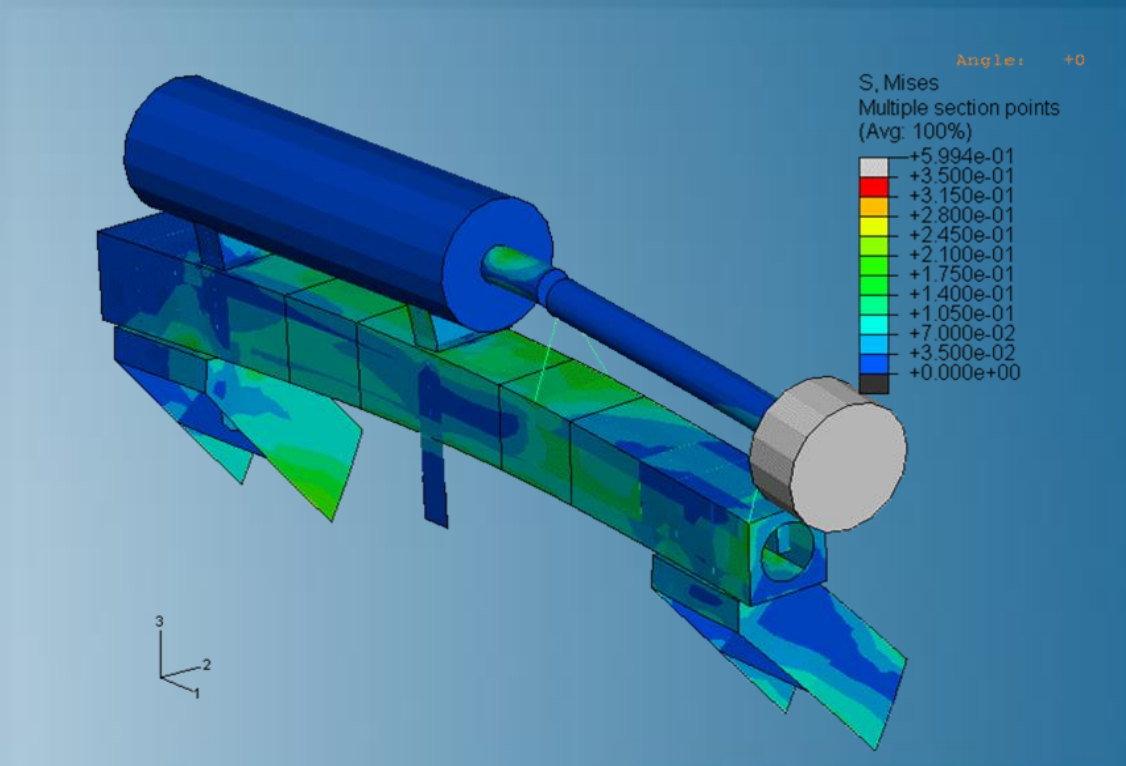


Linear Dynamics with Abaqus

Abaqus 2018



3DEXPERIENCE®



About this Course

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



2 days

Day 1

- ▶ Lecture 1 Introduction to Abaqus Linear Dynamics
- ▶ Lecture 2 Extracting Real Eigenvalues
 - Workshop 1 Eigenvalue Natural Frequency Extraction
- ▶ Lecture 3 Modal Superposition
- ▶ Lecture 4 Damping
- ▶ Lecture 5 Base Motion Excitation
- ▶ Lecture 6 Modal Transient Dynamics
 - Workshop 2 Modal Dynamics

Day 2

- ▶ Lecture 7 Response Spectrum Analysis
 - Workshop 3 Response Spectrum
- ▶ Lecture 8 Steady-State Harmonic Response
 - Workshop 4 Steady-State Dynamics
- ▶ Lecture 9 Introduction to Random Response
 - Workshop 5 Random Response Analysis
- ▶ Lecture 10 Complex Eigenvalue Analysis

Additional Material

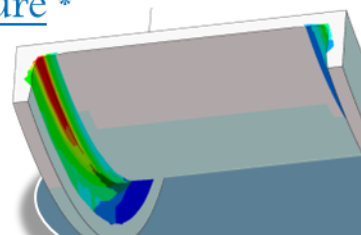
- ▶ Appendix 1 Introduction to Nonlinear Dynamics
- ▶ Appendix 2 Nonlinear Dynamics: Abaqus Usage
- ▶ Appendix 3 Nonlinear Dynamics Examples

SIMULIA

- ▶ SIMULIA is the Dassault Systèmes brand for Realistic Simulation solutions
- ▶ Portfolio of established, best-in-class products
 - Abaqus, Isight, Tosca, fe-safe, Simpack

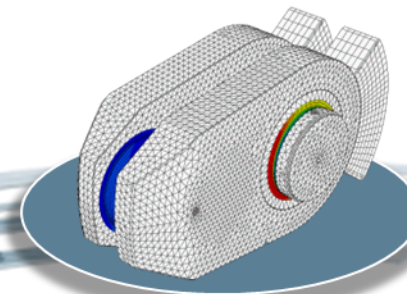
Design Optimization: Tosca Structure *

Simulation-driven design refinement to improve performance



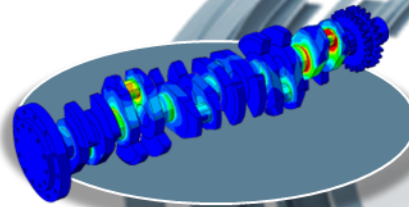
Durability Assessment: fe-safe *

Accurate life estimation to achieve certification



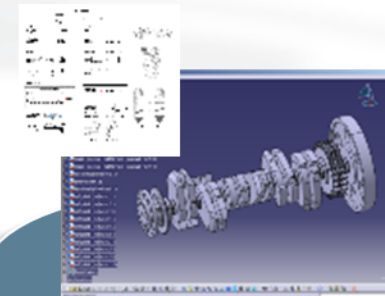
FEA Stress Analysis: Abaqus *

Detailed stress analysis using extracted load history from MBS



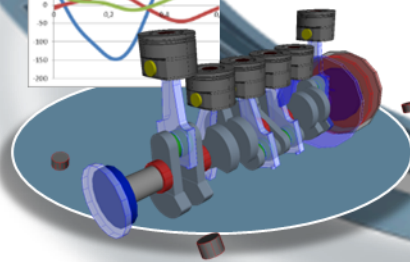
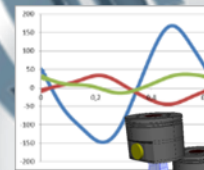
CAD Geometry: CATIA

Fully parameterized 3D geometry; FEA model generation via associative interface



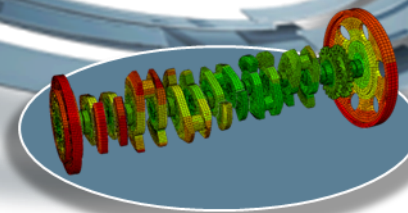
Multibody Simulation: Simpack

System analysis to extract virtual load history of complete working cycle



Mesh Calibration: Isight *

Automated mesh calibration; sufficient mesh quality for accurate results

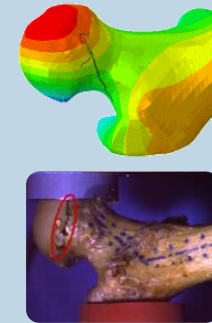


* Included in extended licensing pool

SIMULIA's Power of the Portfolio

Abaqus

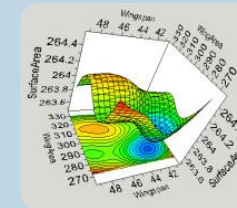
- Routine and Advanced Simulation
- Linear and Nonlinear, Static and Dynamic
- Thermal, Electrical, Acoustics
- Extended Physics through Co-simulation
- Model Preparation and Visualization



**Realistic Human Simulation
High Speed Crash & Impact
Noise & Vibration**

Isight

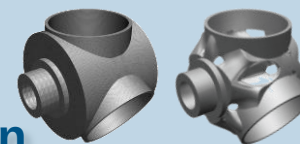
- Process Integration
- Design Optimization
- Parametric Optimization
- Six Sigma and Design of Experiments



**Material Calibration
Workflow Automation
Design Exploration**

Tosca

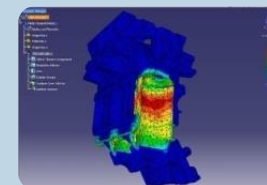
- Non-Parametric Optimization
- Structural and Fluid Flow Optimization
- Topology, Sizing, Shape, Bead Optimization



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

fe-safe

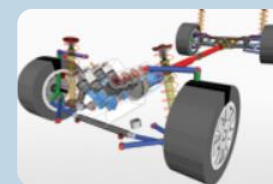
- Durability Simulation
- Low Cycle and High Cycle Fatigue
- Weld, High Temperature, Non-metallics



**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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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
Appendix 1	11/17	Updated for Abaqus 2018
Appendix 2	11/17	Updated for Abaqus 2018
Appendix 3	11/17	Updated for Abaqus 2018
Workshop 1	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 Abaqus Linear Dynamics

Lesson content:

- ▶ Dynamic Response
- ▶ When to Consider Dynamic Effects
- ▶ Linear Dynamics Procedures
- ▶ Linear Dynamics Software Architecture



1.5 hours

Lesson 2: Extracting Real Eigenvalues

Lesson content:

- ▶ Problem Formulation
- ▶ Eigenvalue Solution Methods
- ▶ Example: Engine Block Frequency Extraction
- ▶ 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.



3 hours

Lesson 3: Modal Superposition

Lesson content:

- ▶ Introduction
- ▶ Modal Superposition
- ▶ Example: Modal Reduction and Superposition
- ▶ Example: Cantilever Beam



0.5 hours

Lesson 4: Damping

Lesson content:

- ▶ Introduction
- ▶ Damping in Direct Solutions
- ▶ Damping in Modal Subspace Projection Solutions
- ▶ Damping in Modal Superposition Procedures
- ▶ Material Damping
- ▶ Element Damping
- ▶ Global Damping
- ▶ Modal Damping
- ▶ Damping Controls
- ▶ Summary



1.5 hours

Lesson 5: Base Motion Excitation

Lesson content:

- ▶ Introduction
- ▶ Primary Base Motion
- ▶ Secondary Base Motions
- ▶ Usage
- ▶ Example



45 minutes

Lesson 6: Modal Transient Dynamics

Lesson content:

- ▶ Introduction
- ▶ Excitation and Output
- ▶ Example
- ▶ Subspace Solutions for Transient Dynamics
- ▶ Workshop 2: Modal Dynamics (IA)
- ▶ Workshop 2: Modal Dynamics (KW)



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



2 hours

Lesson 7: Response Spectrum Analysis

Lesson content:

- ▶ Introduction
- ▶ The Response Spectrum
- ▶ Determining Peak Modal Response
- ▶ Modal Summation Methods
- ▶ Separation of Modal Responses into Periodic and Rigid Responses
- ▶ Combining Results from Multiple Spectrums
- ▶ Spectrum Definition
- ▶ Response Spectrum Usage
- ▶ Response Spectrum Example
- ▶ Workshop 3: Response Spectrum (IA)
- ▶ Workshop 3: Response Spectrum (KW)



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



2 hours

Lesson 8: Steady-State Harmonic Response

Lesson content:

- ▶ Introduction
- ▶ Steady-State Dynamics Solution Procedures
- ▶ Excitation and Output
- ▶ Steady-State Dynamics Usage
- ▶ Comparative Example
- ▶ Workshop 4: Steady-State Dynamics (IA)
- ▶ Workshop 4: Steady-State Dynamics (KW)



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



2 hours

Lesson 9: Introduction to Random Response

Lesson content:

- ▶ Overview
- ▶ Excitation and Output
- ▶ Random Response Usage
- ▶ Base Motion Example
- ▶ Steady-State Dynamics Alternative Approach
- ▶ Workshop 5: Random Response Analysis (IA)
- ▶ Workshop 5: Random Response Analysis (KW)



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



2 hours

Lesson 10: Complex Eigenvalue Analysis

Lesson content:

- ▶ Overview
- ▶ Implementation
- ▶ Brake Squeal Analysis



75 minutes

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



45 minutes

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



1 hour