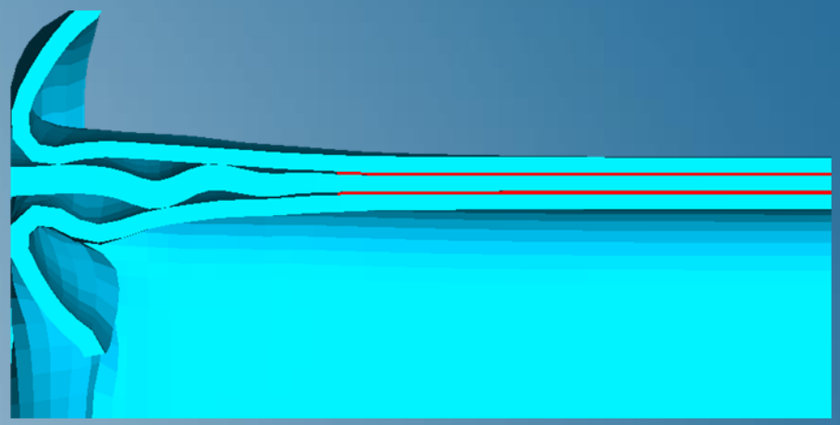
Analysis of Composite Materials with Abaqus

Abaqus 2022



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About this Course

Course objectives

Upon completion of this course you will be able to:

- Define anisotropic elasticity for combining the fiber-matrix response
- Define composite layups
- Model progressive damage and failure in composites
- Model delamination and fatigue crack growth of composite structures
- Model sandwich composite structures and stiffened composite panels

Targeted audience

Simulation Analysts

Prerequisites

This course is recommended for engineers with experience using Abaqus

3 days

Day 1

- Lesson 1 Introduction
- Lesson 2 Macroscopic Modeling
- Lesson 3 Laminate Modeling
  - Workshop 1 The Pagano Plate Problem
- Lesson 4 Composite Modeling with Abaqus
  - Workshop 2a Buckling of a Laminate Panel
  - Workshop 2b Composite Wing Section
  - Workshop 3 Composite Yacht Hull (Optional)

Day 2

- Lesson 5 Modeling Damage and Failure in Composites
- Lesson 6 Cohesive Behavior
  - Workshop 4 Analysis of a DCB using Cohesive Behavior
- Lesson 7 Virtual Crack Closure Technique (VCCT)
  - Workshop 5 Analysis of a DCB using VCCT (Abaqus/Standard)
  - Workshop 6 Analysis of a DCB using VCCT (Abaqus/Explicit)

Day 3

- Lesson 8 Reinforcement Modeling
- Lesson 9 Modeling of Sandwich Composites
  - Workshop 7 Bending of a Sandwich Beam
- Lesson 10 Modeling of Stiffened Panels
  - Workshop 8 Bending of a Reinforced Flat Panel under Uniform Pressure
- Lesson 11 Fatigue Crack Growth at Material Interfaces
  - Workshop 9 Fatigue Crack Growth in a DCB Specimen

Additional Material

- Appendix 1 Debond Capability
- Appendix 2 Cohesive Element Modeling Techniques
- Appendix 3 More on Continuum Shell Elements
- Appendix 4 Alternative Modeling Techniques
- Appendix 5 Modeling Composite Material Impact
  - Workshop 10 Perforation of a Composite Plate
- Appendix 6 Material Orientation Examples
- Appendix 7 Multiscale Modeling

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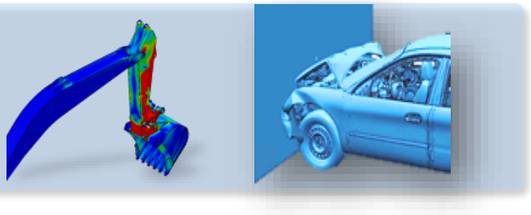
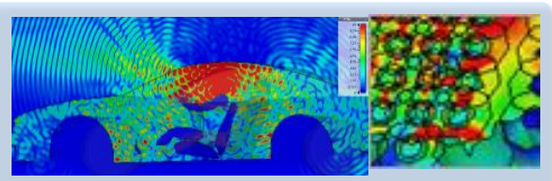
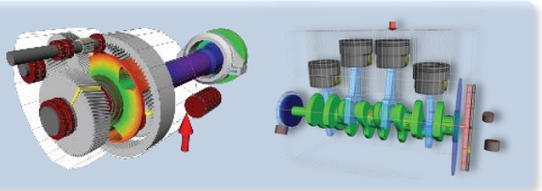
Structures



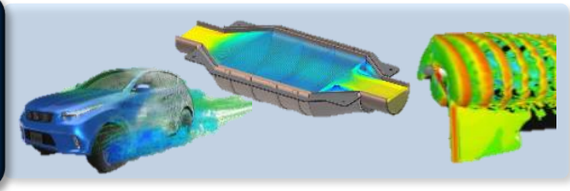
Electromagnetics



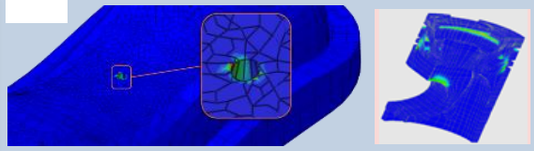
Multibody



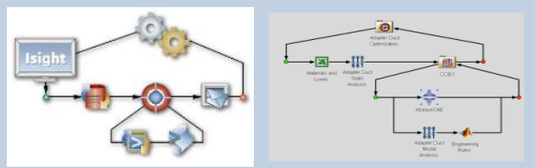
Fluids



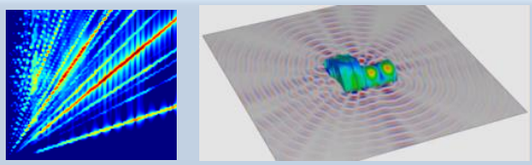
Durability



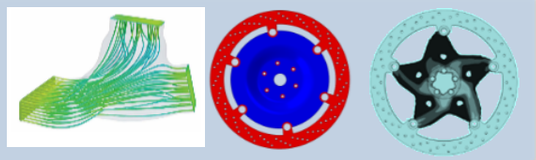
Automation



Vibro-acoustics



Optimization



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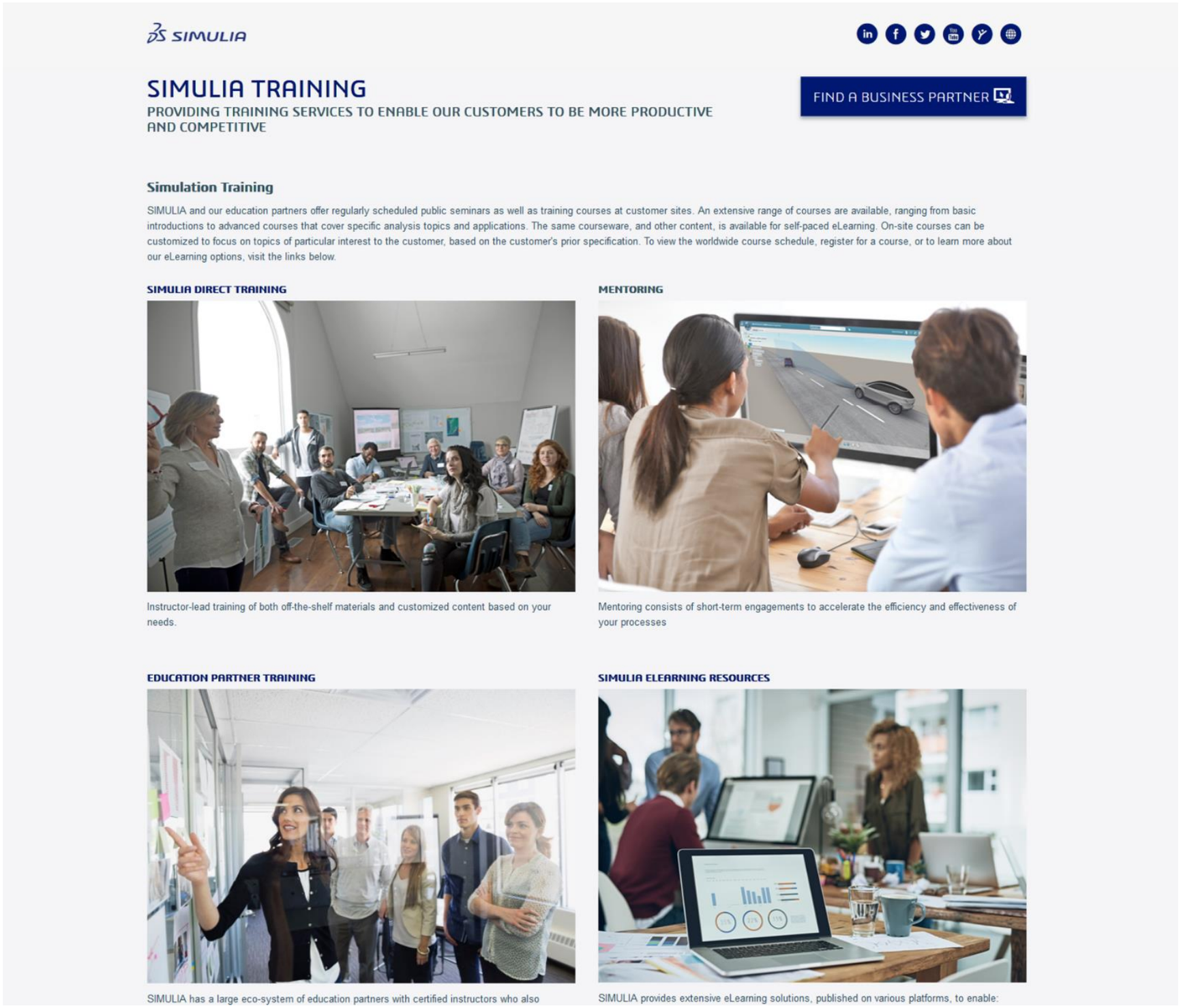

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Revision Status

Lesson 1	11/21	Updated for Abaqus 2022
Lesson 2	11/21	Updated for Abaqus 2022
Lesson 3	11/21	Updated for Abaqus 2022
Lesson 4	11/21	Updated for Abaqus 2022
Lesson 5	11/21	Updated for Abaqus 2022
Lesson 6	11/21	Updated for Abaqus 2022
Lesson 7	11/21	Updated for Abaqus 2022
Lesson 8	11/21	Updated for Abaqus 2022
Lesson 9	11/21	Updated for Abaqus 2022
Lesson 10	11/21	Updated for Abaqus 2022
Lesson 11	11/21	Updated for Abaqus 2022
Appendix 1	11/21	Updated for Abaqus 2022
Appendix 2	11/21	Updated for Abaqus 2022
Appendix 3	11/21	Updated for Abaqus 2022
Appendix 4	11/21	Updated for Abaqus 2022
Appendix 5	11/21	Updated for Abaqus 2022
Appendix 6	11/21	Updated for Abaqus 2022
Appendix 7	11/21	Updated for Abaqus 2022

Workshop 1	11/21	Updated for Abaqus 2022
Workshop 2a	11/21	Updated for Abaqus 2022
Workshop 2b	11/21	Updated for Abaqus 2022
Workshop 3	11/21	Updated for Abaqus 2022
Workshop 4	11/21	Updated for Abaqus 2022
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Workshop 7	11/21	Updated for Abaqus 2022
Workshop 8	11/21	Updated for Abaqus 2022
Workshop 9	11/21	Updated for Abaqus 2022
Workshop 10	11/21	Updated for Abaqus 2022

Lesson 1: Introduction

Lesson content:

- Description of a Composite
- Some Typical Composites
- Finite Element Modeling of Composites

20 minutes

Lesson 2: Macroscopic Modeling

Lesson content:

- Introduction
- Anisotropic Elasticity
- Viscoelasticity
- Thermal Expansion
- Material Orientation
- Multiscale Modeling

45 minutes

Lesson 3: Laminate Modeling

Lesson content:

- Introduction
- Laminated Composite Shells
- Continuum Shell Elements
- Continuum Shell Meshing
- Continuum Solid Elements
- Continuum Solid Shell Elements
- Symmetry Conditions and Laminated Structures
- Workshop Preliminaries
- Workshop 1: The Pagano Plate Problem

3 hours

Lesson 4: Composite Modeling with Abaqus

Lesson content:

- Introduction
- Understanding Composite Layups
- Understanding Composite Layup Orientations
- Defining Composite Layup Output
- Viewing a Composite Layup
- Abaqus/CAE Demonstration: Three-ply composite
- Composites Modeler for Abaqus/CAE
- Workshop 2a: Buckling of a Laminate Panel
- Workshop 2b: Composite Wing Section
- Workshop 3: Composite Yacht Hull

3 hours

Lesson 5: Modeling Damage and Failure in Composites

Lesson content:

- Failure Criteria in Laminates
- Failure Theories
- Progressive Damage of Fiber-Reinforced Composites
- Example
- Import of Composite Damage Model

75 minutes

Lesson 6: Cohesive Behavior

Lesson content:

- Introduction
- Cohesive Element Technology
- Constitutive Response in Cohesive Elements
- Viscous Regularization for Cohesive Elements
- Cohesive Element Examples
- Surface-based Cohesive Behavior
- Element-based vs. Surface-based Cohesive Behavior
- Workshop 4: Analysis of a DCB using Cohesive Behavior

Note: Appendix 2 contains an in-depth discussion of modeling techniques for cohesive elements using both the interactive and keywords interfaces.

3 hours

Lesson 7: Virtual Crack Closure Technique (VCCT)

Lesson content:

- Introduction
- VCCT Criterion
- LEFM Example using Abaqus/Standard
- LEFM Example using Abaqus/Explicit
- Output
- Ductile Fracture with VCCT
- VCCT Plug-in
- Comparison with Cohesive Behavior
- Examples
- Advanced Topics
  - Unstable crack growth
  - Smoothing crack tangential directions
- Workshop 5: Analysis of a DCB using VCCT (Abaqus/Standard)
- Workshop 6: Analysis of a DCB using VCCT (Abaqus/Explicit)

3 hours

Lesson 8: Reinforcement Modeling

Lesson content:

- Introduction
- Rebar Layers
- Embedded Elements

45 minutes

Lesson 9: Modeling of Sandwich Composites

Lesson content:

- Introduction to Sandwich Composites
- Abaqus Usage
- Modeling Skins with Abaqus/CAE
- Examples
  - Comparison to NAFEMS solution
  - Comparison of Conventional and Continuum Shells
  - Stacking Elements Through the Thickness
  - Tapered Sandwich Composite
- Workshop 7: Bending of a Sandwich Beam

1.5 hours

Lesson 10: Modeling of Stiffened Panels

Lesson content:

- Stiffened Composite Panels
- Abaqus Usage
- Example
- Workshop 8: Bending of a Reinforced Flat Panel under Uniform Pressure

2 hours

Lesson 11: Fatigue Crack Growth at Material Interfaces

Lesson content:

- Introduction
- Linear Elastic Fatigue Crack Growth Analysis Procedure
- Fatigue Crack Growth Criterion
- Example: Fatigue Crack Growth Prediction for a DCB
- Improving Crack Front Smoothness
- Workshop 9: Fatigue Crack Growth in a DCB Specimen

1 hour

Appendix 1: Debond Capability

Appendix content:

- Introduction
- Modeling Interface Behavior

30 minutes

Appendix 2: Cohesive Element Modeling Techniques

Appendix content:

- Viscous Regularization
- Modeling Techniques

1 hour

Appendix 3: More on Continuum Shell Elements

Appendix content:

- Defining the Thickness Direction for Continuum Shell Elements
- Shell Thickness
- Change in Thickness and Thickness Modulus

1 hour

Appendix 4: Alternative Modeling Techniques

Appendix content:

- Introduction
- Laminated Shell Section Definition
- Laminated Solid Section Definition
- Section Point-Based Postprocessing Technique

1 hour

Appendix 5: Modeling Composite Material Impact

Appendix content:

- Introduction
- Composite Damage Models in Abaqus/Explicit
- Unidirectional Fibers
  - Example – Composite Plate Impact
- Woven Fabrics
  - Example – Corrugated Beam Crushing
- Modeling Techniques
- Workshop 10: Perforation of a Composite Plate

1.5 hours

Appendix 6: Material Orientation Examples

Appendix content:

- Example 1: Layered Shell Elements
- Example 2: Solid Elements
- Example 3: Layered Solid Elements

30 minutes

Appendix 7: Multiscale Modeling

Appendix content:

- Introduction
- Linear vs. Nonlinear Short-fiber Reinforced Composites
- Mean-field Homogenization
- Mean-field Homogenization for Linear Elastic Composites
- Specifying the Microstructure of the Composite
- Validation: Unit Cube with Spherical Inclusion
- Validation: Matrix with Cylindrical Inclusion
- Fiber Orientation
- Example: Unidirectional stiffened panel subjected to axial compression
- Validation: Short Fiber Composites
- Multi-step Homogenization
- Example: Multiple Inclusion Model
- Composites with Thermal Expansion
- Incremental Mean-field Homogenization for Nonlinear Composites
- Output
- Examples
- Micromechanics Plug-in
- Upscaling
- Downscaling

1.5 hour