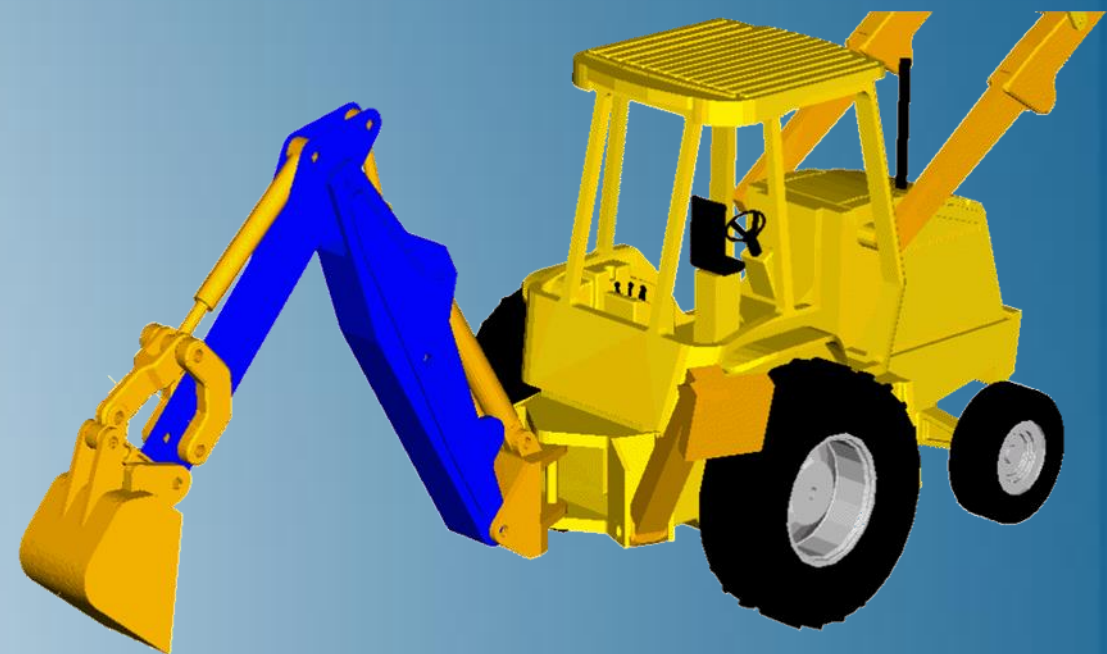


# Connector Elements and Mechanism Analysis with Abaqus

Abaqus 2018



**3DEXPERIENCE®**



# About this Course

## Course objectives

The topics include:

- ▶ Comparison of connectors and MPCs
- ▶ Basic connector components
- ▶ Assembled kinematic connections
- ▶ Local relative displacements and rotations
- ▶ Defining stops and locks
- ▶ Defining connector friction
- ▶ Connector failure
- ▶ Actuating components of relative motion
- ▶ Sensors and actuators
- ▶ Output and postprocessing

## Targeted audience

Simulation Analysts

## Prerequisites

This course is recommended for engineers with experience using Abaqus



2 days

# Day 1

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- ▶ Lecture 1                      Mechanisms and Multibodies in Abaqus
  
- ▶ Lecture 2                      Connection Elements and Library (Part 1)
  - Workshop 1      Hinge Connection
  
- ▶ Lecture 3                      Connection Elements and Library (Part 2)
  - Workshop 2a    Analysis of a UJOINT
  - Workshop 2b    Four-Stroke Engine (Part 1)
  
- ▶ Lecture 4                      Connector Builder
  - Workshop 3a    Modeling Pliers
  - Workshop 3b    Four-Stroke Engine (Part 2)
  
- ▶ Lecture 5                      Overconstraints and Connectors
  - Workshop 4      Overconstraints: Hinge Model

## Day 2

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- ▶ Lecture 6                      Connector Behavior (Part 1)
  - Workshop 5a    Connector Attributes – Hinge Model
  - Workshop 5b    Connector Attributes – Four-Stroke Engine Model
  
- ▶ Lecture 7                      Connector Behavior (Part 2)
  - Workshop 6a    Analysis of a Spot Weld
  - Workshop 6b    Connector Friction
  
- ▶ Lecture 8                      Rotational Connector Elements in Mechanism Analysis
  - Workshop 7     Rotational Connector Elements
  
- ▶ Lecture 9                      Connector Actuation and Output
  - Workshop 8     Analysis of a Simple Four-Stroke Engine

## Additional Material

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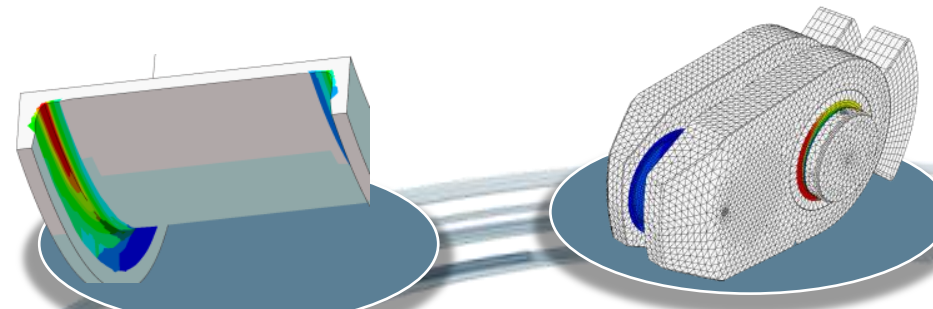
- ▶ Appendix 1      Some Advanced Connection Types
- ▶ Appendix 2      Connector Uniaxial Behavior

# SIMULIA

- ▶ SIMULIA is the Dassault Systèmes brand for Realistic Simulation solutions
- ▶ Portfolio of established, best-in-class products
  - Abaqus, Isight, Tosca, fe-safe, Simpack
  - Most use a common extended licensing pool

## Design Optimization: Tosca Structure

Simulation-driven design refinement to improve performance

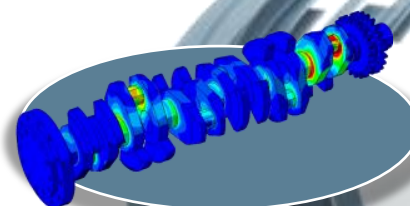


## Durability Assessment: fe-safe

Accurate life estimation to achieve certification

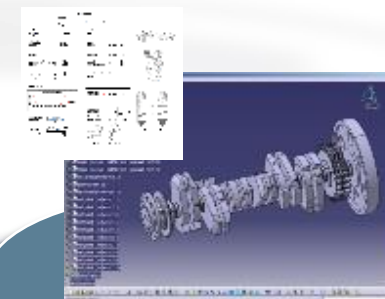
## FEA Stress Analysis: Abaqus

Detailed stress analysis using extracted load history from MBS



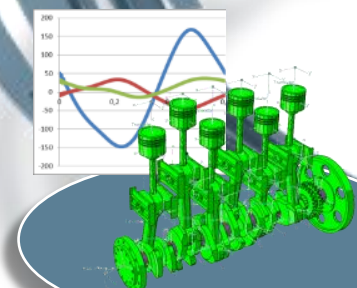
## CAD Geometry: CATIA

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



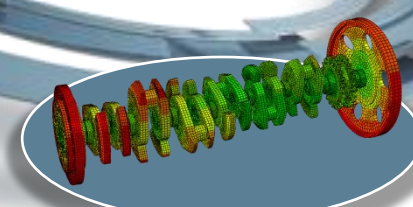
## Multibody Simulation: Simpack

System analysis to extract virtual load history of complete working cycle



## Mesh Calibration: Isight

Automated mesh calibration:  
sufficient mesh quality for accurate results

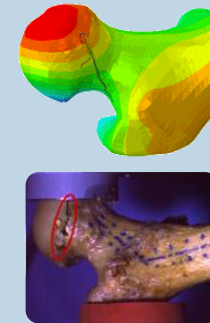




# SIMULIA's Power of the Portfolio

## Abaqus

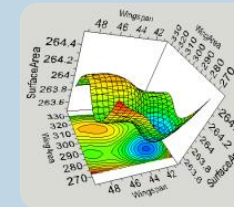
- Routine and Advanced Simulation
- Linear and Nonlinear, Static and Dynamic
- Thermal, Electrical, Acoustics
- Extended Physics through Co-simulation
- Model Preparation and Visualization



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

## Isight

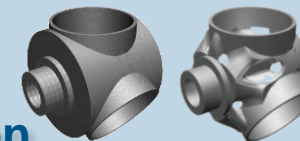
- Process Integration
- Design Optimization
- Parametric Optimization
- Six Sigma and Design of Experiments



**Material Calibration**  
**Workflow Automation**  
**Design Exploration**

## Tosca

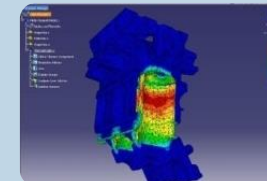
- Non-Parametric Optimization
- Structural and Fluid Flow Optimization
- Topology, Sizing, Shape, Bead Optimization



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

## fe-safe

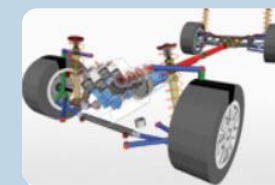
- Durability Simulation
- Low Cycle and High Cycle Fatigue
- Weld, High Temperature, Non-metallics



**Safety Factors**  
**Creep-Fatigue Interaction**  
**Weld Fatigue**

## Simpack

- Multibody Dynamics Simulation
- Mechanical or Mechatronic Systems



**Flexible Bodies**  
**Single Component Design**  
**Complete System Analyses**

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- > By Course

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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 |
| Appendix 1 | 11/17 | Updated for Abaqus 2018 |
| Appendix 2 | 11/17 | Updated for Abaqus 2018 |

|             |       |                         |
|-------------|-------|-------------------------|
| Workshop 1  | 11/17 | Updated for Abaqus 2018 |
| Workshop 2a | 11/17 | Updated for Abaqus 2018 |
| Workshop 2b | 11/17 | Updated for Abaqus 2018 |
| Workshop 3a | 11/17 | Updated for Abaqus 2018 |
| Workshop 3b | 11/17 | Updated for Abaqus 2018 |
| Workshop 4  | 11/17 | Updated for Abaqus 2018 |
| Workshop 5a | 11/17 | Updated for Abaqus 2018 |
| Workshop 5b | 11/17 | Updated for Abaqus 2018 |
| Workshop 6a | 11/17 | Updated for Abaqus 2018 |
| Workshop 6b | 11/17 | Updated for Abaqus 2018 |
| Workshop 7  | 11/17 | Updated for Abaqus 2018 |
| Workshop 8  | 11/17 | Updated for Abaqus 2018 |

# Lesson 1: Mechanisms and Multibodies in Abaqus

## *Lesson content:*

- ▶ Introduction
- ▶ Interaction Options in Abaqus
- ▶ Connector Element Basics
- ▶ Connector Applications and Capabilities
- ▶ Connectors vs. Multi-point Constraints
- ▶ Flexible and Rigid components in a Model
- ▶ Procedures



1 hour

# Lesson 2: Connection Elements and Library (Part 1)

## *Lesson content:*

- ▶ Introduction
- ▶ Defining Connector Elements
- ▶ Understanding Connector Sections
- ▶ Understanding Connection Types
- ▶ Understanding Connector Local Directions
- ▶ Connector Element Output
- ▶ Effects of Node Ordering and Rotation on Results
- ▶ Workshop Preliminaries
- ▶ Workshop 1: Hinge Connection (IA)
- ▶ Workshop 1: Hinge Connection (KW)



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



1.5 hours



# Lesson 3: Connection Elements and Library (Part 2)

## ***Lesson content:***

- ▶ Rotational Degrees of Freedom at Nodes
- ▶ Surface-Based Coupling Constraints
- ▶ Mesh-Independent Fasteners
- ▶ Components of Relative Motion
- ▶ Connector Local Kinematics
- ▶ Summary of Orientations and Local Directions
- ▶ Workshop 2a: Analysis of a UJOINT (IA)
- ▶ Workshop 2a: Analysis of a UJOINT (KW)
- ▶ Workshop 2b: Four-Stroke Engine (Part 1) (IA)
- ▶ Workshop 2b: Four-Stroke Engine (Part 1) (KW)



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



**2 hours**

# Lesson 4: Connector Builder

## *Lesson content:*

- ▶ Introduction
- ▶ Connector Builder
- ▶ Coincident Point Builder
- ▶ Workshop 3a: Modeling Pliers (IA)
- ▶ Workshop 3a: Modeling Pliers (KW)
- ▶ Workshop 3b: Four-Stroke Engine (Part 2) (IA)
- ▶ Workshop 3b: Four-Stroke Engine (Part 2) (KW)



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



1.5 hours

# Lesson 5: Overconstraints and Connectors

## *Lesson content:*

- ▶ General Remarks
- ▶ Overconstraints Detected during Model Processing
- ▶ Overconstraints Detected during Analysis Execution
- ▶ Controlling the Overconstraint Checks
- ▶ Example: Multibody System
- ▶ Workshop 4: Overconstraints: Hinge Model (IA)
- ▶ Workshop 4: Overconstraints: Hinge Model (KW)



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



1.5 hours

# Lesson 6: Connector Behavior (Part 1)

## ***Lesson content:***

- ▶ Introduction
- ▶ Defining Connector Behavior
- ▶ Connector Elasticity
- ▶ Reference Configuration for Constitutive Behavior
- ▶ Connector Damping
- ▶ Connector Stops
- ▶ Connector Locks
- ▶ Connector Failure
- ▶ Workshop 5a: Connector Attributes – Hinge Model (IA)
- ▶ Workshop 5a: Connector Attributes – Hinge Model (KW)
- ▶ Workshop 5b: Connector Attributes – Four-Stroke Engine Model (IA)
- ▶ Workshop 5b: Connector Attributes – Four-Stroke Engine Model (KW)



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



**2 hours**

# Lesson 7: Connector Behavior (Part 2)

## ***Lesson content:***

- ▶ Connectors in Series/Parallel
- ▶ Connector Functions
- ▶ Connector Friction
- ▶ Connector Plasticity
- ▶ Connector Damage
- ▶ Connector Failure
- ▶ Workshop 6a: Analysis of a Spot Weld (IA)
- ▶ Workshop 6a: Analysis of a Spot Weld (KW)
- ▶ Workshop 6b: Connector Friction (IA)
- ▶ Workshop 6b: Connector Friction (KW)



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



**2.5 hours**



# Lesson 8: Rotational Connectors

## *Lesson content:*

- ▶ Cardan
- ▶ Euler
- ▶ Flexion-Torsion
- ▶ Projection Flexion-Torsion
- ▶ Rotation
- ▶ Workshop 7: Rotational Connector Elements (IA)
- ▶ Workshop 7: Rotational Connector Elements (KW)



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



1 hour

# Lesson 9: Connector Actuation

## *Lesson content:*

- ▶ Introduction
- ▶ Fixed Relative Motion
- ▶ Displacement-Controlled Actuation
- ▶ Force-Controlled Actuation
- ▶ Sensors and Actuators
- ▶ Workshop 8: Analysis of a Simple Four-Stroke Engine (IA)
- ▶ Workshop 8: Analysis of a Simple Four-Stroke Engine (KW)



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



2 hours

# Appendix 1: Some Advanced Connection Types

## *Appendix content:*

- ▶ Overview
- ▶ SLIPRING
- ▶ FLOW-CONVERTER/RETRACTOR
- ▶ Example
- ▶ Limitations



20 minutes

# Appendix 2: Connector Uniaxial Behavior

## *Appendix content:*

- ▶ Connector Uniaxial Behavior



20 minutes