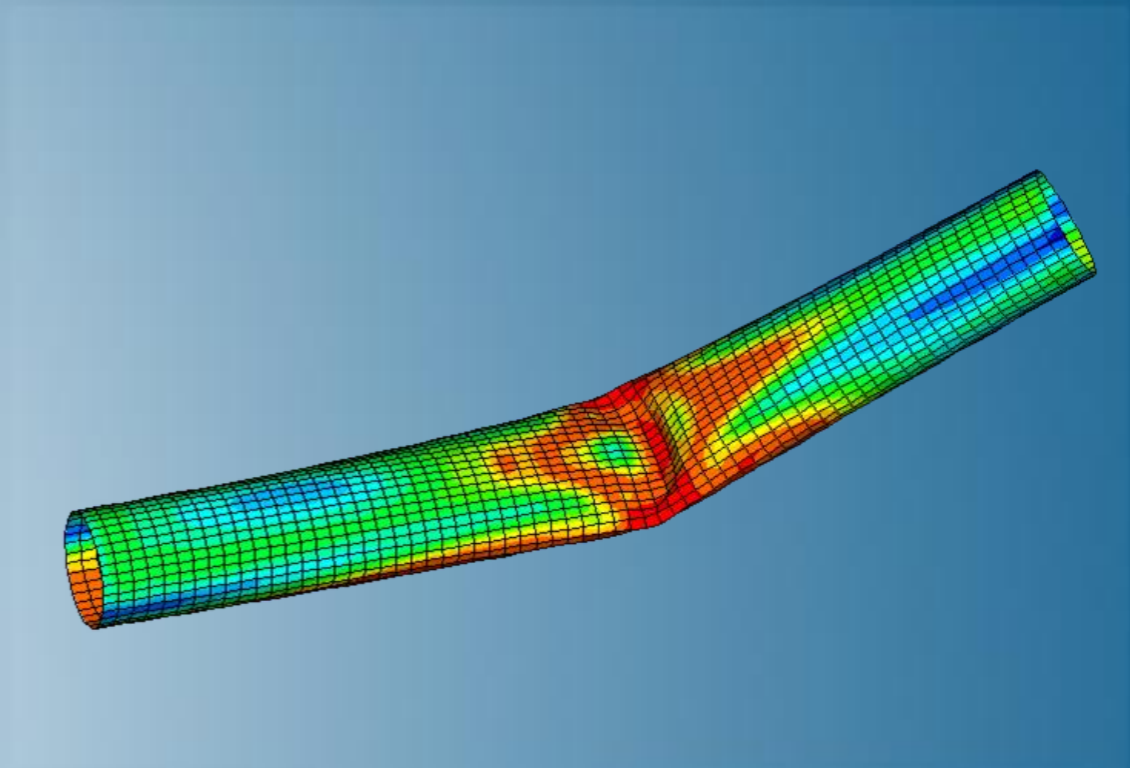


Buckling, Postbuckling, and Collapse Analysis with Abaqus

Abaqus 2018



3DEXPERIENCE[®]



About this Course

Course objectives

Upon completion of this course you will be able to:

- ▶ Perform linear eigenvalue buckling analysis
- ▶ Perform postbuckling analysis using the regular and damped static solution procedures
- ▶ Perform postbuckling analysis using the modified Riks method
- ▶ Perform postbuckling analysis using dynamics solution procedures

Targeted audience

Simulation Analysts

Prerequisites

This course is recommended for engineers with experience using Abaqus



2 days

Day 1

- ▶ Lecture 1 Basic Concepts and Overview
- ▶ Lecture 2 Linear and Nonlinear FEA with Abaqus
- ▶ Lecture 3 Eigenvalue Buckling Analysis
 - Workshop 1 Elastic Buckling of a Stiffened Cylindrical Shell
 - Workshop 2 Eigenvalue Buckling of a Ring (optional)
- ▶ Lecture 4 Regular Static Solution Procedure
 - Workshop 3 Nonlinear Buckling of a Stiffened Cylindrical Shell

Day 2

- ▶ Lecture 5 Damped Static Solution Procedure
 - Workshop 3 Nonlinear Buckling of a Stiffened Cylindrical Shell (continued)
 - Workshop 4 Static Buckling Analysis of a Circular Arch

- ▶ Lecture 6 Modified Riks Static Solution Procedure
 - Workshop 4 Static Buckling Analysis of a Circular Arch (continued)

- ▶ Lecture 7 Dynamic Analysis Solution Procedures
 - Workshop 4 Static Buckling Analysis of a Circular Arch (continued)
 - Workshop 5 Tube Crush Dynamic Analysis

- ▶ Lecture 8 Putting It All Together...
 - Workshop 6 Lee's Frame Buckling Problem
 - Workshop 7 Buckling and Postbuckling of a Crane Structure (optional)
 - Workshop 8 Buckling and Postbuckling of a Stiffened Panel (optional)

Additional Material

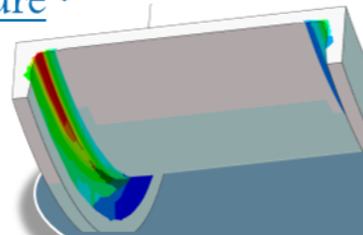
- ▶ Appendix 1 Geometrically Nonlinear Analysis
- ▶ Appendix 2 Dashpots

SIMULIA

- ▶ SIMULIA is the Dassault Systèmes brand for Realistic Simulation solutions
- ▶ Portfolio of established, best-in-class products
 - Abaqus, Isight, Tosca, fe-safe, Simpack

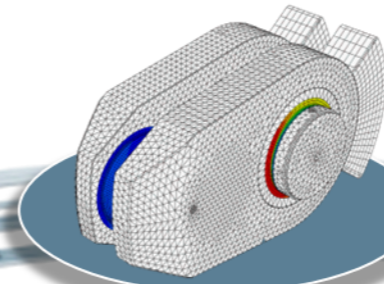
Design Optimization: Tosca Structure *

Simulation-driven design refinement to improve performance



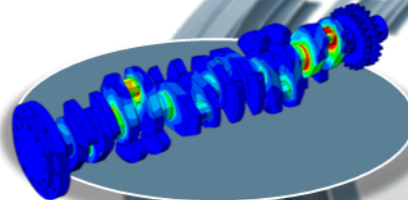
Durability Assessment: fe-safe *

Accurate life estimation to achieve certification



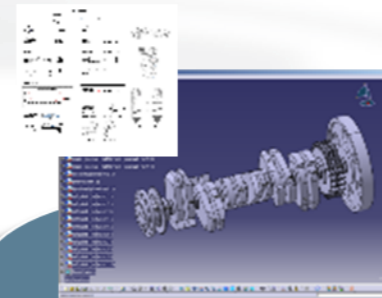
FEA Stress Analysis: Abaqus *

Detailed stress analysis using extracted load history from MBS



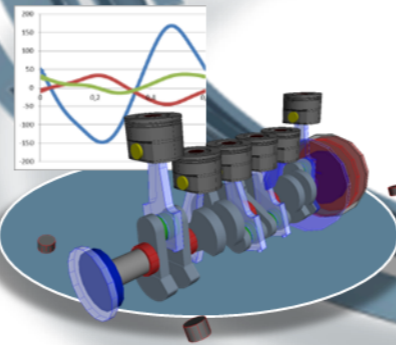
CAD Geometry: CATIA

Fully parameterized 3D geometry; FEA model generation via associative interface



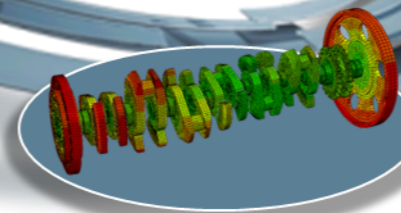
Multibody Simulation: Simpack

System analysis to extract virtual load history of complete working cycle



Mesh Calibration: Isight *

Automated mesh calibration; sufficient mesh quality for accurate results

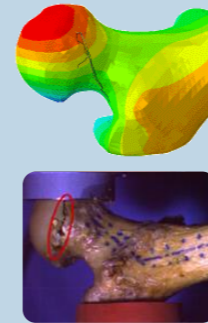


* Included in extended licensing pool

SIMULIA's Power of the Portfolio

Abaqus

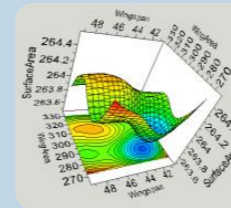
- Routine and Advanced Simulation
- Linear and Nonlinear, Static and Dynamic
- Thermal, Electrical, Acoustics
- Extended Physics through Co-simulation
- Model Preparation and Visualization



Realistic Human Simulation
High Speed Crash & Impact
Noise & Vibration

Isight

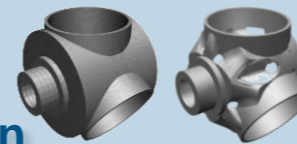
- Process Integration
- Design Optimization
- Parametric Optimization
- Six Sigma and Design of Experiments



Material Calibration
Workflow Automation
Design Exploration

Tosca

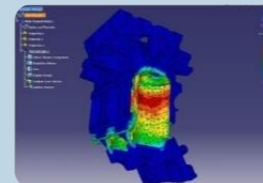
- Non-Parametric Optimization
- Structural and Fluid Flow Optimization
- Topology, Sizing, Shape, Bead Optimization



Conceptual/Detailed Design
Weight, Stiffness, Stress
Pressure Loss Reduction

fe-safe

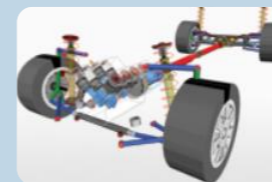
- Durability Simulation
- Low Cycle and High Cycle Fatigue
- Weld, High Temperature, Non-metallics



Safety Factors
Creep-Fatigue Interaction
Weld Fatigue

Simpack

- 3D Multibody Dynamics Simulation
- Mechanical or Mechatronic Systems
- Detailed Transient Simulation (Offline and Realtime)



Complete System Analyses
(Quasi-)Static, Dynamics, NVH
Flex Bodies, Advanced
Contact

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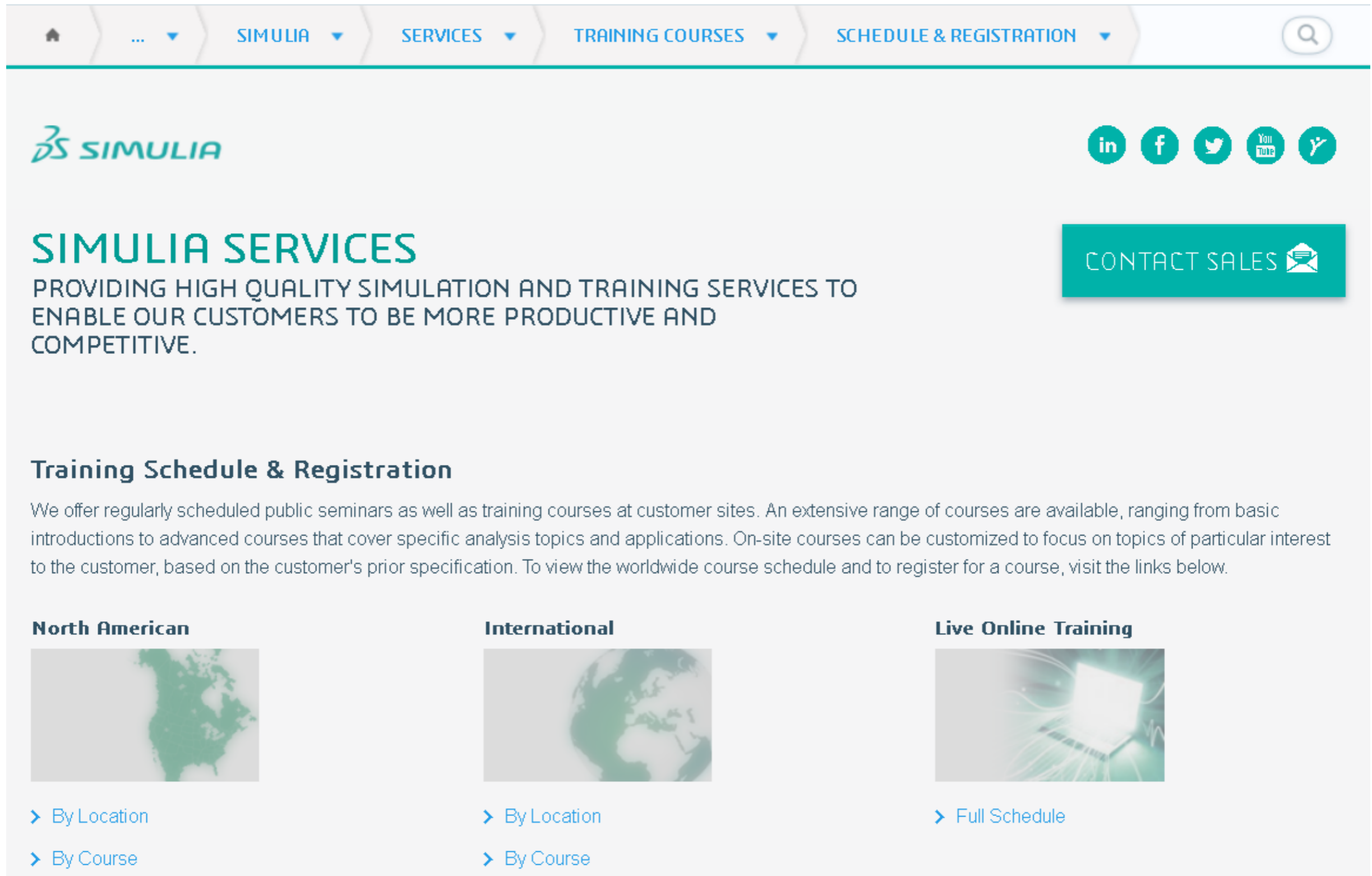
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Revision Status

Lecture 1	11/17	Updated for Abaqus 2018
Lecture 2	11/17	Updated for Abaqus 2018
Lecture 3	11/17	Updated for Abaqus 2018
Lecture 4	11/17	Updated for Abaqus 2018
Lecture 5	11/17	Updated for Abaqus 2018
Lecture 6	11/17	Updated for Abaqus 2018
Lecture 7	11/17	Updated for Abaqus 2018
Lecture 8	11/17	Updated for Abaqus 2018
Appendix 1	11/17	Updated for Abaqus 2018
Appendix 2	11/17	Updated for Abaqus 2018
Workshop 1	11/17	Updated for Abaqus 2018
Workshop 2	11/17	Updated for Abaqus 2018
Workshop 3	11/17	Updated for Abaqus 2018
Workshop 4	11/17	Updated for Abaqus 2018
Workshop 5	11/17	Updated for Abaqus 2018
Workshop 6	11/17	Updated for Abaqus 2018
Workshop 7	11/17	Updated for Abaqus 2018
Workshop 8	11/17	Updated for Abaqus 2018

Lesson 1: Basic Concepts and Overview

Lesson content:

- ▶ Introduction
- ▶ Revisiting Classical Stability Problems
- ▶ Solution Techniques
- ▶ Example: Lee's Frame Buckling Problem
- ▶ Summary



1 hour

Lesson 2: Linear and Nonlinear FEA with Abaqus

Lesson content:

- ▶ Basic Equations in Finite Element Analysis
- ▶ Linearization
- ▶ Nonlinear Problems in Mechanics
- ▶ General and Perturbation Procedures
- ▶ Including Nonlinear Effects in an Abaqus Simulation
- ▶ Summary



1 hour

Lesson 3: Eigenvalue Buckling Analysis

Lesson content:

- ▶ Introduction
- ▶ Eigenvalue Problem Formulation
- ▶ Abaqus Usage
- ▶ Example: Buckling of a Thin Cylindrical Shell
- ▶ Closely Spaced Eigenvalues
- ▶ Boundary Conditions and Symmetry in Buckling Analyses
- ▶ Concluding Remarks
- ▶ Workshop Preliminaries
- ▶ Workshop 1: Elastic Buckling of a Stiffened Cylindrical Shell (IA)
- ▶ Workshop 1: Elastic Buckling of a Stiffened Cylindrical Shell (KW)
- ▶ Workshop 2: Eigenvalue Buckling of a Ring (IA)
- ▶ Workshop 2: Eigenvalue Buckling of a Ring (KW)



Both interactive (IA) and keywords (KW) versions of the workshops are provided. Complete only one.



2 hours

Lesson 4: Regular Static Solution Procedure

Lesson content:

- ▶ Introduction
- ▶ Introducing Imperfections for Postbuckling Simulations
- ▶ Solving Nonlinear Problems with Implicit Techniques
- ▶ Solution Control
- ▶ Automatic Time Incrementation
- ▶ Diagnostic Information
- ▶ Limitations of Regular Static Procedure
- ▶ Concluding Remarks
- ▶ Workshop 3: Nonlinear Buckling of a Stiffened Cylindrical Shell (IA)
- ▶ Workshop 3: Nonlinear Buckling of a Stiffened Cylindrical Shell (KW)



Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.



2.5 hours

Lesson 5: Damped Static Solution Procedure

Lesson content:

- ▶ Introduction
- ▶ Damping in Static Analyses
- ▶ Automatic Stabilization
- ▶ Automatic Stabilization Examples
- ▶ Postbuckling and Loss of Contact
- ▶ Concluding Remarks
- ▶ Workshop 3: Nonlinear Buckling of a Stiffened Cylindrical Shell (IA, cont'd)
- ▶ Workshop 3: Nonlinear Buckling of a Stiffened Cylindrical Shell (KW, cont'd)
- ▶ Workshop 4: Static Buckling Analysis of a Circular Arch (IA)
- ▶ Workshop 4: Static Buckling Analysis of a Circular Arch (KW)



Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.



2 hours

Lesson 6: Modified Riks Static Solution Procedure

Lesson content:

- ▶ Introduction
- ▶ Abaqus Implementation
- ▶ Abaqus Usage
- ▶ Snap-Through Problems
- ▶ Postbuckling Problems
- ▶ Postbuckling Examples
- ▶ Usage Tips
- ▶ Limitations
- ▶ Concluding Remarks
- ▶ Workshop 4 (continued): Static Buckling Analysis of a Circular Arch (IA)
- ▶ Workshop 4 (continued): Static Buckling Analysis of a Circular Arch (KW)



Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.



1.5 hours

Lesson 7: Dynamic Analysis Solution Procedures

Lesson content:

- ▶ Overview
- ▶ What Makes a Problem Dynamic?
- ▶ Equations for Dynamic Problems
- ▶ Nonlinear Dynamics
- ▶ Comparing Abaqus/Standard and Abaqus/Explicit
- ▶ Workshop 4 (continued): Static Buckling Analysis of a Circular Arch (IA)
- ▶ Workshop 4 (continued): Static Buckling Analysis of a Circular Arch (KW)
- ▶ Analyzing Highly Nonlinear Quasi-Static Problems
- ▶ Quasi-Static Simulations Using Explicit Dynamics
- ▶ Example: Dynamic Tube Collapse
- ▶ Concluding Remarks
- ▶ Workshop 5: Tube Crush Dynamic Analysis (IA)
- ▶ Workshop 5: Tube Crush Dynamic Analysis (KW)



Both interactive (IA) and keywords (KW) versions of the workshops are provided. Complete only one.



2.5 hours

Lesson 8: Putting It All Together...

Lesson content:

- ▶ Buckling Analysis Selection Guide
- ▶ Weatherseal Example
- ▶ References for Further Study
- ▶ Workshop 6: Lee's Frame Buckling Problem (IA)
- ▶ Workshop 6: Lee's Frame Buckling Problem (KW)
- ▶ Workshop 7: Buckling and Postbuckling of a Crane Structure (IA)
- ▶ Workshop 7: Buckling and Postbuckling of a Crane Structure (KW)
- ▶ Workshop 8: Buckling and Postbuckling of a Stiffened Panel (IA)
- ▶ Workshop 8: Buckling and Postbuckling of a Stiffened Panel (KW)



Both interactive (IA) and keywords (KW) versions of the workshops are provided. Complete only one.



1.5 hours

Appendix 1: Geometrically Nonlinear Analysis

Appendix content:

- ▶ Introduction
- ▶ Equilibrium and Virtual Work
- ▶ Deformation and Strain
- ▶ Large Rotations
- ▶ Follower Forces



30 minutes

Appendix 2: Dashpots

Appendix content:

- ▶ Dashpots



15 minutes