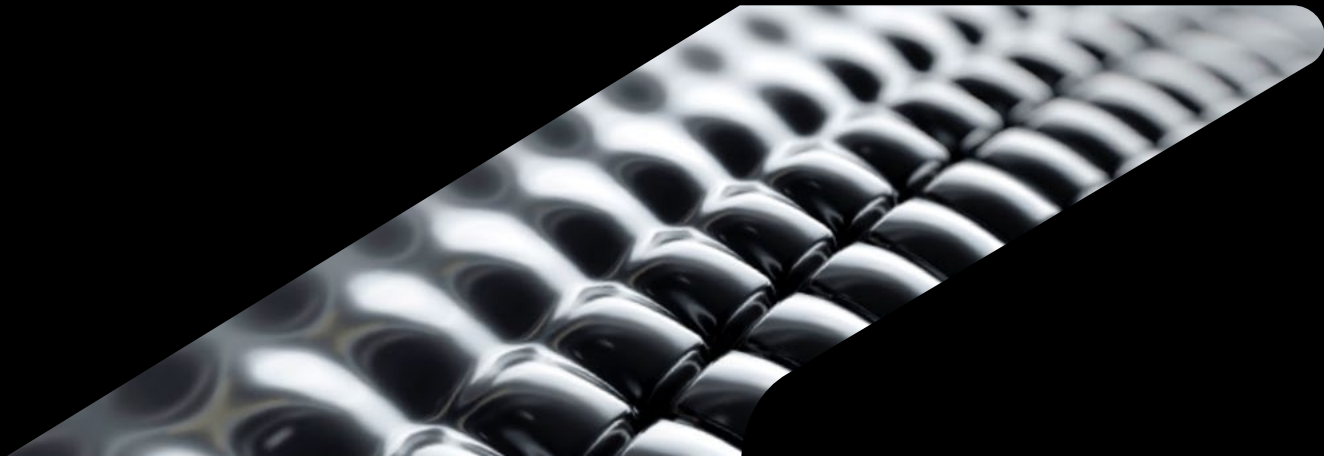


Up and Running with Inventor Nastran Nonlinear Analysis – Real World Examples

Wasim Younis
Simulation Manager – Symetri



About me

A passionate simulation solutions expert been involved with Autodesk simulation software from when it was first introduced, and is well-known throughout the Autodesk simulation community, worldwide.

Also authored the Up and Running with Autodesk Inventor Professional books. He also manages a dedicated forum for simulation users on LinkedIn – Up and Running with Autodesk Simulation.

Wasim has a bachelor's degree in mechanical engineering from the University of Bradford and a master's degree in computer- aided-engineering from Staffordshire University.



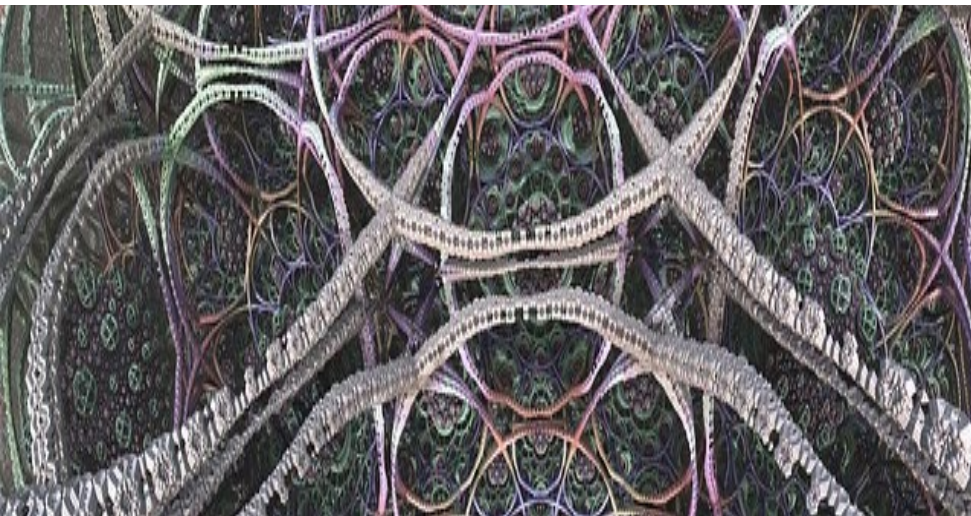


Agenda

- 1- Overview of Nonlinear Analysis
- 2- Real world examples
- 3- Top 10 Tips
- 4- Q&A



COMPLEX



Masters/PHD?





DEMISTIFY NONLINEAR ANALYSIS

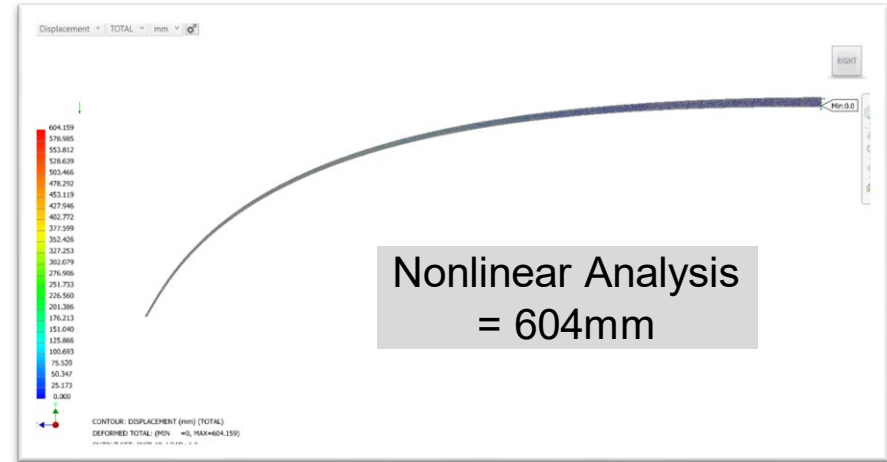
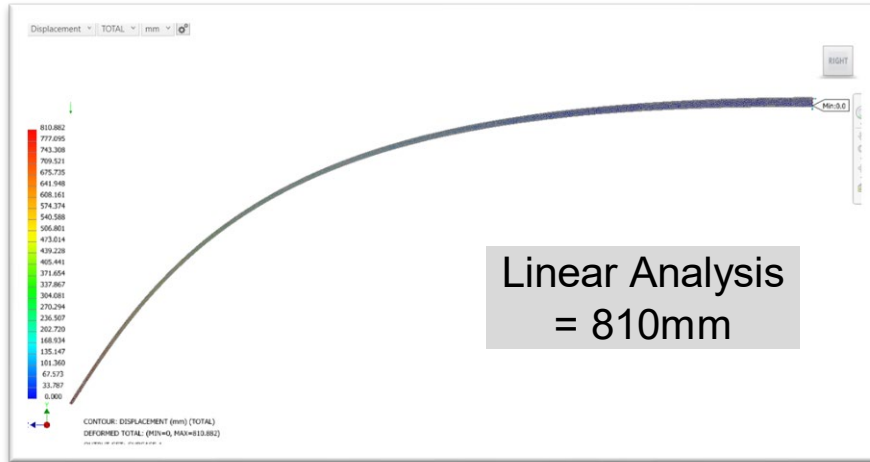


The background of the slide features a black field with a diagonal band of rounded, reflective, dark shapes that create a grid-like pattern, possibly representing a mesh or a surface with a repeating pattern.

Nonlinear Analysis- **An overview**

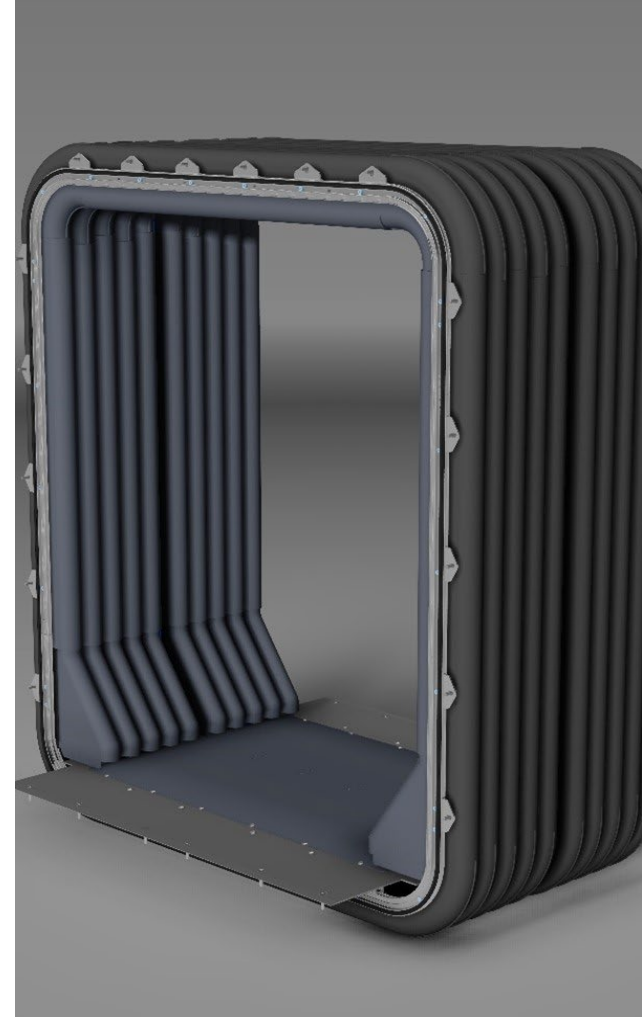
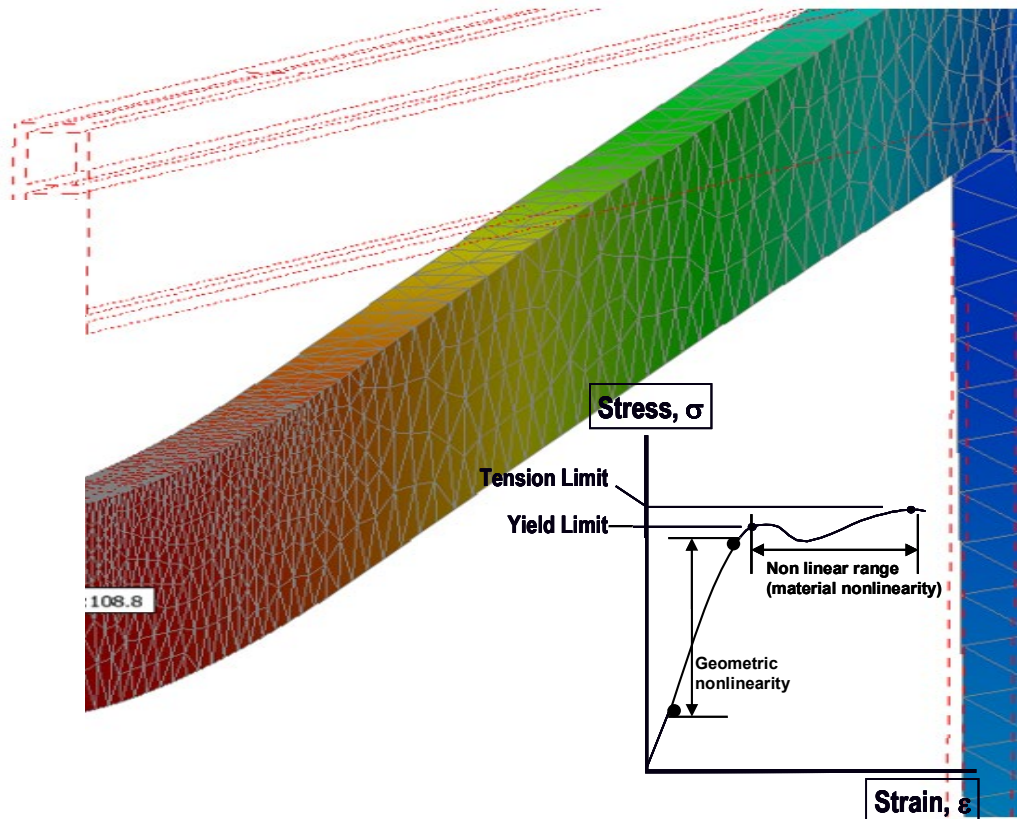
Nonlinear analysis general types

Geometric Nonlinearity



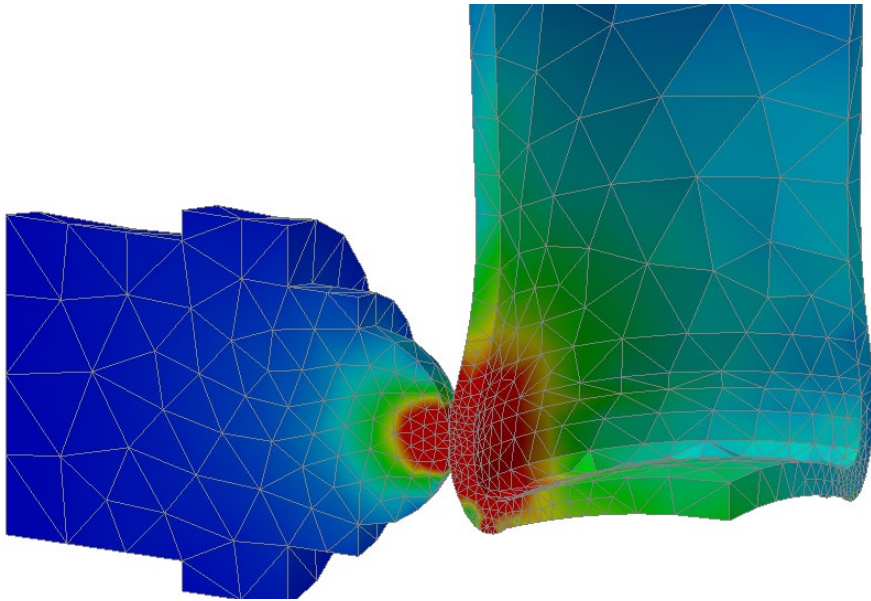
Nonlinear analysis general types

Material Nonlinearity



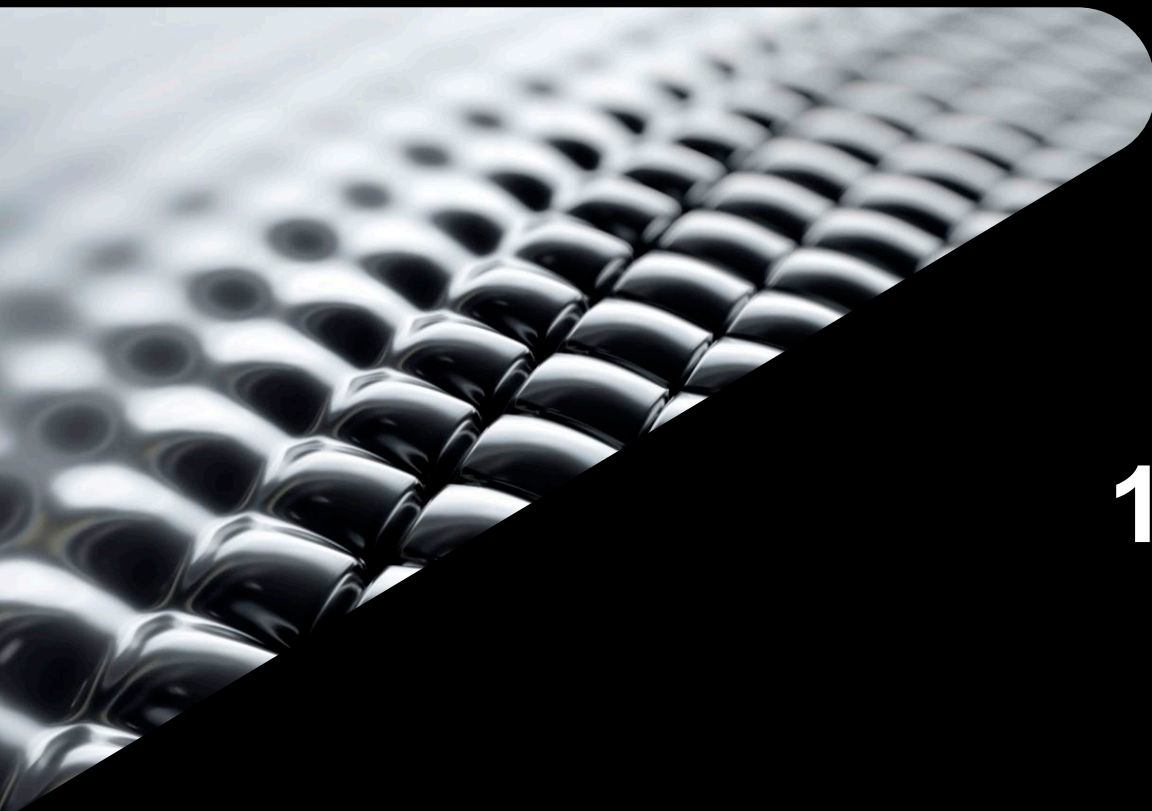
Nonlinear Analysis general types

Contact



Nonlinear Analysis Studies within Nastran

Solver	Application
Nonlinear Static (Implicit)	1 - Critical Load
Nonlinear Transient Response (Implicit)	2 - Drop Test
Explicit Dynamics	3 - Blast Analysis
Nonlinear Buckling (Implicit)	Not covered in this session
Explicit Quasi-Static	
Impact Analysis (Implicit)	



1- Simatek A/S

Inlet

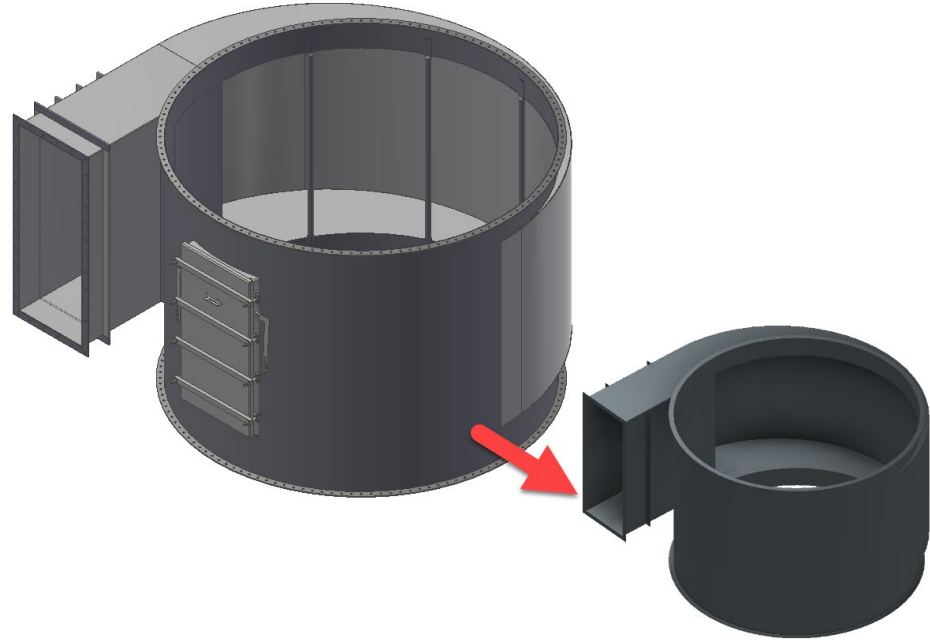
- Goal
 - Is to determine maximum permanent deformation at Critical Load.
- Key Information
 - AISI Carbon Steel 304 nonlinear material behavior.
 - Critical (Limit) Load is 0.082MPa
- Limits
 - Permanent Deformation to be less than 10%



Workflow considerations

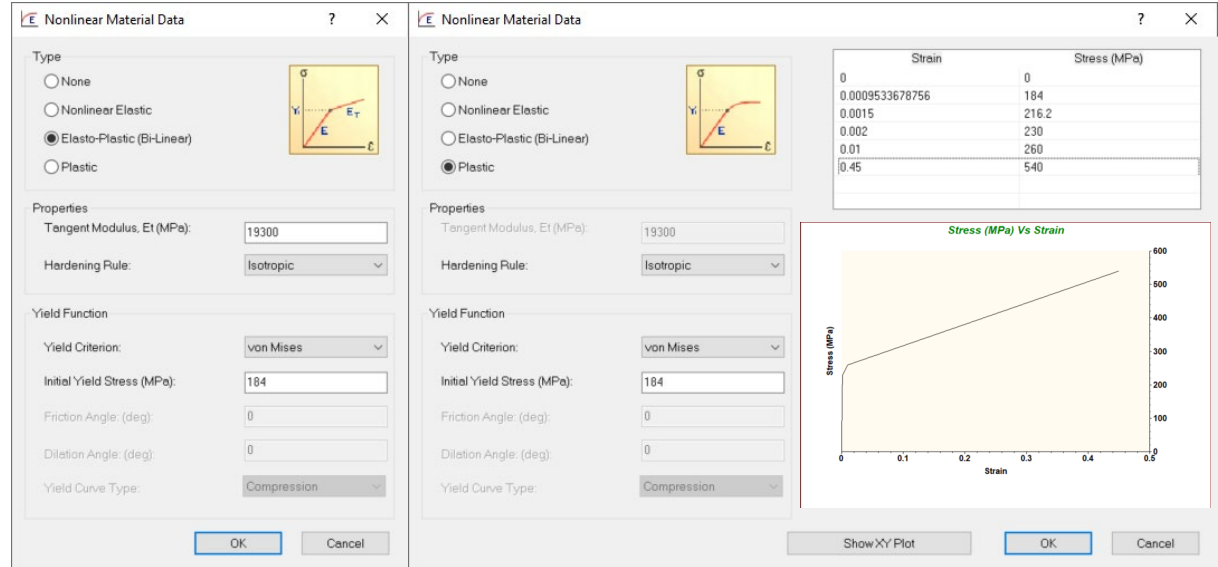
Alternative physical test is not sustainable.

- Geometry
 - Simplification
 - Remove nonstructural components
 - Remove nonstructural features
 - Remodeling
 - A simplified solid assembly
 - A simplified solid model (part)
 - A simplified surface model



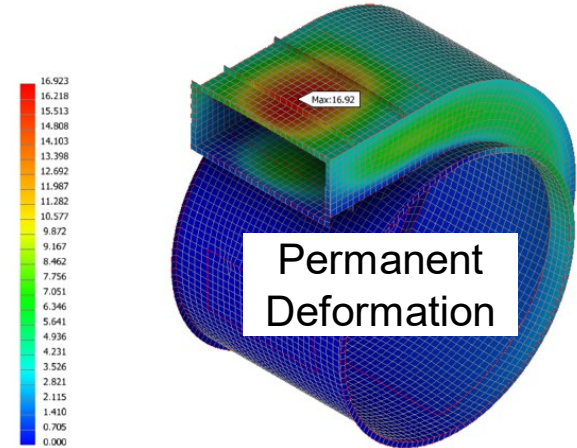
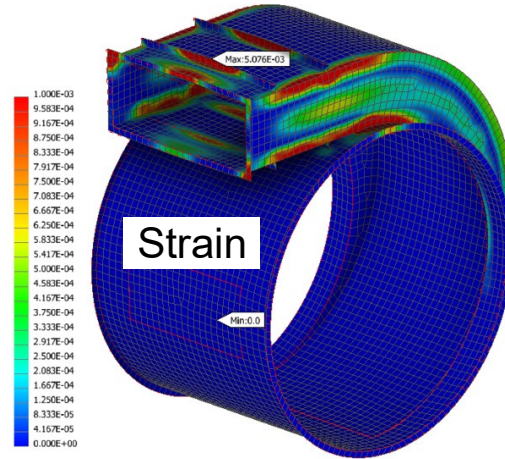
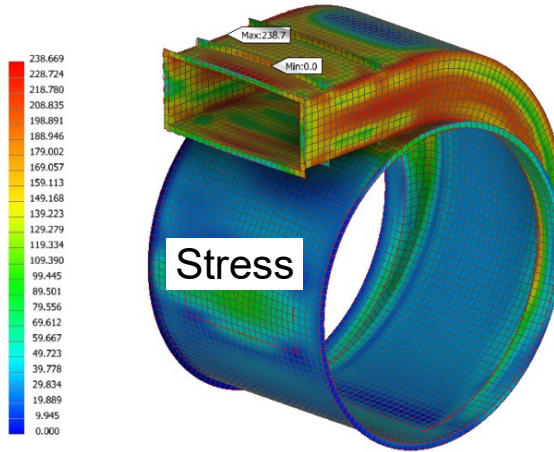
Workflow considerations

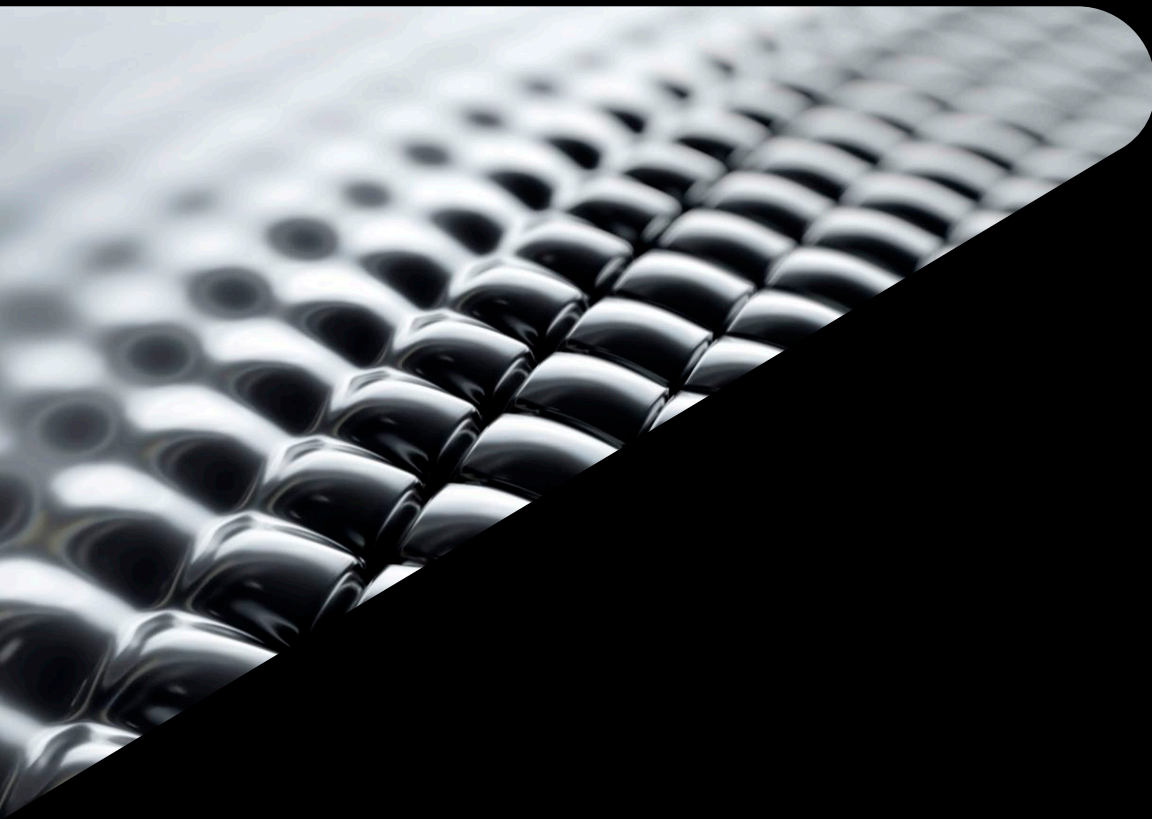
- Material Information (Elastic/Plastic)
 - Bilinear (Approximation)
 - Is an approximation
 - Plastic portion of the curve is typically set to 10%.
 - Plastic (More accurate)
 - More accurate
 - But need to find data and information to define curve



Nastran Demonstration 1

Nastran Nonlinear Static Analysis

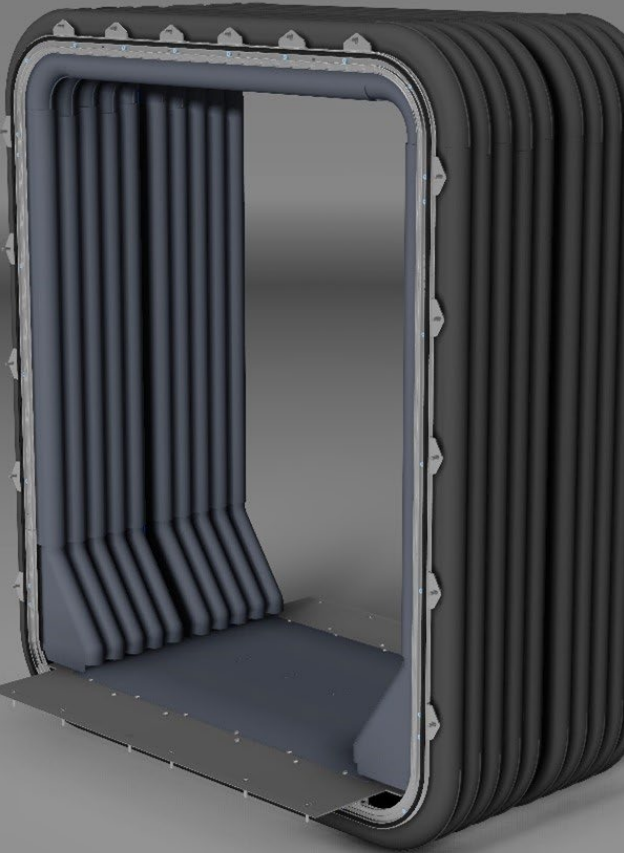




2- Dellner

Gangway

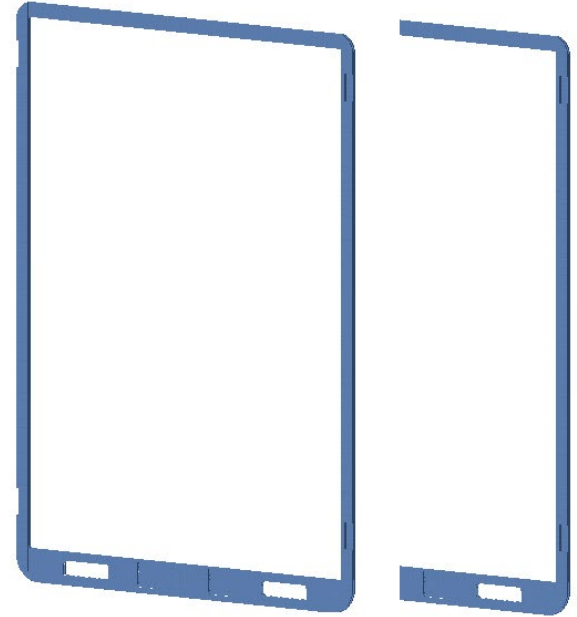
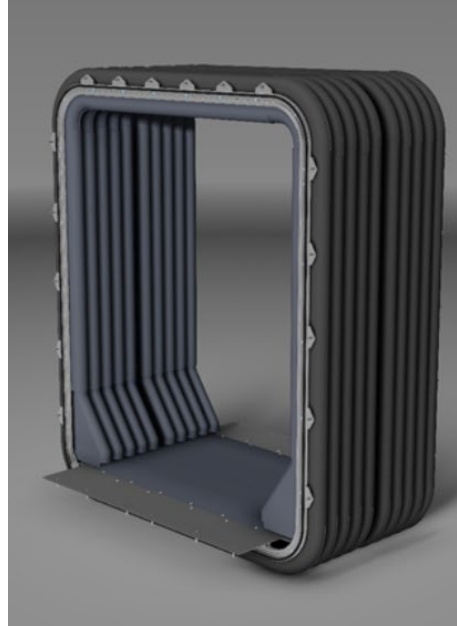
- Goal
 - Is to determine maximum permanent deformation due to a large stone/rock being dropped from a 5m height.
- Key Information
 - Aluminum nonlinear material behavior.
 - Impact Velocity.
 - Time of Impact.
 - Material Damping.



Workflow considerations

Alternative physical test is not sustainable.

- Geometry
 - Simplification
 - Remove nonstructural components
 - Remove nonstructural features
 - Remodeling
 - A simplified solid assembly (half)
 - A simplified surface/solid assembly (half)



Workflow considerations

- Material Information (Elastic/Plastic)
 - Bilinear (Approximation)
 - Is an approximation
 - Plastic portion of the curve is typically set to 10%.

Nonlinear Material Data

Type

- ☐ None
- ☐ Nonlinear Elastic
- ☒ Elasto-Plastic (Bi-Linear)
- ☐ Plastic

Properties

Tangent Modulus, Et (MPa): 6890

Hardening Rule: Isotropic

Yield Function

Yield Criterion: von Mises

Initial Yield Stress (MPa): 275

Friction Angle: (deg): 0

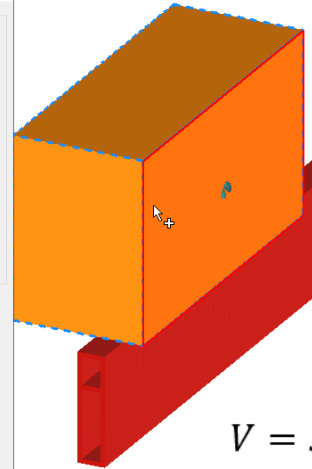
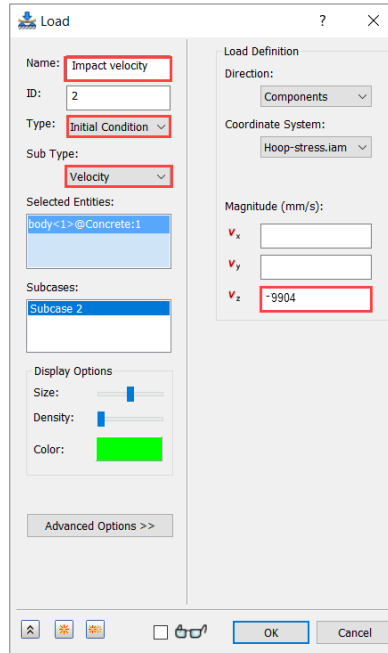
Dilation Angle: (deg): 0

Yield Curve Type: Compression

OK Cancel

Workflow considerations

- Impact Velocity
 - To speed up analysis bring block near target



$$V = \sqrt{2 \times g \times d}$$

$$V = \sqrt{2 \times 9810 \times 5000}$$

$$V = 9904 \text{ mm/s}$$

Workflow considerations

- Damping Data
 - Damping Value
 - Damping Frequency

Damping

Name:

ID:

☒ Structural Damping

Damping Value, G (%):

P

Dominant Frequency, W3 (Hz):

P

Dominant Frequency, W4 (Hz):

P

☐ Rayleigh Damping

Mass Proportional, ALPHA:

P

Stiffness Proportional, BETA:

P

☒ Modal Damping

Type:

Damping Definition:

Damping Value(%):

Workflow considerations

- Dynamic Setup Data (Impact)
 - Time Step
 - Time duration
- Dynamic Setup Data (After Impact)
 - Larger Time Step
 - Longer Time Duration

$$T = D/V = 10/9904 = 0.001$$

Dynamics Setup

Name: Dynamics Setup 1

ID: 1

Interval Listing:

0 to 0.01 s

Add Remove

Interval Setup

Cycle Dependent

Duration (s)

Time Step (s): 0.0005

Number of Timesteps: 20

Duration (s): 0.01

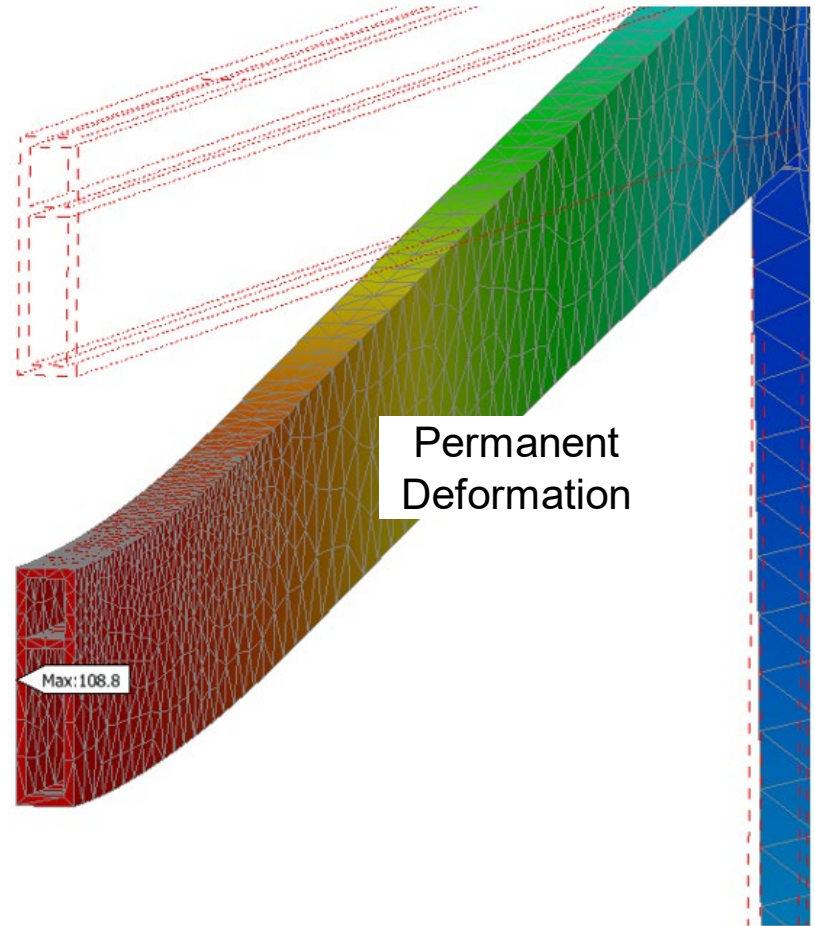
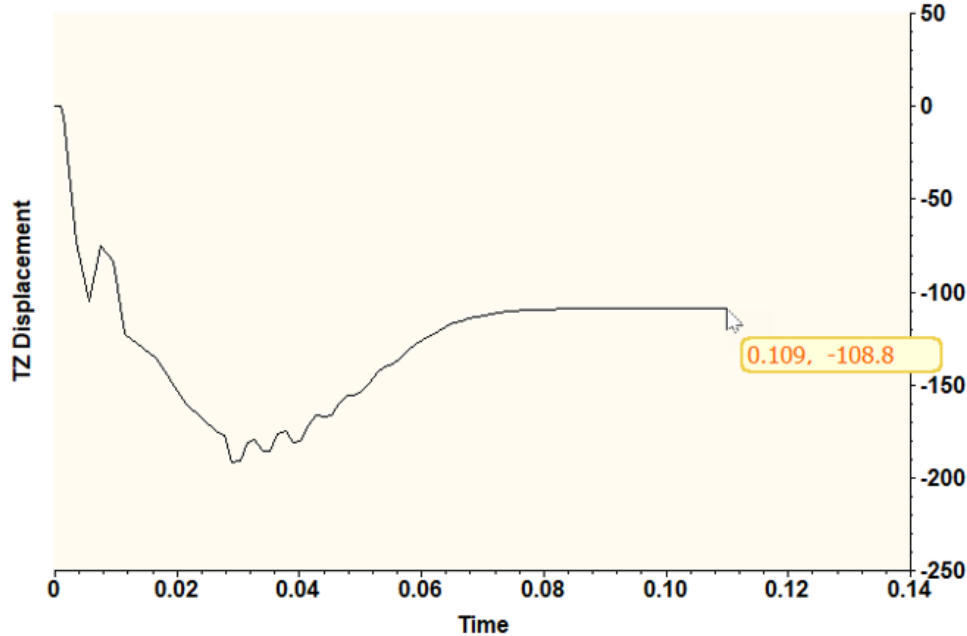
Skip Factor (for output): 1

OK Cancel

Nastran Demonstration 2

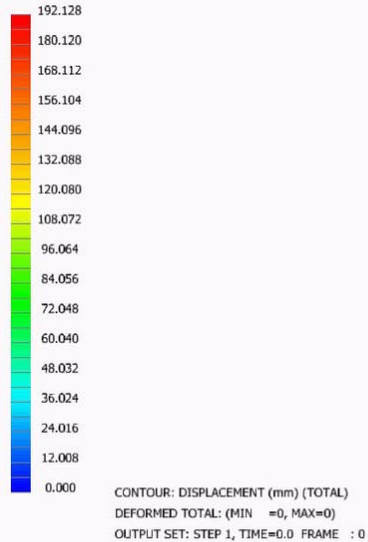
Nastran Nonlinear Transient Response Analysis

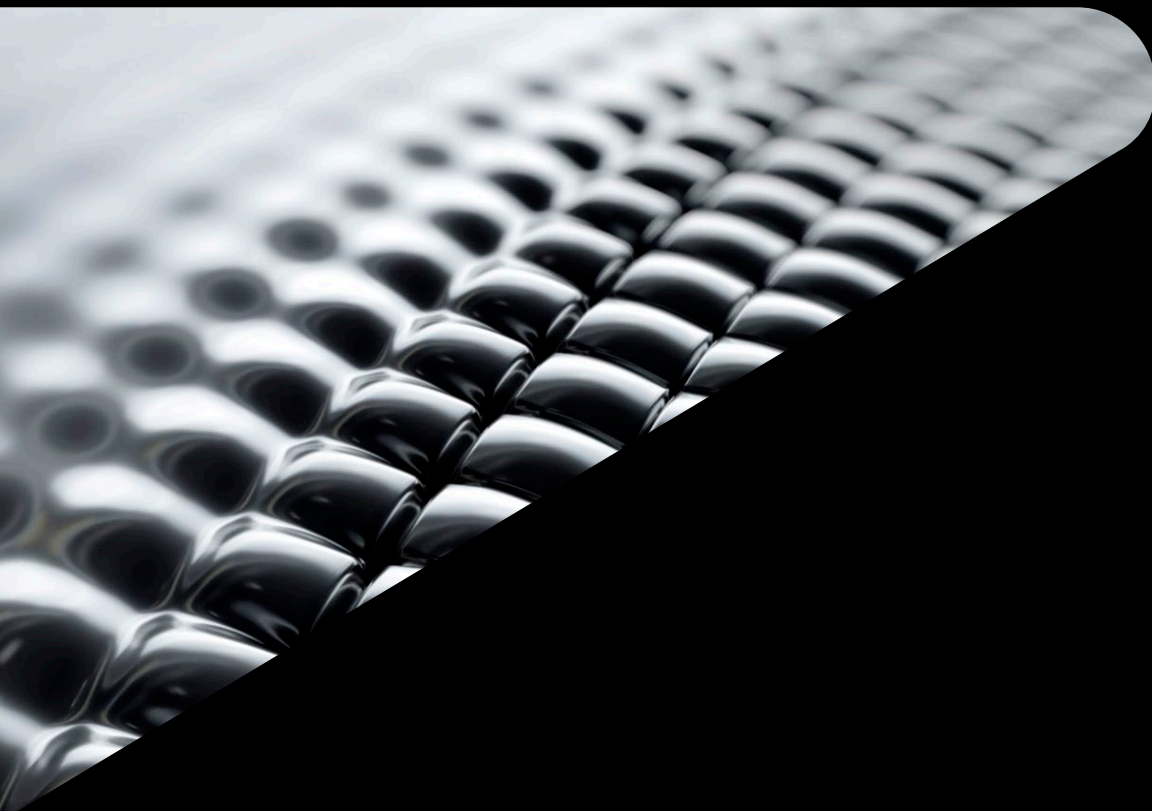
TZ Displacement vs Time, Node 10915



Nastran Demonstration 2

Nastran Nonlinear Transient Response Analysis





3- Euro EMC Products



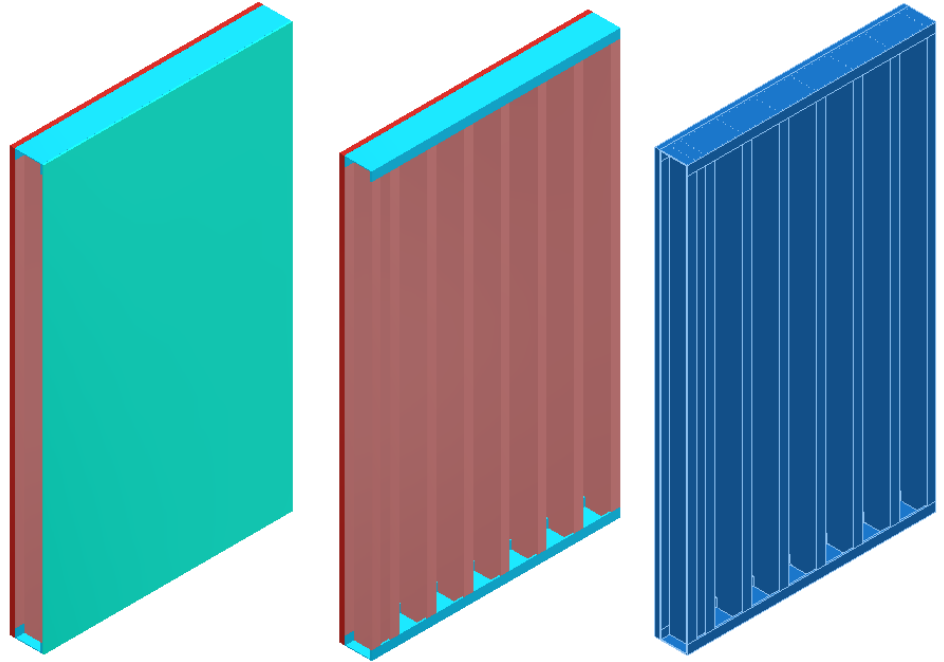
Blast Door

- Goal
 - Is to determine whether the door contains the blast from outside
- Key Information
 - Steel 355 nonlinear material behavior.
 - Blast Load = 200MN of 3ms impulse duration

Workflow considerations

Alternative physical test is not sustainable.

- Geometry
 - Simplification
 - Remove nonstructural components
 - Remove nonstructural features
 - Remodeling
 - A simplified solid assembly
 - A simplified solid model (part)
 - A simplified surface model



Workflow considerations

- Material Information (Elastic/Plastic)
 - Plastic (100% Plastic)
 - Worst case scenario

Nonlinear Material Data

Type

☐ None

☐ Nonlinear Elastic

☐ Elasto-Plastic (Bi-Linear)

☒ Plastic

Properties

Tangent Modulus, E_t (MPa): 20500

Hardening Rule: Isotropic

Yield Function

Yield Criterion: von Mises

Initial Yield Stress (MPa): 355

Friction Angle (deg): 0

Dilation Angle (deg): 0

Yield Curve Type: Compression

Strain	Stress (MPa)
0	0
0.001731707317	355
0.5	355

Stress (MPa) Vs Strain

Show XY Plot OK Cancel

Workflow considerations

- Dynamic Load Information
 - Set up Load duration

The image shows two overlapping dialog boxes from a software application. The 'Load' dialog box on the left is for defining a load, and the 'Table Data' dialog box on the right is for defining a table of data.

Load Dialog Box:

- Name: Load 1
- ID: 1
- Type: Force
- Sub Type: (empty)
- Selected Entities: face<145>
- Subcases: Subcase 1
- Display Options: Size (slider), Density (slider), Color (green)
- Advanced Options >>
- Load Definition: Direction (Components), Coordinate System (Part 1), Total Force (checkbox), Magnitude (N): F_x (0), F_y (0), F_z (2e+8)
- Transient Table Data: Table 1

Table Data Dialog Box:

- Name: Table 1
- ID: 1
- Type: Load Scale Factor vs. Time
- Table:

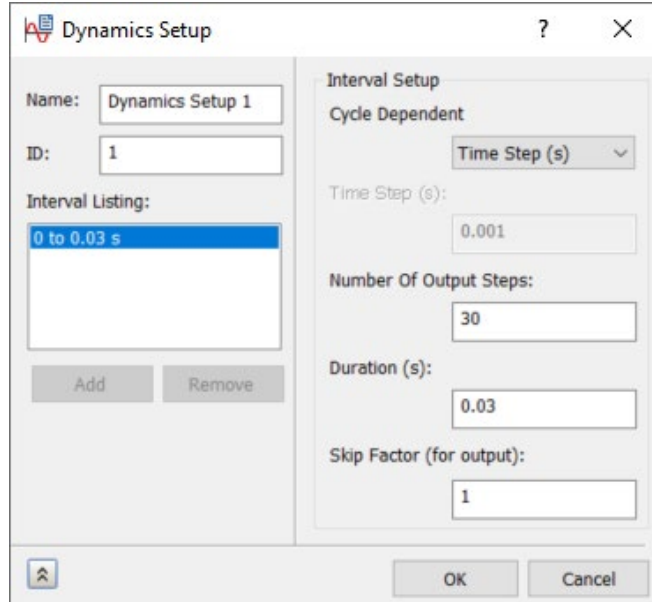
Time (s)	Load Scale Factor
0	1
0.003	1
0.0031	0
0.005	0

- Sort Data button
- Show XY Plot button
- OK button
- Cancel button

The 'Table Data' dialog box also includes a plot titled 'Load Scale Factor vs. Time' showing a step function where the load scale factor drops from 1 to 0 at 0.0031 seconds.

Workflow considerations

- Dynamic Setup Data
 - Number of Result steps
 - Time duration (maximum deformation achieved)



The screenshot shows the 'Dynamics Setup' dialog box. It has a title bar with a question mark and a close button. The dialog is divided into two main sections. The left section contains fields for 'Name' (Dynamics Setup 1) and 'ID' (1). Below these is an 'Interval Listing' section with a list box containing '0 to 0.03 s'. There are 'Add' and 'Remove' buttons below the list box. The right section is titled 'Interval Setup' and contains a 'Cycle Dependent' dropdown menu set to 'Time Step (s)'. Below this are input fields for 'Time Step (s)' (0.001), 'Number Of Output Steps' (30), 'Duration (s)' (0.03), and 'Skip Factor (for output)' (1). At the bottom of the dialog are 'OK' and 'Cancel' buttons.

Dynamics Setup

Name: Dynamics Setup 1

ID: 1

Interval Listing:

- 0 to 0.03 s

Add Remove

Interval Setup

Cycle Dependent: Time Step (s)

Time Step (s): 0.001

Number Of Output Steps: 30

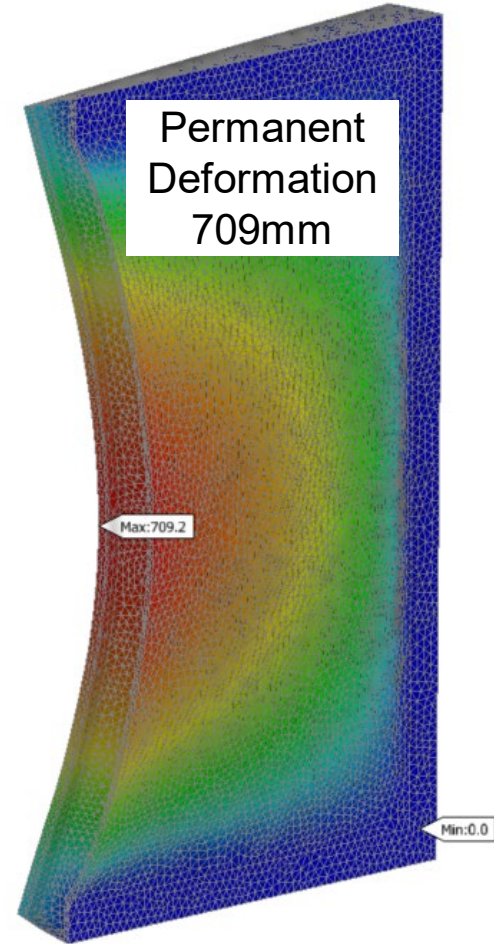
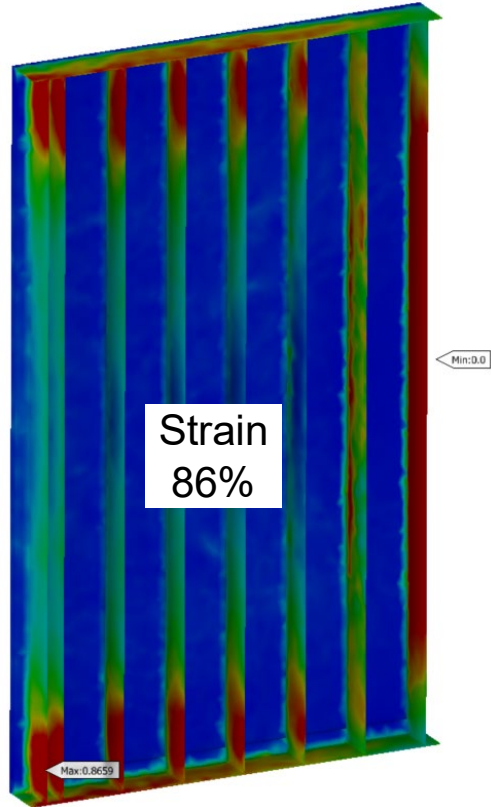
Duration (s): 0.03

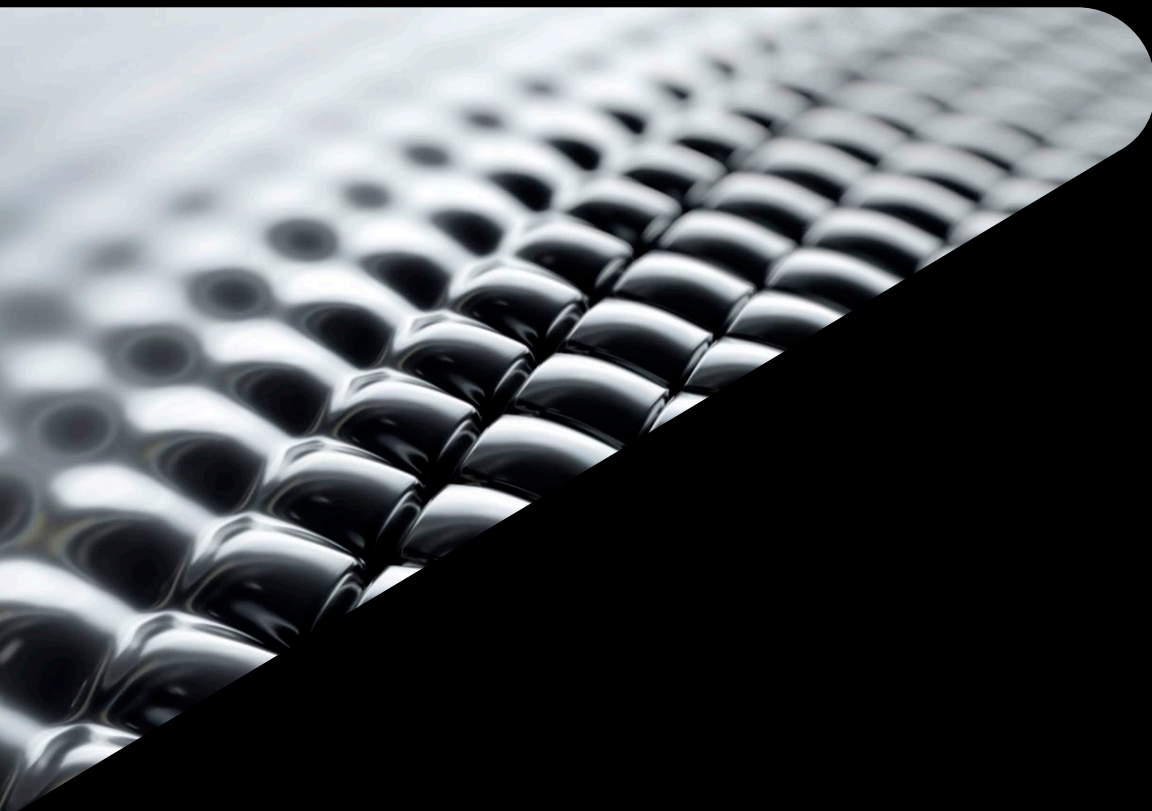
Skip Factor (for output): 1

OK Cancel

Nastran Demonstration 3

Explicit Dynamics Study

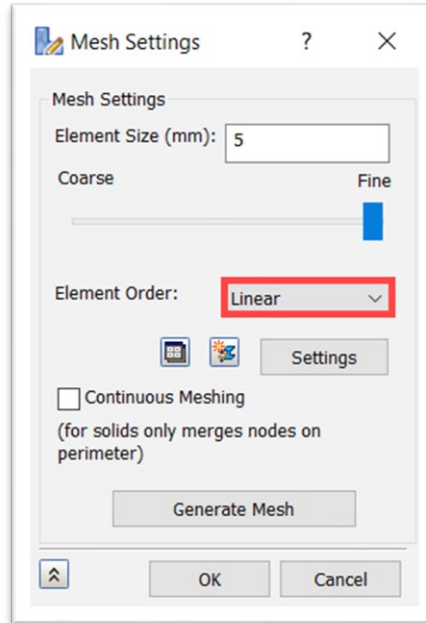




10 TOP TIPS

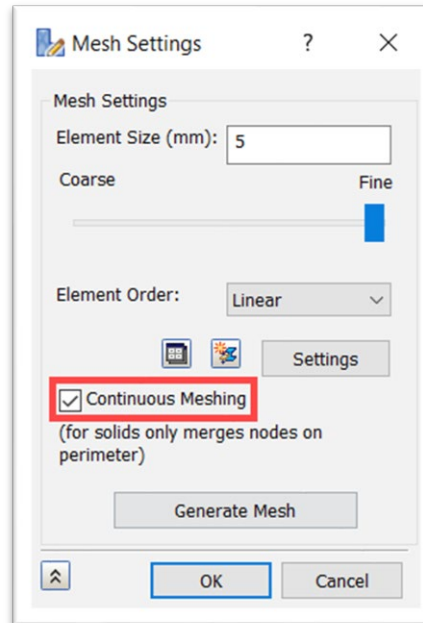
TIP 1

- Use Linear Elements



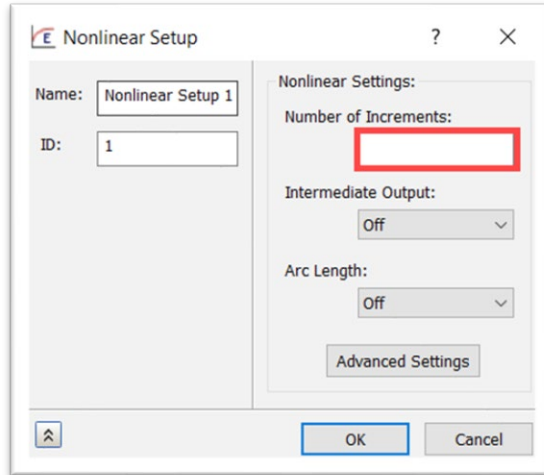
TIP 2

- Use Continuous Meshing for Surface models
 - Surfaces will need to be connected



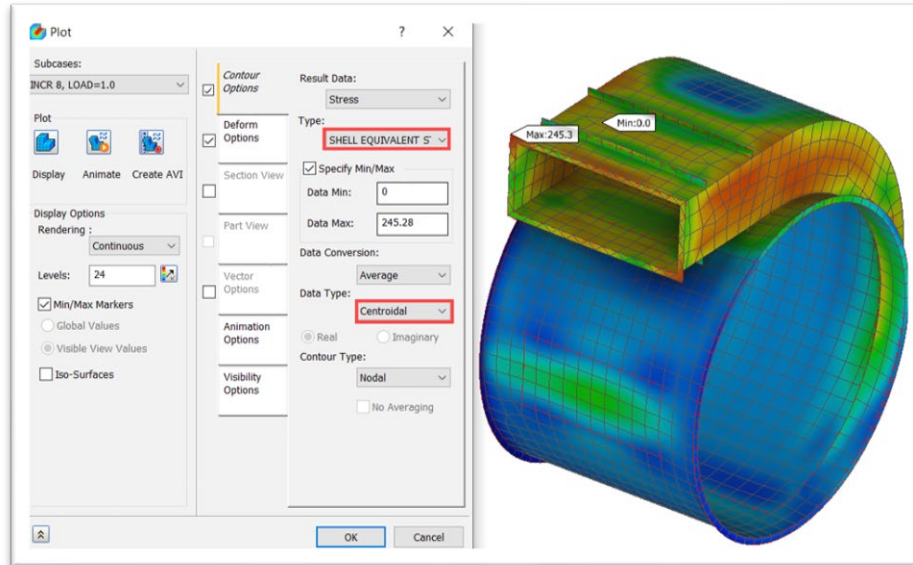
TIP 3

- Leave the Number of Increments field blank



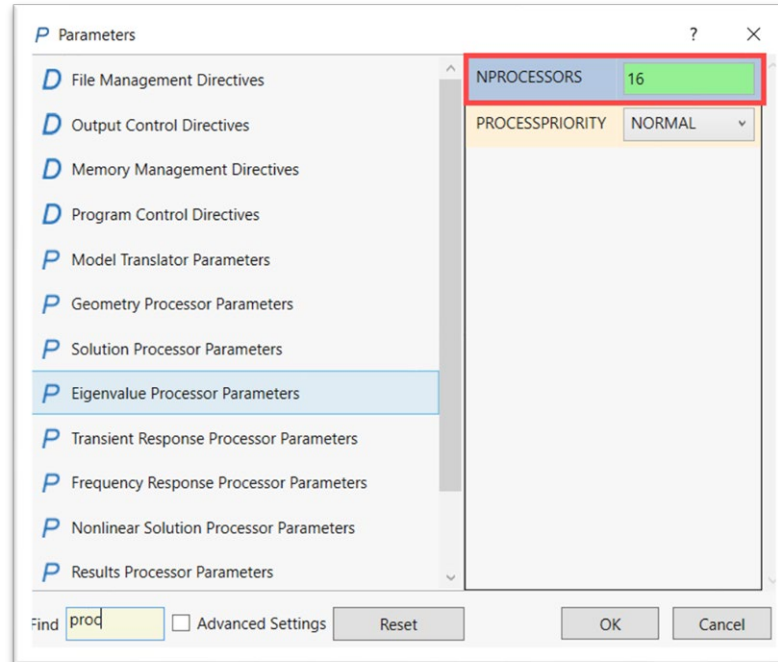
TIP 4

- Use and Display Equivalent Stress Results
 - This stress plot follows the defined stress & strain curve
 - Centroidal Data Type



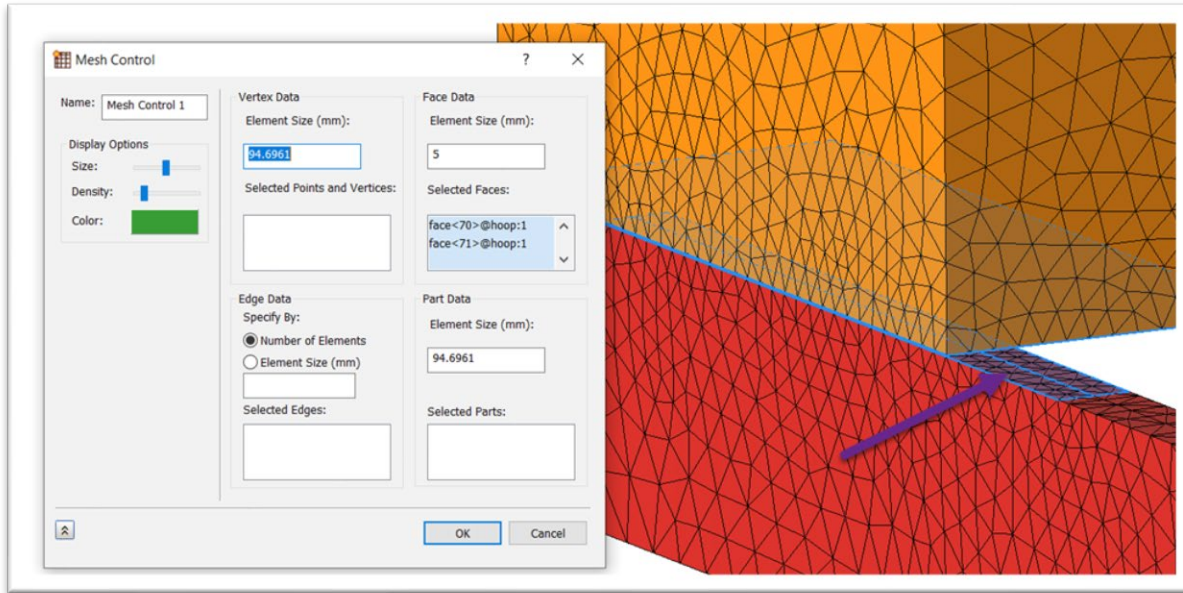
TIP 5

- Use the NPROCESSORS Parameter
 - To enable Nastran to use all cores available



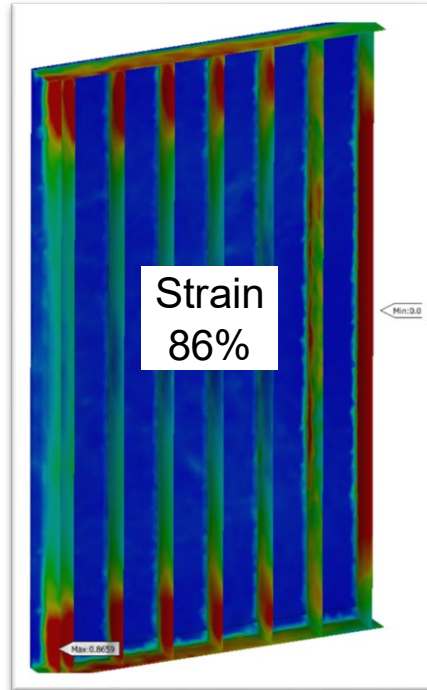
TIP 6

- Use Split faces to reduce mesh size when defining local mesh control



TIP 7

- Use Explicit Solvers when your designs are experiencing high strains



TIP 8

- Run Modal Analysis to determine Dominant Frequency W3

Damping

Name: Damping 1
ID: 1

☒ Structural Damping
Damping Value, G (%):
P 5

Dominant Frequency, W3 (Hz):
P 50

Dominant Frequency, W4 (Hz):
P

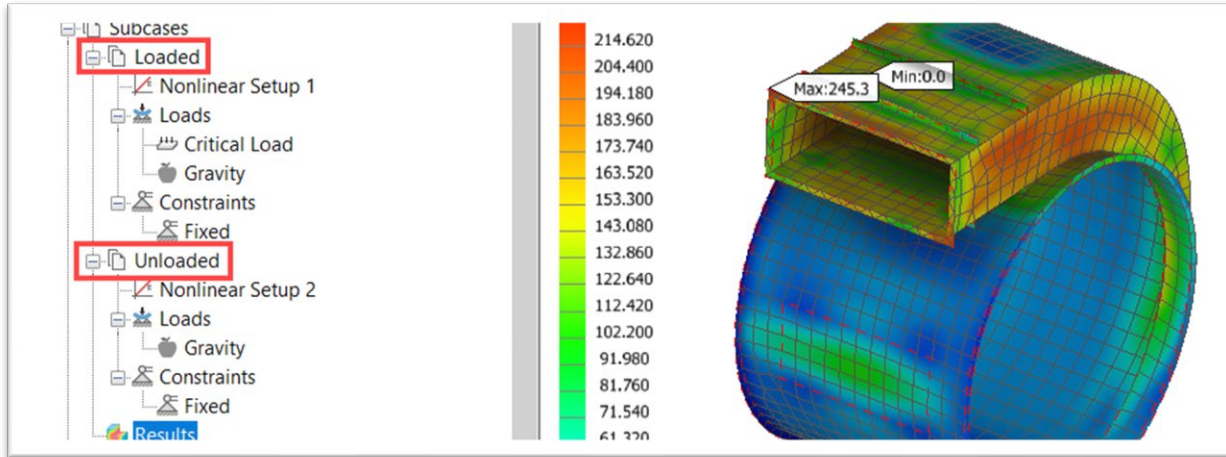
☐ Rayleigh Damping
Mass Proportional, ALPHA:
P
Stiffness Proportional, BETA:
P

☐ Modal Damping
Type: Constant
Damping Definition: Percent Critical
Damping Value(%):

OK Cancel

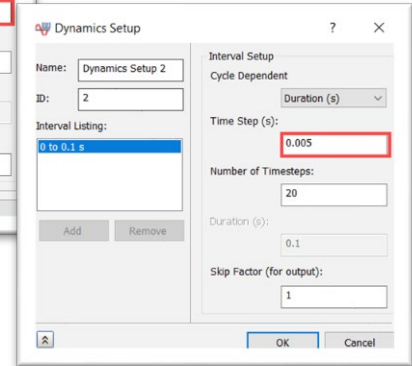
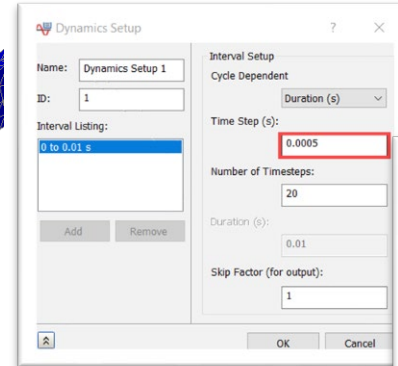
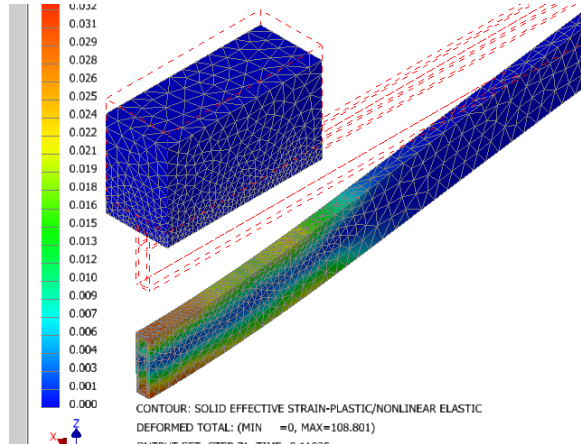
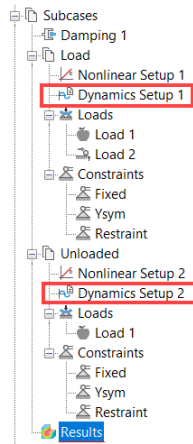
TIP 9

- Use multiple subcases to determine permanent deformations in Nonlinear Static Analysis



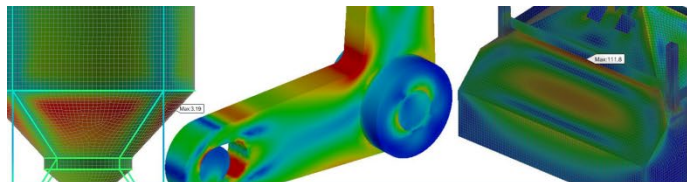
TIP 10

- Use multiple subcases to allow different time steps in Nonlinear Transient Response Analysis



Further learning

Book available from Amazon worldwide.



Up and Running with Autodesk® Inventor® Nastran® 2023 Nonlinear Analysis

Unleash the advanced power of Autodesk® Inventor® Nastran® to streamline your product design process with expert guidance, tips and knowledge from a leading simulation expert.

This 1st Edition covers Nonlinear Analysis capabilities of Inventor Nastran 2023. This edition covers both Implicit and Explicit solvers including Impact and Elastic/Plastic Analysis.

Step-by-step guide to engineering design solutions, with extensive tips and guidance throughout the book.

Book primarily designed for self-paced learning by individuals, but can be equally used in an instructor-led classroom environment.

Gain confidence in your results fast by analysing real-life design problems.

Up and Running with Autodesk® Inventor® Nastran® 2023 is dedicated to the requirements of Inventor users who need to quickly learn or refresh their skills and apply advanced Inventor Nastran analysis capabilities on real life examples. Providing clear guidance and all-important real-world tutorials, the step-by-step, heavily-illustrated approach of this book will help designers, engineers, and manufacturers of all skill levels become Simulation experts.



A passionate simulation expert with more than 30 years of experience in the manufacturing field. Been involved with Autodesk simulation software from when it was first introduced, and is well-known throughout the Autodesk simulation community, worldwide. He has also authored the Up and Running with Autodesk Inventor Professional books including both Inventor Stress Analysis and Dynamic Simulation.

Download book exercises from:
<https://tinyurl.com/2c5w49bk>

Up and Running with
Autodesk® Inventor® Nastran® 2023

Wasim Younis

Up and Running with Autodesk® Inventor® Nastran 2023

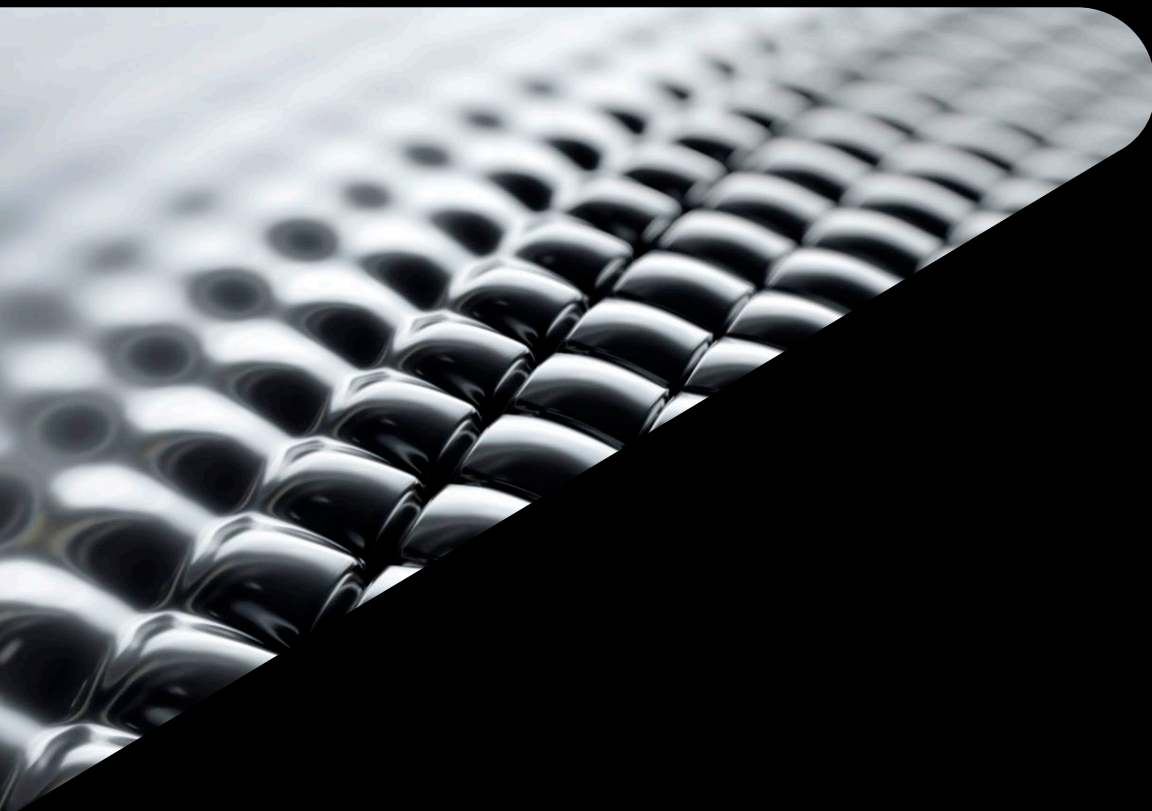
Nonlinear Analysis





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Q & A