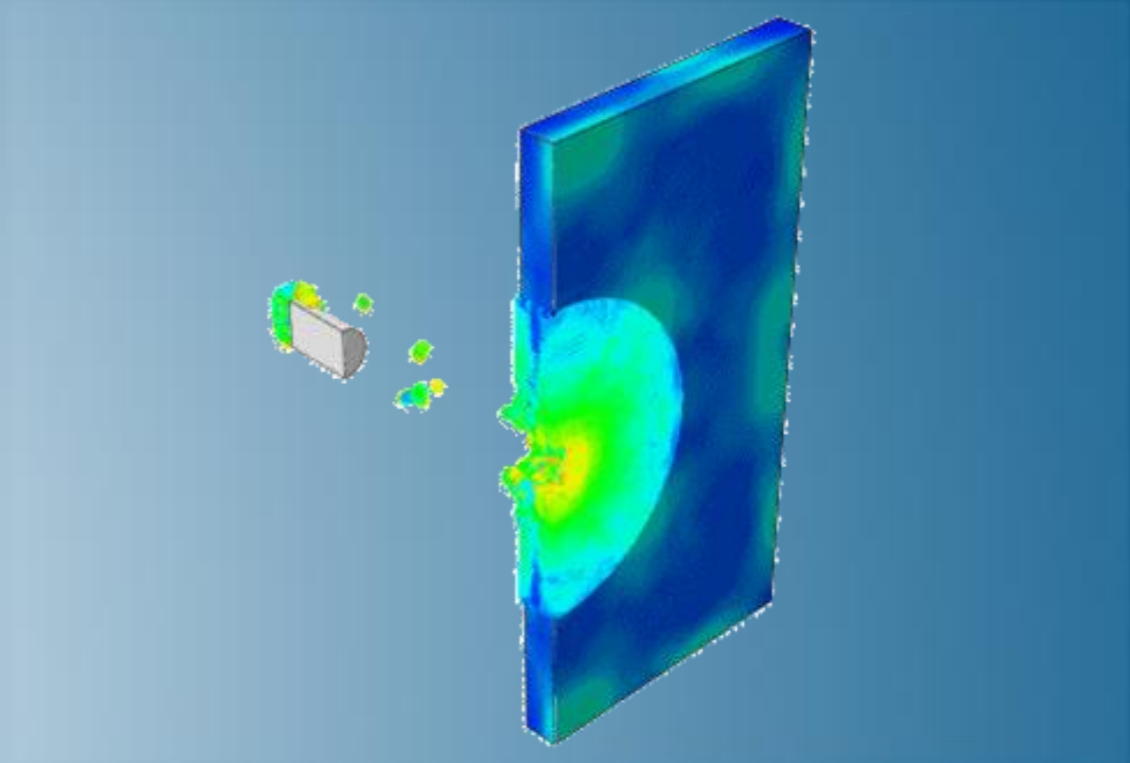


# Modeling Extreme Deformation and Fluid Flow with Abaqus

Abaqus 2019



**3DEXPERIENCE**<sup>®</sup>



# About this Course

## Course objectives

Upon completion of this course you will be able to:

- ▶ Create Eulerian meshes and define the initial material location within an Eulerian mesh
- ▶ Specify initial conditions, boundary conditions and loads to materials in the Eulerian domain
- ▶ Use general contact to model Eulerian-Lagrangian interactions
- ▶ Create SPH meshes
- ▶ Automatically convert conventional continuum elements to SPH particles
- ▶ Define initial conditions, boundary conditions, and loads on SPH particles
- ▶ Define contact interactions between SPH particles and element-based or analytical surfaces
- ▶ Understand the differences between the CEL and SPH approaches

## 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 Introduction
- ▶ Lecture 2 Overview of CEL (Coupled Eulerian-Lagrangian) Analysis
- ▶ Lecture 3 Creating a CEL Model
  - Workshop 1 Deformation of an Elastic Dam under Time-dependent Water Pressure
- ▶ Lecture 4 Abaqus/CAE Volume Fraction Tool
- ▶ Lecture 5 CEL Modeling Techniques
  - Workshop 2 Bird Strike Impact on Double-walled Aircraft Fuselage

## Day 2

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- ▶ Lecture 6            CEL for Fluid Applications
- ▶ Lecture 7            Overview of SPH (Smoothed Particle Hydrodynamics)
- ▶ Lecture 8            SPH Modeling Techniques
  - Workshop 3    Bird Strike on an Airplane Engine Blade
- ▶ Lecture 9            Comparison of CEL and SPH

## Additional Material

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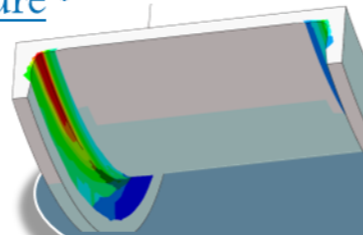
- ▶ Appendix 1      SPH Theory

# SIMULIA

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

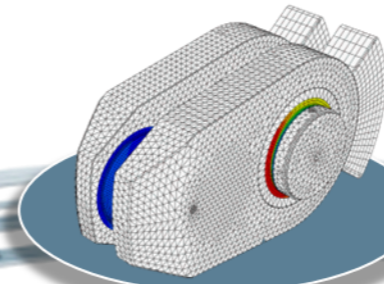
## Design Optimization: Tosca Structure \*

Simulation-driven design refinement to improve performance



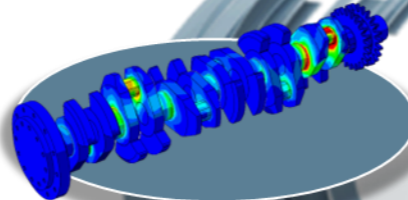
## Durability Assessment: fe-safe \*

Accurate life estimation to achieve certification



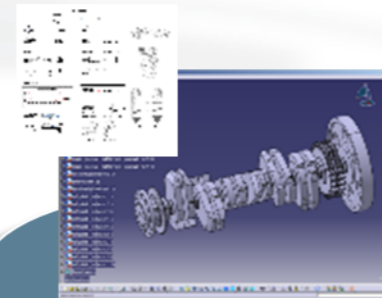
## FEA Stress Analysis: Abaqus \*

Detailed stress analysis using extracted load history from MBS



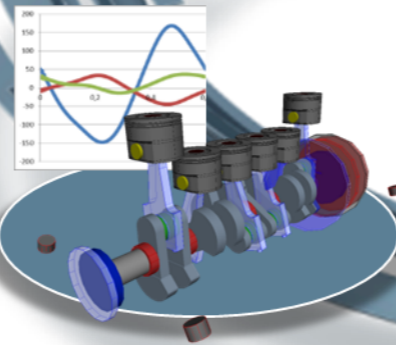
## CAD Geometry: CATIA

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



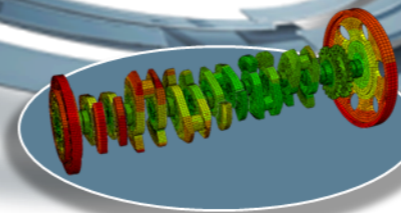
## Multibody Simulation: Simpack

System analysis to extract virtual load history of complete working cycle



## Mesh Calibration: Isight \*

Automated mesh calibration; sufficient mesh quality for accurate results

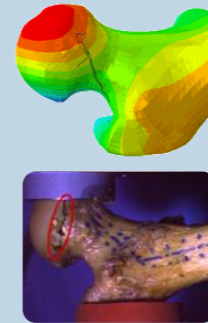


\* Included in extended licensing pool

# SIMULIA's Power of the Portfolio

## Abaqus

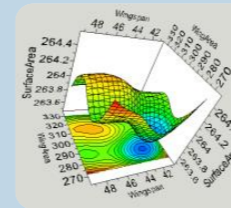
- Routine and Advanced Simulation
- Linear and Nonlinear, Static and Dynamic
- Thermal, Electrical, Acoustics
- Extended Physics through Co-simulation
- Model Preparation and Visualization



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

## Isight

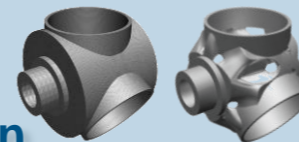
- Process Integration
- Design Optimization
- Parametric Optimization
- Six Sigma and Design of Experiments



**Material Calibration  
Workflow Automation  
Design Exploration**

## Tosca

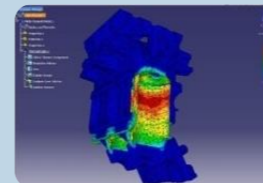
- Non-Parametric Optimization
- Structural and Fluid Flow Optimization
- Topology, Sizing, Shape, Bead Optimization



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

## fe-safe

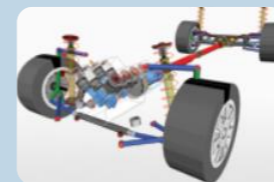
- Durability Simulation
- Low Cycle and High Cycle Fatigue
- Weld, High Temperature, Non-metallics



**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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to log in or join!



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# Revision Status

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Lecture 1	11/18	Updated for Abaqus 2019
Lecture 2	11/18	Updated for Abaqus 2019
Lecture 3	11/18	Updated for Abaqus 2019
Lecture 4	11/18	Updated for Abaqus 2019
Lecture 5	11/18	Updated for Abaqus 2019
Lecture 6	11/18	Updated for Abaqus 2019
Lecture 7	11/18	Updated for Abaqus 2019
Lecture 8	11/18	Updated for Abaqus 2019
Lecture 9	11/18	Updated for Abaqus 2019
Appendix 1	11/18	Updated for Abaqus 2019
Workshop 1	11/18	Updated for Abaqus 2019
Workshop 2	11/18	Updated for Abaqus 2019
Workshop 3	11/18	Updated for Abaqus 2019

# Lesson 1: Introduction

## *Lesson content:*

- ▶ Multiphysics / Multiscale Simulation
- ▶ SIMULIA Multiphysics
- ▶ Abaqus Multiphysics
- ▶ Coupled Eulerian-Lagrangian (CEL) approach
- ▶ Smoothed Particle Hydrodynamics (SPH) approach



1 hour

# Lesson 2: Overview of CEL (Coupled Eulerian-Lagrangian) Analysis

## *Lesson content:*

- ▶ CEL Analysis Technique
- ▶ CEL Examples
- ▶ Detailed case study: Tire Hydroplaning/Aquaplaning



45 minutes

# Lesson 3: Creating a CEL Model

## *Lesson content:*

- ▶ Case Study Introduction: Front-load washing machine
- ▶ Defining the Eulerian Domain
- ▶ Eulerian-Lagrangian Coupling
- ▶ Postprocessing—Basic tips
- ▶ Postprocessing—Additional suggestions
- ▶ Summary
- ▶ Workshop Preliminaries
- ▶ Workshop 1: Deformation of an Elastic Dam under Time-dependent Water Pressure



2 hours

# Lesson 4: Abaqus/CAE Volume Fraction Tool

## *Lesson content:*

- ▶ Introduction
- ▶ Using the volume fraction tool
- ▶ Tips



30 minutes

# Lesson 5: Coupled Eulerian-Lagrangian Modeling Techniques

## *Lesson content:*

- ▶ Element types and procedures
- ▶ Initial conditions, boundary conditions, and loads
- ▶ Eulerian mesh motion
- ▶ Contact
- ▶ Mesh density
- ▶ Adaptive mesh refinement
- ▶ Materials and material instances
- ▶ Output and postprocessing
- ▶ Tracer particles
- ▶ Comparison to Lagrangian analysis
- ▶ Limitations
- ▶ Workshop 2: Bird Strike Impact on Double-walled Aircraft Fuselage



2.5 hours

# Lesson 6: CEL for Fluid Applications

## *Lesson content:*

- ▶ EOS Materials
- ▶ CEL and Flow Problems
- ▶ Flow Benchmarks
- ▶ Hourglass Control
- ▶ Boundary Reflections
- ▶ Tips
- ▶ Troubleshooting Checklist



2 hours

# Lesson 7: Overview of SPH (Smoothed Particle Hydrodynamics)

## *Lesson content:*

- ▶ Introduction
- ▶ Examples
  - Water-wave impact
  - Priming a Pump
  - Bottle Drop
  - Garden Hose
  - Taylor Test
  - Projectile Impact on a Plate
  - Hail Impact
- ▶ SPH Basics
- ▶ SPH Interpolation



1 hour

# Lesson 8: SPH Modeling Techniques

## *Lesson content:*

- ▶ Overview
- ▶ Particle elements
- ▶ Model definition
- ▶ Optional controls
- ▶ Converting finite elements to SPH particles
- ▶ Inflow and outflow
- ▶ Limitations
- ▶ Workshop 3: Bird Strike on an Airplane Engine Blade



2 hours

# Lesson 9: Comparison of CEL and SPH

## *Lesson content:*

- ▶ Abbreviations
- ▶ Material considerations
- ▶ Contact considerations
- ▶ Geometry and mesh considerations
- ▶ Analysis type considerations
- ▶ Computational considerations
- ▶ Summary tables
  - Functionality-based comparison
  - Application-based comparison



45 minutes

# Appendix 1: SPH Theory

## *Appendix content:*

- ▶ Introduction
- ▶ Basic Properties of Kernels
- ▶ Particle Approximation
- ▶ SPH Interpolation
- ▶ Lucy's Weight Function
- ▶ Characteristic Properties of SPH
- ▶ SPH Applications
- ▶ References



45 minutes