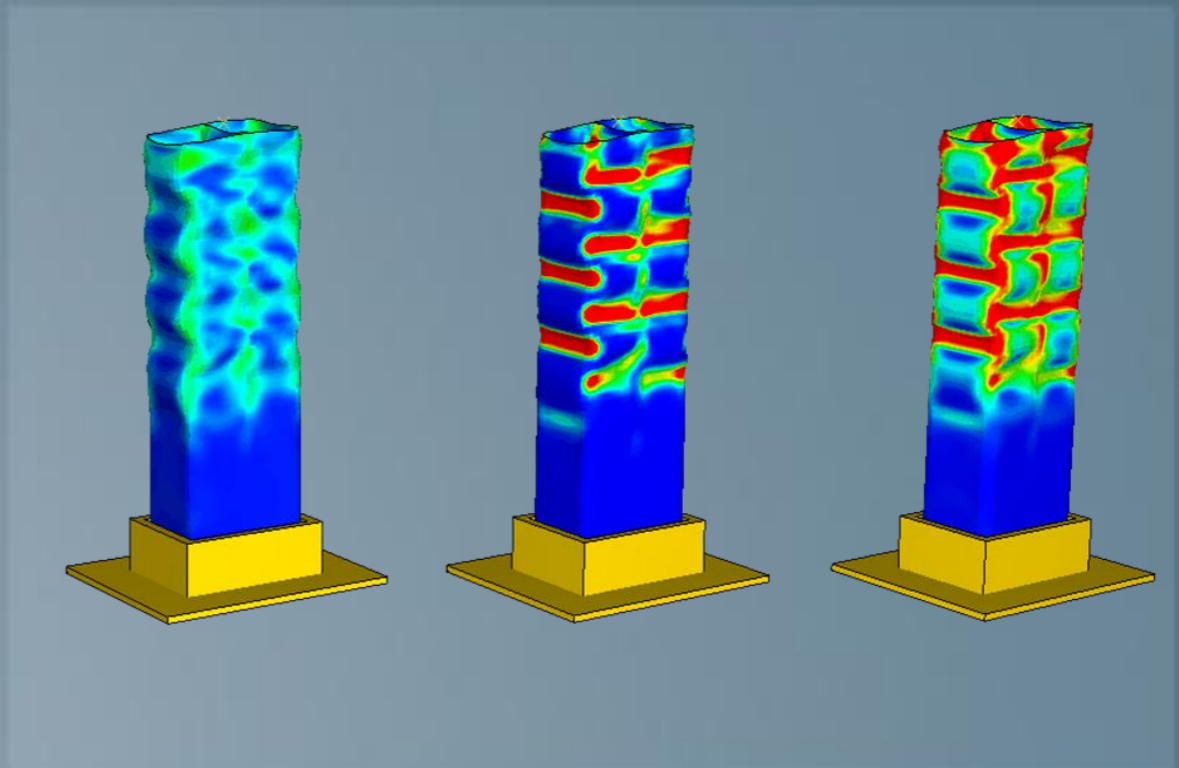


# Metal Inelasticity in Abaqus

6.14



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
- ▶ "Ratchetting" 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 porous and 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

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- ▶ 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
- ▶ Lecture 5            Metal Failure Models

## Day 2

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- ▶ Lecture 6            Creep and Swelling
  - Workshop 3      Sagging of a Pipe
- ▶ Lecture 7            Two-Layer Viscoplasticity
- ▶ Lecture 8            Gray Cast Iron Plasticity
- ▶ Lecture 9            Porous Metal Plasticity
- ▶ Lecture 10           Time Integration

## Additional Material

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- ▶ Appendix 1      Basic Concepts of Plasticity Theory
- ▶ Appendix 2      References

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# Revision Status

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Lecture 1	5/14	Updated for 6.14
Lecture 2	5/14	Updated for 6.14
Lecture 3	5/14	Updated for 6.14
Lecture 4	5/14	Updated for 6.14
Lecture 5	5/14	Updated for 6.14
Lecture 6	5/14	Updated for 6.14
Lecture 7	5/14	Updated for 6.14
Lecture 8	5/14	Updated for 6.14
Lecture 9	5/14	Updated for 6.14
Lecture 10	5/14	Updated for 6.14
Appendix 1	5/14	Updated for 6.14
Appendix 2	5/14	Updated for 6.14
Workshop 1	5/14	Updated for 6.14
Workshop 2	5/14	Updated for 6.14
Workshop 3	5/14	Updated for 6.14



# 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
- ▶ Elasticity
- ▶ Strain Rate Decomposition
- ▶ Yield Functions
- ▶ Calibrating Hill's Anisotropic Plasticity Model
- ▶ Hardening
- ▶ Initial Hardening
- ▶ Rate Dependence
- ▶ Temperature and Field Variable Dependence
- ▶ 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)



2 hours



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

# 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
- ▶ Example



1.5 hours

# 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: Porous Metal Plasticity

## *Lesson content:*

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



45 minutes

# Lesson 10: 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

