Writing User Subroutines with Abaqus

Abaqus 2018
Course objectives
In this course you will learn about:

- When and how to use subroutines
- DLOAD, VDLOAD, and UTRACLOAD for specifying user-defined loading
- FILM for specifying user-defined film conditions
- USDFLD and VUSDFLD for defining field variable dependence
- UVARM for defining a user output variable
- UHYPER for modeling hyperelastic materials
- UMAT and VUMAT for allowing constitutive models to be added to the program
- UEL and VUEL for allowing the creation of user-defined elements

Targeted audience
This course is recommended for engineers with experience using Abaqus.

Prerequisites
A working knowledge of the finite element method and programming in either Fortran or C
Day 1

- Lecture 1  Introduction
- Lecture 2  User Subroutines (V)DLOAD and UTRACLOAD
- Lecture 3  User Subroutine FILM
- Workshop 1 User Subroutine FILM
- Lecture 4  User Subroutine (V)USDFLD
- Lecture 5  User Subroutine UVARM
Day 2

- Lecture 6  User Subroutine UHYPER
- Lecture 7  Writing a UMAT or VUMAT
  - Workshop 2  User Subroutine UMAT: Tangent Stiffness
- Lecture 8  Creating a Nonlinear User Element (UEL and VUEL)
Additional Material

Appendix 1 Logical Modeling in Abaqus

Workshop 3 Controlling an Inverted Pendulum with VUAMP

Appendix 2 User Subroutine URDFIL

Appendix 3 User Subroutine (V)UANISOHYPER

Workshop 4 User Subroutine UANISOHYPER_INV: anisotropic hyperelastic material behavior

Appendix 4 Introduction to Parallel Computing

Appendix 5 Getting Started with Abaqus Parallel Execution

Workshop 5 User Subroutines with Threads

Workshop 6 User Subroutines with MPI

Appendix 6 Accessing Table Collections in User Subroutines

Workshop 7 User Table: Implementation with User Subroutine Film

Workshop 8 User Table: Implementation with User Subroutine Creep
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- Non-Parametric Optimization
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- Topology, Sizing, Shape, Bead Optimization

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

### Simpack
- 3D Multibody Dynamics Simulation
- Mechanical or Mechatronic Systems
- Detailed Transient Simulation (Offline and Realtime)

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### Realistic Human Simulation
- High Speed Crash & Impact
- Noise & Vibration

### Material Calibration
- Workflow Automation
- Design Exploration

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

### Safety Factors
- Creep-Fatigue Interaction
- Weld Fatigue

### Complete System Analyses
- (Quasi-)Static, Dynamics, NVH
- Flex Bodies, Advanced Contact
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Lesson content:

- Overview of Some User Subroutines
- Where User Subroutines Fit into Abaqus/Standard
- Including User Subroutines in a Model
- Writing Output from User Subroutines
- Compiling and Linking User Subroutines
- Debugging Techniques and Proper Programming Habits
- C/C++ interface
- Property and Parameter Tables
- Support for User Subroutines

1 hour
Lesson 2: User Subroutines (V)DLOAD and UTRACLOAD

Lesson content:

- Introduction
- Abaqus Usage
- DLOAD Subroutine Interface
- Example: Viscoelastic Cylinder
- Example: Asymmetric Pressure Loads
- VDLOAD Subroutine Interface
- Example: Viscoelastic Cylinder Revisited
- UTRACLOAD Subroutine Interface
- Example: Flexure of a Cantilever Beam
Lesson content:

- Introduction
- Abaqus Usage
- FILM Subroutine Interface
- Example: Radiation in Finned Surface
- Workshop Preliminaries
- Workshop 1: User Subroutine FILM (IA)
- Workshop 1: User Subroutine FILM (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 4: User Subroutine (V)USDFLD

Lesson content:

- Introduction
- Abaqus Usage
- Utility Routine GETVRM
- USDFLD Subroutine Interface
- Example: Laminated Composite Plate Failure
- Utility Routine VGETVRM
- VUSDFLD Subroutine Interface
- Example: Laminated Composite Plate Failure Revisited
Lesson content:

- Introduction
- Abaqus Usage
- UVARM Subroutine Interface
- Example 1: Calculation of Stress Relative to Shift Tensor
- Example 2: Creating Contour Plots for UELs
Lesson 6: User Subroutine UHYPER

Lesson content:

- Overview
- Motivation
- Steps Required in Writing a UHYPER Interface
- Example 1: UHYPER for Neo-Hookean Hyperelasticity
Lesson content:

- Overview
- Motivation
- Steps Required in Writing a UMAT or VUMAT
- UMAT Interface
  - Example 1: UMAT for Isotropic Isothermal Elasticity
  - Example 2: UMAT for Non-Isothermal Elasticity
  - Example 3: UMAT for Neo-Hookean Hyperelasticity
  - Example 4: UMAT for Kinematic Hardening Plasticity
  - Example 5: UMAT for Isotropic Hardening Plasticity
- VUMAT Interface
  - Example 6: VUMAT for Isotropic Isothermal Elasticity
  - Example 7: VUMAT for Neo-Hookean Hyperelasticity
  - Example 8: VUMAT for Kinematic Hardening Plasticity
  - Example 9: VUMAT for Isotropic Hardening Plasticity
- Workshop 2: User Subroutine UMAT: Tangent Stiffness (IA)
- Workshop 2: User Subroutine UMAT: Tangent Stiffness (KW)

3 hours

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Lesson 8: Creating a Nonlinear User Element

Lesson content:

- Overview
- Motivation
- Defining a User Element in Abaqus/Standard
- UEL Interface
- Example 1: Planar Beam Element with Nonlinear Section Behavior
- Example 2: Force Control Element
- Example 3: Plane Strain Element
- UELMAT Interface
- Using Nonlinear User Elements in Various Analysis Procedures
- Defining a User Element in Abaqus/Explicit
- VUEL Interface
- Example 4: Three-Dimensional Truss Element

3 hours
Appendix 1: Logical Modeling in Abaqus

Appendix content:

- Introduction
- Defining Logical Modeling
- Example: Force Control
- Workshop 3: Controlling an Inverted Pendulum with VUAMP (IA)
- Workshop 3: Controlling an Inverted Pendulum with VUAMP (KW)

Both interactive (IA) and keywords (KW) versions of the workshop are provided. Complete only one.
Appendix 2: User Subroutine URDFIL

Appendix content:

- Introduction
- Abaqus Usage
- URDFIL Subroutine Interface
- Example: Using URDFIL to Terminate an Analysis
Appendix 3: User Subroutine (V)UANISOHYPER

**Appendix content:**

- Overview
- Motivation
- Steps Required in Writing a UANISIOHYPER or VUANISOHYPER
- UANISOHYPER_INV interface
- Example 1: UANISOHYPER_INV for Kaliske and Schmidt
- UANISOHYPER_STRAIN Interface
- Example 2: UANISOHYPER_STRAIN for Saint-Venant Kirchhoff
- VUANISOHYPER_INV interface
- Example 3: VUANISOHYPER_INV for Kaliske and Schmidt
- VUANISOHYPER_STRAIN Interface
- Example 4: VUANISOHYPER_STRAIN for Saint-Venant Kirchhoff
- Workshop 4: User Subroutine UANISOHYPER_INV: Anisotropic hyperelastic material behavior

**2 hours**
Appendix 4: Introduction to Parallel Computing

Appendix content:

- Overview
- What is Parallel Computing?
- Why do we use Parallel Computing?
- Computer Memory Architecture Basics
- Different Models of Parallel Computing
- Limits of Parallel Computing
- Challenges of Parallel Computing
- Abaqus Performance Benchmark

1 hour
Appendix 5: Getting Started with Abaqus Parallel Execution

Appendix content:

- Overview
- Parallel Execution in User Subroutines
- User Subroutines with Threads
- User Subroutines with MPI
- User Subroutines with hybrid MPI and Threads
- Workshop 5: User Subroutines with Threads
- Workshop 6: User Subroutines with MPI

2.5 hours
Appendix 6: Accessing Table Collections in User Subroutines

Appendix content:

- Overview
- Property Tables, Parameter Tables and Table Collections
- Property Tables
- Parameter Tables
- Table Collections
- Utility Routines: Accessing User Data in User Subroutines
- Example of Keyword Interface and Subroutine Usage
- Workshop 7: Implementation with User Subroutine FILM (IA)
- Workshop 7: Implementation with User Subroutine FILM (KW)
- Workshop 8: Implementation with User Subroutine CREEP (IA)
- Workshop 8: Implementation with User Subroutine CREEP (KW)

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