Substructures and Submodeling with Abaqus

Abaqus 2018
Course objectives
Upon completion of this course you will be able to:

- Understand the difference between substructuring and submodeling
- Build, translate, rotate and reflect substructures
- Build preloads into substructures
- Design meshes for submodel analysis
- Perform solid-to-solid, shell-to-shell, and shell-to-solid submodeling

Targeted audience
Simulation Analysts

Prerequisites
This course is recommended for engineers with experience using Abaqus

2 days
Day 1

- Lecture 1  Introduction to Substructures
- Lecture 2  Using Static Substructuring in Abaqus
- Lecture 3  Linear Perturbations about a Preloaded State
- Lecture 4  Dynamic Substructuring
- Lecture 5  Substructure Output
- Lecture 6  Substructuring Examples

  - Workshop 1a Substructures: Plane Frame Analysis
  - Workshop 1b Substructures: Surface Mount Analysis

- Lecture 7  Using substructures with Abaqus/Explicit

  - Workshop 2  Substructures: Beam Impact (optional)
Day 2

- Lecture 8  Introduction to Submodeling
- Lecture 9  Submodeling in Abaqus
- Lecture 10  Abaqus Usage and Examples (Part 1)
  - Workshop 3  Submodeling: Pressure Vessel Nozzle Analysis
- Lecture 11  Abaqus Usage and Examples (Part 2)
  - Workshop 4  Submodeling: Ceramic-Metal Braze Joint
- Lecture 12  Submodeling Practices
  - Workshop 5  Submodeling: Composite Tube Joint
- Lecture 13  Limitations of Submodeling
Additional Material

- Appendix 1 Theory of Substructures
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- Portfolio of established, best-in-class products
  - Abaqus, Isight, Tosca, fe-safe, Simpack

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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

**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

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

**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

**Complete System Analyses**
- (Quasi-)Static, Dynamics, NVH Flex Bodies, Advanced Contact
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Lesson 1: Introduction to Substructures

Lesson content:

- Why Substructuring?
- Static Substructuring
- Advantages of Substructuring
- Procedures Supporting Substructures
Lesson content:

- The Basics
- Substructure Generation
- Substructure Usage: Abaqus/CAE
- Substructure Usage: Keywords
- Substructure Load Cases
- Substructure Gravity Loading
- Kinematic Constraints in Substructures
- Flexible Body Dynamics
- Limitations
Lesson 3: Linear Perturbations about a Preloaded State

Lesson content:

- Introduction
- Substructure Tangent Stiffness Calculation
- Response Quantities
- Effect of Preloads at the Usage Level
- Preloading Syntax
- Preloading Example: Rotating Structure

30 minutes
Lesson 4: Dynamic Substructuring

Lesson content:

- Guyan Reduction
- Dynamic Mode Addition
- Damping with Substructures

45 minutes
Lesson 5: Substructure Output

Lesson content:

- Introduction
- Visualizing Substructure Results
- Output of Eliminated Degrees of Freedom
- Output of Substructure Matrices
- Substructure Library Utilities
Lesson 6: Substructuring Examples

Lesson content:

- Cyclic Symmetry
- Multilevel Substructuring
- Workshop Preliminaries
- Workshop 1a: Substructures: Plane Frame Analysis (IA)
- Workshop 1a: Substructures: Plane Frame Analysis (KW)
- Workshop 1b: Substructures: Surface Mount Analysis (IA)
- Workshop 1b: Substructures: Surface Mount Analysis (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 7: Using Substructures with Abaqus/Explicit

Lesson content:

- Introduction
- Examples
- General Concepts
- Keyword Interface
- Interactive Interface
- Postprocessing
- Technology Notes
- Workshop 2: Substructures: Beam Impact (IA)
- Workshop 2: Substructures: Beam Impact (KW)

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

Lesson content:

- Concept of Submodeling
- Motivation for Submodeling
Lesson 9: Submodeling in Abaqus

Lesson content:

- Fundamental Assumptions
- Submodeling Techniques
- Node-based Implementation
- Surface-based Implementation
Lesson content:

- Terminology
- Transfer of Data
- Prescribed Values
- Submodeling Workflow
- Surface-Based Submodel Boundaries
- Example: Conical Crack in a Half Space
- Example: Pressure Vessel
- Workshop 3: Submodeling: Pressure Vessel Nozzle Analysis (IA)
- Workshop 3: Submodeling: Pressure Vessel Nozzle Analysis (KW)

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

- Node-Based Submodel Boundaries
- Example: Stacked Sheet Metal Assembly
- Example: Large Displacement Analysis
- Tolerances at the Submodel Boundary
- Shell-to-Solid Submodeling
- Example: Shell-to-Solid Submodel of a Pipe Joint
- Workshop 4: Submodeling: Ceramic-Metal Braze Joint (IA)
- Workshop 4: Submodeling: Ceramic-Metal Braze Joint (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 12: Submodeling Practices

Lesson content:

- Perturbation Analysis
- Changing Procedures
- The Frequency Domain
- Submodeling and Thermal Stress Analysis
- Example: Thermal Strain in a Bar
- Submodeling in Dynamic Procedures
- Example: Speaker Diaphragm
- Workshop 5: Submodeling: Composite Tube Joint (IA)
- Workshop 5: Submodeling: Composite Tube Joint (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 13: Limitations of Submodeling

Lesson content:

- Elements
- Procedures
- Shell-to-Solid
Appendix 1: Theory of Substructures

Appendix content:

- Static Substructuring
- Guyan Reduction
- Restrained Mode Addition