Linear Dynamics with Abaqus

Abaqus 2020
Course objectives
Upon completion of this course you will be able to:

- Extract eigenmodes about a certain frequency
- Determine whether the number of extracted eigenmodes is sufficient to represent the structure's response adequately
- Perform transient, steady-state, response spectrum and random response analyses using the eigenmodes
- Use multiple base motions
- Apply damping in linear problems

Targeted audience
Simulation Analysts

Prerequisites
This course is recommended for engineers with experience using Abaqus

About this Course
2 days
Day 1

- **Lesson 1**  Introduction to Linear Dynamics in Abaqus
- **Lesson 2**  Modal-Based Solutions
- **Lesson 3**  Extracting Real Eigenvalues
  - **Workshop 1**  Eigenvalue Natural Frequency Extraction
- **Lesson 4**  Damping
- **Lesson 5**  Base Motion Excitation
- **Lesson 6**  Modal Transient Dynamics
  - **Workshop 2**  Modal Transient Dynamics of a Layered Beam
Day 2

- Lesson 7  Response Spectrum Analysis
  - Workshop 3  Response Spectrum Analyses of a Layered Beam and Storage Rack
- Lesson 8  Steady-State Dynamics
  - Workshop 4  Steady-State Dynamics of a Mounted Circuit Board
- Lesson 9  Complex Eigenvalue Analysis
- Lesson 10  Introduction to Random Response
  - Workshop 5  Random Response Analysis of a Mounted Circuit Board
Additional Material

- Appendix 1  Introduction to Nonlinear Dynamics
- Appendix 2  Nonlinear Dynamics: Abaqus Usage
- Appendix 3  Nonlinear Dynamics Examples
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# Revision Status

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Lesson 1: Introduction to Linear Dynamics in Abaqus

Lesson content:

- Dynamic Response
- When to Consider Dynamic Effects
- Linear Dynamics Procedures
- Linear Dynamics Software Architecture
Lesson content:

- Introduction
- Modal Superposition
- Example: Modal Reduction and Superposition
- Example: Cantilever Beam
- Subspace Projection vs. Modal Superposition
- Solution Architectures for Mode-Based Solutions
Lesson content:

- Problem Formulation
- Eigenvalue Solution Methods
- Lanczos Eigensolver – Engine Block Example
- AMS Eigensolver – Mounted Circuit Boards Example
- Frequency Output
- Frequencies of Preloaded Structures
- Extracting Repeated Eigenfrequencies
- Residual Modes
- Workshop Model Description
- Workshop Preliminaries
- Workshop 1: Eigenvalue Natural Frequency Extraction (IA)
- Workshop 1: Eigenvalue Natural Frequency Extraction (KW)

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

2.5 hours
Lesson 4: Damping

Lesson content:

- Introduction
- Damping Concepts
- Damping in Direct Solutions
  - Material Damping
  - Element Damping
  - Global Damping
- Damping Controls
- Damping in Modal Superposition Procedures
  - Modal Damping
  - Composite Modal Damping
- Damping in Modal Subspace Projection Solutions
- Summary
Lesson 5: Base Motion Excitation

Lesson content:

- Introduction
- Primary Base Motion
- Secondary Base Motions
- Usage
- Example: Double Cantilever

45 minutes
Lesson 6: Modal Transient Dynamics

Lesson content:

- Introduction
- Excitation and Output
- Example
- Subspace Projection Solution for Transient Dynamics
- Workshop 2: Modal Transient Dynamics of a Layered Beam (IA)
- Workshop 2: Modal Transient Dynamics of a Layered Beam (KW)

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

Lesson content:

- Introduction
- The Response Spectrum
- Spectrum Definition
- Determining Peak Modal Response
- Modal Summation Methods
- Combining Response Spectrum Results from Multiple Directions
- Response Spectrum Usage
- Missing Mass
- Periodic and Rigid Responses – USNRC Regulatory Guide 1.92
- Workshop 3: Response Spectrum Analyses of a Layered Beam and Storage Rack (IA)
- Workshop 3: Response Spectrum Analyses of a Layered Beam and Storage Rack (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 8: Steady-State Dynamics

Lesson content:

- Introduction
- Steady-State Dynamics Solution Procedures
- Excitation and Output
- Steady-State Dynamics Usage
- Example – Mounted Circuit Boards
- Workshop 4: Steady-State Dynamics of a Mounted Circuit Board (IA)
- Workshop 4: Steady-State Dynamics of a Mounted Circuit Board (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 9: Complex Eigenvalue Analysis

Lesson content:

- Overview
- Implementation
- Example: Brake Squeal Analysis

60 minutes
Lesson content:

- Overview
- Implementation
- Random Response Output
- Correlation Example – Cantilever Beam
- Base Motion Excitation Example
- Steady-State Dynamics Alternative Approach
- Workshop 5: Random Response Analysis of a Mounted Circuit Board (IA)
- Workshop 5: Random Response Analysis of a Mounted Circuit Board (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Appendix 1: Introduction to Nonlinear Dynamics

Appendix content:

- Introduction
- Equations for Dynamic Problems
- Time integration of the equations of motion
- Automatic time incrementation
- Dynamic Contact
- Comparing Abaqus/Standard and Abaqus/Explicit
Appendix 2: Nonlinear Dynamics: Abaqus Usage

Appendix content:

- Implicit Dynamics
- Explicit Dynamics
- Algorithmic Details
- Initial Conditions and Loads
- Stability and Accuracy of the Trapezoidal Rule
- Material Damping
- Half-Increment Residual Tolerance

75 minutes
Appendix 3: Nonlinear Dynamics Examples

Appendix content:

- Damped shallow arch
- Ball impact
- Tennis racket and ball
- Crimp forming
- Blade containment
- Inertia relief