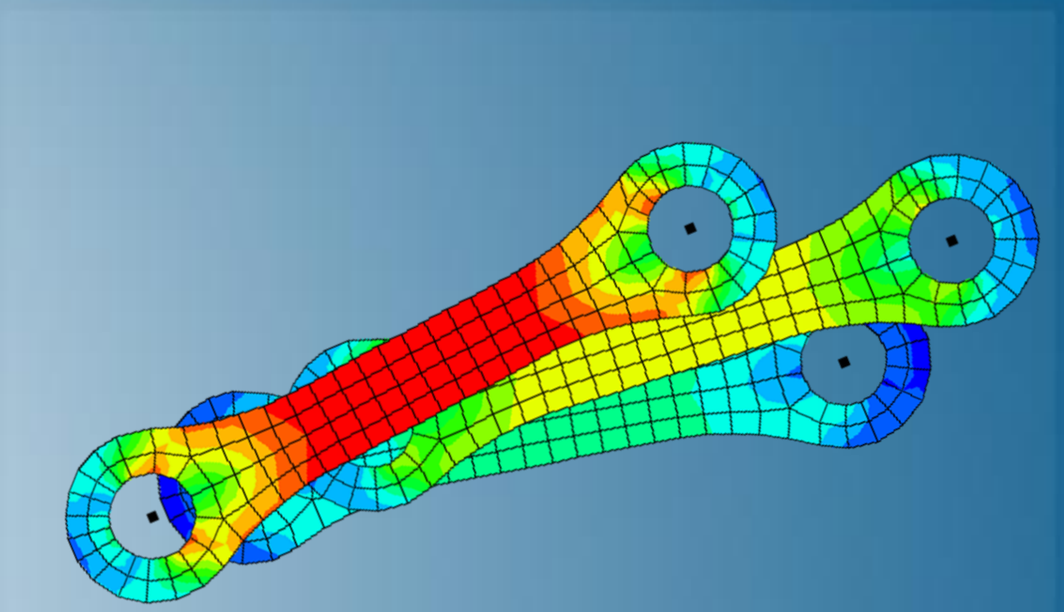
Substructures and Submodeling with Abaqus

Abaqus 2018



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About this Course

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

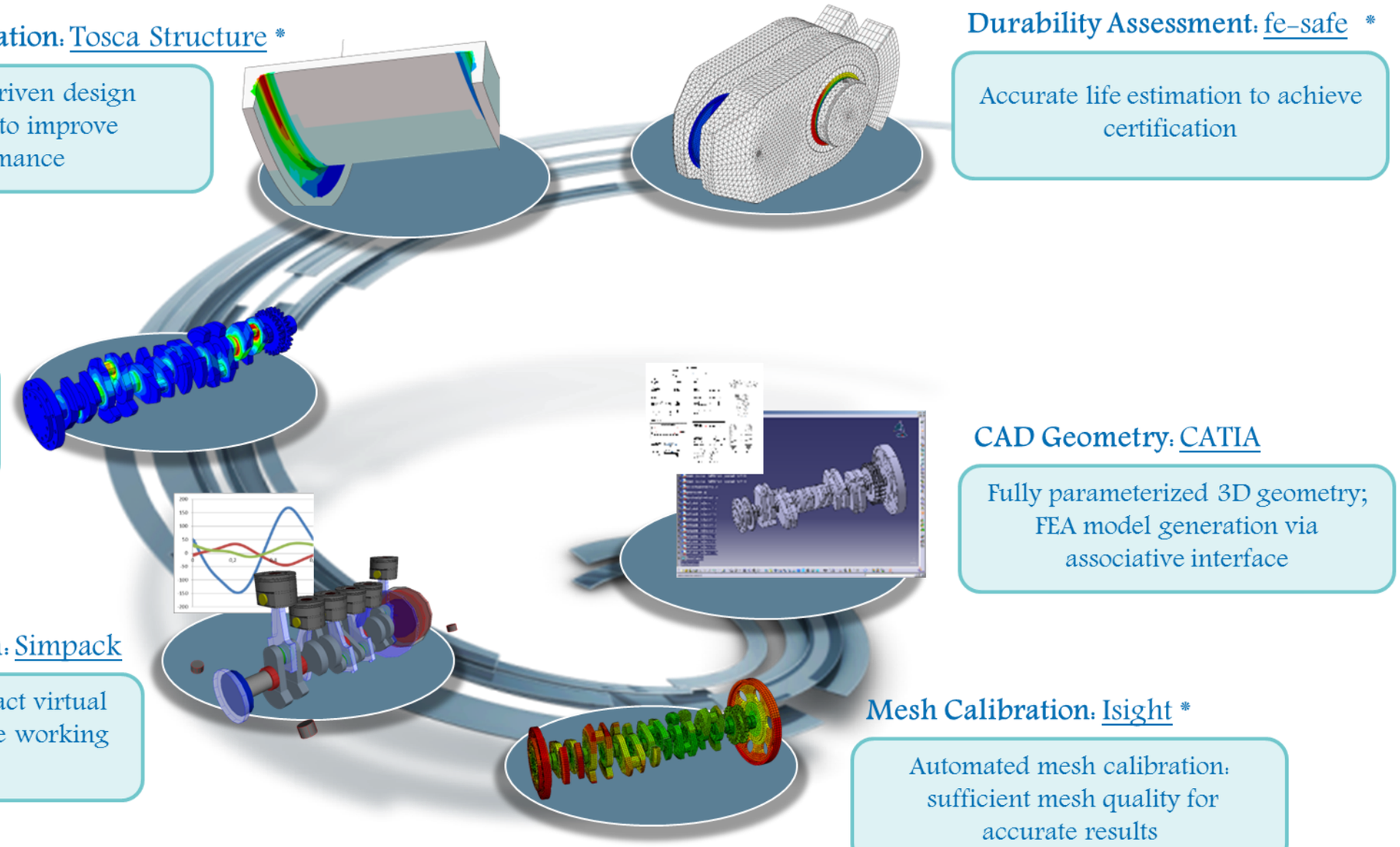
- Lecture 8 Introduction to Submodeling
- Lecture 9 Submodeling in Abaqus
- Lecture 10 Abaqus Usage and Examples (Part 1)
  - Workshop 3 Submodeling: Pressure Vessel Nozzle Analysis
- Lecture 11 Abaqus Usage and Examples (Part 2)
  - Workshop 4 Submodeling: Ceramic-Metal Braze Joint
- Lecture 12 Submodeling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

Additional Material

- Appendix 1 Theory of Substructures

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 *

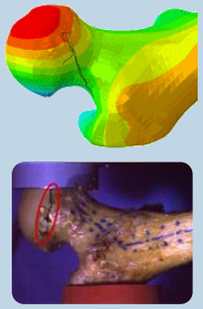
Automated mesh calibration: sufficient mesh quality for accurate results

* Included in extended licensing pool

SIMULIA's Power of the Portfolio

Abaqus

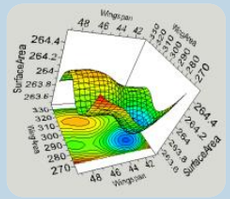
- Routine and Advanced Simulation
- Linear and Nonlinear, Static and Dynamic
- Thermal, Electrical, Acoustics
- Extended Physics through Co-simulation
- Model Preparation and Visualization



Realistic Human Simulation
High Speed Crash & Impact
Noise & Vibration

Isight

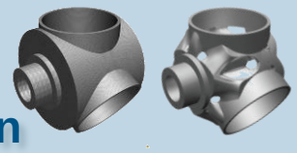
- Process Integration
- Design Optimization
- Parametric Optimization
- Six Sigma and Design of Experiments



Material Calibration
Workflow Automation
Design Exploration

Tosca

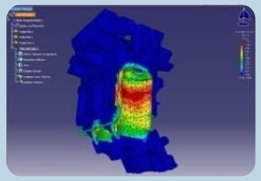
- Non-Parametric Optimization
- Structural and Fluid Flow Optimization
- Topology, Sizing, Shape, Bead Optimization



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

fe-safe

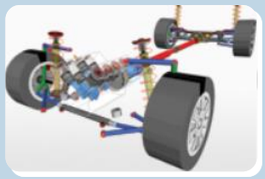
- Durability Simulation
- Low Cycle and High Cycle Fatigue
- Weld, High Temperature, Non-metallics



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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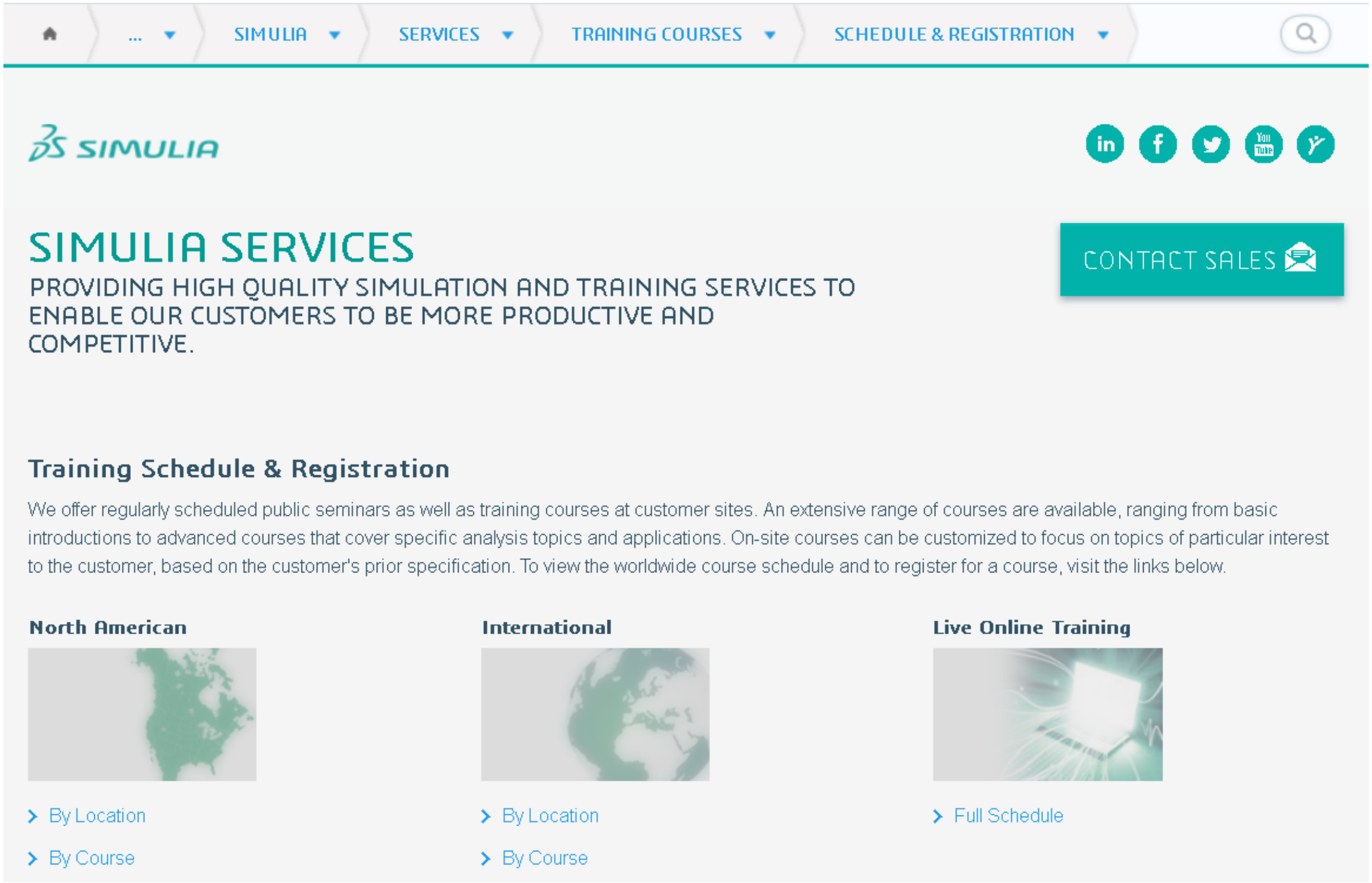

Legal Notices

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
Lecture 9	11/17	Updated for Abaqus 2018
Lecture 10	11/17	Updated for Abaqus 2018
Lecture 11	11/17	Updated for Abaqus 2018
Lecture 12	11/17	Updated for Abaqus 2018
Lecture 13	11/17	Updated for Abaqus 2018
Appendix 1	11/17	Updated for Abaqus 2018

Workshop 1a	11/17	Updated for Abaqus 2018
Workshop 1b	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

Lesson 1: Introduction to Substructures

Lesson content:

- Why Substructuring?
- Static Substructuring
- Advantages of Substructuring
- Procedures Supporting Substructures

30 minutes

Lesson 2: Using Static Substructuring in Abaqus

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

1 hour

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

45 minutes

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.

3 hours

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.

2 hours

Lesson 8: Introduction to Submodeling

Lesson content:

- Concept of Submodeling
- Motivation for Submodeling

15 minutes

Lesson 9: Submodeling in Abaqus

Lesson content:

- Fundamental Assumptions
- Submodeling Techniques
- Node-based Implementation
- Surface-based Implementation

30 minutes

Lesson 10: Abaqus Usage and Examples (Part 1)

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.

2.5 hours

Lesson 11: Abaqus Usage and Examples (Part 2)

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.

2 hours

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.

1 hour

Lesson 13: Limitations of Submodeling

Lesson content:

- Elements
- Procedures
- Shell-to-Solid

15 minutes

Appendix 1: Theory of Substructures

Appendix content:

- Static Substructuring
- Guyan Reduction
- Restrained Mode Addition

15 minutes