ENGINEER 3D!
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SIMULATION TIPS, TRICKS, AND TROUBLESHOOTING

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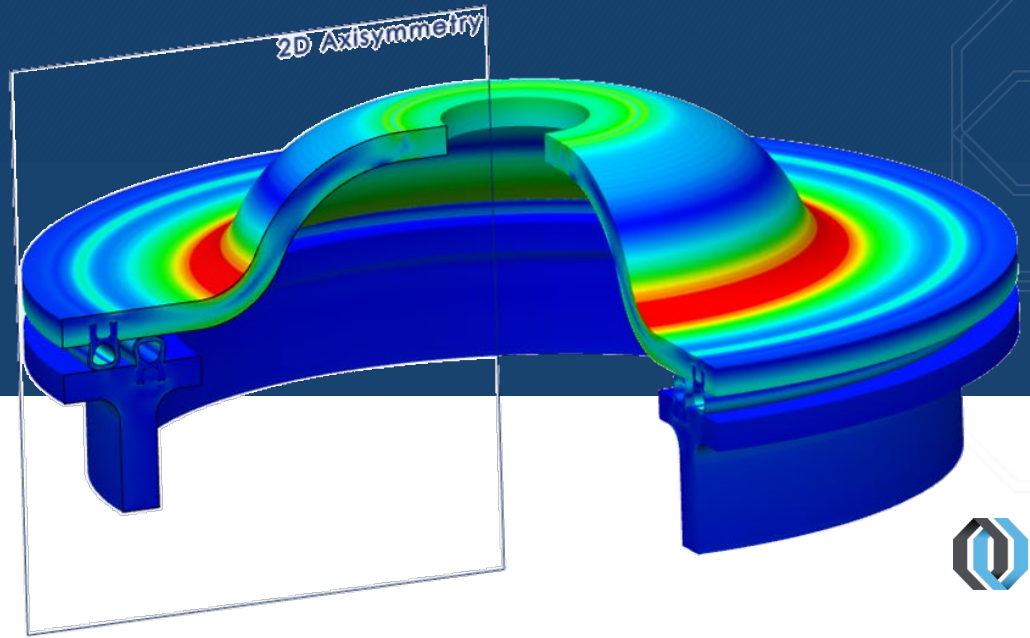
GSC

GSC SIMULATION TEAM

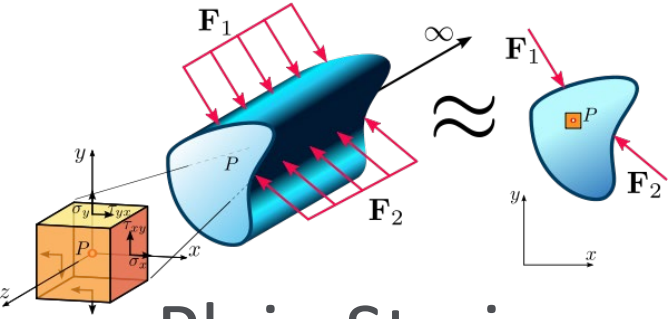
Madhav Puppala
Director of Simulation

Chris Olson
Simulation Engineer

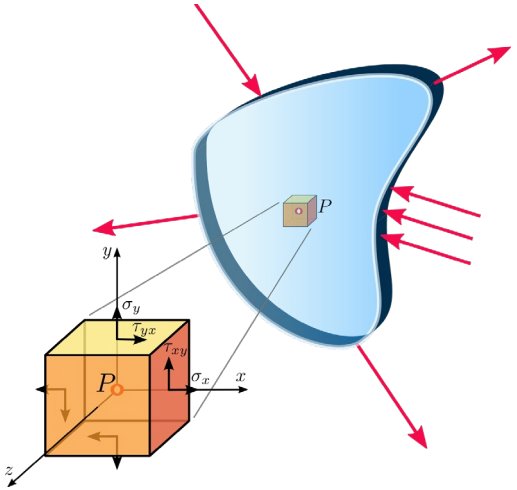
2D Simplification



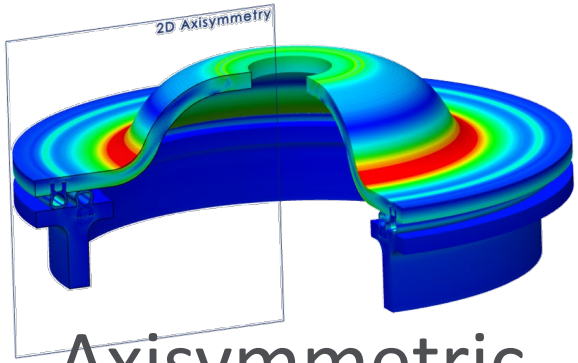
2D SIMPLIFICATION TYPES



Plain Strain



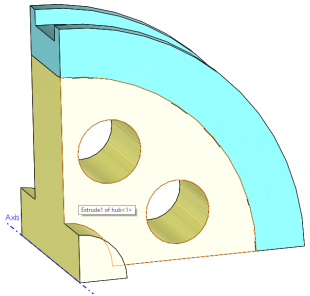
Plain Stress



Axisymmetric

Utilizing Symmetry

SYMMETRY ADVANTAGES



Efficient

Cut Problem by
½, ¼, $\frac{1}{8}$

Symmetry Acts as Fixture

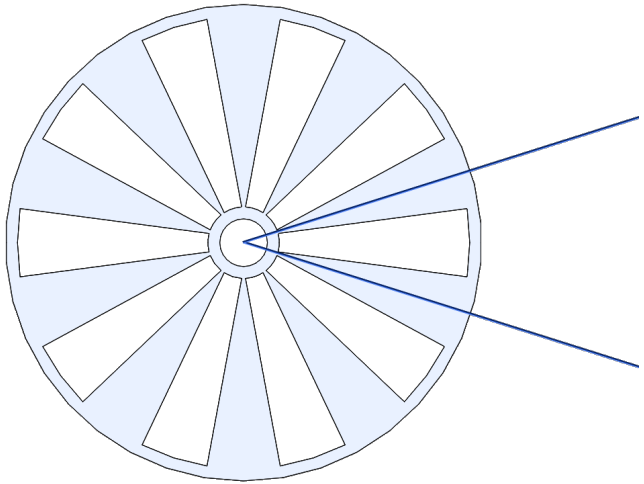
Simplify Fixtures

More Accurate Mesh

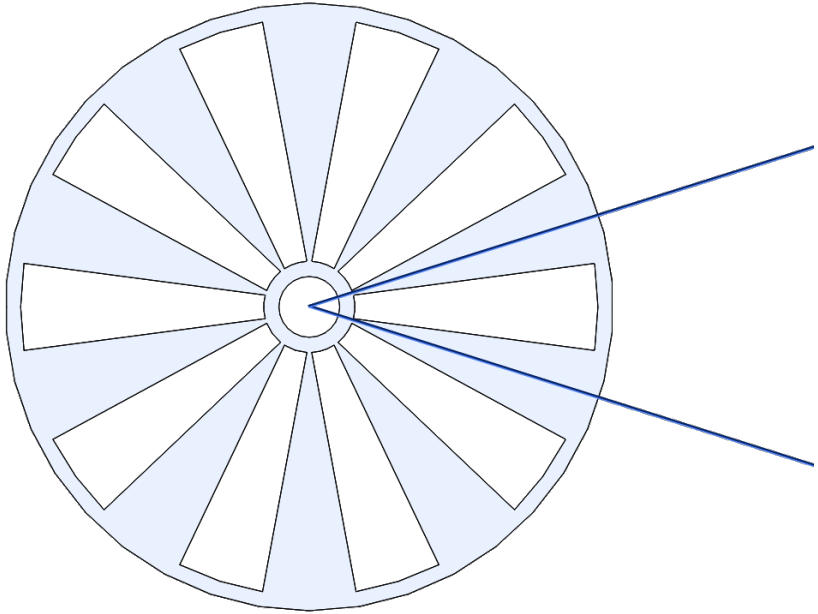
Smaller problem allows for refined mesh

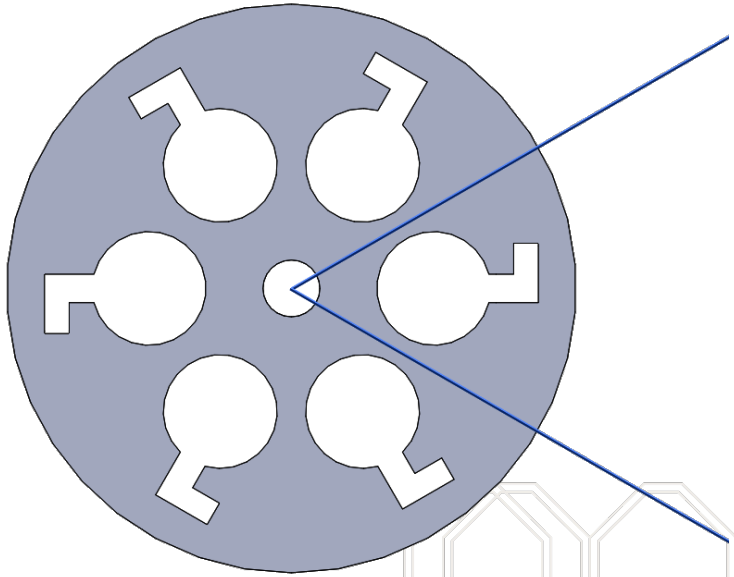
ADVANCED SYMMETRY

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



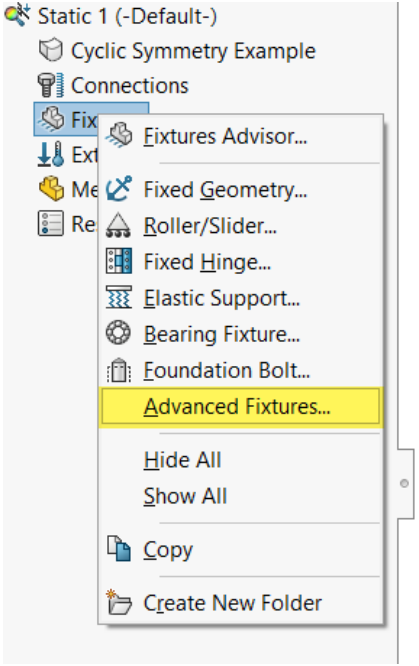
SYMMETRY VS CYCLIC SYMMETRY

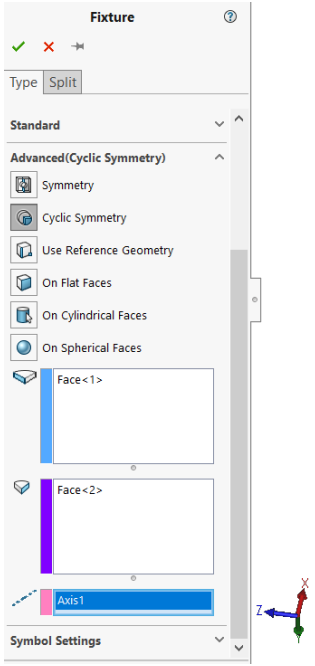


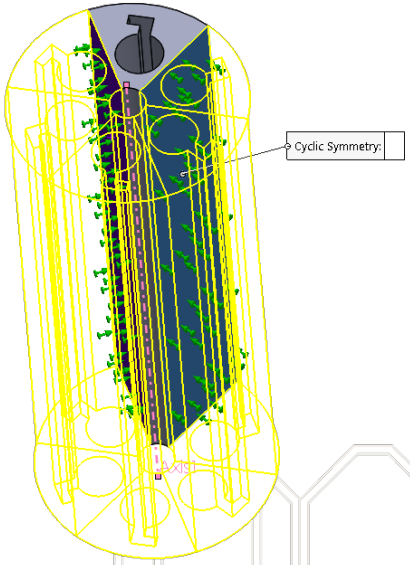


If using solids you can use cyclic symmetry for either one

CYCLIC SYMMETRY







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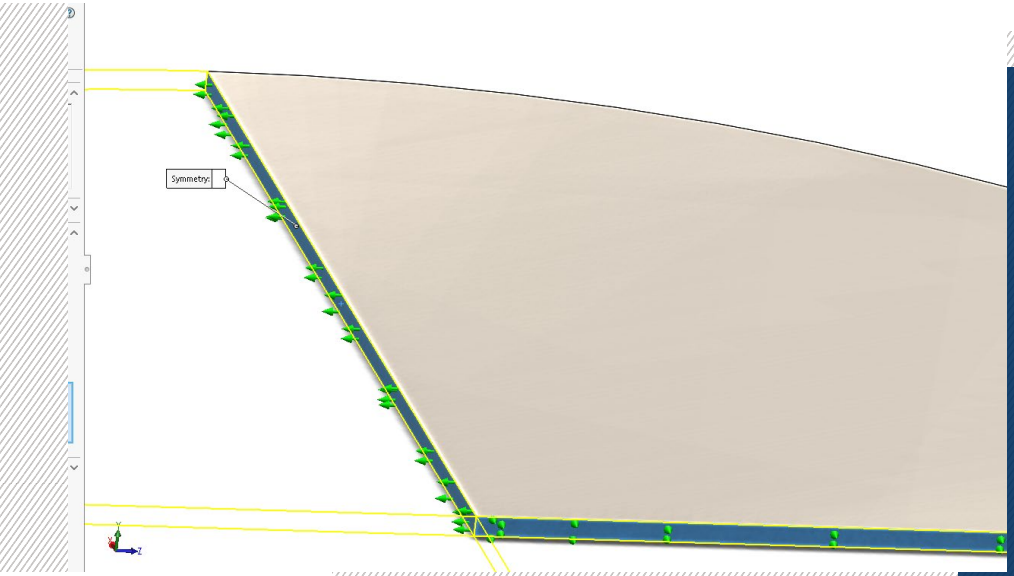
Symmetrical Geometry



How To

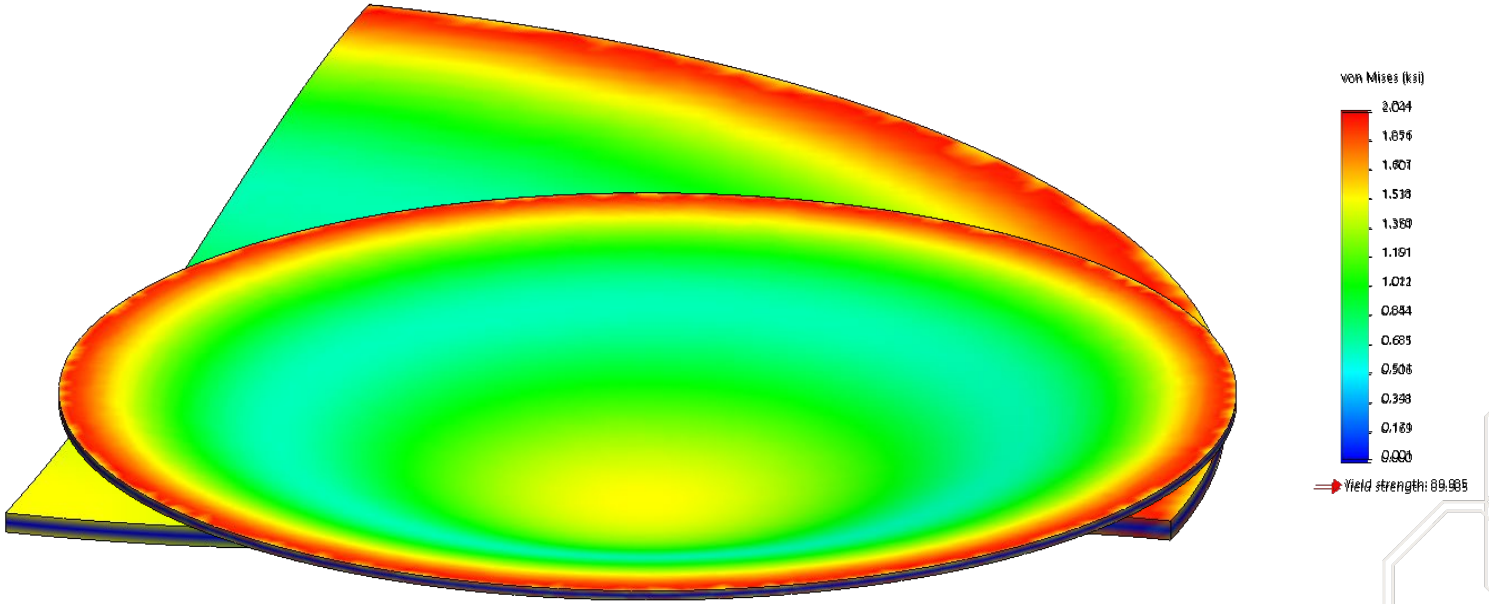
- Cut Geometry
- Apply Fixture
- Select Faces
- Divide Loads

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

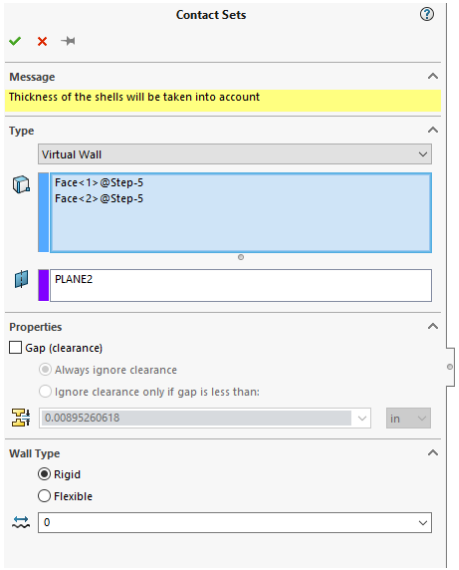
SYMMETRY EXAMPLE

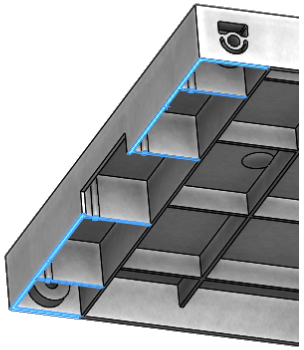


Virtual Wall

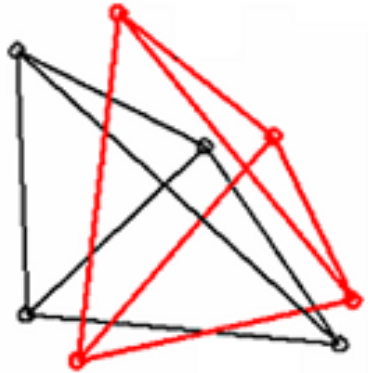
VIRTUAL WALL

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





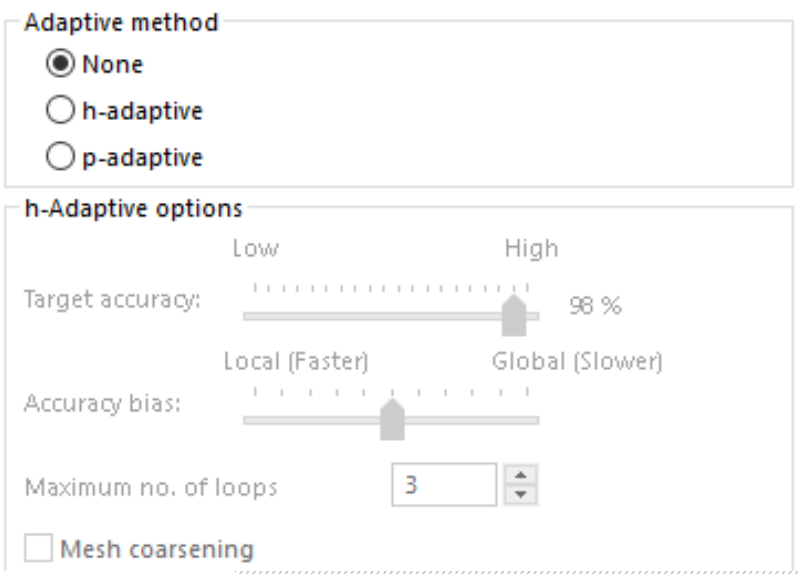
DRAFT QUALITY MESH



1st order
(Draft Quality)

DRAFT QUALITY MESH

- Linear Deformation
- First Pass Analysis
- Trend Studies



Adaptive Meshing

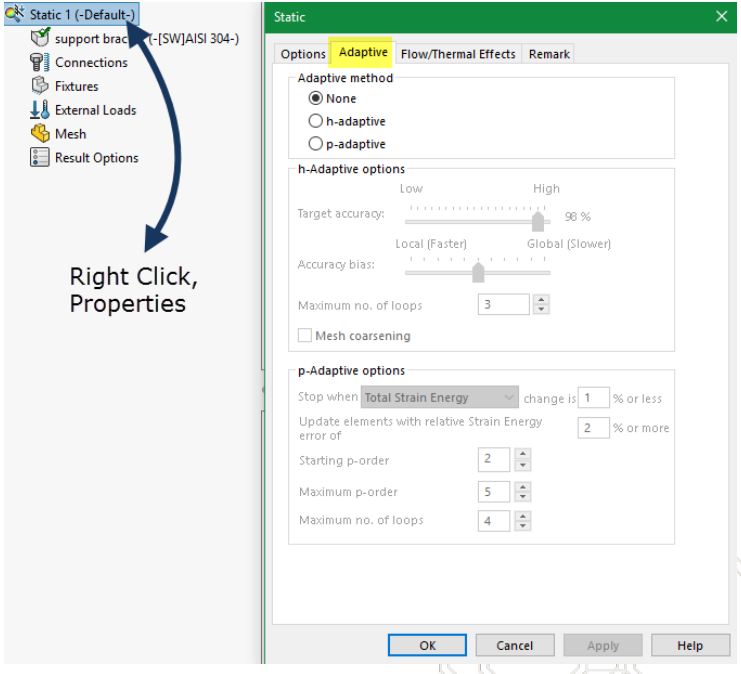
ADAPTIVE MESHING

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



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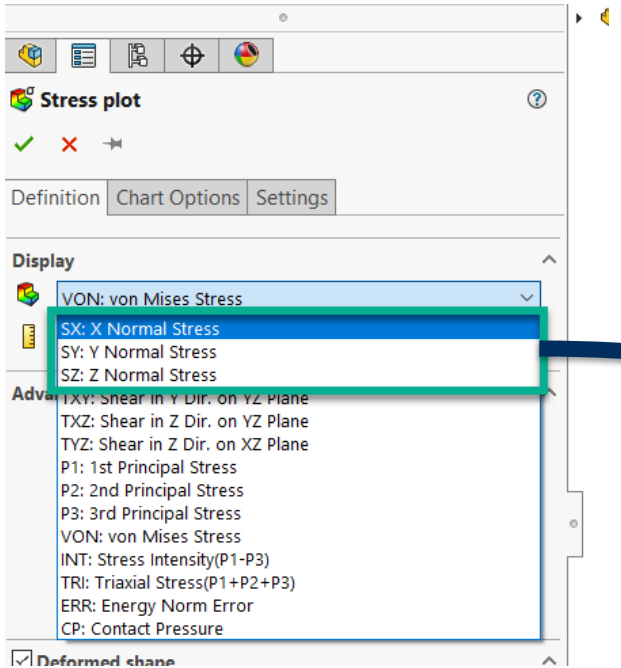
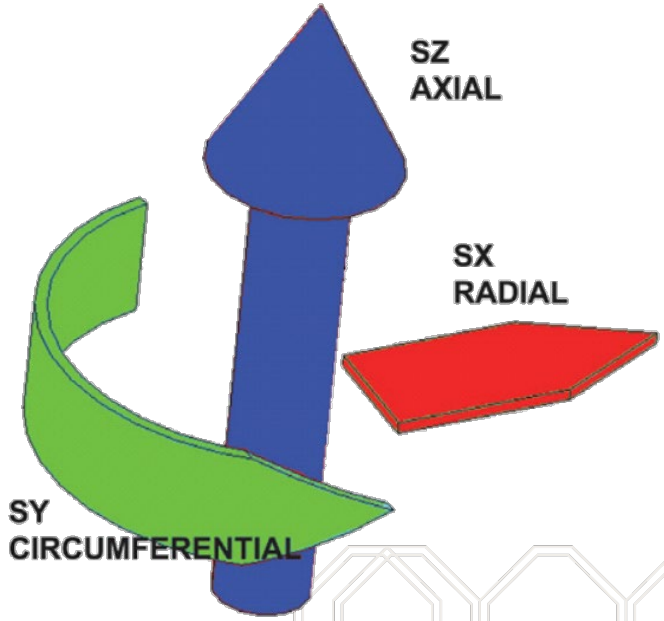
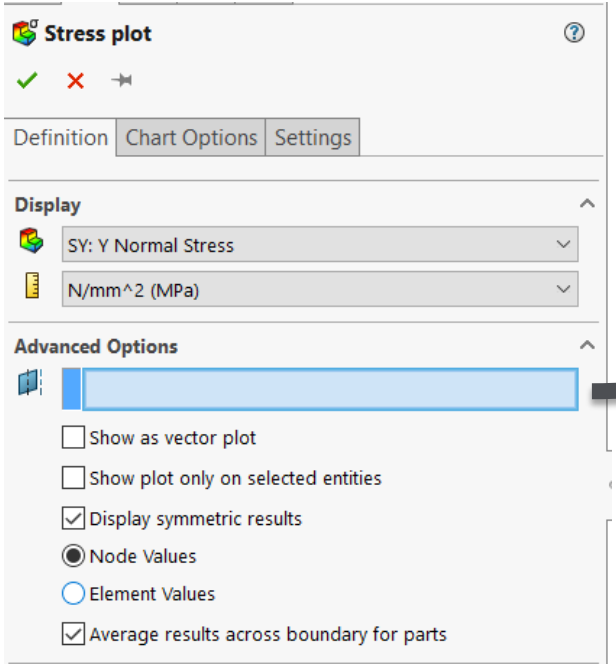
Angular Displacements

CYLINDRICAL COORDINATE SYSTEM RESULTS





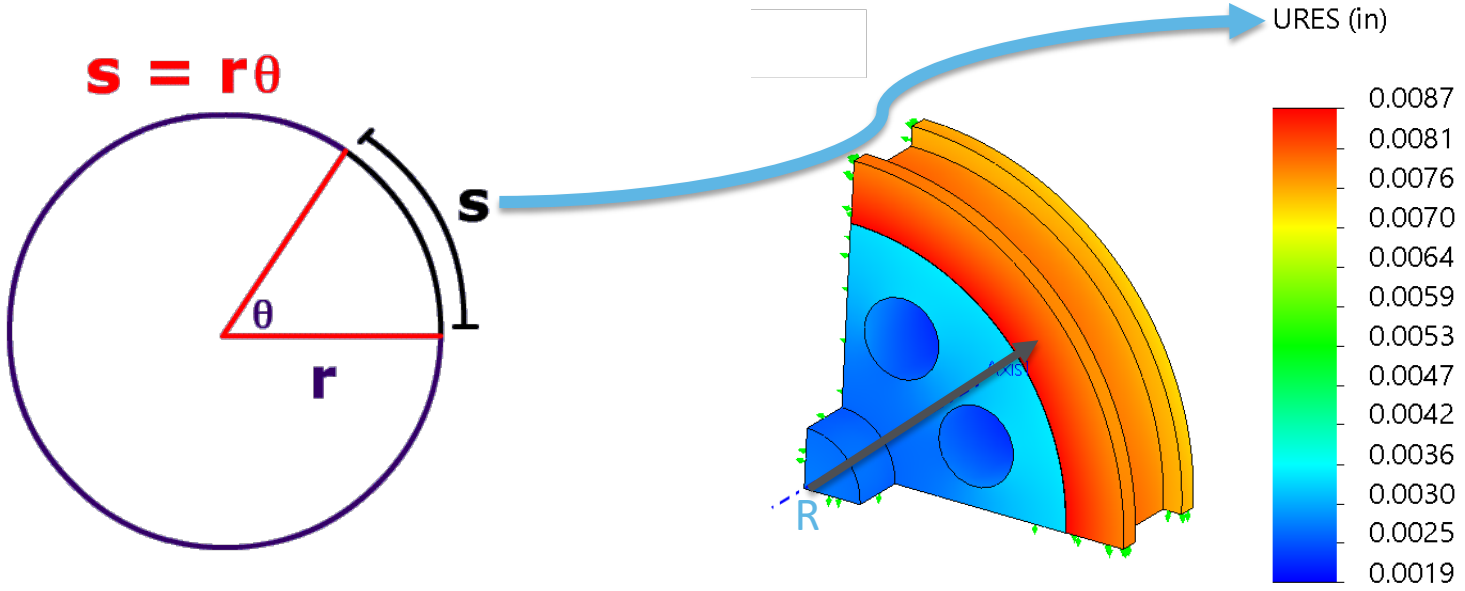
CYLINDRICAL COORDINATE SYSTEM RESULTS



Axis of Revolution

Can also be used with a plane to show results relative to that plane

ANGULAR DISPLACEMENT CALCULATION

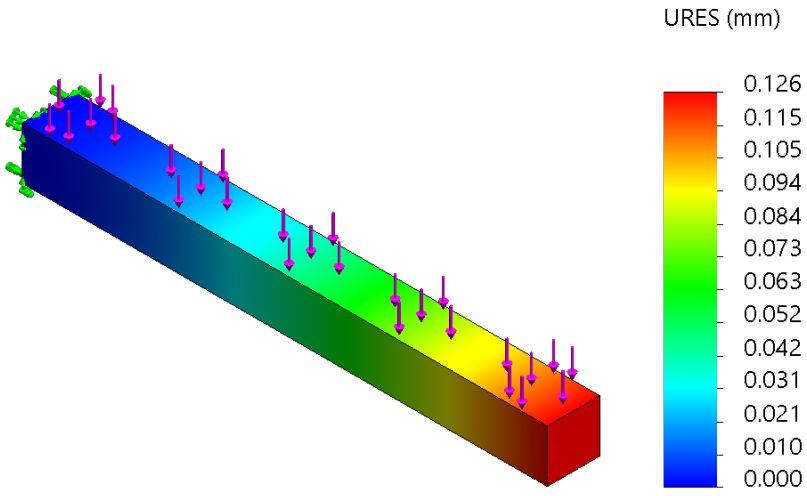


$$F = kx$$

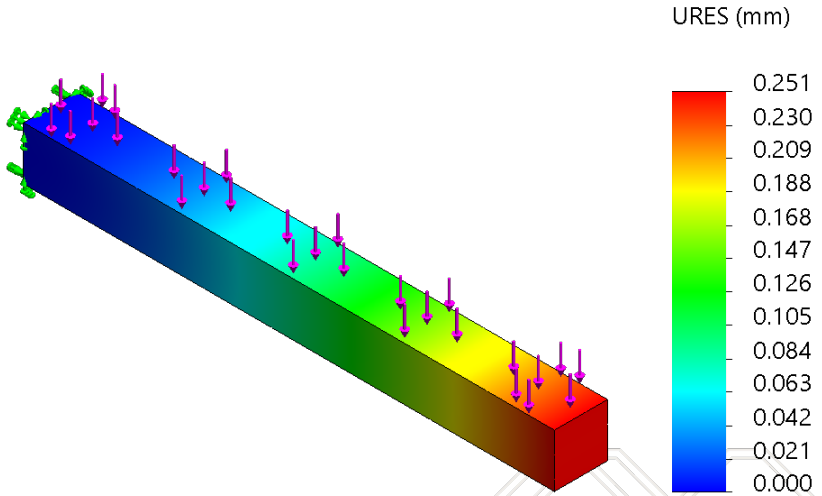
Leveraging the "linear" in Linear Static

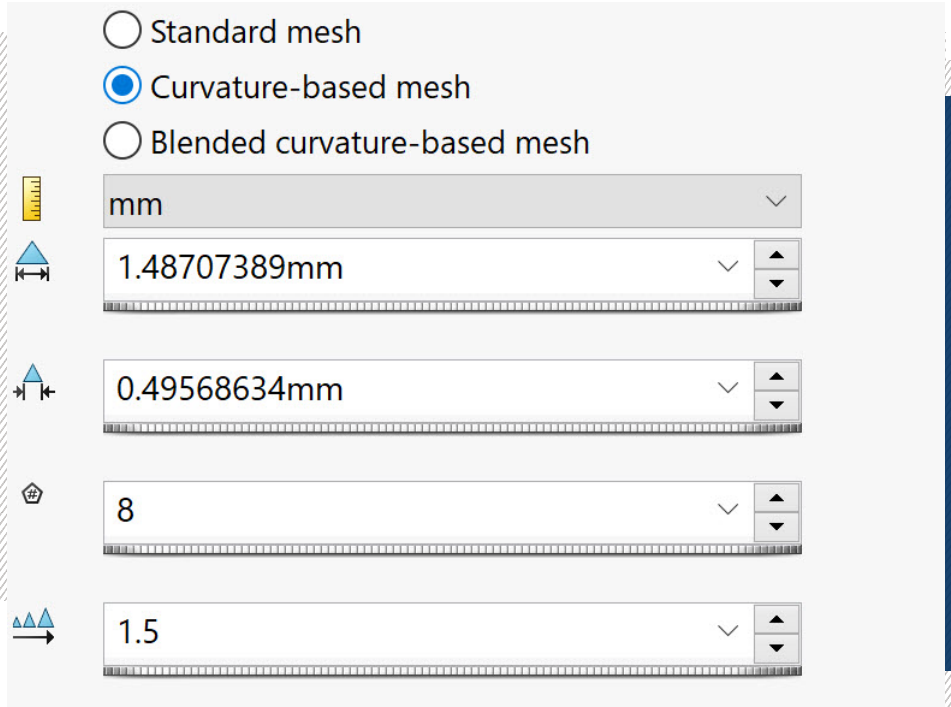
FORCE = STIFFNESS * DISPLACEMENT

100 lbs



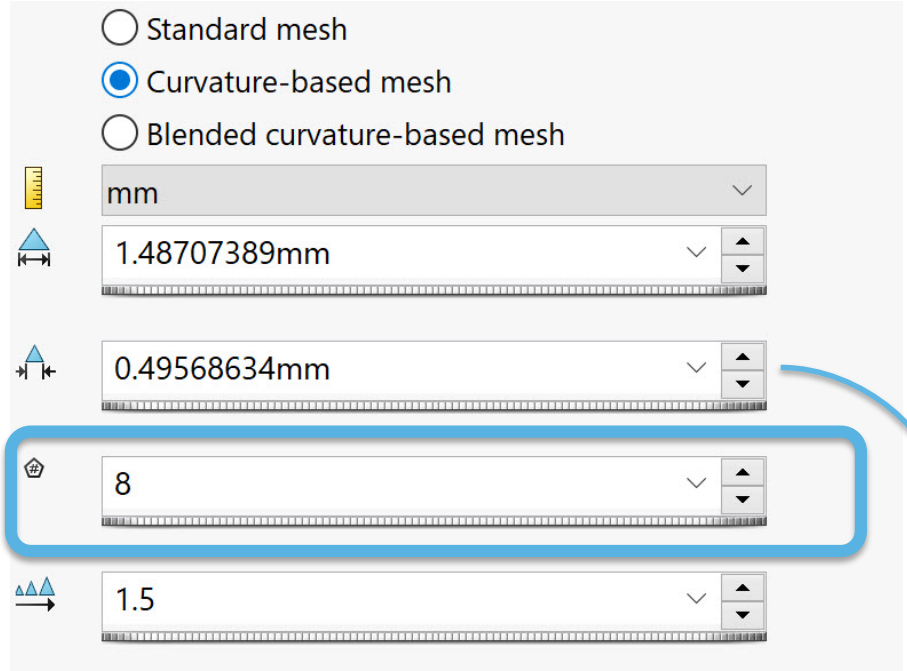
200 lbs





Global Mesh Controls

ELEMENTS IN A CIRCLE

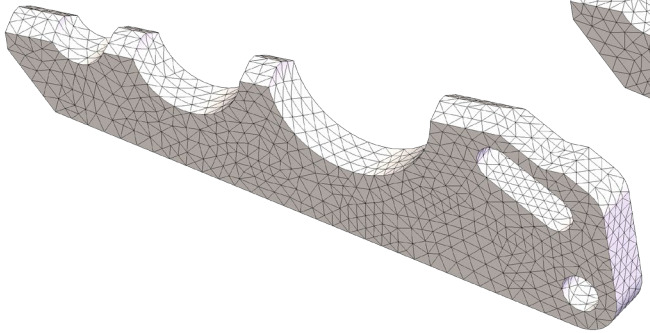


Use Elements in a Circle to Globally refine Fillets

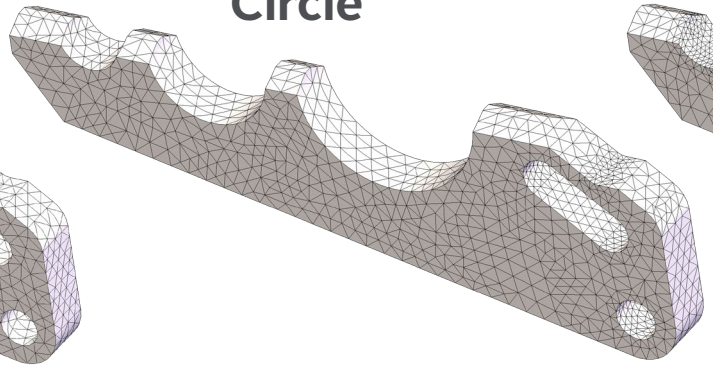
Minimum Element Size is the limiting factor

GLOBAL MESH CONTROL

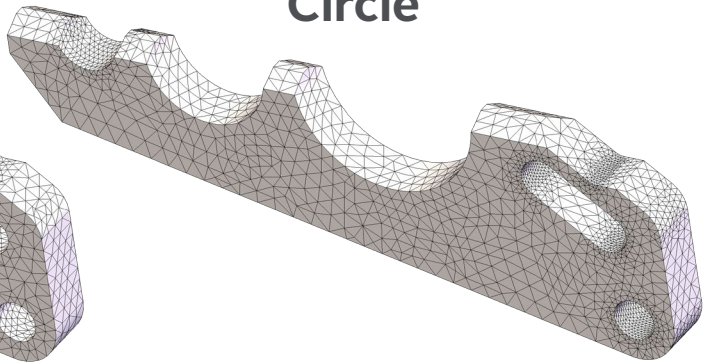
8 Elements in a Circle



16 Elements in a Circle



32 Elements in a Circle



Simulating Welds

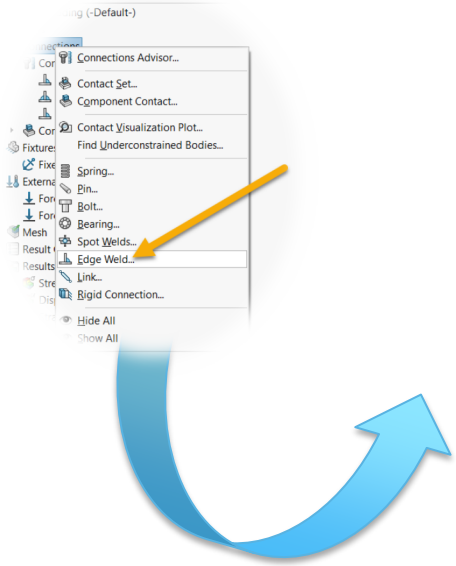
SIMULATING WELDS

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:

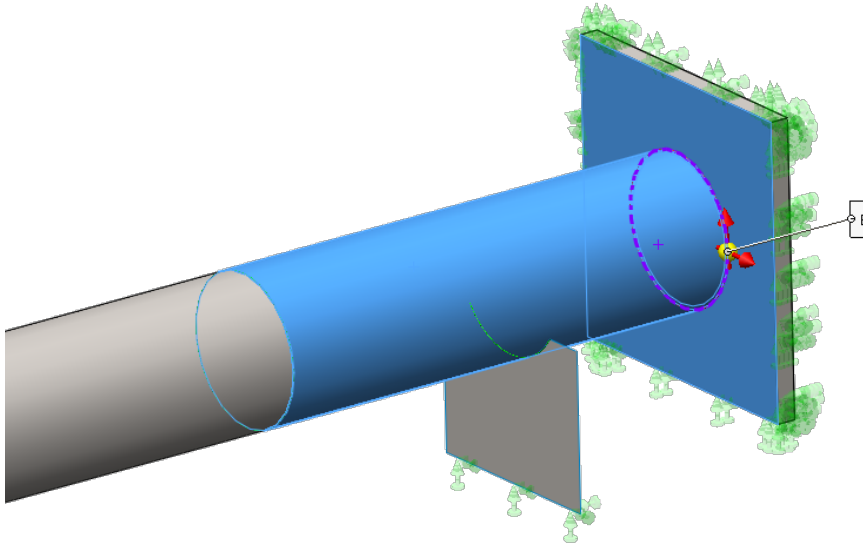
American National Standard for Automotive Lifts

Under The Hook Lifting Devices

3

Estimated weld size

4 mm



Shell/Shell & Shell/Solid Combinations Only!

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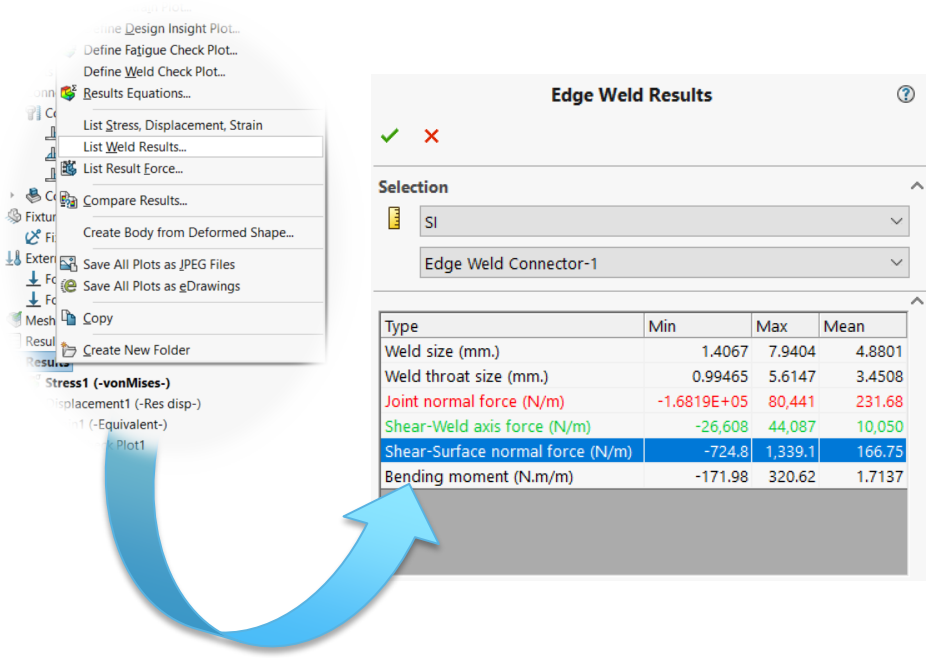
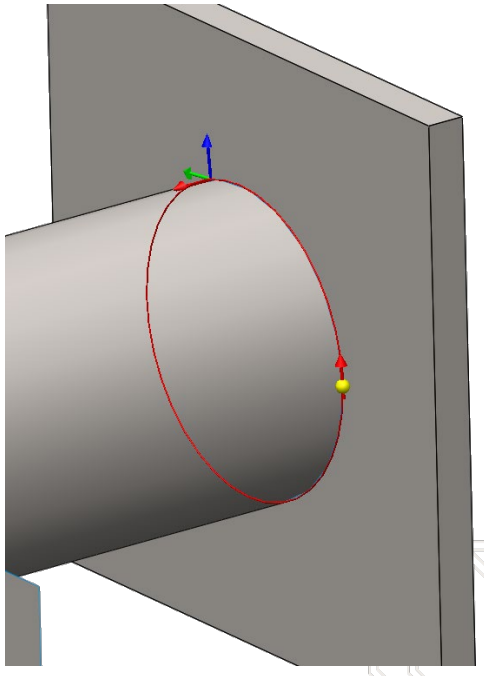
EDGE WELD CONNECTOR





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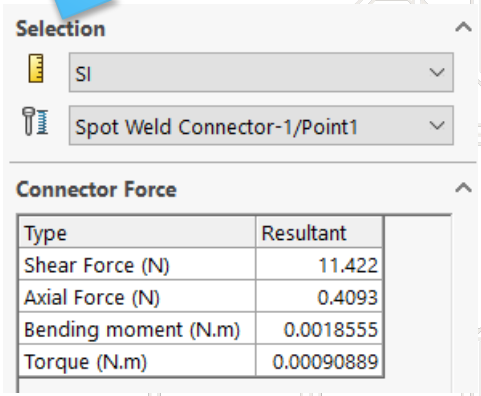
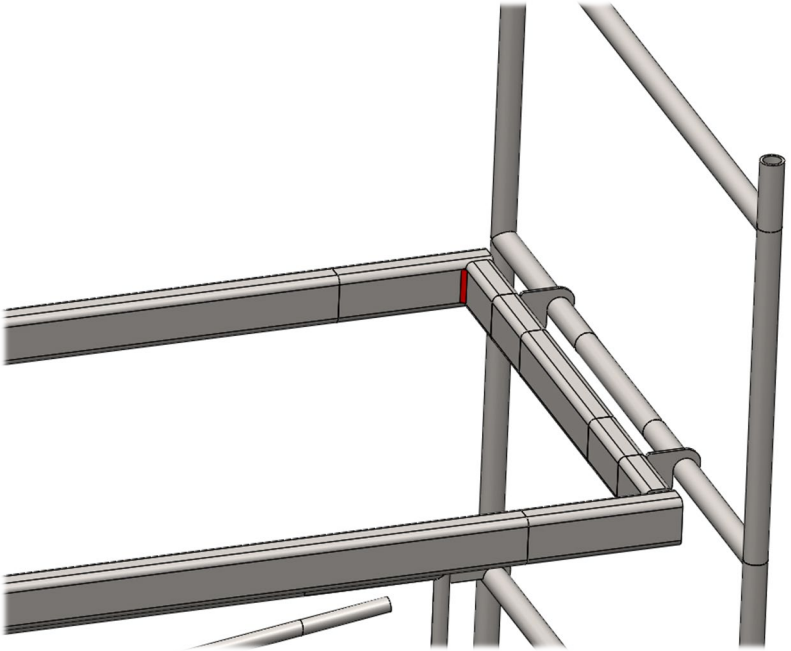
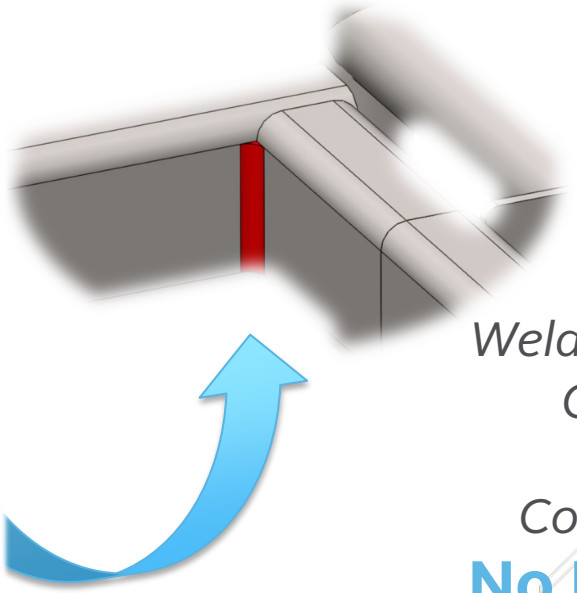
SPOT WELD



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

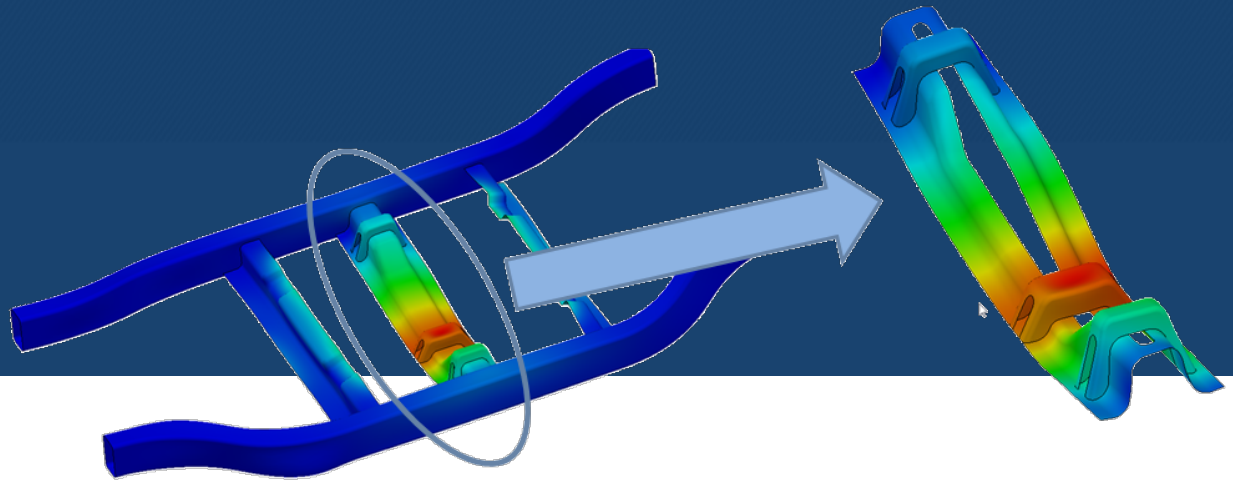




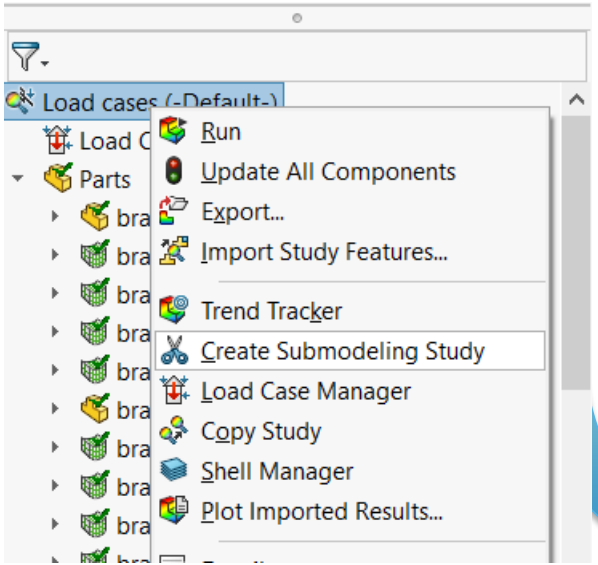
Weld is **Bonded** *to Components*

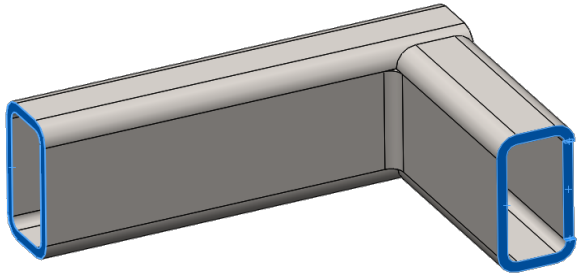
Components are **No Penetration** *to each other*

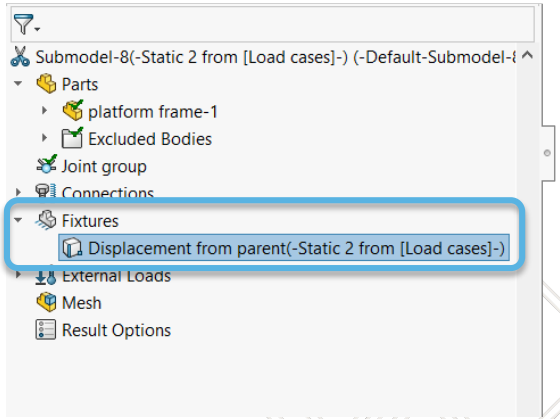
Submodeling



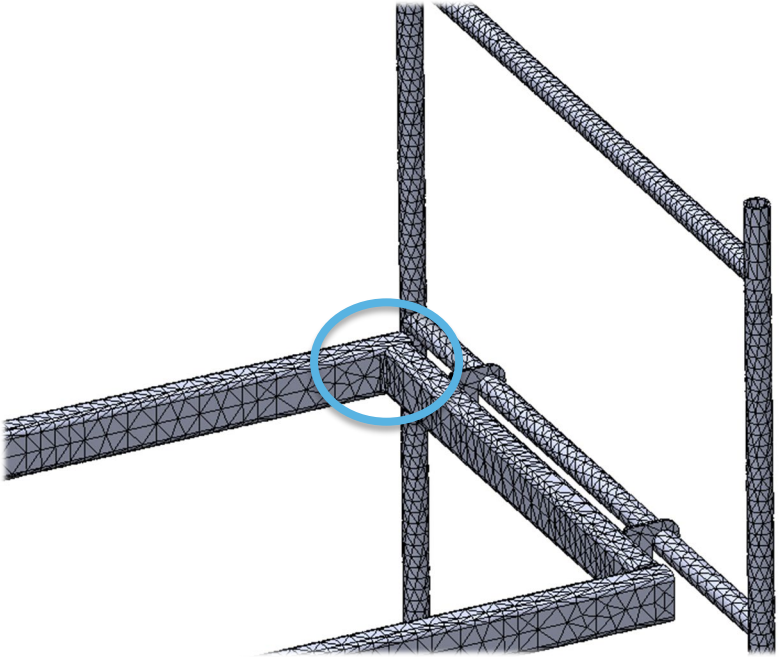
SUBMODELING

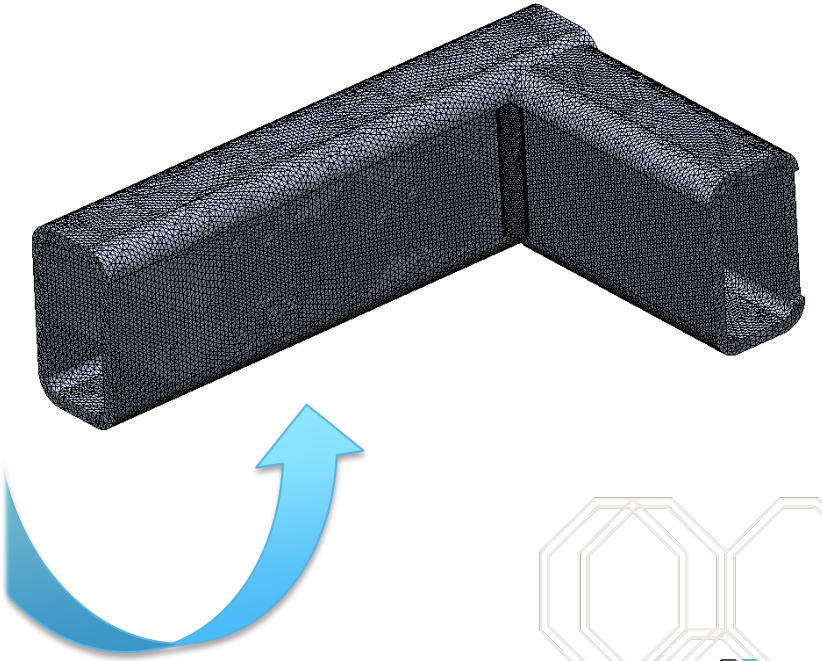




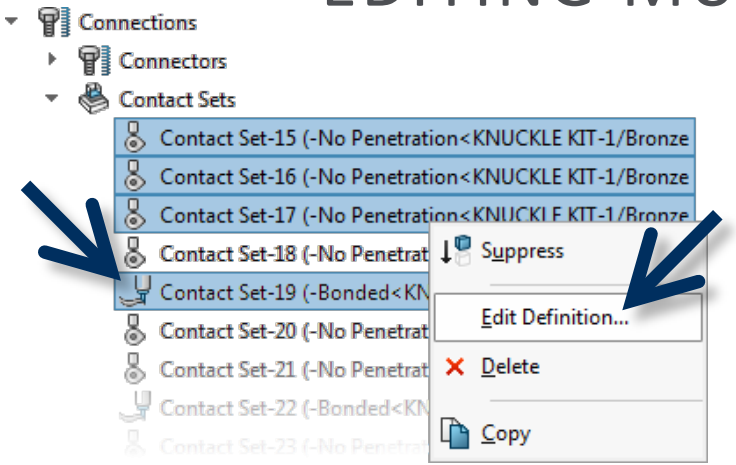


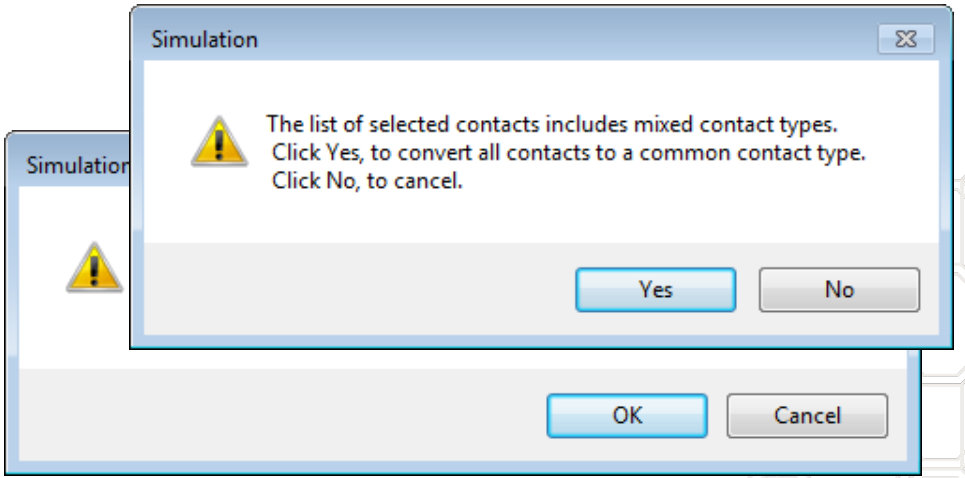
SUBMODELING

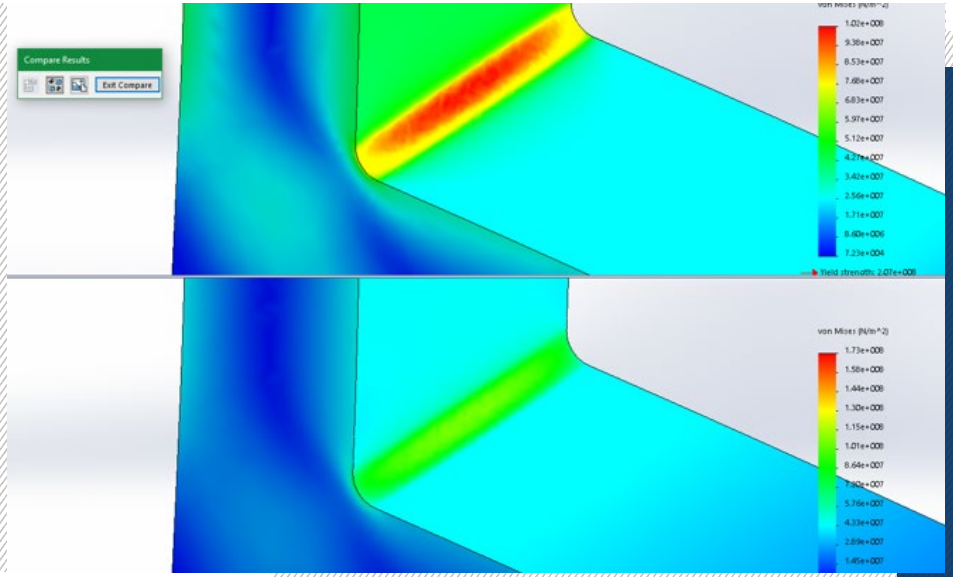




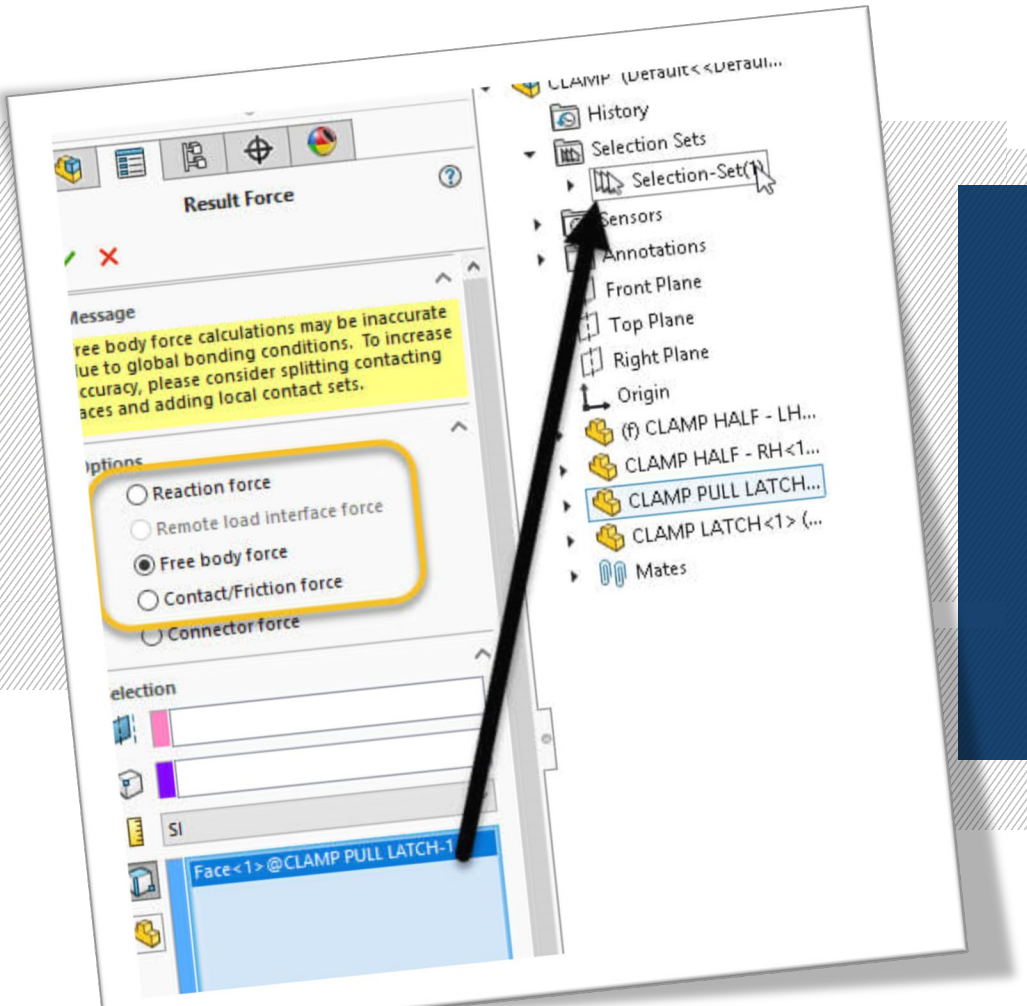
EDITING MULTIPLE CONTACT SETS







Compare Results



Selection Sets

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Troubleshooting

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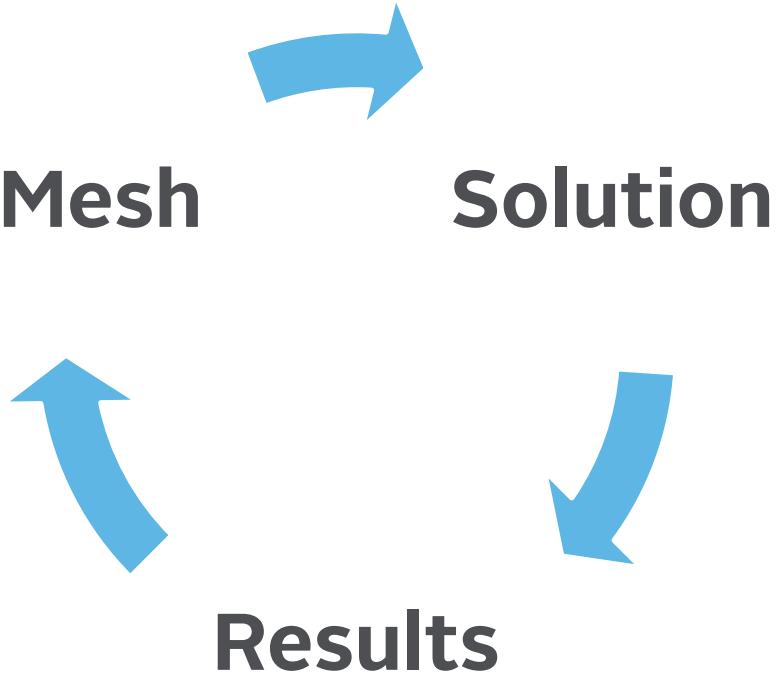
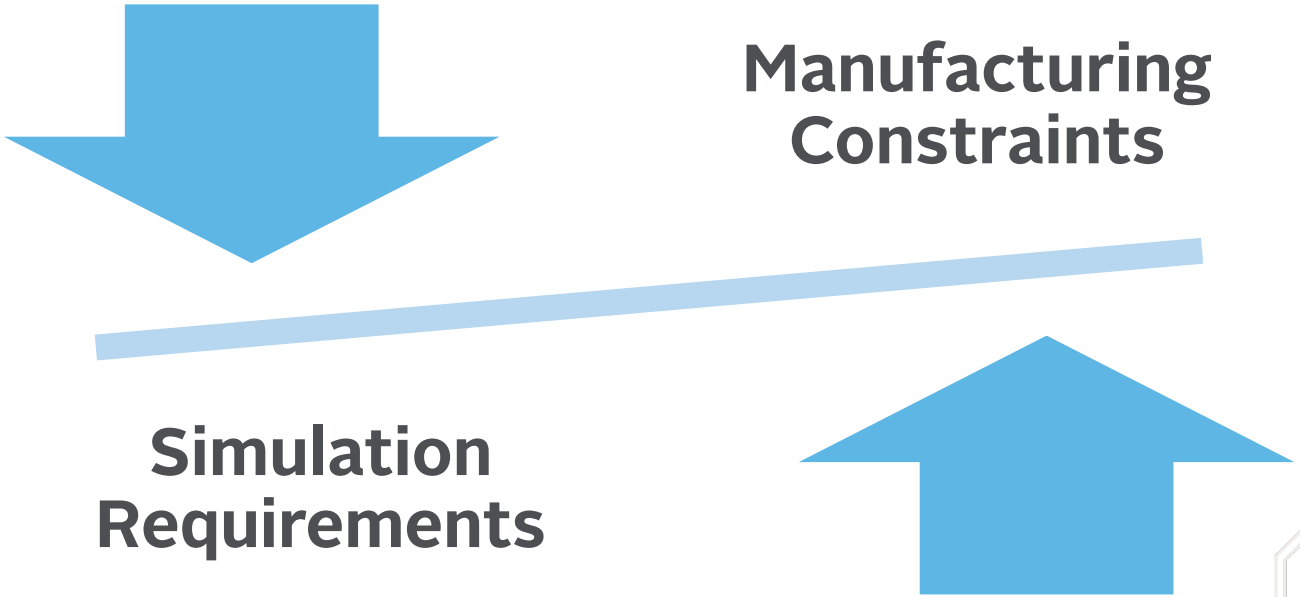
TROUBLESHOOTING AN ANALYSIS

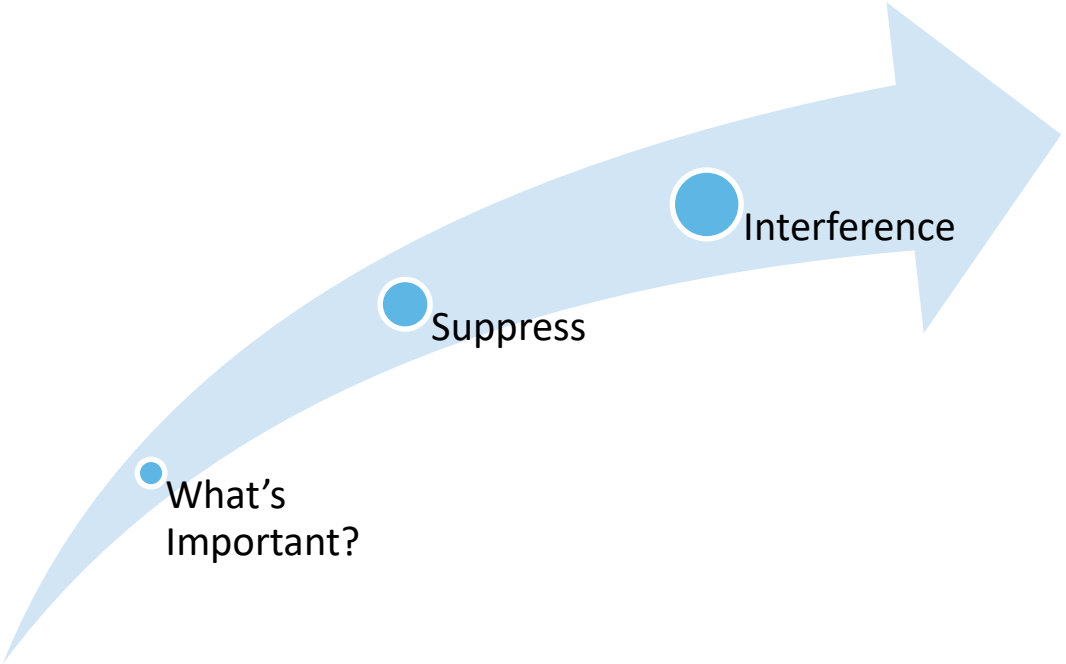


The **number 1** way to **avoid** trouble is to **do it right** the **first time!**

IT ALL STARTS WITH GEOMETRY….



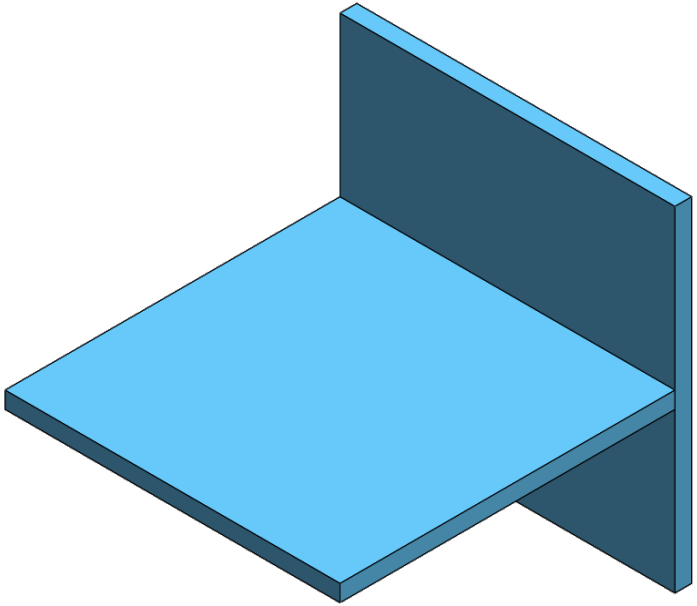
ANALYSIS PREPARATION

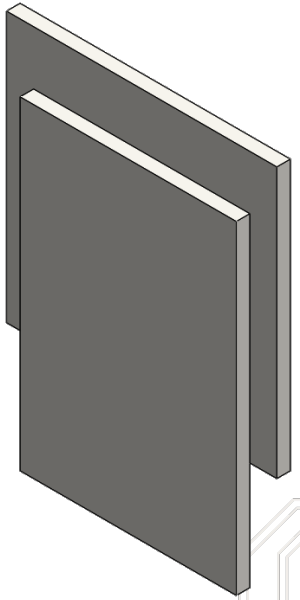


MINIMIZE COMPONENTS

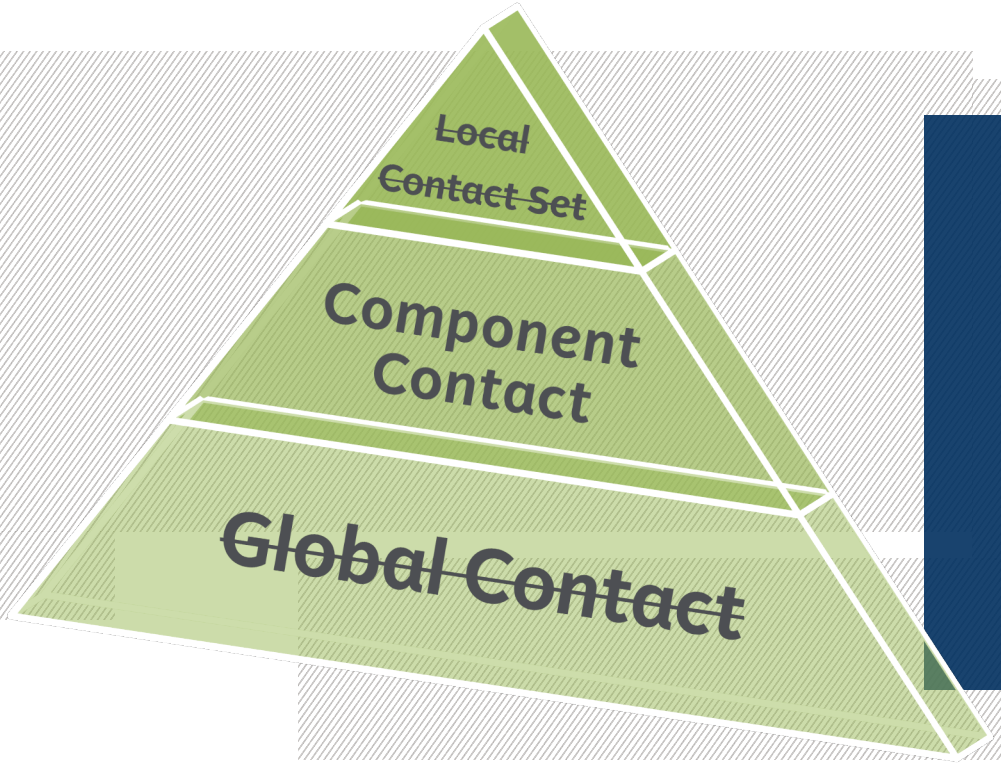
Minimizing the amount of Components in your Analysis makes Troubleshooting Easier

COMBINED COMPONENTS VS BONDED CONTACT





EXAMPLE...

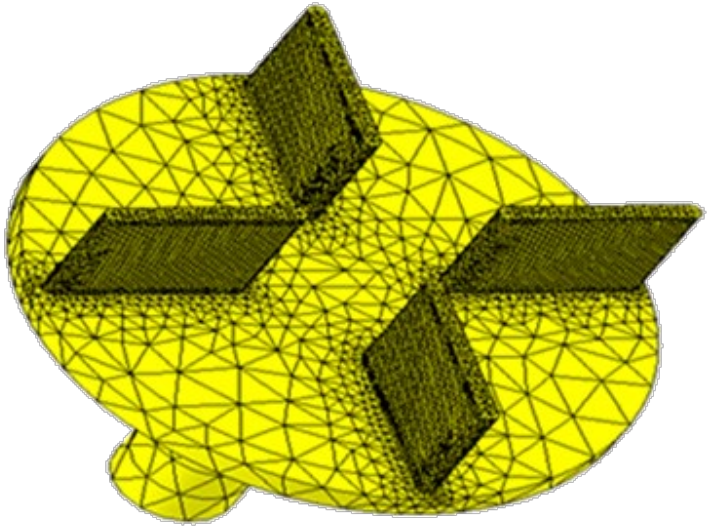


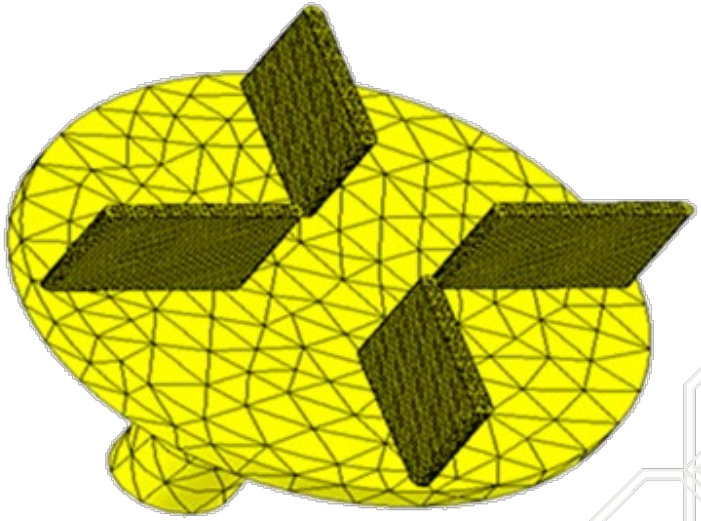
Component Contacts are your Friend!

CONTACTING FACES

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

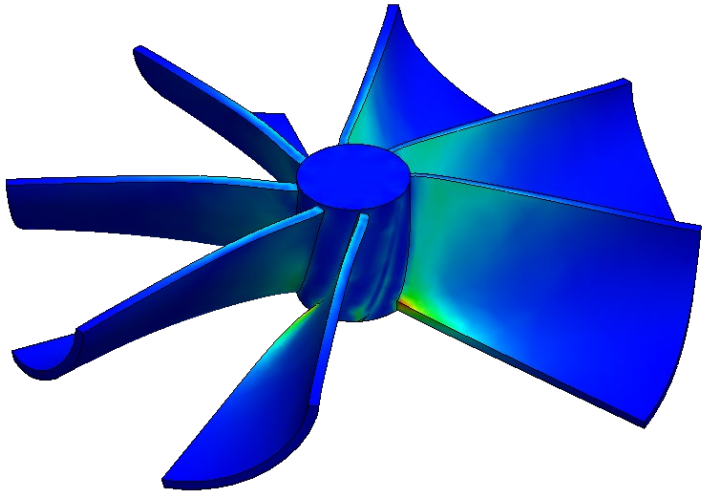
COMPATIBLE VS INCOMPATIBLE MESH



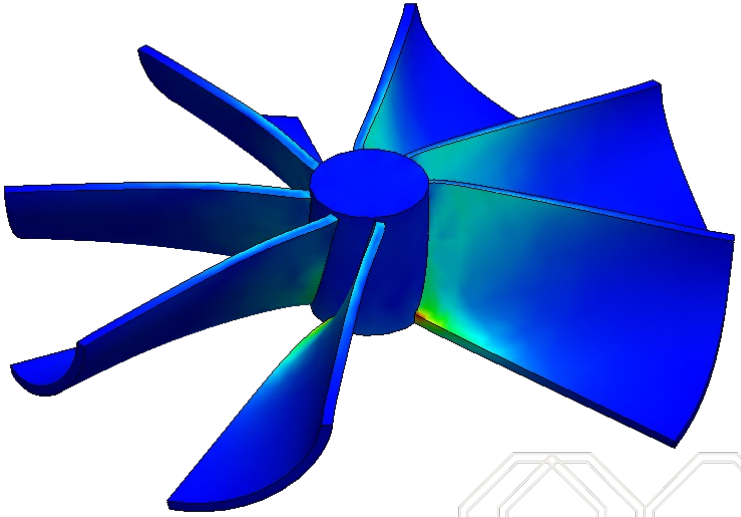


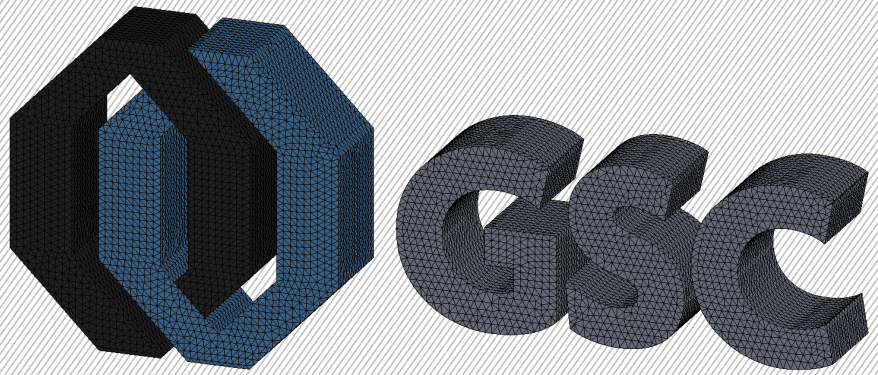
COMPATIBLE VS INCOMPATIBLE MESH

Compatible



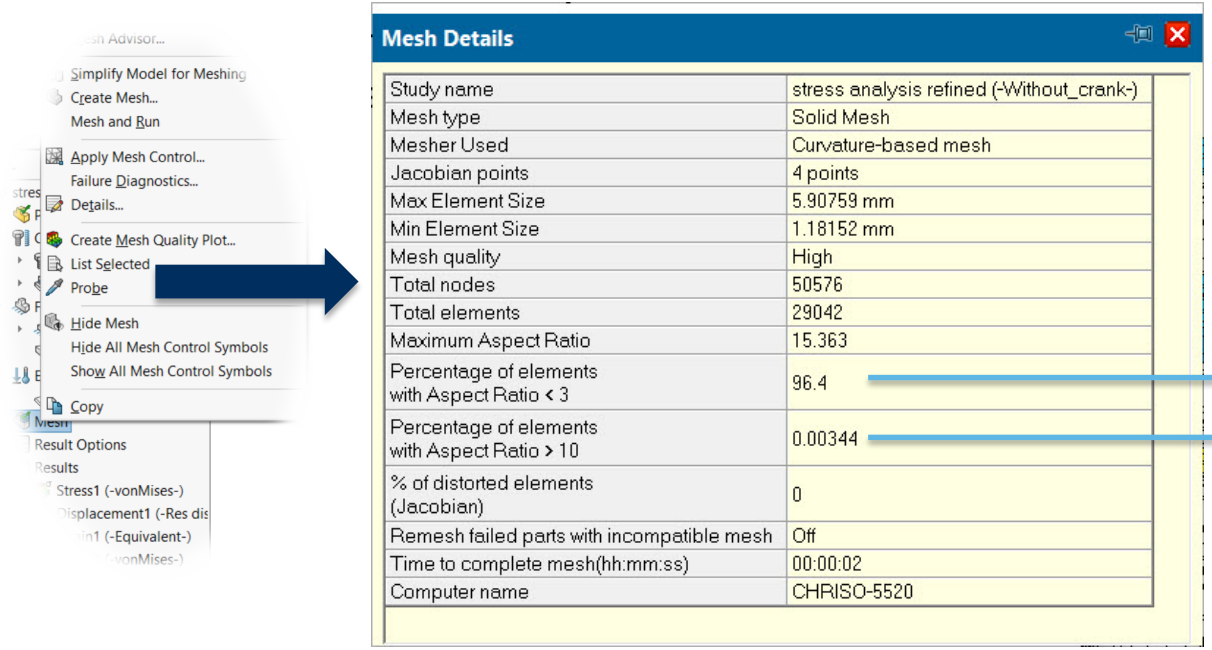
Incompatible





Mesh

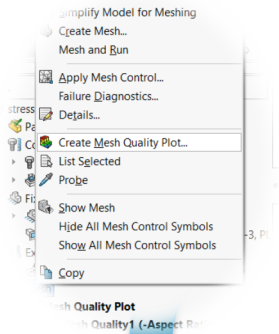
MESH SUMMARY BEST PRACTICES

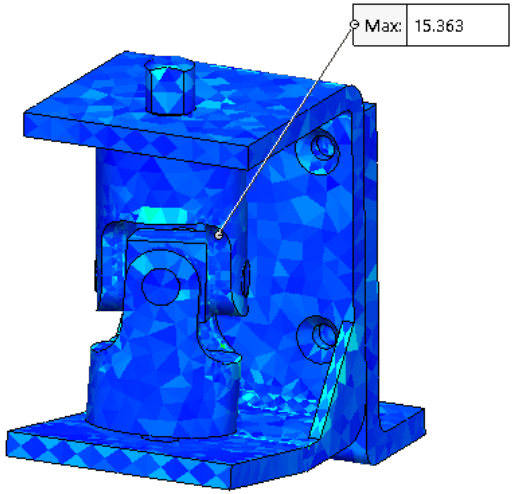


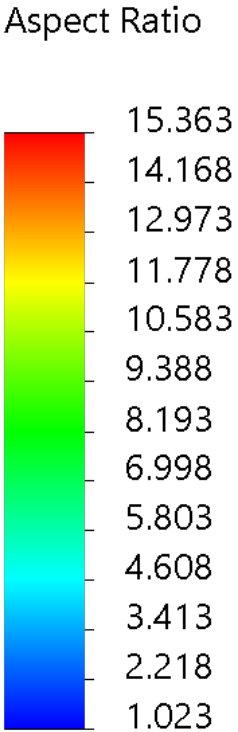
More than 95%

Less than 1-2%

ASPECT RATIO PLOT







Lower in High Stress Areas

ENGINEER 3D!
TRAINING + TECHNOLOGY CONFERENCE

GSC

So It Fails…Now What??

FINER MESH

Shortest Edge Length

=

Element Size

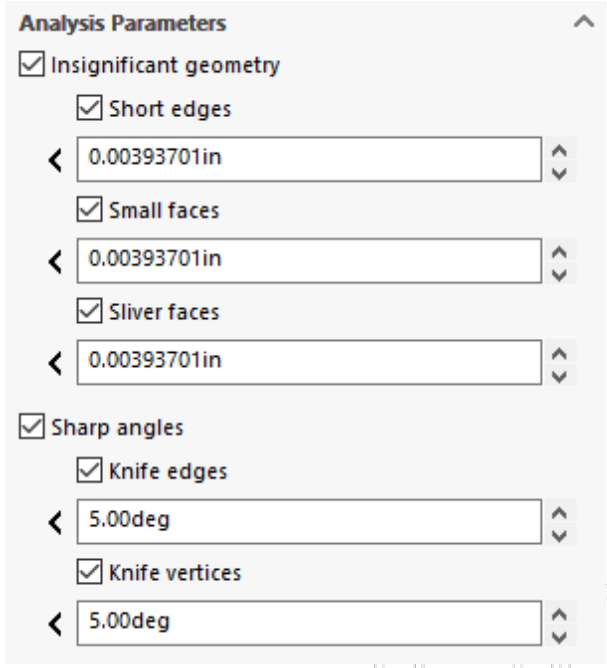
GEOMETRY ANALYSIS

GEOMETRY ANALYSIS

Shortest Significant Edge

Sharp Angles

Review Results



ADJUST MESH SIZE

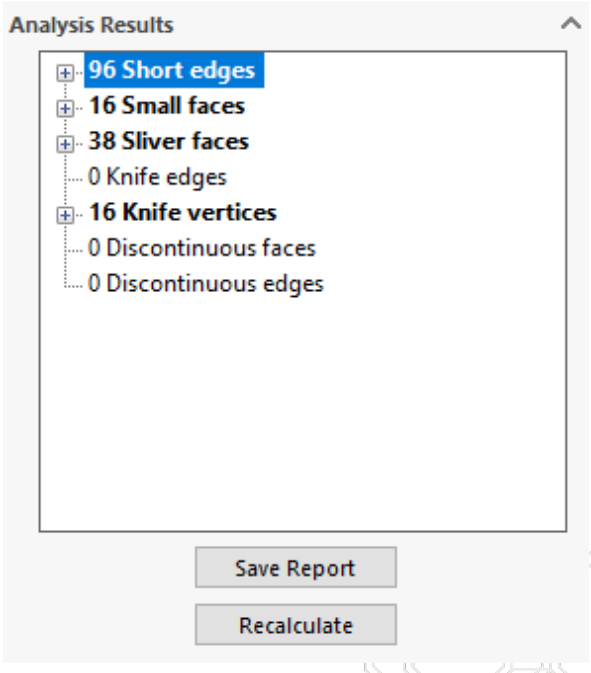
Adjust Mesh Size

↓

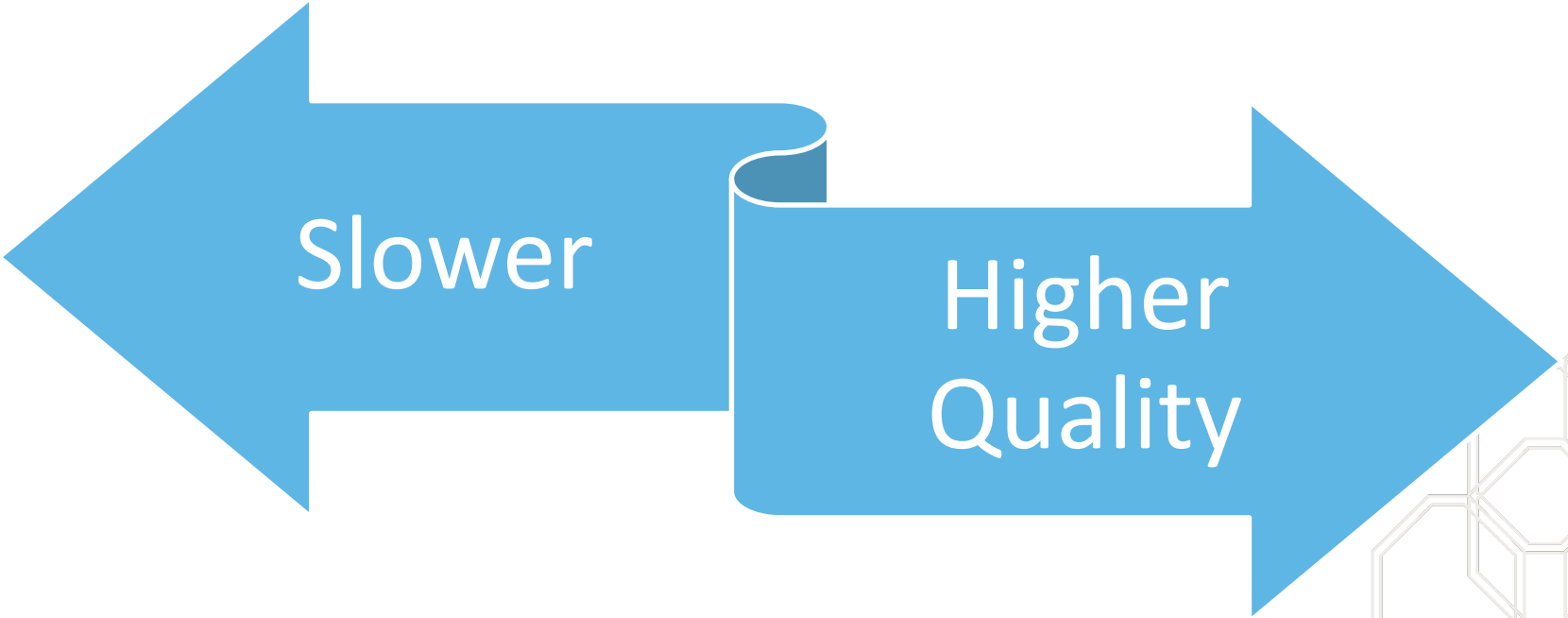
Remove Small Features

↓

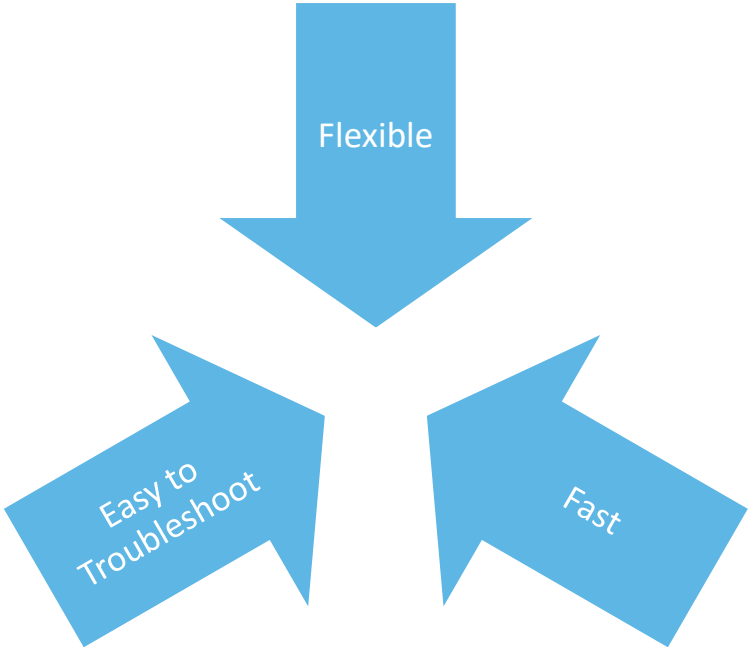
Use Different Mesher



BLENDED CURVATURE BASED MESHER

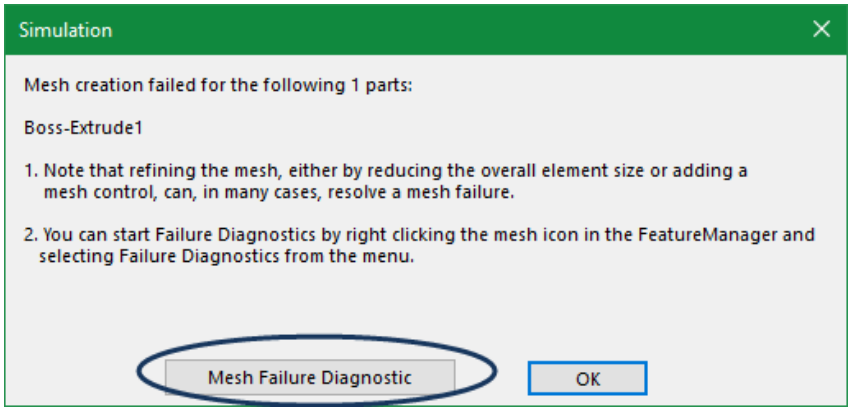


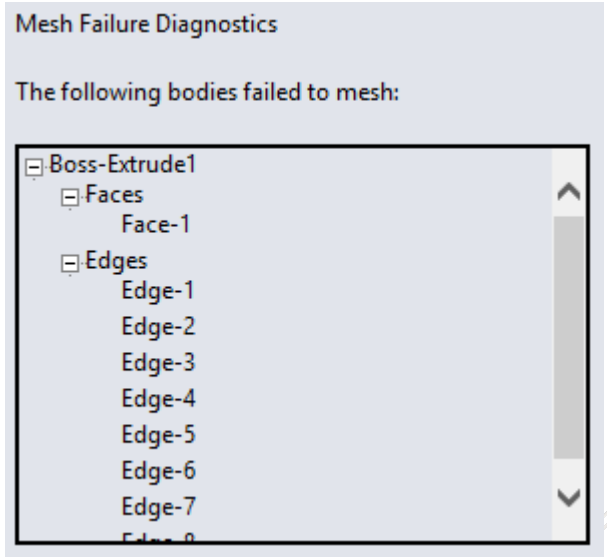
STANDARD MESH



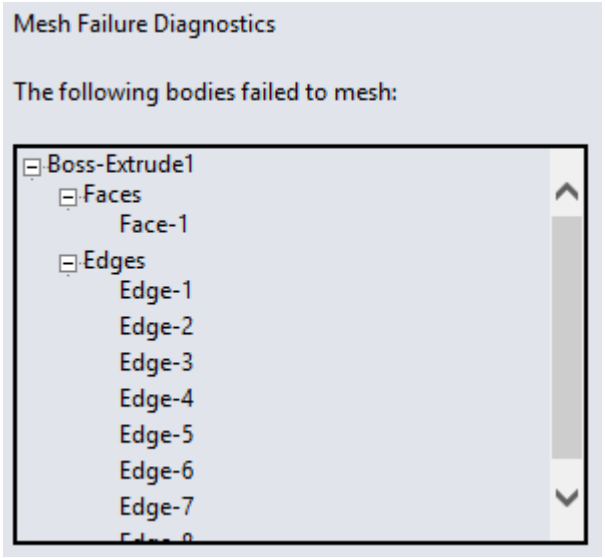
Oldies But Goodies

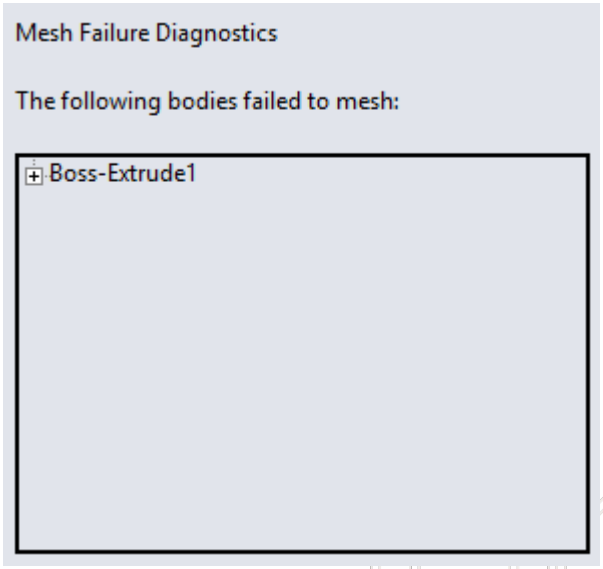
MESH FAILURE DIAGNOSTICS





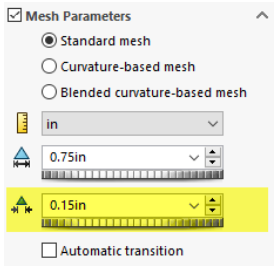
STANDARD MESH VS CURVATURE BASED MESH

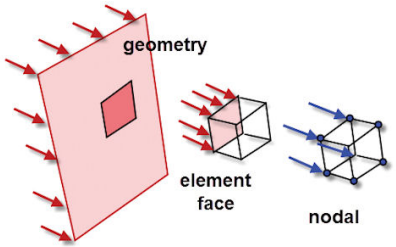




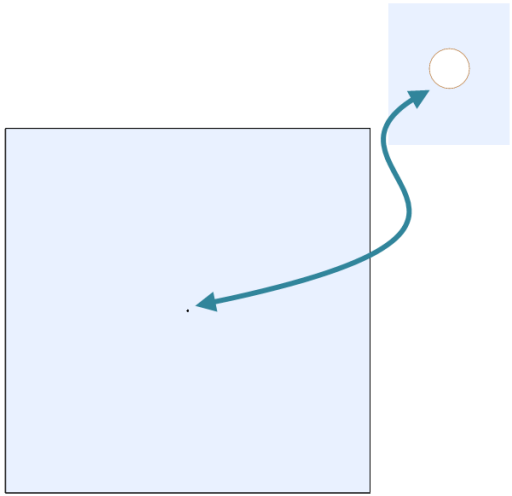
STANDARD MESH

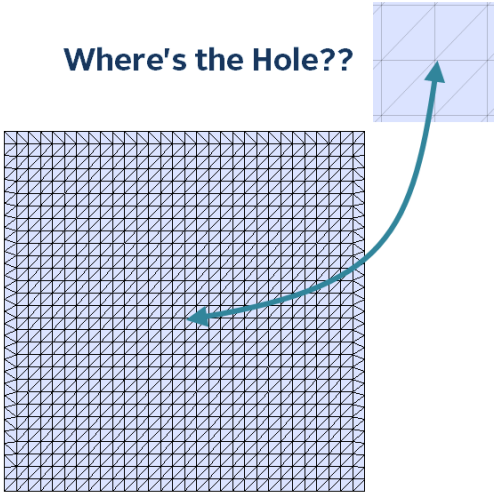
Tolerance > Nodes = Merged



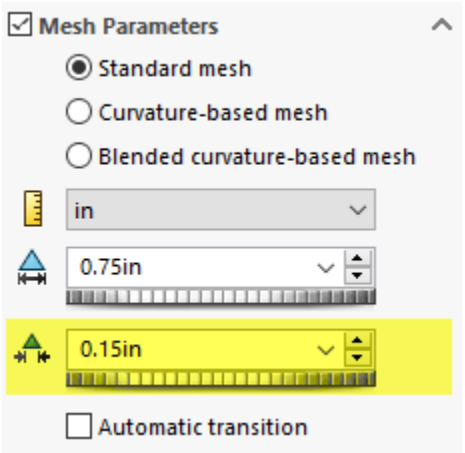


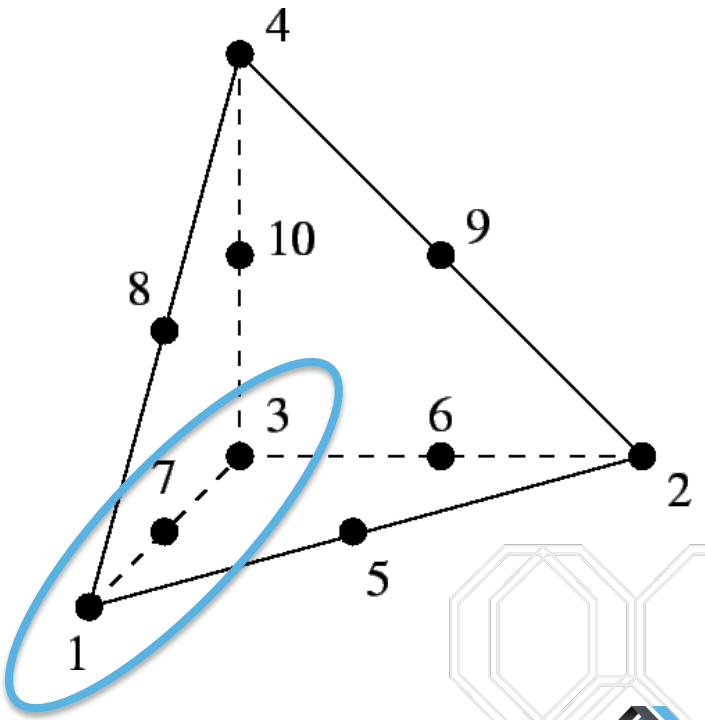
STANDARD MESH



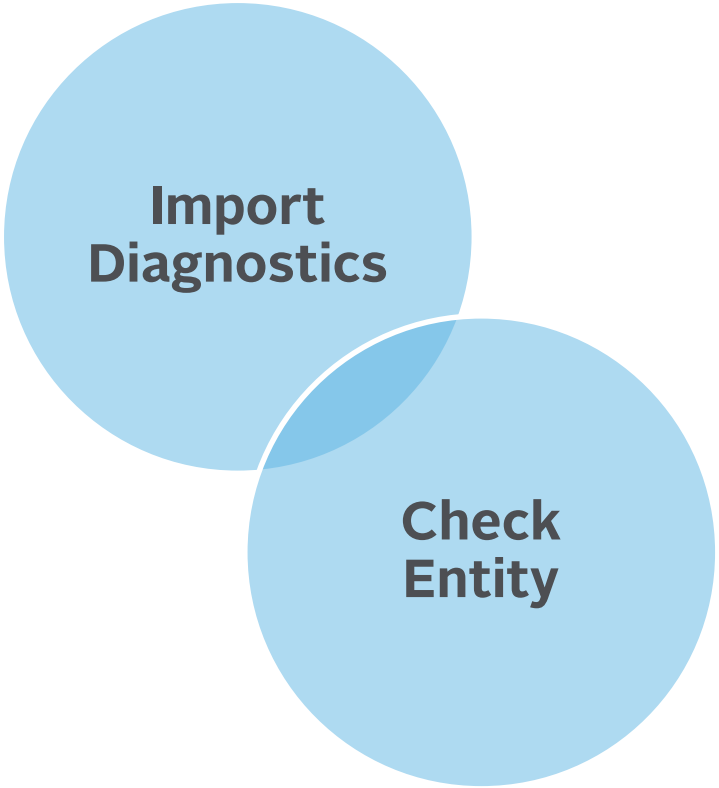


STANDARD MESH: A WORD OF CAUTION!





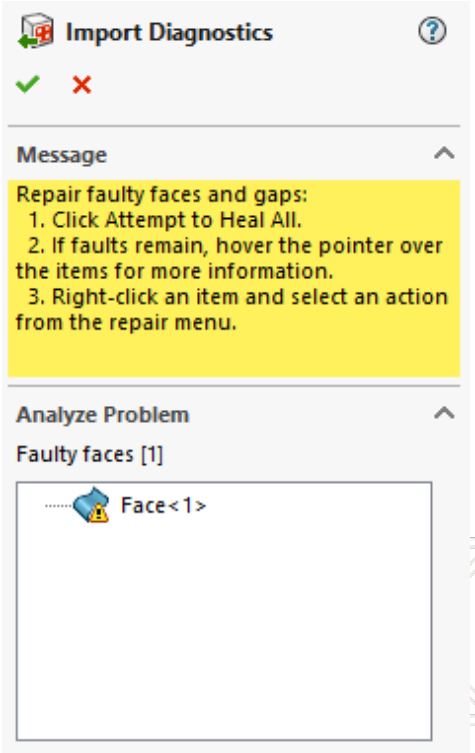
GEOMETRY CHECK



IMPORT DIAGNOSTICS

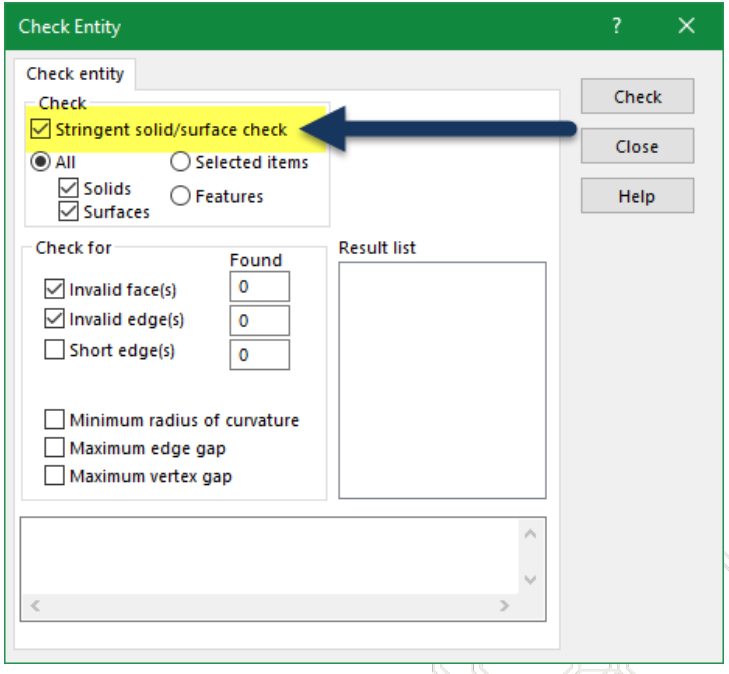
Imported Geometry

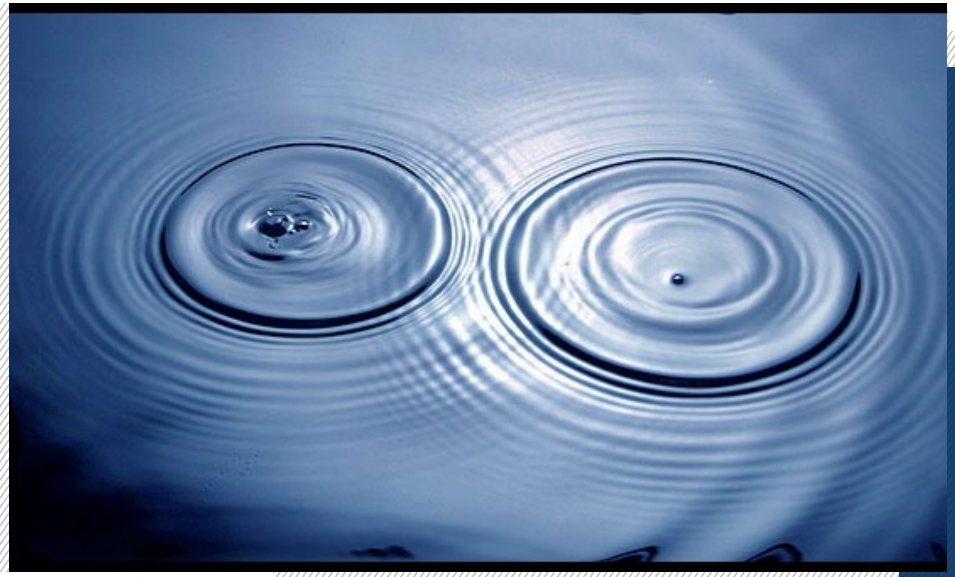
- Faulty Faces
- Gaps



CHECK ENTITY

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

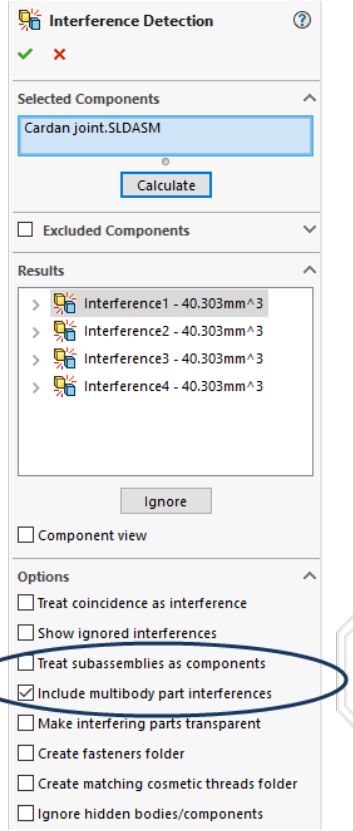




Check Interferences

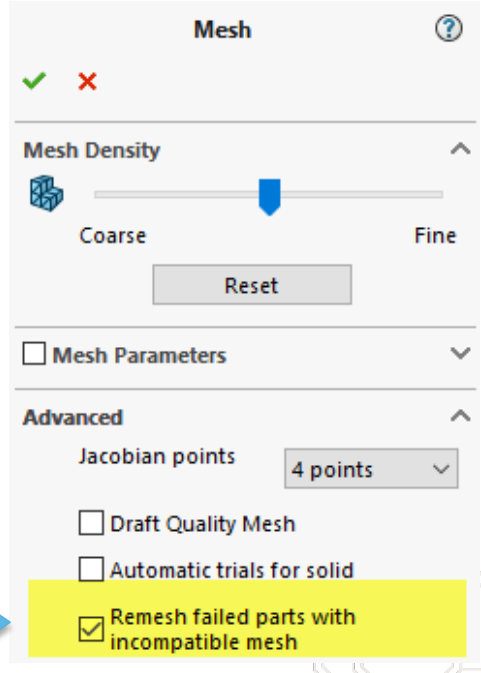
INTERFERENCE DETECTION

- **Treat Subassemblies as components**
- **Include multibody part interferences**

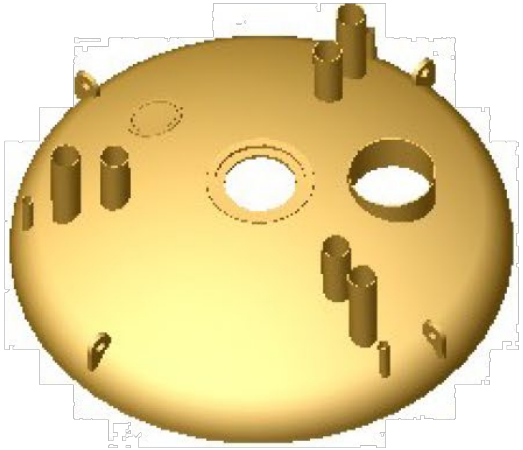


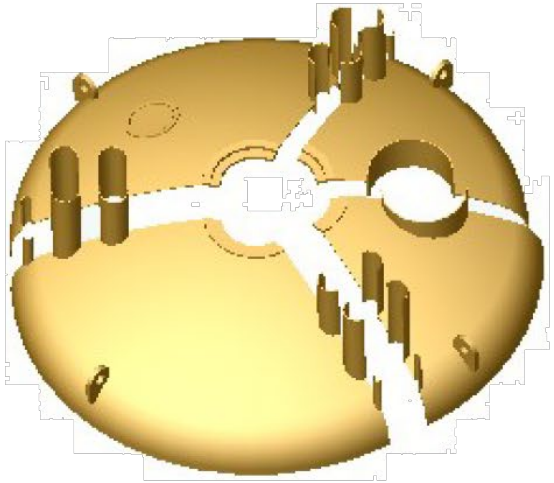
REMESH FAILED PARTS WITH INCOMPATIBLE MESH

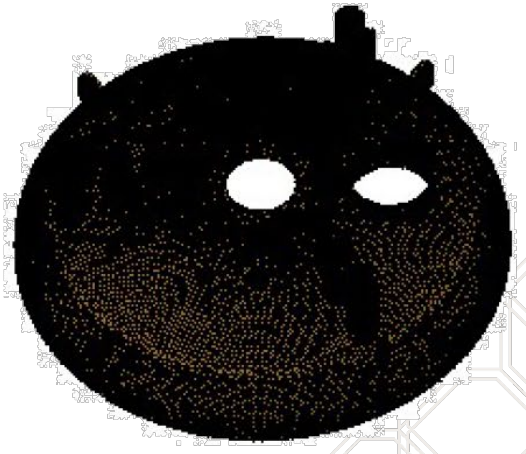
Re-meshes components that fail **independently** of the other components



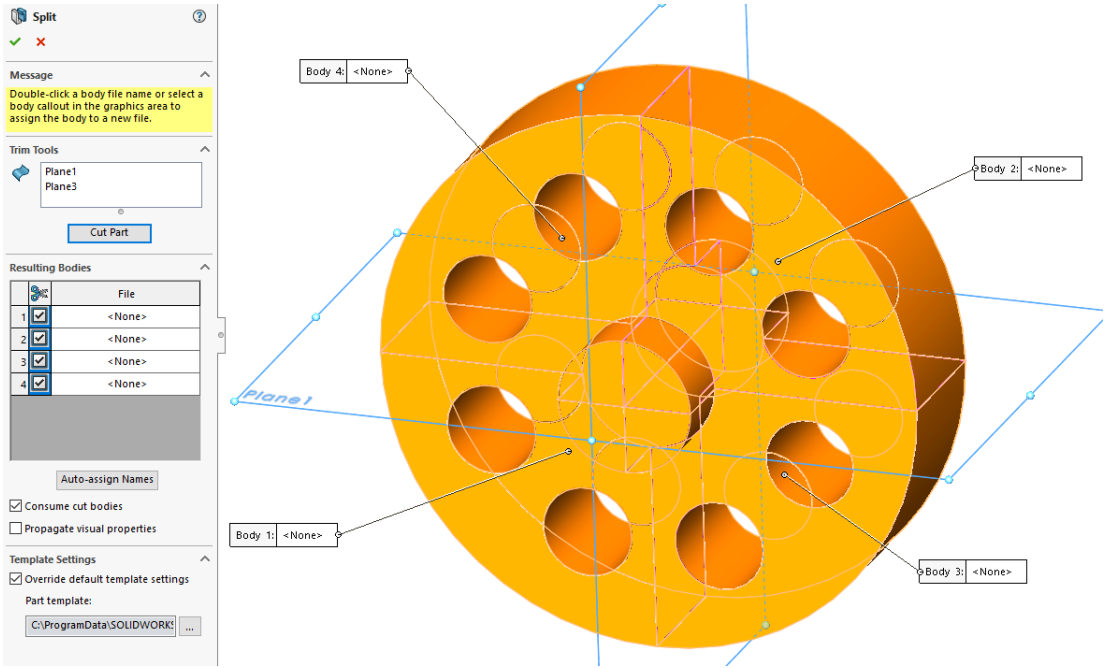
ISOLATE PROBLEM



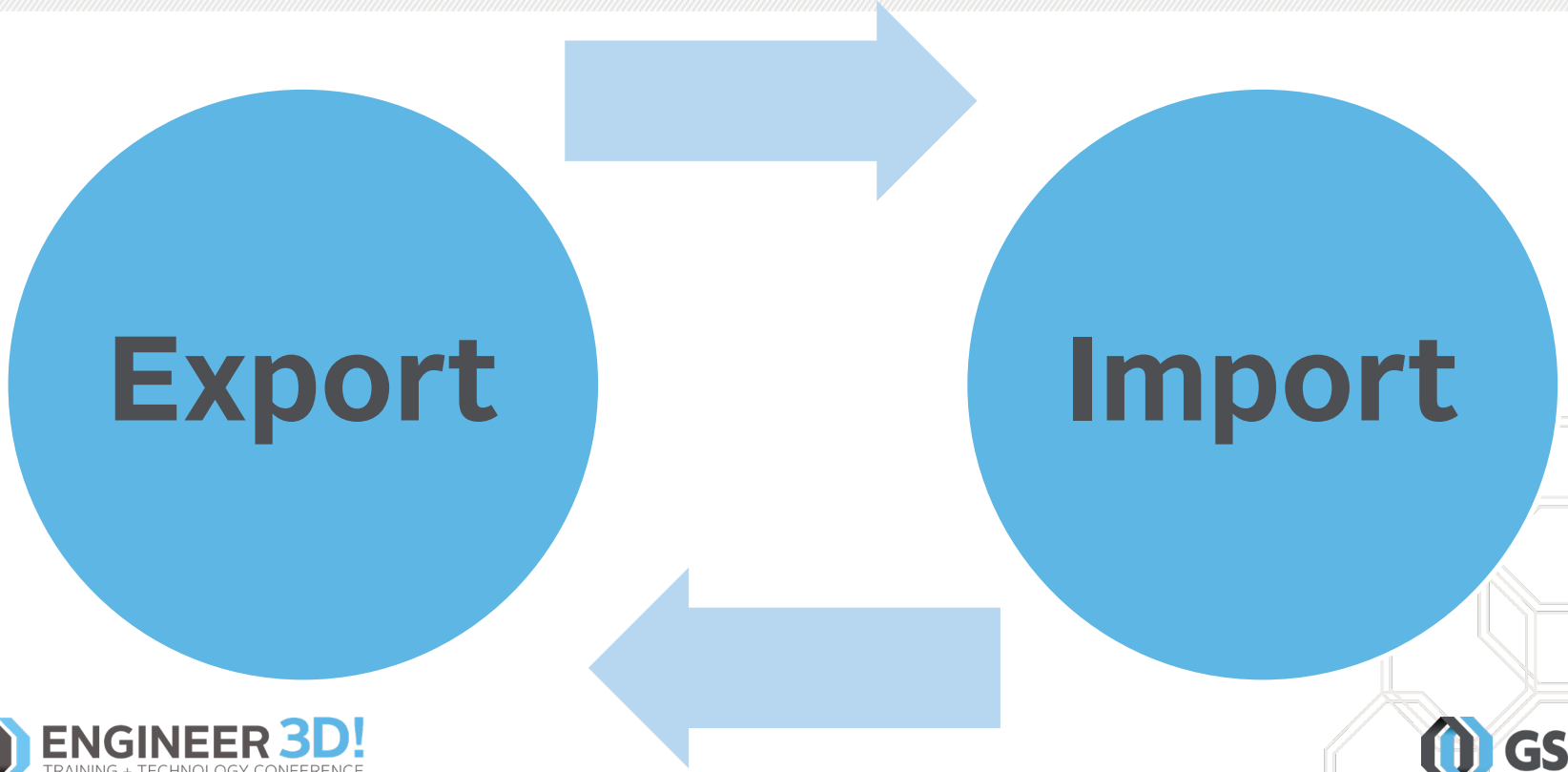




SPLIT COMMAND

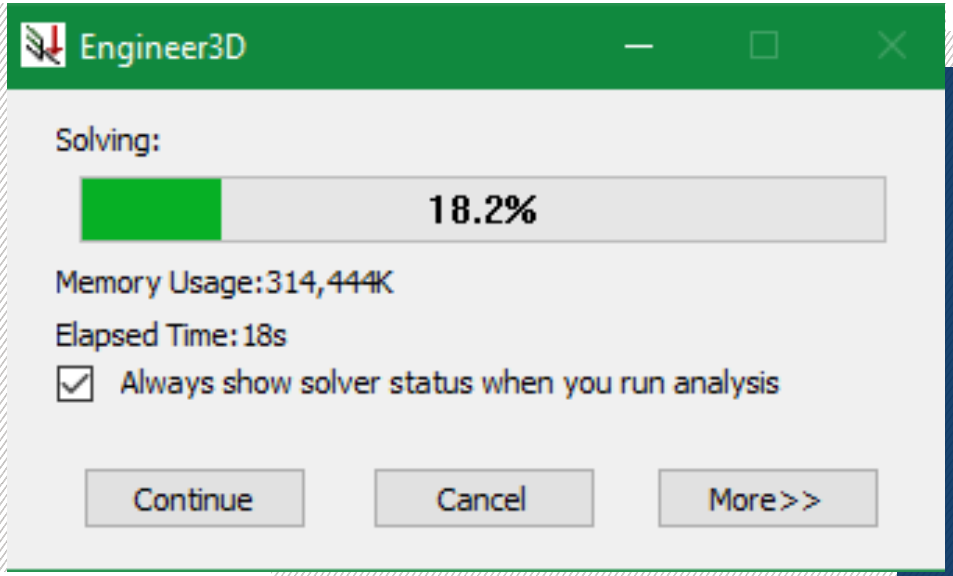


CREATE PARASOLID



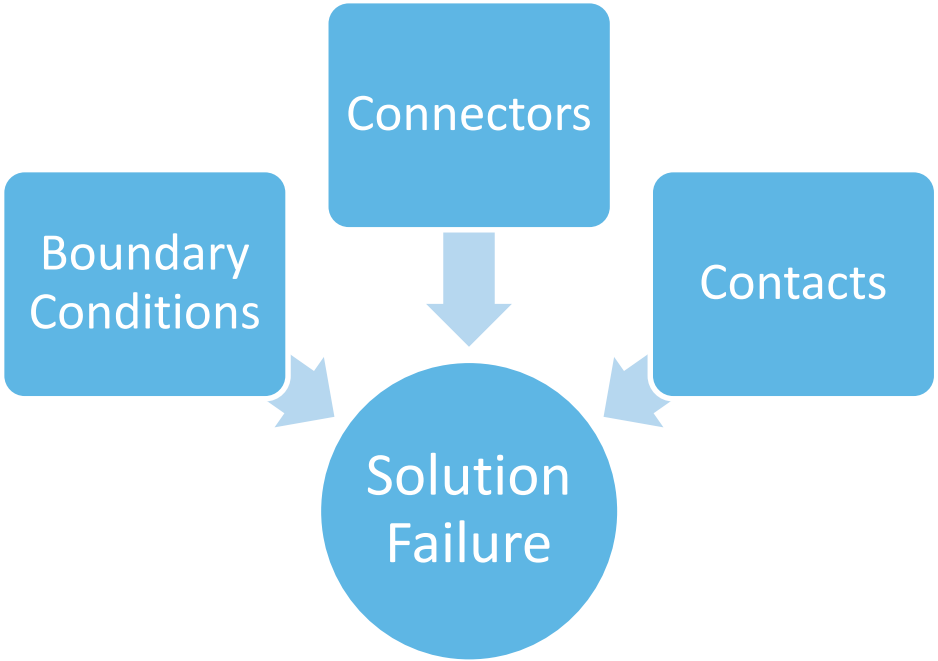
AND IF THAT FAILS…CALL US!

GSC CAN


Engineer3D
Solving:
18.2%
Memory Usage:314,444K
Elapsed Time:18s
Always show solver status when you run analysis
Continue
Cancel
More>>

Solution

REVIEW THE SETUP

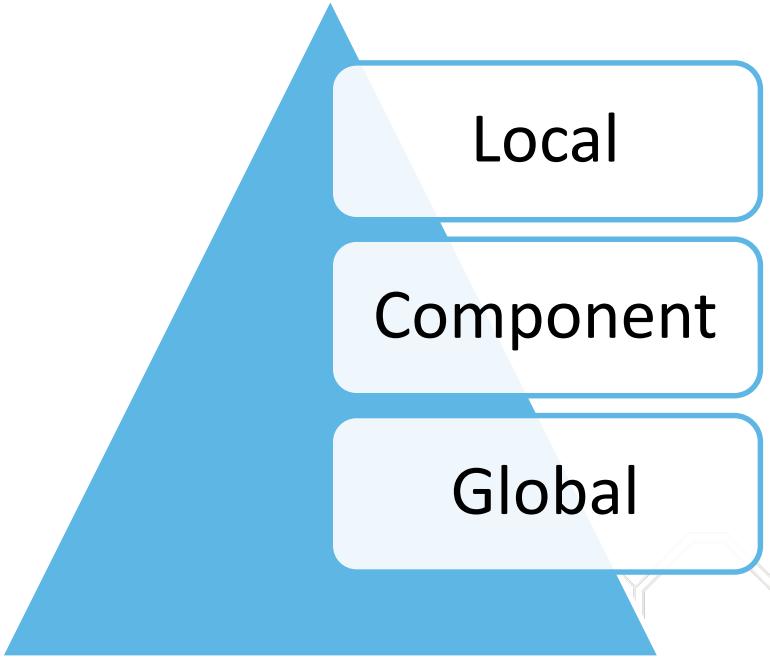


BOUNDARY CONDITIONS

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

CONTACTS

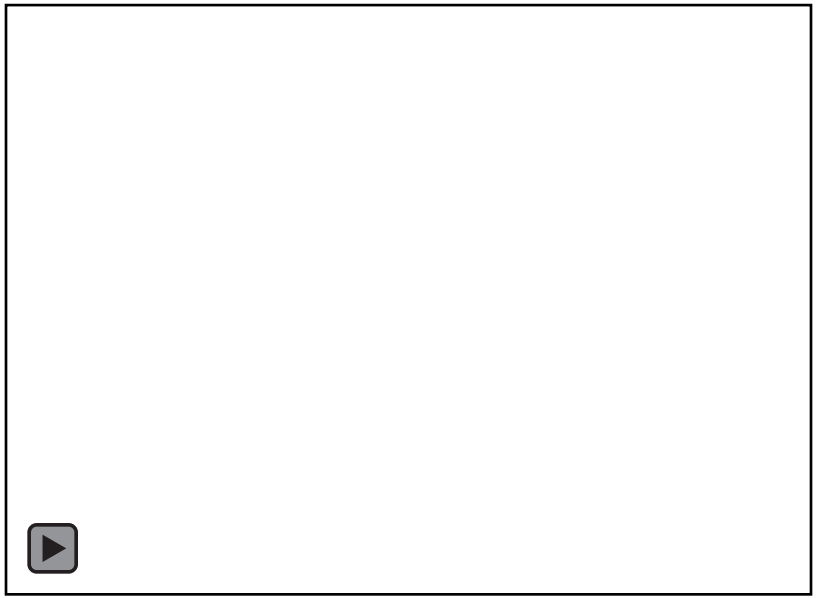
Review all **Bonded** and **No Penetration** contacts to verify **none** were **missed**

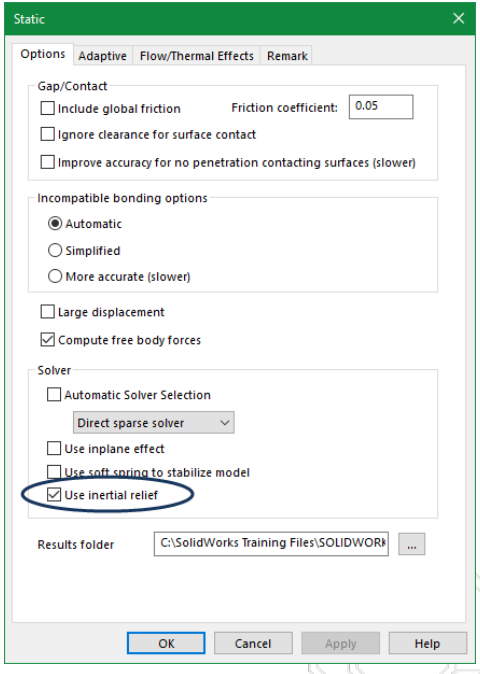


Contact Type	Color Rendering
Bonded	Red
No Penetration	Purple
Allow penetration (Free contact)	Green
Shrink Fit	Orange
Virtual Wall	Yellow
Thermal Contact Resistance	Purple
Insulated	Green

Contact Visualization Plot

TROUBLESHOOTING WITH INERTIAL RELIEF





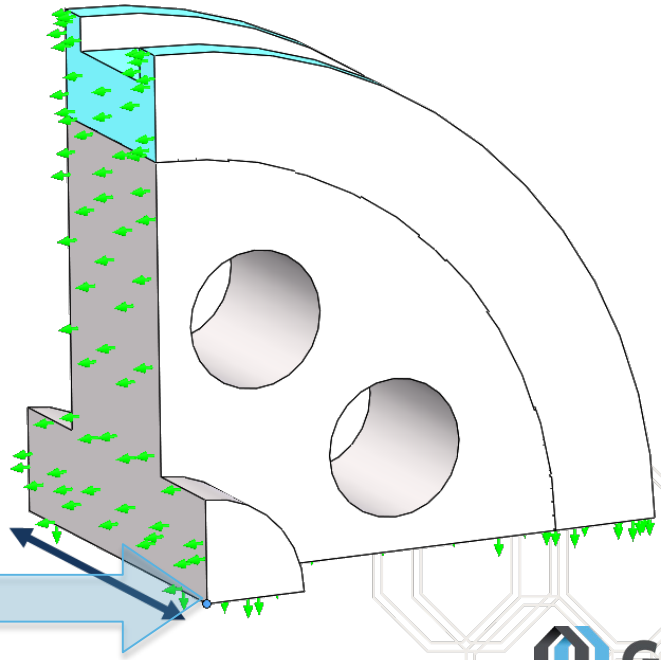
WHERE ARE MY RESULTS BEING SAVED?

START WITH GRAVITY

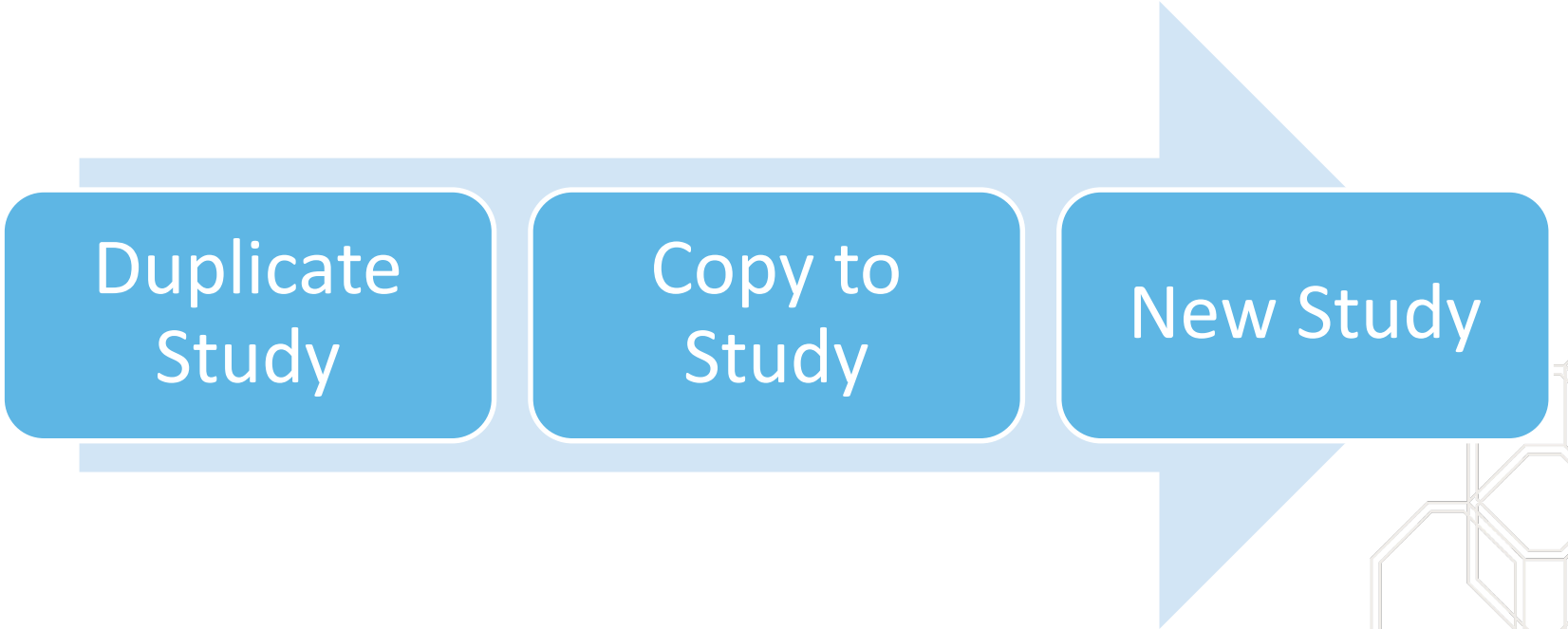
start with **gravity** and incrementally **add loads** back into the **analysis**

STABILIZING RESTRAINT

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

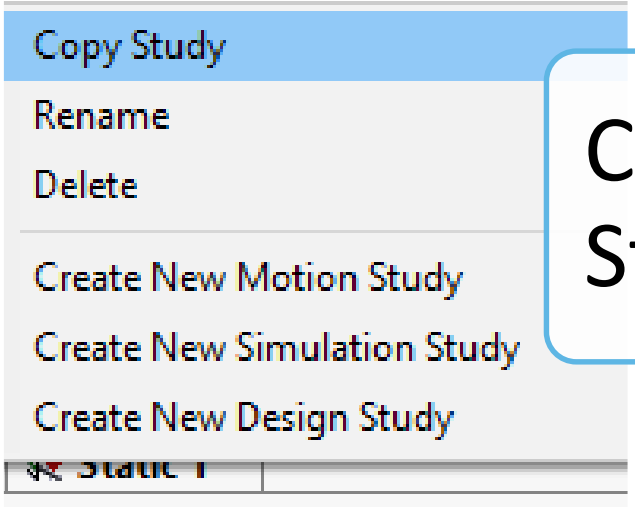


CORRUPTED STUDY

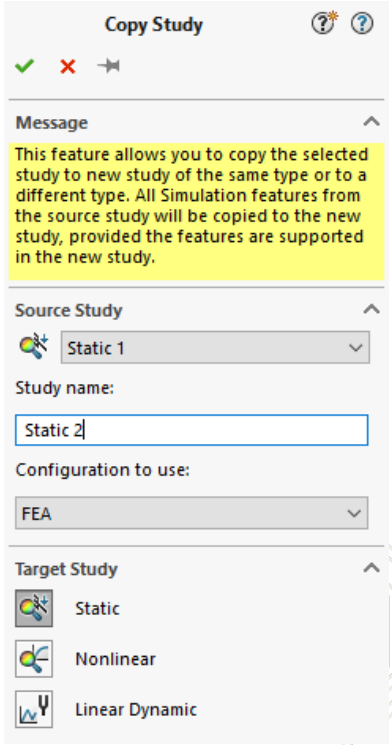


DUPLICATE STUDY

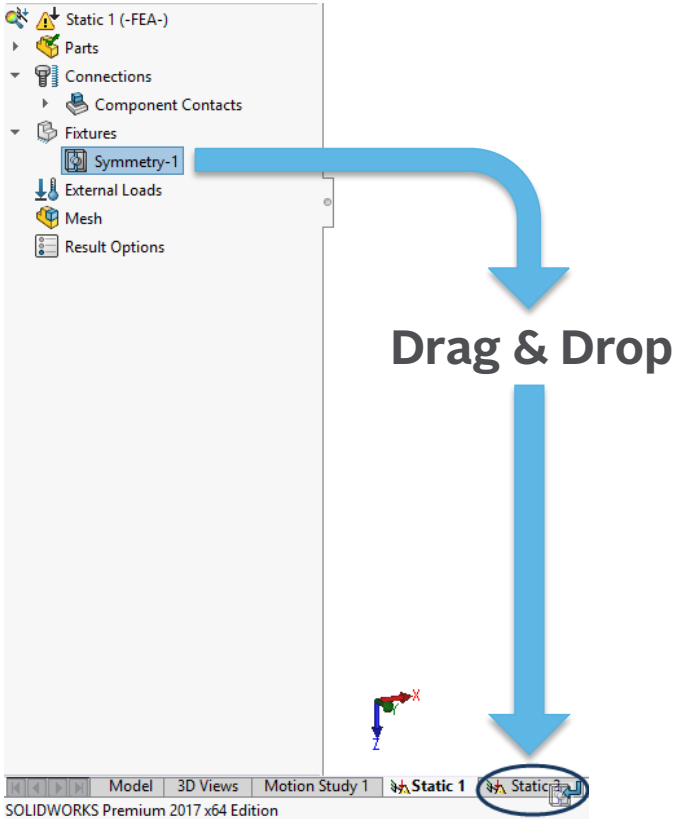
Right Click Study Name



Copy Study

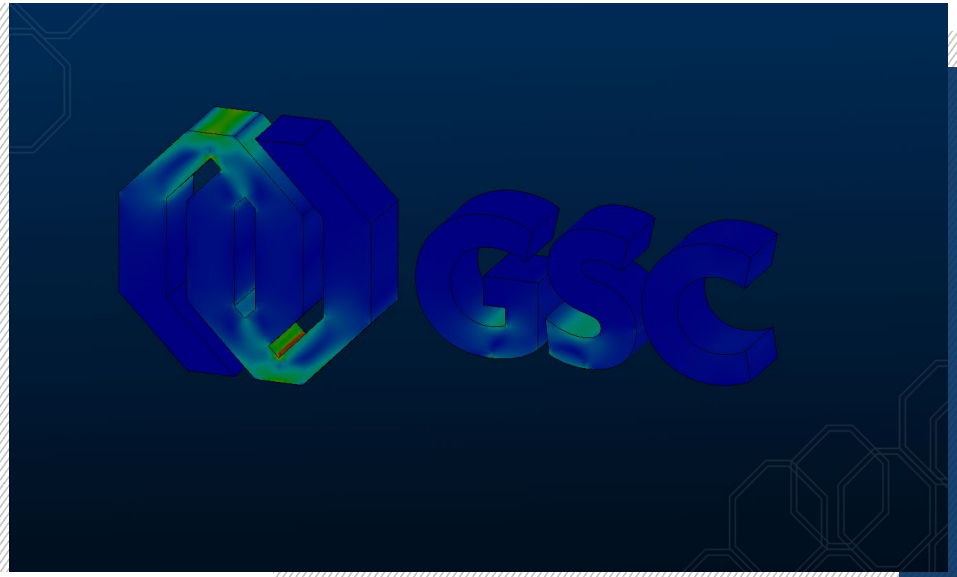


COPY TO STUDY



AND IF THAT FAILS…CALL US!

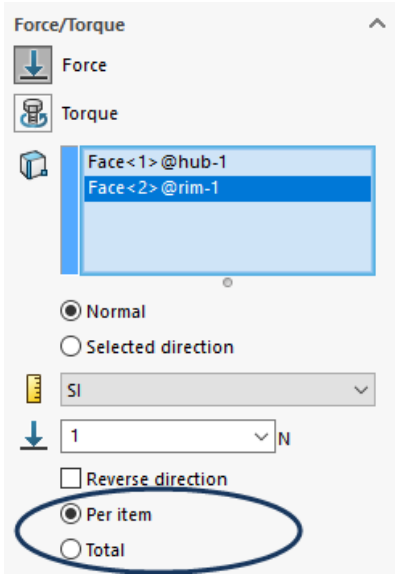
GSC CAN



Results

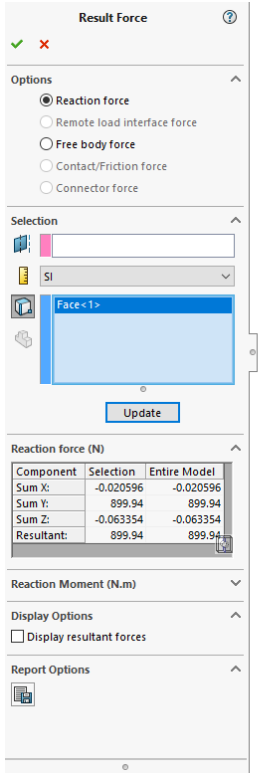
PER ITEM VS TOTAL LOAD

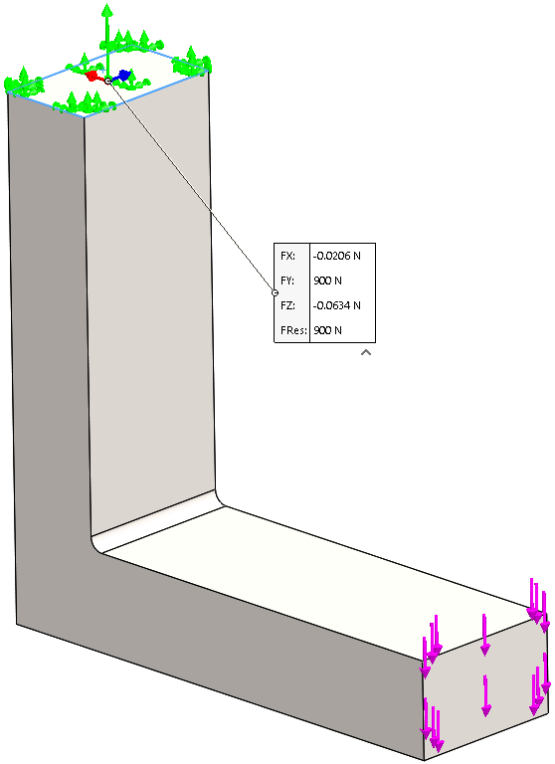
Per Item



Total Load

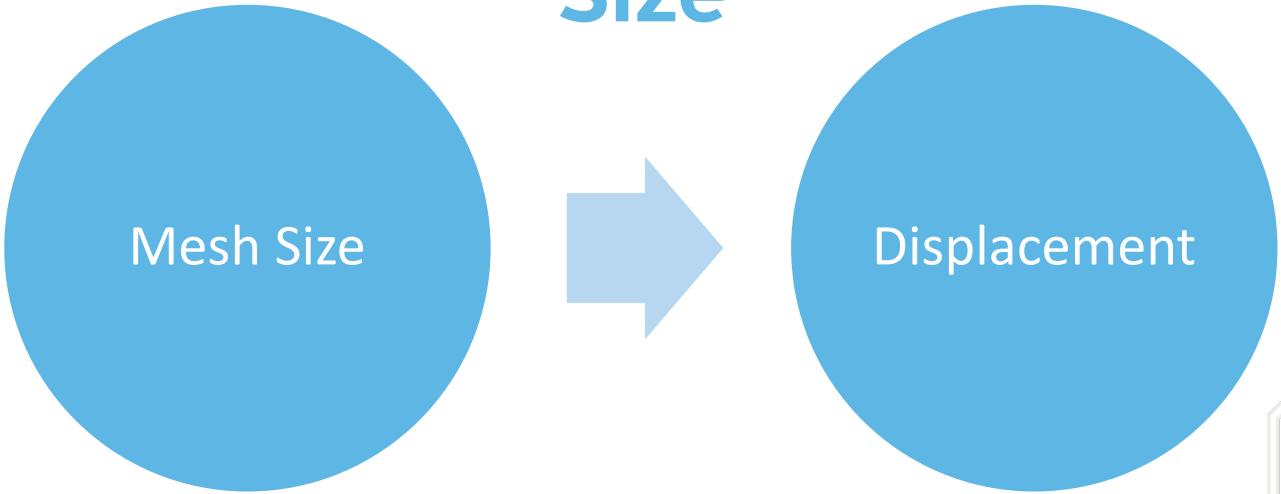
CHECKING REACTION FORCES



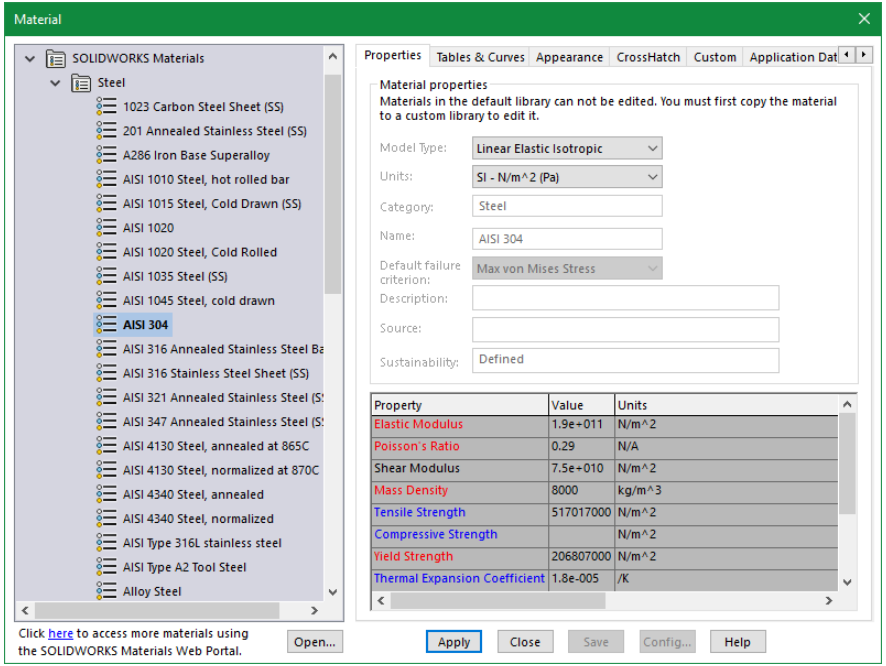


MODEL STIFFNESS

Displacement should be Independent of Mesh Size

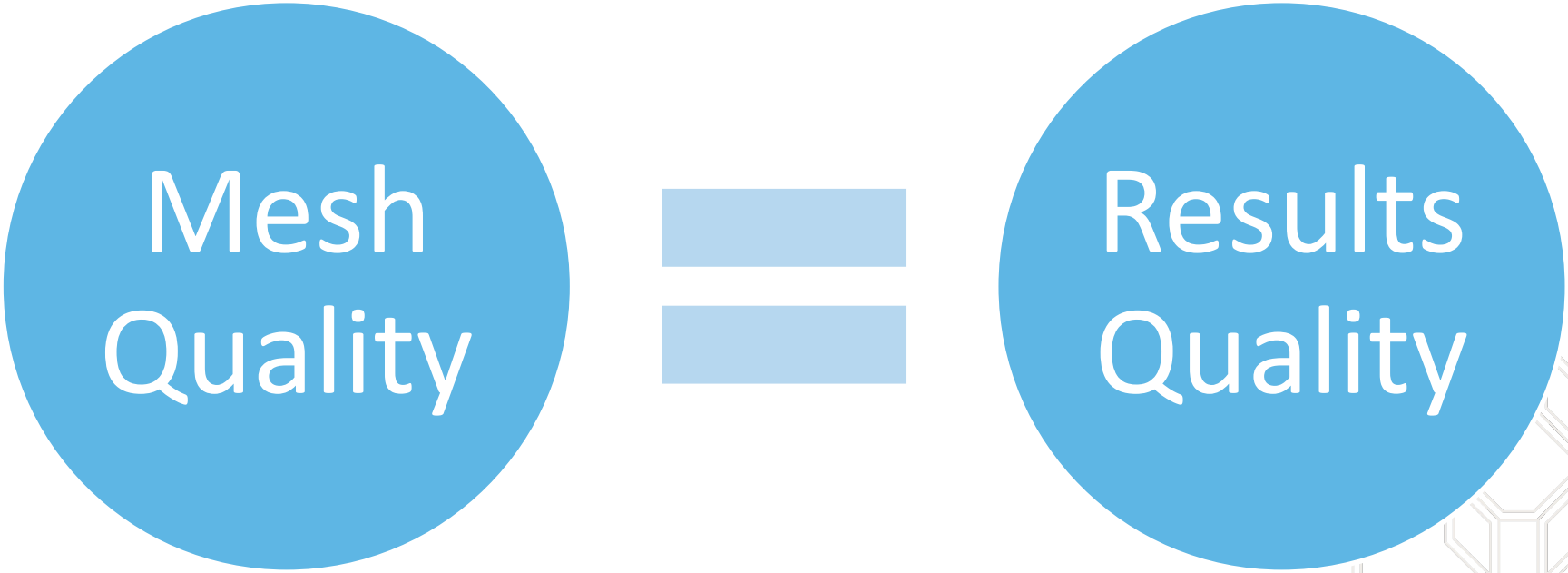


MATERIAL PROPERTIES CORRECT

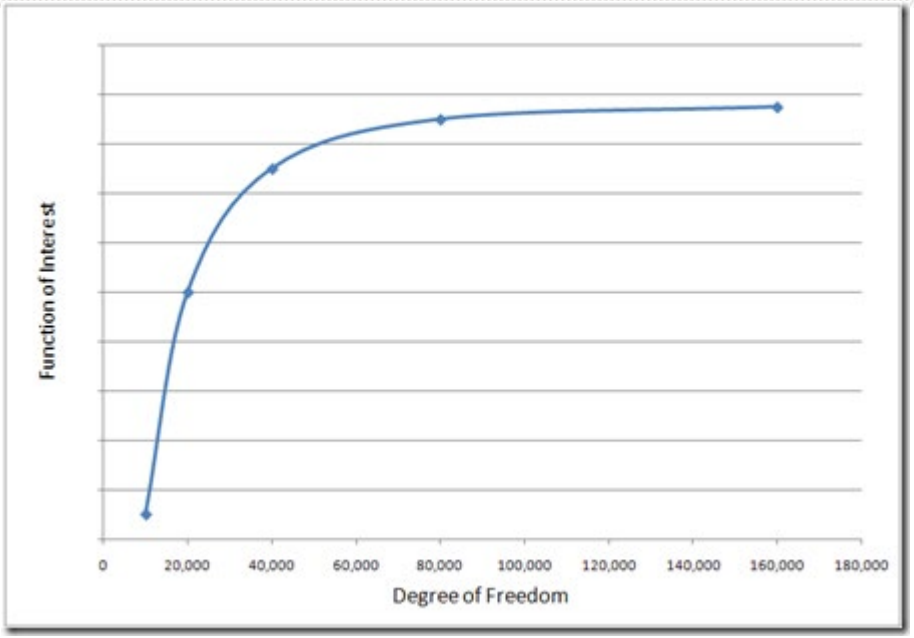


DOUBLE CHECK UNITS!

MESH QUALITY



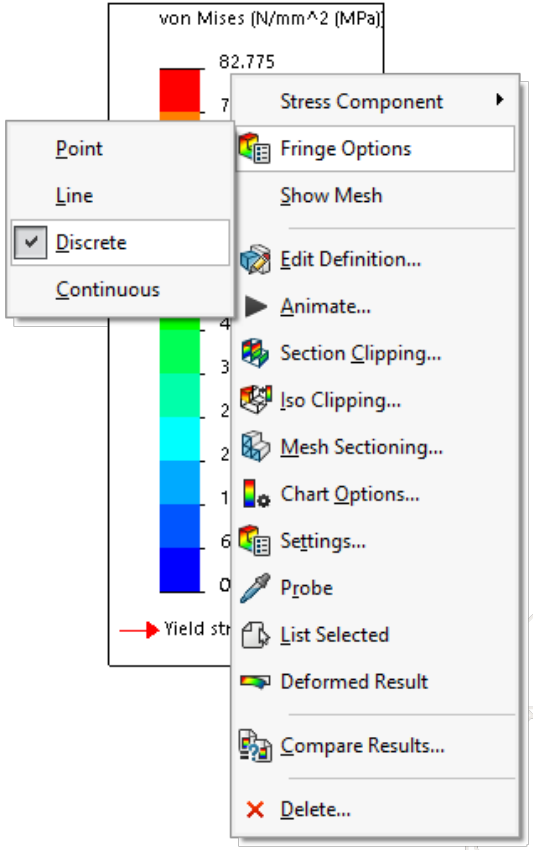
CONVERGENCE



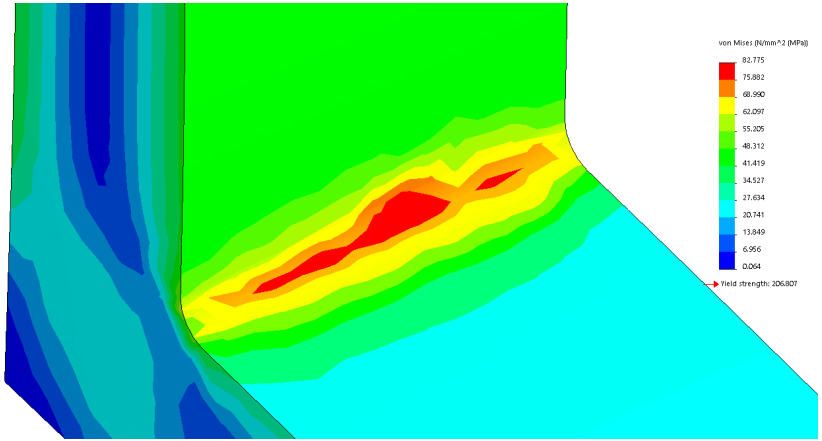
Stress should be **Independent** of **Mesh Size**

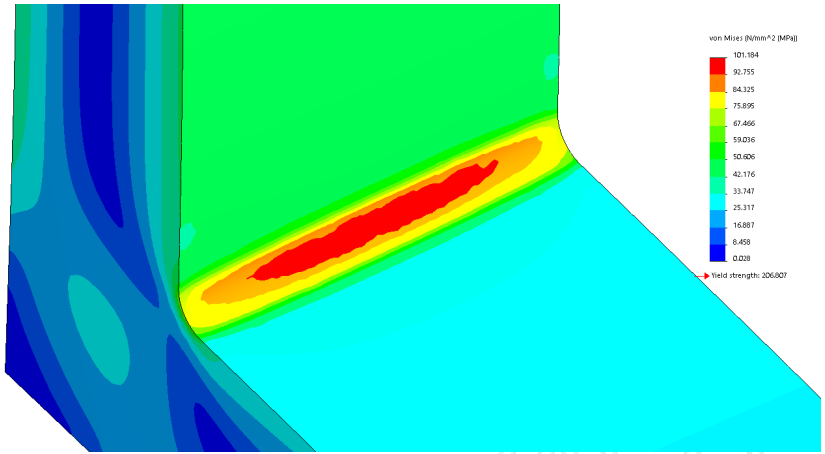
CONTOUR PLOT

Right Click Legend → Fringe Options → Discrete

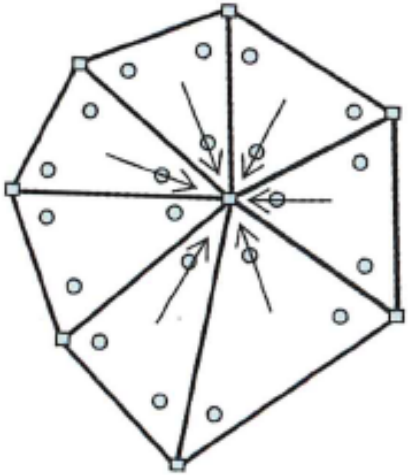


CONTOUR QUALITY

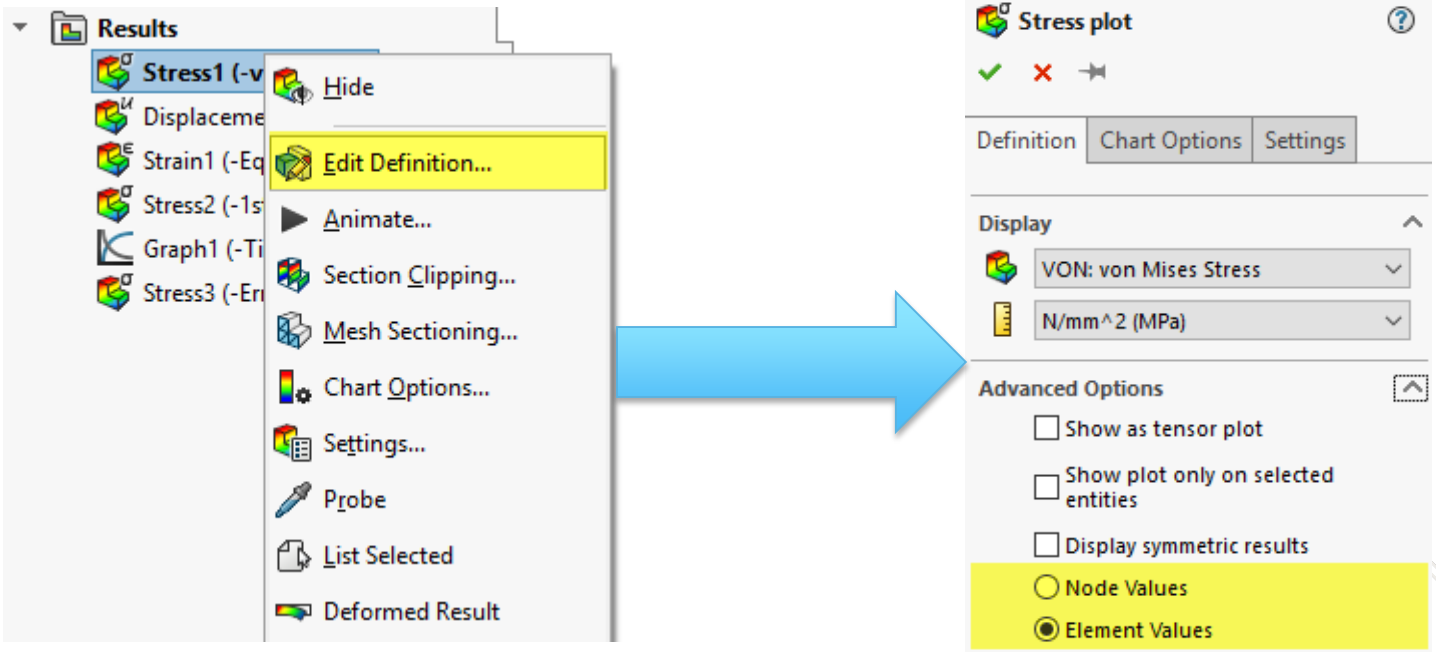




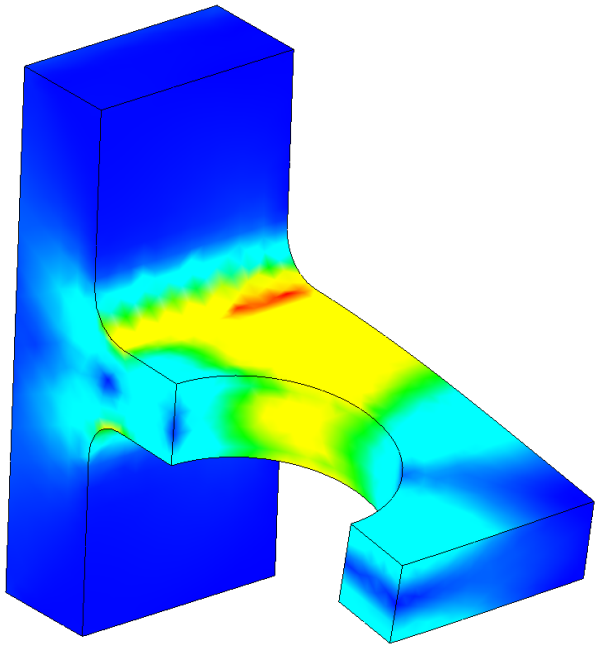
NODAL VS ELEMENTAL VALUES

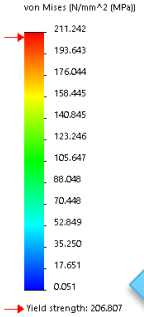


NODAL VS ELEMENTAL VALUES

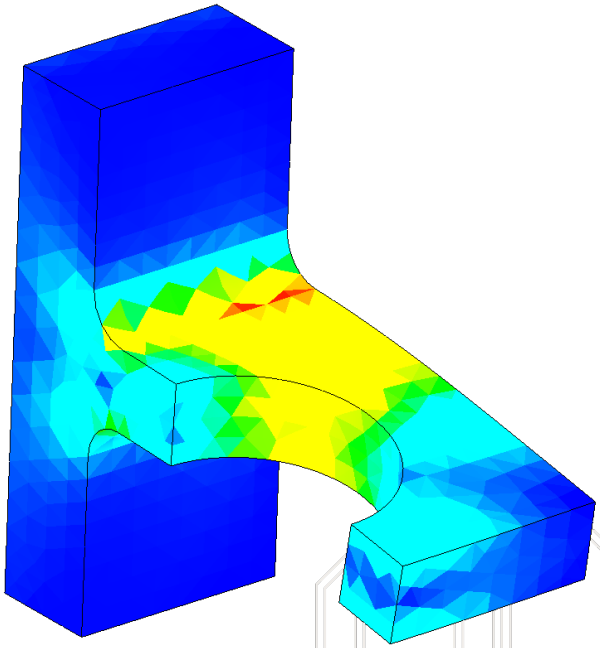


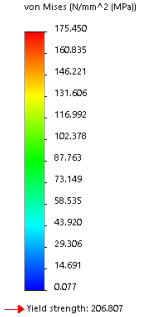
NODAL VS ELEMENTAL VALUES (COURSE MESH)





17%





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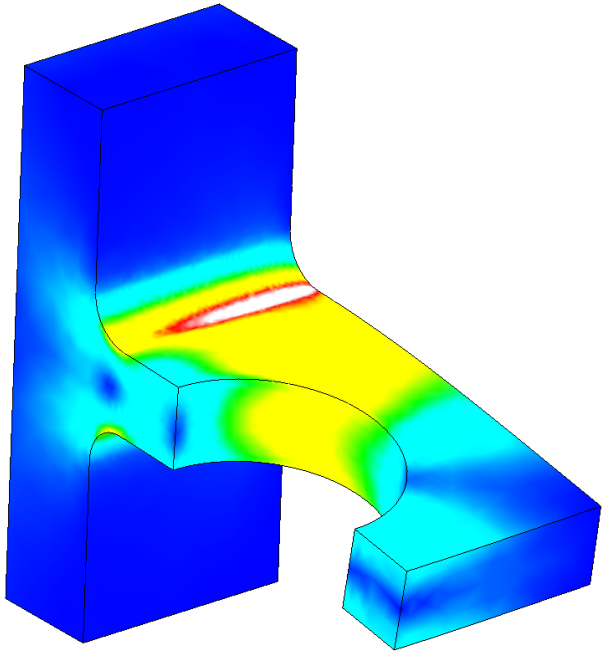
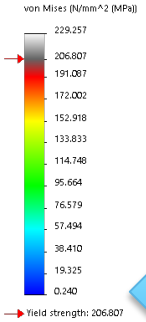
NODAL VS ELEMENTAL VALUES (FINE MESH)





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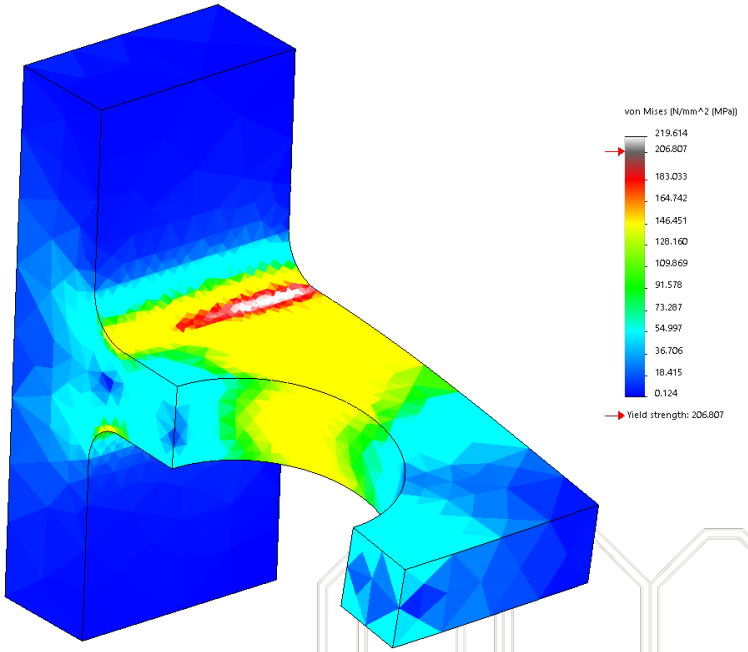

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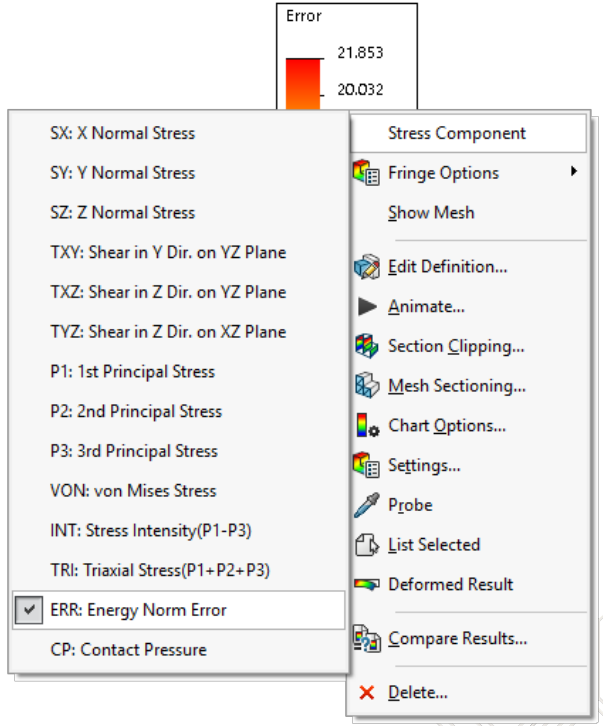
ENERGY NORM ERROR

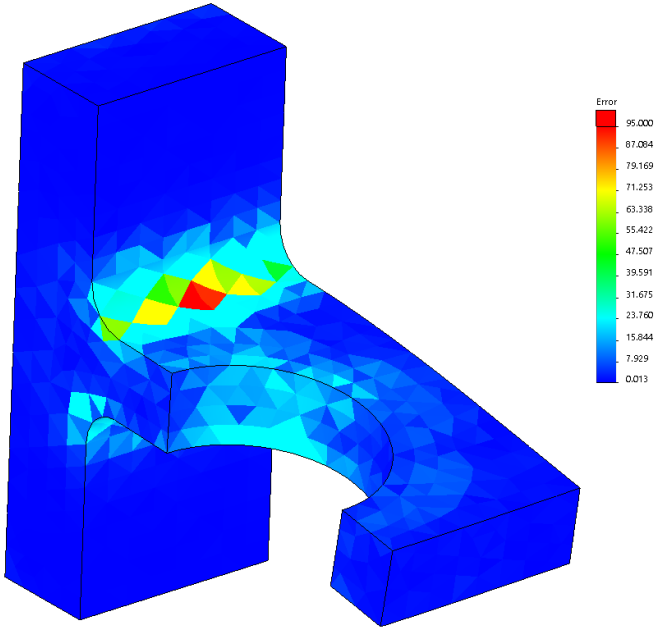
Stress Plot

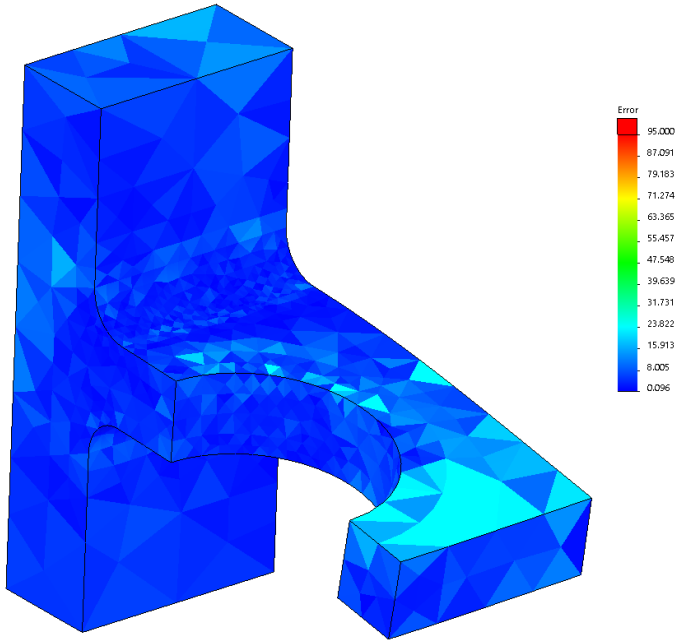
Stress Component

ERR: Energy Norm Error



ENERGY NORM ERROR



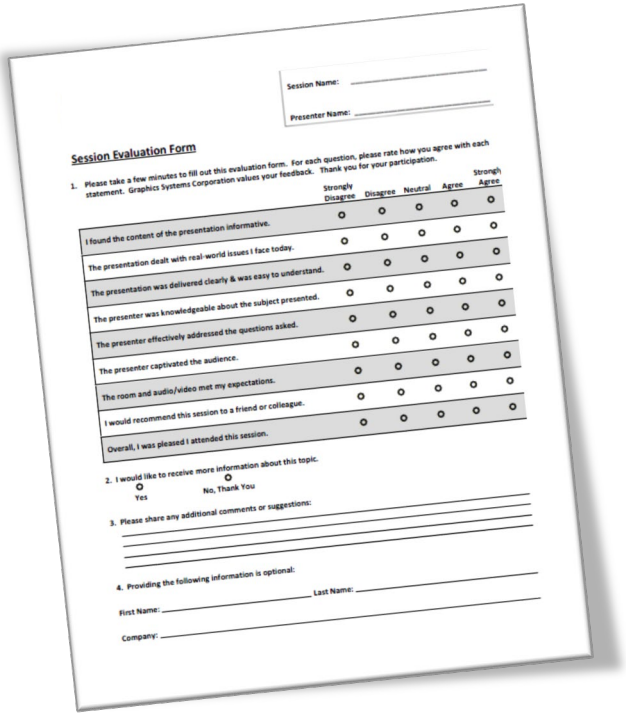


AND IF THAT FAILS…CALL US!

GSC CAN


Questions?

YOUR FEEDBACK IS NEEDED!



Session Name: _____

Presenter Name: _____

Session Evaluation Form

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

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

3. Please share any additional comments or suggestions:

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