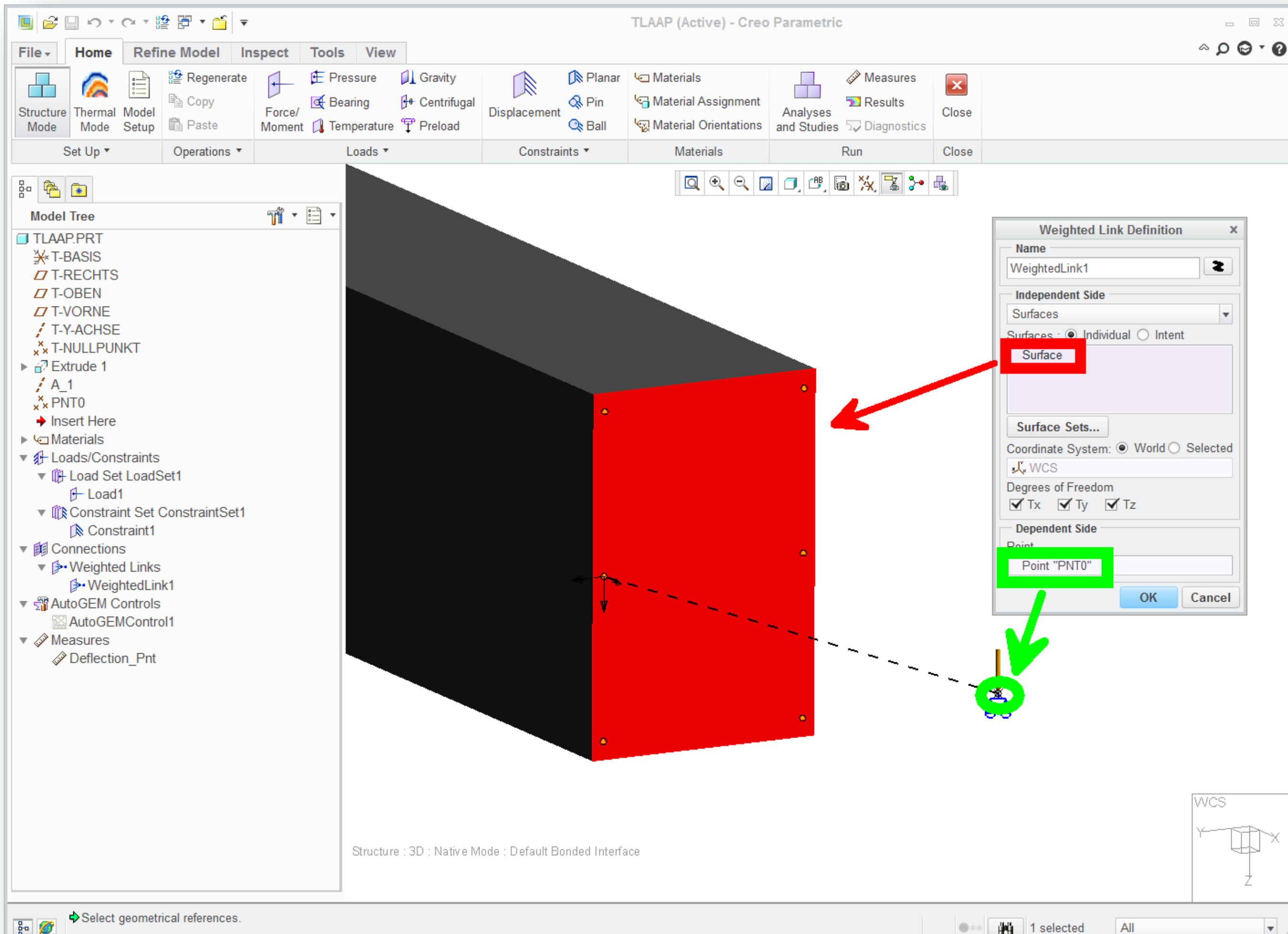


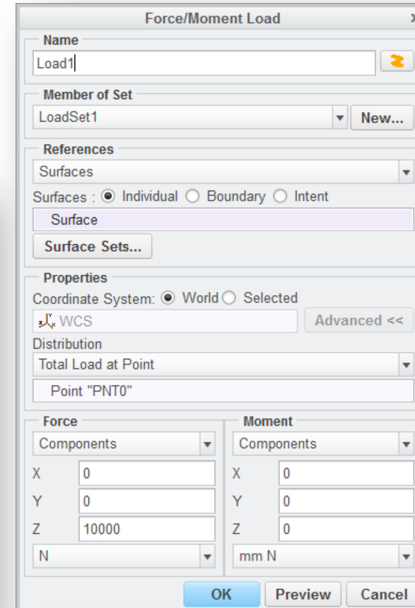


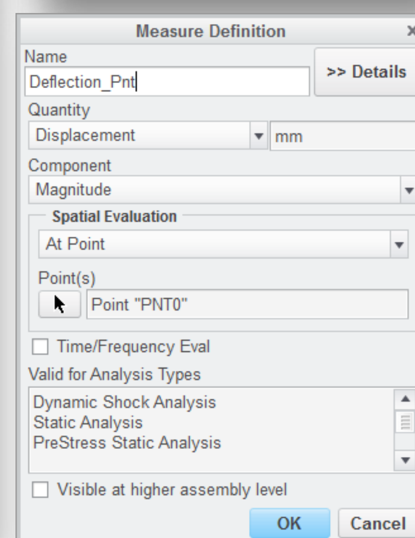


Use-Cases: Weighted Links

Total Load Applied at Point: Measuring the Point-Deflection







Use-Cases: Weighted Links

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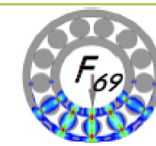
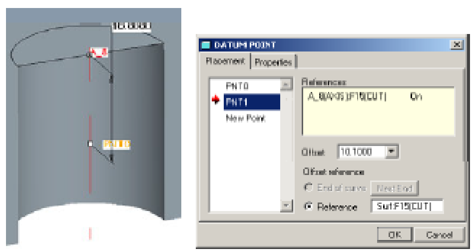
Applying a Moment-Free Enforced Displacement”

In the first approach, we were not successful in answering the question: “What force do we need if we bend the leg end 1.25 mm upwards, and what are the resulting stresses?” This card shows how we can define a moment-free enforced displacement at the thread hole that leads to correct results.
Remark: Applying an enforced point constraint in the upper hole surface is not a good solution, since then we create a singularity and an unrealistic high local deformation there!

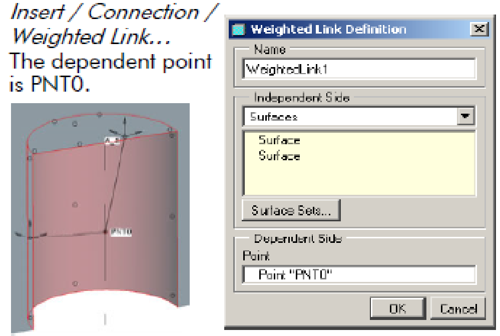


1. Delete the surface constraint in the hole defined for the previous analysis.
2. Create two points within the hole axis (→Step 1).
3. Create a weighted link (→Step 2).
4. Create a simple spring (→Step 3).
5. Create an enforced displacement at the free spring end (→Step 4).
6. Define an MPA analysis with 5 % on local disp, strain energy and global RMS stress.
7. Evaluate the results.

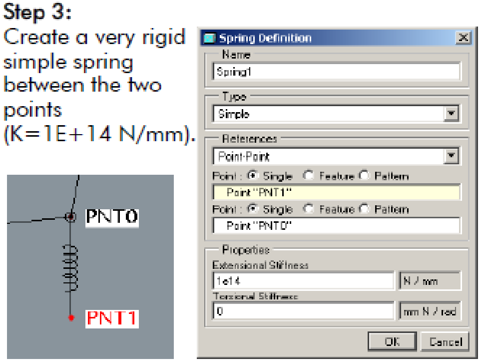
Step 1:
Create two very close points on the hole axis. Distances from the upper hole end surface are 10 (PNT 0) and 10.1 mm.



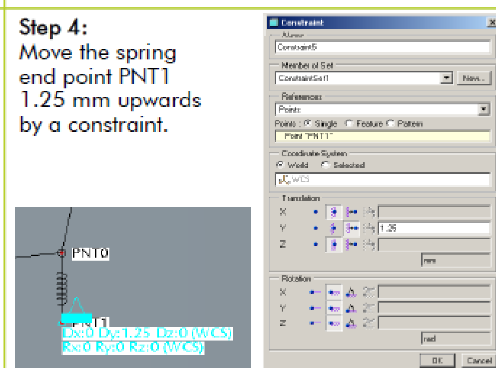
Step 2:
Insert / Connection / Weighted Link…
The dependent point is PNT0.



Step 3:
Create a very rigid simple spring between the two points (K=1E+14 N/mm).



Step 4:
Move the spring end point PNT1 1.25 mm upwards by a constraint.



Technique Purpose:
- Applying enforced “surface” displacement constraints that do not create unwanted bending moments
- Use resulting force measures

Prerequisites:
- Example: An Office Chair Leg
- Techniques: Applying a Moment-Free Enforced Displacement

Context Information:
- Functionality: Rigid and Weighted Links
- Functionality: Springs
- Functionality: Measures (all cards are in the workshop booklet “Mechanica Fundamentals II”)

The steps shown left just describe the most important basics. Use the cards listed under “Prerequisites” as a minimum for more details.
Check your work with help of →Techniques: Assuring Result Quality.
The example results for comparing with your own analysis results are shown on the back side of this card.

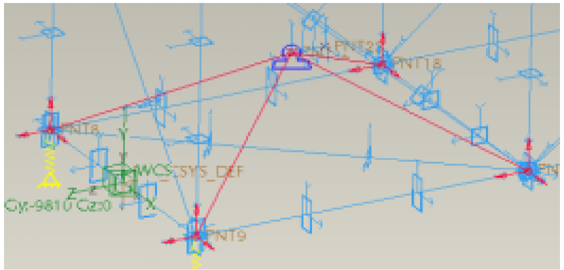
Workshop ”Mechanica Fundamentals II” for Wildfire 4 by Dr.-Ing. Roland Jakel

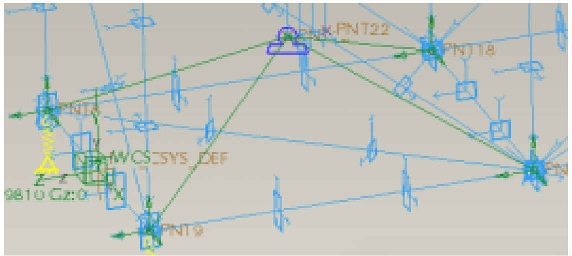
Use-Cases: Weighted Links

Connecting Mass Elements

Connecting Mass Elements – Weighted Links (If Advanced Licence available)

- In WF2, use light stiff beams or rigid links to connect the a mass element representing the engine mass to the chassis. We will connect the engine mass to the chassis with Point to point Weighted Links
- In WF3 can use Weighted Links from PNT12 to the four points at the bottom corners of the engine bay
- Go to Insert>Connections>Weighted Links or click on the Weighted Link Icon
- For the 'Dependent Side', select PNT12, the point to which the Engine mass element is attached.
- For the 'Independent Side', select the 4 points at the corners at the bottom of the engine bay; PNT2, PNT3, PNT11, PNT18
- Then click OK
- These points will then show as connected in the model





http://www.elite-consulting.com/DL_Files/Mechanica_Wildfire_3.pdf

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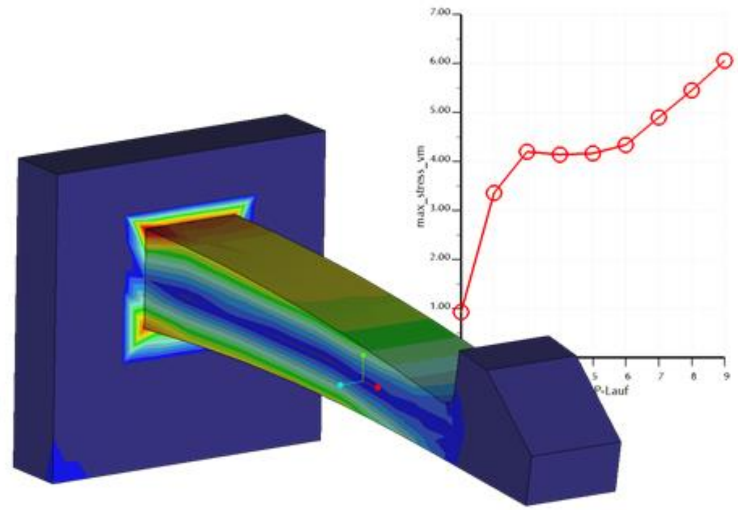
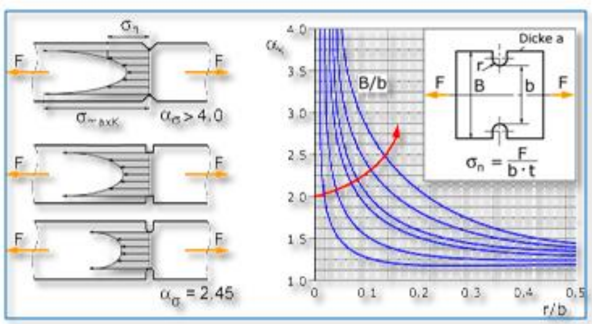
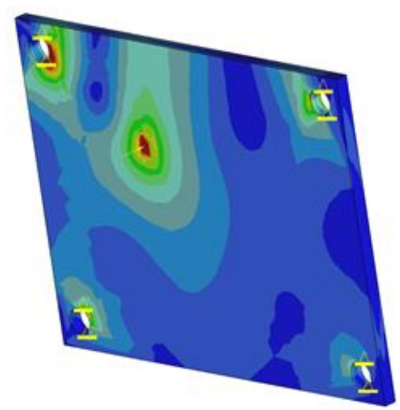
Avoid Singularities

- Reasons for singularities can be:
- Constraints (Rigid Regions)
- Loads (point-, edge-loads)
- Geometry („inner“ sharp corners)
- Result of a singularity are are stress-peaks
- A „Multi Pass“ analysis will not converge with dominant singularities in the model
- When analyzing a singular model with „Multi Pass“: use local measures as convergence crtiteria
- Do NOT interpret stresses near to a singularity !!!
- Solution: → Use Weighted Links





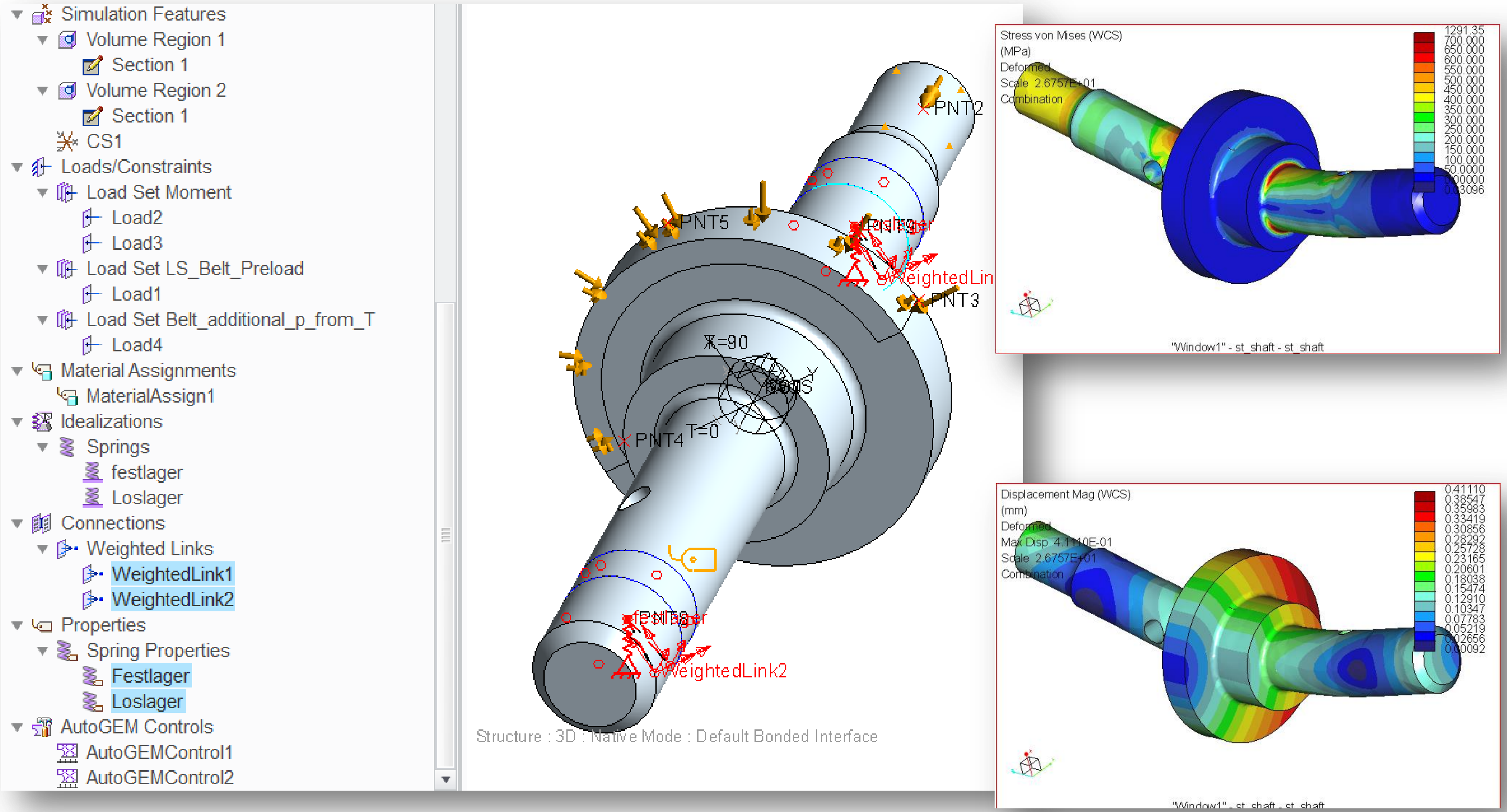


Creo Simulate: ”Best Practice.CD” by Urs Simmler

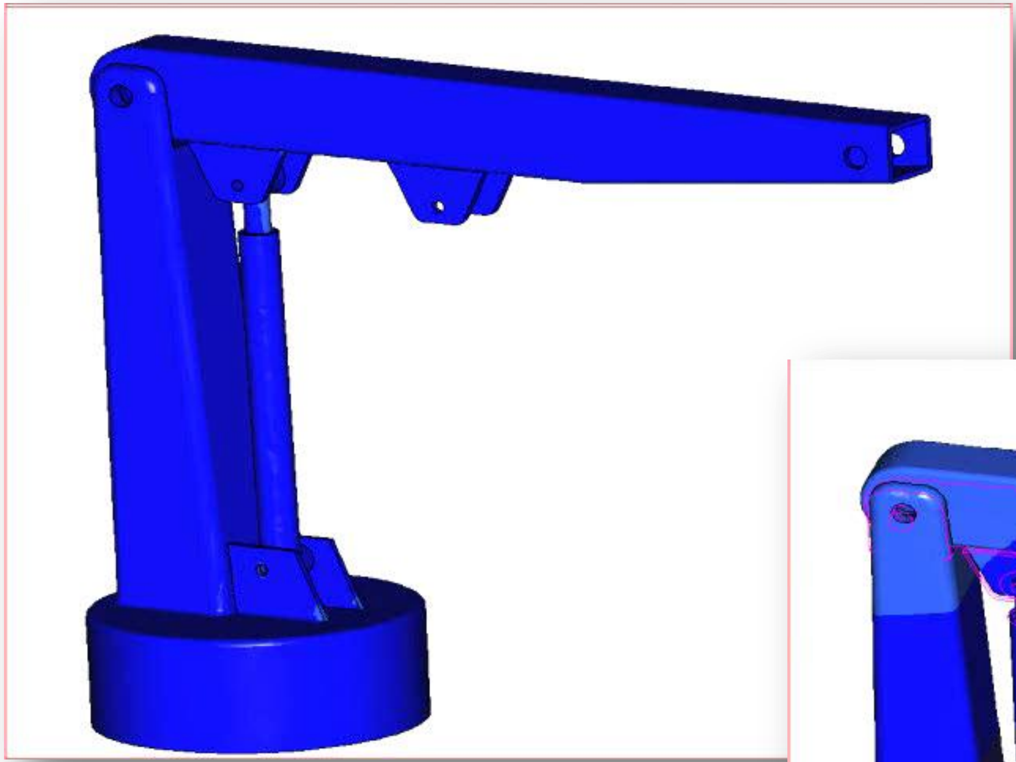

Pro/ENGINEER Advanced Mechanica
Pro/ENGINEER Mechanica
ANALYSIS
Mechanism Dynamics Option
Springs
Dampers
Friction
Forces
Torques

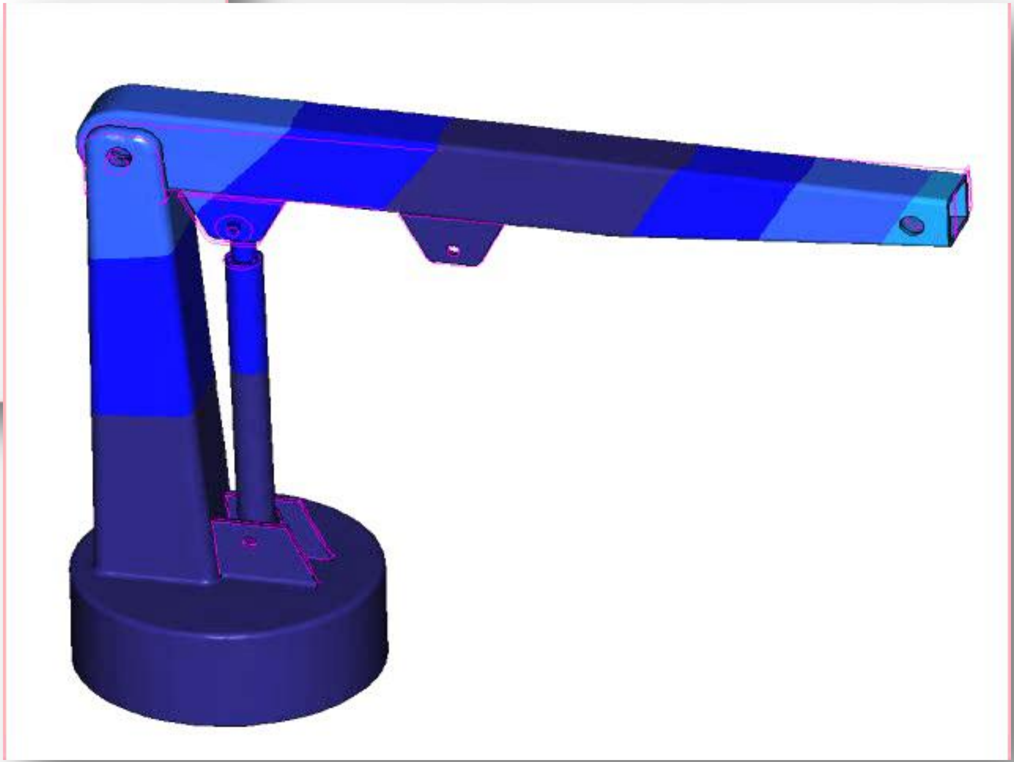
Live-Demos

Live: Connections with Stiffness (e.g. Roller-Bearing)



Live: Mechanism-Connections





Questions

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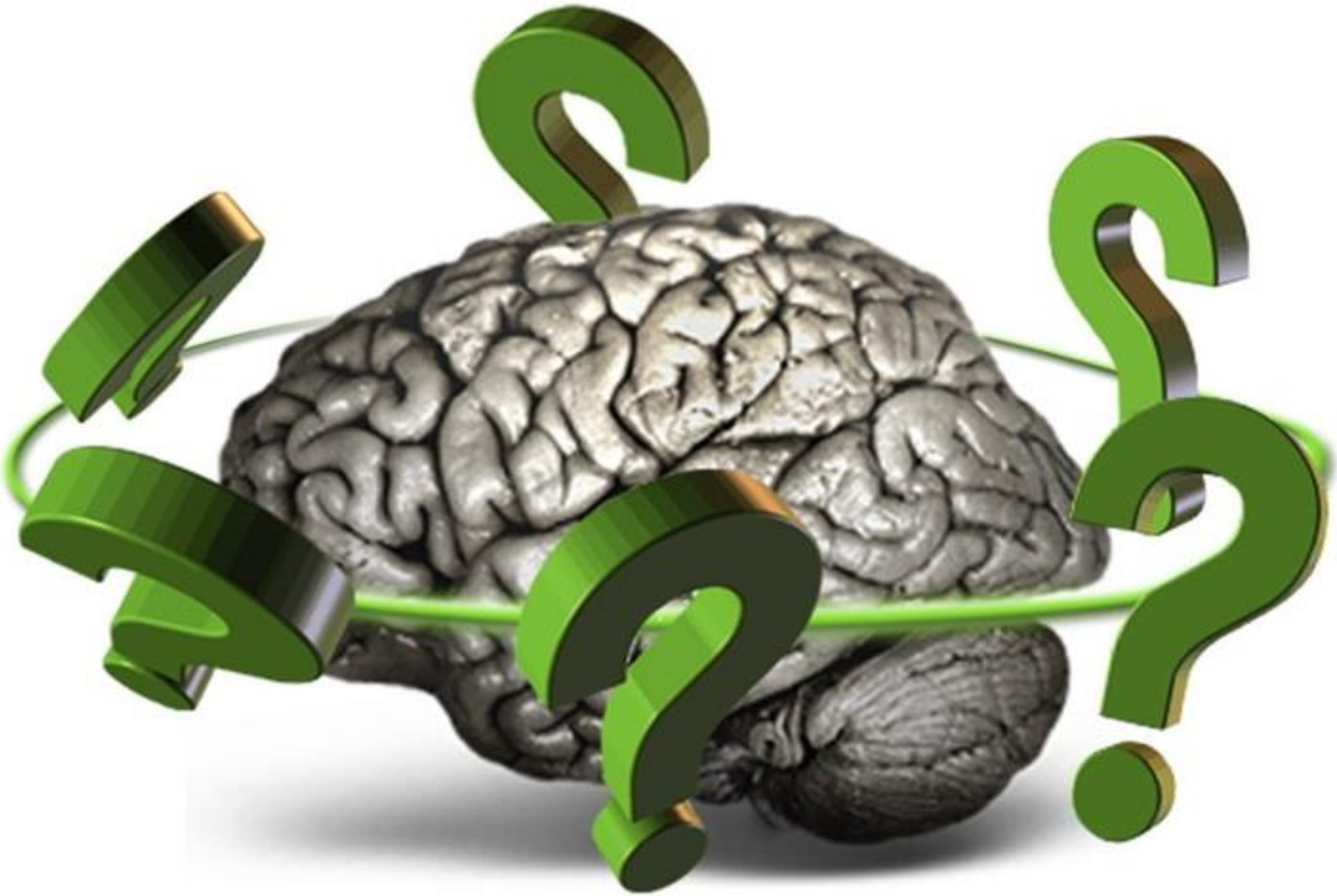

Thank You