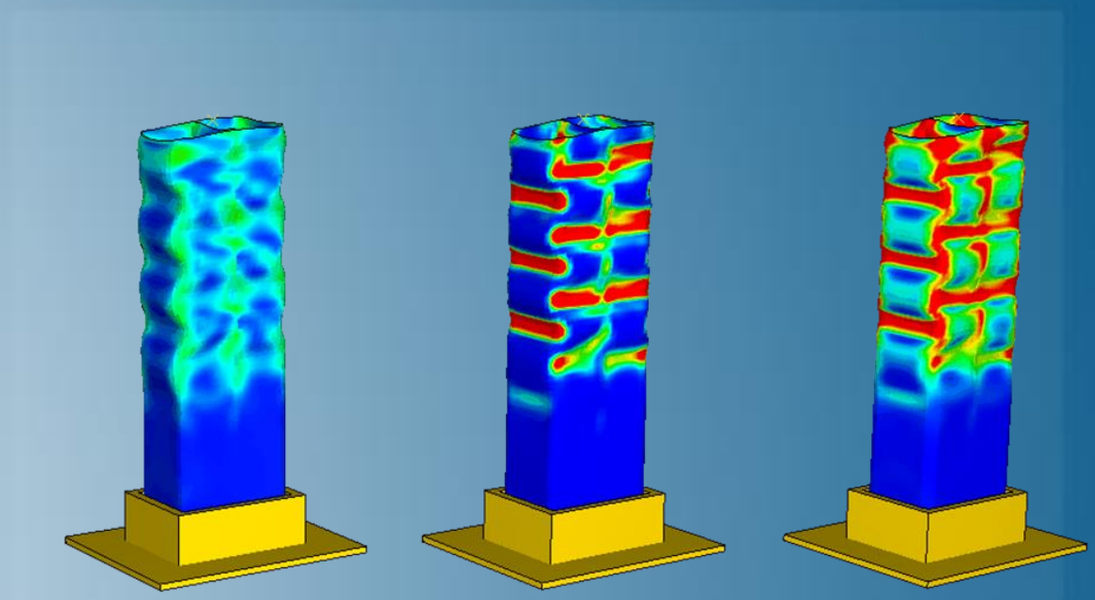
Metal Inelasticity in Abaqus

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

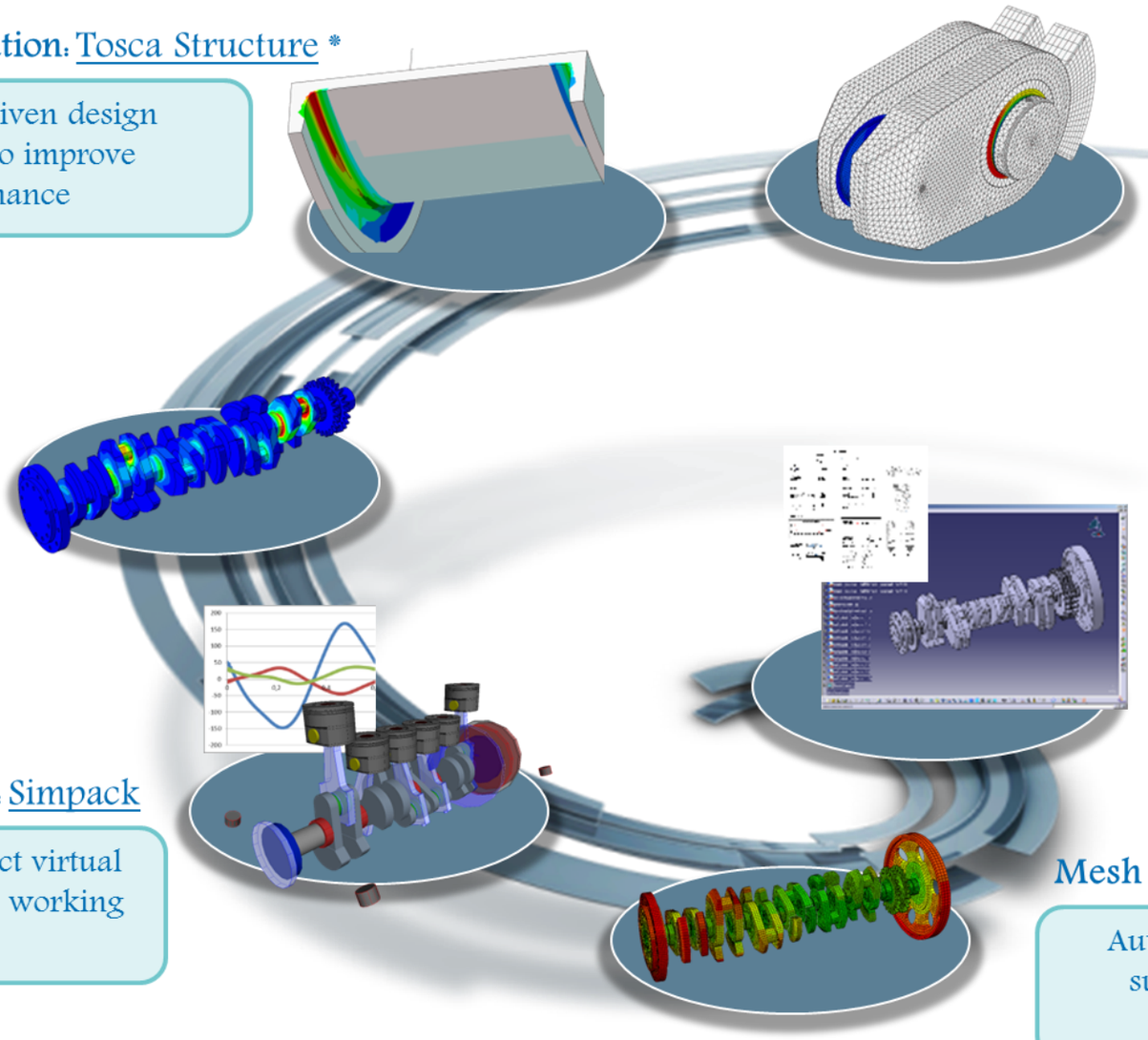
- Lecture 5 — Metal Failure Models
- Lecture 6 — Creep and Swelling
  - Workshop 3 — Sagging of a Pipe
- Lecture 7 — Two-Layer Viscoplasticity
- Lecture 8 — Gray Cast Iron Plasticity
- Lecture 9 — Time Integration

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 *

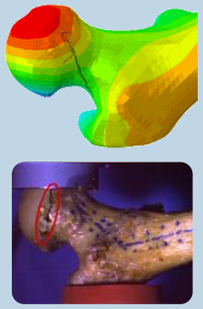
Automated mesh calibration: sufficient mesh quality for accurate results

* Included in extended licensing pool

SIMULIA's Power of the Portfolio

Abaqus

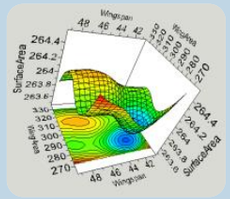
- Routine and Advanced Simulation
- Linear and Nonlinear, Static and Dynamic
- Thermal, Electrical, Acoustics
- Extended Physics through Co-simulation
- Model Preparation and Visualization



Realistic Human Simulation
High Speed Crash & Impact
Noise & Vibration

Isight

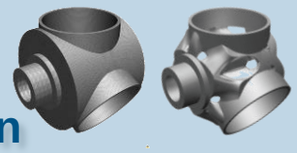
- Process Integration
- Design Optimization
- Parametric Optimization
- Six Sigma and Design of Experiments



Material Calibration
Workflow Automation
Design Exploration

Tosca

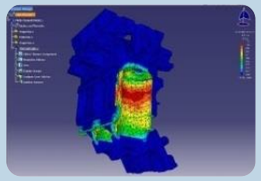
- Non-Parametric Optimization
- Structural and Fluid Flow Optimization
- Topology, Sizing, Shape, Bead Optimization



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

fe-safe

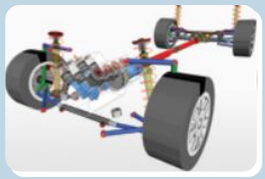
- Durability Simulation
- Low Cycle and High Cycle Fatigue
- Weld, High Temperature, Non-metallics



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 Contact

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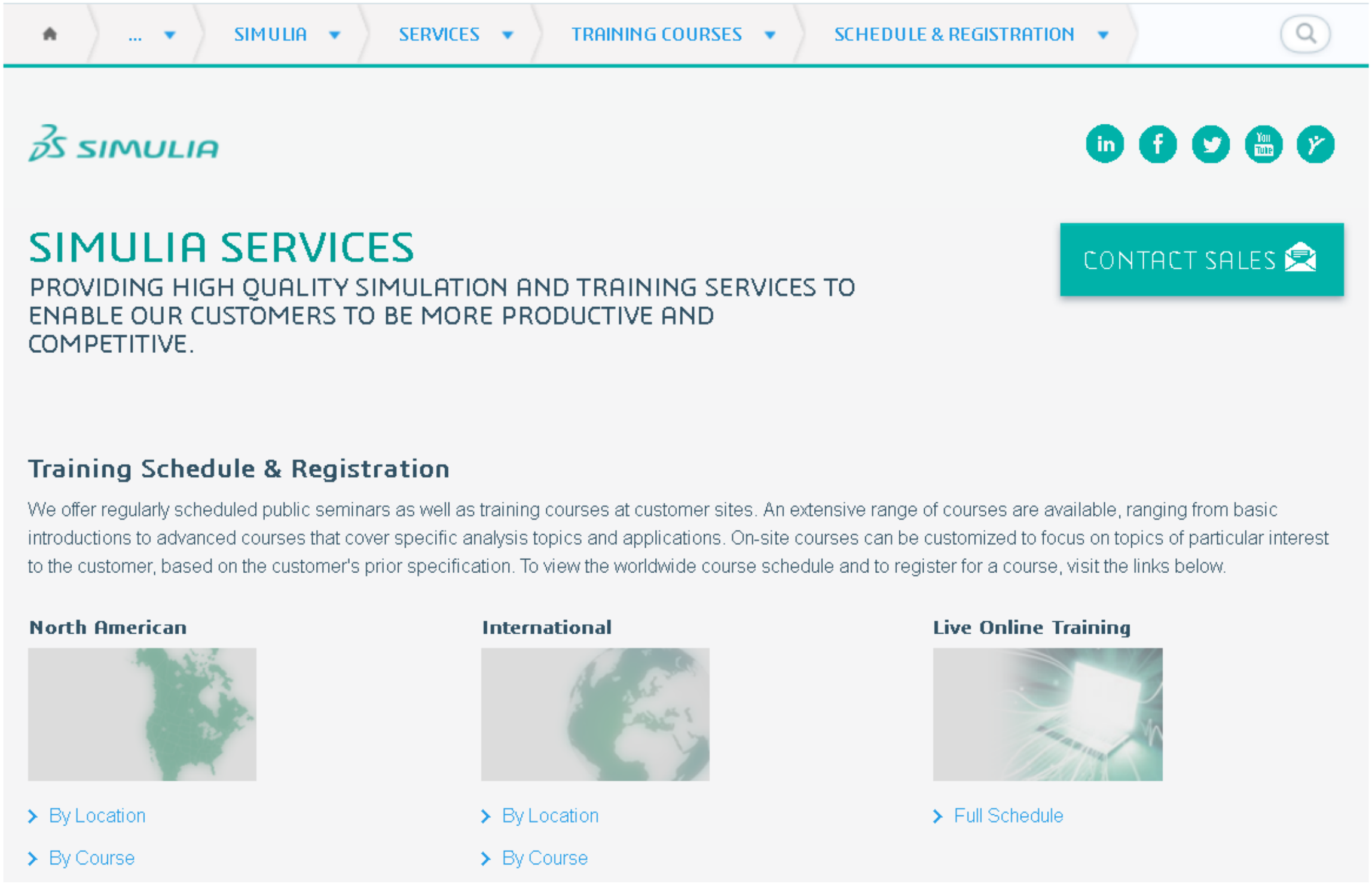

Legal Notices

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