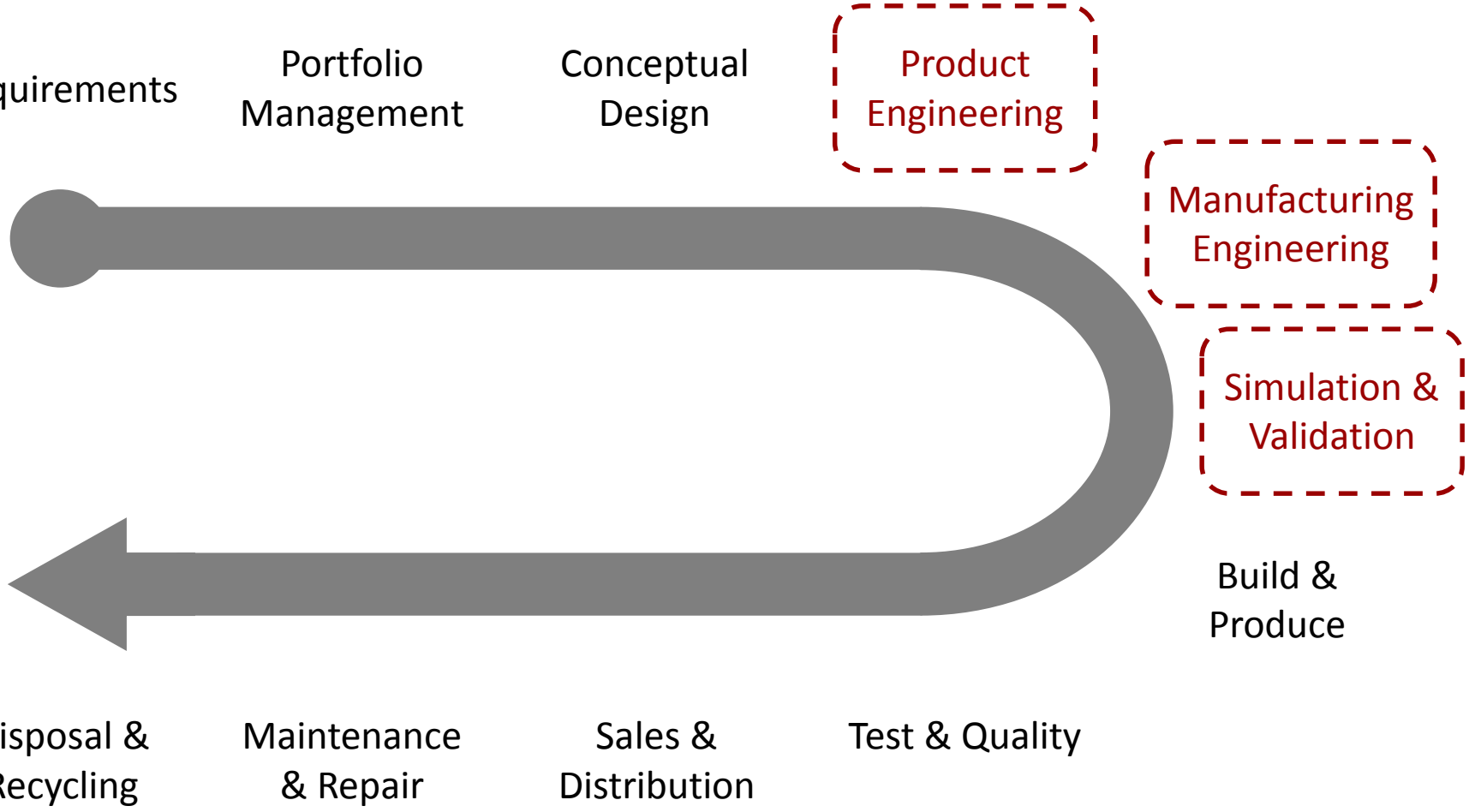
Week 10 - Lecture
Nonlinear Structural Analysis

Product Lifecycle – Week 10



Goals of Simulation

- Validate Designs
- Predict Product Performance
- Optimize Designs

Replicate the Physical World

The more closely a simulation conforms to what happens in the physical world, the more value it has to offer.

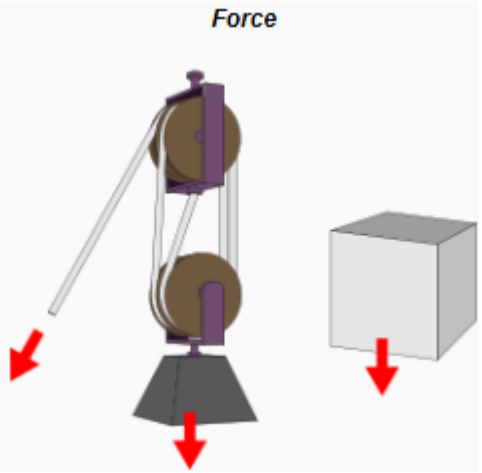
- Model Geometry
- Analysis Type
- Materials
- Boundary Conditions
- Loading Conditions

Materials

- The available material selection is vast and changes everyday.
- The material properties and material model determine the behavior under operating conditions.

Force Estimation Methods

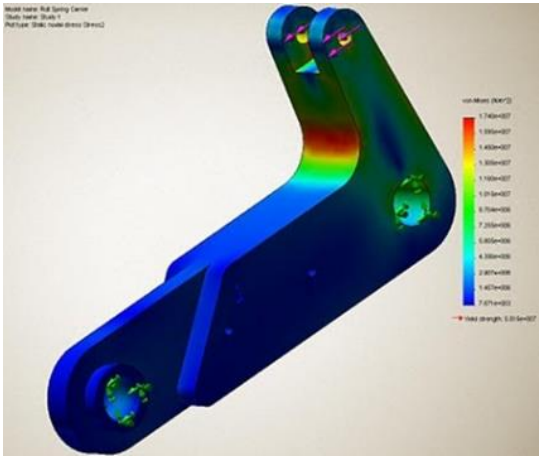
- Experience
  - Engineers reply on past experience from similar projects to estimate forces.



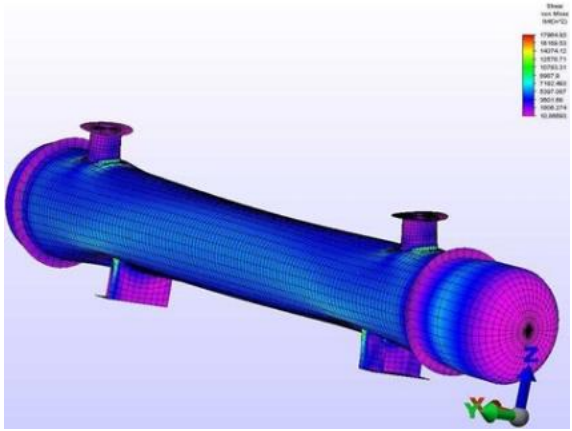
- Rigid-Body Dynamics
  - Leverage the 3D design data to perform a motion simulation using rigid bodies to gain insights into force values.
- Physical Experimentation
  - Experiment with prototypes or past products to obtain accurate force values.

Linear vs. Nonlinear Analysis

- Linear
  - Structure returns to original form
  - No changes in loading direction or magnitude
  - Material properties do not change
  - Small deformation and strain

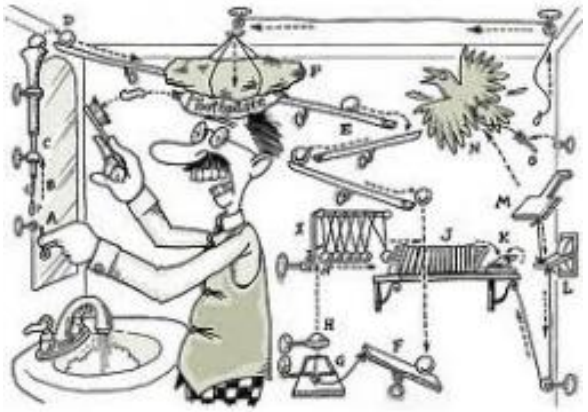


- Nonlinear ⟵ Focus for this week
  - Geometry changes resulting in stiffness change
  - Material deformation that may not return to original form
  - Supports changes in load direction and constraint locations
  - Support of nonlinear load curves



Nonlinear Analysis

- Design Engineer Belief
  - Too Complicated
  - Time Consuming
  - Specialized software packages

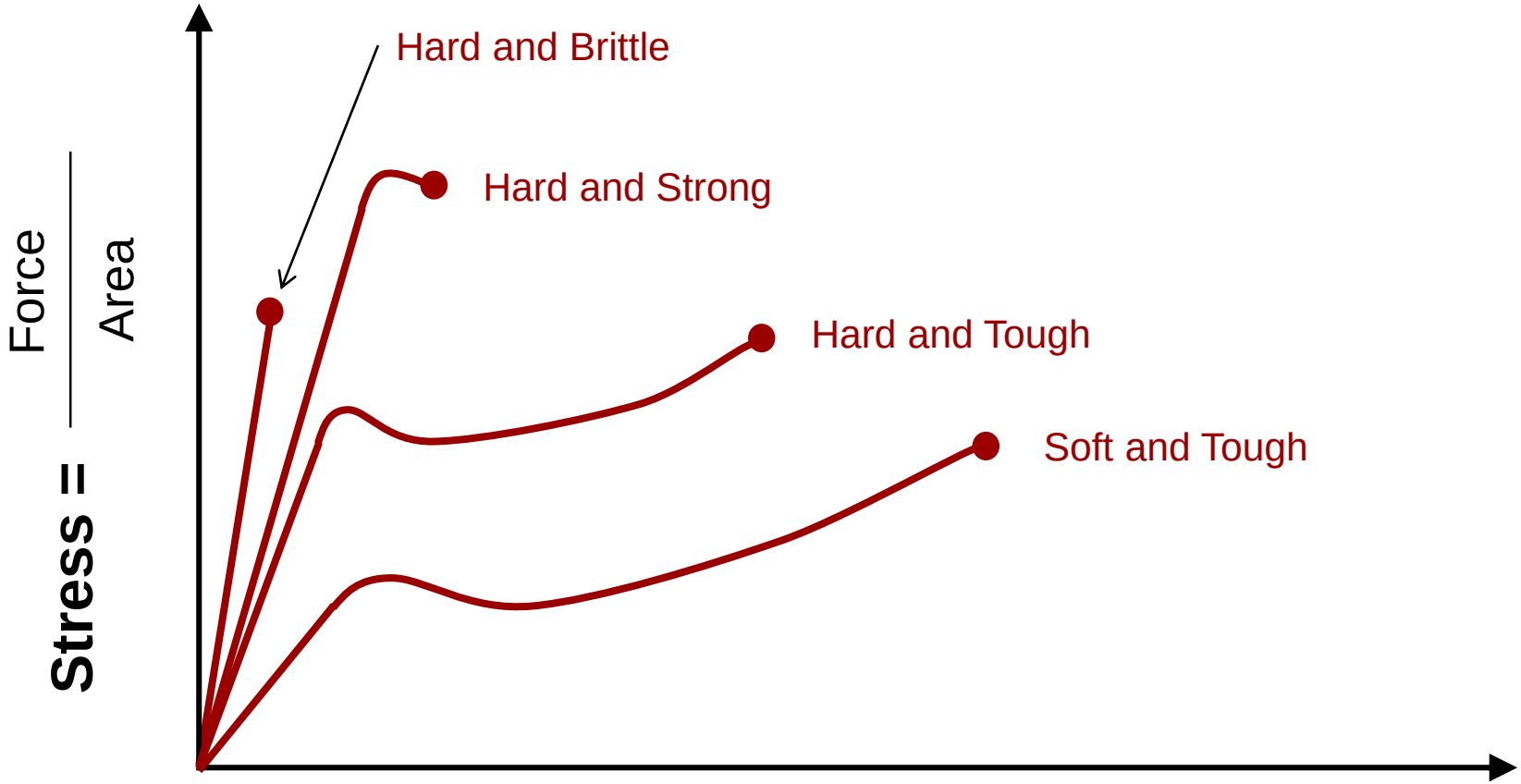


- Reality
  - Nonlinearities are common.
  - Advances in FEA Software
  - Advances in Computing Hardware

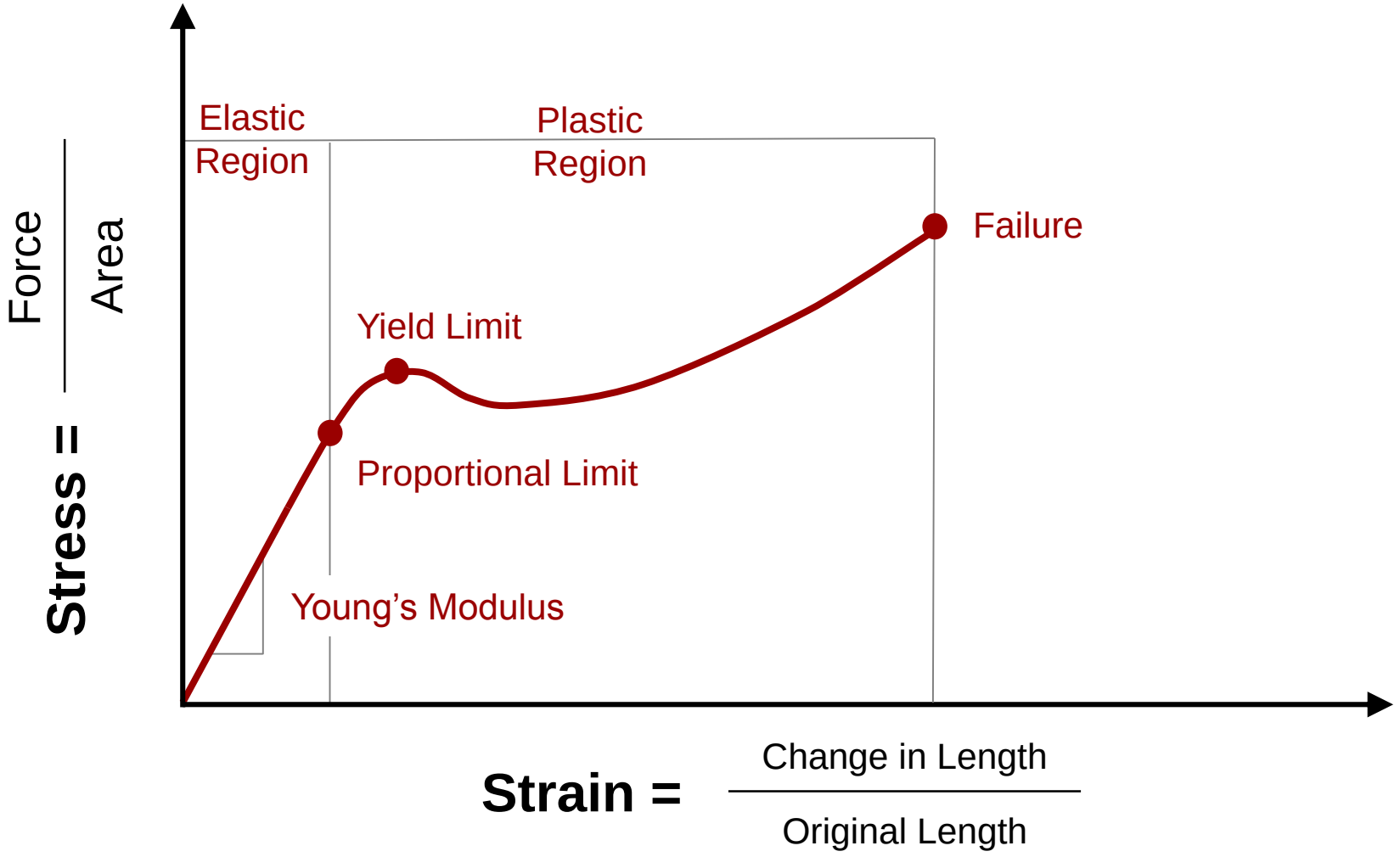
Types of Nonlinearity

- Nonlinear Material
  - Materials that do not have a complete linear stress strain curve as seen in plastic and rubber materials for example.
- Nonlinear Geometry
  - The changing shape of a model when large deformations exists provide nonlinear changes in the components stiffness.
- Nonlinear Boundary Condition
  - Boundary conditions that involve components in contact with one another often produce disproportionate changes in deformation.
- Nonlinear Loading Condition
  - Loading changes over time.

Materials Types

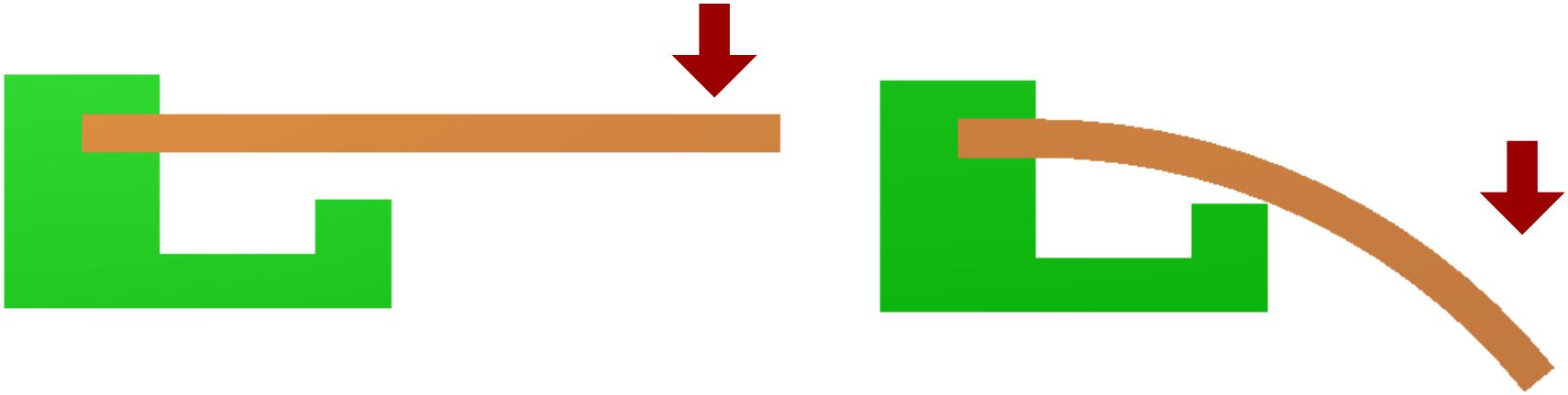


Polymeric Material Example



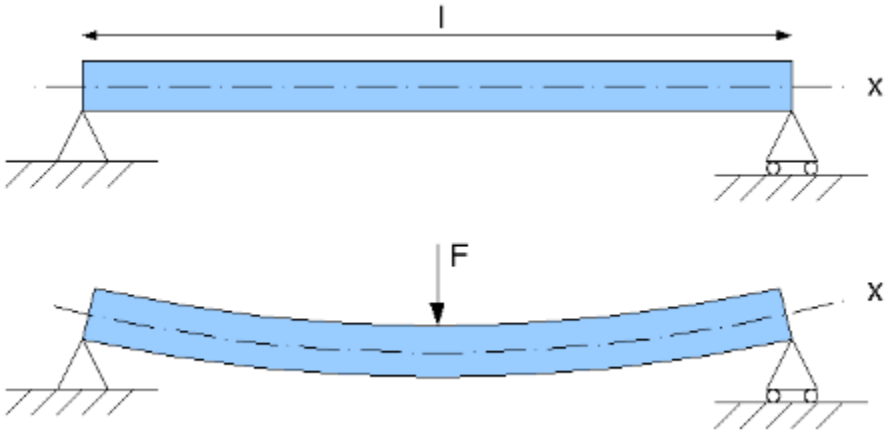
Nonlinear Boundary Condition

- Component contacts produce stresses and friction that result in disproportionate changes in deformation.



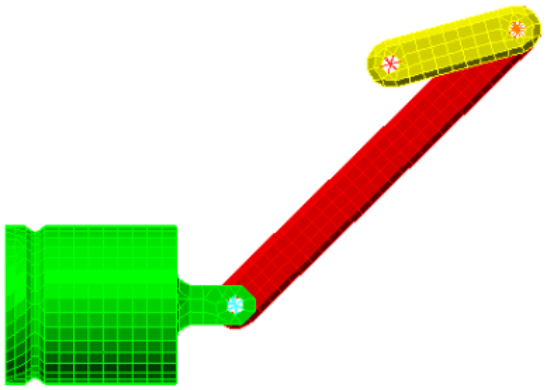
Nonlinear Geometry

- Changing shape triggers nonlinear changes in stiffness of the part model.

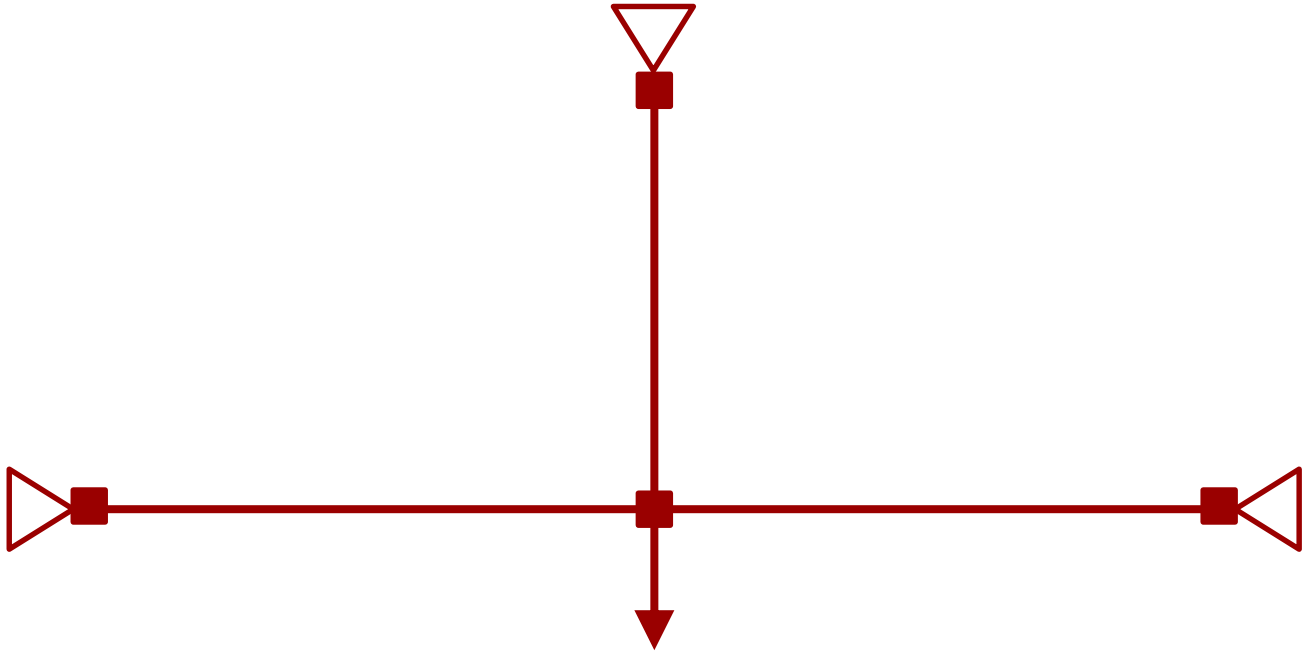


Event Simulation

- Event simulation allows for the entire event of a condition not just a static solution.
- In mechanical engineering the static case often does not dictate the design.
- Designs must consider the worst-case scenario which often occurs after loading.

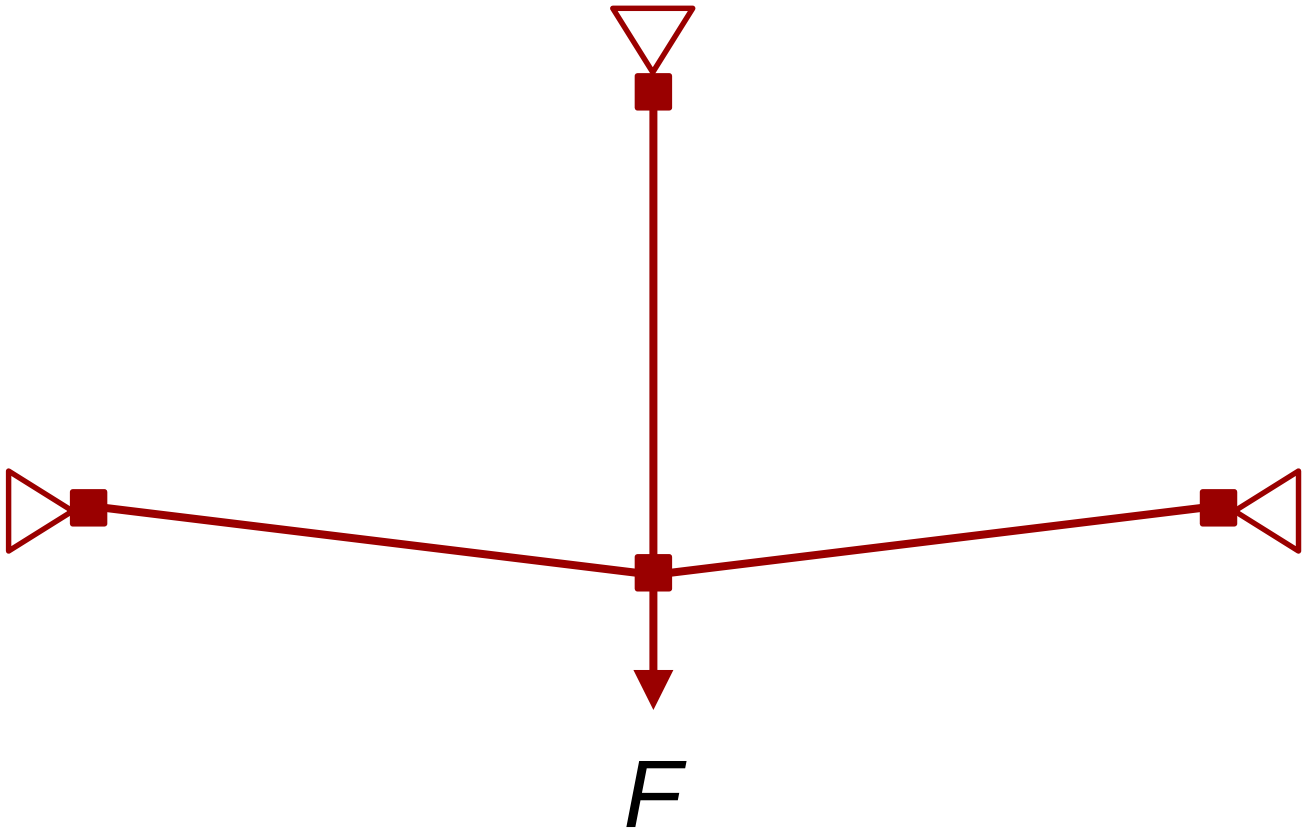


Event Simulation Example



Linear static solution would have the entire load carried by vertical member.

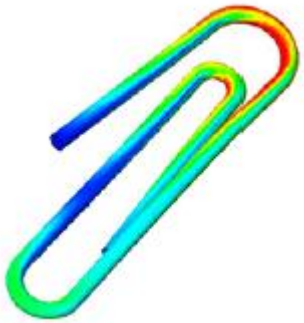
Event Simulation Example



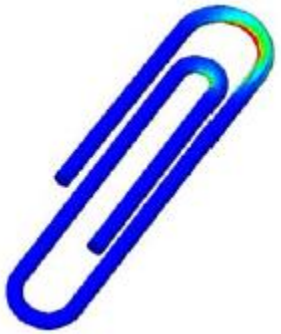
With an event simulation the horizontal members would carry some of the load.

Nonlinear Example

- Unbending and bending a paperclip back into position has nonlinear material and geometry effects.



Plastic Stresses



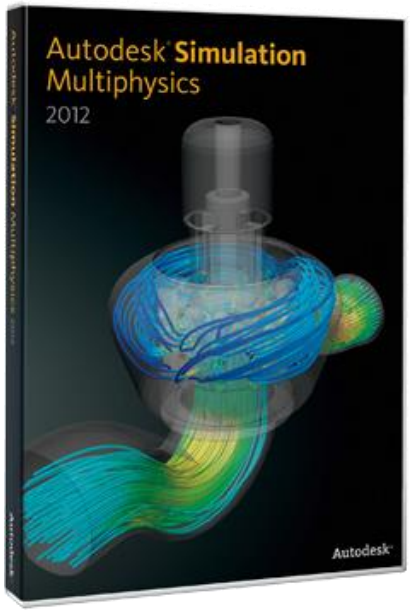
Residual Stresses

Everyday Nonlinear Requirements

Autodesk Simulation

Autodesk Simulation helps designers and engineers make decisions earlier and predict product performance.

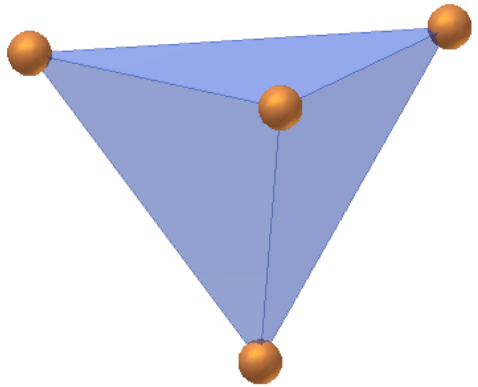
- Linear and Nonlinear Static Stress
- Fatigue Analysis
- Linear Dynamic
- Mechanical Event
- Heat Transfer
- CFD
- Multiphysics



Element Types

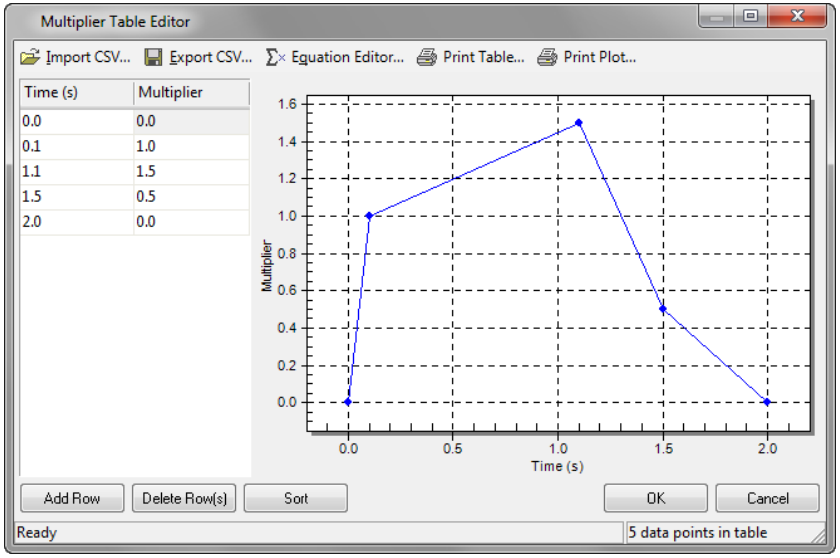
The following are some of the element types available in Autodesk Simulation

- Beam
- Spring
- Brick
- Shell
- Truss
- Special (Actuator)
- Special (Membrane)
- Special (Slider)

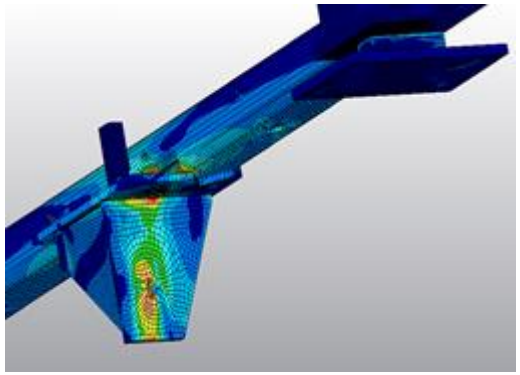


Load Curves

Load curves control the load value through a multiplier over a time period. Each specific load can follow a different load curve.



Six Flags Theme Parks - Case Study



Challenge

Maintain and renovate hundreds of thrill rides with minimal downtime.

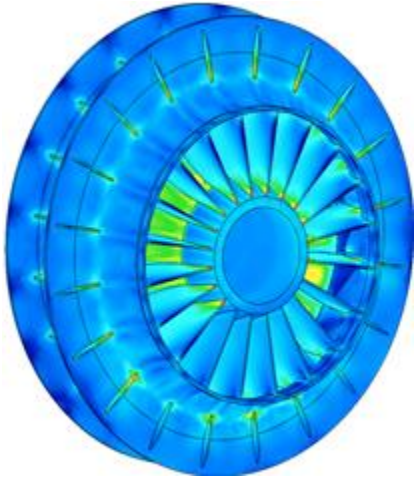
Results

- New, in-house design of anti-rollback mechanism to modernize a wooden roller coaster, the Texas Giant
- Better collaboration with fabricators through use of high-quality drawings and documentation
- Improve quality by increasing reliability of high-wear parts.

"Our primary concern is safety. Inventor and Autodesk Simulation allow us to study real-world loading scenarios so we can be sure we have appropriate safety factors in our designs."

Mike Neuzil
Corporate Engineer
Six Flags Theme Parks, Inc.
United States

Howden - Case Study



Challenge

Reduce the time taken to produce tenders with technically and economically competitive proposals, while taking account of increasingly detailed customer requirements

Results

- Substantial reduction in total design time.
- Faster response to customer design requirements.
- Simulation allows investigation and validation of new design approaches.
- Weight reduction through design optimization brings reduced costs.

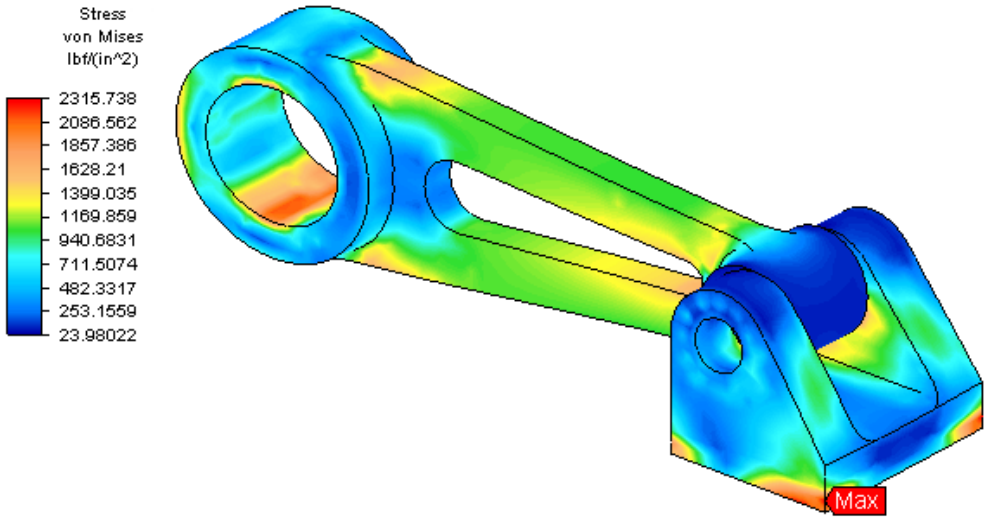
"Flexibility, adaptability and reliability are the key benefits that we enjoy with Autodesk Simulation products."

Laurent Tisserand
Technical Director
Howden
France

Computer-Cluster Projects (CP10)

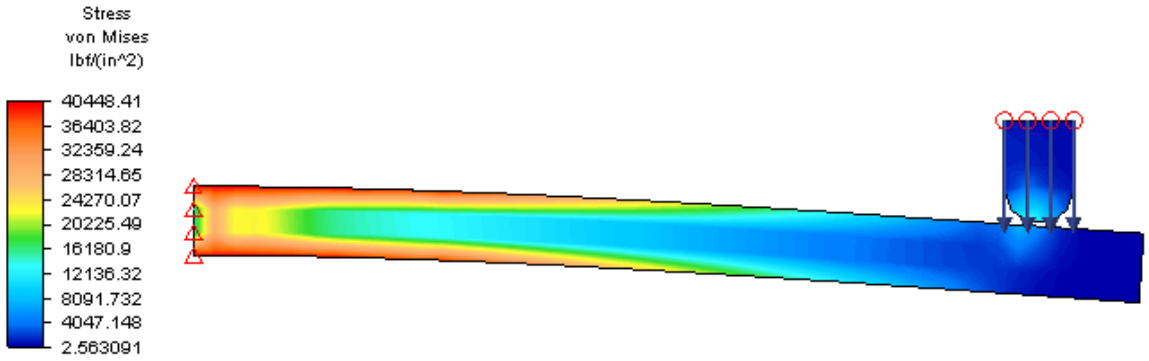
Guided Lab Project 1

Guides instructions for completing a static stress linear simulation in Autodesk Simulation.



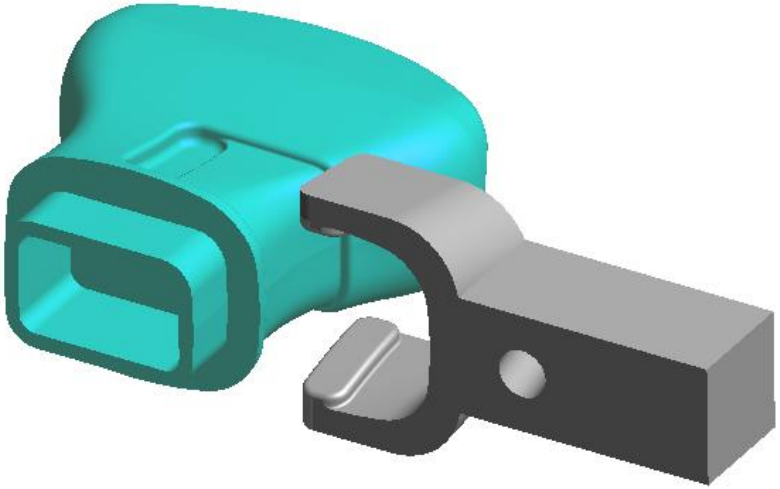
Guided Lab Project 2

Guided instructions for completing a mechanical event nonlinear analysis in Autodesk Simulation.



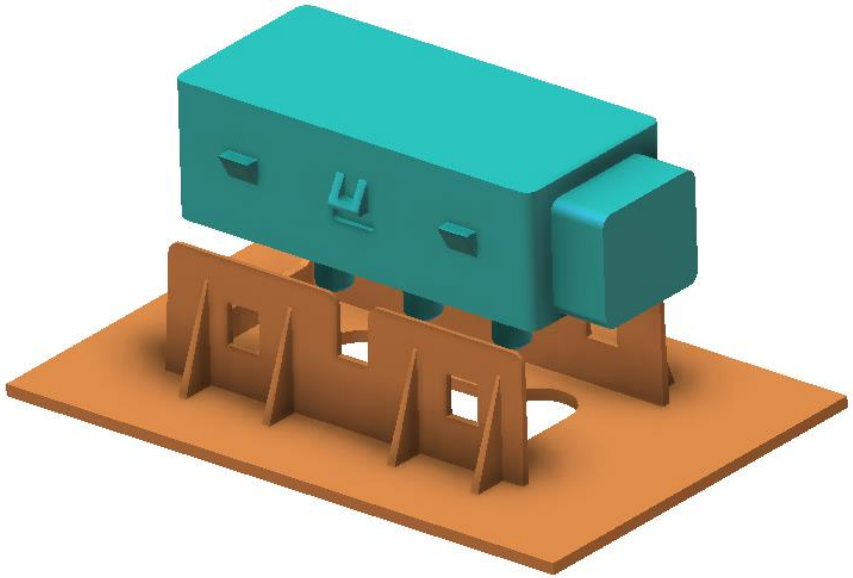
Guided Lab Project 3

Guided instructions for completing a snap fit nonlinear analysis on a medical device in Autodesk Simulation.



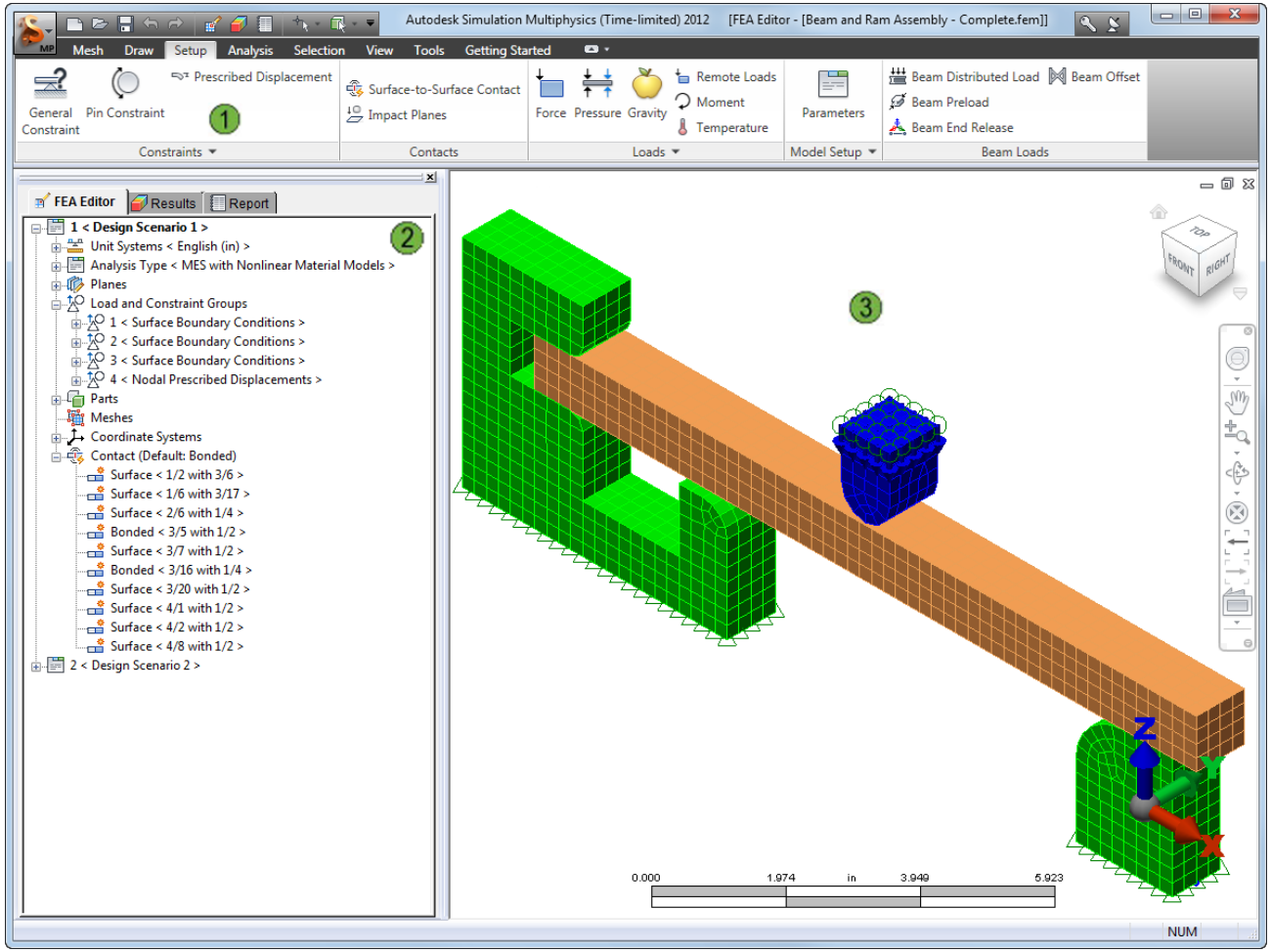
Problem Set Assignment

Analyze the electrical switch snap fit mounting to determine force required and design quality.



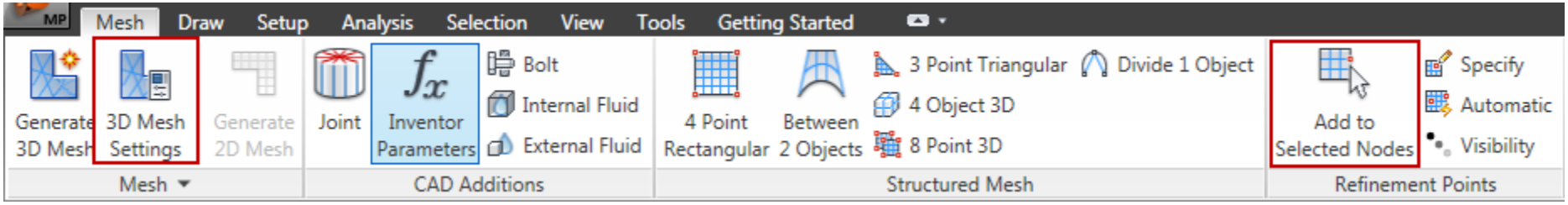
Demo Topics

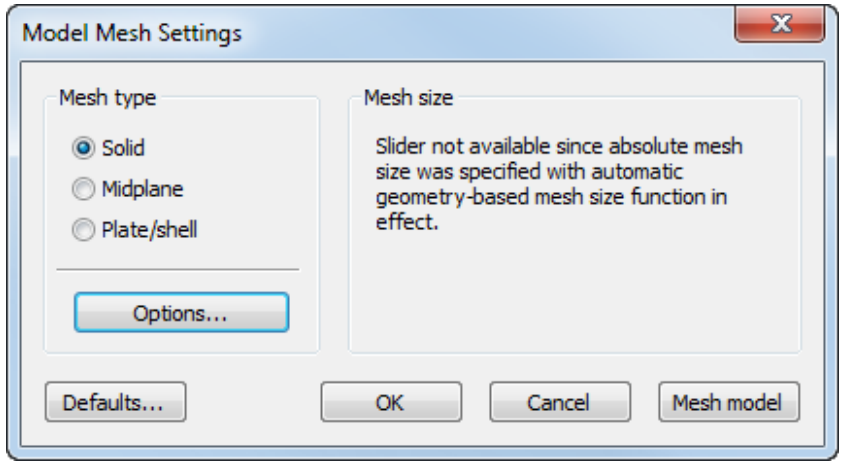
User Interface

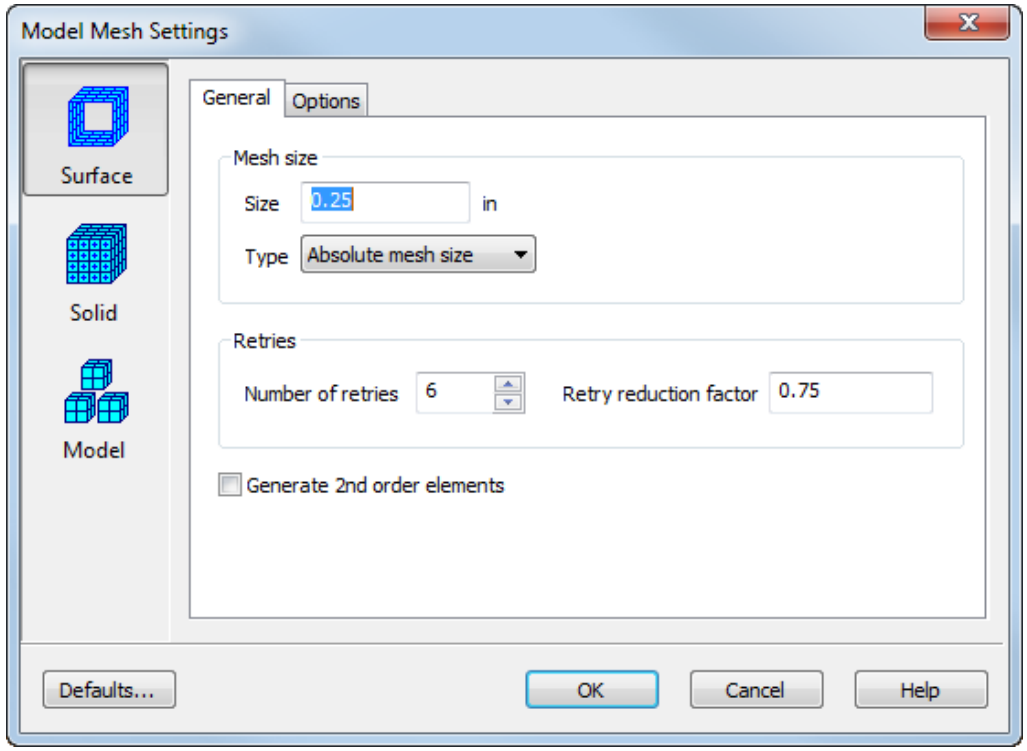


1. Setup tab
2. Stress Analysis browser
3. Graphical display

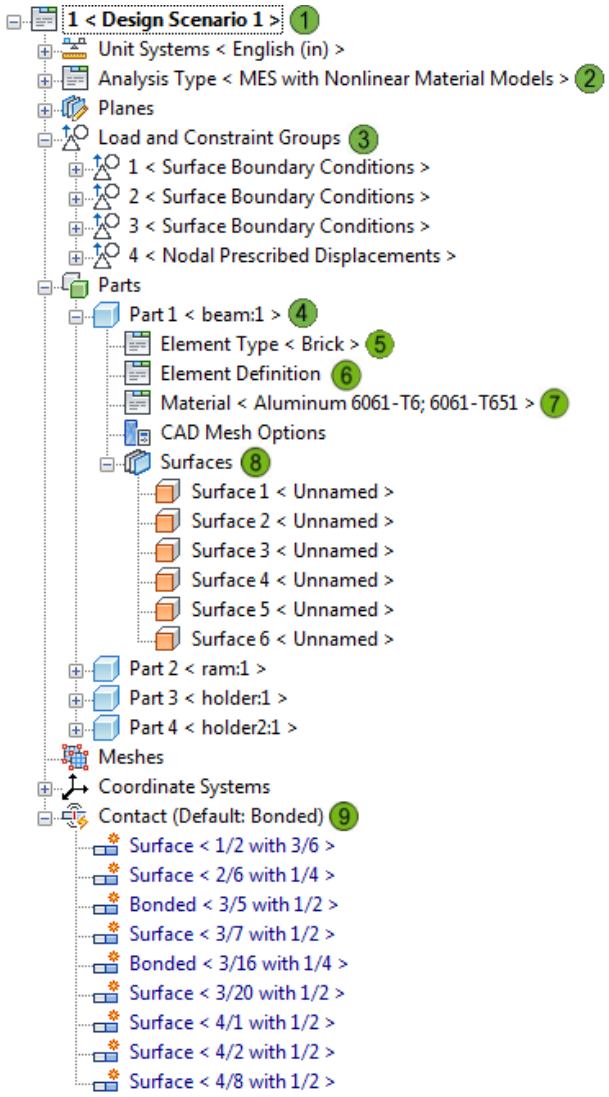
Mesh Panel and Settings





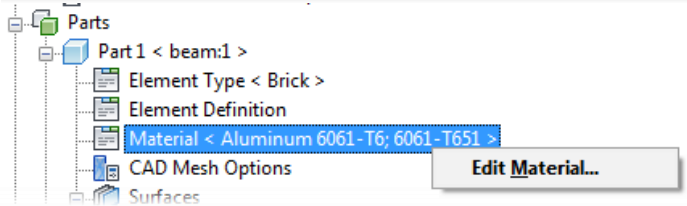


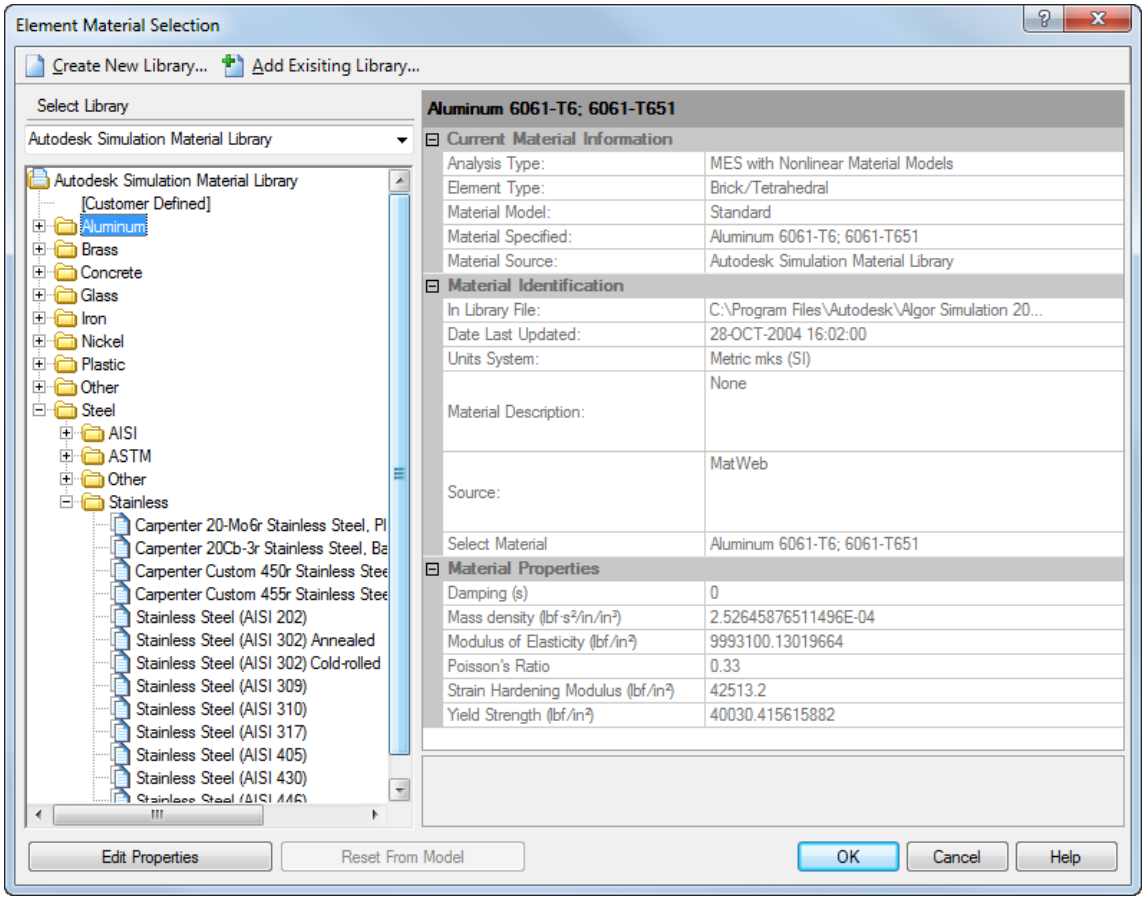
Simulation Browser



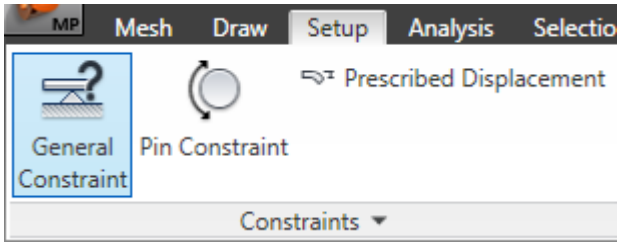
1. Multiple simulations
2. Analysis Type
3. Constraints and Loads
4. Part
5. Element Type
6. Element Definition
7. Material
8. Surfaces
9. Contacts

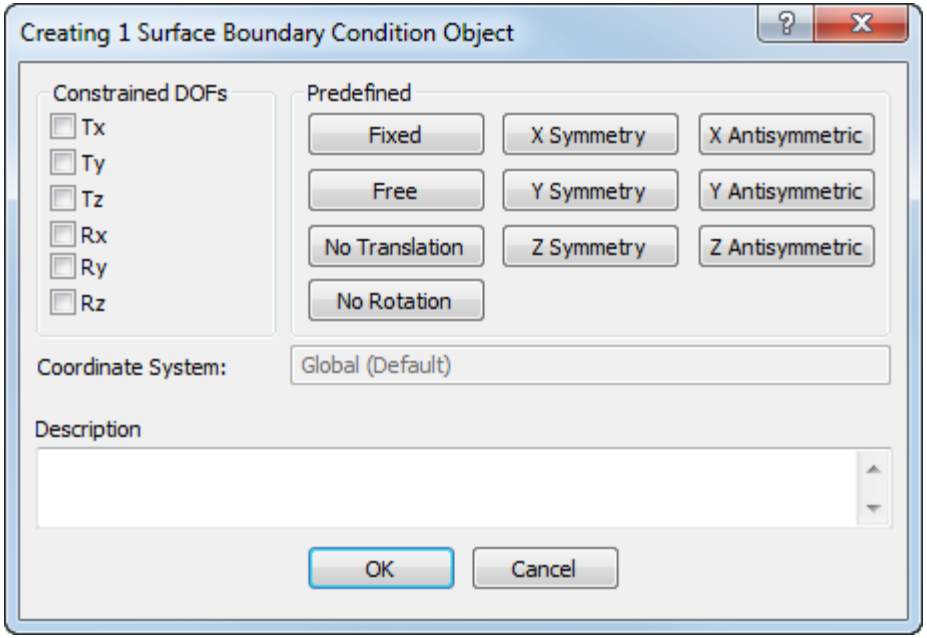
Assign Materials

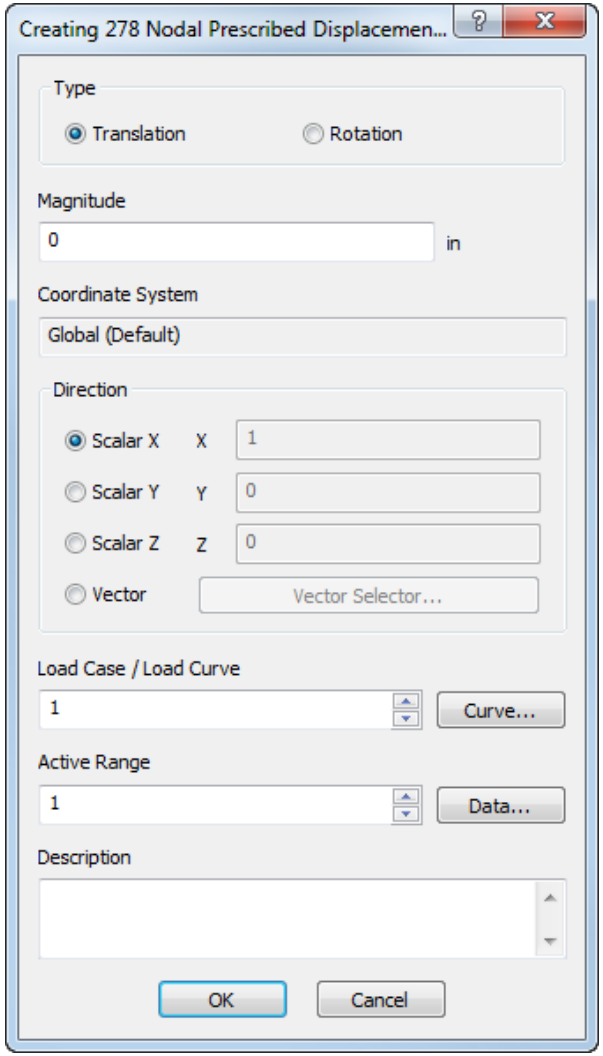




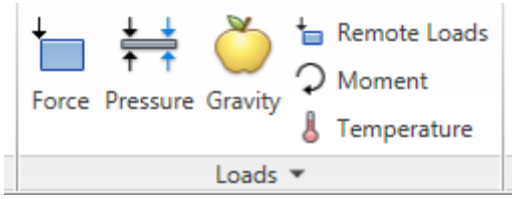
Assign Constraints

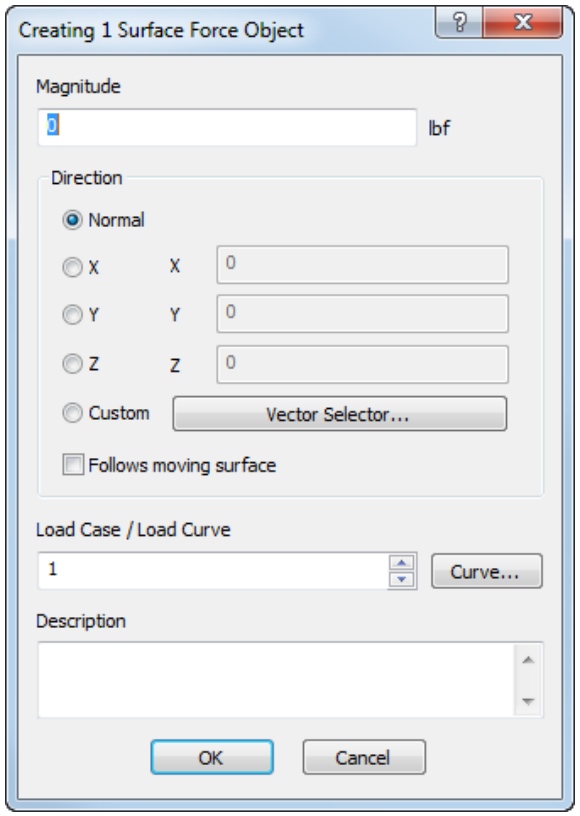


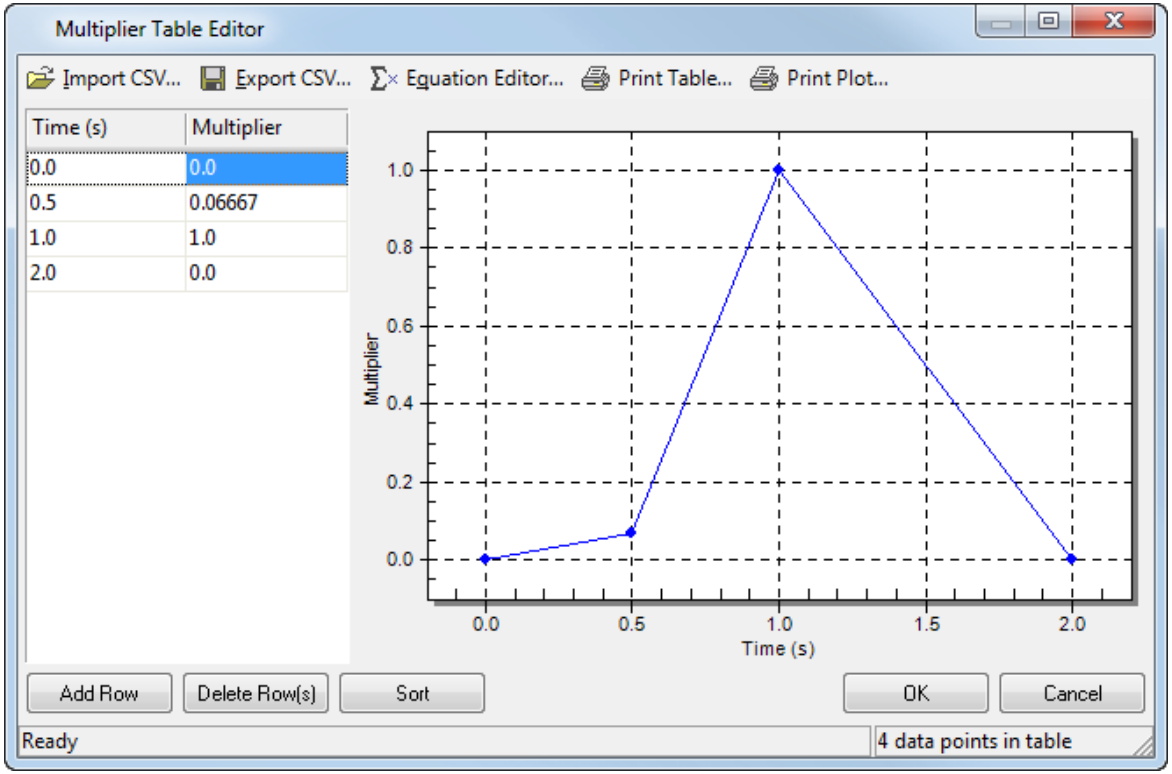




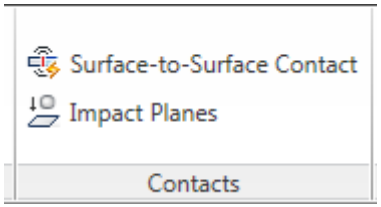
Assign Loads

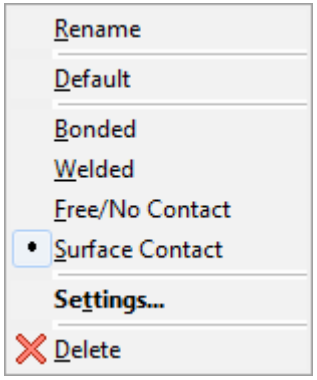


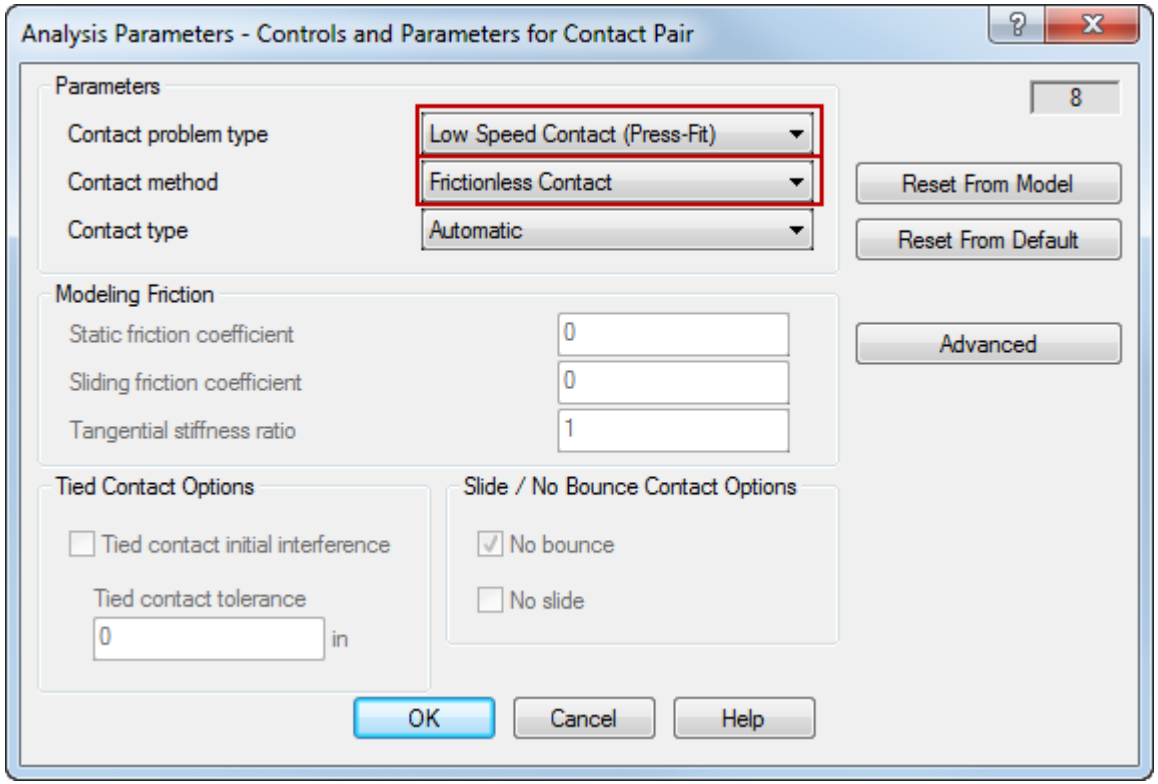




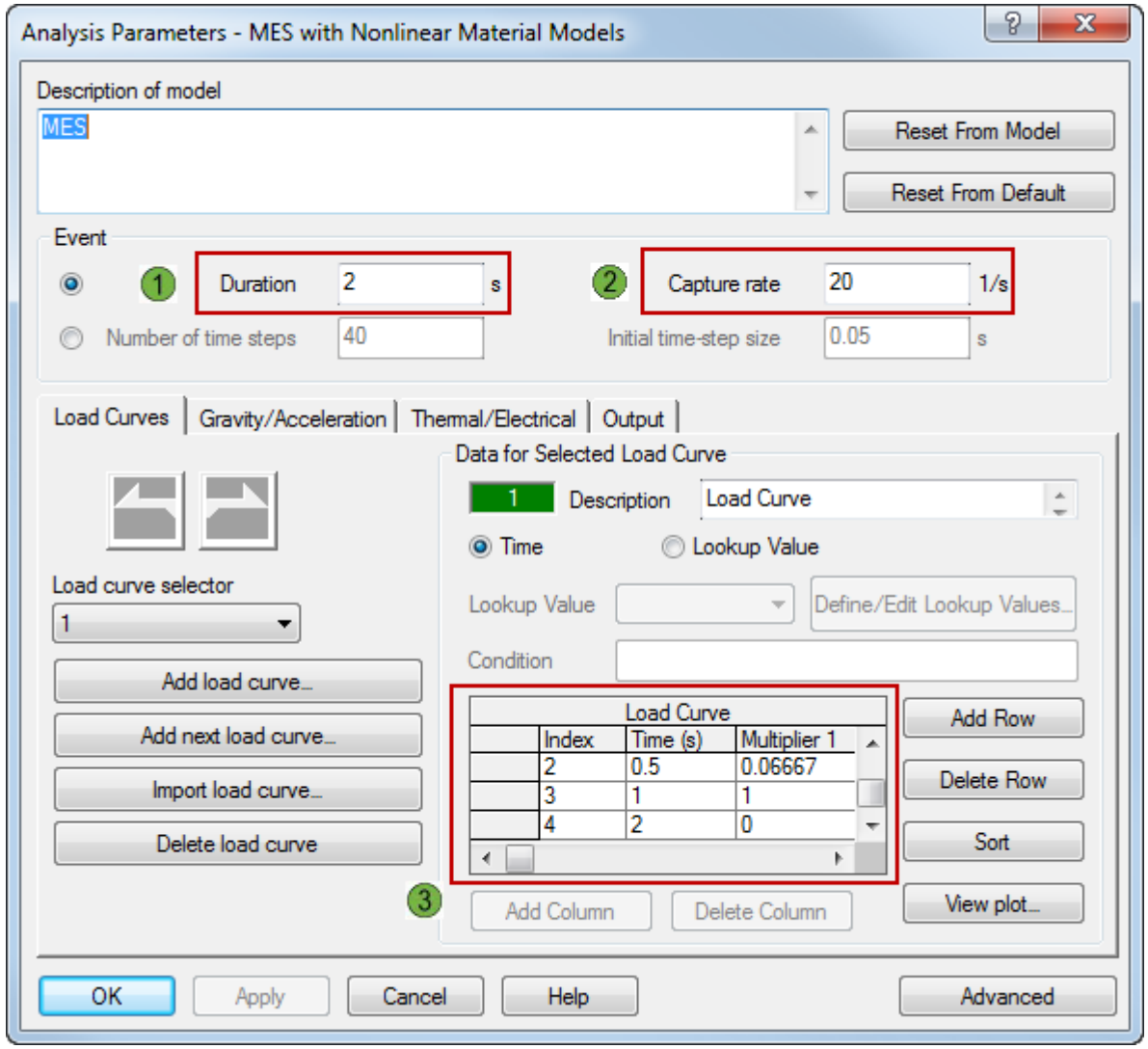
Contacts


Surface-to-Surface Contact
Impact Planes
Contacts


Rename
Default
Bonded
Welded
Free/No Contact
Surface Contact
Settings...
Delete

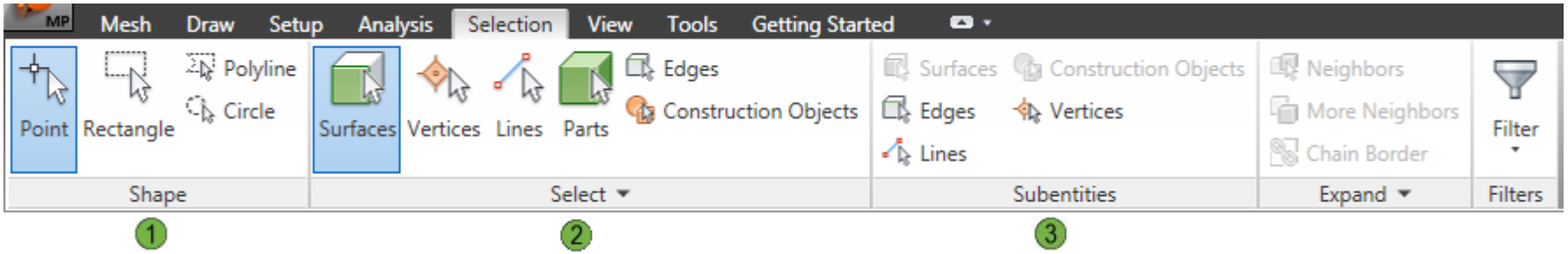

Analysis Parameters - Controls and Parameters for Contact Pair
Parameters
8
Contact problem type
Low Speed Contact (Press-Fit)
Contact method
Frictionless Contact
Contact type
Automatic
Reset From Model
Reset From Default
Modeling Friction
Static friction coefficient
0
Sliding friction coefficient
0
Tangential stiffness ratio
1
Advanced
Tied Contact Options
Tied contact initial interference
Tied contact tolerance
0
in
Slide / No Bounce Contact Options
No bounce
No slide
OK
Cancel
Help

Analysis Parameters



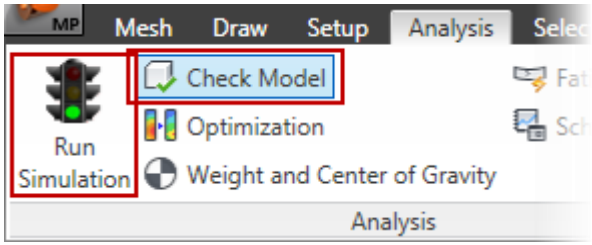
1. Duration
2. Capture Rate
3. Load Curves

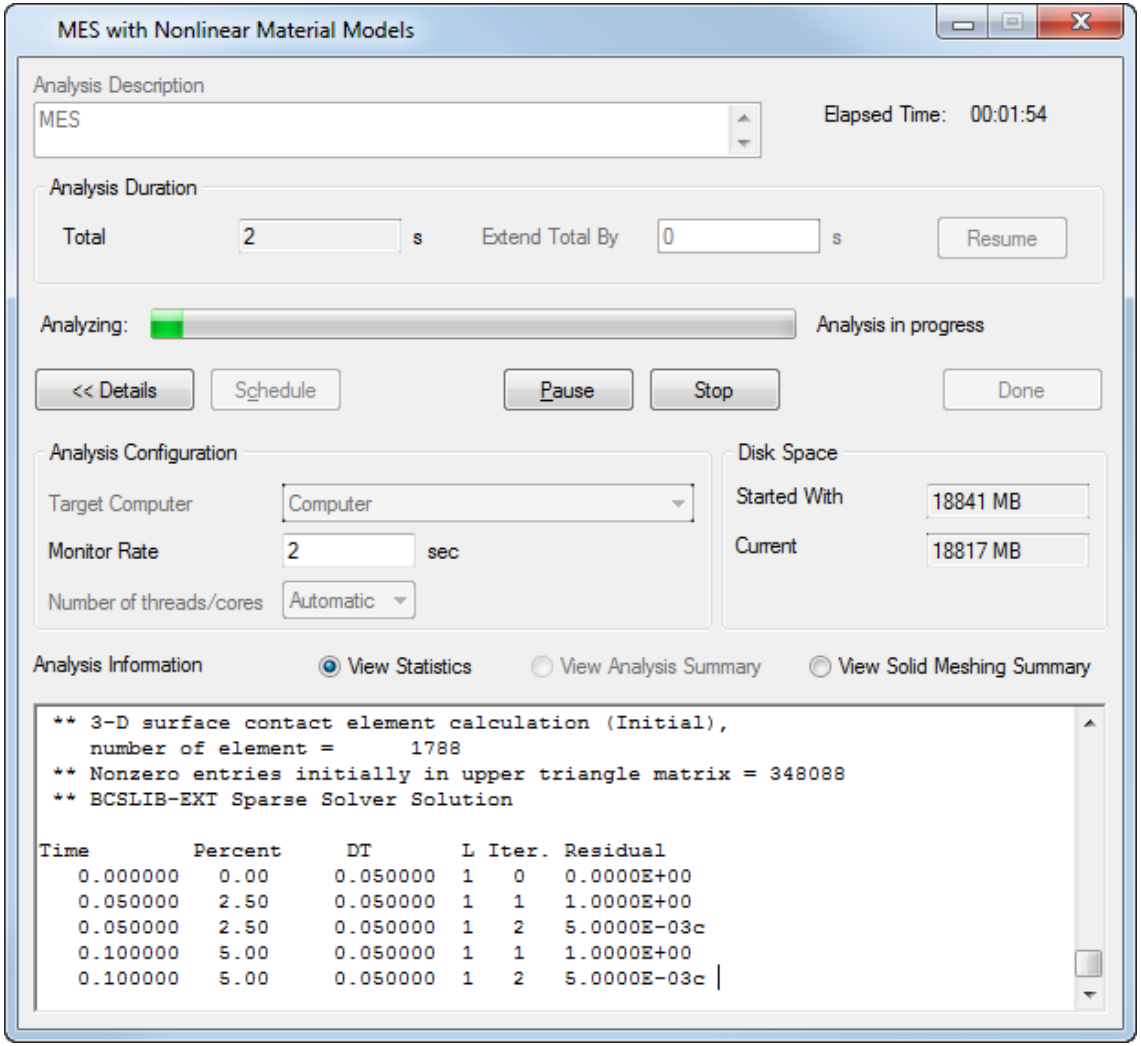
Selection Panel



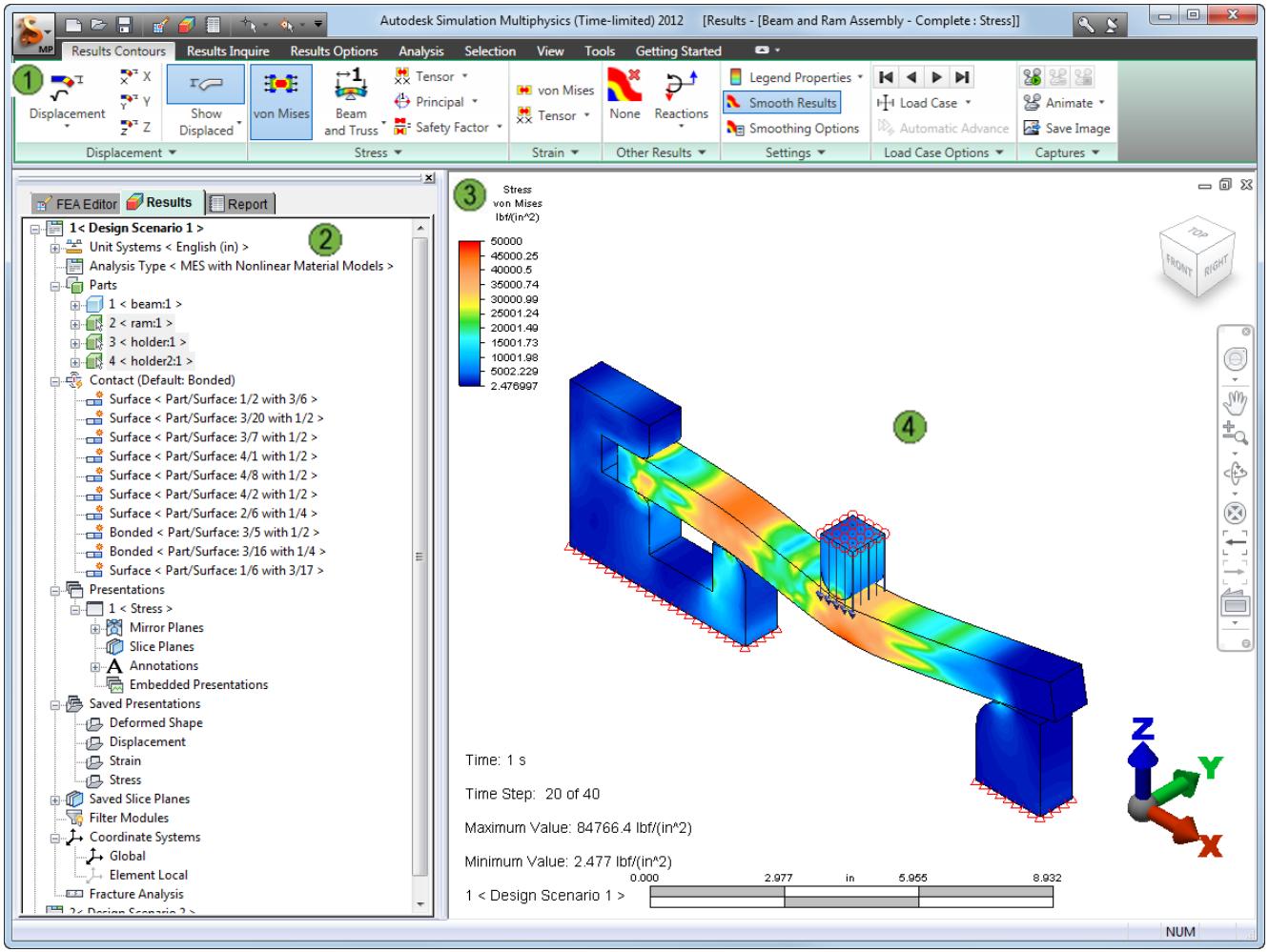
1. Selection Shape
2. Select Type
3. Subentites of Selection

Run Simulation



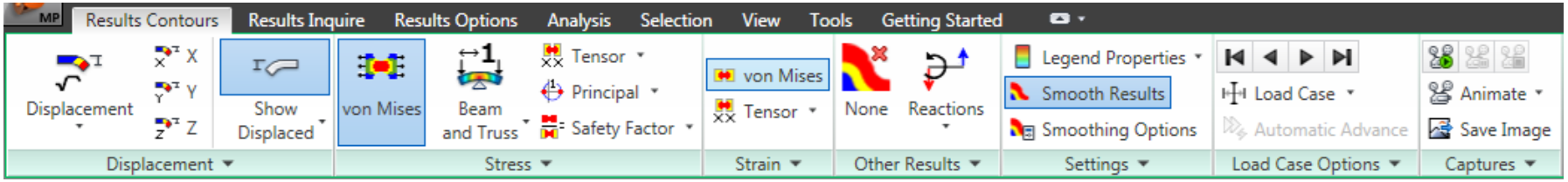


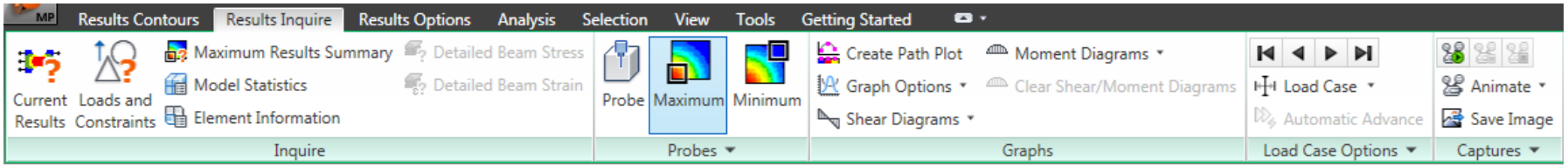
Results User Interface



1. Results Contours tab
2. Stress Analysis browser
3. Legend
4. Graphical display

Results Contours / Results Inquire





Graph Results