Analysis of Composite Materials with Abaqus

V6
R6.12

About this Course

Course objectives

Upon completion of this course you will be able to:

- Define anisotropic elasticity with Hookean models for combining the fiber-matrix response
- Define composite layups using Abaqus/CAE
- Model sandwich composite structures and stiffened composite panels
- Model progressive damage and failure in composites
- Model delamination and low-cycle fatigue of composite structures

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Targeted audience

Simulation Analysts

Prerequisites

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

3 days

Day 1

- Lecture 1 Introduction
- Lecture 2 Macroscopic Modeling
- Lecture 3 Mixed Modeling
  - Workshop 1 The Pagano Plate Problem
- Lecture 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

- Lecture 5 Reinforcement Modeling
- Lecture 6 Modeling of Sandwich Composites
  - Workshop 4 Bending of a Sandwich Beam
- Lecture 7 Modeling of Stiffened Panels
  - Workshop 5 Bending of a Reinforced Flat Panel under Uniform Pressure
- Lecture 8 Modeling Damage and Failure in Composites

Day 3

- Lecture 9 Cohesive Behavior
  - Workshop 6 Analysis of a DCB using Cohesive Behavior
- Lecture 10 Virtual Crack Closure Technique (VCCT)
  - Workshop 7 Analysis of a DCB using VCCT (Abaqus/Standard)
  - Workshop 8 Analysis of a DCB using VCCT (Abaqus/Explicit)
- Lecture 11 Low-cycle Fatigue
  - Workshop 9 Fatigue Crack Growth in a DCB Specimen

Additional Material

- Appendix 1 Crack Propagation Analysis using the Debond Capability
- Appendix 2 Cohesive Element Modeling Techniques
- Appendix 3 Modeling Issues for Continuum Shell Elements
- Appendix 4 Alternative Modeling Techniques for Composites
- Appendix 5 Modeling Composite Material Impact with Abaqus/Explicit
  - Workshop 10 Perforation of a Composite Plate
- Appendix 6 Material Orientation Examples

Legal Notices

Revision Status

Lecture 1	5/12	Updated for 6.12
Lecture 2	5/12	Updated for 6.12
Lecture 3	5/12	Updated for 6.12
Lecture 4	5/12	Updated for 6.12
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Lecture 7	5/12	Updated for 6.12
Lecture 8	5/12	Updated for 6.12
Lecture 9	5/12	Updated for 6.12
Lecture 10	5/12	Updated for 6.12
Lecture 11	5/12	Updated for 6.12
Appendix 1	5/12	Updated for 6.12
Appendix 2	5/12	Updated for 6.12
Appendix 3	5/12	Updated for 6.12
Appendix 4	5/12	Updated for 6.12
Appendix 5	5/12	Updated for 6.12
Appendix 6	5/12	Updated for 6.12

Workshop 1	5/12	Updated for 6.12
Workshop 2a	5/12	Updated for 6.12
Workshop 2b	5/12	Updated for 6.12
Workshop 3	5/12	Updated for 6.12
Workshop 4	5/12	Updated for 6.12
Workshop 5	5/12	Updated for 6.12
Workshop 6	5/12	Updated for 6.12
Workshop 7	5/12	Updated for 6.12
Workshop 8	5/12	Updated for 6.12
Workshop 9	5/12	Updated for 6.12
Workshop 10	5/12	Updated for 6.12

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Lesson 1: Introduction

The following topics are covered in this lesson.

Lesson content:

- Introduction

Introduction

Here are the steps to be followed:

1. Description of a Composite
2. Typical Applications of Composites
3. Some Typical Composites
4. Finite Element Modeling of Composites

Lesson 2: Macroscopic Modeling

The following topics are covered in this lesson.

Lesson content:

- Macroscopic Modeling

Macroscopic Modeling

Here are the steps to be followed:

1. Introduction
2. Anisotropic Elasticity
3. Viscoelasticity
4. Thermal Expansion
5. Material Orientation

Lesson 3: Mixed Modeling

The following topics are covered in this lesson.

Lesson content:

- Mixed Modeling
- Workshop Preliminaries
- Workshop 1: The Pagano Plate Problem

Mixed Modeling

Here are the steps to be followed:

1. Introduction
2. Laminated Composite Shells
3. Continuum Shell Elements
4. Continuum Shell Meshing
5. Continuum Solid Elements
6. Symmetry Conditions and Laminated Structures

Lesson 4: Composite Modeling with Abaqus

The following topics are covered in this lesson.

Lesson content:

- Composite Modeling with Abaqus
- Workshop 2a: Buckling of a Laminate Panel
- Workshop 2b: Composite Wing Section
- Workshop 3: Composite Yacht Hull

Composite Modeling with Abaqus

Here are the steps to be followed:

1. Introduction
2. Understanding Composite Layups
3. Understanding Composite Layup Orientations
4. Defining Composite Layup Output
5. Viewing a Composite Layup
6. Abaqus/CAE Demonstration: Three-ply composite
7. Composites Modeler for Abaqus/CAE

Lesson 5: Reinforcement Modeling

The following topics are covered in this lesson.

Lesson content:

- Reinforcement Modeling

Reinforcement Modeling

Here are the steps to be followed:

1. Introduction
2. Rebar Layers
3. Embedded Elements

Lesson 6: Analysis of Sandwich Composites

The following topics are covered in this lesson.

Lesson content:

- Analysis of Sandwich Composites
- Workshop 4: Bending of a Sandwich Beam

Analysis of Sandwich Composites

Here are the steps to be followed:

1. Introduction to Sandwich Composites
2. Abaqus Usage
3. Modeling Skins with Abaqus/CAE
4. Abaqus Examples
   a. Comparison to NAFEMS solution
   b. Comparison of Conventional and Continuum Shells
   c. Stacking Elements Through the Thickness
   d. Tapered Sandwich Composite

Lesson 7: Analysis of Stiffened Composite Panels

The following topics are covered in this lesson.

Lesson content:

- Analysis of Stiffened Composite Panels
- Workshop 5: Bending of a Reinforced Flat Panel under Uniform Pressure

Analysis of Stiffened Composite Panels

Here are the steps to be followed:

1. Stiffened Composite Panels
2. Abaqus Usage
3. Abaqus Example

Lesson 8: Modeling Damage and Failure in Composites

The following topics are covered in this lesson.

Lesson content:

- Modeling Damage and Failure in Composites

Modeling Damage and Failure in Composites

Here are the steps to be followed:

1. Failure Criteria in Laminates
2. Failure Theories
3. Progressive Damage of Fiber-Reinforced Composites
4. Example
5. Import of Composite Damage Model

Lesson 9: Cohesive Behavior

The following topics are covered in this lesson.

Lesson content:

- Cohesive Behavior
- Workshop 6: 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

Cohesive Behavior

Here are the steps to be followed:

1. Introduction
2. Cohesive Element Technology
3. Constitutive Response in Cohesive Elements
4. Viscous Regularization for Cohesive Elements
5. Cohesive Element Examples
6. Surface-based Cohesive Behavior
7. Element- vs. Surface-based Cohesive Behavior

Lesson 10: Virtual Crack Closure Technique (VCCT)

The following topics are covered in this lesson.

Lesson content:

- Virtual Crack Closure Technique (VCCT)
- Workshop 7: Analysis of a DCB using VCCT (Abaqus/Standard)
- Workshop 8: Analysis of a DCB using VCCT (Abaqus/Explicit)

Virtual Crack Closure Technique (VCCT)

Here are the steps to be followed:

1. Introduction
2. VCCT Criterion
3. LEFM Example using Abaqus/Standard
4. LEFM Example using Abaqus/Explicit
5. Output
6. Ductile Fracture with VCCT
7. VCCT Plug-in
8. Comparison with Cohesive Behavior
9. Examples

Lesson 11: Low-cycle Fatigue Criterion

The following topics are covered in this lesson.

Lesson content:

- Low-cycle Fatigue Criterion
- Workshop 9: Fatigue Crack Growth in a DCB Specimen

Low-cycle Fatigue Criterion

Here are the steps to be followed:

1. Introduction
2. Direct Cyclic Low-cycle Fatigue Analysis
3. Low-cycle Fatigue Criterion

Appendix 1: Crack Propagation Analysis using the Debond Capability

The following topics are covered in this lesson.

Lesson content:

- Crack Propagation Analysis using the Debond Capability

30 minutes

Crack Propagation Analysis using the Debond Capability

Here are the steps to be followed:

1. Introduction
2. Modeling Interface Behavior

Appendix 2: Cohesive Element Modeling Techniques

The following topics are covered in this lesson.

Lesson content:

- Cohesive Element Modeling Techniques

60 minutes

Cohesive Element Modeling Techniques

Here are the steps to be followed:

1. Viscous Regularization
2. Modeling Techniques

Appendix 3: Modeling Issues for Continuum Shell Elements

The following topics are covered in this lesson.

Lesson content:

- Modeling Issues for Continuum Shell Elements

60 minutes

Modeling Issues for Continuum Shell Elements

Here are the steps to be followed:

1. Defining the thickness direction for continuum shell elements
2. Shell thickness
3. Change in thickness and thickness modulus

Appendix 4: Alternative Modeling Techniques for Composites

The following topics are covered in this lesson.

Lesson content:

- Alternative Modeling Techniques for Composites

Alternative Modeling Techniques for Composites

Here are the steps to be followed:

1. Introduction
2. Laminated Shell Section Definition
3. Laminated Solid Section Definition
4. Section Point Based Postprocessing Technique

Appendix 5: Modeling Composite Material Impact with Abaqus/Explicit

The following topics are covered in this lesson.

Lesson content:

- Modeling Composite Material Impact with Abaqus/Explicit
- Workshop 10: Perforation of a Composite Plate

90 minutes

Modeling Composite Material Impact with Abaqus/Explicit

Here are the steps to be followed:

1. Introduction
2. Composite Damage Models in Abaqus/Explicit
3. Unidirectional Fiber
   a. Example – Composite Plate Impact
4. Woven Fabric
   a. Example – Corrugated Beam Crushing
5. Modeling Techniques

Appendix 6: Material Orientation Examples

The following topics are covered in this lesson.

Lesson content:

- Material Orientation Examples

30 minutes

Material Orientation Examples

Here are the steps to be followed:

1. Example 3: Shell elements
2. Example 4: Layered shell elements
3. Example 5: Solid elements
4. Example 6: Layered solid elements