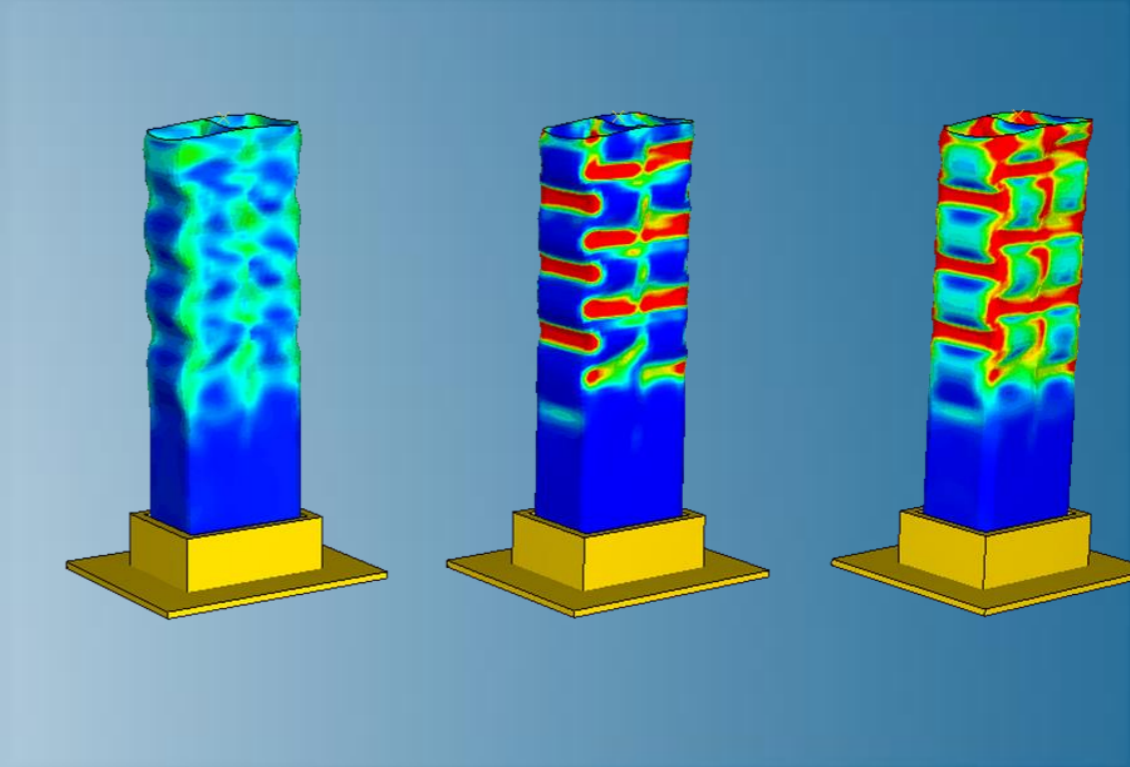


Metal Inelasticity in Abaqus

Abaqus 2019



3DEXPERIENCE[®]



About this Course

Course objectives

Upon completion of this course you will be able to model:

- ▶ Metals that show inelastic work hardening
- ▶ The Bauschinger effect
- ▶ "Ratcheting" and relaxation of the mean stress under cyclic loading
- ▶ Strain-rate-dependent inelastic behavior
- ▶ Temperature-dependent plasticity
- ▶ Heat generated by plastic deformation
- ▶ Ductile failure of metallic materials
- ▶ Plastic behavior in brittle (cast iron) metals
- ▶ Creep behavior in metals

Targeted audience

Simulation Analysts

Prerequisites

This course is recommended for engineers with experience using Abaqus



2 days

Day 1

- ▶ Lecture 1 Introduction
- ▶ Lecture 2 Ductile Metal Response
 - Workshop 1 Metal Plasticity Tutorials
- ▶ Lecture 3 Classical Metal Plasticity in Abaqus
 - Workshop 2 Cyclic Loading of a Flange
- ▶ Lecture 4 Johnson-Cook Plasticity

Day 2

- ▶ Lecture 5 Metal Failure Models
- ▶ Lecture 6 Creep and Swelling
 - Workshop 3 Sagging of a Pipe
- ▶ Lecture 7 Two-Layer Viscoplasticity
- ▶ Lecture 8 Gray Cast Iron Plasticity
- ▶ Lecture 9 Time Integration

Additional Material

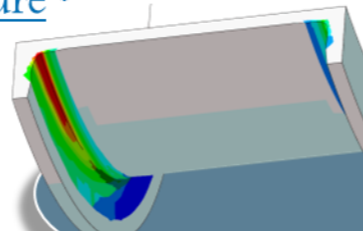
- ▶ Appendix 1 Basic Concepts of Plasticity Theory
- ▶ Appendix 2 Porous Metal Plasticity
- ▶ Appendix 3 References

SIMULIA

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

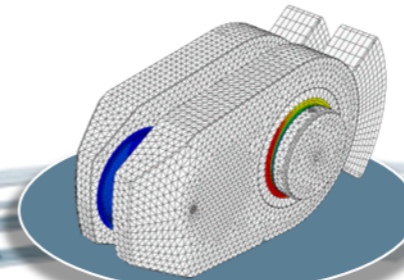
Design Optimization: Tosca Structure *

Simulation-driven design refinement to improve performance



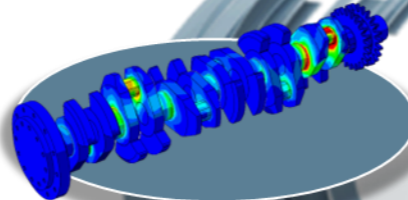
Durability Assessment: fe-safe *

Accurate life estimation to achieve certification



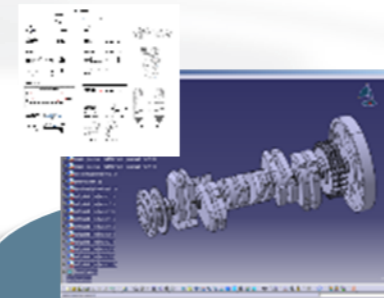
FEA Stress Analysis: Abaqus *

Detailed stress analysis using extracted load history from MBS



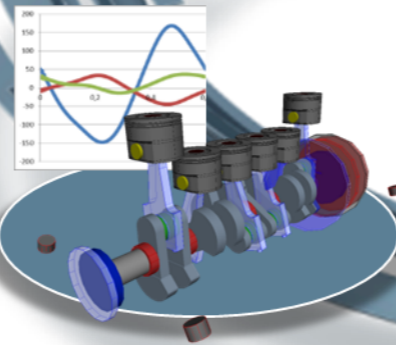
CAD Geometry: CATIA

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



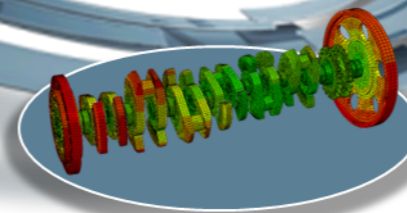
Multibody Simulation: Simpack

System analysis to extract virtual load history of complete working cycle



Mesh Calibration: Isight *

Automated mesh calibration; sufficient mesh quality for accurate results

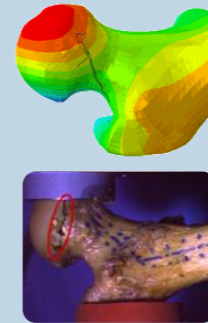


* Included in extended licensing pool

SIMULIA's Power of the Portfolio

Abaqus

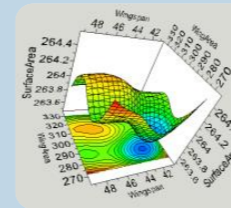
- Routine and Advanced Simulation
- Linear and Nonlinear, Static and Dynamic
- Thermal, Electrical, Acoustics
- Extended Physics through Co-simulation
- Model Preparation and Visualization



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

Isight

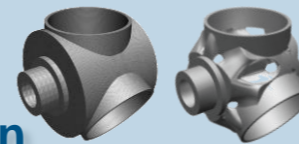
- Process Integration
- Design Optimization
- Parametric Optimization
- Six Sigma and Design of Experiments



**Material Calibration
Workflow Automation
Design Exploration**

Tosca

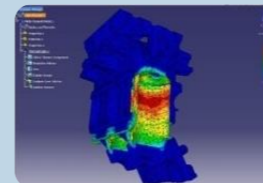
- Non-Parametric Optimization
- Structural and Fluid Flow Optimization
- Topology, Sizing, Shape, Bead Optimization



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

fe-safe

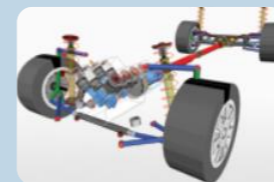
- Durability Simulation
- Low Cycle and High Cycle Fatigue
- Weld, High Temperature, Non-metallics



**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
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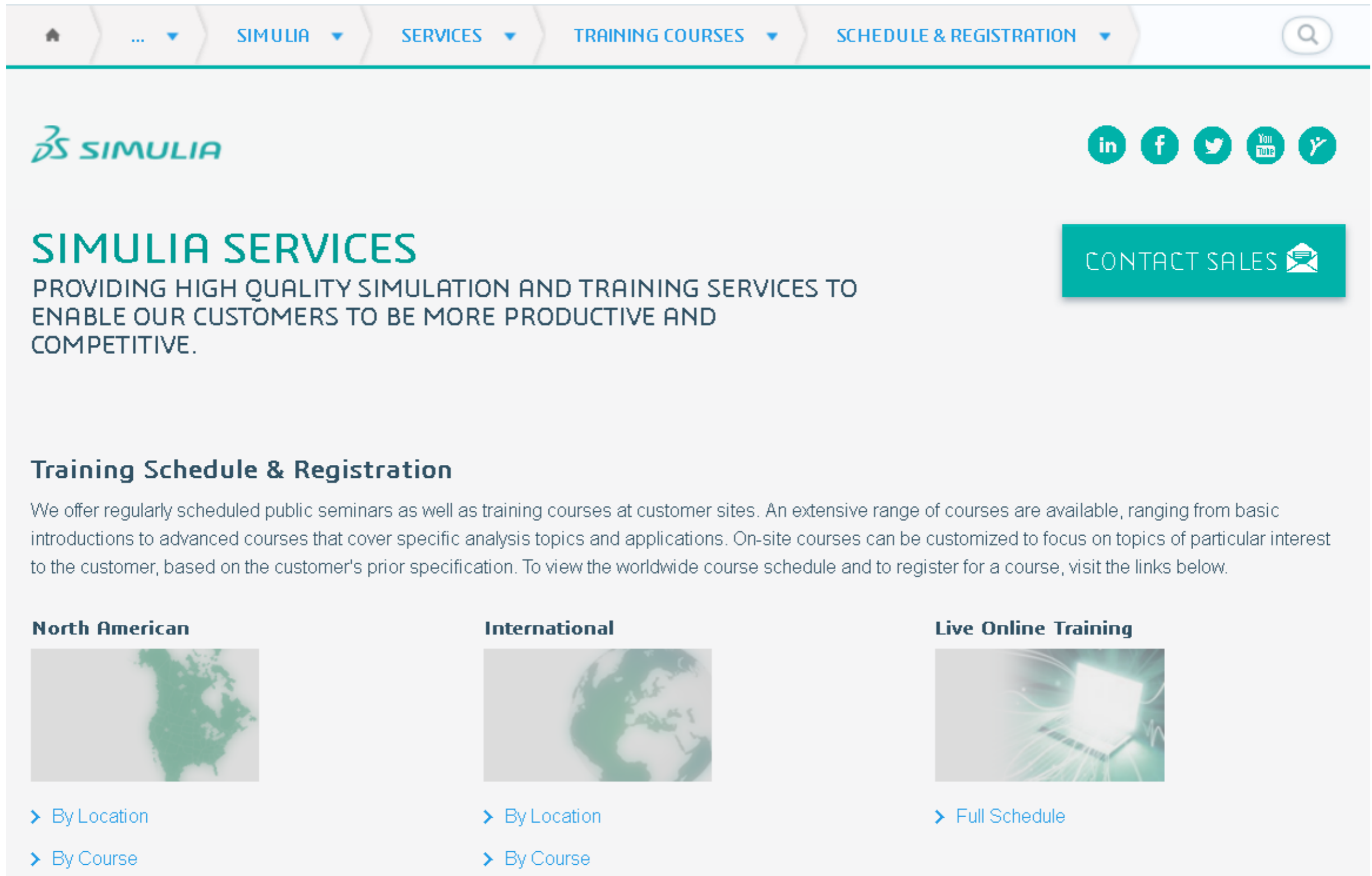
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Revision Status

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
Appendix 2	11/18	Updated for Abaqus 2019
Appendix 3	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:

- ▶ Purpose
- ▶ Focus on design applications
- ▶ Micromechanics approach
- ▶ Phenomenological approach



10 minutes

Lesson 2: Ductile Metal Response

Lesson content:

- ▶ Uniaxial Test at Low Temperatures
 - Stress and strain measures
 - Yield
 - Strain reversal after yield
 - Cyclic loading
 - Necking
 - Temperature and strain-rate dependence
- ▶ Uniaxial Test at Elevated Temperatures
- ▶ Workshop Preliminaries
- ▶ Workshop 1: Metal Plasticity Tutorials



75 minutes

Lesson 3: Classical Metal Plasticity in Abaqus

Lesson content:

- ▶ Basic Assumptions
- ▶ Temperature and Field Variable Dependence
- ▶ Elasticity
- ▶ Strain Rate Decomposition
- ▶ Yield Functions
- ▶ Calibrating Hill's Anisotropic Plasticity Model
- ▶ Hardening
- ▶ Initial Hardening
- ▶ Rate Dependence
- ▶ Chaboche Unified Viscoplastic Model
- ▶ Annealing or Melting
- ▶ User Subroutine (V)UHARD
- ▶ Heat Generation for Thermo-Mechanical Problems
- ▶ Element Selection Issues
- ▶ Procedure Considerations
- ▶ Direct Cyclic Procedure
- ▶ Workshop 2: Cyclic Loading of a Flange (IA)
- ▶ Workshop 2: Cyclic Loading of a Flange (KW)



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



3 hours

Lesson 4: Johnson-Cook Plasticity

Lesson content:

- ▶ Introduction
- ▶ Elasticity
- ▶ Yield Function and Plastic Flow
- ▶ Hardening
- ▶ Strain Rate Dependence
- ▶ Annealing or Melting
- ▶ Heat Generation
- ▶ Dynamic Failure
- ▶ Example: Oblique Impact of a Copper Rod



30 minutes

Lesson 5: Metal Failure Models

Lesson content:

- ▶ Progressive Damage and Failure
- ▶ Damage Initiation Criteria for Fracture of Metals
- ▶ Damage Initiation Criteria for Sheet Metal Instability
- ▶ Damage Evolution for Ductile Metals
- ▶ Element Removal
- ▶ Damage and Failure in Low-cycle Fatigue
- ▶ Alternative Failure Models



2 hours

Lesson 6: Creep and Swelling

Lesson content:

- ▶ Basic Assumptions
- ▶ Elasticity
- ▶ Stress Potentials
- ▶ Deviatoric Creep Models
- ▶ Volumetric Swelling
- ▶ Inelastic Flow in Creep/Swelling Models
- ▶ Temperature and Field Variable Dependence
- ▶ Analysis Procedures
- ▶ Creep Integration and Time Incrementation
- ▶ Workshop 3: Sagging of a Pipe (IA)
- ▶ Workshop 3: Sagging of a Pipe (KW)



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



1 hour

Lesson 7: Two-Layer Viscoplasticity

Lesson content:

- ▶ Two-Layer Viscoplasticity
- ▶ Abaqus Usage
- ▶ Calibration Procedure
- ▶ Example



30 minutes

Lesson 8: Gray Cast Iron Plasticity

Lesson content:

- ▶ Introduction
- ▶ Elasticity
- ▶ Yield Function
- ▶ Flow Rule
- ▶ Hardening
- ▶ Element Selection and Output
- ▶ Example: Biaxial Loads on Gray Cast Iron
- ▶ Limitations
- ▶ Alternative Cast Iron Model



1 hour

Lesson 9: Time Integration

Lesson content:

- ▶ Plasticity
- ▶ Creep



30 minutes

Appendix 1: Basic Concepts of Plasticity Theory

Appendix content:

- ▶ Introduction
- ▶ The Strain Rate Decomposition
- ▶ The Yield Function
- ▶ The Flow Rule
- ▶ The Hardening Rule
- ▶ Summary



2 hours

Appendix 2: Porous Metal Plasticity

Appendix content:

- ▶ Basic Assumptions
- ▶ Yield Function
- ▶ Hardening and Plastic Flow
- ▶ Void Nucleation and Growth
- ▶ Failure Model in Abaqus/Explicit
- ▶ Initial Conditions
- ▶ Element Selection



45 minutes

Appendix 3: References

Appendix content:

- ▶ References



10 minutes