



# Nonlinear Structural Materials Module

User's Guide

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# The Nonlinear Structural Materials Module

The Nonlinear Structural Materials Module is an optional add-on package for COMSOL Multiphysics® designed to assist you to model structural behavior that includes nonlinear materials. The module is an add-on to the Structural Mechanics Module or the MEMS Module and extends them with support for modeling nonlinear materials, including hyperelasticity, creep, plasticity, and viscoplasticity. The Nonlinear Structural Materials Module is designed for researchers, engineers, developers, teachers, and students who want to simulate nonlinear structural materials, including a full range of possible multiphysics couplings.

The module provides an extensive set of nonlinear structural material models, including:

- Predefined and user-defined hyperelastic materials: neo-Hookean, Mooney–Rivlin, St. Venant–Kirchhoff, Arruda–Boyce, Ogden, and others.
- Small-strain and large-strain plasticity models using different types of hardening.
- Volume-preserving and pressure-dependent plasticity.
- User-defined plasticity, flow rule, and hardening models.
- Porous plasticity models, used for example for powder compaction simulation.
- Predefined and user-defined nonlinear elastic materials: Ramberg–Osgood, Power law, and others.
- Shape memory alloys.
- Predefined and user-defined creep material models: Norton, Garofalo, Anand, potential, volumetric, deviatoric, and others.
- Viscoplastic models, such as Anand, Chaboche, and Perzyna.
- Dedicated models for polymer viscoplasticity, for example, Bergstrom–Boyce and Parallel network.
- Models for damage in brittle materials.

## ACCESSING THE NONLINEAR STRUCTURAL MATERIALS DOCUMENTATION

This is an add-on module requiring either the Structural Mechanics Module or the MEMS Module. The feature information, including theory and modeling details, is included in the *Structural Mechanics Module User's Guide*.

When you install COMSOL Multiphysics, the documentation sets are installed in several locations, both on your computer and most easily accessible while you are working in COMSOL Multiphysics. The next section details where to access it.

### ACCESSING COMSOL DOCUMENTATION AND APPLICATION LIBRARIES

A number of online resources have more information about COMSOL, including licensing and technical information. The electronic documentation, topic-based (or context-based) help, and the Application Libraries are all accessed through the COMSOL Desktop.



If you are reading the documentation as a PDF file on your computer, the [blue links](#) do not work to open an application or content referenced in a different guide. However, if you are using the Help system in COMSOL Multiphysics, these links work to open other modules, application examples, and documentation sets.

### THE DOCUMENTATION AND ONLINE HELP

The *COMSOL Multiphysics Reference Manual* describes the core physics interfaces and functionality included with the COMSOL Multiphysics license. This book also has instructions on how to use COMSOL Multiphysics and how to access the electronic Documentation and Help content.

#### *Opening Topic-Based Help*

The Help window is useful as it is connected to the features in the COMSOL Desktop. To learn more about a node in the Model Builder, or a window on the Desktop, click to highlight a node or window, then press F1 to open the Help window, which then

displays information about that feature (or click a node in the Model Builder followed by the **Help** button (  ). This is called *topic-based* (or *context*) *help*.

|       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Win   | <p>To open the <b>Help</b> window:</p> <ul style="list-style-type: none"><li>• In the <b>Model Builder</b>, <b>Application Builder</b>, or <b>Physics Builder</b>, click a node or window and then press F1.</li><li>• On any toolbar (for example, <b>Home</b>, <b>Definitions</b>, or <b>Geometry</b>), hover the mouse over a button (for example, <b>Add Physics</b> or <b>Build All</b>) and then press F1.</li><li>• From the <b>File</b> menu, click <b>Help</b> (  ).</li><li>• In the upper-right corner of the COMSOL Desktop, click the <b>Help</b> (  ) button.</li></ul> |
| Mac   | <p>To open the <b>Help</b> window:</p> <ul style="list-style-type: none"><li>• In the <b>Model Builder</b> or <b>Physics Builder</b>, click a node or window and then press F1.</li><li>• In the main toolbar, click the <b>Help</b> (  ) button.</li><li>• From the main menu, select <b>Help&gt;Help</b>.</li></ul>                                                                                                                                                                                                                                                                                                                                                    |
| Linux |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

*Opening the Documentation Window*

|       |                                                                                                                                                                                                                                                                                                                                                   |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mac   | <p>To open the <b>Documentation</b> window:</p> <ul style="list-style-type: none"><li>• Press Ctrl+F1.</li><li>• In the main toolbar, click the <b>Documentation</b> (  ) button.</li><li>• From the main menu, select <b>Help&gt;Documentation</b>.</li></ul> |
| Linux |                                                                                                                                                                                                                                                                                                                                                   |

**THE APPLICATION LIBRARIES WINDOW**

Each model or application includes documentation with the theoretical background and step-by-step instructions to create a model or application. The models and applications are available in COMSOL Multiphysics as MPH-files that you can open for further investigation. You can use the step-by-step instructions and the actual models as templates for your own modeling. In most models, SI units are used to describe the relevant properties, parameters, and dimensions, but other unit systems are available.

Once the Application Libraries window is opened, you can search by name or browse under a module folder name. Click to view a summary of the model or application and its properties, including options to open it or its associated PDF document.

#### *Opening the Application Libraries Window*

To open the **Application Libraries** window (  ):

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