

SIMULATION TIPS, TRICKS, AND TROUBLESHOOTING

Chris Olson, Simulation Engineer

GSC SIMULATION TEAM

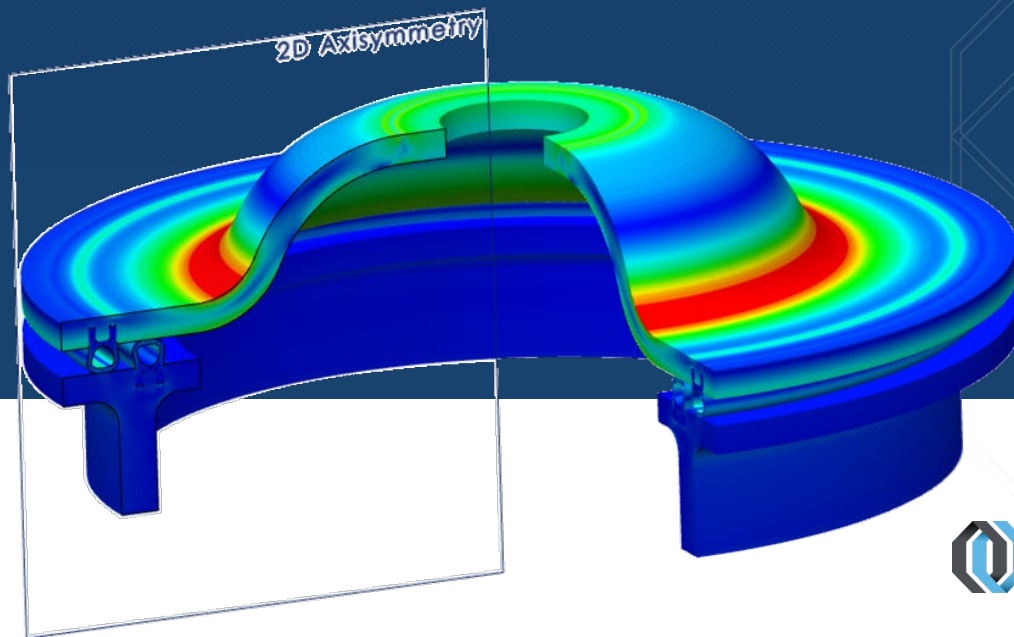


Madhav Puppala
Director of Simulation

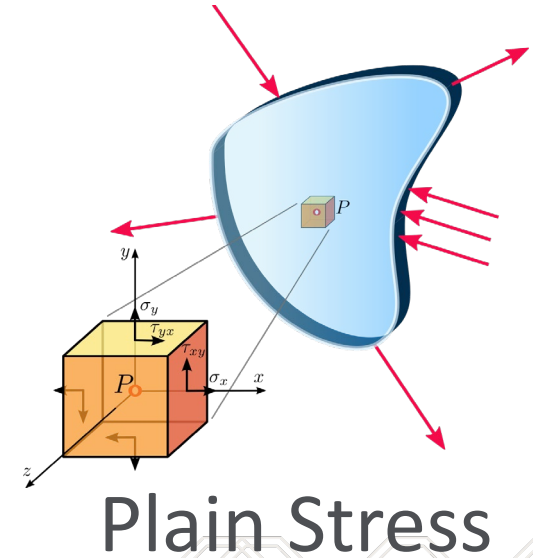
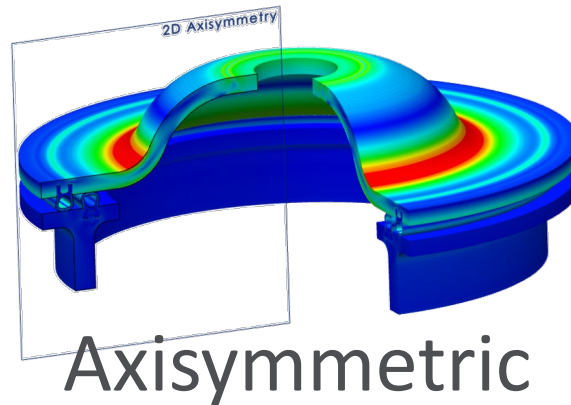
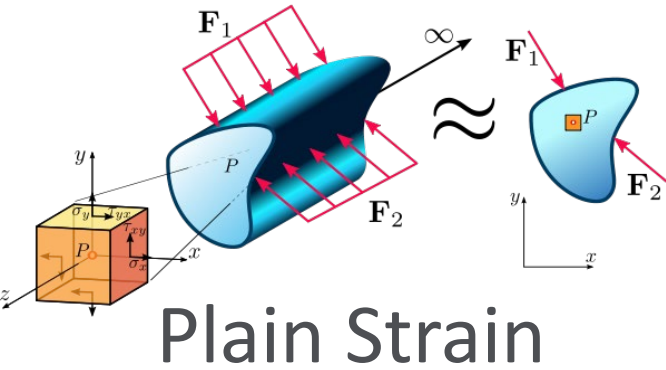


Chris Olson
Simulation Engineer

2D Simplification



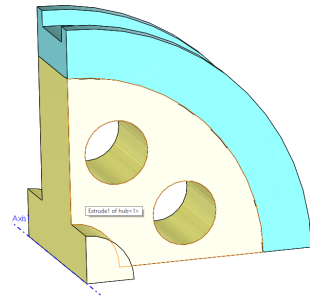
2D SIMPLIFICATION TYPES





Utilizing Symmetry

SYMMETRY ADVANTAGES



Symmetry Acts as
Fixture

Simplify
Fixtures

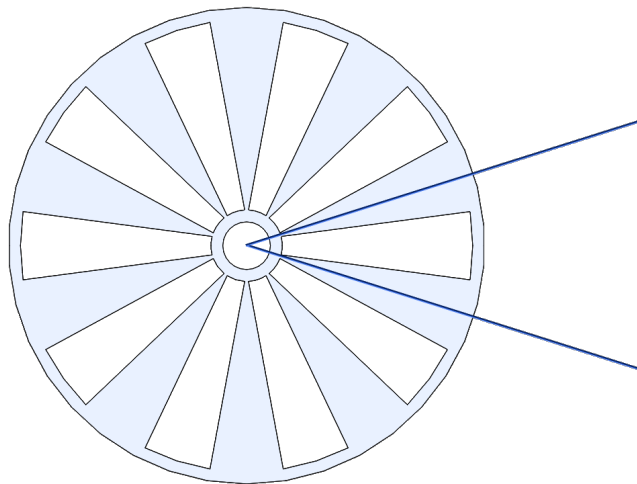
Efficient

Cut Problem by
 $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}$

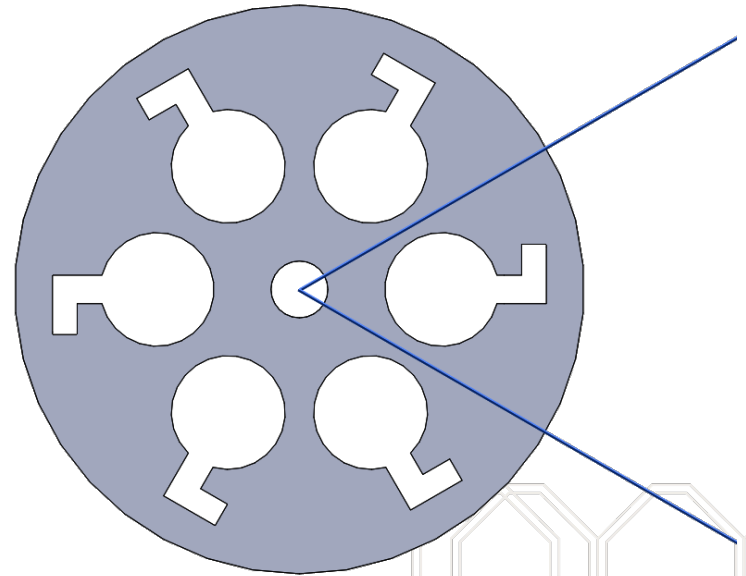
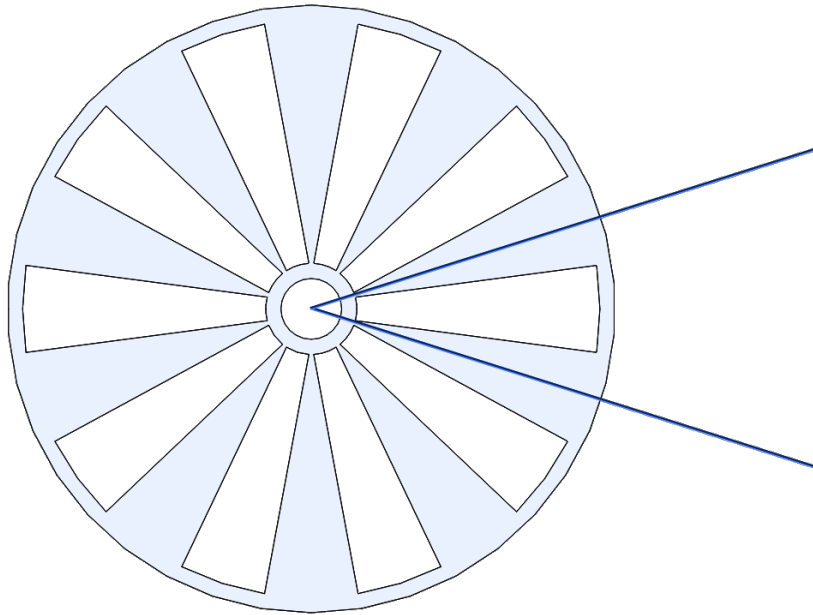
More
Accurate
Mesh

Smaller problem allows
for refined mesh

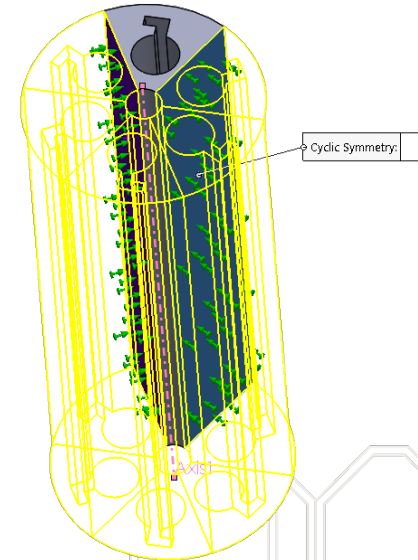
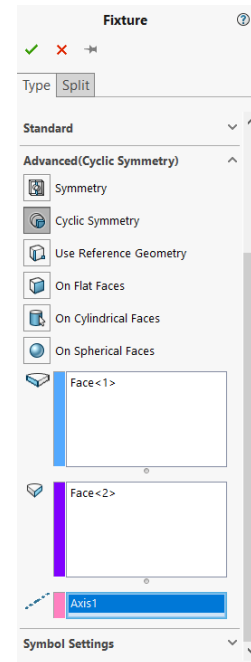
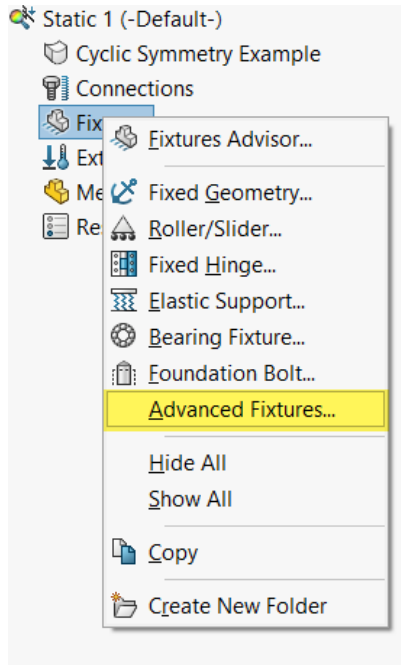
Utilize the **Roller Slider** restraint for more
Advanced Symmetry conditions



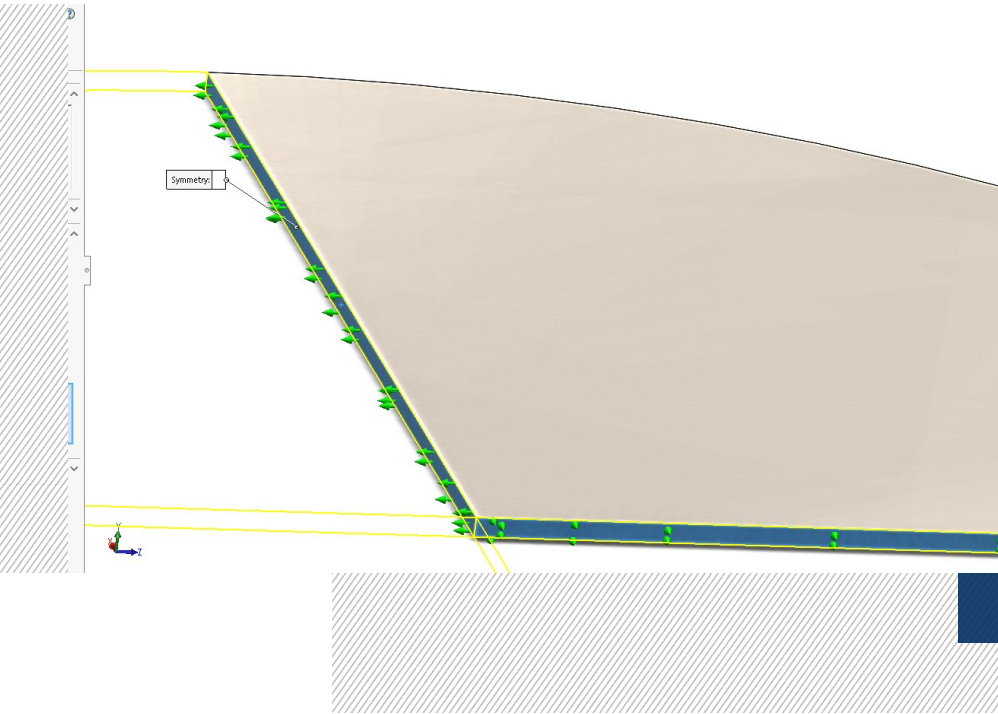
SYMMETRY VS CYCLIC SYMMETRY



CYCLIC SYMMETRY



Symmetrical Geomtry



How To

- Cut Geometry
- Apply Fixture
- Select Faces
- Divide Loads

SYMMETRY RULE OF DIVIDING LOADS

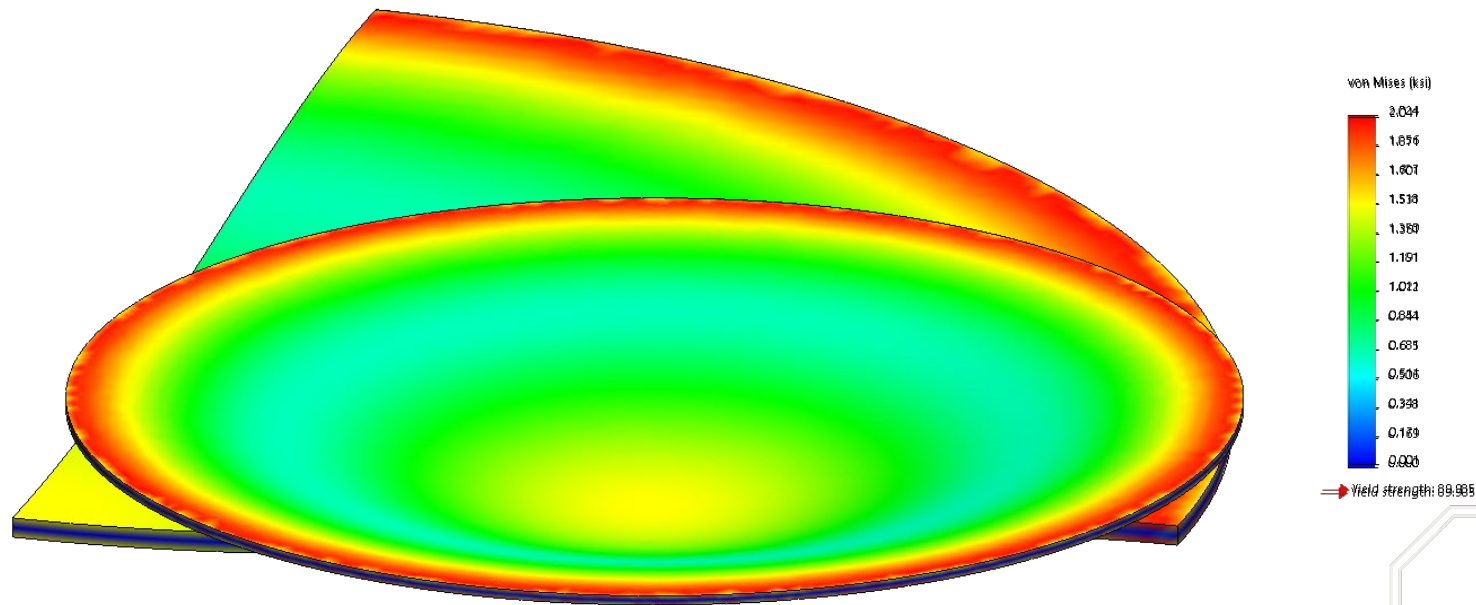
Divide the loads by **Two Times** the number of **Symmetry Cuts** through a **Load Bearing** face

1 Symmetry Cut – Divide by 2

2 Symmetry Cuts – Divide by 4

3 Symmetry Cuts – Divide by 8

SYMMETRY EXAMPLE

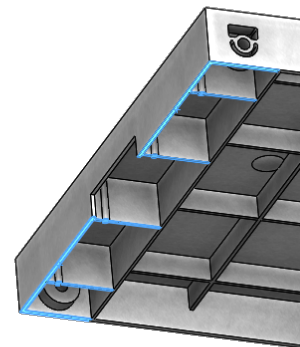
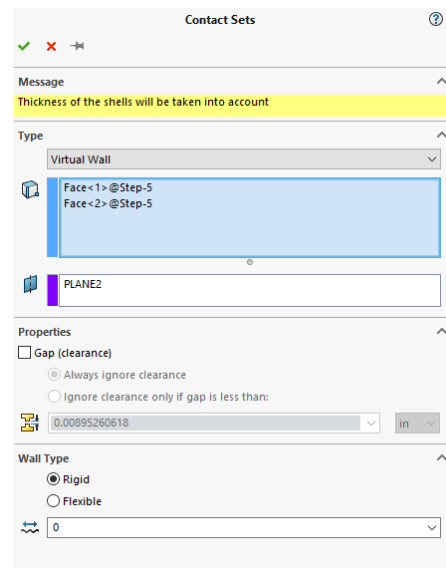




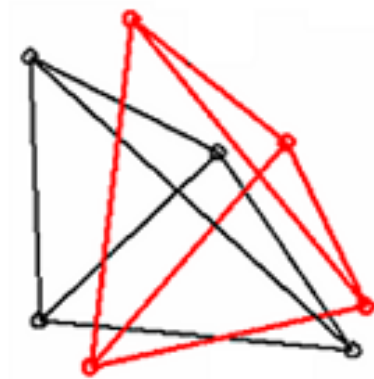
Virtual Wall

VIRTUAL WALL

- **Contact** type that acts like a **No Penetration** contact with a **Plane**



DRAFT QUALITY MESH



1st order
(Draft Quality)

DRAFT QUALITY MESH

Linear
Deformation

First Pass
Analysis

Trend Studies



Adaptive method

- ☒ None
- ☐ h-adaptive
- ☐ p-adaptive

h-Adaptive options



Maximum no. of loops

3

☐ Mesh coarsening

Adaptive Meshing

ADAPTIVE MESHING

H-Adaptive

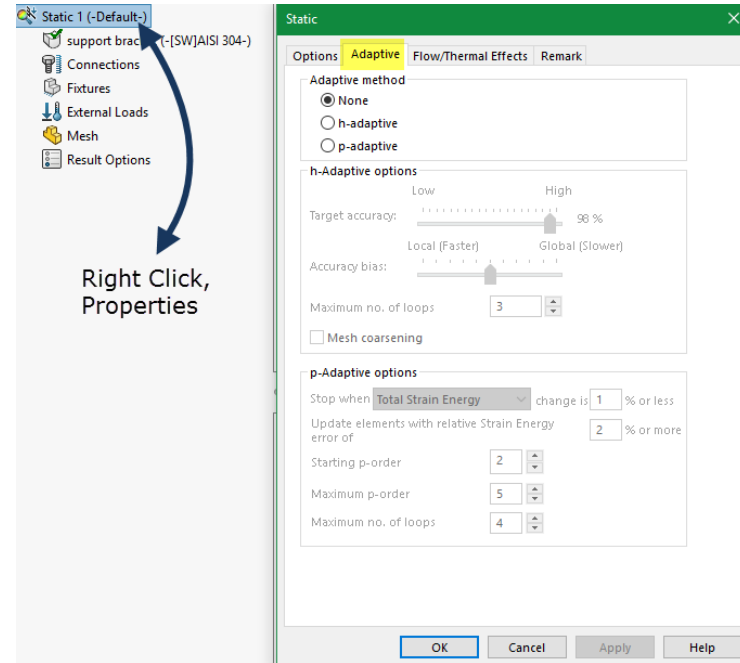


- ☐ Refines Element Size
- ☐ Target Accuracy
- ☐ Accuracy Bias
- ☐ Max Number of Loops

P-Adaptive

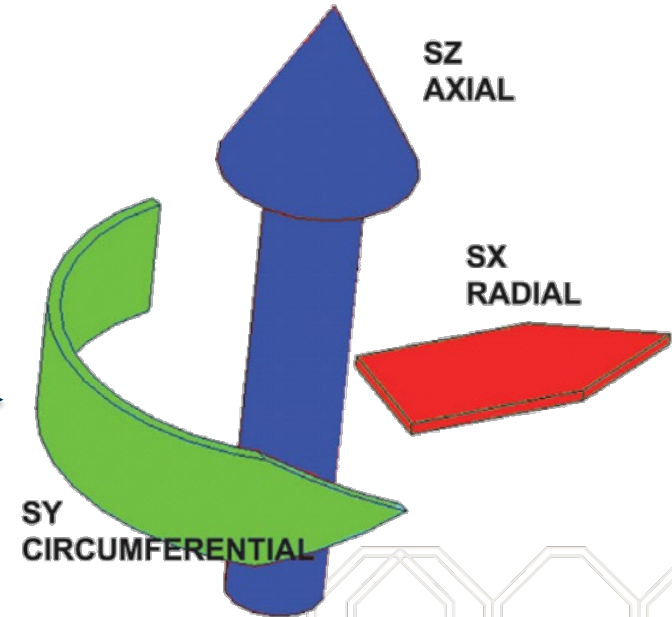
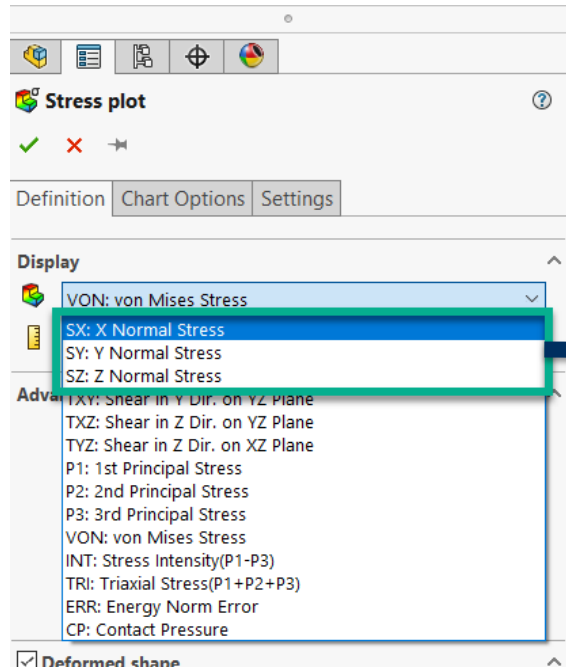


- ☐ Refines Element Order
- ☐ Target Accuracy
- ☐ Max/Min Order
- ☐ Max Number of Loops

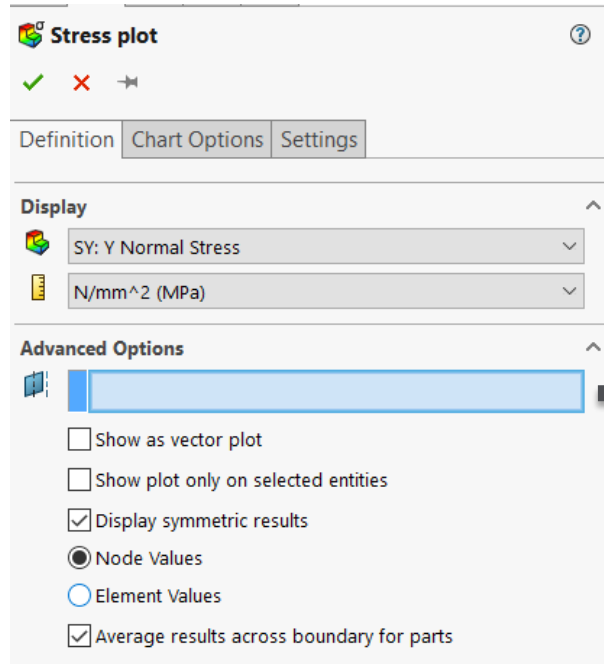


Angular Displacements

CYLINDRICAL COORDINATE SYSTEM RESULTS

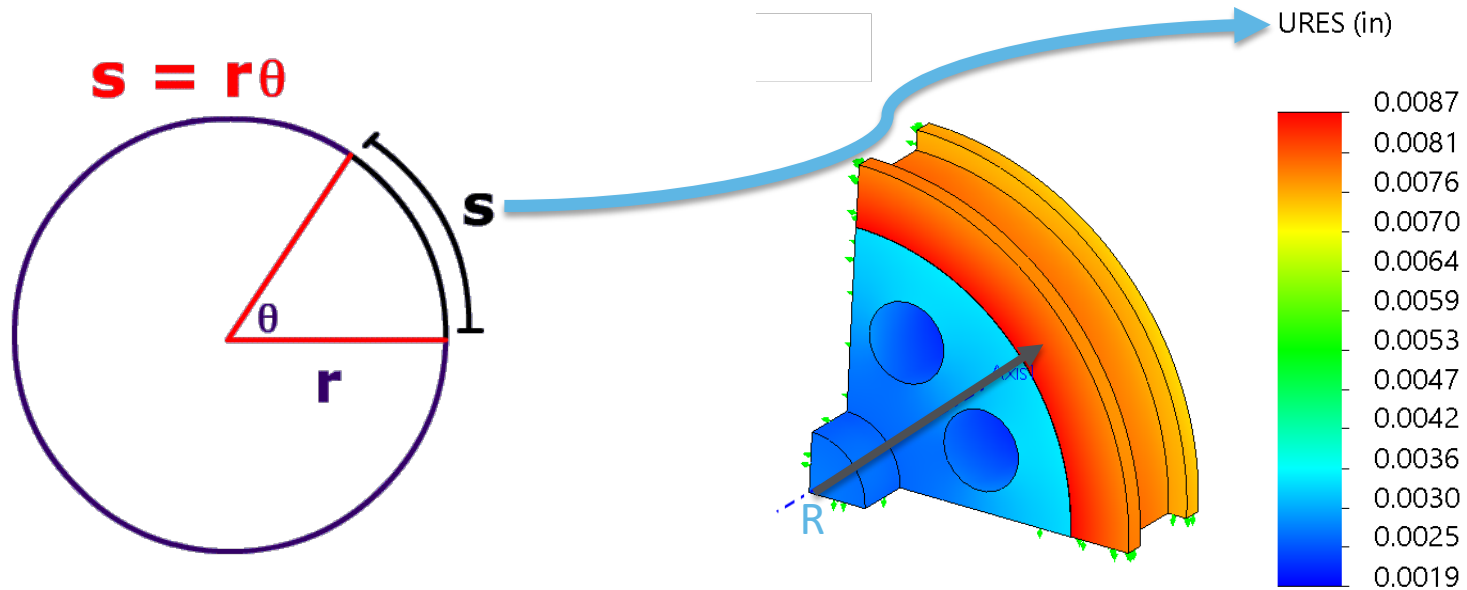


CYLINDRICAL COORDINATE SYSTEM RESULTS



Axis
of
Revolution

ANGULAR DISPLACEMENT CALCULATION

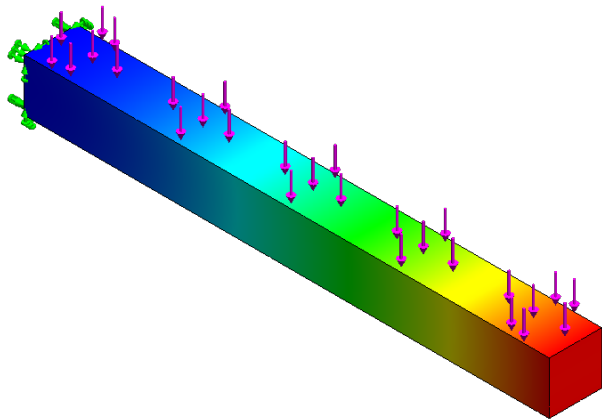


$$F = kx$$

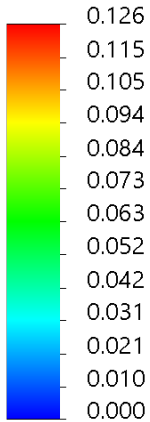
Leveraging the
“linear” in
Linear Static

$$\text{FORCE} = \text{STIFFNESS} * \text{DISPLACEMENT}$$

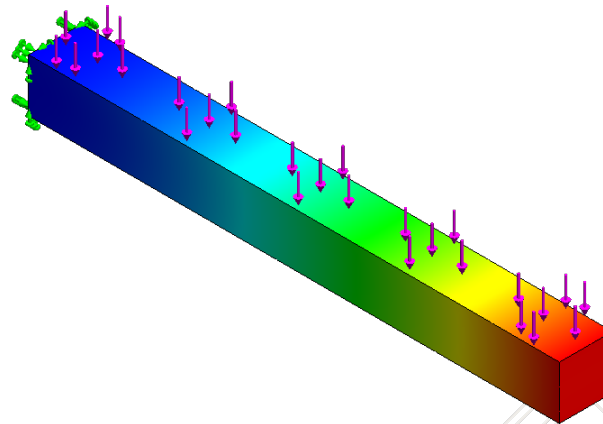
100 lbs



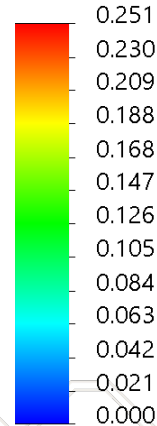
URES (mm)



200 lbs



URES (mm)



☐ Standard mesh

☒ Curvature-based mesh

☐ Blended curvature-based mesh

 mm

 1.48707389mm

 0.49568634mm

 8

 1.5

Global Mesh Controls

ELEMENTS IN A CIRCLE

☐ Standard mesh
☒ Curvature-based mesh
☐ Blended curvature-based mesh

 mm

 1.48707389mm

 0.49568634mm

 8

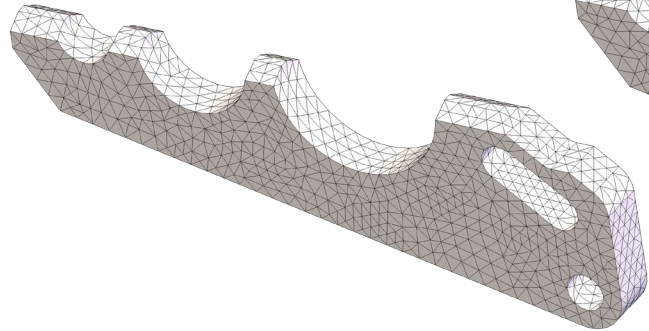
 1.5

Use **Elements** in a
Circle to **Globally**
refine **Fillets**

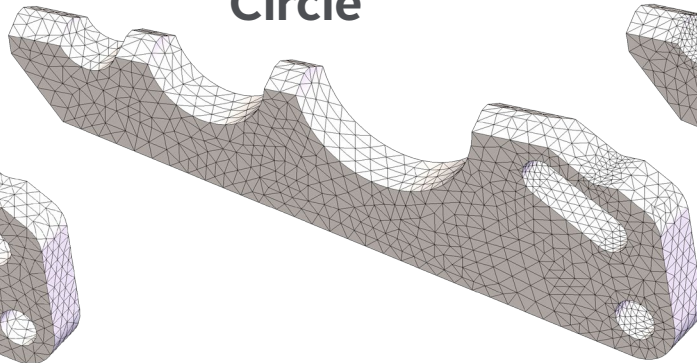
Minimum Element Size is the
limiting factor

GLOBAL MESH CONTROL

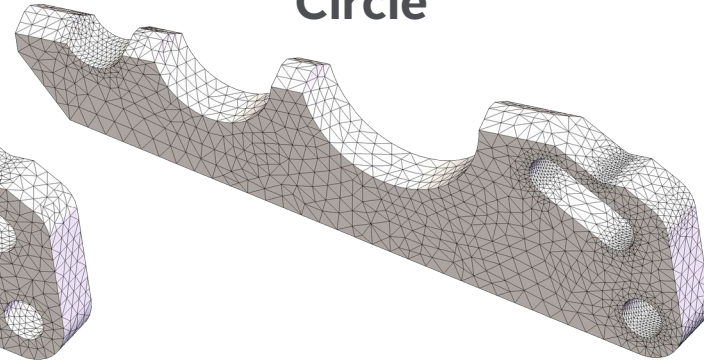
8
Elements in a
Circle



16
Elements in a
Circle



32
Elements in a
Circle





Simulating Welds

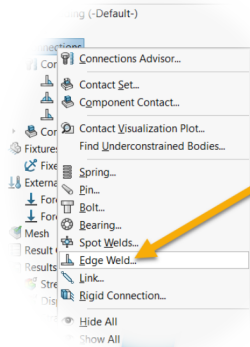
Connectors

Edge Weld & Spot Weld



Modeling The Weld

EDGE WELD CONNECTOR



Weld Type

Fillet, Single-Sided

Face Set1 :
Face<1>@torque tube-1

Face Set2 :
Face<2>@torque tube-1

Intersecting Edges :
Edge<1>@torque tube-1

Weld Orientation

☐ Include the induced bending moment due to unsymmetry of the joint loading

Weld Sizing

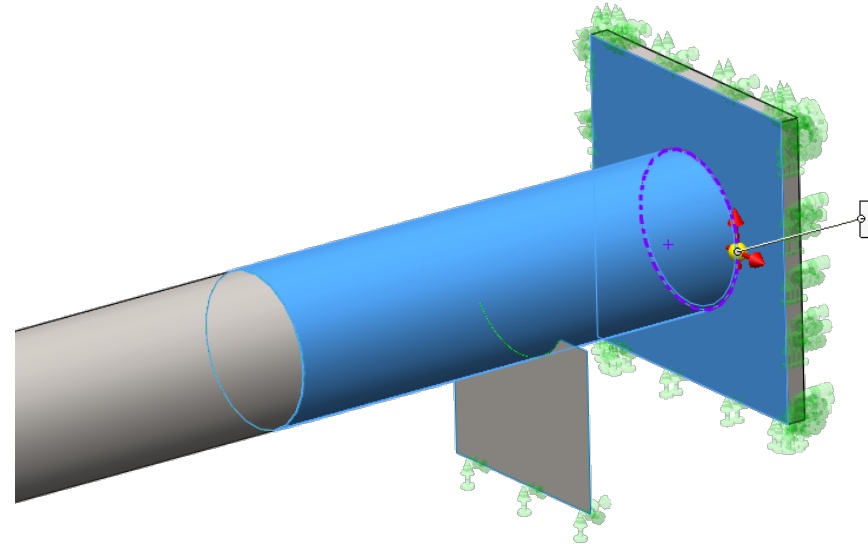
☒ American Standard
☐ European Standard

Electrode
E60

Weld strength
273032388.80945277 N/m^2

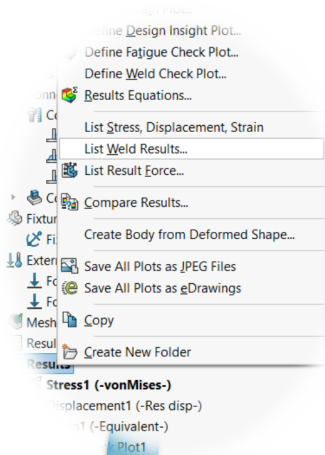
Safety Factor:
☒ American National Standard for Automotive Lifts
☐ Under The Hook Lifting Devices
3

☒ Estimated weld size
4 mm



**Shell/Shell &
Shell/Solid
Combinations Only!**

EDGE WELD CONNECTOR



Edge Weld Results

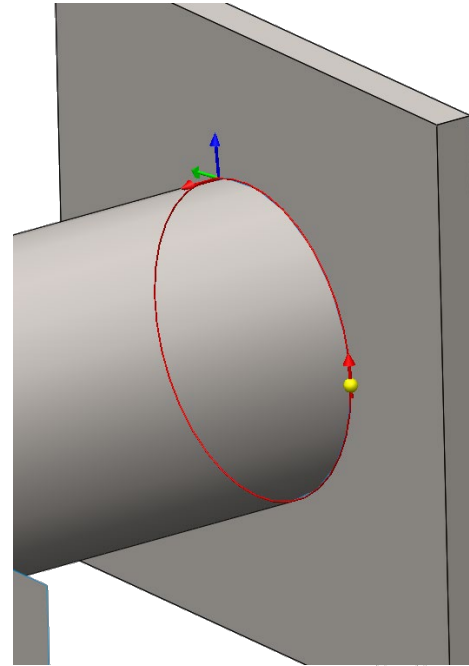
✓ ✗

Selection

SI

Edge Weld Connector-1

Type	Min	Max	Mean
Weld size (mm.)	1.4067	7.9404	4.8801
Weld throat size (mm.)	0.99465	5.6147	3.4508
Joint normal force (N/m)	-1.6819E+05	80,441	231.68
Shear-Weld axis force (N/m)	-26,608	44,087	10,050
Shear-Surface normal force (N/m)	-724.8	1,339.1	166.75
Bending moment (N.m/m)	-171.98	320.62	1.7137



SPOT WELD

Connectors

✓ ✗ ⇄

Type

Message

When using Spot Welds, you should also define a No Penetration contact between the two faces.

Type

Spot Welds

Face<2>@tube 30-2

Face<1>@tube 30-1

Vertex<6>@tube 30-1

0.25 in

Symbol Settings

Spot Weld Diameter (in): 0.25



Selection



SI

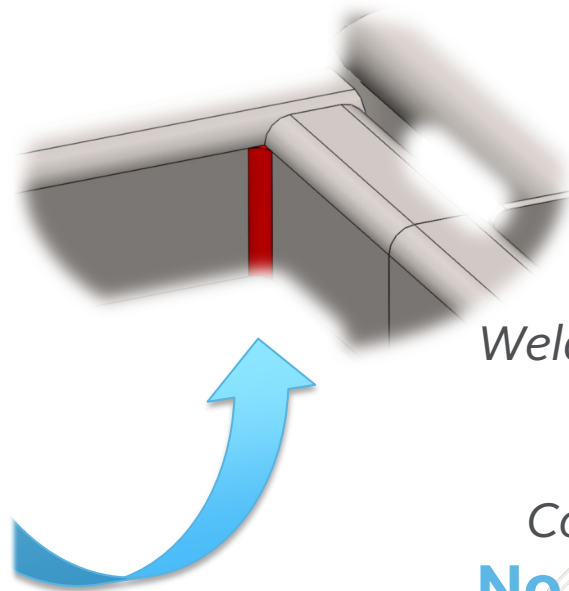
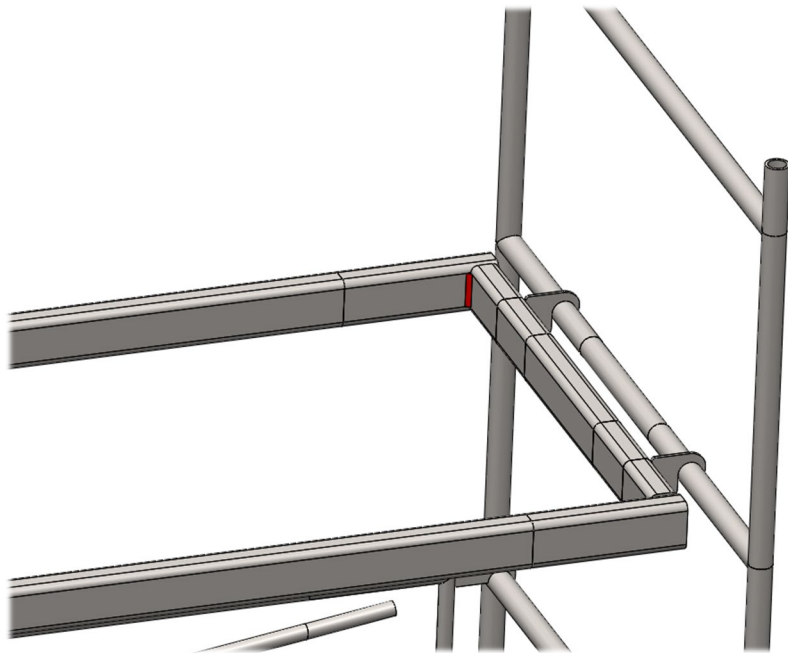


Spot Weld Connector-1/Point1

Connector Force

Type	Resultant
Shear Force (N)	11.422
Axial Force (N)	0.4093
Bending moment (N.m)	0.0018555
Torque (N.m)	0.00090889

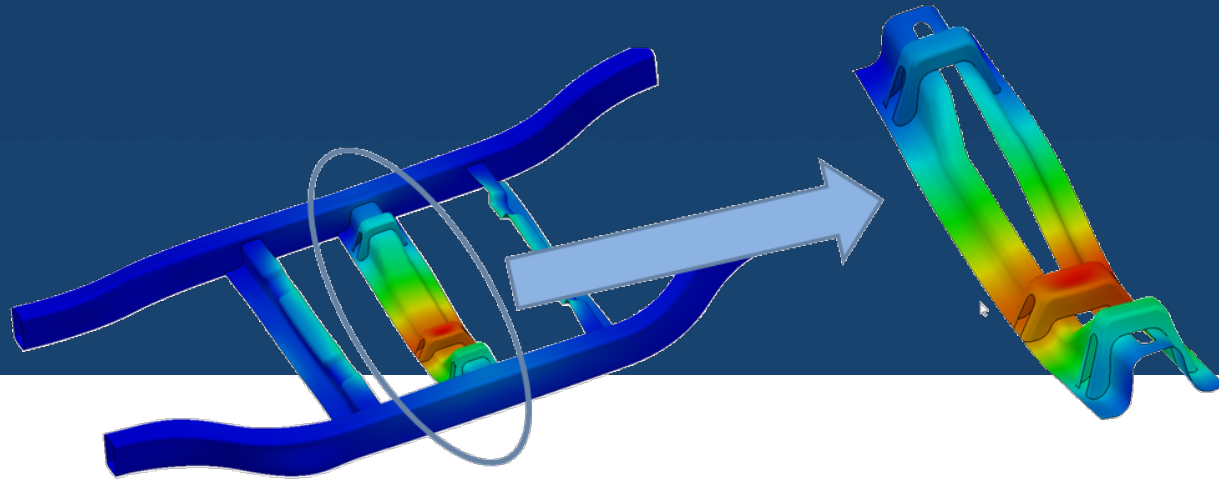
MODELING THE WELD



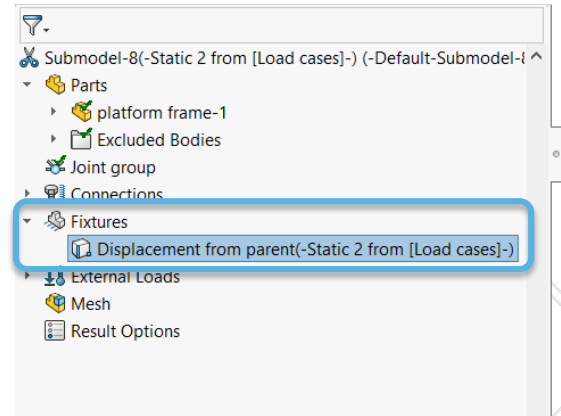
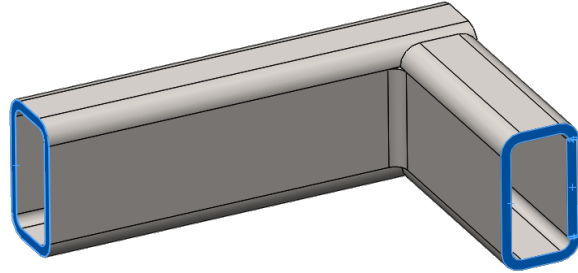
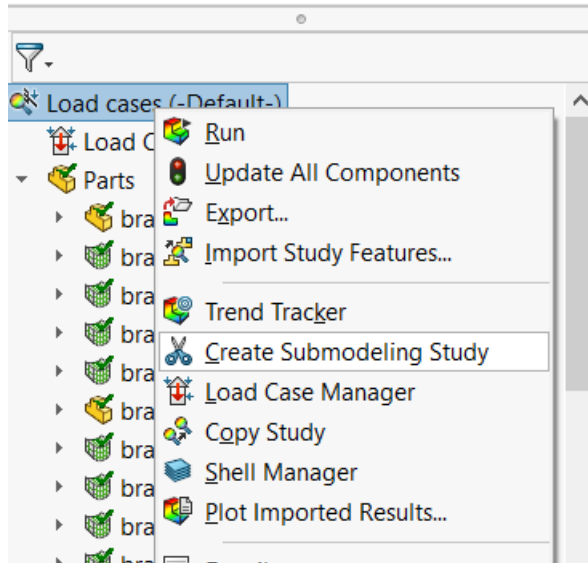
Weld is **Bonded** to
Components

Components are
No Penetration
to each other

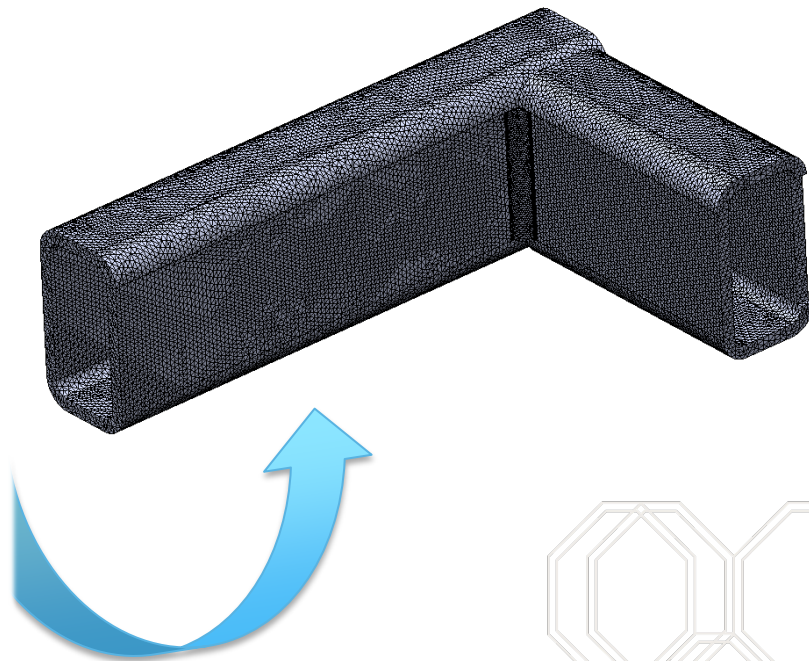
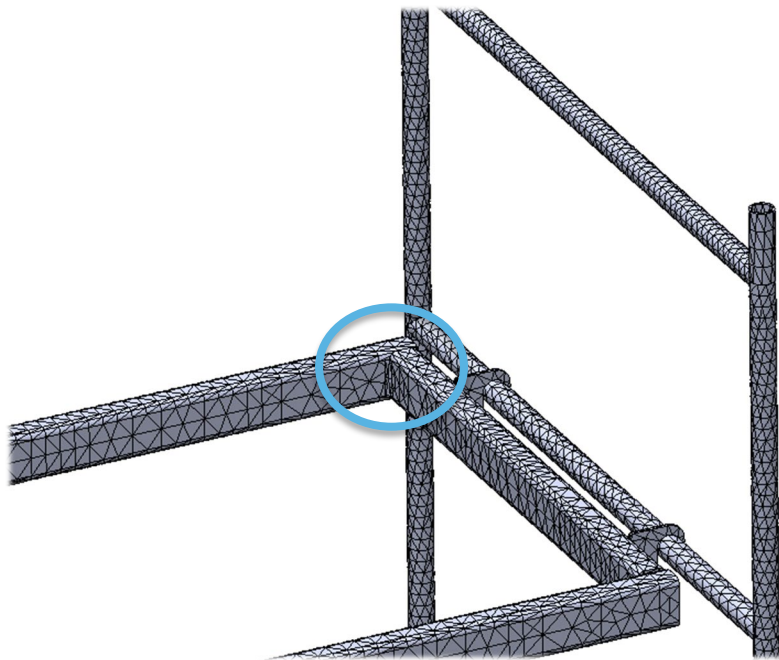
Submodeling



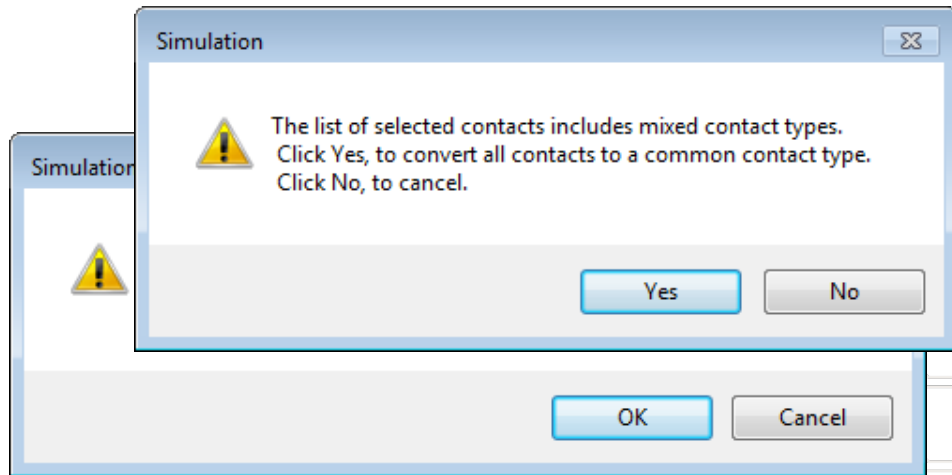
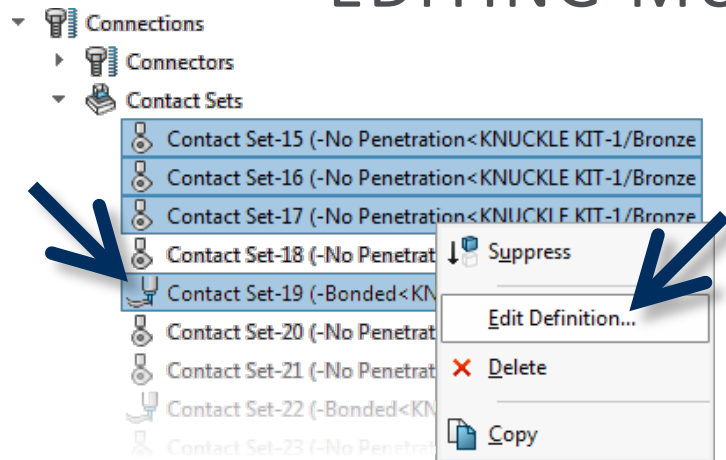
SUBMODELING

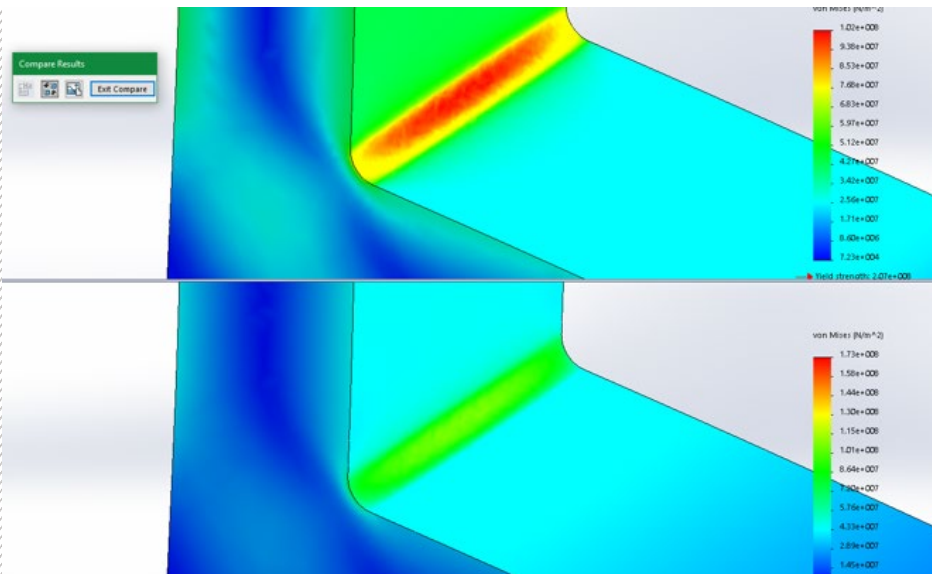


SUBMODELING



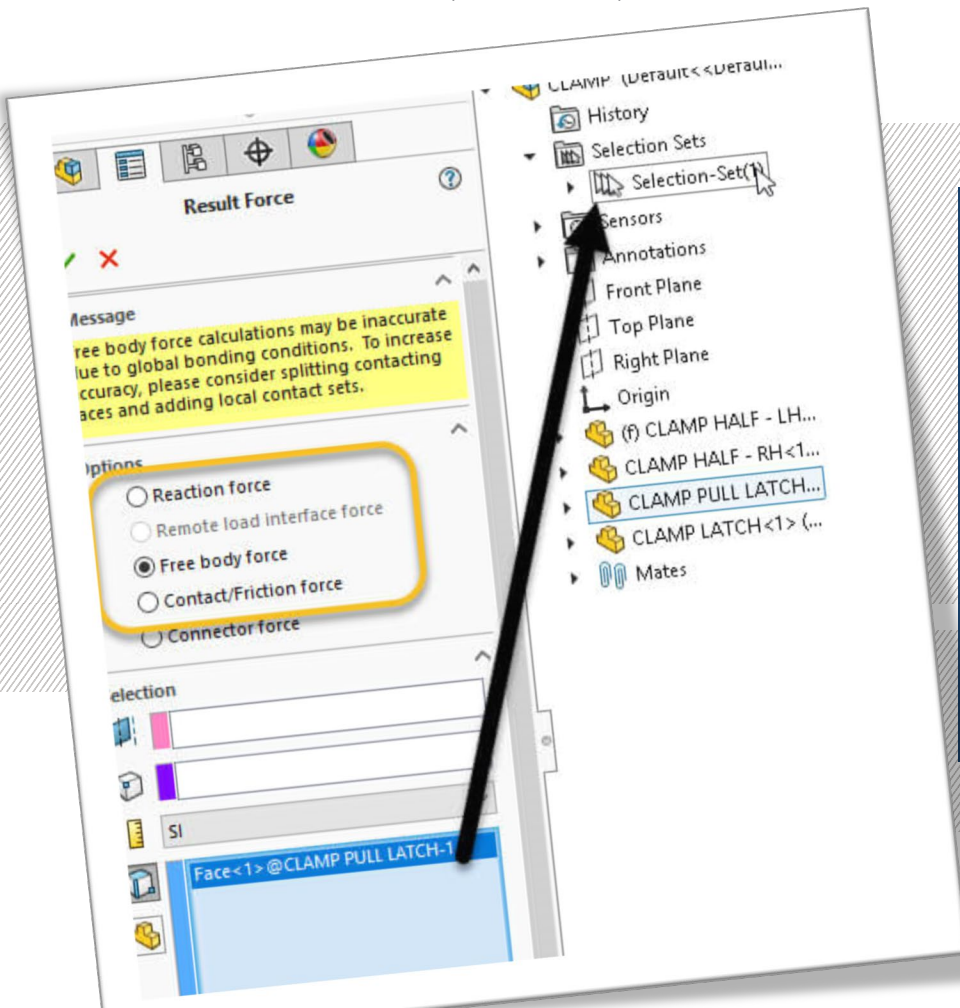
EDITING MULTIPLE CONTACT SETS





Compare Results

SIMULATION TIPS, TRICKS, AND TROUBLESHOOTING

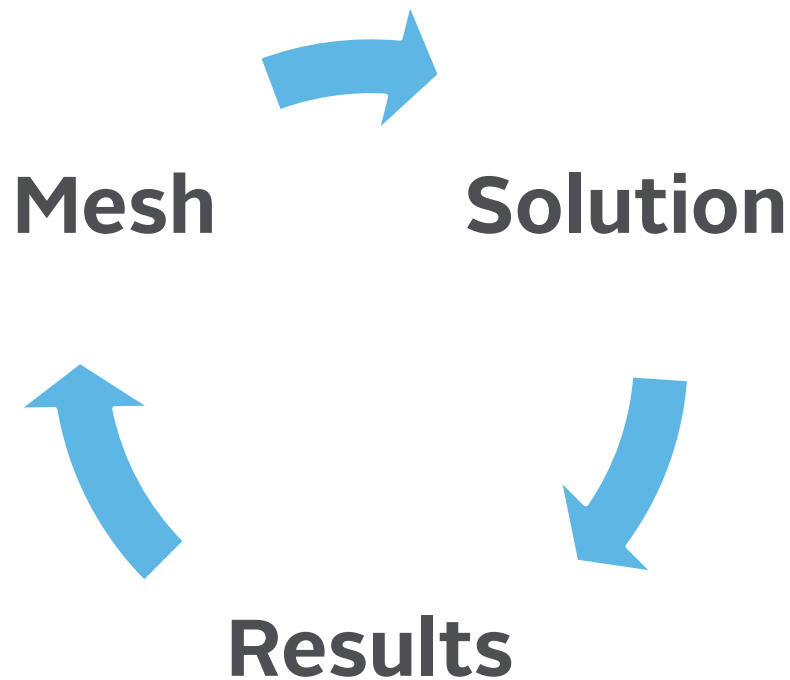


Selection Sets

Troubleshooting



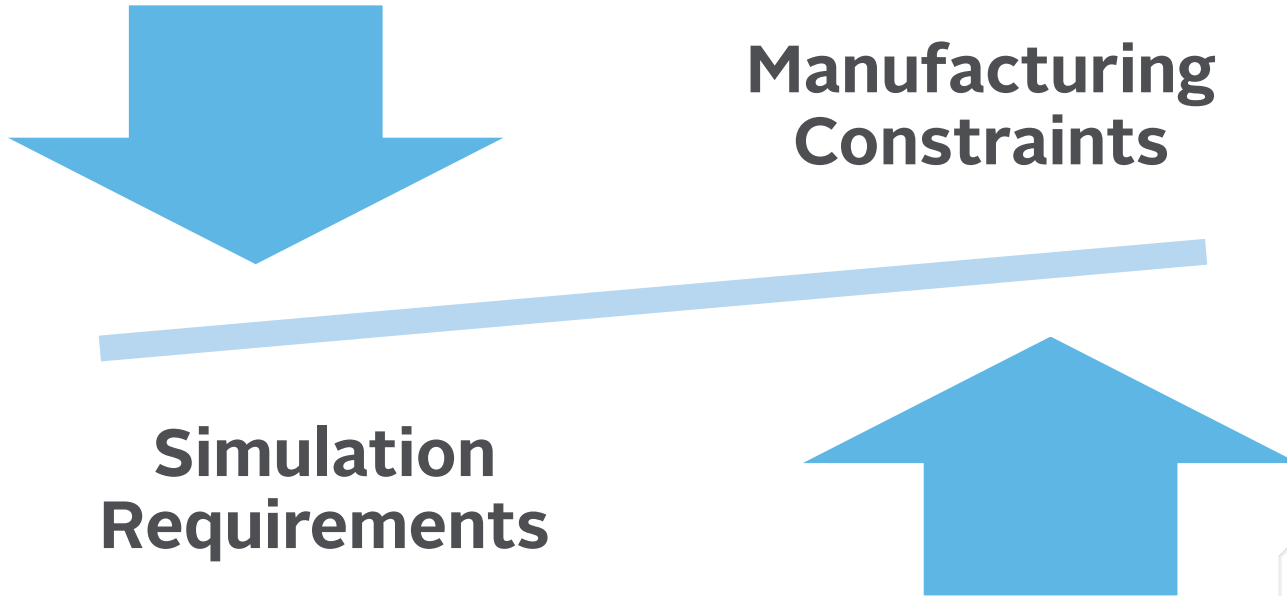
TROUBLESHOOTING AN ANALYSIS



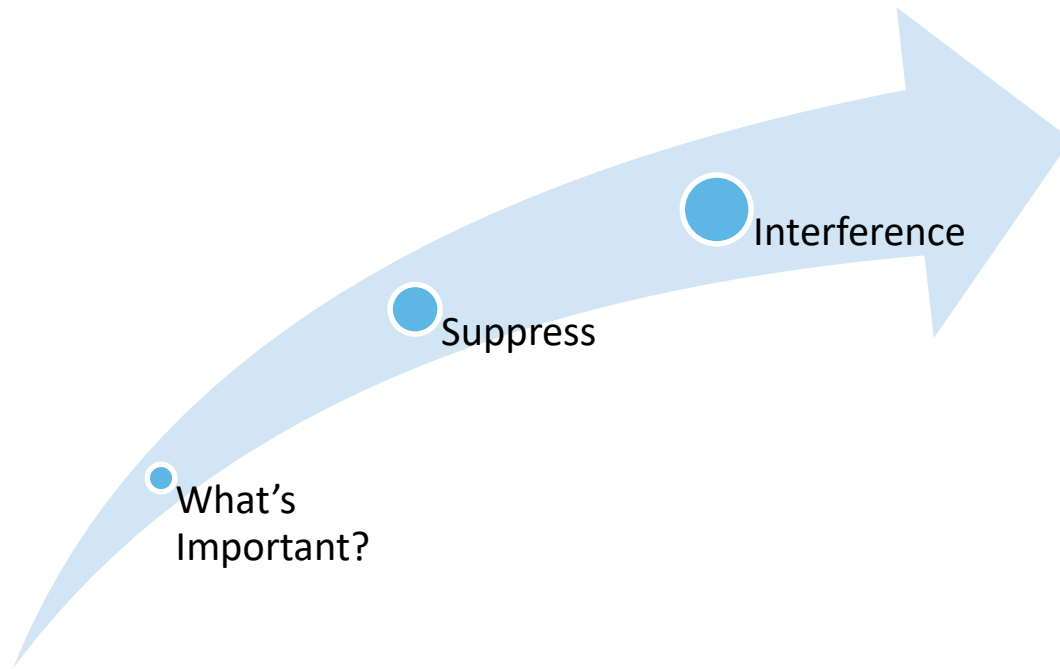


The **number 1** way to **avoid** trouble is to **do it right** the **first time!**

IT ALL STARTS WITH GEOMETRY....



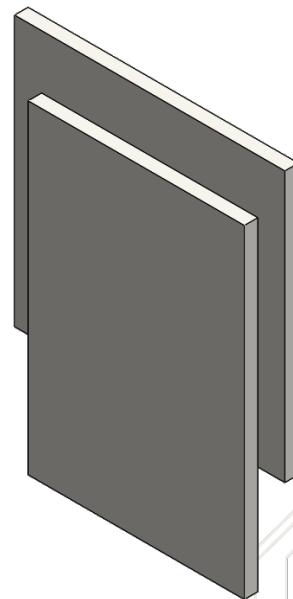
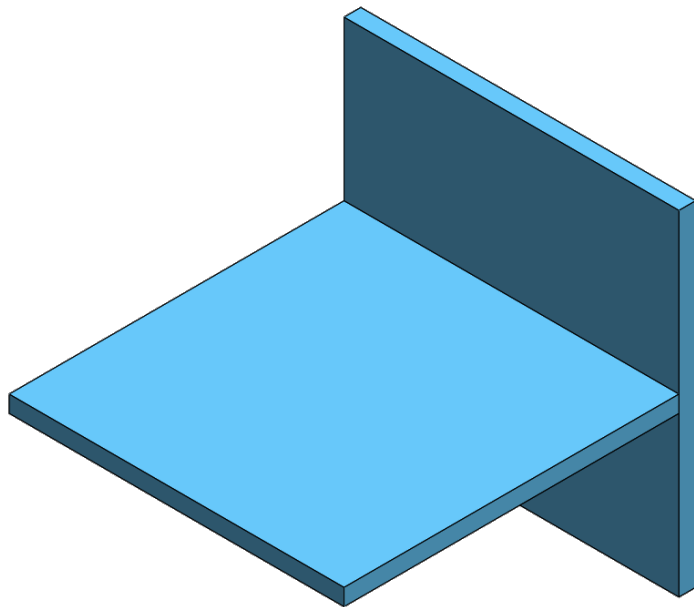
ANALYSIS PREPARATION



MINIMIZE COMPONENTS

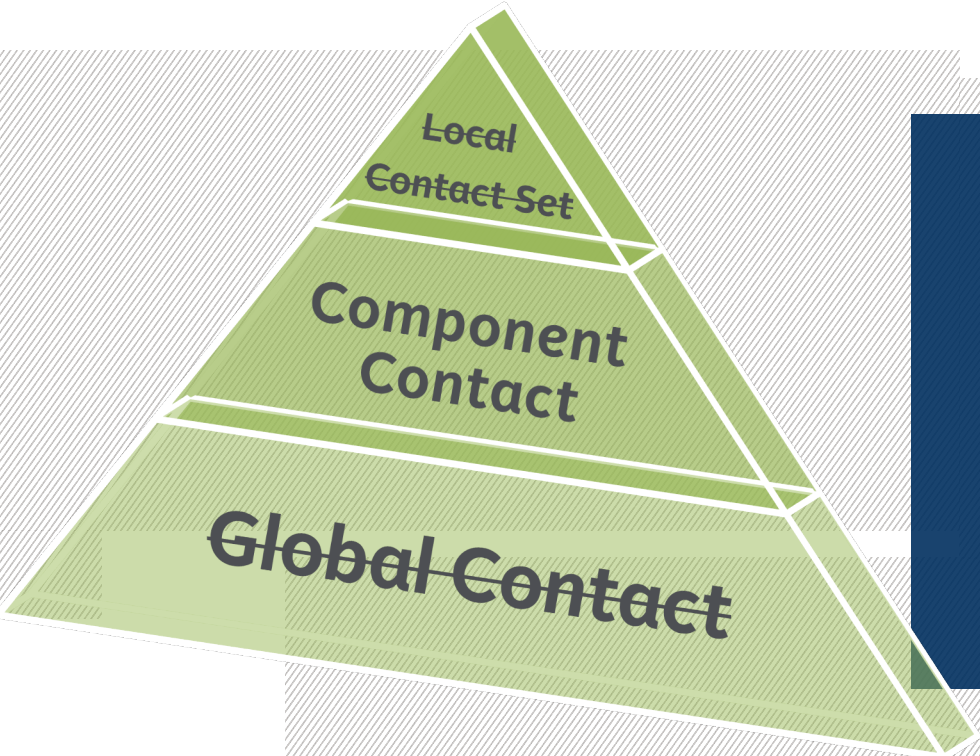
Minimizing the amount of Components in your Analysis makes Troubleshooting Easier

COMBINED COMPONENTS VS BONDED CONTACT



EXAMPLE...





Local
Contact Set

Component
Contact

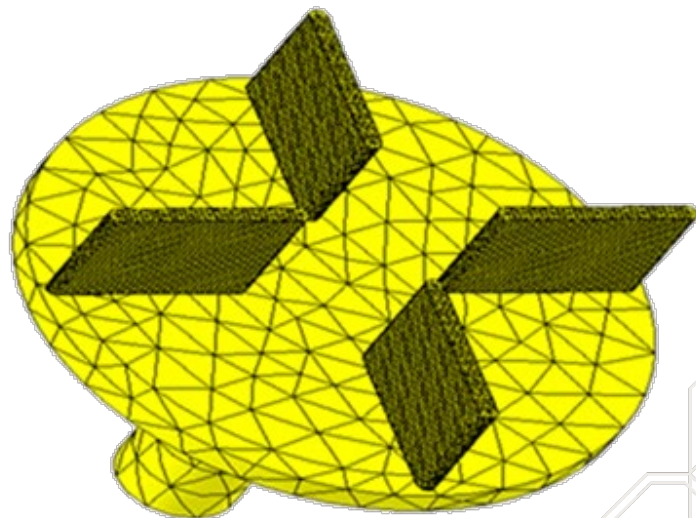
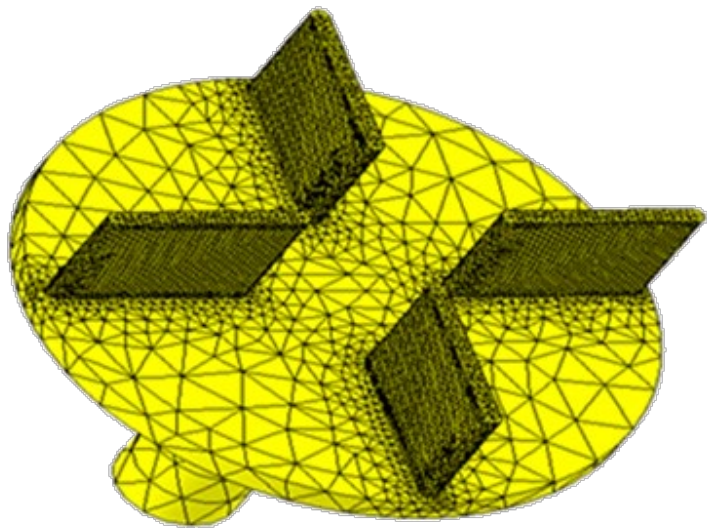
Global Contact

Component
Contacts are
your Friend!

CONTACTING FACES

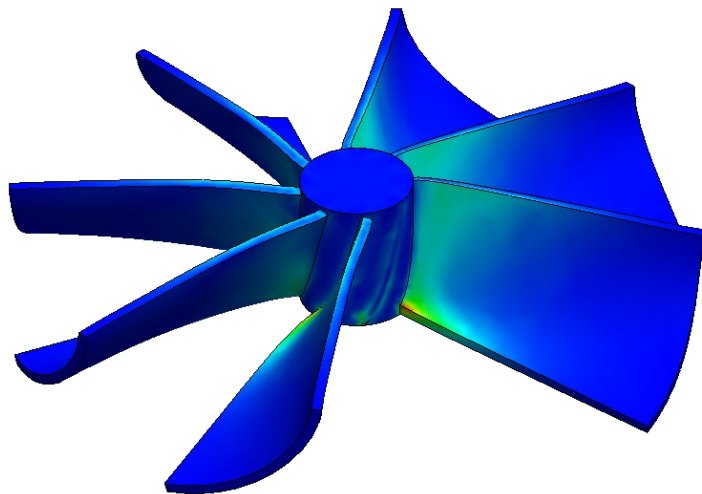
creating **Contacting Faces** that are **Flush** with each other will
minimize **Meshing Problems** and make your analysis more
Accurate and **Efficient**

COMPATIBLE VS INCOMPATIBLE MESH

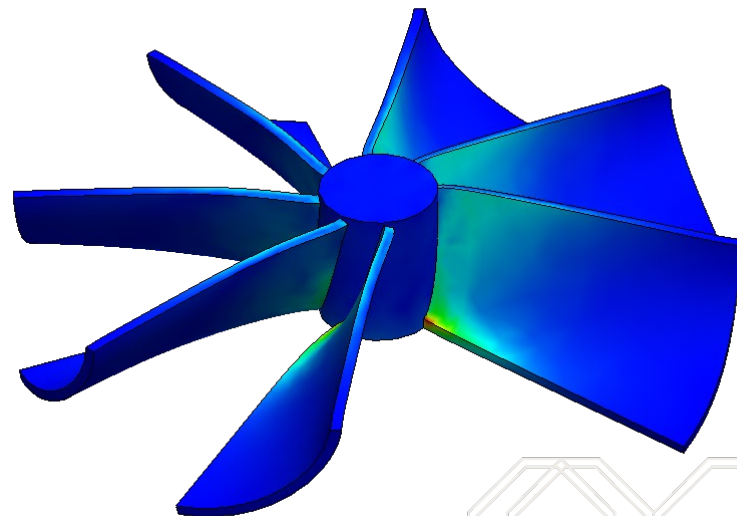


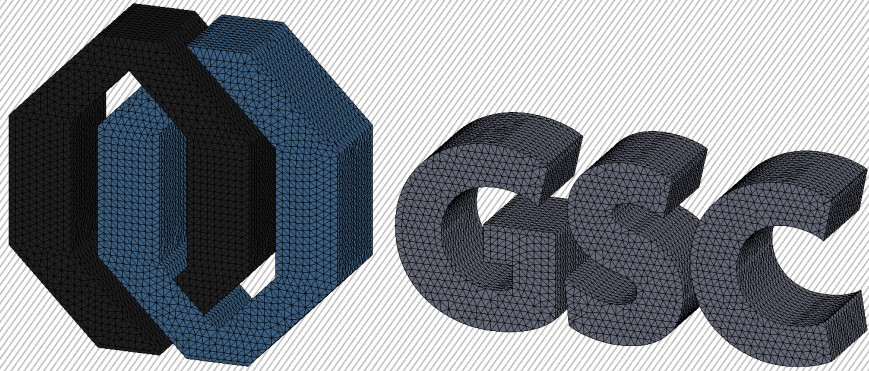
COMPATIBLE VS INCOMPATIBLE MESH

Compatible



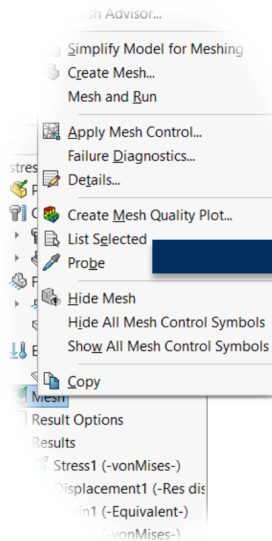
Incompatible





Mesh

MESH SUMMARY BEST PRACTICES

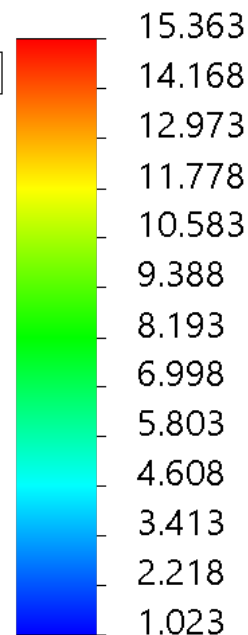
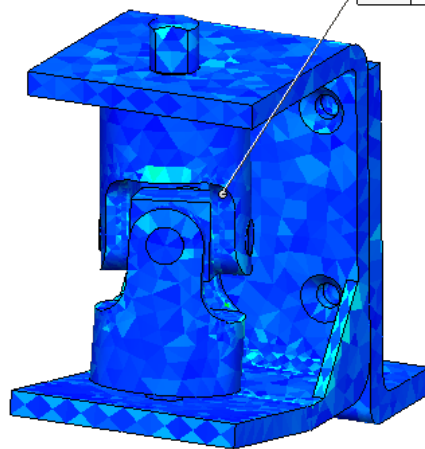
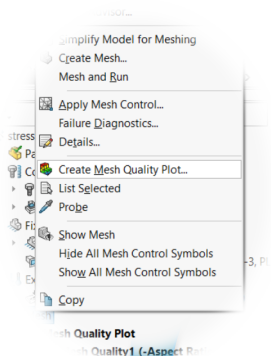


Mesh Details	
Study name	stress analysis refined (-Without_crank-)
Mesh type	Solid Mesh
Mesher Used	Curvature-based mesh
Jacobian points	4 points
Max Element Size	5.90759 mm
Min Element Size	1.18152 mm
Mesh quality	High
Total nodes	50576
Total elements	29042
Maximum Aspect Ratio	15.363
Percentage of elements with Aspect Ratio < 3	96.4
Percentage of elements with Aspect Ratio > 10	0.00344
% of distorted elements (Jacobian)	0
Remesh failed parts with incompatible mesh	Off
Time to complete mesh(hh:mm:ss)	00:00:02
Computer name	CHRISO-5520

More than 95%
Less than 1-2%

ASPECT RATIO PLOT

Aspect Ratio



*Lower in High
Stress Areas*

So It Fails...Now What??

FINER MESH

Shortest
Edge
Length

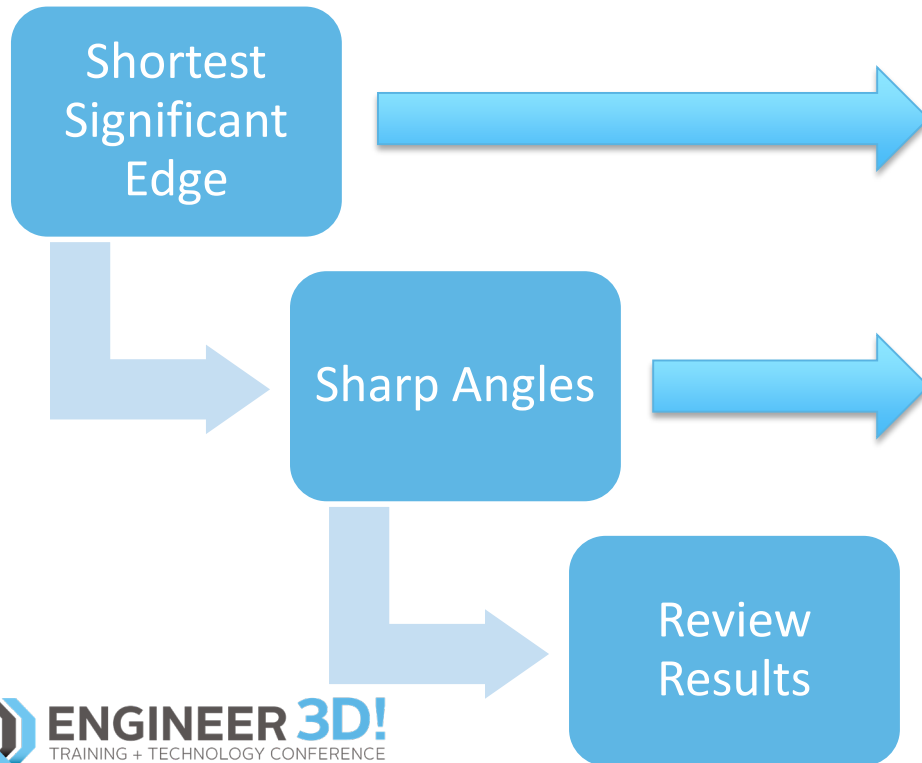


Element
Size

HOW DO I FIND THE SHORTEST EDGE LENGTH??

GEOMETRY ANALYSIS

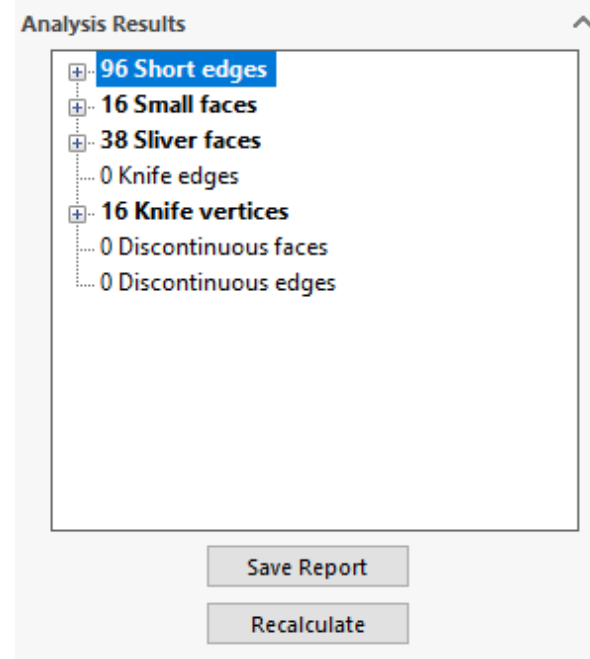
GEOMETRY ANALYSIS



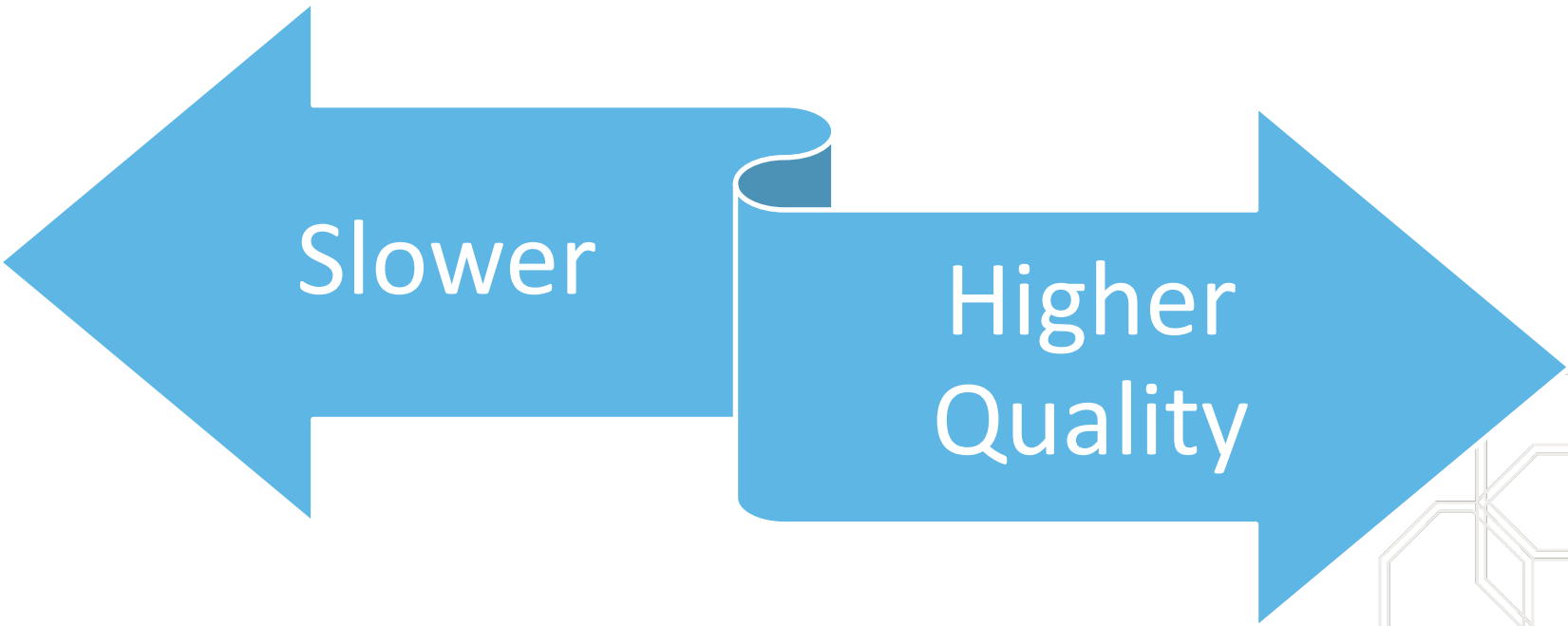
Analysis Parameters

- ☒ Insignificant geometry
 - ☒ Short edges
 - < 0.00393701in
 - ☒ Small faces
 - < 0.00393701in
 - ☒ Sliver faces
 - < 0.00393701in
- ☒ Sharp angles
 - ☒ Knife edges
 - < 5.00deg
 - ☒ Knife vertices
 - < 5.00deg

ADJUST MESH SIZE



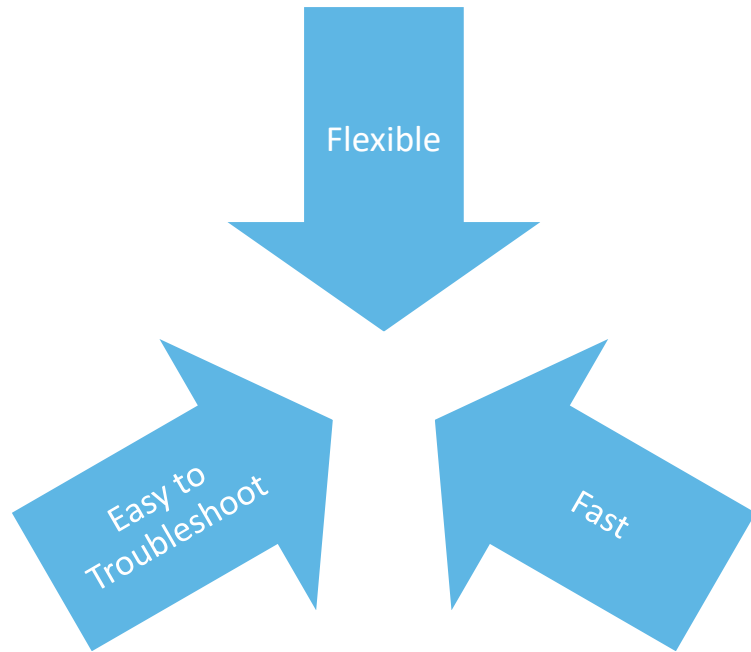
BLENDED CURVATURE BASED MESHER



Slower

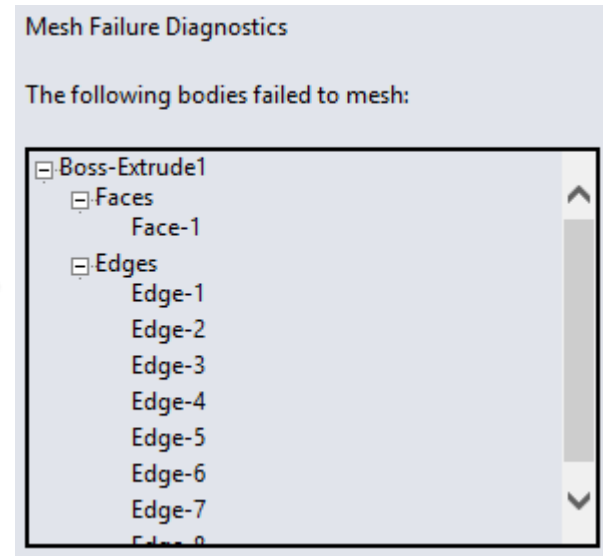
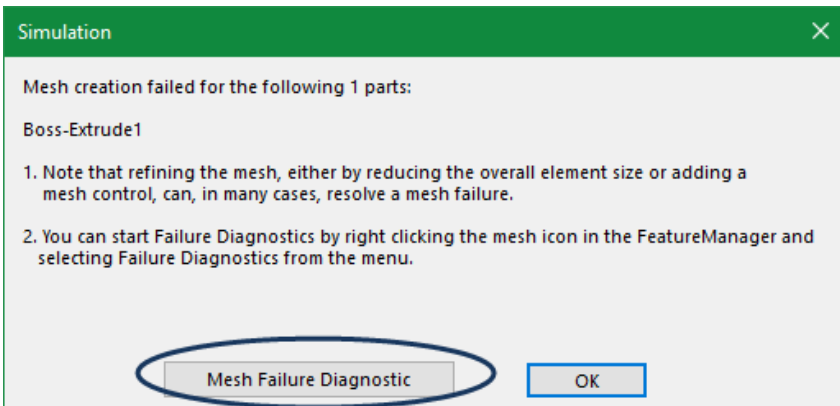
Higher
Quality

STANDARD MESH



Oldies
But
Goodies

MESH FAILURE DIAGNOSTICS



STANDARD MESH VS CURVATURE BASED MESH

Mesh Failure Diagnostics

The following bodies failed to mesh:

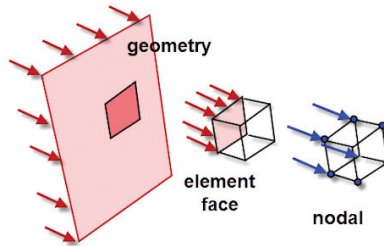
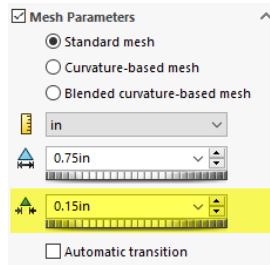
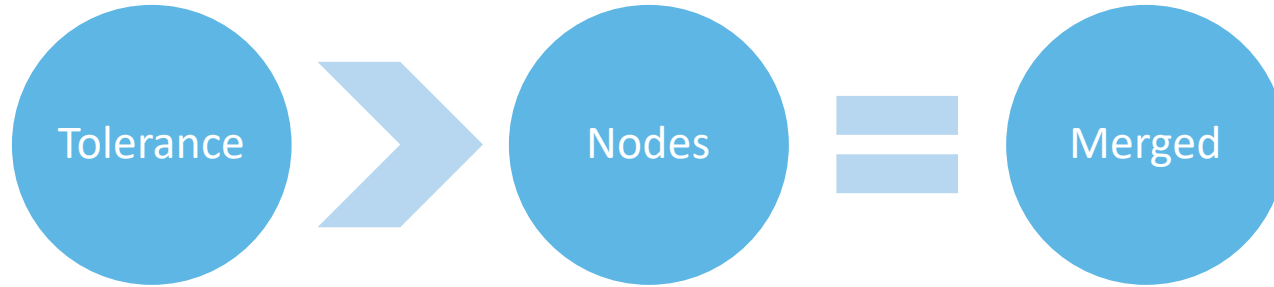
- ☐ Boss-Extrude1
 - ☐ Faces
 - Face-1
 - ☐ Edges
 - Edge-1
 - Edge-2
 - Edge-3
 - Edge-4
 - Edge-5
 - Edge-6
 - Edge-7
 - Edge-8

Mesh Failure Diagnostics

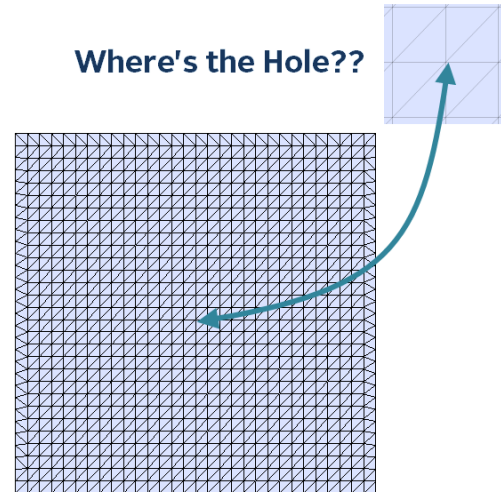
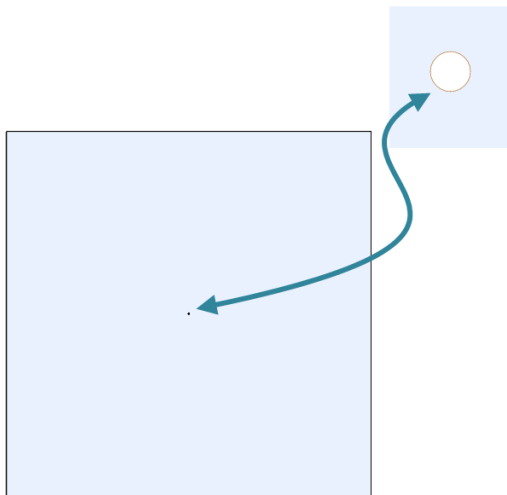
The following bodies failed to mesh:

- ☒ Boss-Extrude1

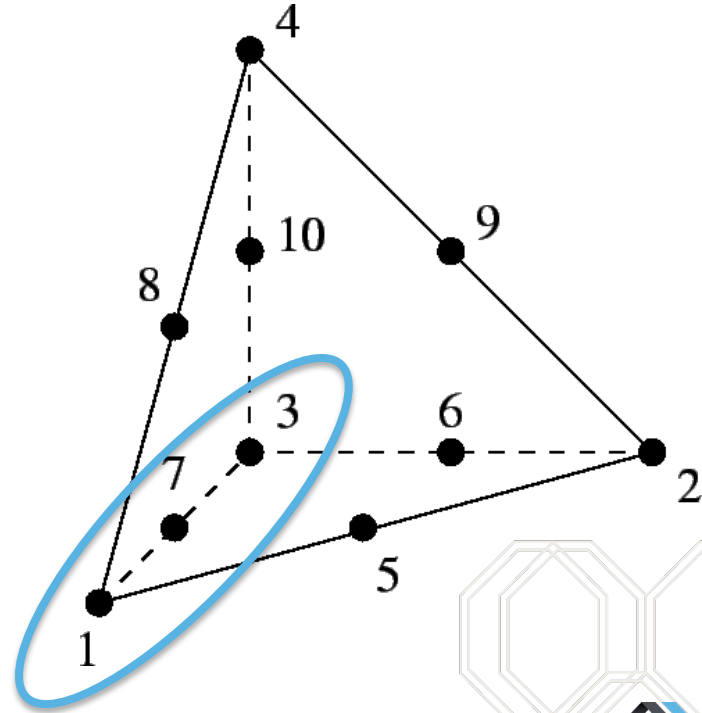
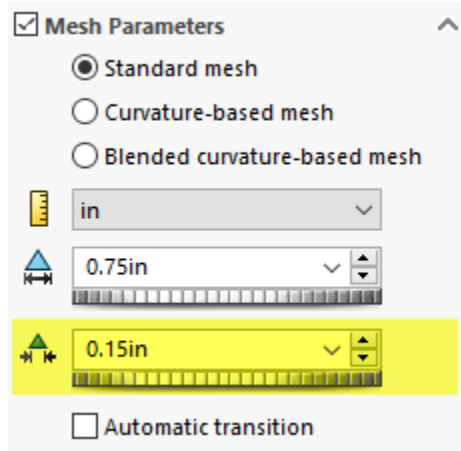
STANDARD MESH



STANDARD MESH



STANDARD MESH: A WORD OF CAUTION!



GEOMETRY CHECK

**Import
Diagnostics**

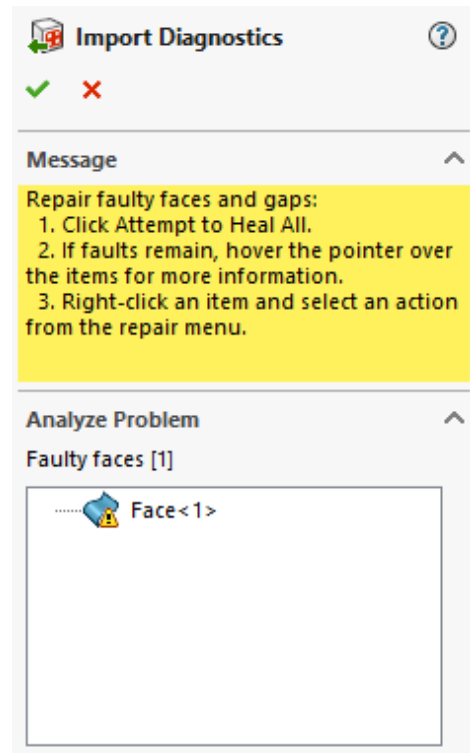
**Check
Entity**

Imported Geometry



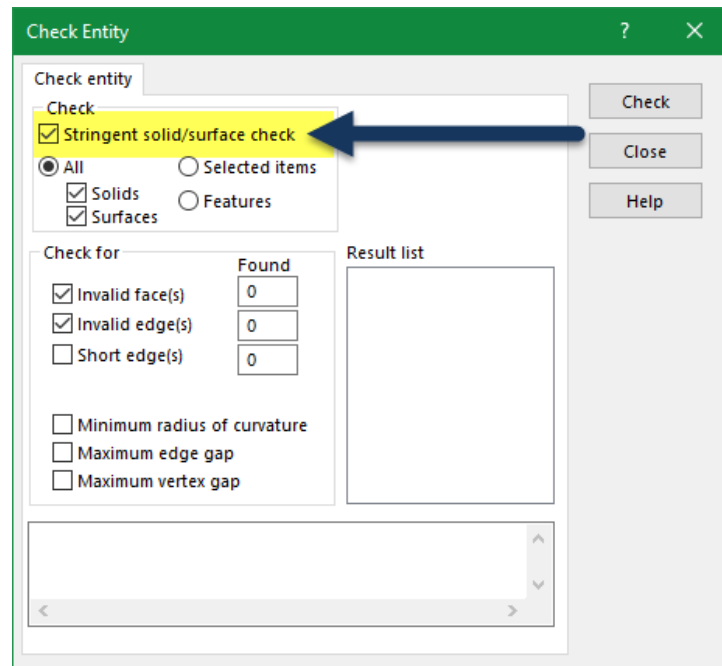
☐ Faulty Faces

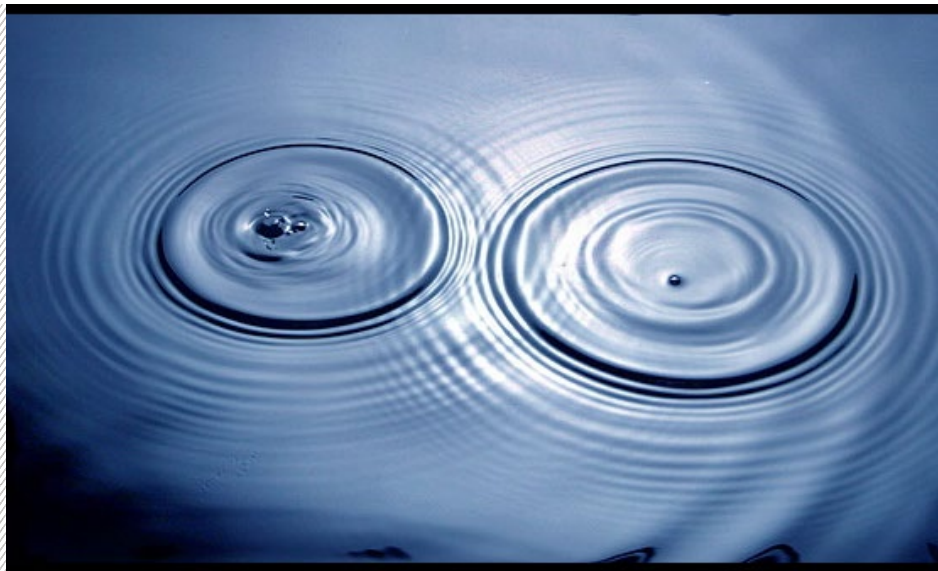
☐ Gaps



CHECK ENTITY

Evaluates the Integrity of
the **geometry** at a
deeper level then
import diagnostics

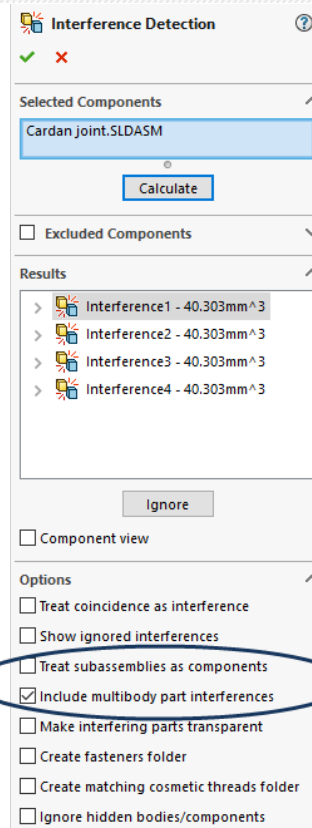




Check
Interferences

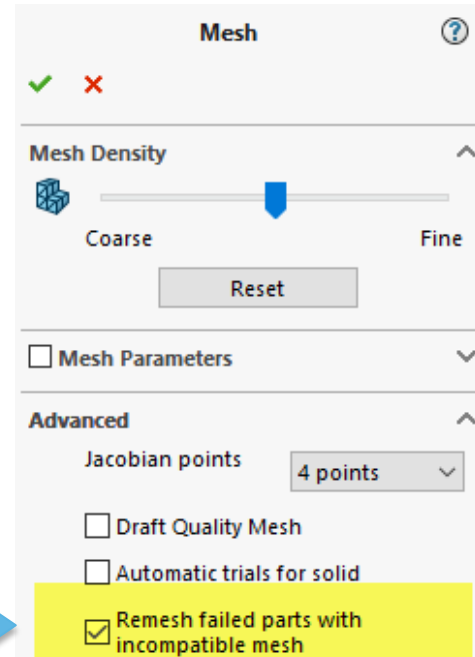
INTERFERENCE DETECTION

- Treat Subassemblies as components
- Include multibody part interferences

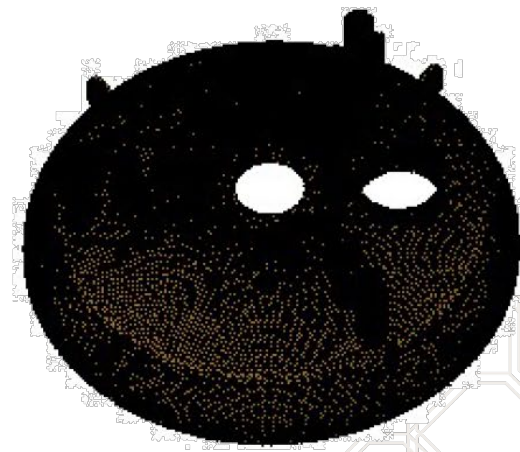
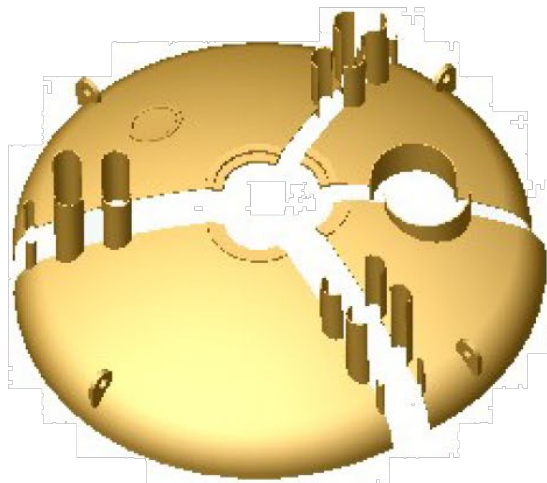
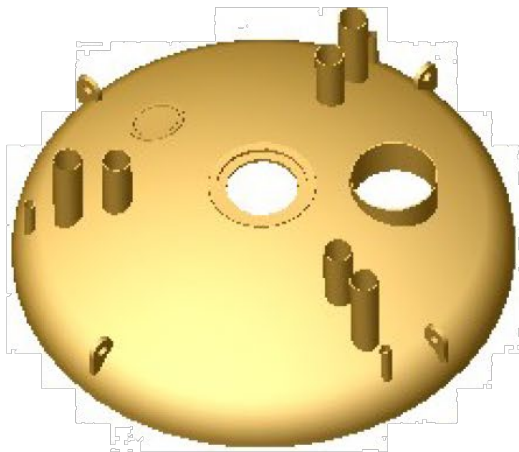


REMESH FAILED PARTS WITH INCOMPATIBLE MESH

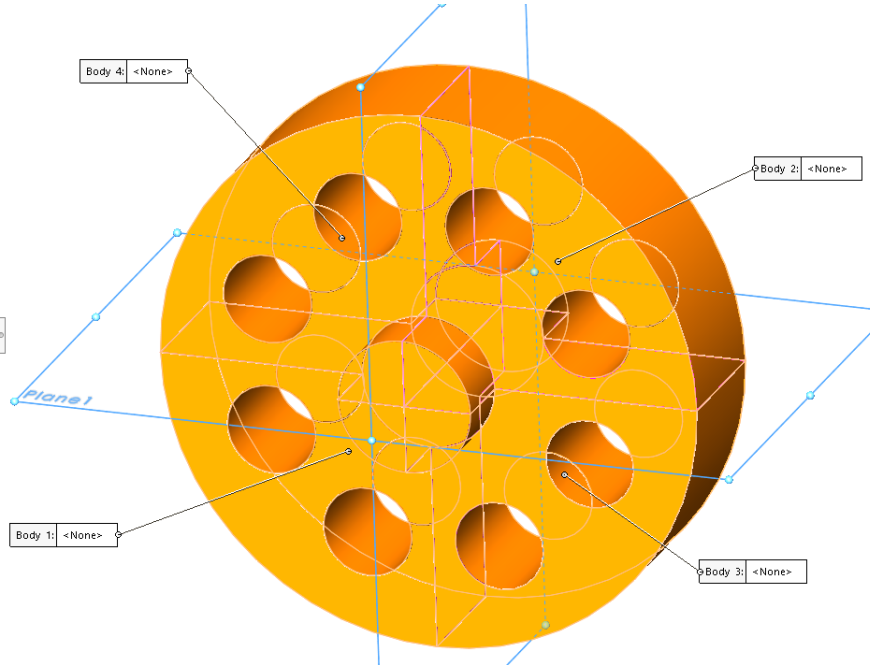
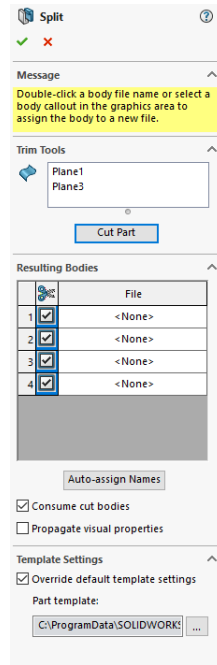
Re-meshes components
that fail
independently of the
other components



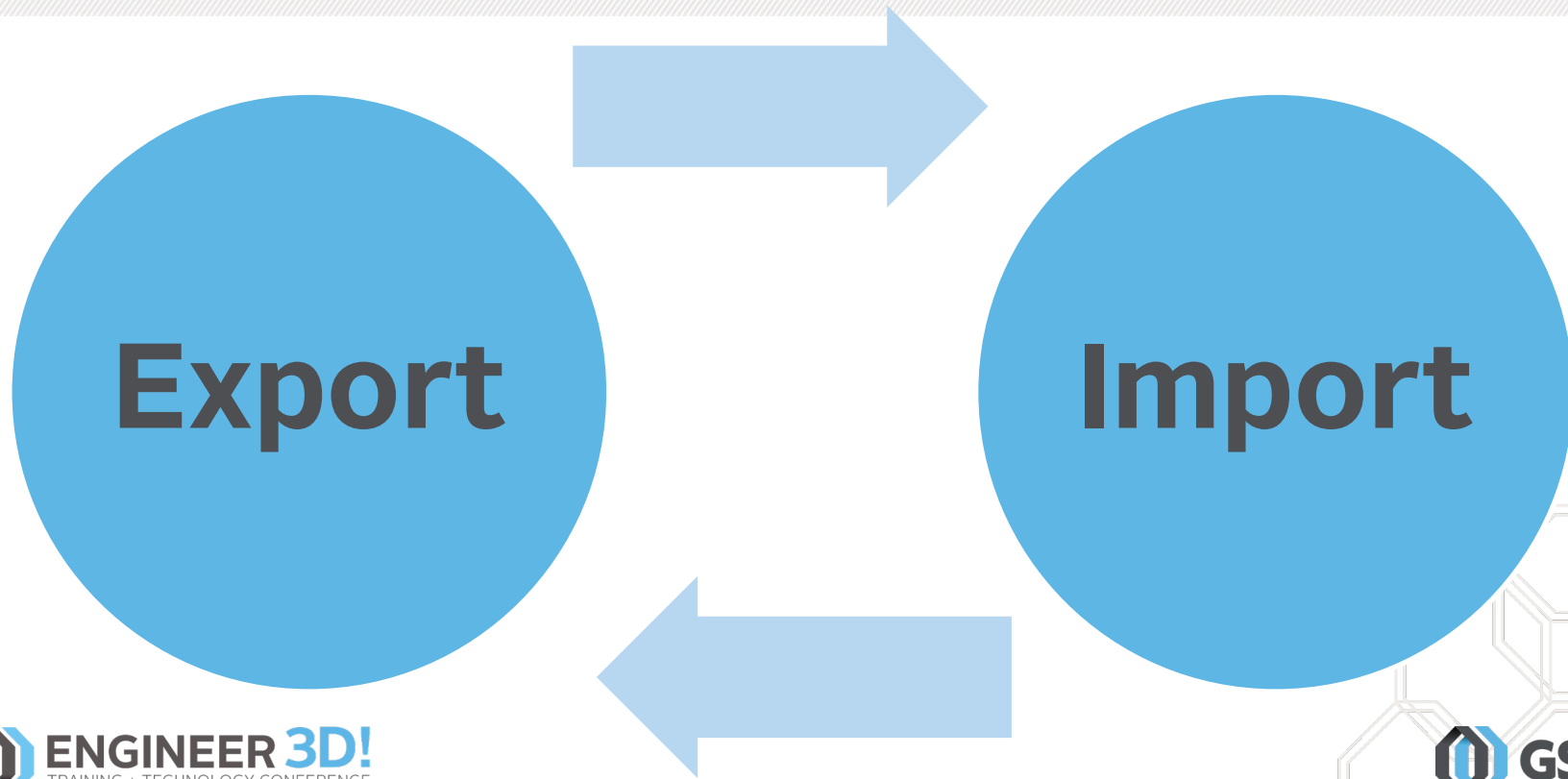
ISOLATE PROBLEM



SPLIT COMMAND

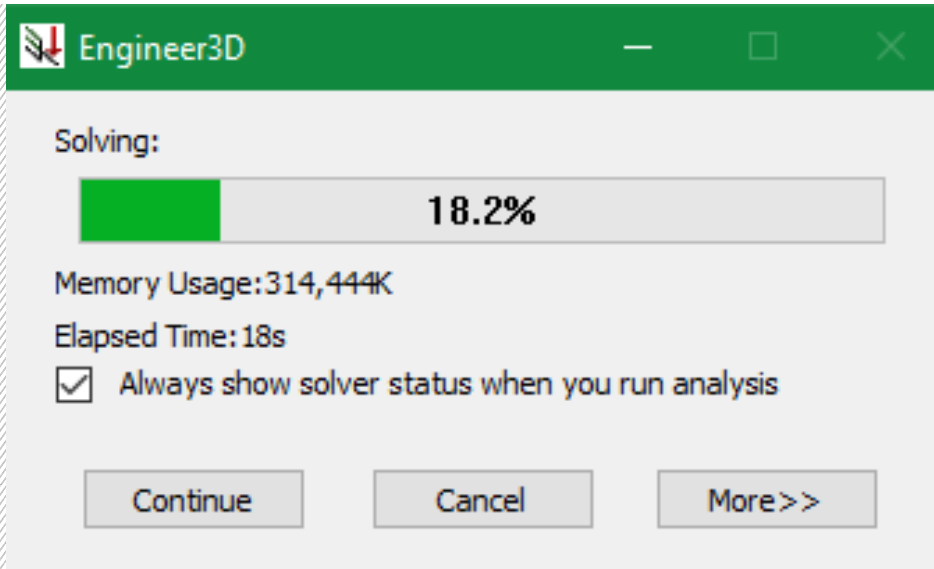


CREATE PARASOLID



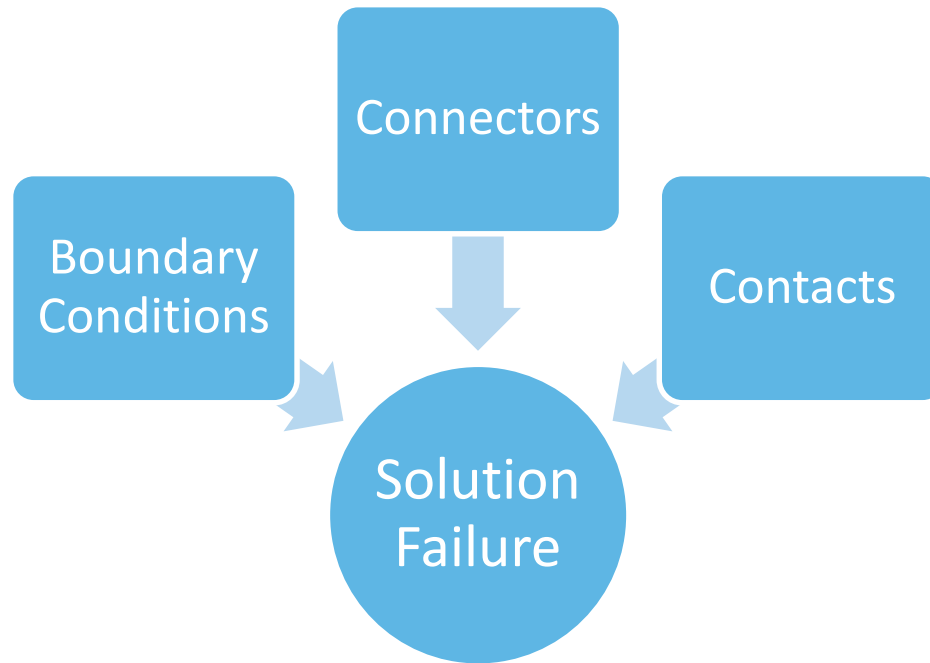
AND IF THAT FAILS...CALL US!





Solution

REVIEW THE SETUP

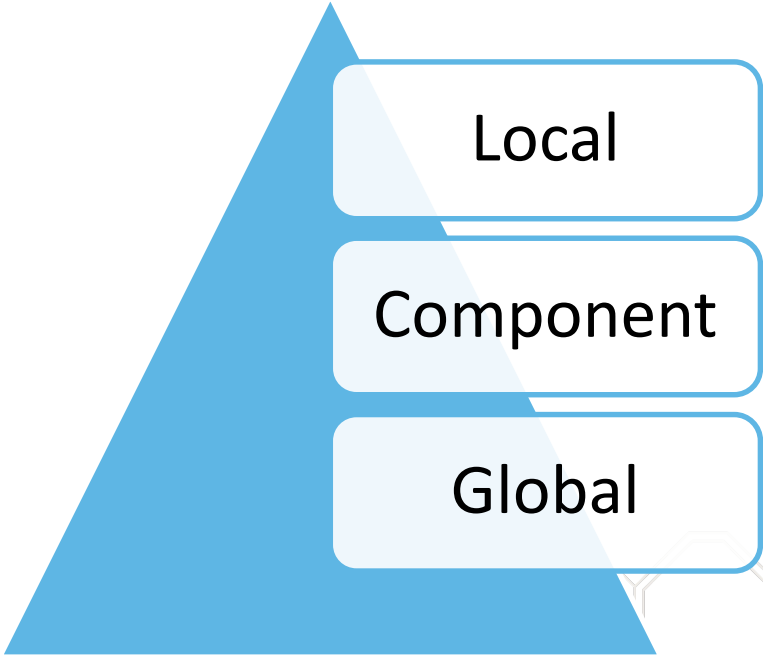


BOUNDARY CONDITIONS

Boundary conditions must restrain all **rigid**
body motion of the **geometry**

CONTACTS

Review all **Bonded**
and **No Penetration**
contacts to verify **none**
were **missed**



Local

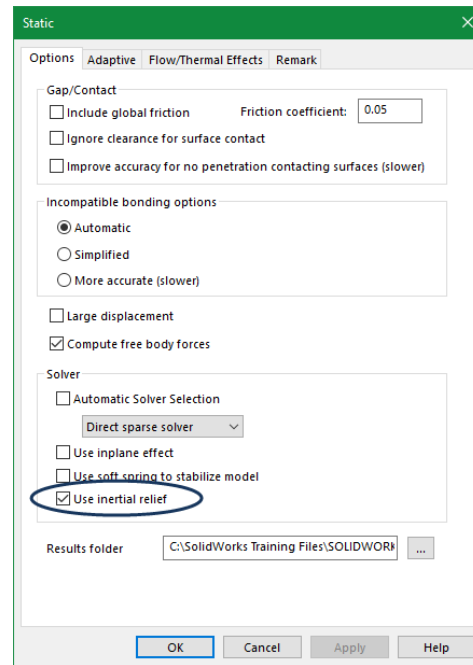
Component

Global

Contact Type	Color Rendering
Bonded	 Red
No Penetration	 Purple
Allow penetration (Free contact)	 Green
Shrink Fit	 Orange
Virtual Wall	 Yellow
Thermal Contact Resistance	 Purple
Insulated	 Green

Contact Visualization Plot

TROUBLESHOOTING WITH INERTIAL RELIEF



WHERE ARE MY RESULTS BEING SAVED?

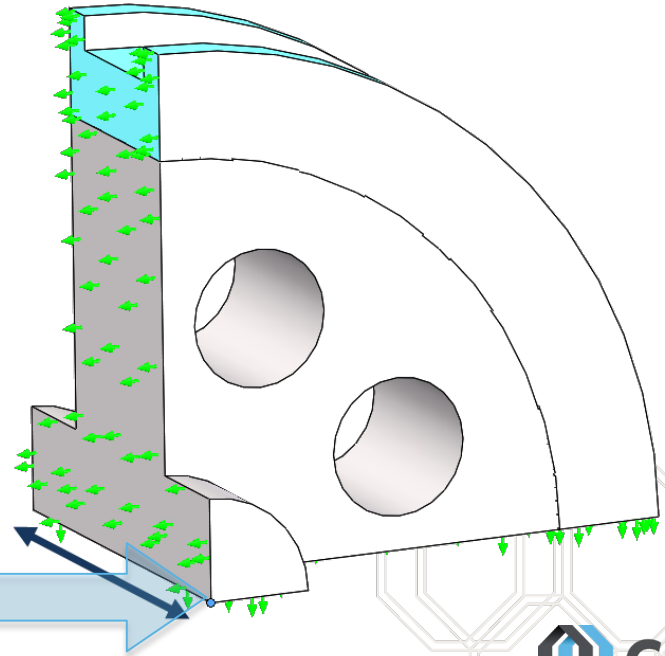


START WITH GRAVITY

start with **gravity** and incrementally **add loads** back into
the **analysis**

STABILIZING RESTRAINT

Single point is
restrained for the
purpose of adding
stability to the **model**



CORRUPTED STUDY

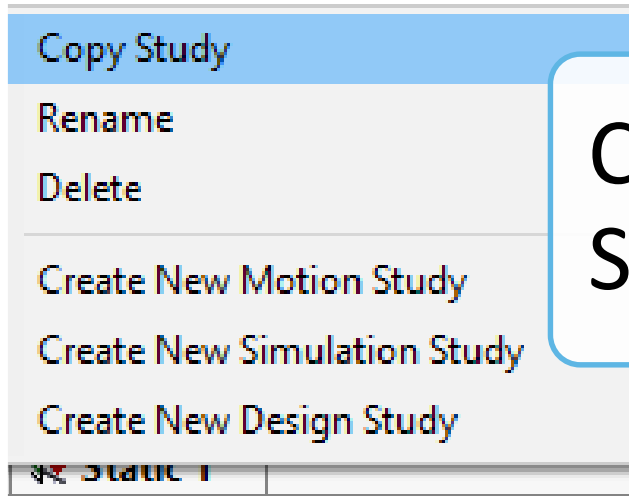
Duplicate
Study

Copy to
Study

New Study

DUPLICATE STUDY

Right Click Study Name



Copy
Study



Copy Study ⓘ ⓘ

✓ ✗ ⚙

Message ^

This feature allows you to copy the selected study to new study of the same type or to a different type. All Simulation features from the source study will be copied to the new study, provided the features are supported in the new study.

Source Study ^

 Static 1 v

Study name:

Static 2

Configuration to use:

FEA v

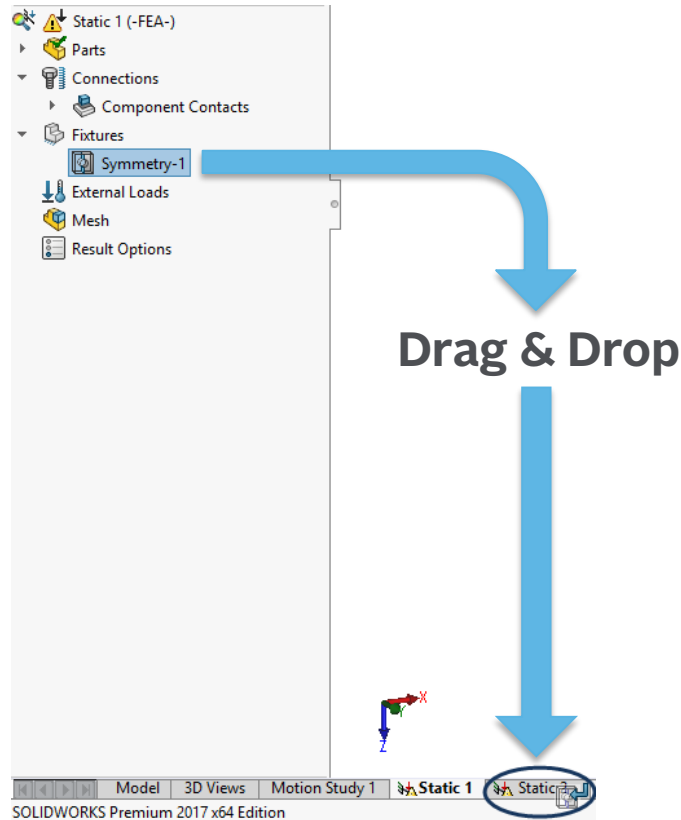
Target Study ^

 Static

 Nonlinear

 Linear Dynamic

COPY TO STUDY

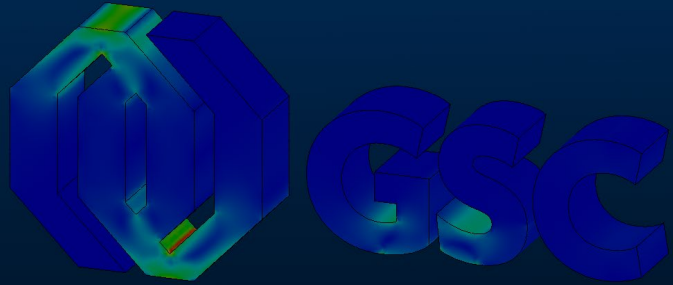


AND IF THAT FAILS...CALL US!



sarahj-art.tumblr
CAN'T

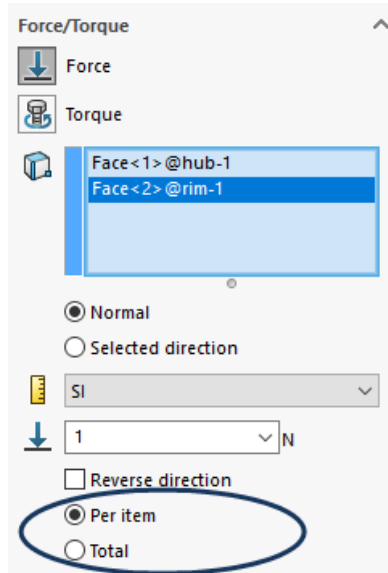
CAN



Results

PER ITEM VS TOTAL LOAD

Per Item



Total Load

CHECKING REACTION FORCES

Result Force ?

✓ ✗

Options ^

☒ Reaction force
☐ Remote load interface force
☐ Free body force
☐ Contact/Friction force
☐ Connector force

Selection ^

SI

Face<1>

Update

Reaction force (N) ^

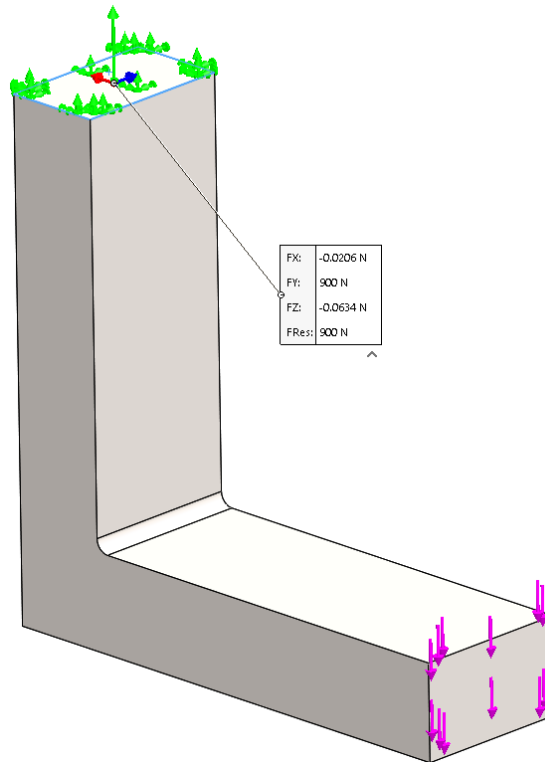
Component	Selection	Entire Model
Sum X:	-0.020596	-0.020596
Sum Y:	899.94	899.94
Sum Z:	-0.063354	-0.063354
Resultant:	899.94	899.94

Reaction Moment (N.m) v

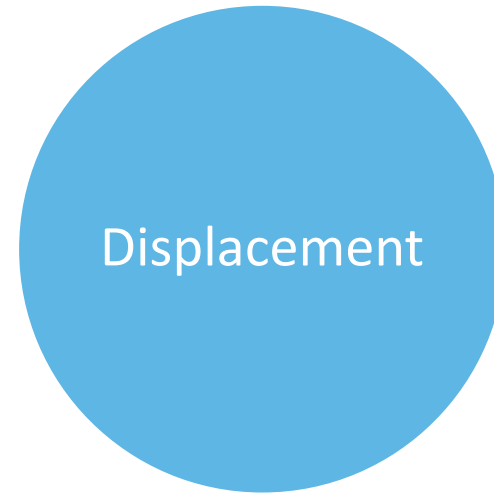
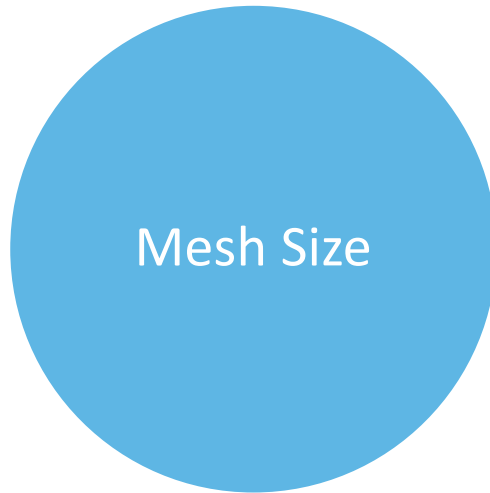
Display Options ^

☐ Display resultant forces

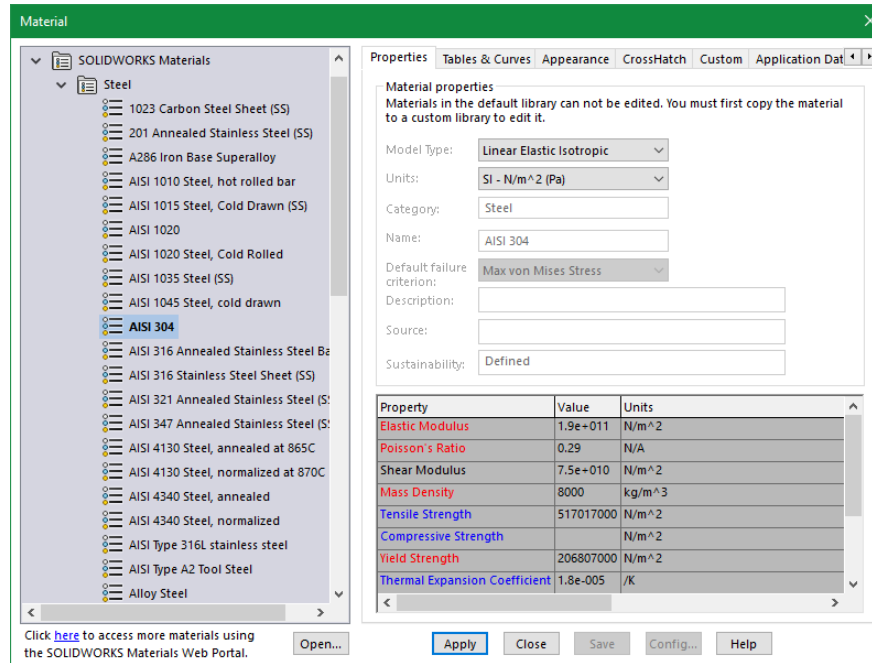
Report Options ^



Displacement should be **Independent** of **Mesh Size**



MATERIAL PROPERTIES CORRECT



DOUBLE CHECK UNITS!



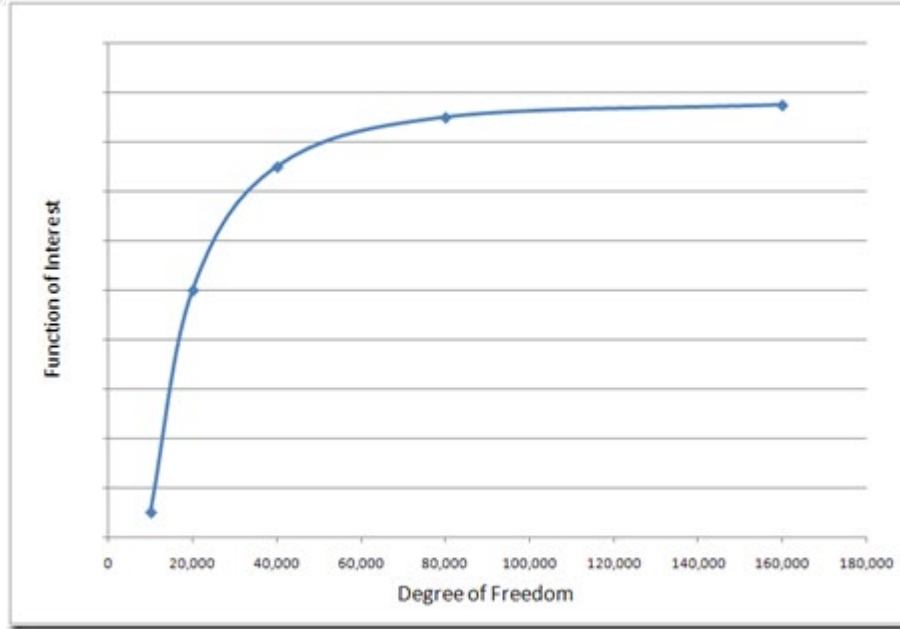
MESH QUALITY

Mesh
Quality



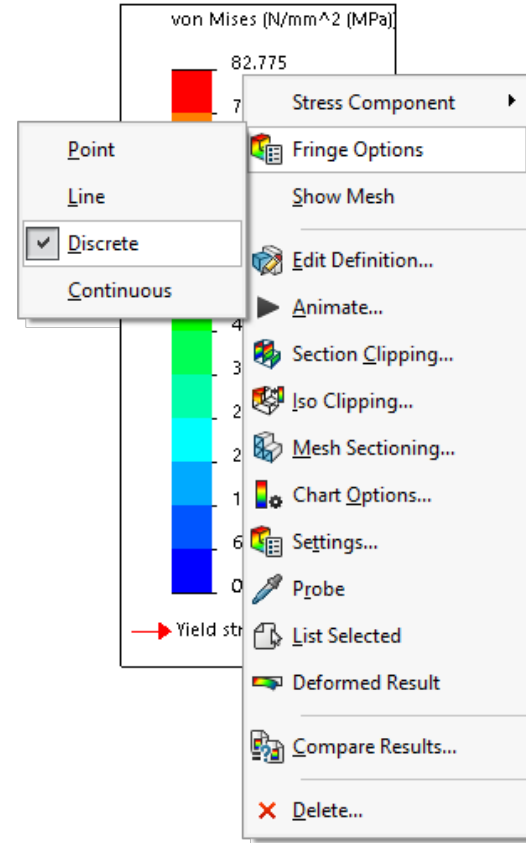
Results
Quality

CONVERGENCE

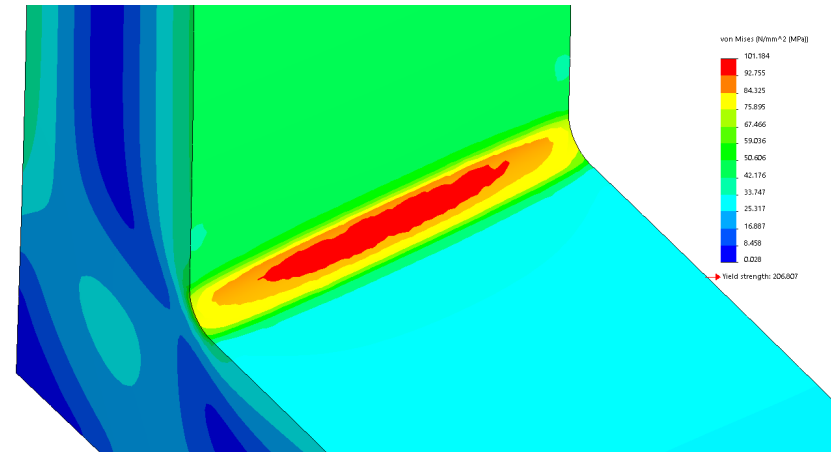
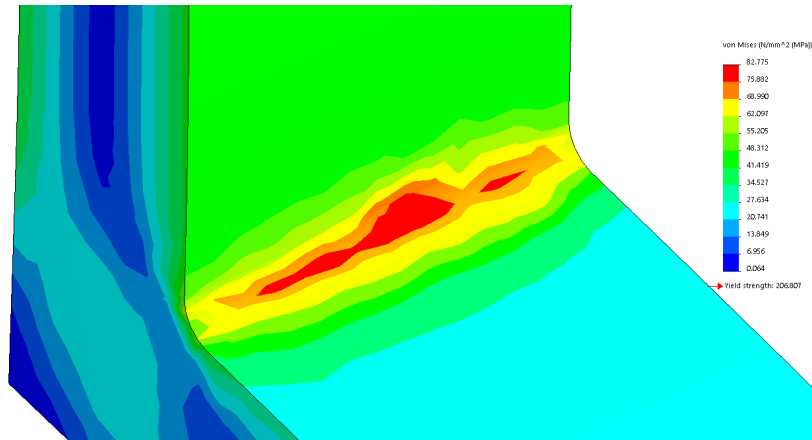


Stress should be **Independent** of **Mesh Size**

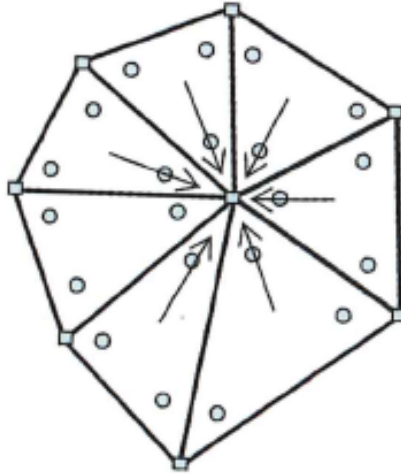
CONTOUR PLOT



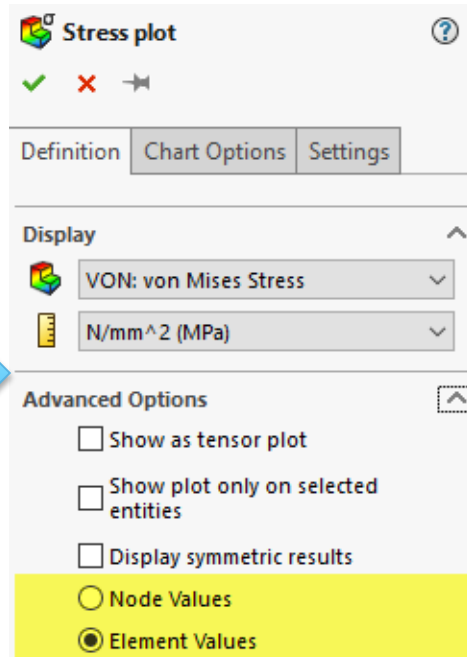
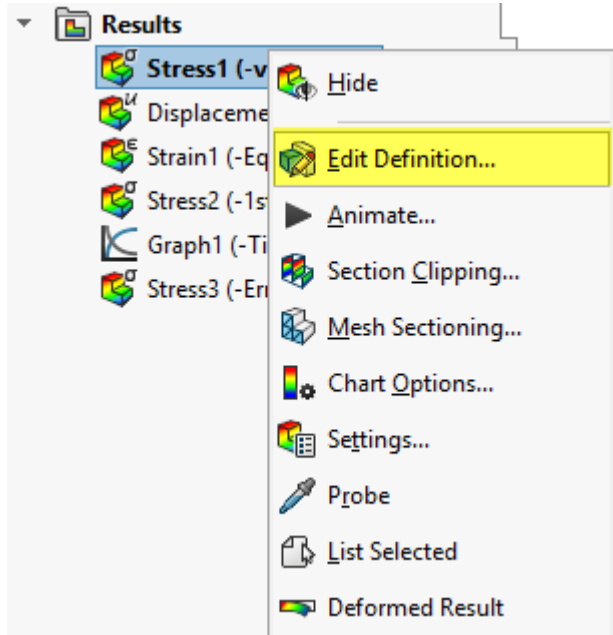
CONTOUR QUALITY



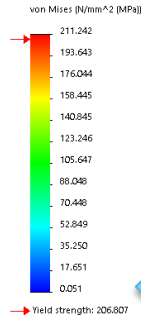
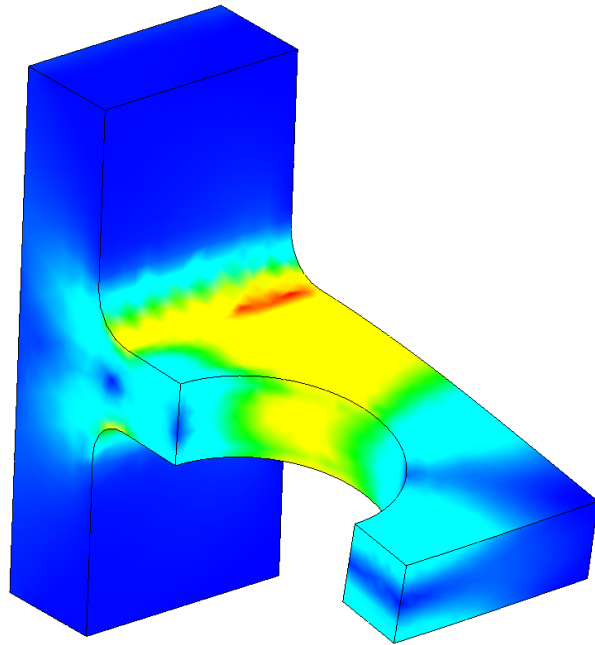
NODAL VS ELEMENTAL VALUES



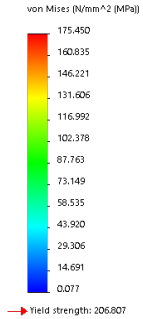
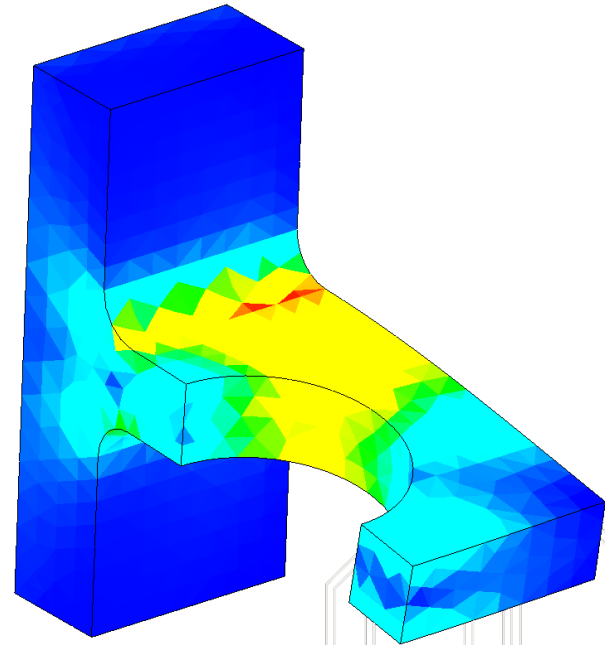
NODAL VS ELEMENTAL VALUES



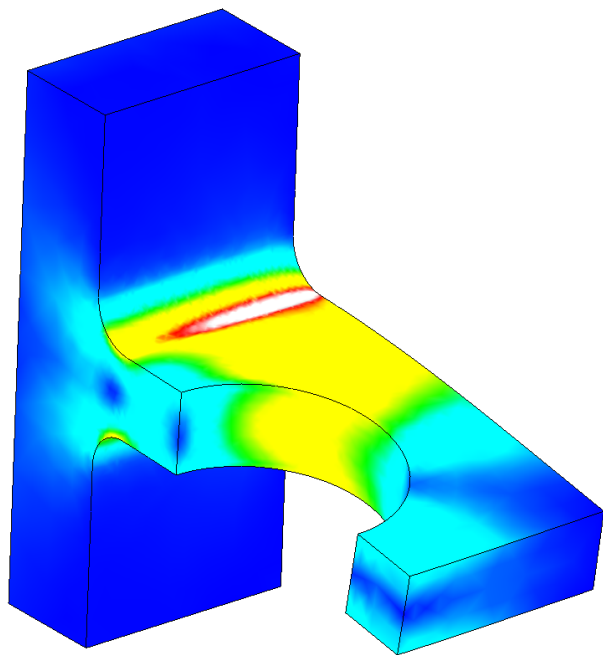
NODAL VS ELEMENTAL VALUES (COURSE MESH)



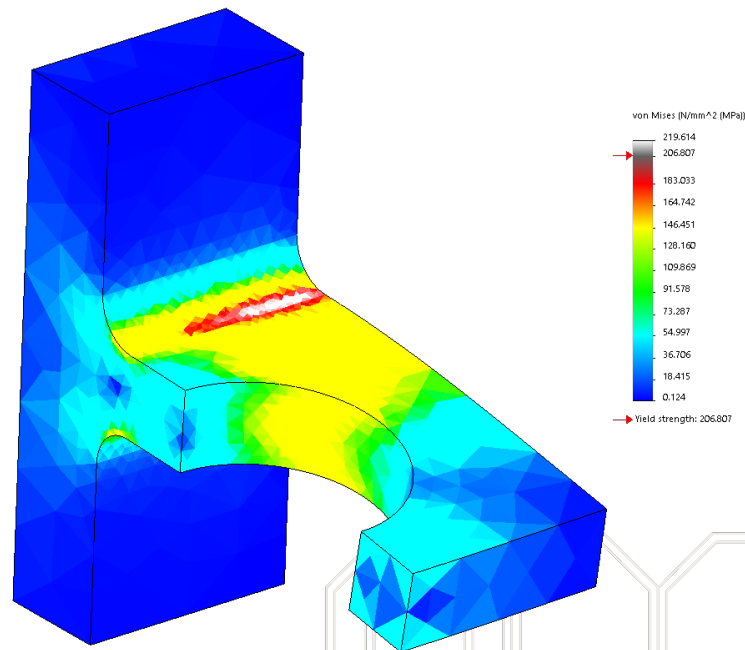
17%



NODAL VS ELEMENTAL VALUES (FINE MESH)



4.4%

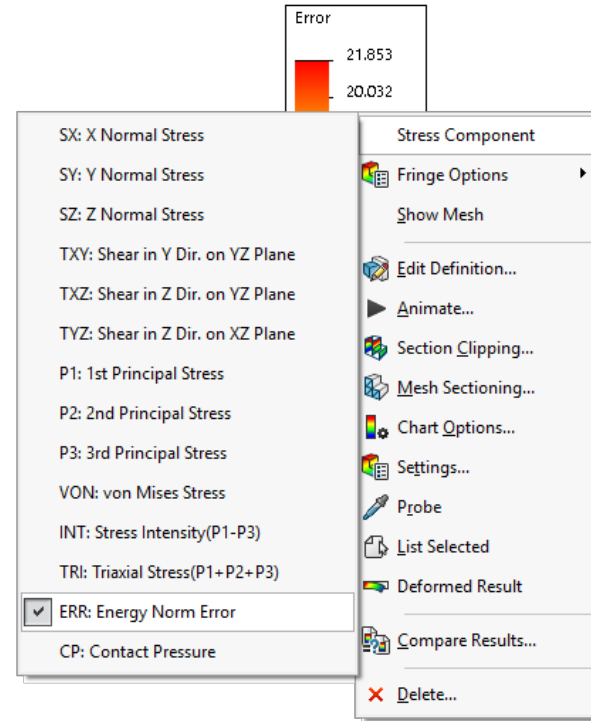
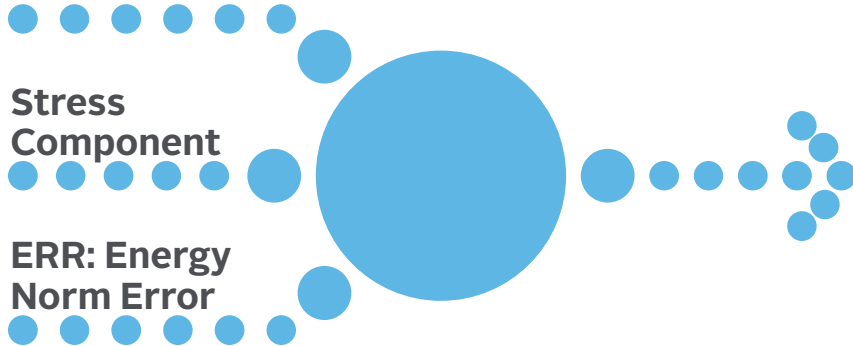


ENERGY NORM ERROR

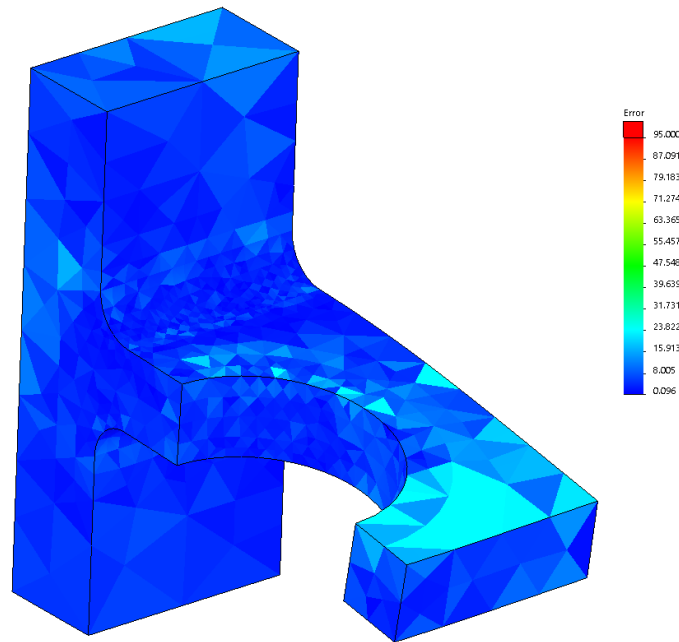
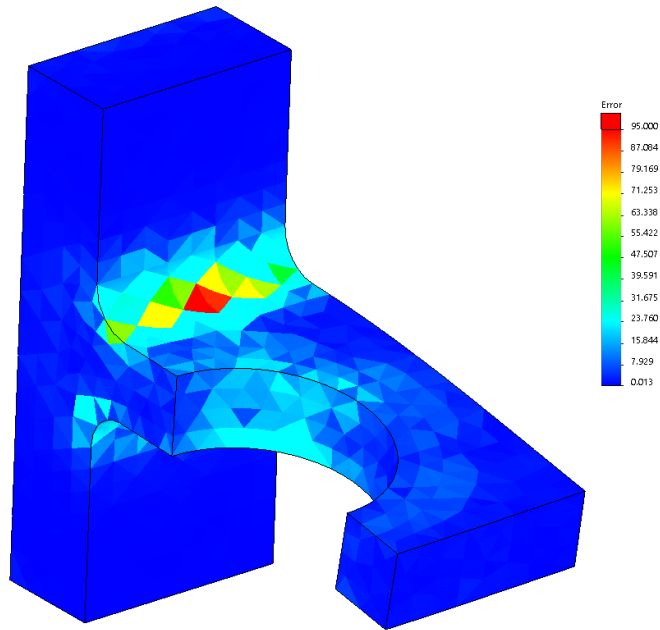
Stress Plot

Stress
Component

ERR: Energy
Norm Error



ENERGY NORM ERROR



AND IF THAT FAILS...CALL US!





YOUR FEEDBACK IS NEEDED!

Session Evaluation Form

Session Name: _____
Presenter Name: _____

1. Please take a few minutes to fill out this evaluation form. For each question, please rate how you agree with each statement. Graphics Systems Corporation values your feedback. Thank you for your participation.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I found the content of the presentation informative.	☐	☐	☐	☐	☐
The presentation dealt with real-world issues I face today.	☐	☐	☐	☐	☐
The presentation was delivered clearly & was easy to understand.	☐	☐	☐	☐	☐
The presenter was knowledgeable about the subject presented.	☐	☐	☐	☐	☐
The presenter effectively addressed the questions asked.	☐	☐	☐	☐	☐
The presenter captivated the audience.	☐	☐	☐	☐	☐
The room and audio/video met my expectations.	☐	☐	☐	☐	☐
I would recommend this session to a friend or colleague.	☐	☐	☐	☐	☐
Overall, I was pleased I attended this session.	☐	☐	☐	☐	☐

2. I would like to receive more information about this topic.
☐ Yes ☐ No, Thank You

3. Please share any additional comments or suggestions:

4. Providing the following information is optional:
First Name: _____ Last Name: _____
Company: _____

Session evaluation forms are located in the [back of your conference program.](#)

Session Name: Simulation Tips, Tricks, and Troubleshooting
Presenter Name: Chris Olson

Please remove your completed form and [place in box by the door.](#)

Thank you!



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