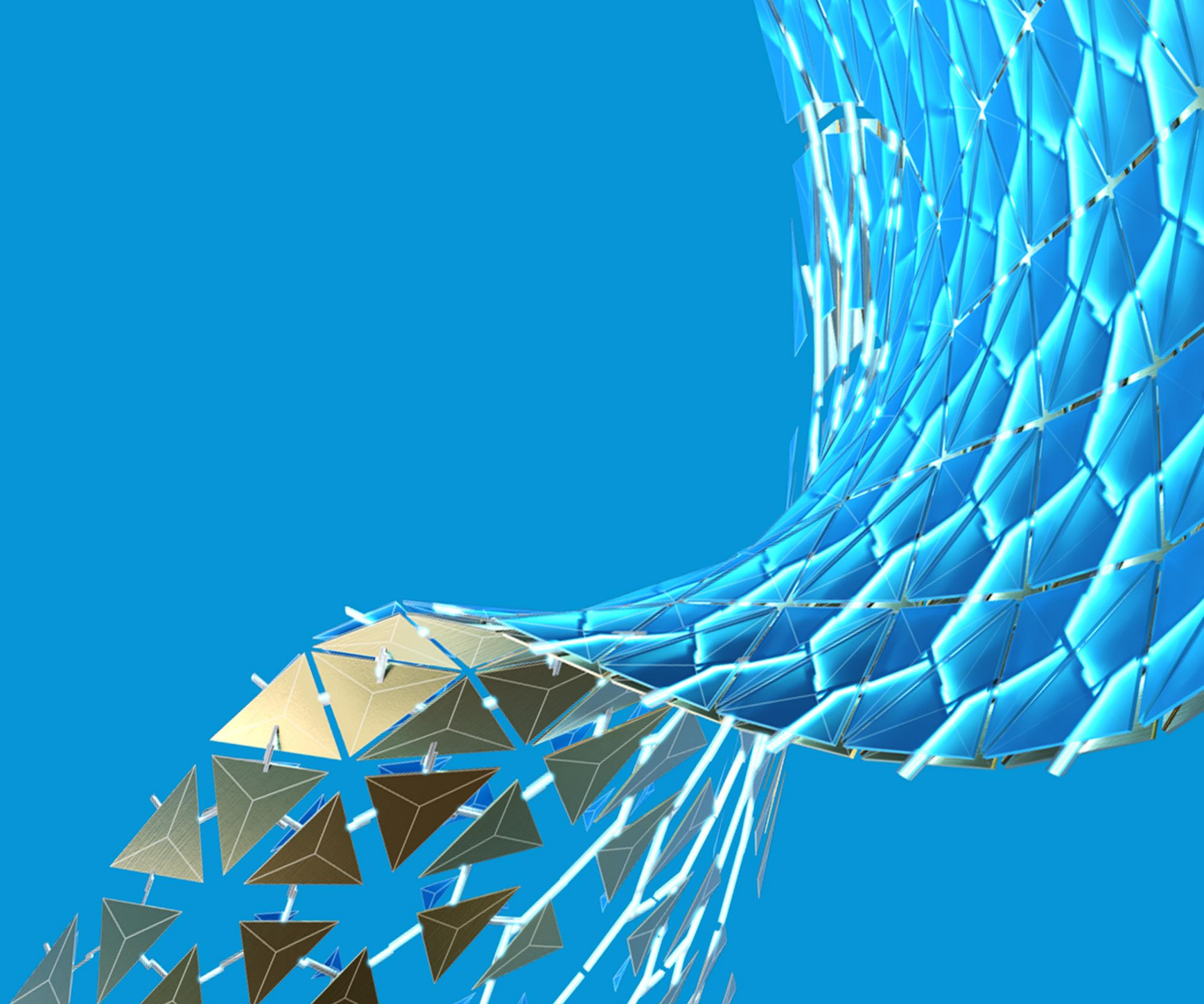
AUTODESK® UNIVERSITY

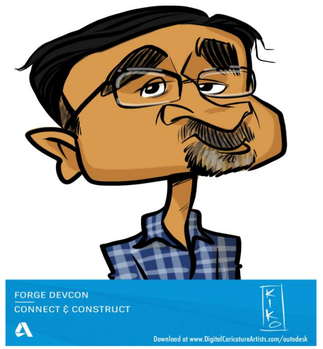
# IM463460: Become a Simulation expert in 60 minutes

Shekar Sub, Hugh Henderson

# Introduction



# Shekar Sub




- Dev lead for Fusion-Ansys collaboration
- Working on Fusion Sim & Generative
- 23 years @ Autodesk
- Many times @ AU
- Bachelors Masters Doctorate in Mech Engg
- Co-author of “Mastering Inventor….”
- Volunteer for FIRST robotics
- Walking, Yoga and Tennis

# Hugh Henderson

- Quality Assurance Engineer
- 18 years @ Autodesk
- Fusion Simulation (past Inventor Sim)
- Fixture Design Engineer – Industry Exp.
- BSME, Univ. of Illinois at Urbana-Champaign ('95-'98) Thermo, FEA, Simulation focus

# Contents


- Introduction
- Simplification
- Studies
- Materials
- Constraints
- Loads
- Contacts
- Meshing
- Pre-check/Solve
- Results

# Why Simulation?

- Samsung Note 7 phone fire!!!
- Recalled 1 million of 2.5 million phones manufactured
- Lost ~$5 billion

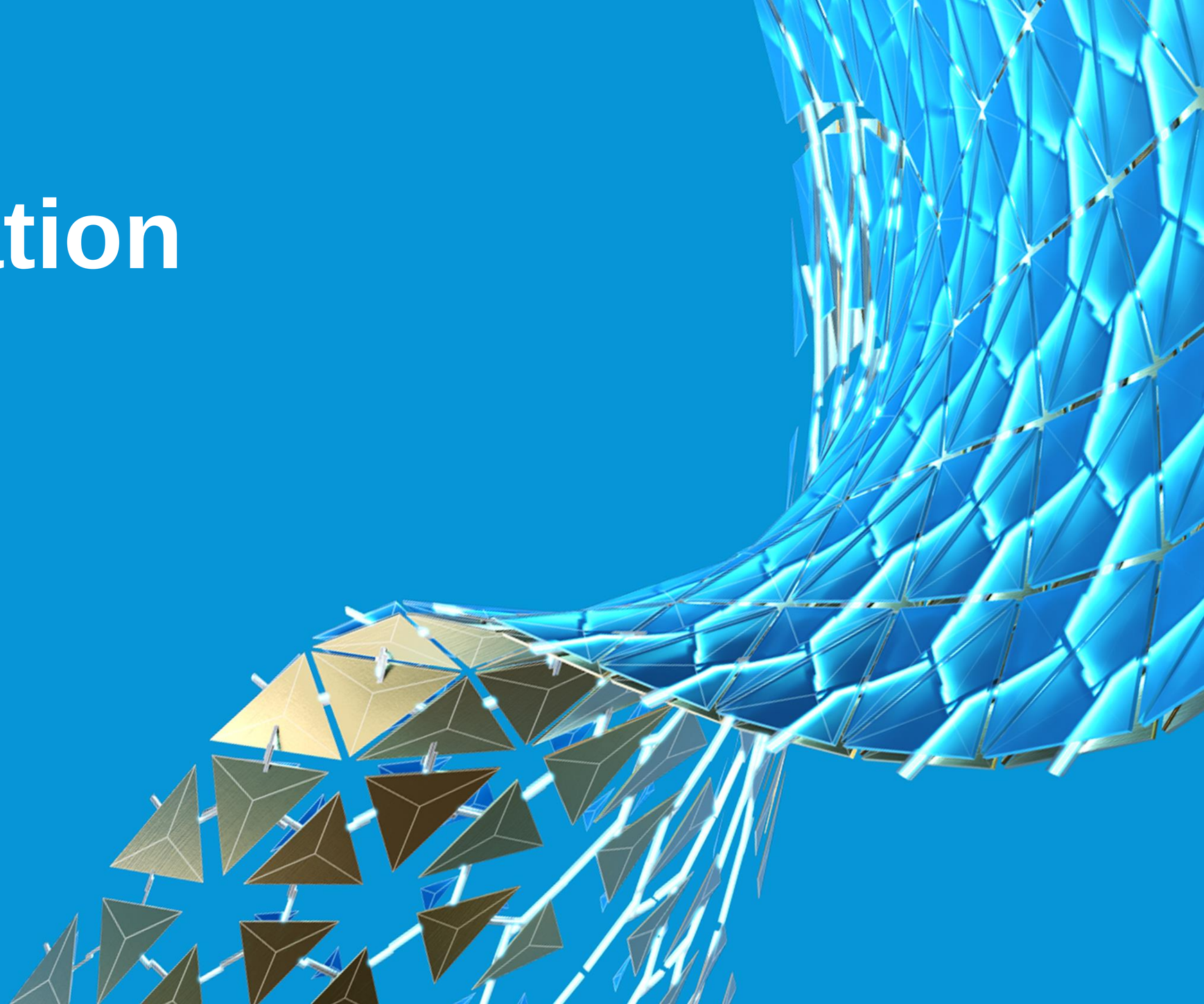
# Why Simulation?

# Fusion Simulation

- Integrated with CAD, CAM
- Easy to use
- Local & Cloud solve
- Meshing (Tetrahedral)
- Industry acclaimed Nastran, Explicit Solvers, Moldflow, CFD solvers.  Send to Ansys
- Multi-threaded
- Multi-platform (Windows, MAC)

# Simulation Steps

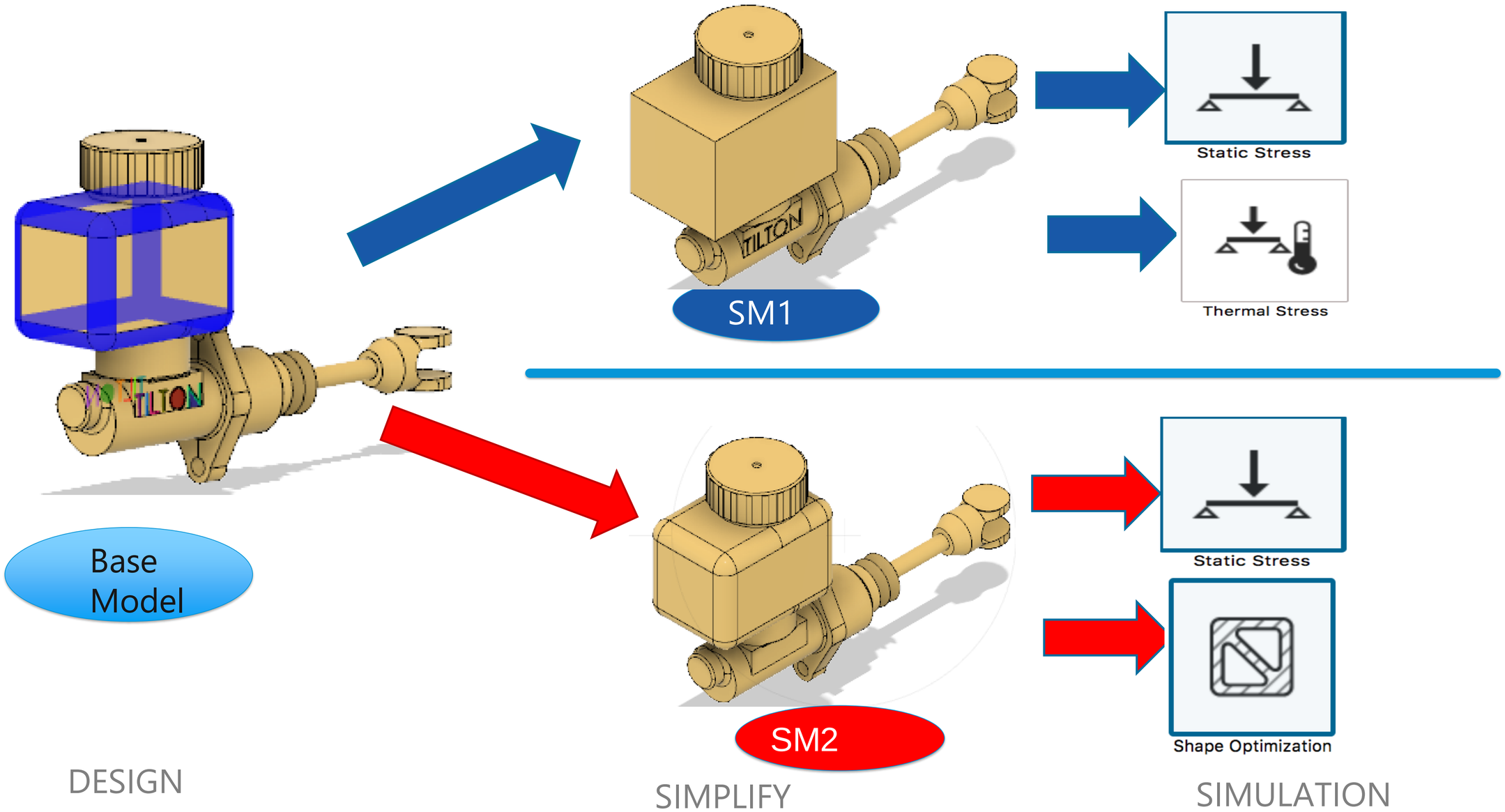
# Simplification



# Simplify workspace

- Create multiple variants of the design workspace model ("What-if" scenarios)
- Simplify the simulation models
- Remove unneeded geometry
- Advantages
  - Reduced element count
  - Faster simulation solves (~6X)

# Simulation Models



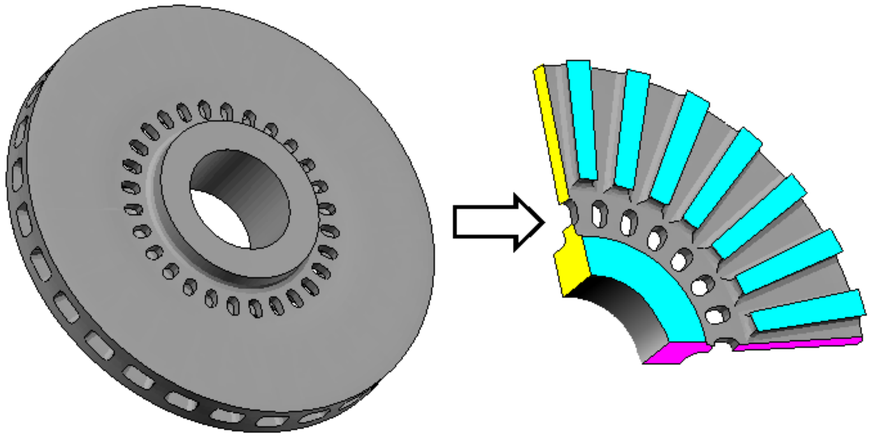
# What to Remove? What to Use?

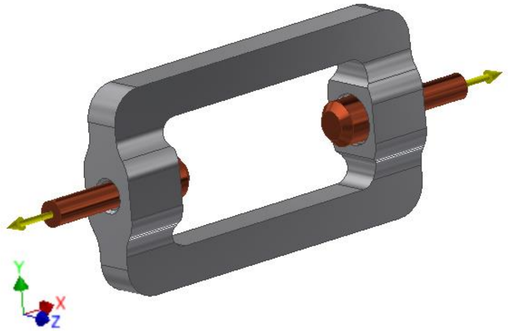
**Tip: Keep these internal fillets**

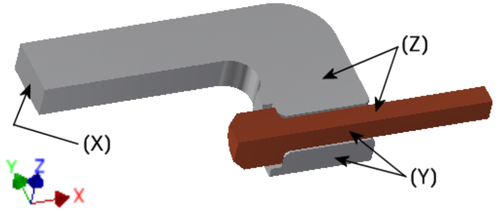
- **Small features**
  - Not part of critical stress regions
  - No impact on overall stiffness
  - Shouldn't significantly alter mass for frequency analysis
- **Screws and bolts.** Use connectors
- **Lifting eyes or handles**
- **Panel switches or indicator lights.** Use point masses

# Symmetry

- Split body + Remove
- Facilitates making Model statically stable



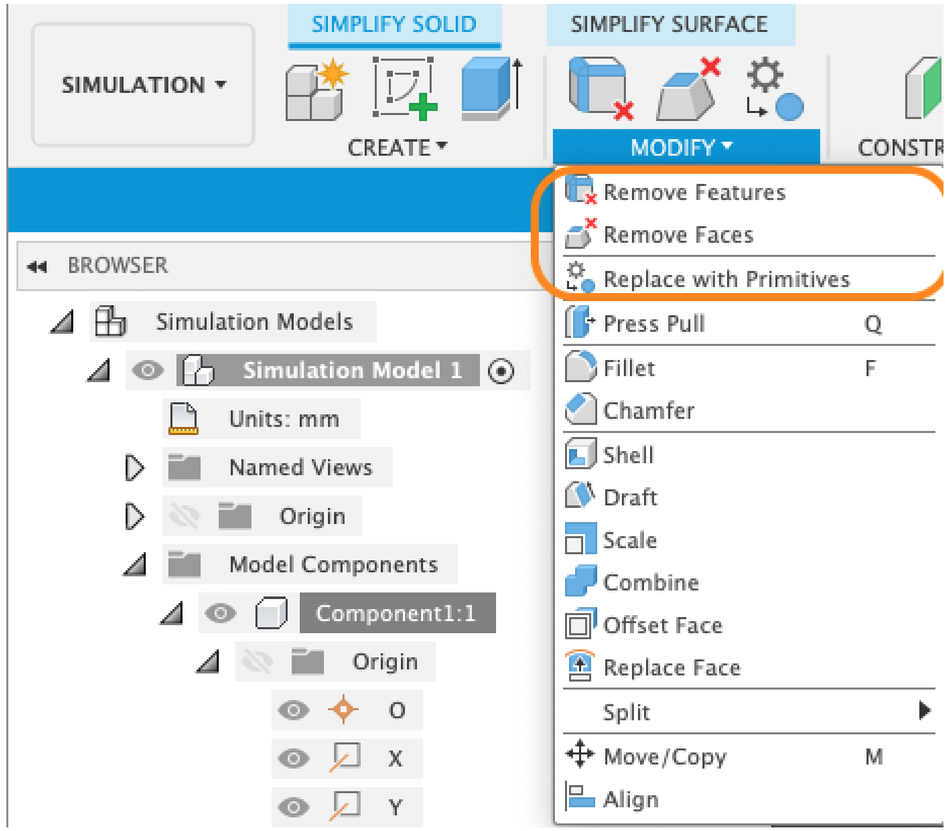


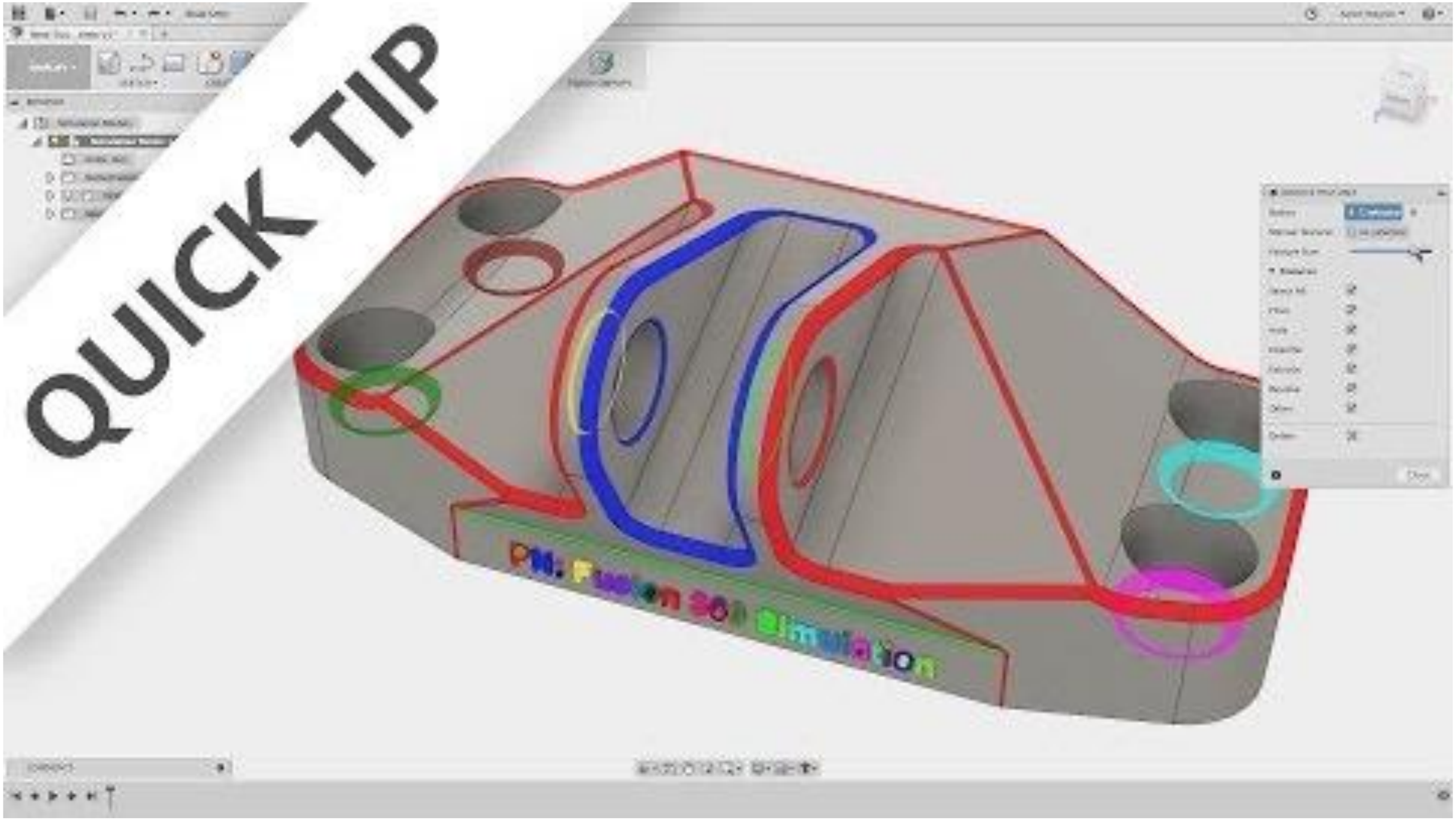



- Tip: Do symmetry changes in Simplify workspace.
- Tip: Avoid modeling with symmetry when performing Modal Frequencies or Structural Buckling simulations. Even symmetrical structures have asymmetrical vibration modes, such as when the structure is twisting.

# Simplify commands

- **What**
  - Features: **Remove Features**
  - Faces**: Remove Faces (for fillets)**
  - Bodies/Components:
    - **Remove**
    - **Remove All except Selected**
- **Replace with Primitives** (Box, Sphere, Cylinder)

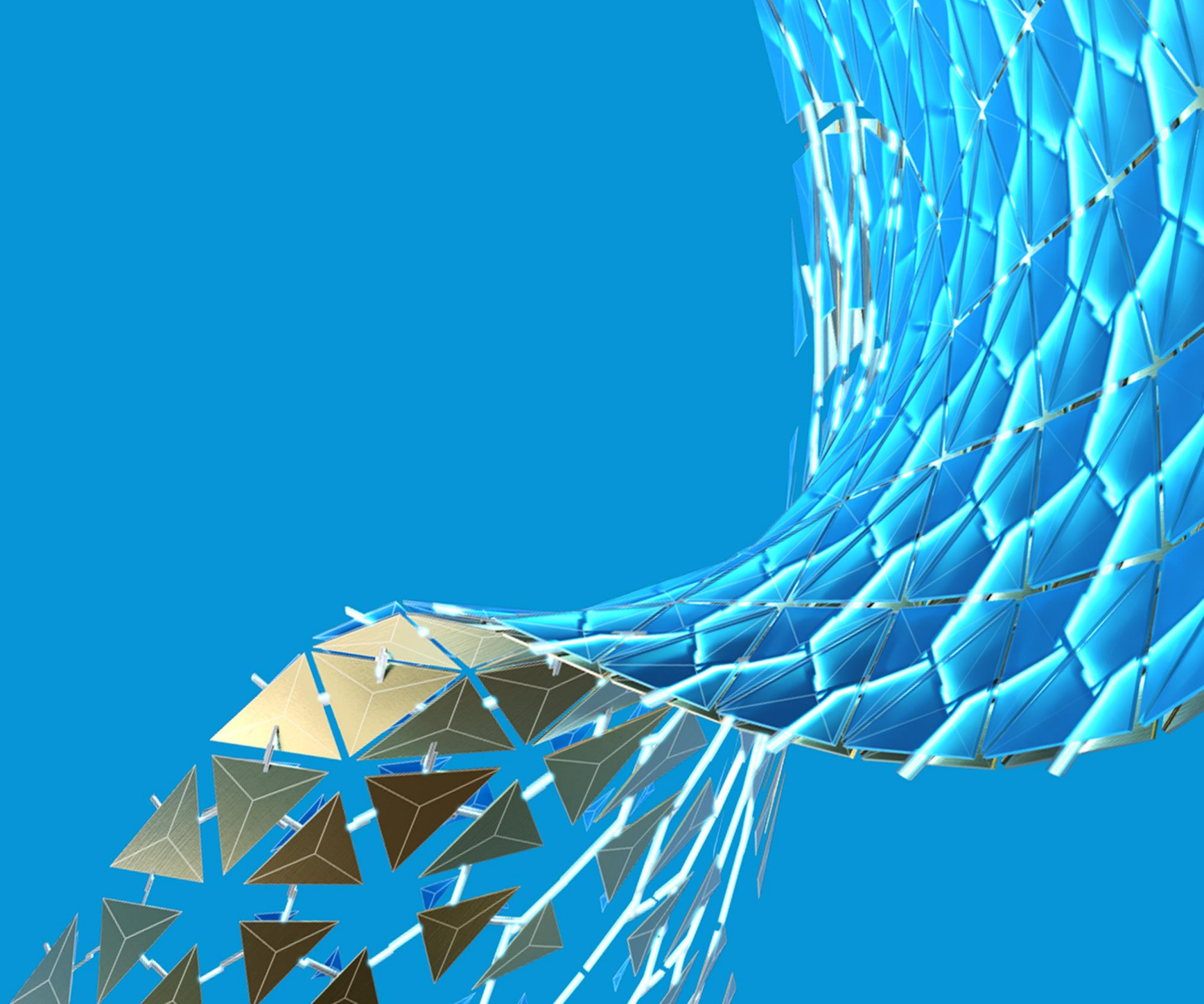



QUICK TIP
Fusion 360 Simulation

# Demo

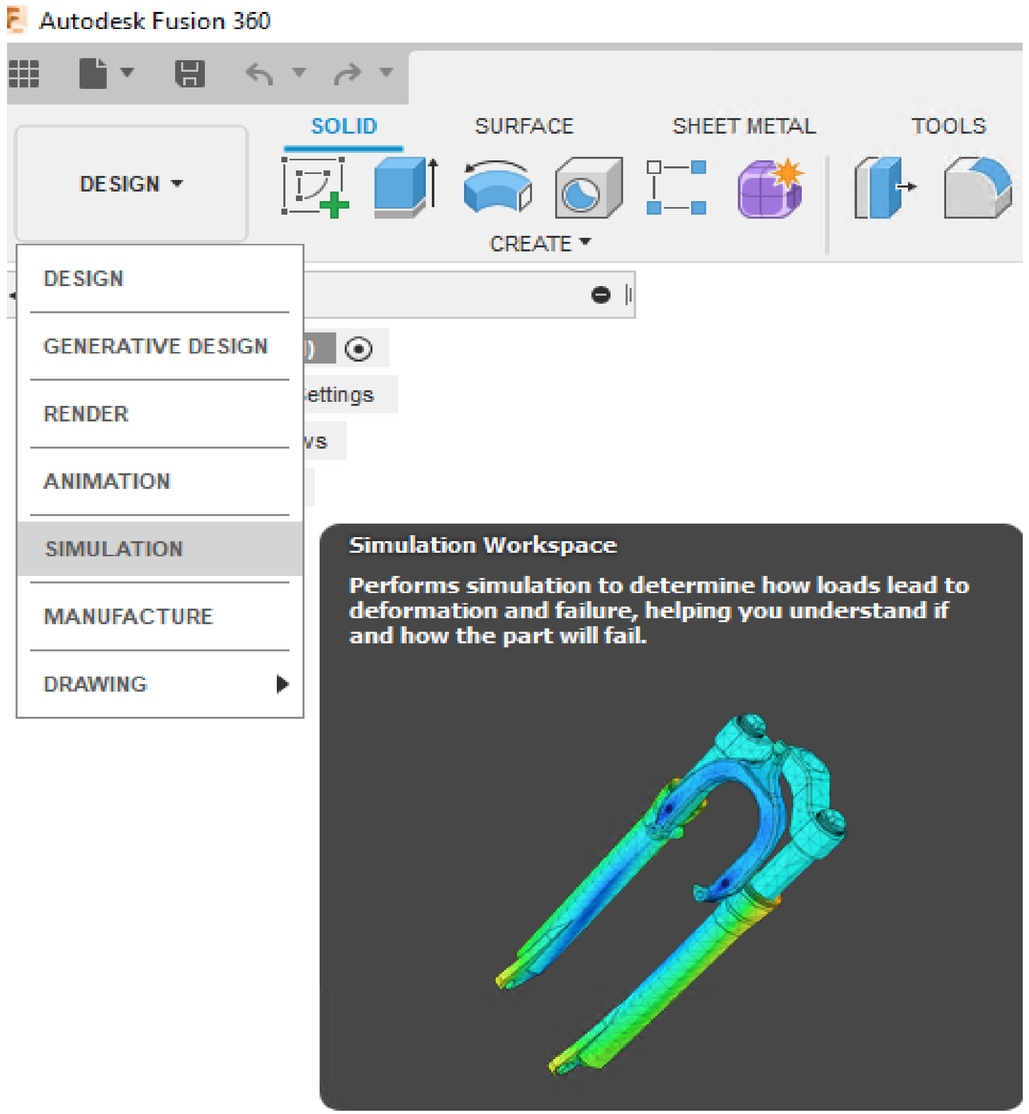
- Tip: In some fillet over fillet/complex fillet cases it is difficult/impossible to remove the fillet. Add Spheres at the intersections of fillet faces and then use **Remove faces** command**.**
- **Demo: Simplify tools**

# Studies

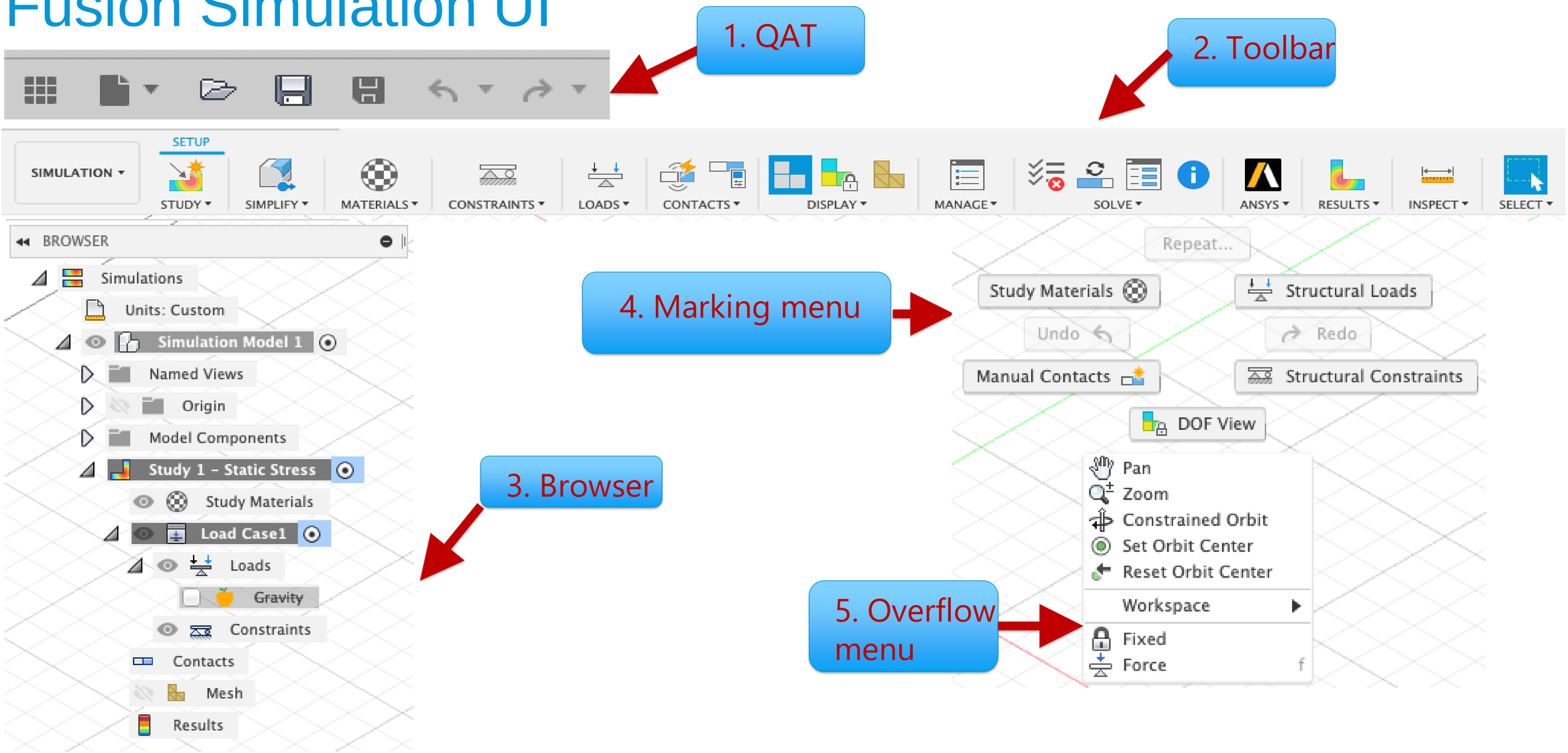


# Sim Workspace

- Integrated
- Fully associative copy of Design
  - Tip: No geometry creation
- Has Compare workspace
- Similar to Generative Design workspace

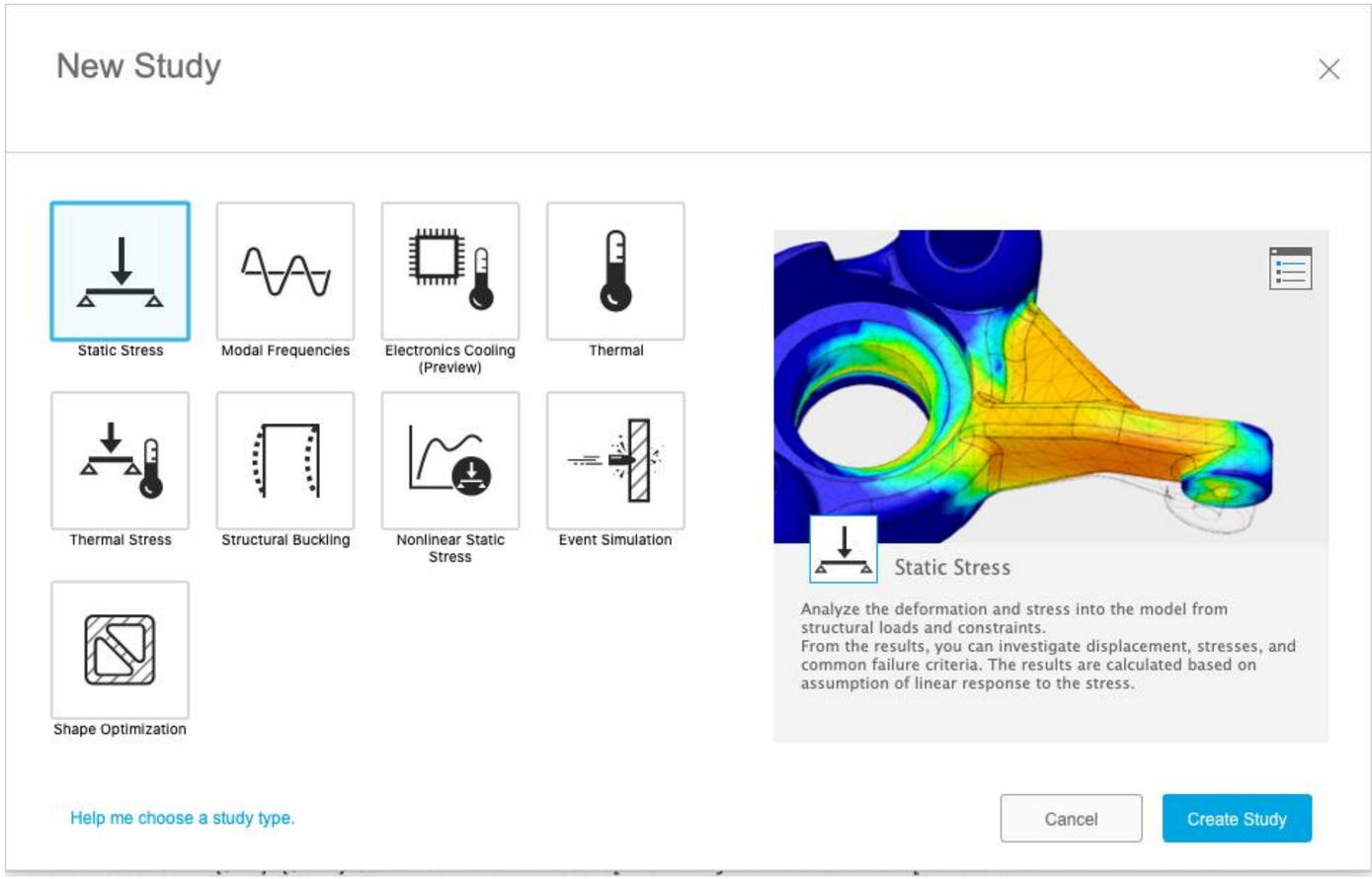


# Fusion Simulation UI



# Study types

- Nine study types
- Help with “Choose a study type” available
- Tip: Create & then Edit. Studies are interchangeable
- Clone, Delete, Properties available
- Tech Preview: E-cooling
- Insider preview: Injection Molding



# Main Study types

## Static stress

Model response to L&C

Small displacement,

Linear response

Local/Cloud

## Modal

Frequency Values (Hz)

Normalized displacement

## Thermal

Temp distribution

Heat flow

Tip: 1 thermal load is must

Local/Cloud

## Shape

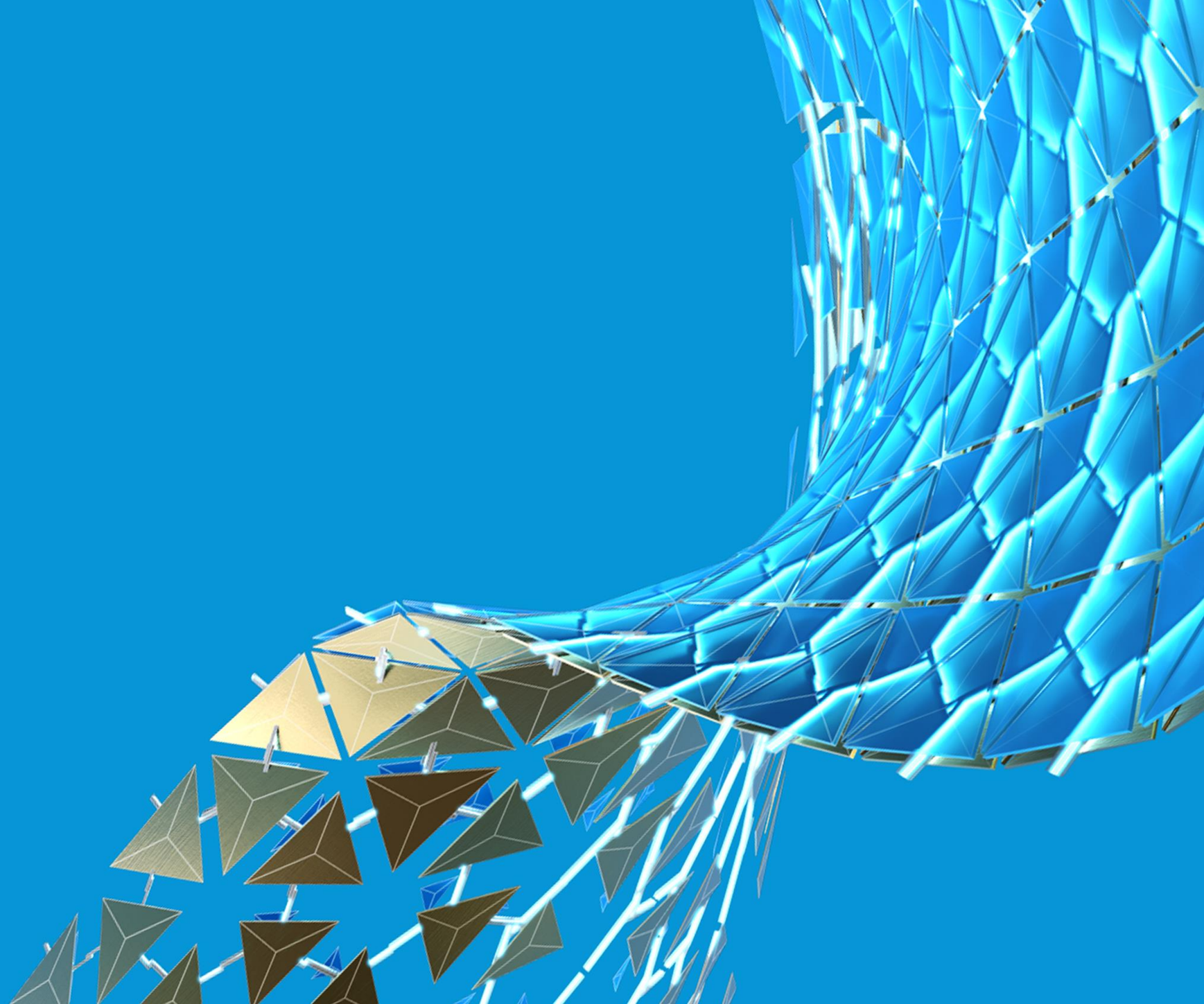
Lightweighting

Stress, displacement objectives

Cloud only

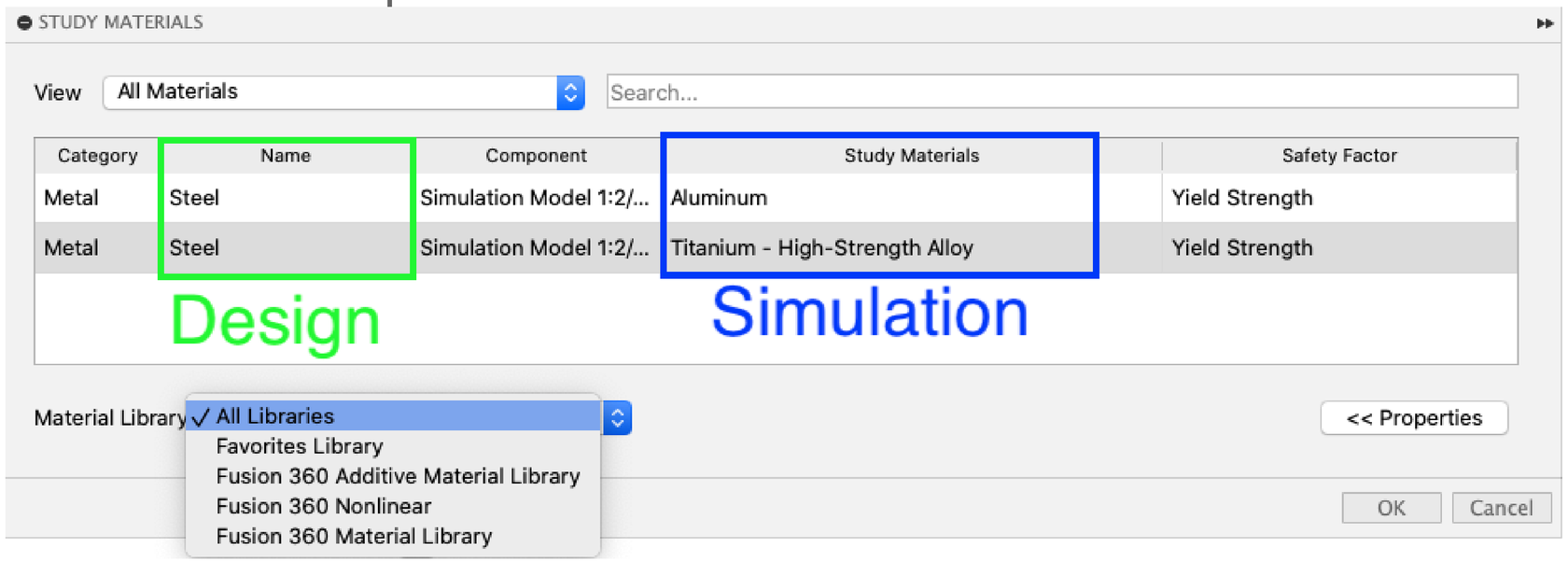
Tip: Use fine mesh size

# Materials



# Physical Materials

- Assign to bodies in Simulation workspace

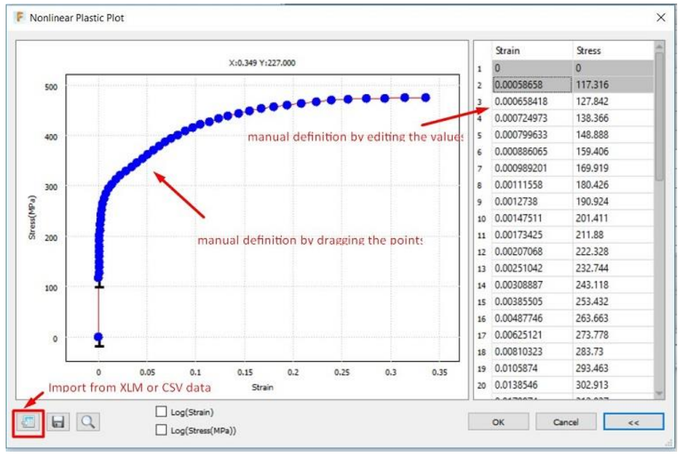


- Material cannot be used for solve
- Value missing or not allowable
- Linear material for Non-Linear solve

# Physical Materials

- Isotropic material properties ✓
- **Custom materials** **(**Example:Steel material A516M Grade 65**)** ✓
- **Orthotropic (Wood)** ☒
- Visco-Elastic (Foam, Shoe insoles) ☒
- Tip: RMB on a material in the browser to access the Study Materials command, all components that use the same material are automatically preselected

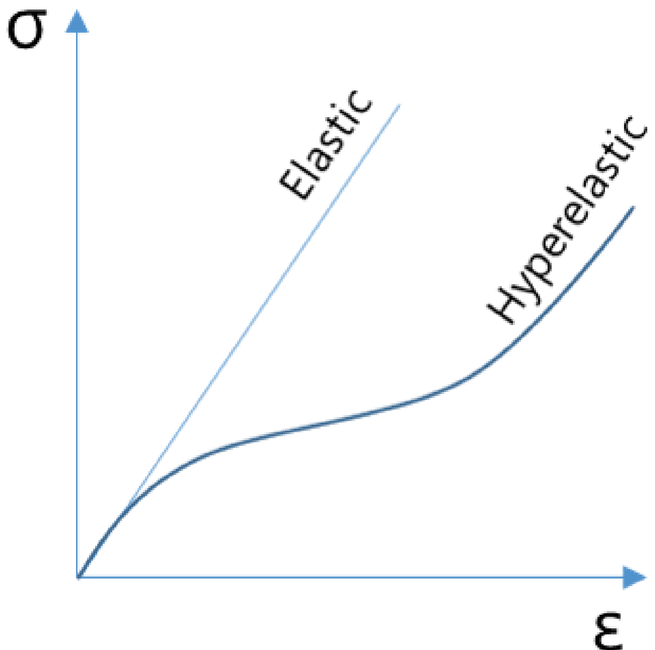
# Advanced Materials



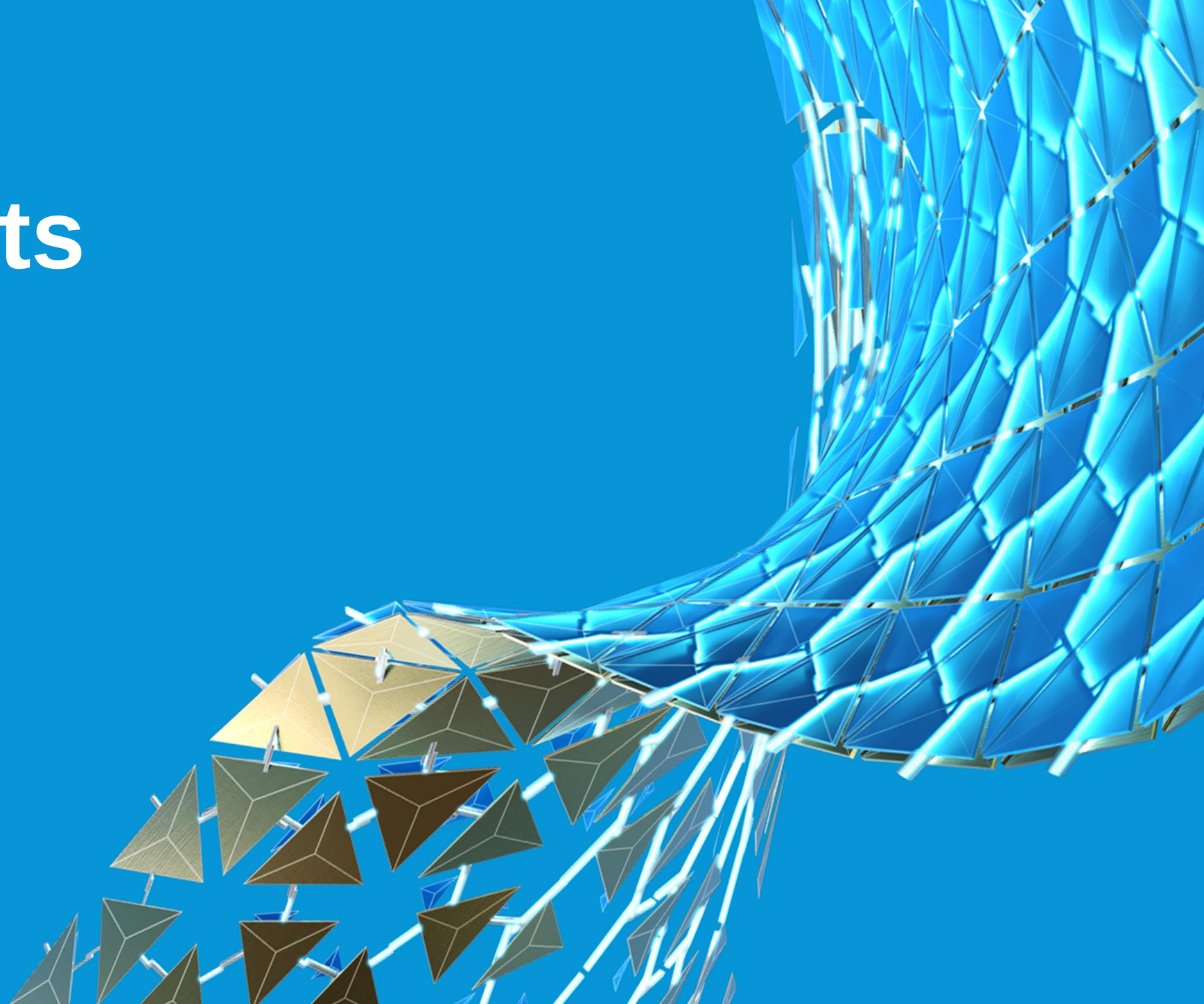

- **You can define a stress-strain curve for a non-linear material.**

  Bring in from MatWeb website.

- **Tip: Ctrl to add rows in Transient Properties plot dialog. Shift to select a bunch of rows**
- Non-Linear
  - Plastic
  - Elastic
  - Elasto-Plastic
- Hyperelastic
- Temperature-dependent
- Additive

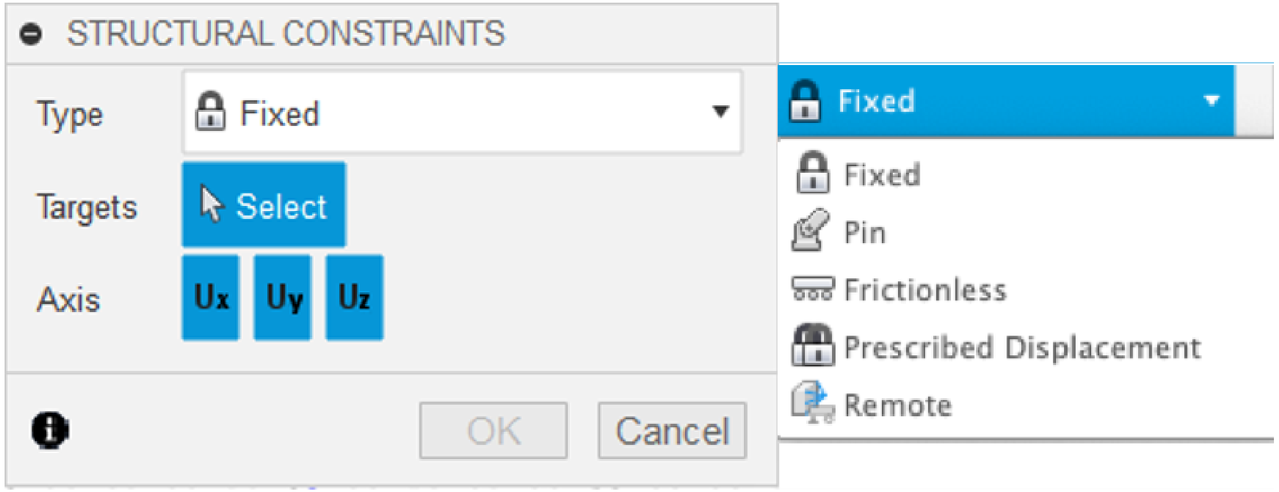


# Constraints



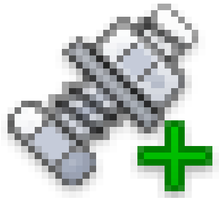
# Constraints

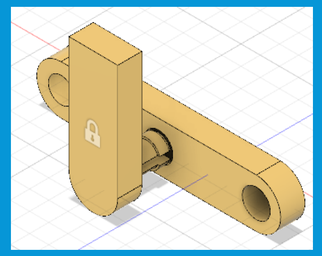
- Goal: Limit translational, rotational motion
- Need at least a few
- Entities: Faces, Edges, Vertices



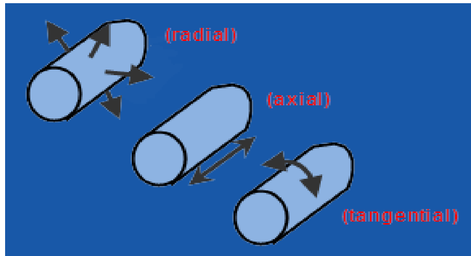

- **Tip: In some situations partially constrain the model and use the Remove rigid body modes option(RMB, Study Settings). Solver will apply an acceleration load to keep model statically stable.**

# Constraint types

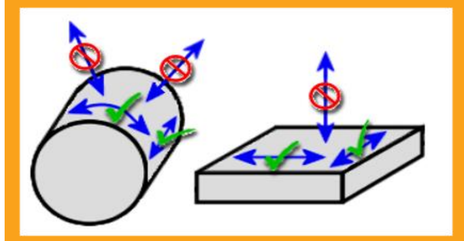




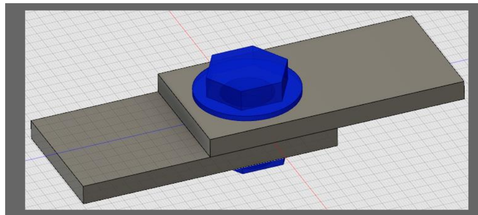
**Fixed**




**Pin**



**Frictionless**



**Connector**

DOF Ux Uy Uz

Unselect to unfix

DOF Radial Axial Tangential

Cylindrical faces

No movement normal

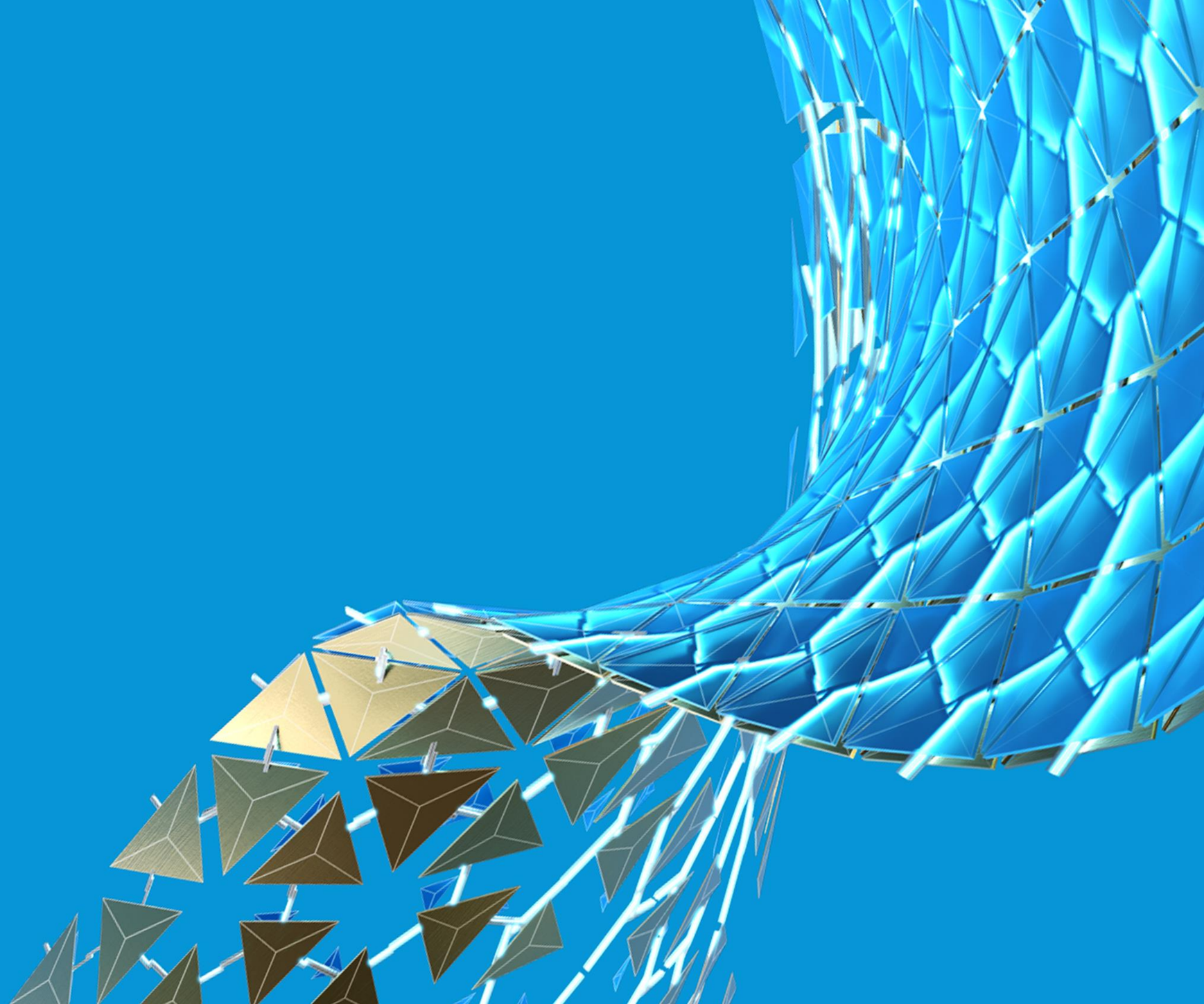
to surface

Bolt

Rigid Body

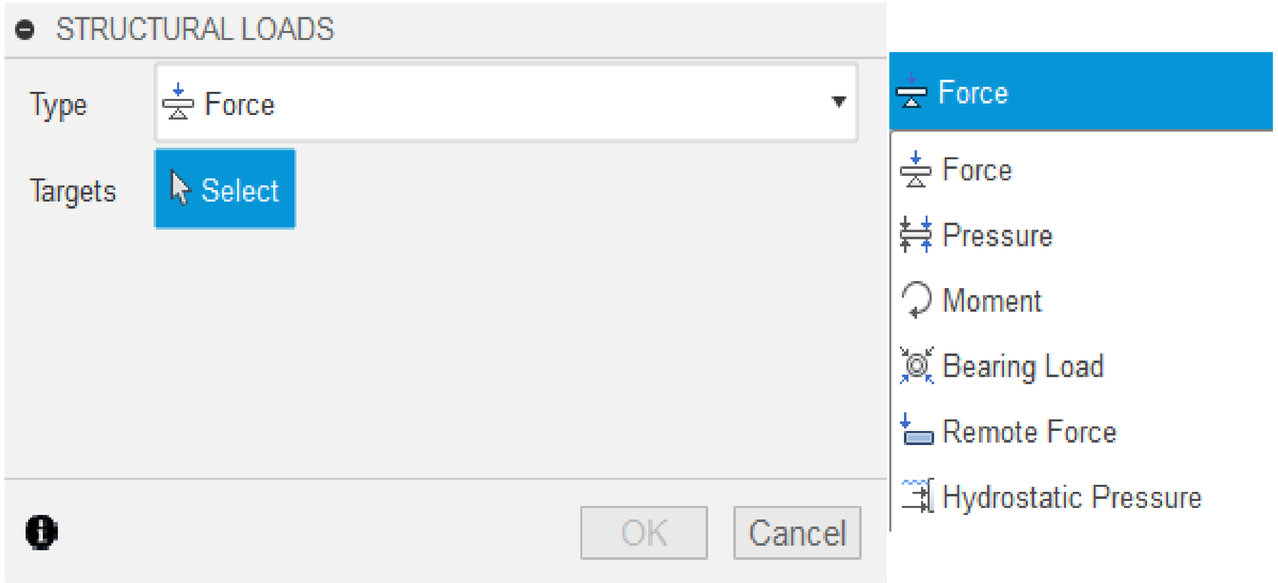
Idealized geometry

# Loads

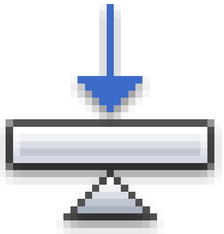


# Loads

- **Goal: Specify load magnitude and type accurately causes displacements**



# Main Load types



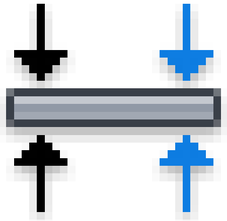
## Force

Normal/Any direction

Limit target

Force per entity

Multiple entities

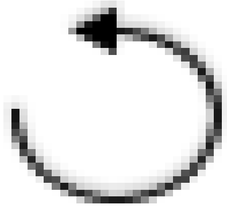


## Pressure

Uniformly distributed

Always Normal

Multiple entities

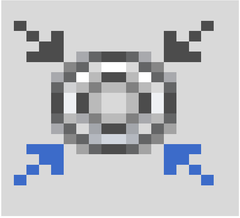


## Moment

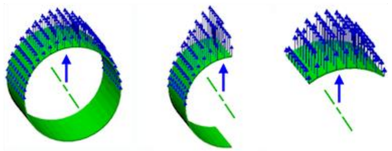
Centroid of faces

Axis passes centroid

Multiple entities

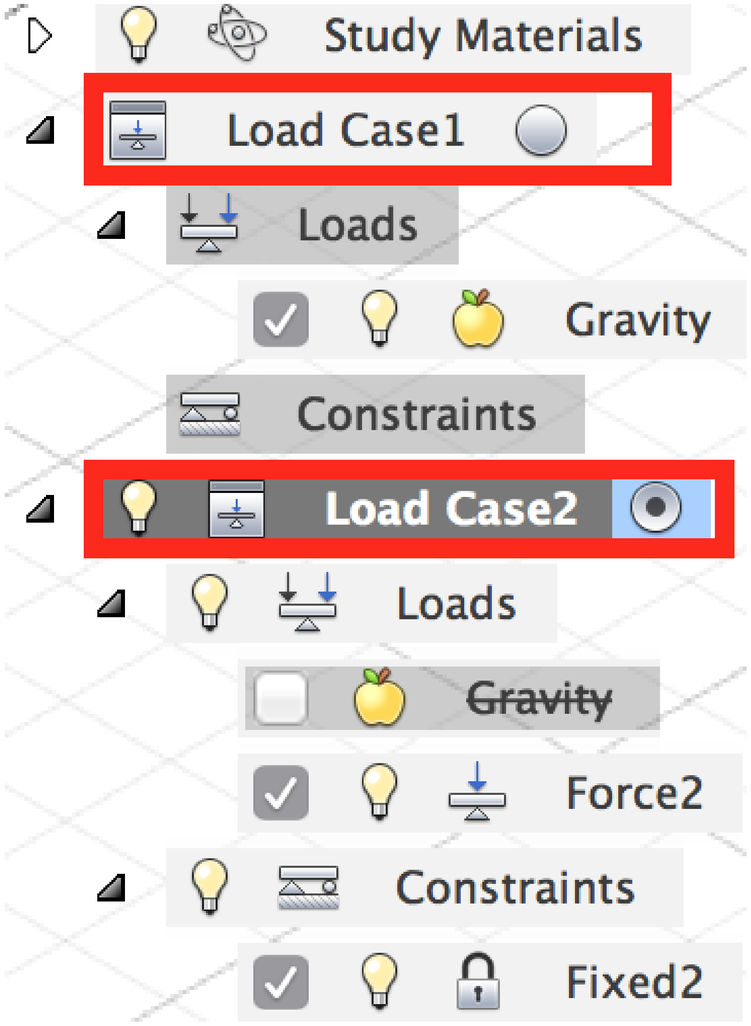


## Bearing

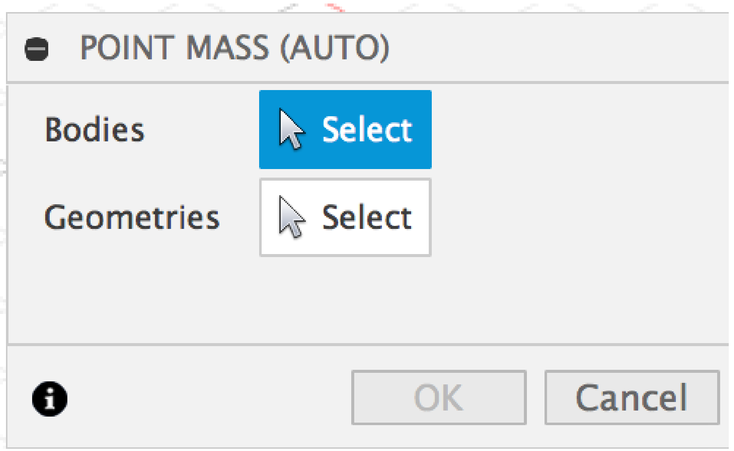


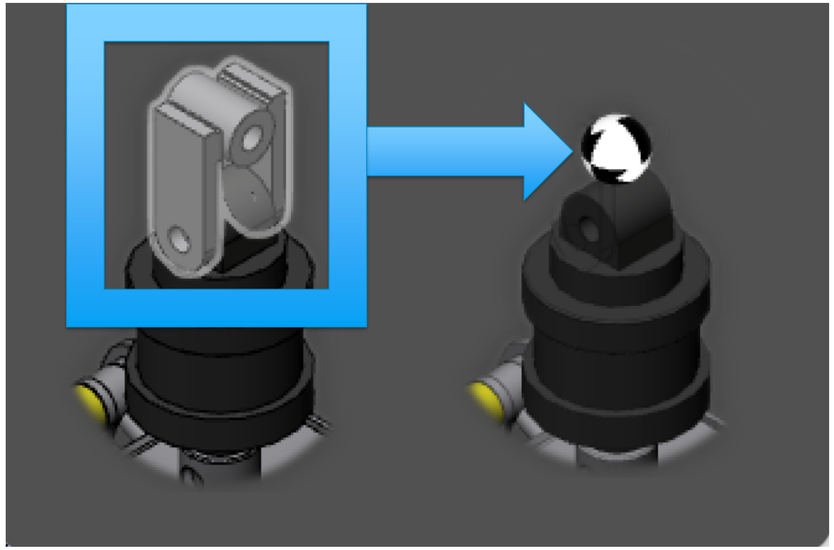
# Load Cases

- **Load Case 1: Weight of rider**
- **Load Case 2: Accelerating/Braking**
- **Load Case 3: Cornering forces**
- **Not unique to a load case**
  - Removed components
  - Materials
  - Contacts
  - Mesh settings
  - Local mesh control
  - Tip: Double-click activates a load case. Cannot have 0 LCs



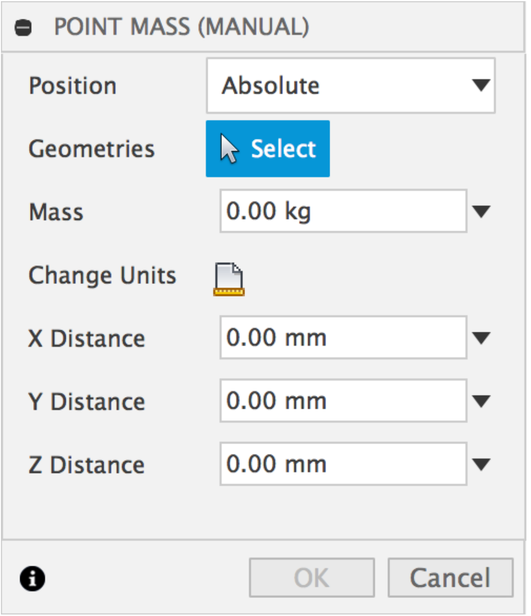
# Point Masses - Auto

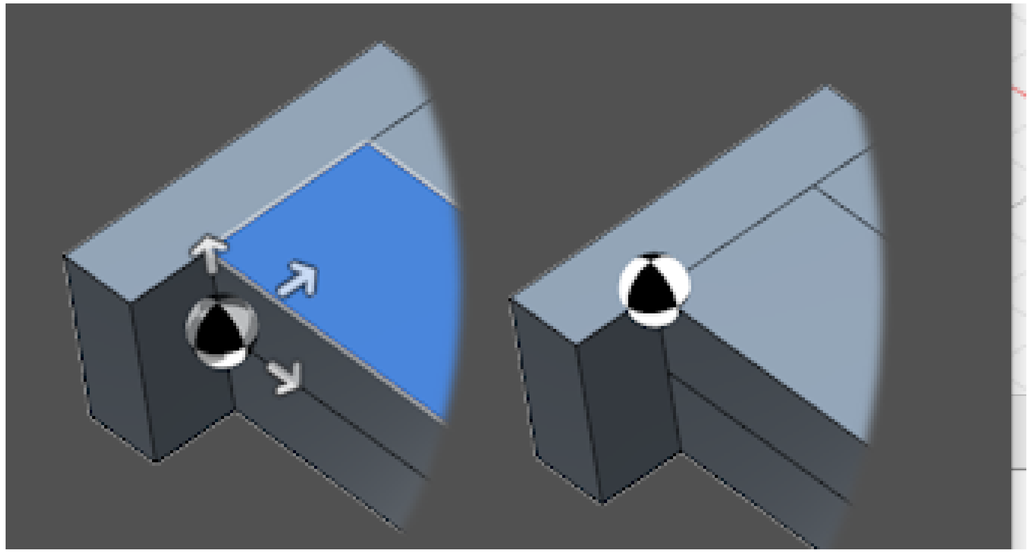


- Idealize geometry
- Reduces file size, element count and processing time
- Selected solid bodies will be suppressed

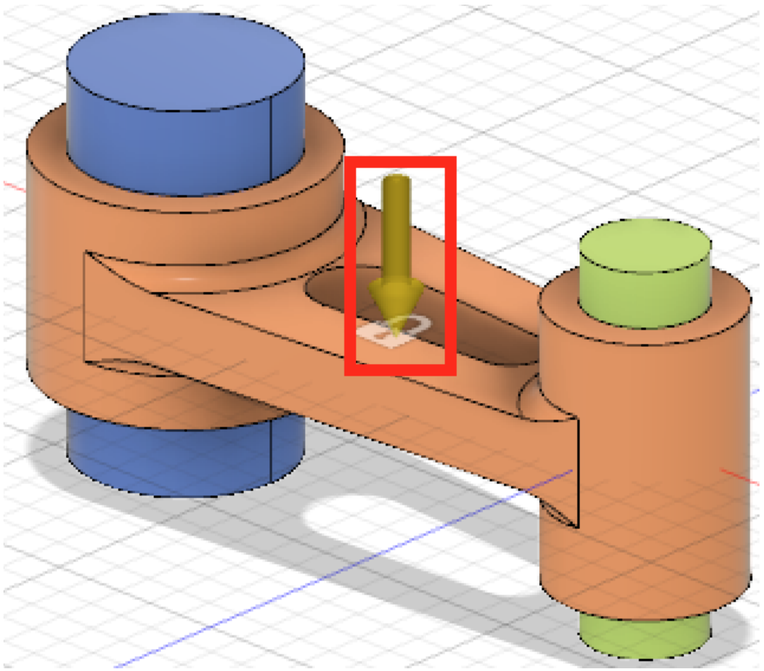
# Point Masses - Manual



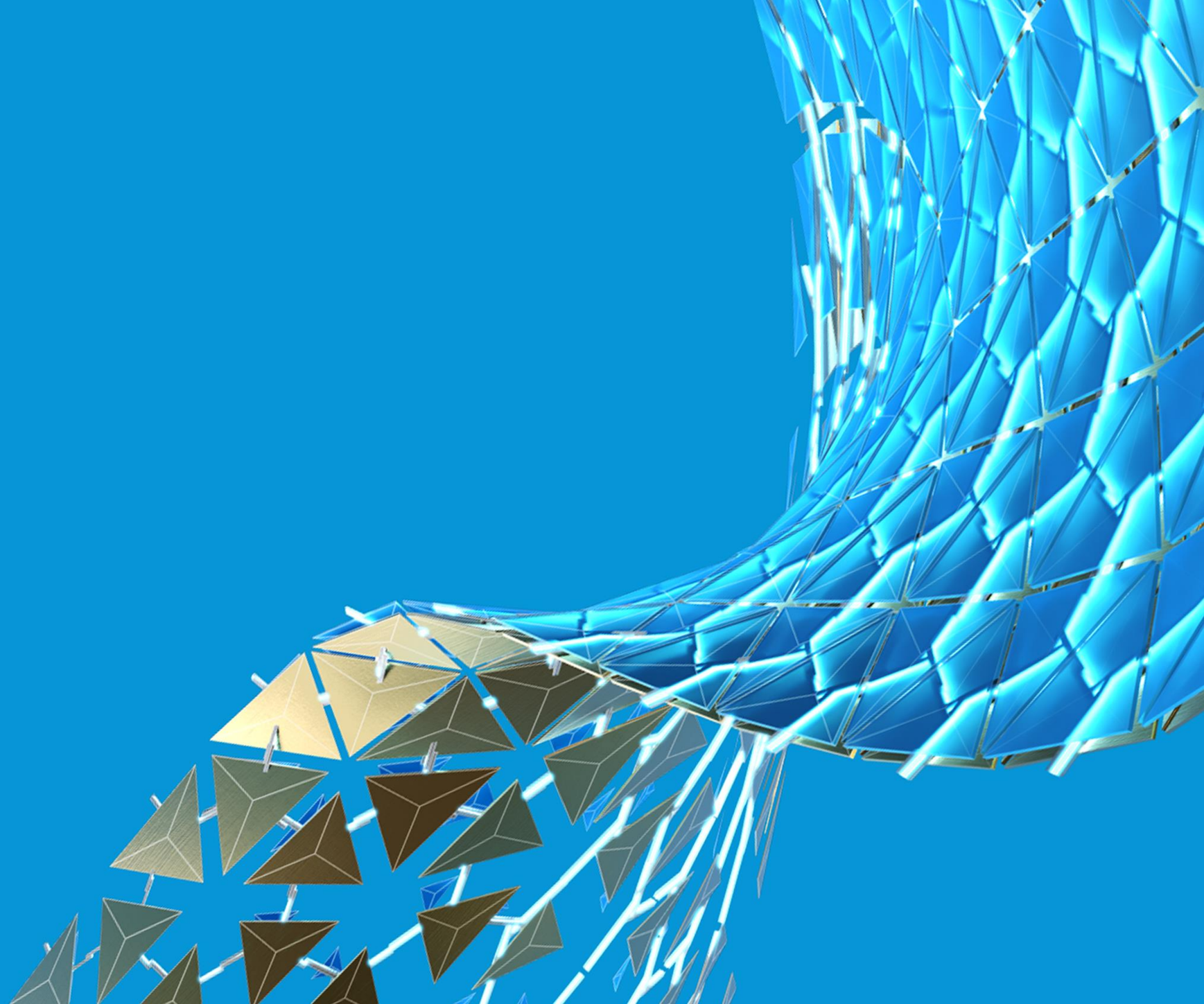
- No geometry needed. Specify point for centroid.
- **Tip: Which input field corresponds to which offset direction? Drag a manipulator arrow. Then, notice which Distance field has a changing value while you are dragging the arrow.**

# Gravity



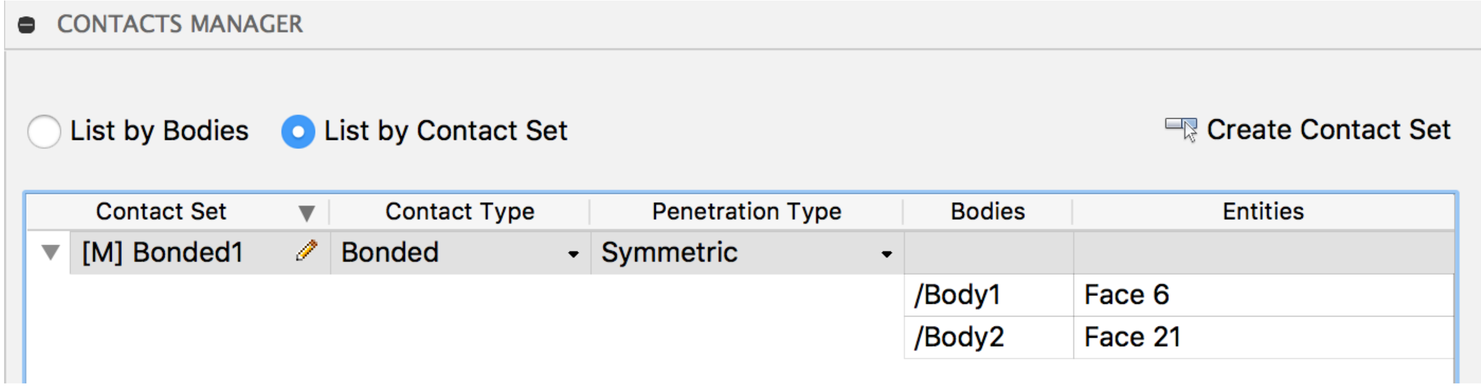
- Global load, affects point masses
- ON/OFF
- Gravity direction
  - Face: Normal
  - Edge: Average vector of normal vectors @ edge
  - Tip: When you apply a Hydrostatic Pressure load to any face of the model, the program automatically activates gravity. The direction of gravity controls the direction of increasing pressure for this type of load.

# Contacts



# Contacts

- Specify how 2 bodies are connected
- Has no relation to joints in assembly




- Use Contacts, Manage Contacts to edit contacts

# Contact types

## Bonded

Welded

Offset allowed

## Separation

No penetration

Partial or full separation

Slide freely

## Sliding

No penetration

No separation

Sliding allowed

## Rough

No penetration

Partial or full separation

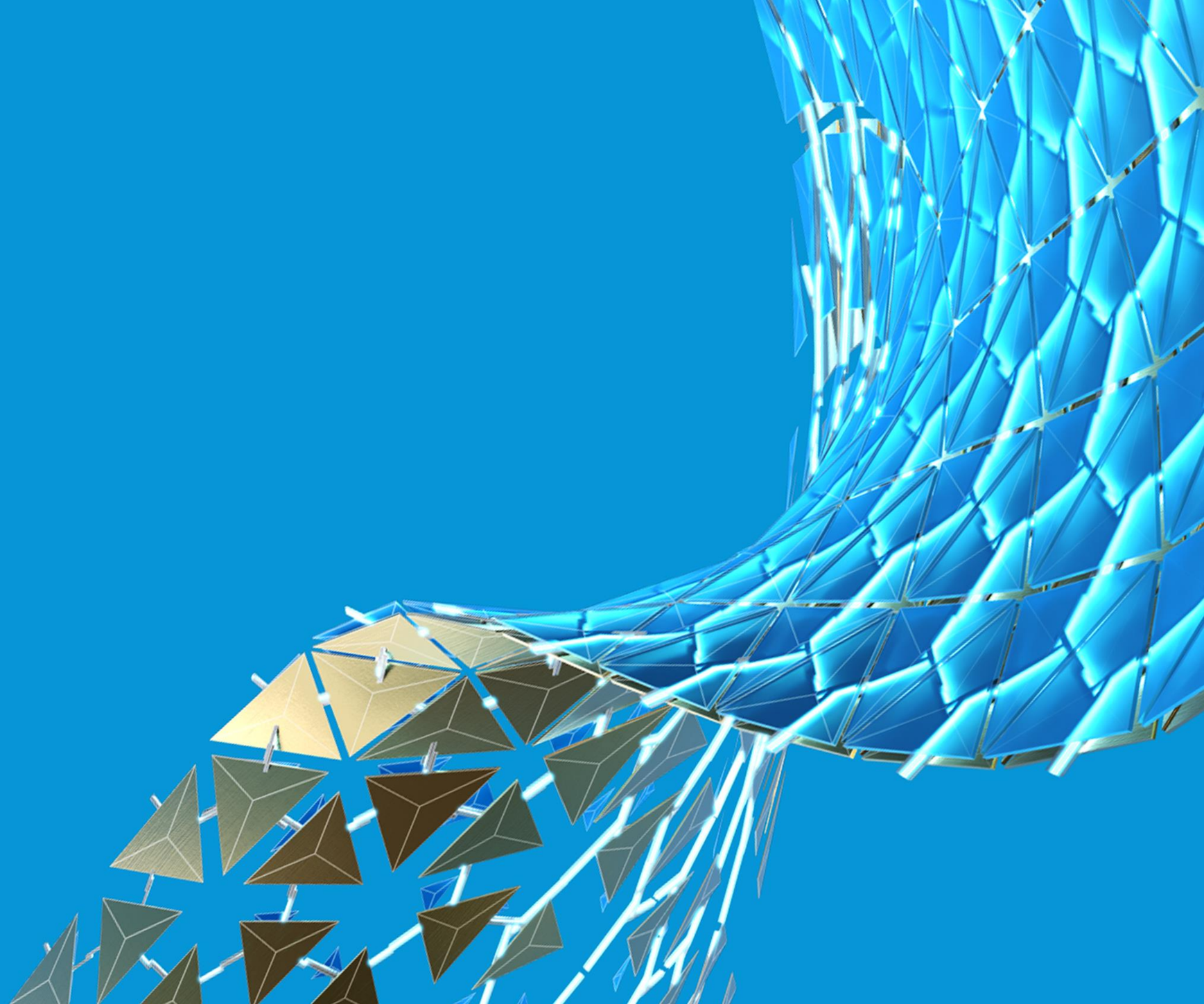
No sliding

Supports friction-coefficient

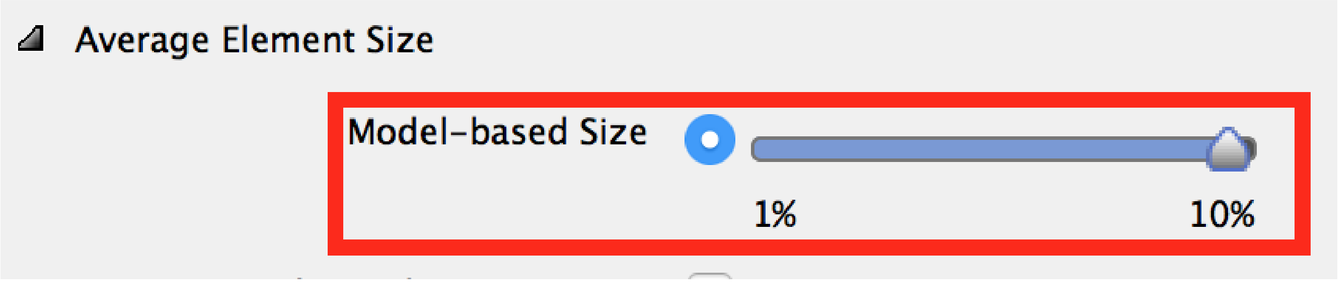
# Contacts

| Type | What | Penetration | DOF of 2 entities | Separation | Frictionless (Mu) | Sliding | Other |
|---|---|---|---|---|---|---|---|
| **Bonded** | "welded together“. | No | Same | No | No | No | Treated as single body. Same equal deformation for adjacent nodes |
| **Separation** | Separates and slides | No | Separate | In normal direction | Yes | Yes, in tangential direction | Tip: Further constraints may be required to modify the DOF’s for each body. |
| **Sliding** | No separation between parts | No | Separate | No | Yes | Yes, in tangential direction | |
| **Rough** | Similar to separation but no sliding | No | Separate | No gaps or separations | Yes/Defined | No | |

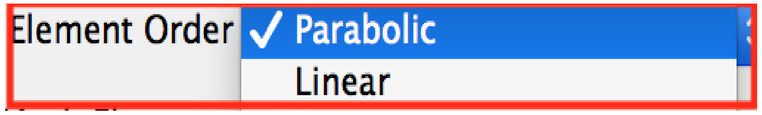
# Meshing



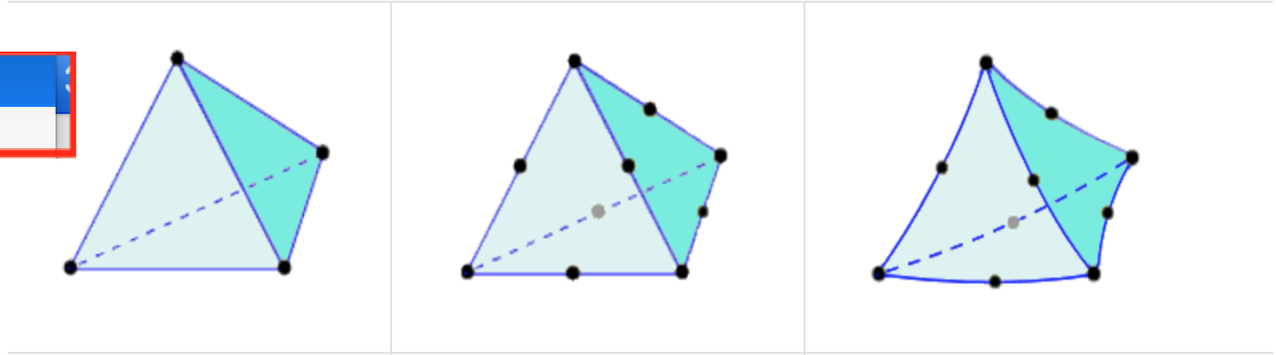
# Mesh quality




- How large is your mesh element? Tip: For Shape Optimization use a small mesh size to get reasonable results.

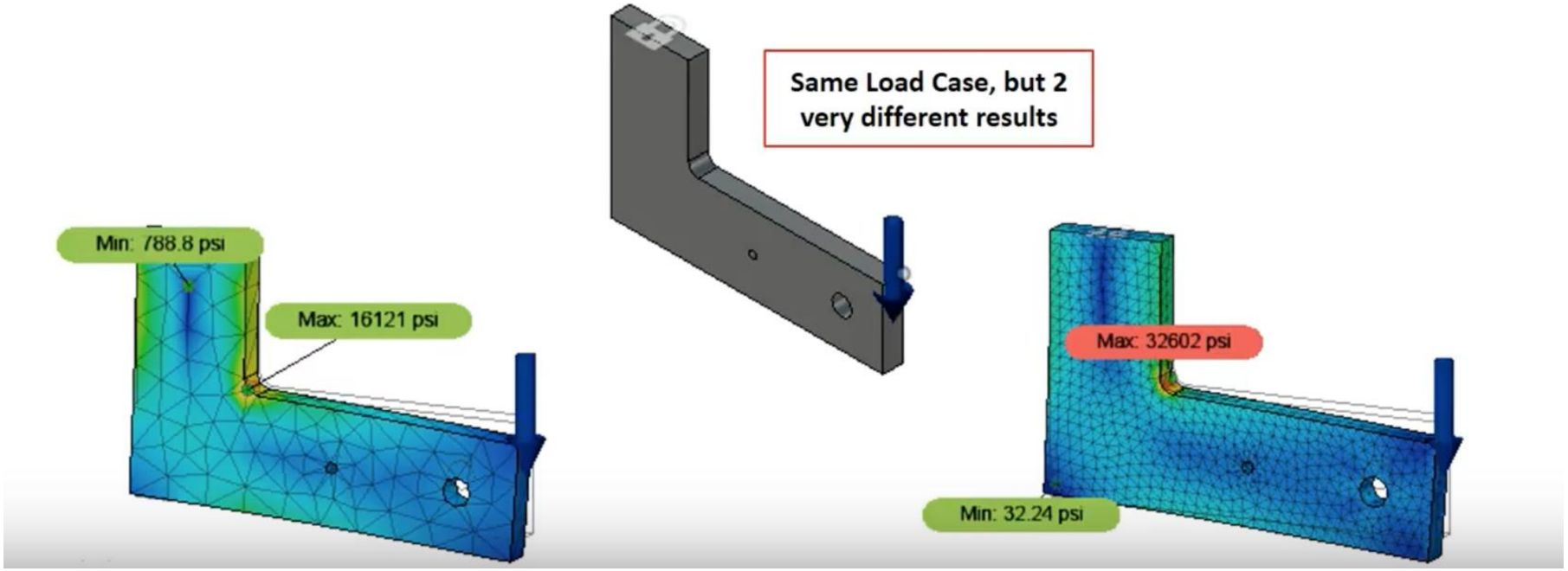



- Linear:
- Parabolic:



| Linear Tetrahedron (4 Nodes) | Parabolic Tetrahedron (10 Nodes) | Parabolic Tetrahedron with Curved Edges (10 Nodes) |
|---|---|---|

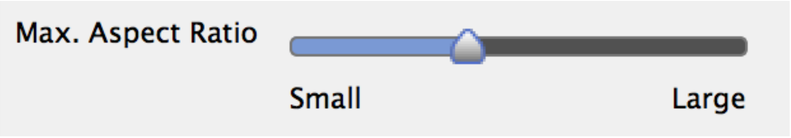
# Mesh Settings

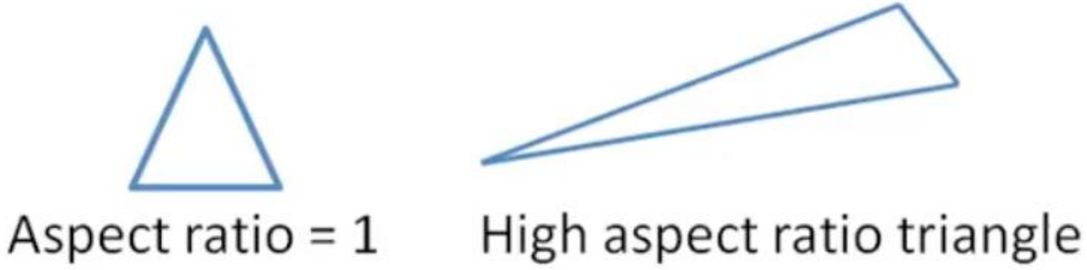



- **Tip: Good mesh extremely important for good results.**

# Mesh Settings

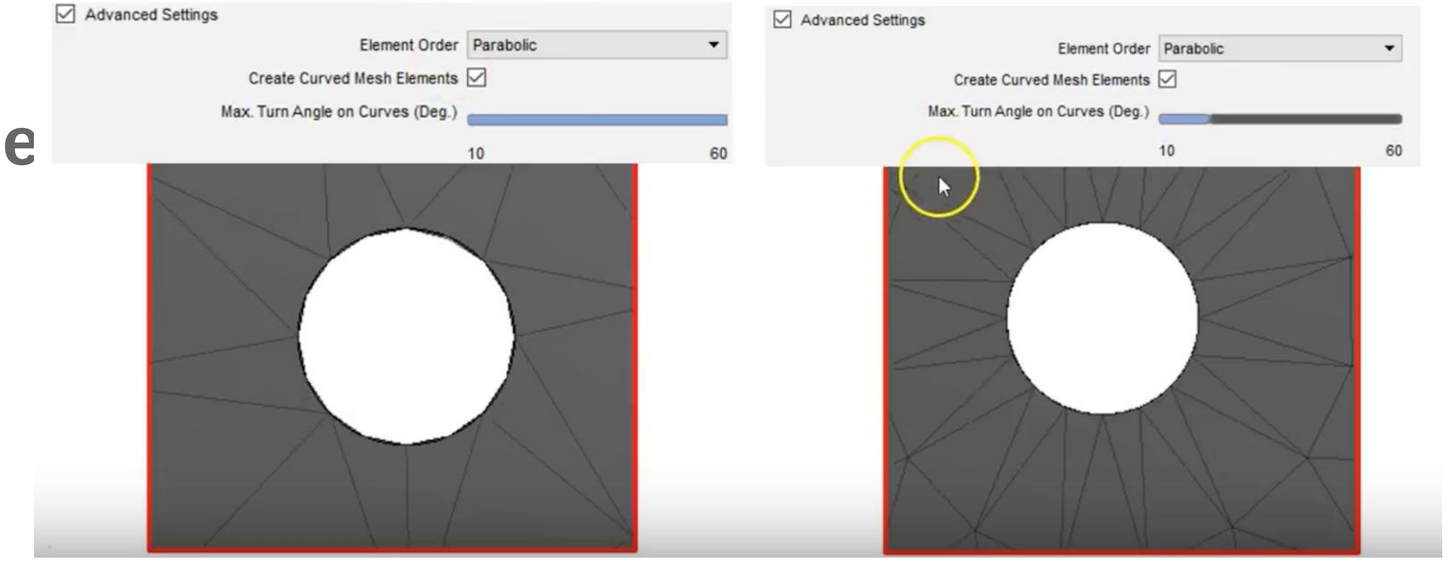
- **Aspect ratio**



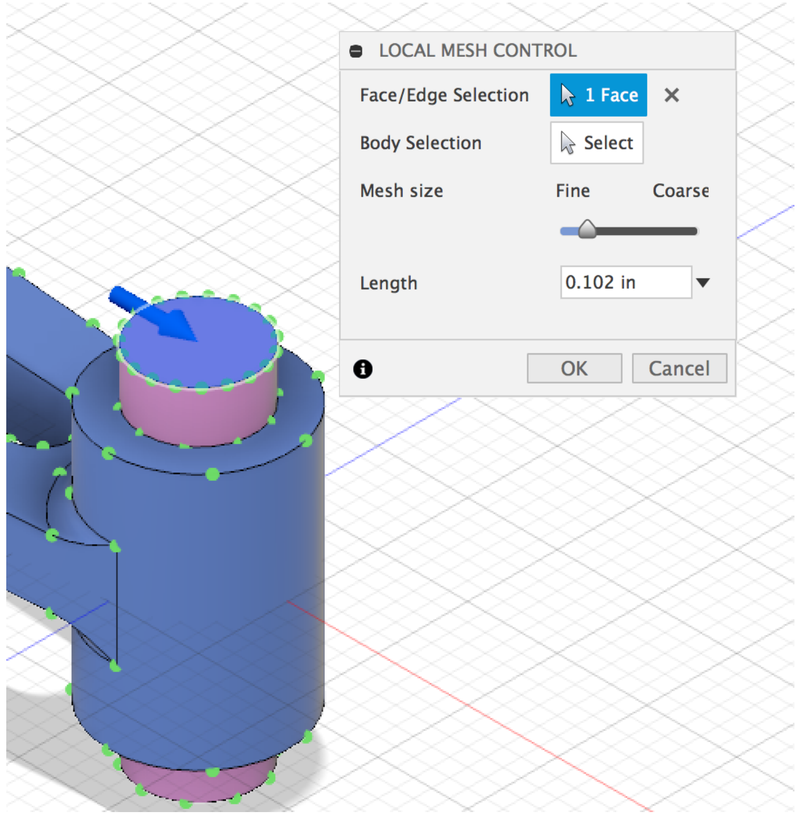

- **Maximum turn angle**
- **Tip:** Lower the turn

**angle smoother the circle**



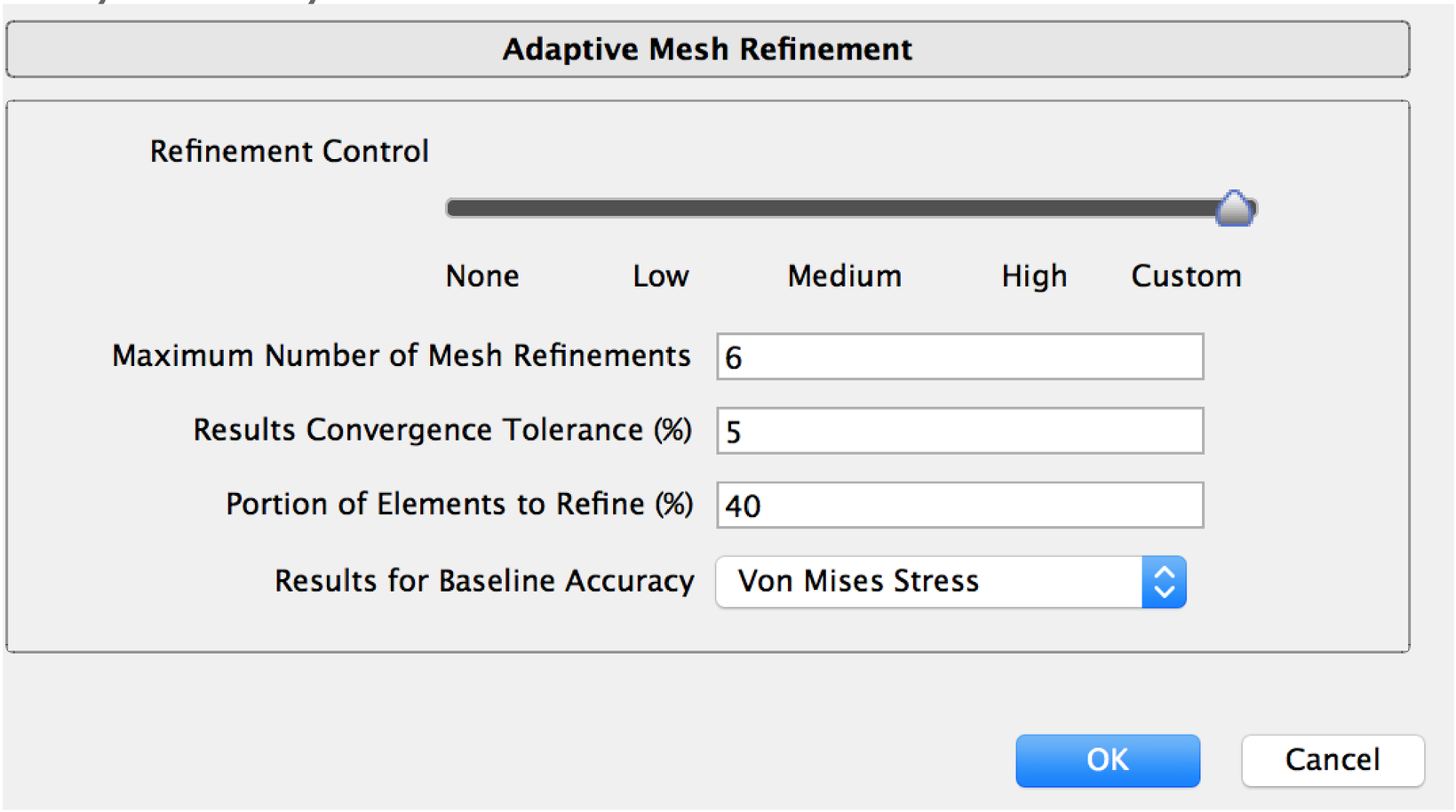
# Local Mesh control

- Manual mesh refinement in localized regions
- Faces, edges or bodies
- Adaptive mesh refinement
- Finer than overall mesh



# Adaptive Mesh refinement

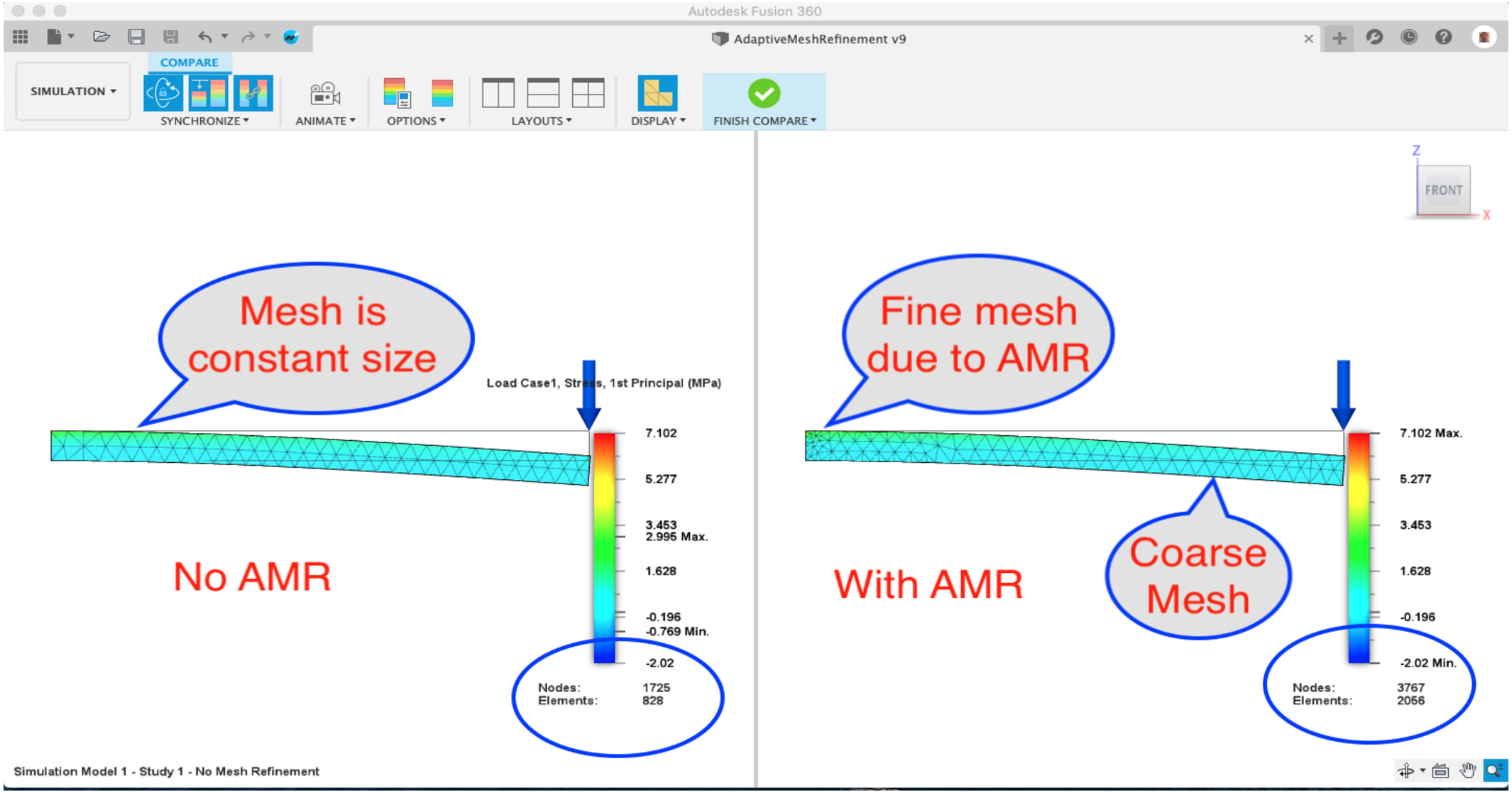
- **Static, Modal, Thermal and Thermal Stress**

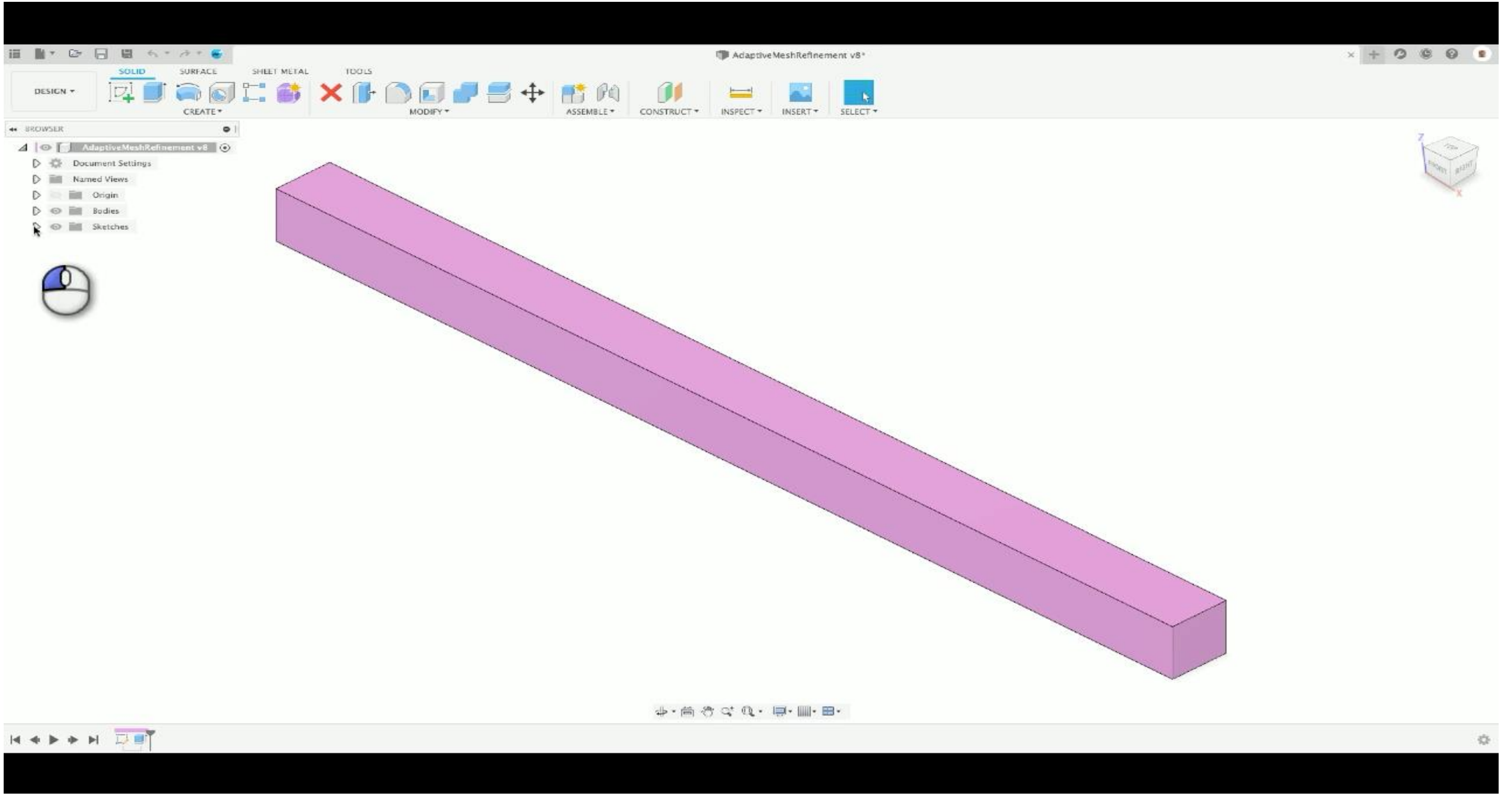


# Adaptive Mesh refinement

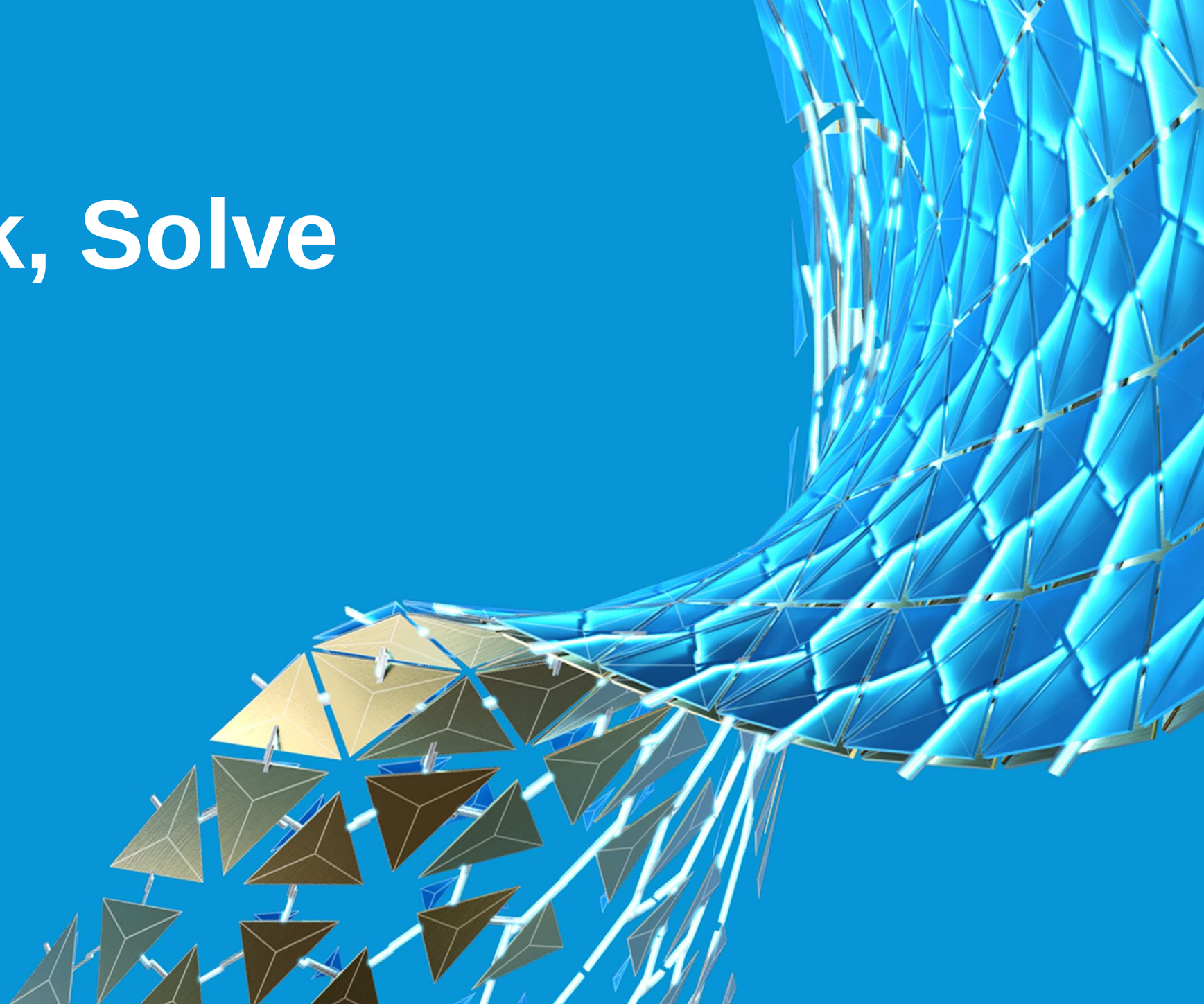
- Maximum # of mesh refinements Tip: <3 gives good results
- Results Convergence Tolerance:% change between 2 iterations <= tolerance it stops (3%)
- Portion of elements to refine(%)
  - X%: Top X% w.r.t critical result are refined
- Frequency Mode: Modal frequencies only. Basis for refinement

# Adaptive mesh refinement demo




AdaptiveMeshRefinement v8*
DESIGN
SOLID
SURFACE
SHEET METAL
TOOLS
CREATE
MODIFY
ASSEMBLE
CONSTRUCT
INSPECT
INSERT
SELECT
BROWSER
AdaptiveMeshRefinement v8
Document Settings
Named Views
Origin
Bodies
Sketches

# Pre-Check, Solve



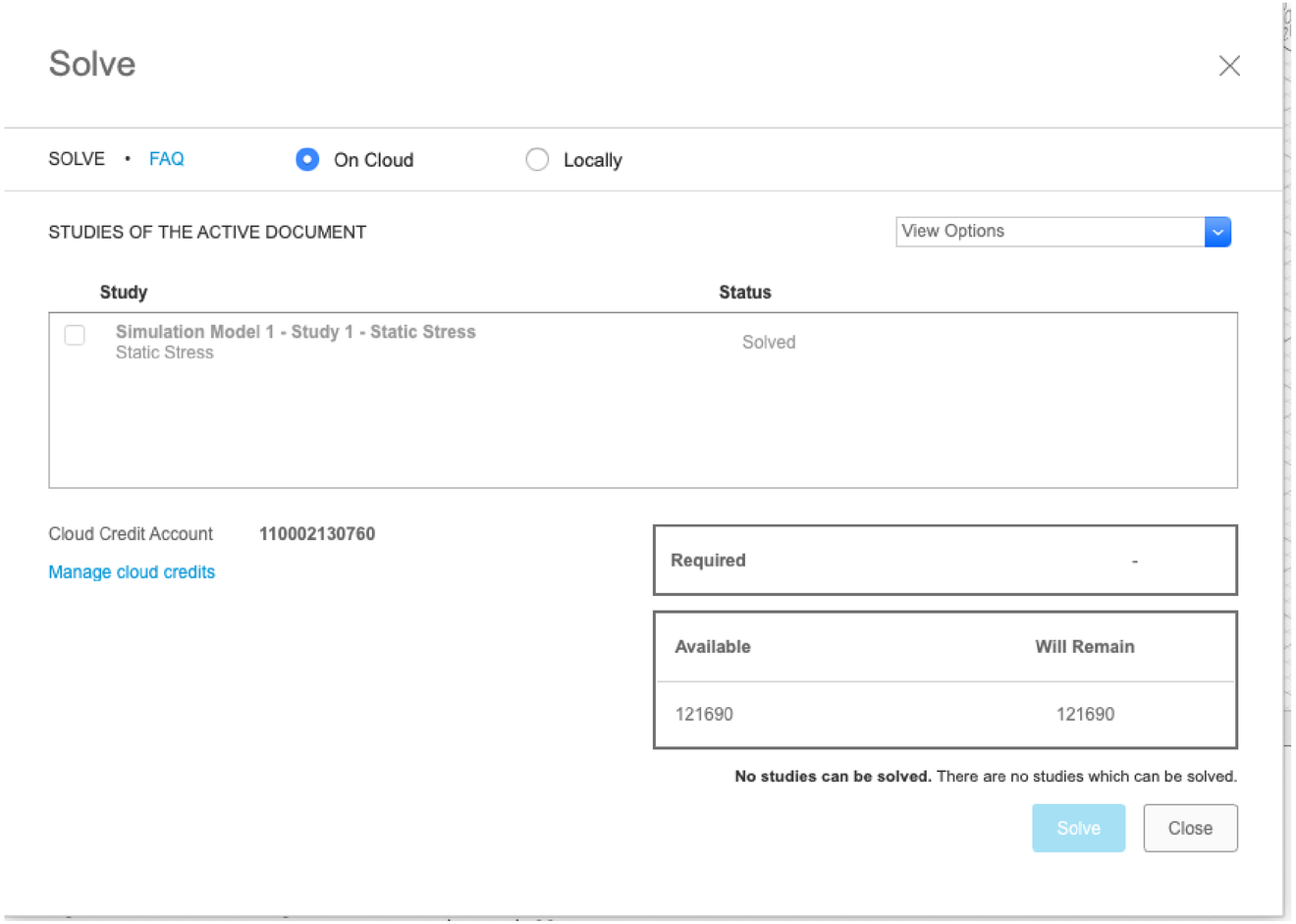
# Pre-Check

| Icon | What it means | Study can be solved? | Examples |
|---|---|---|---|
| | Serious issues, missing inputs. | No | Missing loads, constraints, materials |
| | Potential issues. Solve may issue warnings | Yes | Unconstrained fully |
| | All inputs are supplied | Yes | Tip: Desired state |

**Tip: Error v/s Warning: Missing loads v/s using linear material for non-linear analysis**

# Solve dialog

- Local only 1 study. Synchronous
- Cloud: Multiple. Asynchronous
- Studies that cannot be solved can be hidden




- Tip: Even though you solve locally, your results are automatically uploaded to cloud after the solve.
- Tip: You can share results with anyone

# Cloud Credits

**Preferences for cloud credits usage**

**What are cloud credits?**

Autodesk cloud credits are pay-as-you-go currency units that let you access cloud services in Fusion 360.
For more information, see Cloud credits in Fusion 360.

**How many cloud credits do I have?**

The table below lists the balances for the cloud credit accounts available to you.

| Contract | Balance | Credit type | |
|---|---|---|---|
| 110002130760 | 121690 | Shared | Buy credits \| History |
| 201401141801584 | 0 | Individual | Buy credits \| History |

**How do I use my cloud credits?**

Choose the default contract balance to use for each task listed below.

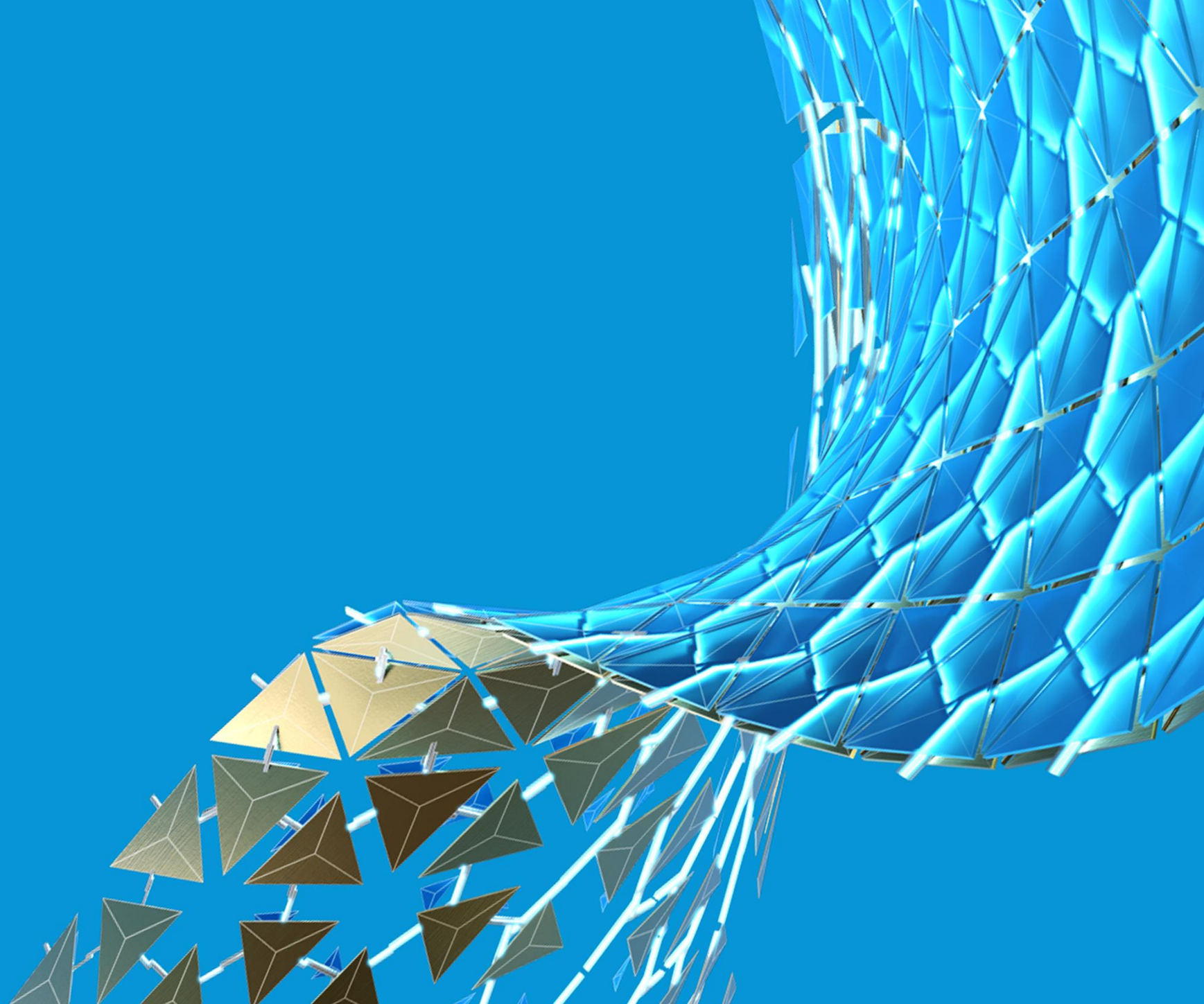
| Task | Contract to use |
|---|---|
| Simulation tasks | 110002130760 |
| Generative Design tasks | 110002130760 |

☑ Show balances in dialogs for tasks requiring cloud credits

It enables you to preview cloud credit balances by inserting a cost and balance calculation in these dialogs.

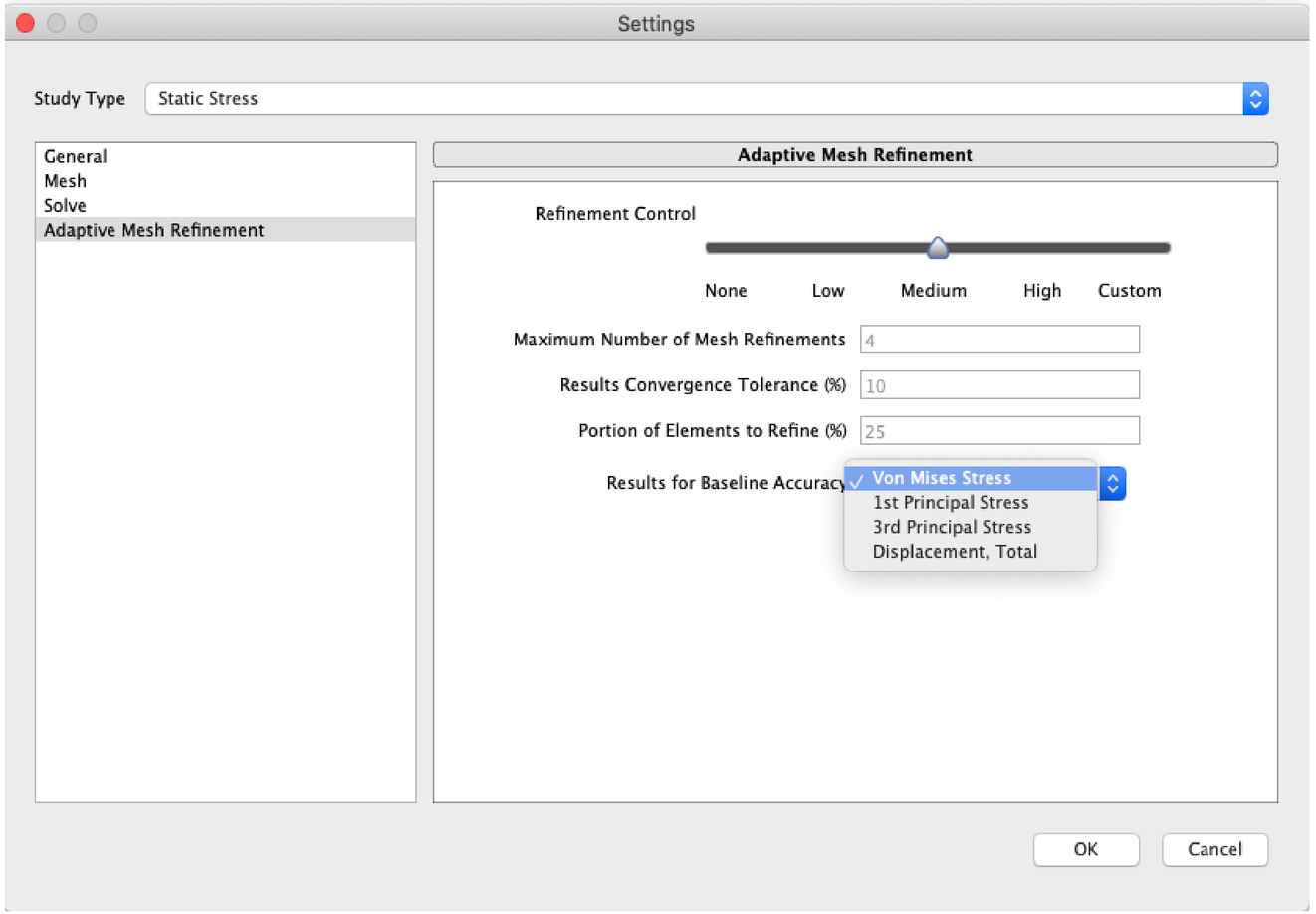
Tip: No CC charged for cancelled solves. You can only cancel 1 job at a time.

# Results



# Results for baseline accuracy

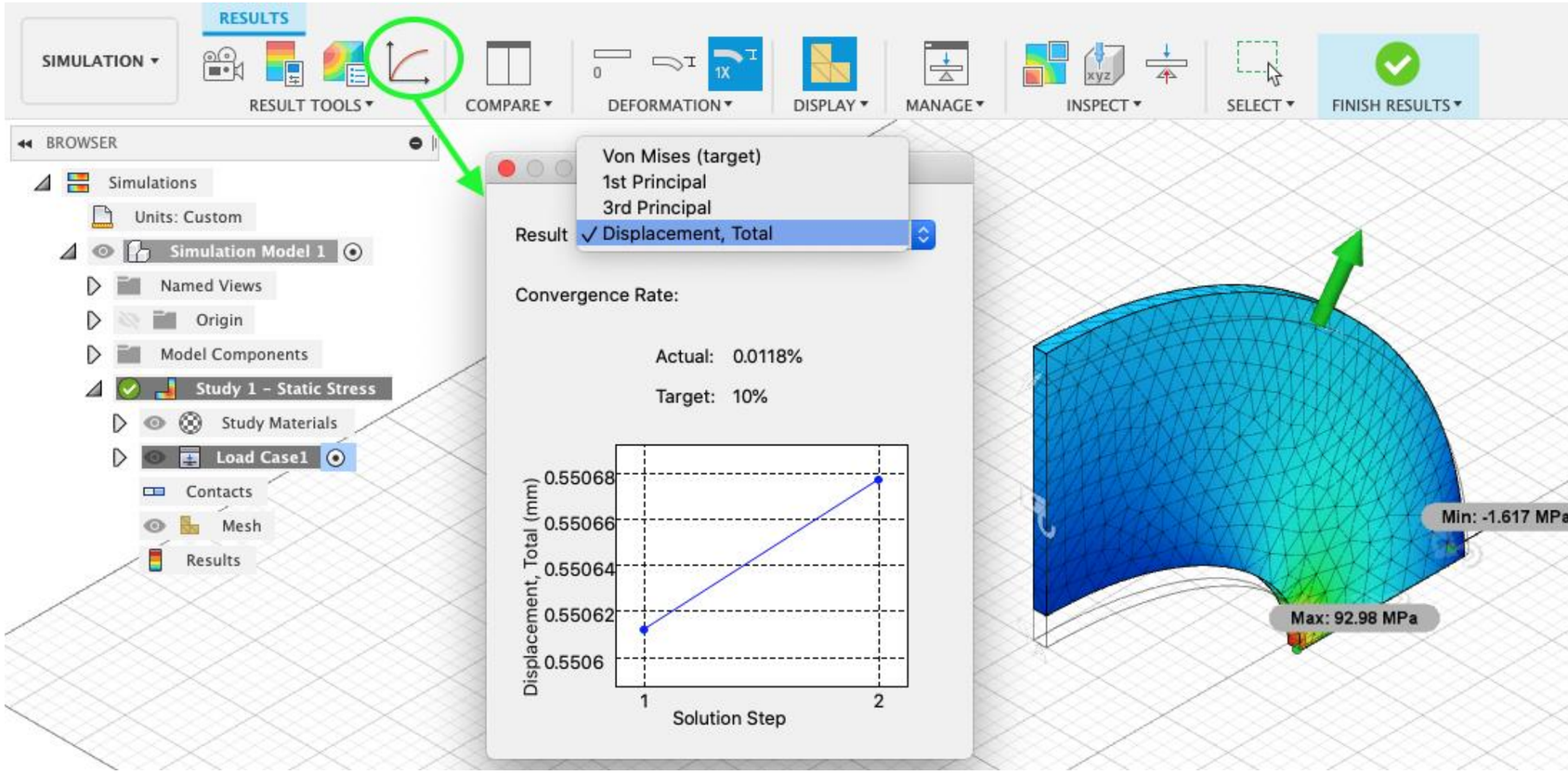
- **Static Stress**
  - Von Mises
  - 1st principal
  - 3rd principal
  - Displacement, total
- **Thermal**
  - Heat flux, temperature
- **Thermal stress: All previously listed**




- **Tip:** **You can specify the desired result on which to base the convergence test regardless of whether you are using a refinement preset or custom settings. Use displacement for faster analysis**

# Results

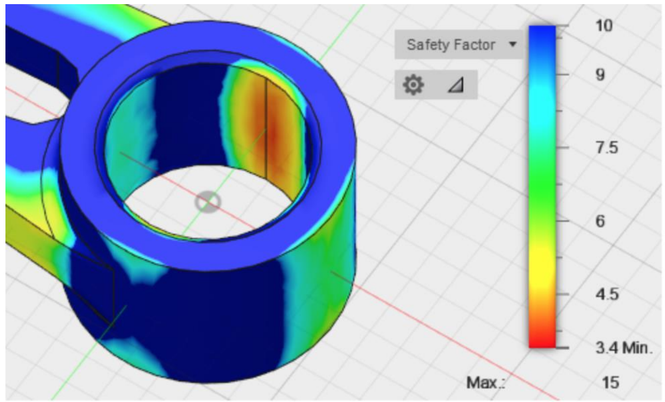
- 3D graphical results
- Legend
- Result type
- Units
- Convergence plot



# Result types

| Study type | Result type |
|---|---|
| Linear Static Stress, Non-Linear, Thermal Stress, Explicit | Safety Factor, Stress, Displacement, Reaction Force Reaction Moment, Strain |
| Thermal, Thermal Stress | Temperature, Heat Flux, Thermal Gradient, Applied Heat Flow |
| Modal Frequencies | Total Modal Displacement, Modal Displacement X, Modal Displacement Y, Modal Displacement Z (Normalized) |
| Shape Optimization | Load path criticality |
| Structural buckling | Total Displacement, Displacement X, Displacement Y, Displacement Z (Normalized), Critical Load Factor |

# Results: Safety factor



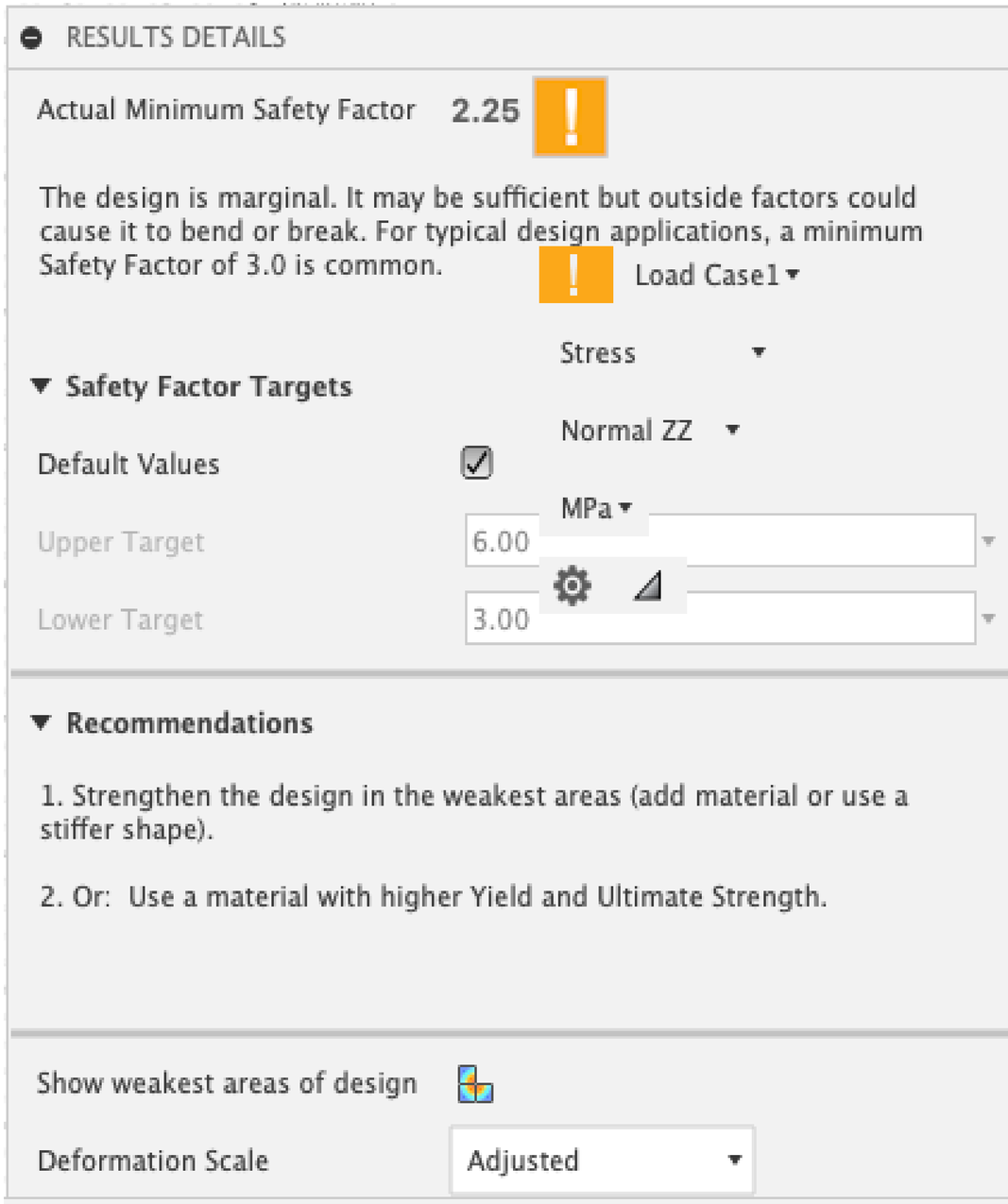

- Safety factor is the default result
- For example NASA® (aerospace industry) and the pressure vessel and crane industries have strict guidelines for design safety factors.
- Tip: A safety factor of <=1.0 means it will fail and not good. For example, an elevator should be designed using higher safety factors than a bracket used to mount a camera.
- Safety Factor = Material Strength / Actual Stress

# Results: Contact Pressure

- **Tip: Contact Pressure results are generated only where Separation contact is defined between two adjacent parts of a model. Contact pressure results are not computed for any other contact type (such as Bonded, Rough, or Sliding).**

# Result details

| Icon | Indicator | Issue? | Action |
|---|---|---|---|
| | Insufficient | Bends/breaks. | Material > YS<br>Reinforce weaker areas<br>NLSS for bending |
| | Marginal | Transitional area | Investigate SF<br>Mesh convergence |
| | Sufficient | Good | Run other studies<br>Slender->buckling |
| | Excessive | Over-engineered | Material < YS<br>Reduce weight, SO |

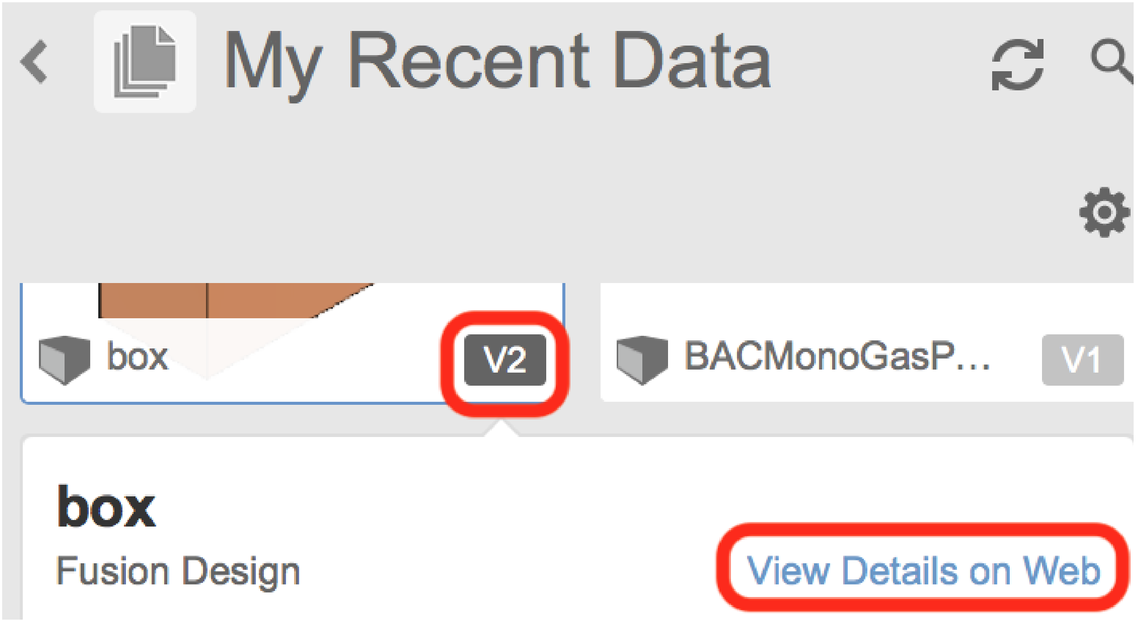


# Results sharing - Reports

- Report generates reports with images
- Customizable
- NLSS result charts can be included for steps
- Tip: Use Dynamic Content (Javascript) option which provides collapsible sections

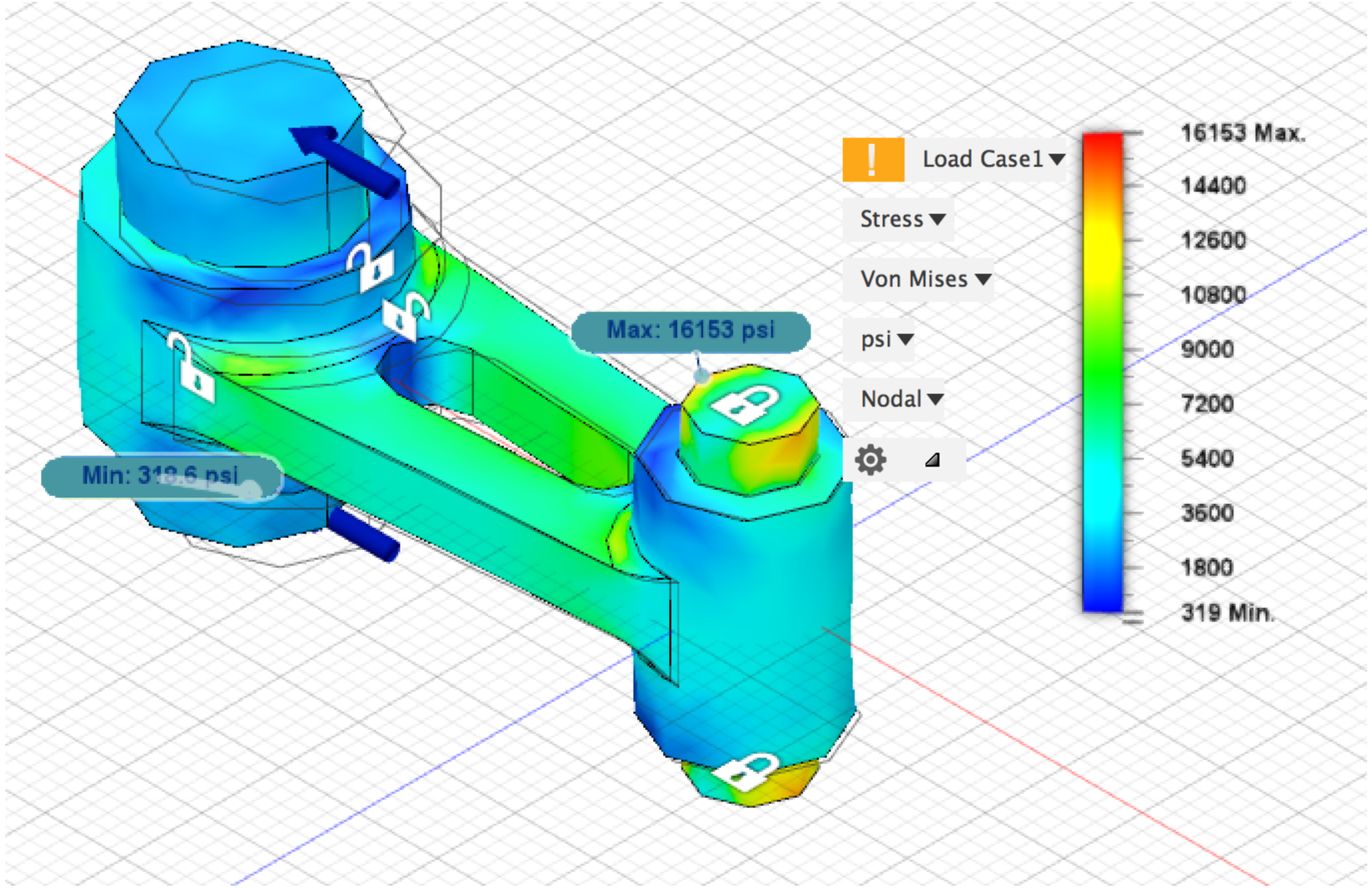
# Results sharing – A360

- Generate results and save the file
- Data Panel, click on versions v2
- Click on ”View Details on Web”



- In Fusion-Team click on the Share icon

# Demo


Max: 16153 psi
Min: 318.6 psi
Load Case1
Stress
Von Mises
psi
Nodal
16153 Max.
14400
12600
10800
9000
7200
5400
3600
1800
319 Min.

Autodesk Fusion 360

Somashekar Subrahmanyam

Back >

ALL PROJECTS

New Project

WeRobotics

LIBRARIES

**Assets**
Project that contains assets used by Fusion 360 including templates, libraries, and other configuration files.

SAMPLES

**Basic Training**
Samples used in the Hands-on exercises in our Help topics.

**CAM Samples**
Samples demonstrating CAM functionality.
http://autode.sk/f360cam

**Design Samples**
Samples of completed Fusion designs.

**Electronics Samples**
Electronic project files with reference to circuit Schematics-PCB, PCB with 3D view and Enclosure.

**Generative Design Samples**
Samples demonstrating Generative Design functionality.

**Simulation Samples**
Samples demonstrating Simulation functionality.

**Workshops & Events**
Samples used for Autodesk sponsored Workshops & Events

Untitled

DESIGN

SOLID | SURFACE | SHEET METAL | TOOLS

CREATE | MODIFY | ASSEMBLE | CONSTRUCT | INSPECT | INSERT | SELECT

BROWSER

(Unsaved)

Document Settings

Named Views

Origin

# Links

- **About Fusion 360 Simulation Learning: Main learning link**
- **How to: Specific and general steps for managing studies**
- **Hands-on exercises: Tutorials**

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