

# Buckling, Postbuckling, and Collapse Analysis with Abaqus

Abaqus 2020







## **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



### Day 1

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

	Lesson 5	Damped Static Solution Procedure		
	Workshop 3	Nonlinear Buckling of a Stiffened Cylindrical Shell (continued)		
	Workshop 4	Static Buckling Analysis of a Circular Arch		
	Lesson 6	Modified Riks Static Solution Procedure		
	Workshop 4	Static Buckling Analysis of a Circular Arch (continued)		
	Lesson 7	Dynamic Analysis Solution Procedures		
	Workshop 4	Static Buckling Analysis of a Circular Arch (continued)		
	Workshop 5	Tube Crush Dynamic Analysis		
Lesson 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

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Lesson 1	11/19	Updated for Abaqus 2020
Lesson 2	11/19	Updated for Abaqus 2020
Lesson 3	11/19	Updated for Abaqus 2020
Lesson 4	11/19	Updated for Abaqus 2020
Lesson 5	11/19	Updated for Abaqus 2020
Lesson 6	11/19	Updated for Abaqus 2020
Lesson 7	11/19	Updated for Abaqus 2020
Lesson 8	11/19	Updated for Abaqus 2020
Appendix 1	11/19	Updated for Abaqus 2020
Appendix 2	11/19	Updated for Abaqus 2020
Workshop 1	11/19	Updated for Abaqus 2020
Workshop 2	11/19	Updated for Abaqus 2020
Workshop 3	11/19	Updated for Abaqus 2020
Workshop 4	11/19	Updated for Abaqus 2020
Workshop 5	11/19	Updated for Abaqus 2020
Workshop 6	11/19	Updated for Abaqus 2020
Workshop 7	11/19	Updated for Abaqus 2020
Workshop 8	11/19	Updated for Abaqus 2020

## **Lesson 1: Basic Concepts and Overview**

#### Lesson content:

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

# **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



# Lesson 3: Eigenvalue Buckling Analysis

### Lesson content:

- Introduction
- Eigenvalue Problem Formulation
- Abaqus Usage
- Example: Buckling of an Imperfection-Sensitive 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.



## **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.



## **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.



# **Lesson 6: Modified Riks Static Solution Procedure**

#### Lesson content:

- Introduction
- How Does the Riks Method Work?
- Abaqus Usage
- Snap-Through Example
- 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.



## **Lesson 7: Dynamic Solution Procedures**

### Lesson content:

- Introduction
- Equations for Dynamic Problems
- Direct Integration of the Equations of Motion
- Implicit Dynamics for Quasi-Static Postbuckling Problems
- ▶ Workshop 4 (continued): Static Buckling Analysis of a Circular Arch (IA)
- Workshop 4 (continued): Static Buckling Analysis of a Circular Arch (KW)
- Explicit Dynamics for Quasi-Static Postbuckling Problems
- Explicit Dynamics for Dynamic Postbuckling Problems
- 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.



## 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.



# **Appendix 1: Geometrically Nonlinear Analysis**

### Appendix content:

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



# **Appendix 2: Dashpots**

### Appendix content:

Dashpots

