Modeling Contact with Abaqus/Standard

2016
Course objectives
Upon completion of this course you will be able to:

- Define general contact and contact pairs
- Define appropriate surfaces (rigid or deformable)
- Model frictional contact
- Model large sliding between deformable bodies
- Resolve overclosures in interference fit problems

Targeted audience
Simulation Analysts

Prerequisites
This course is recommended for engineers with experience using Abaqus/Standard
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Day 2

- Lecture 5: Contact Properties
  - Workshop 4 Disk Forging Analysis
- Lecture 6: Interference Fits
  - Workshop 5 Interference Fit Analysis
  - Workshop 6 Syringe Analysis (optional)
- Lecture 7: Additional Features
  - Workshop 7 Pipe Reel Analysis
- Lecture 8: Modeling Tips
  - Workshop 8 Snap Fit Analysis
  - Workshop 9 Analysis of a Radial Shaft Seal
Additional Material

- Appendix 1: Node-to-Surface Formulation
- Appendix 2: Contact Elements
- Appendix 3: Dynamic Contact using Implicit Integration
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- Portfolio of established, best-in-class products
  - Abaqus, Isight, Tosca, fe-safe
  - All using a common extended licensing pool
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**Abaqus**
- Routine and Advanced Simulation
- Linear and Nonlinear, Static and Dynamic
- Fluid, Thermal, Electrical, Acoustics
- Extended Physics through Co-simulation
- Model Preparation and Visualization

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

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

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

- Realistic Human Simulation
- High Speed Crash & Impact
- Noise & Vibration

- Material Calibration
- Workflow Automation
- Design Exploration

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

- Safety Factors
- Creep-Fatigue Interaction
- Weld Fatigue
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Lesson content:

- General Considerations
- Surface-based Contact
- Contact Examples
- Ingredients of a Contact Model
Lesson 2: Contact Workflow

Lesson content:

- Defining Contact Pairs
- Defining Surfaces for Contact Pairs
- Defining General Contact
- Workshop Preliminaries
- Workshop 1: Compression of a Rubber Seal (IA)
- Workshop 1: Compression of a Rubber Seal (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 3: Surface-based Contact

Lesson content:

- Contact Formulations
- Contact Discretization
- Contact Enforcement Methods
- Relative Sliding Between Bodies
- Output of Contact Results
- Summary
- Workshop 2: Lap Joint Analysis (IA)
- Workshop 2: Lap Joint Analysis (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 4: Contact Logic and Diagnostics Tools

Lesson content:

- Newton Method
- The Contact Algorithm
- Contact Diagnostics: Visual
- Contact Diagnostics: Text
- Workshop 3: Bolted Flange Analysis (IA)
- Workshop 3: Bolted Flange Analysis (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 5: Contact Properties

Lesson content:

- Pressure-Overclosure Models
- Friction Models
- Friction Enforcement
- Workshop 4: Disk Forging Analysis (IA)
- Workshop 4: Disk Forging Analysis (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 6: Interference Fits

Lesson content:

- Initial Overclosure
- Strain-free Adjustments
- Interference Fit Problems
- Interference Fit Techniques for General Contact
- Interference Fit Techniques for Contact Pairs
- Interference Fit Example
- Precise Specification of Clearances
- Geometric Smoothing for Curved Surfaces
- Workshop 5: Interference Fit Analysis (IA)
- Workshop 5: Interference Fit Analysis (KW)
- Workshop 6: Syringe Analysis (IA)
- Workshop 6: Syringe Analysis (KW)

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

3 hours
Lesson 7: Additional Features

Lesson content:

- Beam Contact
- Tie Constraints
- Rigid Bodies and Contact
- Analytical Rigid Surfaces
- Pre-Tensioning of Cross-Sections
- Pressure Penetration
- Workshop 7: Pipe Reel Analysis (IA)
- Workshop 7: Pipe Reel Analysis (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 8: Modeling Tips

Lesson content:

- Initial Rigid Body Motion
- Overconstraint
- Contact with Quadratic Elements
- Unsymmetric Matrices in Finite-Sliding Problems
- Dynamic Instabilities
- Modeling Corners and Edges
- Workshop 8: Snap Fit Analysis (IA)
- Workshop 8: Snap Fit Analysis (KW)
- Workshop 9: Analysis of a Radial Shaft Seal (IA)
- Workshop 9: Analysis of a Radial Shaft Seal (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Appendix 1: Node-to-Surface Formulation

Appendix content:

- Discretization
- Finite Sliding: Surface Considerations
- Small Sliding Characteristics
- Small Sliding: Local Contact Plane
- Small Sliding: Surface Considerations
Appendix 2: Contact Elements

Appendix content:

- Surface-Based vs. Contact Element Approach
- Contact Elements
- Contact Element Output
- Contact Element Visualization
Appendix 3: Dynamic Contact using Implicit Integration

Appendix content:

- Time Integration Issues
- Implicit Dynamics
- Damping
- Impact Problems
- Contact in Linear Perturbation Procedures
Obtaining a Converged Solution with Abaqus

2016
Course objectives
Upon completion of this course you will be able to:

- Understand how nonlinear problems are solved in Abaqus
- Develop Abaqus models that will converge
- Identify modeling errors that cause models to experience convergence difficulties
- Recognize when a problem is too difficult or too ill-posed to be solved effectively

Targeted audience
Simulation Analysts

Prerequisites
This course is recommended for engineers with experience using Abaqus

About this Course
2 days
Day 1

- Lecture 1  Introduction to Nonlinear FEA
- Lecture 2  Nonlinear FEA with Abaqus/Standard
  - Workshop 1  Nonlinear Spring
- Lecture 3  Solution of Unstable Problems
  - Workshop 2  Reinforced Plate Under Compressive Loads
- Lecture 4  Why Abaqus Fails to Converge
  - Workshop 3  Crimp Forming Analysis
- Lecture 5  Contact Simulations
  - Workshop 4  Contact: Beam Lift-Off
  - Workshop 5  Contact: Stabilization
Day 2

- Lecture 6  Element Behavior
  - Workshop 6  Element Selection
- Lecture 7  Constraints and Loading
- Lecture 8  Materials
  - Workshop 7  Limit Load Analysis
  - Workshop 8  Ball Impact
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Lesson 1: Introduction to Nonlinear FEA

Lesson content:

- Why Use FEA to Solve Mechanics Problems?
- What is Convergence?
- When is a Problem Nonlinear?
- Properties of Linear Problems in Mechanics
- Properties of Nonlinear Problems in Mechanics
- Numerical Techniques for Solving Nonlinear Problems

1 hour
Lesson content:

- Equilibrium Revisited
- Nonlinear Solution Methods
- Abaqus/Standard Convergence Criteria: An Overview
- Automatic Time Incrementation
- Contact Convergence
- Workshop Preliminaries
- Workshop 1: Nonlinear Spring (IA)
- Workshop 1: Nonlinear Spring (KW)

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

1.5 hours
Lesson 3: Solution of Unstable Problems

Lesson content:

- Unstable Quasi-Static Problems
- Globally Unstable Problems
- Stabilization of Local Instabilities
- Symptoms of Local Instability
- Automated Viscous Damping
- Implicit Dynamics
- Examples
- Stabilization of Initial Rigid Body Motion
- Workshop 2: Reinforced Plate Under Compressive Loads (IA)
- Workshop 2: Reinforced Plate Under Compressive Loads (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 4: Why Abaqus Fails to Converge

Lesson content:

- The Basic Problems
- Understanding the Warning Messages
- Helping Abaqus Find a Converged Solution
- Workshop 3: Crimp Forming Analysis (IA)
- Workshop 3: Crimp Forming Analysis (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 5: Contact Simulations

Lesson content:

- Nonlinear Solution Methods: Review
- Unstable Separation of Contacting Surfaces
- Chattering Between Contact Surfaces
- Contact with Quadratic Elements
- Poorly Defined Master Surfaces
- Friction
- Workshop 4: Contact: Beam Lift-Off (IA)
- Workshop 4: Contact: Beam Lift-Off (KW)
- Workshop 5: Contact: Stabilization (IA)
- Workshop 5: Contact: Stabilization (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 6: Element Behavior

Lesson content:

- Hourglassing in Reduced-Integration Elements
- Checkerboarding
- Ill-Conditioning
- Workshop 6: Element Selection (IA)
- Workshop 6: Element Selection (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 7: Constraints and Loading

**Lesson content:**

- General Remarks
- Overconstraints Detected during Model Processing
- Overconstraints Detected during Analysis Execution
- Controlling the Overconstraint Checks
- Example: Four-bar Linkage
- Nonconservative Loads

1.5 hours
Lesson 8: Materials

Lesson content:

- Large Strains and Linear Elasticity
- Unstable Material Behavior
- Example: Plate with a Hole
- Unsymmetric Material Stiffness
- Example: Concrete Slump Test
- Workshop 7: Limit Load Analysis (IA)
- Workshop 7: Limit Load Analysis (KW)
- Workshop 8: Ball Impact (IA)
- Workshop 8: Ball Impact (KW)

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

1.5 hours