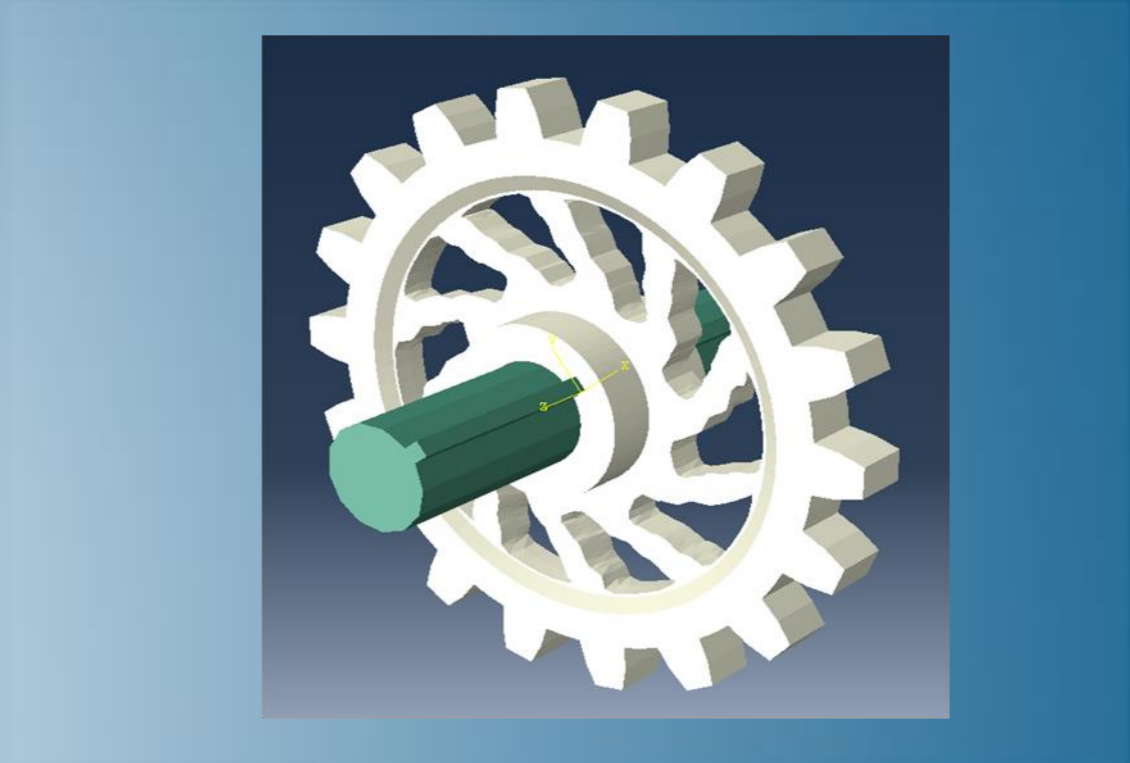


# Non-Parametric Optimization in Abaqus

2016



3DEXPERIENCE



# About this Course

## Course objectives

Upon completion of this course you will be able to:

- ▶ Apply topology, shape, sizing and bead optimization techniques to your designs and produce lightweight, strong and durable components
- ▶ Reduce iterations of designs
- ▶ Use the optimization interface in Abaqus/CAE for setup, execution, monitoring and postprocessing of topology, shape, sizing and bead optimization problems
- ▶ Use Tosca's structural optimization capability for highly nonlinear problems

## Targeted audience

Finite element analysts or product designers with some background in finite element analysis

## Prerequisites

Some familiarity with Abaqus/CAE is useful but not required.



1 day

# Day 1

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- ▶ Lecture 1 Introduction
- ▶ Lecture 2 Condition-based Topology Optimization
- ▶ Workshop 1a Condition-based Topology Optimization of a Gear
- ▶ Workshop 1b Condition-based Topology Optimization of a Landing Gear Torque Link (optional)
- ▶ Lecture 3 Geometric Restrictions and Filtering
- ▶ Workshop 2a Stamping Geometric Restriction
- ▶ Workshop 2b Demold Control Using the Central Plane Technique
- ▶ Workshop 2c Symmetry Geometric Restriction
- ▶ Lecture 4 Sensitivity-based Topology Optimization
- ▶ Workshop 3a Sensitivity-based Topology Optimization of a Gear
- ▶ Workshop 3b Sensitivity-based Topology Optimization of a Landing Gear Torque Link Assembly (optional)
- ▶ Lecture 5 Shape Optimization
- ▶ Workshop 4 Shape Optimization of a Plate with a Hole
- ▶ Lecture 6 Sizing Optimization
- ▶ Workshop 5 Sensitivity-based Sizing Optimization of a Holder
- ▶ Lecture 7 Bead Optimization
- ▶ Workshop 6 Bead Optimization of a Hood

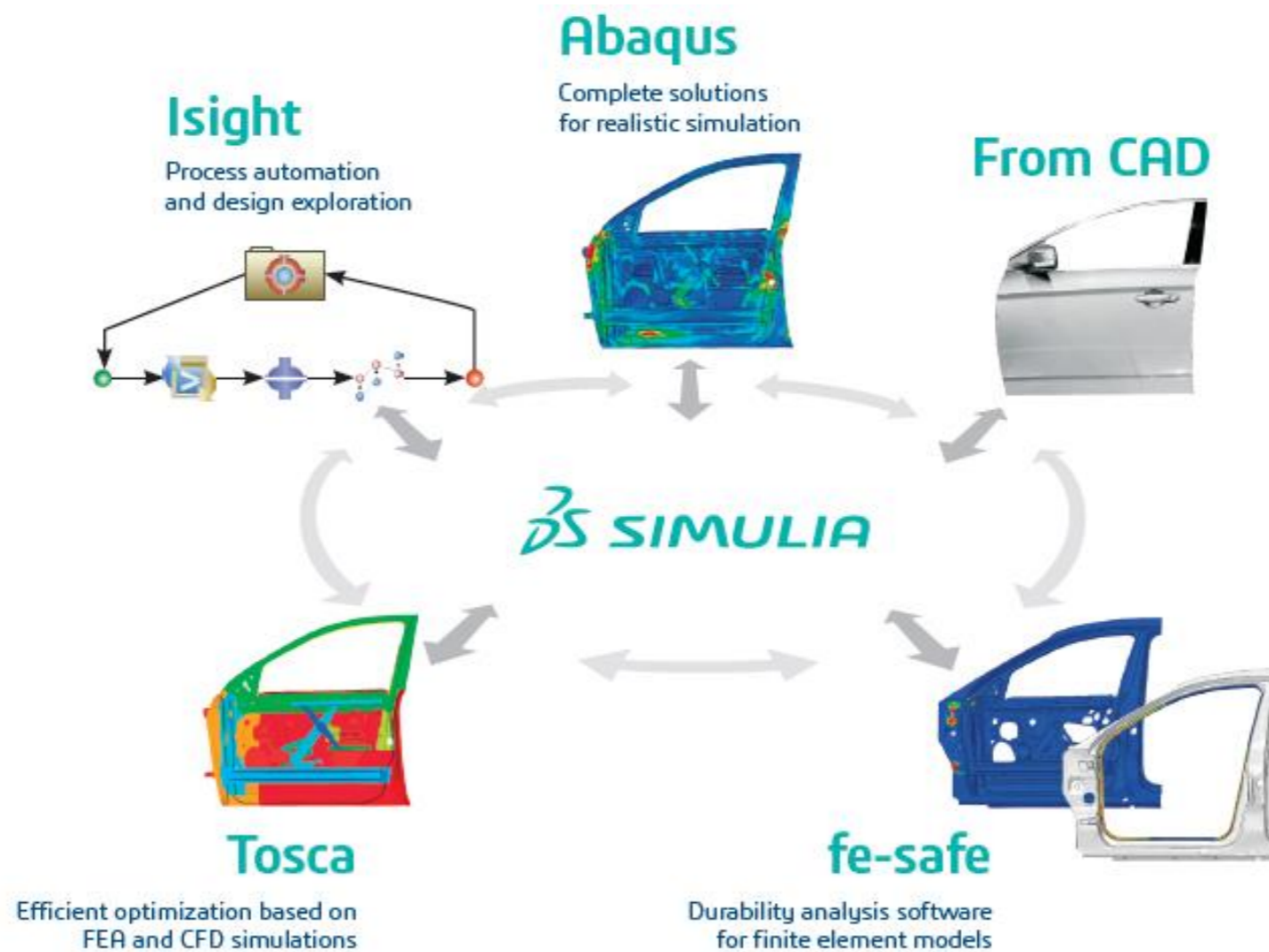
## Additional Material

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- ▶ Appendix 1      Geometric Restrictions in Shape Optimization
- ▶ Appendix 2      Nonlinear Effects in Topology Optimization

# SIMULIA

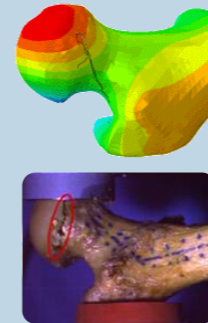
- ▶ SIMULIA is the Dassault Systèmes brand for Realistic Simulation solutions
- ▶ Portfolio of established, best-in-class products
  - Abaqus, Isight, Tosca, fe-safe
  - All using a common extended licensing pool



# SIMULIA's Power of the Portfolio

## Abaqus

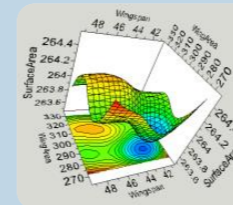
- Routine and Advanced Simulation
- Linear and Nonlinear, Static and Dynamic
- Fluid, Thermal, Electrical, Acoustics
- Extended Physics through Co-simulation
- Model Preparation and Visualization



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

## Isight

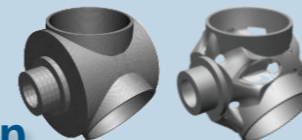
- Process Integration
- Design Optimization
- Parametric Optimization
- Six Sigma and Design of Experiments



**Material Calibration  
Workflow Automation  
Design Exploration**

## Tosca

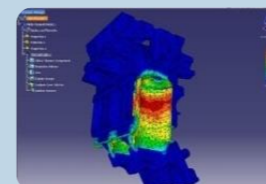
- Non-Parametric Optimization
- Structural and Fluid Flow Optimization
- Topology, Sizing, Shape, Bead Optimization



**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**

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Connect with peers to share knowledge and get technical insights

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 SIMULIA

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**Connect. Share. Spark Innovation.**

 | The 3DEXPERIENCE Company

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- > By Course

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# Revision Status

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Lecture 1	3/16	Updated for 2016
Lecture 2	3/16	Updated for 2016
Lecture 3	3/16	Updated for 2016
Lecture 4	3/16	Updated for 2016
Lecture 5	3/16	Updated for 2016
Lecture 6	3/16	Updated for 2016
Lecture 7	3/16	New for 2016
Appendix 1	3/16	Updated for 2016
Appendix 2	3/16	Updated for 2016
Workshop 1a	3/16	Updated for 2016
Workshop 1b	3/16	Updated for 2016
Workshop 2a	3/16	Updated for 2016
Workshop 2b	3/16	Updated for 2016
Workshop 2c	3/16	Updated for 2016
Workshop 3a	3/16	Updated for 2016
Workshop 3b	3/16	Updated for 2016
Workshop 4	3/16	Updated for 2016
Workshop 5	3/16	Updated for 2016
Workshop 6	3/16	New for 2016

# Lesson 1: Introduction

## *Lesson content:*

- ▶ Overview
- ▶ Tosca and Optimization Module in Abaqus/CAE
- ▶ Tosca and Isight



# Lesson 2: Condition-based Topology Optimization

## *Lesson content:*

- ▶ Algorithms for Topology Optimization
- ▶ Condition-based Topology Optimization
- ▶ Basic Terminology
- ▶ Optimization Workflow
- ▶ Abaqus Model
- ▶ Optimization Task
- ▶ Design Responses
- ▶ Objective Function
- ▶ Constraints
- ▶ Geometric Restrictions
- ▶ Setup
- ▶ Execution and Monitoring
- ▶ Results
- ▶ Extraction
- ▶ Workshop Preliminaries
- ▶ Workshop 1a: Condition-based Topology Optimization of a Gear
- ▶ Workshop 1b: Condition-based Topology Optimization of a Landing Gear Torque Link (Optional)



2 hours

# Lesson 3: Geometric Restrictions and Filtering

## *Lesson content:*

- ▶ Geometric Restrictions
- ▶ Filtering
- ▶ Workshop 2a: Stamping Geometric Restrictions
- ▶ Workshop 2b: Demold Control Using the Central Plane Technique (Optional)
- ▶ Workshop 2c: Symmetry Geometric Restrictions



1 hour

# Lesson 4: Sensitivity-based Topology Optimization

## *Lesson content:*

- ▶ Algorithms for Topology Optimization
- ▶ General Topology Optimization
- ▶ Optimization Tasks
- ▶ Design Responses
- ▶ Objective Function
- ▶ Constraints
- ▶ Condition-based vs. Sensitivity-based Optimization
- ▶ Postprocessing
- ▶ Workshop 3a: Sensitivity-based Topology Optimization of a Gear
- ▶ Workshop 3b: Sensitivity-based Topology Optimization of a Landing Gear Torque Link Assembly (Optional)



1.5 hours

# Lesson 5: Shape Optimization

## *Lesson content:*

- ▶ Basic Terminology
- ▶ Shape Optimization
- ▶ Abaqus Model
- ▶ Optimization Task
- ▶ Design Responses
- ▶ Objective and Constraints
- ▶ Geometric Restrictions
- ▶ Stop Conditions
- ▶ Postprocessing
- ▶ Workshop 4: Shape Optimization of a Plate with a Hole



1 hour

# Lesson 6: Sizing Optimization

## *Lesson content:*

- ▶ Sizing Optimization
- ▶ Basic Terminology
- ▶ Optimization Task
- ▶ Geometric Restrictions
- ▶ Postprocessing
- ▶ Example: Sizing Optimization of a Car Front Door
- ▶ Nonlinearities
- ▶ Workshop 5: Sensitivity-based Sizing Optimization of a Holder



1.5 hours



# Lesson 7: Bead Optimization

## *Lesson content:*

- ▶ Bead stiffeners
- ▶ Bead pattern design
- ▶ Bead optimization in Tosca Structure
- ▶ Example: Beam bending
- ▶ Moment of inertia of a rectangular bead
- ▶ Algorithms for Bead Optimization
- ▶ Basic Terminology
- ▶ Postprocessing
- ▶ Workshop 6: Bead Optimization of a Hood



30 minutes

# Appendix 1: Geometric Restrictions in Shape Optimization

## *Appendix content:*

- ▶ Demold Control
- ▶ Turn Control
- ▶ Drill Control
- ▶ Planar Symmetry
- ▶ Stamp Control
- ▶ Growth
- ▶ Design Direction
- ▶ Penetration Check
- ▶ Slide Region



45 minutes

# Appendix 2: Nonlinear Effects in Topology Optimization

## *Appendix content:*

- ▶ Example: Beam Structure
- ▶ Topology Optimization of a Beam Structure: Linear geometry
- ▶ Topology Optimization of a Beam Structure: Nonlinear geometry
- ▶ Example: Gear Shaft Assembly
- ▶ Conclusions



30 minutes