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
Engineers with experience using Abaqus.

Prerequisites
None

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
- Lecture 5: Metal Failure Models

Day 2

- 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

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

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Lesson 1: Introduction

The following topics are covered in this lesson.

Lesson content:
- Introduction

Here are the steps to be followed:

1. Purpose
2. Focus on design applications
3. Micromechanics approach
4. Phenomenological approach
Lesson 2: Ductile Metal Response

The following topics are covered in this lesson.

Lesson content:
- Ductile Metal Response
- Workshop Preliminaries
- Workshop 1: Metal Plasticity Tutorials

Ductile Metal Response

Here are the steps to be followed:

1. Uniaxial Test at Low Temperatures
   a. Stress and strain measures
   b. Yield
   c. Strain reversal after yield
   d. Cyclic loading
   e. Necking
   f. Temperature and strain-rate dependence

2. Uniaxial Test at Elevated Temperatures
Lesson 3: Classical Metal Plasticity in Abaqus

The following topics are covered in this lesson.

Lesson content:
- Classical Metal Plasticity in Abaqus
- 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 workshops are provided. Complete only one of each.

Classical Metal Plasticity in Abaqus

Here are the steps to be followed:

1. Basic Assumptions
2. Elasticity
3. Strain Rate Decomposition
4. Yield Functions
5. Calibrating Hill’s Anisotropic Plasticity Model
6. Hardening
7. Initial Hardening
8. Rate Dependence
9. Temperature and Field Variable Dependence
10. Annealing or Melting
11. User Subroutine (V)UHARD
12. Heat Generation for Thermo-Mechanical Problems
13. Element Selection Issues
14. Procedure Considerations
15. Direct Cyclic Procedure
Lesson 4: Johnson-Cook Plasticity

The following topics are covered in this lesson.

Lesson content:
- Johnson-Cook Plasticity

Here are the steps to be followed:

1. Introduction
2. Elasticity
3. Yield Function and Plastic Flow
4. Hardening
5. Strain Rate Dependence
6. Annealing or Melting
7. Heat Generation
8. Dynamic Failure
9. Example: Oblique Impact of a Copper Rod
Lesson 5: Metal Failure Models

The following topics are covered in this lesson.

Lesson content:
- Metal Failure Models

Here are the steps to be followed:
1. Progressive Damage and Failure
2. Damage Initiation Criteria for Fracture of Metals
3. Damage Initiation Criteria for Sheet Metal Instability
4. Damage Evolution for Ductile Metals
5. Element Removal
6. Damage and Failure in Low-cycle Fatigue
7. Alternative Failure Models
Lesson 6: Creep and Swelling

The following topics are covered in this lesson.

Lesson content:
- Creep and Swelling
- Workshop 3: Sagging of a Pipe (IA)
- Workshop 3: Sagging of a Pipe (KW)

Here are the steps to be followed:

- 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

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 7: Two-Layer Viscoplasticity

The following topics are covered in this lesson.

Lesson content:
- Two-Layer Viscoplasticity

Here are the steps to be followed:
1. Two-Layer Viscoplasticity
2. Abaqus Usage
3. Example
Lesson 8: Gray Cast Iron Plasticity

The following topics are covered in this lesson.

Lesson content:
- Gray Cast Iron Plasticity

Here are the steps to be followed:

1. Introduction
2. Elasticity
3. Yield Function
4. Flow Rule
5. Hardening
6. Element Selection and Output
7. Example: Biaxial Loads on Gray Cast Iron
8. Limitations
9. Alternative Cast Iron Model
Lesson 9: Porous Metal Plasticity

The following topics are covered in this lesson.

Lesson content:
- Porous Metal Plasticity

Here are the steps to be followed:

1. Basic Assumptions
2. Yield Function
3. Hardening and Plastic Flow
4. Void Nucleation and Growth
5. Failure Model in Abaqus/Explicit
6. Initial Conditions
7. Element Selection
Lesson 10: Time Integration

The following topics are covered in this lesson.

Lesson content:
- Time Integration

Here are the steps to be followed:

1. Plasticity
2. Creep
Appendix 1: Basic Concepts of Plasticity Theory

The following topics are covered in this lesson.

Lesson content:
- Basic Concepts of Plasticity Theory

Here are the steps to be followed:

1. Introduction
2. The Strain Rate Decomposition
3. The Yield Function
4. The Flow Rule
5. The Hardening Rule
6. Summary
Appendix 2: References

The following topics are covered in this lesson.

Lesson content:

References

Appendix 2: References

Here are the steps to be followed:

1. References