

COMSOL Java API

Reference Guide



COMSOL Java API Reference Guide

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C o n t e n t s

Chapter 1: Introduction

About the COMSOL Java API	10
Where Do I Find More Information?	10
Getting Started	13
The Model Object	13
Compiling a Model Java-File	14
The Model Java-File	14
Running a Model Class-file from the Desktop	15
Running a Model Class-file as a Batch Job from the Desktop	15
Running a Model Class-file with the COMSOL Batch Command	15
Getting the COMSOL Installation Path from the Windows Registry	16
Setting up Eclipse for Compiling and Running a Java File	16

Chapter 2: General Commands

About General Commands	20
Extrusion Coupling Operators.	57
Projection Coupling Operators	62
Integration Coupling Operators	64
Average Coupling Operators	65
Maximum/Minimum Coupling Operators	65
Least-Squares Objective Functions	115

Chapter 3: Geometry

About Geometry Commands	164
Features for Creating Geometric Primitives.	166
Features for Geometric Operations.	167
Features for Virtual Operations	169

Features for Mesh Control	169
Geometry Object Information Methods	171
Working with a Geometry Sequence	173
Adding a Model (Geometry)	173
Adding a Geometry Feature.	174
Editing a Geometry Feature.	174
Building Geometry Features.	176
Feature Status	177
Accessing Geometry Object Names	177
Deleting and Disabling Geometry Features	178
Deleting Geometry Objects.	179
Geometry Settings	180
Length Unit	180
Angular Unit	180
Scale Values When Changing Unit	181
Geometry Representation in 3D	181
Default Relative Repair Tolerance	182
Automatic Rebuild	182
Work Planes	183
Virtual Operations	184
About Virtual Operations	184
Mesh Control Entities	184
Geometry Object Information	186
General Information	187
Geometric Entity Counters	187
Adjacency	188
Evaluation on an Edge	189
Evaluation on a Face	190
Geometry Representation Arrays	191
Measurements	193
Measuring Geometric Entities in Objects.	193
Measuring Objects	193

Inserting a Geometry Sequence from a File	195
Exporting Geometry to File	196
How to Export the Finalized Geometry	196
Exporting to an STL File	197
Exporting to a Parasolid File	197
Compatibility in 3D	197
Geometry Commands	198

Chapter 4: Mesh

About Mesh Commands	306
Operation Features	307
Attribute Features	307
Features for Imported Meshes	308
Working with a Meshing Sequence	309
Adding a Meshing Sequence	310
Adding a Mesh Feature	310
Editing a Mesh Feature	311
Building Mesh Features	311
Feature Status	312
Deleting Mesh Features	312
Disabling Mesh Features	312
Clearing Meshes	313
Units	313
Selections	313
Physics-Controlled Meshing	315
Information and Statistics	316
Statistics	316
Number and Types of Elements	317
Quality of Elements	318
Volume of Elements and Mesh	318

Growth Rate in Mesh	319
Mesh Status	319
Getting and Setting Mesh Data	321
Accessing Mesh Data	321
Setting or Modifying Mesh Data	322
Block Versions	326
Element Numbering Conventions	326
Errors and Warnings	328
Continuing Operations	328
Stopping Operations	328
The MeshError Feature	329
The MeshWarning Feature	329
Retrieving Problem Information	329
Exporting Mesh to File	331
Mesh Commands	332

Chapter 5: Solver

About Solver Commands	392
Features Producing and Manipulating Solutions	393
Features with Solver Settings	394
Solution Object Information Methods	395
Solution Feature Information Methods.	398
Solution Object Data	399
General Information	400
Solution Data	402
Solution Creation	405
General Matrix Information.	406
Matrix Data.	407

Chapter 6: Results

About Results Commands	476
Commands Grouped by Function	479
Use of Data Sets	482
Extracting Data	484
Retrieving Plot Data.	484
Retrieving Numerical Results	485
Solution Selection	488
About Selecting Solutions	488
Selecting Solutions by Solution Number	489
Selecting Solutions by Solution Level	489
Choosing Solution Selection Method	489

Chapter 7: Graphical User Interface

Getting Started	700
Example Graphical User Interface	701
Introduction	701
Downloading Extra Material.	702
Creating the Java Code for the Model	702
Construction of the Initial GUI with Graphics	703
Handling of Progress Information.	706
Setting Up Inputs From the GUI to the Model.	708
Displaying Results in the GUI	710
Other Details	712
GUI Classes	717

Introduction

This *COMSOL Java API Reference Guide* details features and techniques that help you control COMSOL Multiphysics using the application programming interface (API). The COMSOL Java API can be used from a standalone Java application as well as from the LiveLink™ for MATLAB® interface.

In this chapter:

- [About the COMSOL Java API](#)
- [Getting Started](#)

About the COMSOL Java API

You can use the COMSOL Java API to develop custom applications based on COMSOL. The COMSOL API is a Java-based interface, which means that a Java Development Kit (JDK) is required in order to compile your Java files into class files. You can download a JDK from www.oracle.com/technetwork/java/index.html. The `comsol compile` command helps you compile your Java files using the JDK.

You can run Java class files with COMSOL API-based applications in different ways:

- From the COMSOL Desktop. A model created using a class file appears automatically in the Desktop.
- From a batch sequence in a study.
- Using the `comsol batch` command.

The LiveLink for MATLAB operates using the COMSOL Java API and additional utility M-file functions. See the *LiveLink™ for MATLAB® User's Guide* for additional information.



See [Typographical Conventions](#) in the *COMSOL Multiphysics User's Guide*.

Where Do I Find More Information?

A number of Internet resources provide more information about COMSOL Multiphysics, including licensing and technical information. The electronic documentation, Dynamic Help, and the Model Library are all accessed through the COMSOL Desktop.





Important

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

THE DOCUMENTATION

The *COMSOL Multiphysics User's Guide* and *COMSOL Multiphysics Reference Guide* describe all interfaces and functionality included with the basic COMSOL Multiphysics license. These guides also have instructions about how to use COMSOL Multiphysics and how to access the documentation electronically through the COMSOL Multiphysics help desk.

To locate and search all the documentation, in COMSOL Multiphysics:



- Press F1 for Dynamic Help,
- Click the buttons on the toolbar, or
- Select **Help>Documentation** () or **Help>Dynamic Help** () from the main menu


and then either enter a search term or look under a specific module in the documentation tree.

THE MODEL LIBRARY

Each model comes with documentation that includes a theoretical background and step-by-step instructions to create the model. The models are available in COMSOL as MPH-files that you can open for further investigation. You can use the step-by-step instructions and the actual models as a template for your own modeling and applications.

SI units are used to describe the relevant properties, parameters, and dimensions in most examples, but other unit systems are available.

To open the Model Library, select **View>Model Library** () from the main menu, and then search by model name or browse under a module folder name. Click to highlight any model of interest, and select **Open Model and PDF** to open both the model and the documentation explaining how to build the model. Alternatively, click the **Dynamic Help** button () or select **Help>Documentation** in COMSOL to search by name or browse by module.

The model libraries are updated on a regular basis by COMSOL in order to add new models and to improve existing models. Choose **View>Model Library Update** () to update your model library to include the latest versions of the model examples.

If you have any feedback or suggestions for additional models for the library (including those developed by you), feel free to contact us at info@comsol.com.

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Getting Started

In this section:

- [The Model Object](#)
- [Compiling a Model Java-File](#)
- [The Model Java-File](#)
- [Running a Model Class-file from the Desktop](#)
- [Running a Model Class-file as a Batch Job from the Desktop](#)
- [Running a Model Class-file with the COMSOL Batch Command](#)
- [Getting the COMSOL Installation Path from the Windows Registry](#)
- [Setting up Eclipse for Compiling and Running a Java File](#)

The Model Object

In the COMSOL Java API you access models through the *model object*, which contains all algorithms and data structures for a COMSOL model. The COMSOL Desktop also uses the model object to represent your model. This means that the model object and the COMSOL Desktop behavior are virtually identical.

You use *methods* to create, modify, and access your model. The model object provides a large number of methods, including methods for setting up and running *sequences of operations* to create geometry, meshes, and for solving your model. The methods are structured in a tree-like way, much similar to the nodes in the model tree in the *Model Builder* window on the COMSOL Desktop. The top-level methods just return references that support further methods. At a certain level the methods perform actions, such as adding data to the model object, performing computations, or returning data.

You must have a basic understanding of the Java programming language in order to fully appreciate how to work with the model object. However, most of the syntax for creating a model using the COMSOL Java API can be learned by first creating a model using the COMSOL Desktop and then saving the model as a Model Java-file.

Compiling a Model Java-File

First make sure that COMSOL Multiphysics is installed. See the *COMSOL Installation and Operations Guide* for more information if required.

Before getting started, also download and install a Java Development Kit (JDK) from www.oracle.com/technetwork/java/index.html. You need the JDK to compile the Java file that COMSOL generates.

To test compiling a Model Java-file, load `feeder_clamp.mph` from the COMSOL Multiphysics Model Library into the COMSOL Desktop. To open the model, choose **Model Library** from the **View** menu. In the Model Library tree, expand **COMSOL Multiphysics** and then **Structural Mechanics**. Select the `feeder_clamp` model, then click the **Open** button to open it. To get a Java file to compile, choose **Save As Model Java-File** from the **File** menu. It is suggested that you save the file as `feeder_clamp.java` in your home directory.

To compile `feeder_clamp.java`, type

```
<COMSOL path>\bin\win32\comsolcompile -jdkroot <JDK path>
  feeder_clamp.java
```

on Windows and

```
<COMSOL path>/bin/comsol compile -jdkroot <JDK path> \
  feeder_clamp.java
```

on Linux and Mac, where `<COMSOL path>` is the COMSOL installation directory and `<JDK path>` is the installation directory for the JDK.

The Model Java-File

The Model Java-file has the following structure:

```
import com.comsol.model.*;
import com.comsol.model.util.*;

public class feeder_clamp {

    public static void main(String[] args) {
        run();
    }

    public static Model run() {
        Model model = ModelUtil.create("Model");
        ...
        return model;
    }
}
```

```
}  
}
```

Any model that you create in the COMSOL Desktop can be saved as a Model Java-file.



Note

When you compile a Model Java-file into a class file and run it, COMSOL runs exactly those instructions that are included in the Model Java-file. When opening an MPH-file and saving it as a Java-file only those sequences that have been explicitly run will be run in the Java-file. For example, when importing an MPH-file from version 3.5a, a solver sequence is set up to solve the problem and a separate container to hold the 3.5a solution. But saving as a Model Java-file does not contain a `runAll` command for the version 4 solver sequence. To run a solver sequence, add a line similar to `model.sol("sol1").runAll();` (where `sol1` is the tag for the solver to run) at the bottom of the Model Java-file, above the line that contains `return model;`.

Running a Model Class-file from the Desktop

Select **Open** on the **File** menu. In the **Open** dialog box, under **File name**, select **Model Class File (*.class)**. Click **Open**. The file is run and appears as the model in the COMSOL Desktop user interface.

Running a Model Class-file as a Batch Job from the Desktop

Right-click **Job Sequences** in a study and add a study. In the added study, right-click and add **External Class** under **Other**. Then right-click on the batch sequence and select **Compute**.

Runs the main function of a compiled class with the system property `cs.currentmodel` set to the tag of the model calling the class. Thus you can retrieve the current model using the steps:

```
import java.io.*;  
  
tag = System.getProperty("cs.currentmodel");  
model = ModelUtil.model(tag);
```

Running a Model Class-file with the COMSOL Batch Command

To run the file, enter

`<COMSOL path>\bin\win32\comsolbatch -inputfile feeder_clamp.class`
on Windows, or enter

`<COMSOL path>/bin/comsol batch -inputfile feeder_clamp.class`
on Linux and Mac, where `<COMSOL path>` is the COMSOL installation directory.

Getting the COMSOL Installation Path from the Windows Registry

If you want to have an application finding a COMSOL installation automatically you can have your application can examine the registry key

`HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432Node\COMSOL\COMSOL43`

on 64-bit computers and

`HKEY_LOCAL_MACHINE\SOFTWARE\COMSOL\COMSOL43\`

on 32-bit computers. The value name `COMSOLROOT` contains the installation path.

Setting up Eclipse for Compiling and Running a Java File

Instead of using COMSOL's commands for compiling and running a Java file that uses the COMSOL Java API one can use an Integrated Development Environment for doing these tasks. Using Eclipse makes it easier to write the Java code because Eclipse has built-in support for code completion and syntax highlighting. Furthermore, the debugger that comes as a part of Eclipse can be used to run the code line by line to verify the function of the code and check for any programming errors. Eclipse is free and can be downloaded from www.eclipse.org. In order to set up Eclipse for running an exported Java file perform the following actions in Eclipse:

- 1 Create a new Java Project and click **Next**.
- 2 Go to the Libraries tab and click **Add External JARs**. Add all the JAR files placed in the `plugins` directory under the COMSOL installation directory (typically `C:\Program Files\COMSOL\COMSOL43`). This allows Eclipse to find the definitions of the classes used by the COMSOL Java API and to run the code in client/server mode. Click **Finish**.
- 3 Drag and drop your exported Java file the `src` folder of your Eclipse project.
- 4 Add this line to the beginning of the main method

```
ModelUtil.initStandalone(false);
```

The argument should be false for programs that do not use graphics and true for applications that does.

5 The Java program can now be started in either Run or Debug mode from Eclipse. The Java program is now being run as a single process where the COMSOL libraries are being loaded as requested. This is the preferred way of running normal, small model files.

6 For large simulation where the application itself has to hold many megabytes in memory in addition to the memory requirement of COMSOL it may be beneficial to run in client/server mode. Open the Java file in the editor and go to the main method. Now you have to remove the line added in step 4 and add two new lines that control the connection to the COMSOL server from your own program. The main method needs to look like this:

```
public static void main(String[] args) {  
    ModelUtil.connect("localhost", 2036);  
    run();  
    ModelUtil.disconnect();  
}
```

When you have edited the main method you must save the file. Eclipse automatically compiles the file.

7 To run the code you must first start the COMSOL server. When the server has started note the port number that is written in the console. If this number does not match the number written in the call to `ModelUtil.connect` you have to edit this call and save the file again.

8 The Java program can now be started in either Run or Debug mode from Eclipse. Notice that the COMSOL server window responds by writing that a connection has been set up when your application starts.

General Commands

This chapter contains reference information about general commands for creating and modifying the main parts of the model object and for creating general-purpose functionality in a model, such as functions, variables, units, coordinate systems, and coupling operators. This chapter is [About General Commands](#).

About General Commands

The following table contains the available general-purpose commands:

TABLE 2-1: GENERAL COMMANDS GROUPED BY FUNCTION

FUNCTION	PURPOSE
<code>getType()</code>	Access objects of the basic data types
<code>set()</code>	Assign objects of the basic data types
<code>setIndex()</code>	Assign objects at indices of the basic data types.
<code>Selections</code>	Manipulate selections
<code>ModelUtil</code>	Model object utility methods
<code>model</code>	Multiphysics model object
<code>model.attr()</code>	Model entity list methods.
<code>model.attr(<tag>)</code>	Model entity methods
<code>model.batch()</code>	Run several jobs in a sequence automatically
<code>model.capeopen()</code>	Manipulate Cape-Open settings
<code>model.coeff()</code>	Manipulate coefficient form contributions
<code>model.constr()</code>	Manipulate constraints
<code>model.coordSystem()</code>	Manipulate coordinate systems
<code>model.cpl()</code>	Manipulate coupling operators
<code>model.elem()</code>	Manipulate elements
<code>model.solverEvent()</code>	Manipulate events
<code>model.field()</code>	Manipulate fields
<code>model.frame()</code>	Manipulate frames
<code>model.func()</code>	Manipulate functions
<code>model.geom()</code>	Manipulate geometry
<code>model.intRule()</code>	Manipulate integration orders
<code>model.init()</code>	Manipulate initial values
<code>model.material()</code>	Manipulate materials
<code>model.mesh()</code>	Manipulate meshes
<code>model.modelNode()</code>	Manipulate model nodes
<code>model.ode()</code>	Manipulate global equation
<code>model.opt()</code>	Manipulate optimization

TABLE 2-1: GENERAL COMMANDS GROUPED BY FUNCTION

FUNCTION	PURPOSE
<code>model.pair()</code>	Manipulate pairs
<code>model.param()</code>	Manipulate model parameters
<code>model.physics()</code>	Manipulate physics interfaces
<code>model.probe()</code>	Manipulate probes
<code>model.result()</code>	Manipulate result objects
<code>model.savePoint()</code>	Manipulate selections and hide feature used by result features
<code>model.selection()</code>	Manipulate domain selections
<code>model.shape()</code>	Manipulate shape functions
<code>model.sol()</code>	Manipulate solutions
<code>model.study()</code>	Manipulate studies
<code>model.unitSystem()</code>	Manipulate units
<code>model.variable()</code>	Manipulate variables
<code>model.view()</code>	Manipulate views
<code>model.weak()</code>	Add and manipulate weak form contributions

Purpose	Access objects of the basic data types.
Syntax	<pre>something.getString(<name>); something.getStringArray(<name>); something.getDblStringArray(<name>); something.getInt(<name>); something.getIntArray(<name>); something.getDouble(<name>); something.getDoubleArray(<name>);</pre>
Description	<p>Use these methods to read parameter/property values.</p> <p>The names of the access methods indicate the data type returned.</p> <p><code>something.getString(<name>)</code> returns the value as a string.</p> <p><code>something.getStringArray(<name>)</code> returns the value as a string array.</p> <p><code>something.getStringMatrix(<name>)</code> returns the value as a string matrix.</p> <p><code>something.getInt(<name>)</code> returns the value as an integer.</p> <p><code>something.getIntArray(<name>)</code> returns the value as an integer array.</p> <p><code>something.getDouble(<name>)</code> returns the value as a double.</p> <p><code>something.getDoubleArray(<name>)</code> returns the value as a double array.</p> <p><code>something.getDoubleMatrix(<name>)</code> returns the value as a double matrix.</p> <p><code>something.selection(<name>)</code> returns the value as a selection object, which can be edited. This is not simply an access function. It used to obtain a selection object both for editing and accessing data from.</p>

Notes

All arrays that are returned contain copies of the data; writing to the array does not change the data in the model object. This observation applies to all access methods of the model object that return arrays of basic data types.

Throughout this manual, the access methods are collectively referred to as `getType(<name>)`, where *Type* can be any of the basic data types listed above.

See Also

[set\(\)](#)

Purpose Assign objects of the basic data types.

Syntax `something.set(name,<value>);`
`something.set(name,pos,<value>);`
`something.set(name,pos1,pos2,<value>);`

Description Use these methods to assign parameter/property values. All assignment methods return the parameter object, which means that assignment methods can be appended to each other.

The basic method for assignments is

```
something.set(name,<value>);
```

The `name` argument is a string with the name of the parameter/property. The `<value>` argument can be of different types as indicated in [Table 2-2](#), where the two different syntaxes for assignment in the COMSOL Java API and the COMSOL MATLAB interface are listed.

TABLE 2-2: JAVA AND MATLAB SYNTAXES FOR ASSIGNMENT METHODS.

TYPE	JAVA SYNTAX	MATLAB SYNTAX
string	<code>set("name","value")</code>	<code>set('name','value')</code>
string array	<code>set("name", new String[]{"val1","val2"})</code>	<code>set('name',{'val1','val2'})</code>
double string array	<code>set("name",new String[][]{{"1","2"}, {"3","4"}})</code>	<code>set('name',{'1','2';'3','4'})</code>
integer	<code>set("name",17)</code>	<code>set('name',17)</code>
integer array	<code>set("name",new int[]{1,2})</code>	<code>set('name',[1 2])</code>
double	<code>set("name",1.3)</code>	<code>set('name',1.3)</code>
double array	<code>set("name",new double[]{1.3,2.3})</code>	<code>set('name',[1.3 2.3])</code>
double matrix	<code>set("name",new double[][]{{1.3,2.3}, {3.3,4.3}})</code>	<code>set('name',... [1.3 2.3; 3.3 4.3])</code>

To modify data in an array use the method

```
something.set(name,pos,<value>)
```

The value can be a string, a string array, an integer, or a double.

The methods changes the value in the given position.

For double string arrays the method

```
something.set(name,pos1,pos2,<value>)
```

can be used to change the value in position (`pos1,pos2`).

For double string arrays the modifying method is also of use when assigning the value in MATLAB, if not all arrays have the same length. When using a cell matrix, all rows must have the same length. The method

```
something.set(name, pos, <value>)
```

can be used to get around that limitation. It inserts a string array in the position `pos` in the double array. The MATLAB code

```
something.set('name', 1, {'1', '2', '3'})  
something.set('name', 2, {'4', '5'})
```

is equivalent to the java code

```
something.set("name", new String[][]{{"1", "2", "3"}, {"4", "5"}})
```

For matrix-type properties, `set(name, <string>)` splits the string at spaces and commas.

See Also[getType\(\)](#)

setIndex()

Purpose	Assign objects at indices of the basic data types.
Syntax	<pre>something.setIndex(name,<value>,<index>); something.setIndex(name,<value>,<firstIndex>,<secondIndex>);</pre>
Description	<p>Use these methods to assign values to specific indices (0-based) in array or matrix properties. All assignment methods return the parameter object, which means that assignment methods can be appended to each other.</p> <p>The <i>name</i> argument is a string with the name of the property. <i><value></i> is a string representation of the value to set. A double array element, for example, can still be set from a string representation of the double, typically used when the property value depends on a model parameter. For example:</p> <pre>something.setIndex(name,"param1",2)</pre> <p>This sets the second index of an array property <i>name</i> to be the value of a parameter <i>param1</i>. If the parameter later changes, this property changes accordingly.</p>
See Also	set()

Purpose	Manipulate selections.
Syntax	<pre> selection.global(); selection.geom(<gtag>); selection.geom(<gtag>,dim); selection.geom(<gtag>,highdim,lowdim,typelist); selection.geom(dim); selection.allGeom(); selection.all(); selection.set(<domlist>); selection.add(<domlist>); selection.remove(<domlist>); selection.inherit(bool); selection.named(<stag>); selection.isGlobal(); selection.isGeom(); selection.geom(); selection.dimension(); selection.entities(dim); selection.interiorEntities(dim); selection.isInheriting(); selection.inputDimension(); selection.inputEntities(); selection.named(); </pre>
Description	<p>This section describes the general syntax for selections. Many objects use selections, but most of them only support a subset of the assignment methods described here. The methods the selections in <code>model.selection()</code> support are listed in the section model.selection(). Other objects which use a selection supports the methods which are relevant for the type of feature they represent. For example, a physics boundary condition feature requires a boundary selection. Therefore it does not support <code>selection.global()</code> which makes the selection global or <code>selection.allGeom()</code> which makes the selection apply to the whole geometry at all levels. Using an unsupported assignment method results in an error.</p> <p>There can also be a filtering of the entities assigned to a selection. Again, take a physics boundary condition as an example. Some boundary conditions only apply to the boundaries exterior to the domains where the physics interface is active, other boundary conditions only to boundaries interior to where the physics interface is active, and so on. Therefore <code>selection.entities(dim)</code> can sometimes return less entities than have been assigned using <code>selection.set(<domlist>)</code>. On the other hand <code>selection.inputEntities()</code> always returns all entities used in the assignment <code>selection.set(<domlist>)</code>.</p>

Some selections only allow a single geometric entity, a single domain, a single boundary, edge, or point. Such selections are called *single selections*. Single selections cannot be defined by another selection and therefore do not support `selection.named(<stag>)`.

`selection.global()` sets the selection to be the global selection.

`selection.geom(<gtag>)` sets the selection to be all domains in the geometry `<gtag>`.

`selection.geom(<gtag>, dim)` specifies that subsequent calls to `all`, `set`, `add`, and `remove` refer to domains at the dimension `dim` on the geometry `<gtag>`. If there is only one possible geometry, using `selection.geom(dim)` is equivalent. Also, if there is only one allowed dimension `dim`, then `all`, `set` and `remove` can be used directly as it is then unambiguous to which geometry and dimension their arguments apply to.

`selection.geom(<gtag>, highdim, lowdim, <typelist>)` specifies that subsequent calls to `all`, `set`, `add`, and `remove` refer to domains of dimension `highdim` on the geometry `<gtag>`. The domains that are obtained are those that are both of dimension `lowdim` and of any of the types listed in `<typelist>`. It is required that `highdim > lowdim`. The available types are:

- `exterior`: All domains of dimension `lowdim` that lie on the exterior of the domains at dimension `highdim`.
- `interior`: All domains of dimension `lowdim` that lie in the interior of the domains at dimension `highdim`.
- `meshinterior`: All mesh boundaries of dimension `lowdim` that lie in the interior of the domains at dimension `highdim`.

`selection.allGeom()` sets the selection to a whole geometry. Can be used instead of `selection.geom(<gtag>)` when the geometry tag is unambiguous.

`selection.geom(dim)` specifies that subsequent calls to `all`, `set`, `add`, and `remove` refer to domains at the dimension `dim`. Can be used instead of `selection.geom(<gtag>, dim)` when the geometry tag is unambiguous.

`selection.all()` sets the selection to use all geometric entities in the geometry at the dimension where the selection applies.

`selection.set(<domlist>)` sets the selection to use the geometric entities in `<domlist>`. Note that the list of domain numbers is always sorted in ascending order and duplicates are removed before storing the numbers in the selection object.

`selection.add(<domlist>)` adds the geometric entities in `<domlist>` in the geometry to the set of geometric entities that the selection uses to obtain the selection.

`selection.remove(<domlist>)` removes the geometric entities in `<domlist>` in the geometry from the set of geometric entities that the selection uses.

`selection.inherit(bool)` indicates whether the selection should include all geometric entities that are specified by any of the other methods and all geometric entities at lower dimensions that are adjacent to the ones already specified.

`selection.named(<stag>)` specifies that the selection is defined by the selection `model.selection(<stag>)`.

`selection.isGlobal()` returns true if the selection is global.

`selection.isGeom()` returns true if the selection is a whole geometry.

`selection.geom()` returns the geometry tag of the selection as a string. If the selection is global, null is returned.

`selection.dimension()` returns the dimensions on a geometry where the selection applies as an integer array.

`selection.entities(dim)` returns the geometric entities of the selection on the given geometry at the given dimension as an integer array.

`selection.interiorEntities(dim)` returns the interior mesh domains as an integer array.

`selection.isInheriting()` returns true if the selection is inherited to lower dimension levels.

`selection.inputDimension()` returns the dimension of the domains used as input to the selection.

`selection.inputEntities()` returns the entities used as input to the selection.

If the selection is defined by another selection, `selection.named()` returns the tag of that selection. Otherwise `selection.named()` returns an empty string.

Notes

The methods `global()`, `geom(<gtag>)`, `geom(<gtag>, dim)`, `geom(<gtag>, highdim, lowdim, typelist)`, and `geom(dim)`, clear the data set by other methods.

Selections

Not all assignment methods are supported by all model entities. The list of supported methods also serves as a guide for the restriction to those named selections that can be used by that entity. All access methods are always supported.

See Also

[model.geom\(\)](#)

Purpose	Model object utility methods.
Synopsis	<pre>import com.comsol.model.*; import com.comsol.model.util.*; ModelUtil.create(<tag>); ModelUtil.remove(<tag>); ModelUtil.clear(); ModelUtil.tags(); ModelUtil.model(<tag>); ModelUtil.load(<tag>,<filename>); ModelUtil.showProgress(bool); ModelUtil.showProgress(<filename>); ModelUtil.initStandalone(bool); ModelUtil.initStandalone(bool,<guiToolkit>); ModelUtil.getPreference(<prefsName>); ModelUtil.setPreference(<prefsName>, <value>); ModelUtil.listPreferences(); ModelUtil.loadPreferences(); ModelUtil.savePreferences(); ModelUtil.connect(); ModelUtil.connect(<host>,<port>); ModelUtil.disconnect();</pre>
Description	<p>This section describes general methods that manipulate the environment for the model object. It also describes methods for the client/server machinery.</p> <p><code>ModelUtil.create(<tag>)</code> creates a model with tag <code><tag></code>. Returns a reference to the model. If there is already a model with this tag the previous model is removed.</p> <p><code>ModelUtil.remove(<tag>)</code> removes the model tagged <code><tag></code>.</p> <p><code>ModelUtil.clear()</code> removes all models.</p> <p><code>ModelUtil.tags()</code> obtains the current list of model tags.</p> <p><code>ModelUtil.model(<tag>)</code> returns a reference to the model tagged <code><tag></code>.</p> <p><code>ModelUtil.load(<tag>,<filename>)</code> loads a model from file and names it <code><tag></code>. Loading a file from a directory sets the model directory. The model directory is used for saving files if you do not provide an absolute path to the file.</p> <p><code>ModelUtil.showProgress(bool)</code> turns on or off showing of progress in a window or on a file when running lengthy tasks when connected to a server.</p> <p><code>ModelUtil.showProgress(<filename>)</code> turns on logging of progress to the file <code><filename></code>. If <code><filename></code> is <code>null</code> progress is logged to the standard output.</p>

`ModelUtil.connect(<host>, <port>)` connects to a COMSOL server. The arguments `<host>` and `<port>` provide host name and port number for the COMSOL server.

`ModelUtil.initStandalone(bool)` Initializes the environment for using the COMSOL API from a standalone Java application. You should *not* use this command from the LiveLink for MATLAB. Set the argument to true if support for plotting in a GUI using Java Swing widgets should be available.

`ModelUtil.initStandalone(bool, <guiToolkit>)` allows to specify that support for using a given Java GUI toolkit should be available. The optional `<guiToolkit>` parameter can have the values "swing" or "swt" telling that Swing widgets or widgets from the Standard Widget Toolkit (SWT) can be used.

`ModelUtil.getPreference(<prefsName>)` returns the value of a preference.

`ModelUtil.setPreference(<prefsName>, <value>)` sets the value of a preference.

`ModelUtil.listPreferences()` returns a string with a listing of the preferences names and their descriptions.

`ModelUtil.loadPreferences()` loads the preferences from file. Use this in standalone java application which do not load the preferences at launch time.

`ModelUtil.savePreferences()` saves the preferences to file.

`ModelUtil.connect()` connects to a COMSOL server. The COMSOL command arguments `-Dcs.host=<host>` and `-Dcs.port=<port>` can provide host name and port number. In case those are not provided, and the both client and server access the same file system, the host and port can be automatically transferred.

`ModelUtil.disconnect()` disconnects from a COMSOL server.

See Also

[model](#)

Purpose	Model object methods.
Syntax	<pre>model.baseSystem(); model.baseSystem(<system>) model.dateModified() model.fontFamily(); model.fontFamily(<family>); model.fontSize(); model.fontSize(<size>); model.hist().isComplete(); model.hist().complete(bool); model.hist().enable(); model.hist().disable(); model.lastModifiedBy(); model.modelPath(); model.modelPath(<path>); model.resetHist() model.save(<filename>); model.save(<filename>,<type>);</pre>
Description	<p>model is a model object that you can create, for example, by using <code>ModelUtil.create(<tag>)</code>.</p> <p><code>model.baseSystem(<system>)</code> sets the unit system for the entire model to the given system. The default is the SI-system, which has the tag <code>SI</code>. Other supported unit systems are <code>bft</code> (British engineering units), <code>cgs</code>, <code>mpa</code>, <code>emu</code>, <code>esu</code>, <code>fps</code>, <code>ips</code>, and <code>psi</code>.</p> <p><code>model.dateModified()</code> returns the modification date of the model.</p> <p><code>model.fontFamily(<family>)</code> sets the font family to be used in plots. The font default is always available. If using Windows, most system fonts can also be used.</p> <p><code>model.fontSize(<size>)</code> sets the font size to be used in plots.</p> <p><code>model.hist().complete(bool)</code> enables or disables history logging for methods where the arguments typically are very large objects.</p> <p><code>model.hist().isComplete()</code> returns true if history logging is enabled for methods where the arguments typically are very large objects.</p> <p><code>model.hist().disable()</code> Disables logging of top-level API calls to the history. Use this method sparingly; the normal state is that the history should be logged.</p> <p><code>model.hist().enable()</code> Removes the most recent disabling of top-level API calls to the history. Calling <code>enable()</code> can be viewed as removing an entry from a stack of disable records; logging will only occur if the stack is empty.</p>

`model.lastModifiedBy()` returns the last user to modify the model.

`model.modelPath(<path>)` sets the model path. The model path is used for reading files required by the model if no path is provided to the file. *<path>* is a list of directories separated by semicolon. It attempts to find a file in the following locations:

- 1 The absolute path as given in the file name
- 2 The model directory, if provided
- 3 The directories defined by `modelPath` model, if any
- 4 The directories in the `cs.path` setting (ordered and semicolon separated)
- 5 The current directory

The model directory is used for saving and exporting files if you do not provide an absolute path to the file.

`model.modelPath()` returns the model path.

`model.resetHist()` rebuilds the model from scratch to generate a compacted Model Java or Model M-file history. If the model has errors, or has invalid property values, the method fails and the old history is kept.

`model.save(<filename>)` saves the model as a multiphysics model file in *<filename>*. The model directory is used if no path is provided.

`model.save(<filename>, <type>)` saves the multiphysics model in *<filename>*. If type is `java`, a Model Java-file is saved. If type is `m` and you have the MATLAB interface, this command saves a Model M-file.

See Also

[model.modelNode\(\)](#), [model.unitSystem\(\)](#)

Purpose	Model entity list methods.
Synopsis	<pre> model.attr().clear(); model.attr().copy(<tag>, <copytag>); model.attr().copy(<tag>, <copytag>, <modeltag>); model.attr().copyTo(<tag>, <copytag>, <insertafter>); model.attr().duplicate(<tag>, <copytag>); model.attr().duplicateTo(<tag>, <copytag>, <insertafter>); model.attr().get(<tag>); model.attr().size(); model.attr().tags(); model.attr().remove(<tag>); model.attr().uniquetag(<tag>); </pre>
Description	<p><code>model.attr()</code> is a <i>model entity list</i>. The symbol <code>attr</code> is a generic method name for accessing the model entity list.</p> <p><code>model.attr().clear()</code> removes all tagged model entities.</p> <p><code>model.attr().copy(<tag>, <copytag>)</code> creates a new model entity with the tag <code><tag></code>, which is a copy of the model entity with the tag <code><copytag></code>. The <code><copytag></code> should be combination of tags separated by slashes to uniquely identify the entity. For example, <code>pg1/surf1/htgh1</code> identifies</p> <p><code>model.result("pg1").feature("surf1").feature("htgh1")</code>. How to interpret the combined tag depends on the context. The difference between <code>duplicate</code> and <code>copy</code> is that <code>copy</code> can use a source anywhere in the model, whereas <code>duplicate</code> requires that the source is in the same list. Not all model entities support the <code>copy</code> operation. The difference between <code>copy</code> and <code>copyTo</code> is that <code>copyTo</code> copies the entity to a specific position in the list, whereas <code>copy</code> copies to a default position in the list. Not all model entities support the <code>copyTo</code> operation.</p> <p><code>model.attr().copy(<tag>, <copytag>, <modeltag>)</code> creates a copy and assigns it to the model <code><modeltag></code>.</p> <p><code>model.attr().copyTo(<tag>, <copytag>, <insertafter>)</code> creates a copy and inserts it in the list after the entity with tag <code><insertafter></code>. If <code><insertafter></code> is an empty string, the entity is inserted first in the list. Not all model entities support the <code>copyTo</code> operation.</p> <p><code>model.attr().duplicate(<tag>, <copytag>)</code> creates a new model entity with the tag <code><tag></code> which is a duplicate of the model entity with tag <code><copytag></code>. Not all model entities support the <code>duplicate</code> operation.</p> <p><code>model.attr().duplicateTo(<tag>, <copytag>, <insertafter>)</code> creates a new model entity and inserts it in the list after the entity with tag <code><insertafter></code>.</p>

model.attr()

If `<insertafter>` is an empty string, the entity is inserted first in the list. Not all model entities support the `duplicateTo` operation.

`model.attr().get(<tag>)` returns the entity with tag `<tag>` from the entity list `model.attr()`.

`model.attr().remove(<tag>)` removes the model entity with tag `<tag>`.

`model.attr().size()` returns the number of model entities.

`model.attr().tags()` returns a string array with the tags of all model entities.

`model.attr().uniqueTag(<tag>)` returns a unique tag in the list context.

See also

[model](#)

Purpose	Model entity methods.
Synopsis	<pre> model.attr(<tag>).active(bool); model.attr(<tag>).author(); model.attr(<tag>).author(<author>); model.attr(<tag>).comments(); model.attr(<tag>).comments(<comments>); model.attr(<tag>).dateCreated(); model.attr(<tag>).isActive(); model.attr(<tag>).name(); model.attr(<tag>).name(<name>); model.attr(<tag>).resetAuthor(<author>); model.attr(<tag>).tag(); model.attr(<tag>).tag(<newtag>); model.attr(<tag>).version(); model.attr(<tag>).version(<version>); </pre>
Description	<p><code>model.attr(<tag>)</code> is a <i>model entity</i> with tag <code><tag></code>. The symbol <code>attr</code> is generic method name for accessing a model entity with tag <code><tag></code>.</p> <p><code>model.attr(<tag>).active(<i>bool</i>)</code> makes the entity with tag <code><tag></code> active or inactive.</p> <p><code>model.attr(<tag>).author()</code> returns the author of the entity.</p> <p><code>model.attr(<tag>).author(<author>)</code> sets the author of the entity.</p> <p><code>model.attr(<tag>).comments()</code> returns the comments of the entity.</p> <p><code>model.attr(<tag>).comments(<comments>)</code> sets the comments of the entity.</p> <p><code>model.attr(<tag>).dateCreated()</code> returns the creation date of the entity.</p> <p><code>model.attr(<tag>).isActive()</code> returns true if the entity with tag <code><tag></code> is active.</p> <p><code>model.attr(<tag>).name()</code> returns the name of the entity.</p> <p><code>model.attr(<tag>).name(<name>)</code> sets the name of the model entity. The name is an arbitrary non-empty string.</p> <p><code>model.attr(<tag>).resetAuthor(<author>)</code> sets the author of the entity and all its children. In particular, when used on the model itself, the method sets the author on all model entities of the model.</p> <p><code>model.attr(<tag>).tag()</code> returns the tag of the entity.</p> <p><code>model.attr(<tag>).tag(<newtag>)</code> assigns the new tag <code><newtag></code> to the entity <code><tag></code>.</p>

model.attr(<tag>)

`model.attr(<tag>).version(<version>)` sets the version of the entity. The version is a user defined string.

`model.attr(<tag>).version()` returns the version of the entity.

`model.attr(<tag>).help()` and `model.attr(<tag>).help(string)` return a string pointer to locally installed HTML documentation. *string* is the name of a method within the model object.

See also

[model](#)

Purpose	Run several jobs in a sequence automatically.
Syntax	<pre> model.batch().create(<tag>, jobtype); model.batch().remove(<tag>); model.batch().size(); model.batch().tags(); model.batch(<tag>).attach(<stag>); model.batch(<tag>).detach(<stag>); model.batch(<tag>).remove(<ttag>); model.batch(<tag>).run(); model.batch(<tag>).set(jtype, <value>); model.batch(<tag>).study(<stag>); model.batch(<tag>).feature().create(<ttag>, tasktype); model.batch(<tag>).feature(<ttag>).set(ttprop, <value>); </pre>
Description	<p>JOBS</p> <p><code>model.batch().create(<tag>, jobtype)</code>; creates a job tagged <code><tag></code> of type <code>jobtype</code>, where <code>jobtype</code> is Parametric, Batch, or Cluster.</p> <p><code>model.batch().remove(<tag>)</code> removes a job.</p> <p><code>model.batch().size()</code> returns number of jobs.</p> <p><code>model.batch().tags()</code> returns the tags of the jobs.</p> <p><code>model.batch(<tag>).attach(<stag>)</code> attaches a job with tag <code><tag></code> to a study with tag <code><stag></code>, which includes <i>assigning</i> it to the study.</p> <p><code>model.batch(<tag>).detach(<stag>)</code> detaches a job from a study with tag <code><stag></code>.</p> <p><code>model.batch(<tag>).remove(<ttag>)</code> removes the task.</p> <p><code>model.batch(<tag>).run()</code> runs the job.</p> <p><code>model.batch(<tag>).set(jprop, <jvalue>)</code> sets the property <code>jprop</code> to the value <code><jvalue></code>.</p> <p><code>model.batch(<tag>).study(<stag>)</code> assigns a job to a study tag <code><stag></code>.</p> <p><code>model.batch(<tag>).study()</code> returns the study tag of job with tag <code><tag></code>.</p>

JOB PROPERTIES

The Parametric job type has the following properties:

PROPERTY	VALUE	DEFAULT	DESCRIPTION
accumtable	string	new	Accumulated probe table
accumtableall	on off	off	Use all probes for the accumulated probe table
control	string	user	Controlling study
param	string array		Name of parameter and its value (output)
pdistrib	on off	off	Distributed (in parallel) the parameter values
pname	string array		Parameter name(s) to vary
plist	string array		Parameter values
plot	on off	off	Update a plot group while solving
plotgroup	string	default	Update this plot group while solving
pwork	int	1	Limit for the number of work groups
pworkactive	on off	off	Use a limit for the number of work groups
stopcond	string		A stop condition expression
err	on off	off	Stop sweep if error
error	string array		The logged error
useaccumtable	on off	off	Produce an accumulated probe table while solving

The Batch job type has the following properties:

PROPERTY	VALUE	DEFAULT	DESCRIPTION
control	string	user	Name of controlling study
np	integer	auto	Number of cores to use
graphics	on off	off	Enable graphics
maxallow	integer	1	Maximum allowed number of batch jobs to start simultaneously
maxrestart	integer	0	Maximum number of restarts before a batch job is failed

PROPERTY	VALUE	DEFAULT	DESCRIPTION
maxalive	integer	300	Maximum number of seconds before the batch job must say it is running
starttime	now 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23	now	The time when the batch job should start
batchdir	string	home directory	The directory to store files used by the batch job
client	on off	off	Run the batch job as client
port	integer	2036	The host port number
host	string	localhost	Name of host
batchfile	string	batchmode1.mph	Name of batch model file
clear	on off	on	Clear the previous model file
clearmesh	on off	off	Clear meshes before saving model
clearsolution	on off	off	Clear solutions before saving model
savefile	on off	on	Save model after run
specbatchdir	on off	off	Specify different directory for batch process than used by the current process
rundir	string	home directory	The directory used by the batch job when specbatchdir is on
speccomsoldir	on off	off	Specify different directory for the COMSOL installation than used by the current process
comsoldir	string	COMSOL installation directory	The COMSOL installation directory used by the batch job when speccomsoldir is on
synchsolutions	on off	off	Synchronize solutions after batch job finishes

PROPERTY	VALUE	DEFAULT	DESCRIPTION
synchaccumprobetable	on off	off	Synchronize accumulated probe tables after batch job finishes
probese1	all none manual	all	The probes to compute
probes	string array		Probes to compute
useaccumtable	on off	off	Use the accumulated probe table
accumtable	string	new	Name of table to use
accumtableall	on off	on	Use all probes
client	on off	off	Run as client
host	string	localhost	Name of server
port	integer		Server port number

The Cluster job type has the following properties:

PROPERTY	VALUE	DEFAULT	DESCRIPTION
clustertype	general whpc2008 wccs2003 sge none	general	The type of cluster job
control	string	user	Name of controlling study
nn	integer	1	Number of processes to start
sgenn	integer	1	Number of slots in SGE
precmd	string		DOS/Linux command to execute prior to the batch job
postcmd	string		DOS/Linux command to execute after the batch job finished
mpd	on off	off	If an mpd is running on the computer or not
perhost	integer	1	Number of processes / host
hostfile	string		Path to hostfile
mpirsh	string		Path to rsh or ssh
sgequeue	string		Name of SGE queue
exclusive	on off	on	Demand exclusive right to nodes on wccs2003 and whpc2008
schedule	string	localhost	Name of the scheduler on wccs2003 and whpc2008

PROPERTY	VALUE	DEFAULT	DESCRIPTION
nodegran	node socket core	node	Node granularity on whpc2008
sgegran	host slot manual	host	Node granularity on SGE
reqnodes	string array		Requested nodes on wccs2003 and whpc2008
corespernode	integer	0	Minimum number of cores per node on wccs2003 and whpc2008
memorypernode	integer	0	Minimum amount of memory per node on wccs2003 and whpc2008
runtime	DD:HH:MM Infinite	Infinite	Maximum time to run before stopping on wccs2003 and whpc2008
user	string		User name on wccs2003 and whpc2008
priority	Highest AboveNormal Normal BelowNormal Lowest	Normal	Priority of job on wccs2003 and whpc2008
sgepriority	integer	0	Priority of job on SGE
batch	string		Tag of batch job to run

TASKS

`model.batch(<tag>).feature().create(<ttag>, tasktype)`; creates a task of type *tasktype* tagged *<ttag>*. Find options for *tasktype* in [Table 2-3](#) below.

TABLE 2-3: BATCH TASK TYPE OPTIONS

TASK TYPE	DESCRIPTION
Geomseq	A geometry sequence to build
Meshseq	A mesh sequence to build
Solutionseq	A solver sequence to compute
Jobseq	A job sequence to run
Postseq	A post sequence to run
Numericalseq	A numerical results seq to run
Exportseq	An export sequence to run
Save	Saves the state of the model at this point in the job sequence

TABLE 2-3: BATCH TASK TYPE OPTIONS

TASK TYPE	DESCRIPTION
Class	Runs the main function of a compiled class with the system property <code>cs.currentmodel</code> set to the name of the model calling the class
Data	Created by batch jobs to store external process information

TASK TYPE PROPERTIES

`model.batch(<tag>).feature(<ttag>).set(ttprop,<tpvalue>)` sets the task type property `ttprop` to the value `<tpvalue>`.

Task type properties can have the values listed in [Table 2-4](#).

TABLE 2-4: TASK TYPE PROPERTY VALUES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
clear	on off	on	Clear the currently stored data
filename	string		Name of file to store or open
openfile	string array	none	Name of file that was saved
param	string array		Name of parameter and its value
files	string array		Name of files for each parameter
input	string array		Input to class file
seq	string	all	Name of sequence to run
num	string array		Name of numerical result feature that generated value
paramvalue	string array		Computed numerical result
store	on off	off	Copy solution
psol	string	none	Tag of solver sequence where solutions are stored

THE DATA TASK TYPE

The Data task type contains child nodes with process information of type `Process`; see [Table 2-5](#).

TABLE 2-5: DATA CHILD NODES

TASKTYPE	DESCRIPTION
Process	Contains information about running processes

`model.batch(<tag>).feature(<ttag>).feature(<ptag>).set(ptype, <pvalue>)` sets the property *ptype* to the value *<pvalue>*. *ptype* can have the values listed in [Table 2-6](#)

TABLE 2-6: PTYPE PROPERTY VALUES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
cmd	string		The command that started the external process
filename	string		Name of file where model is stored
operation	update progress cancel stop clear rerun	update	Name of operation to perform on the process
status	string		Current status of the process

Example

Create a parametric sweep over a geometry sequence that creates a batch job that runs a parametric sweep that runs a solver.

```
Model model = ModelUtil.create("Model");
model.batch().create("sweep1", "Parametric");
model.batch("sweep1").set("pname", "a");
model.batch("sweep1").set("plist", new double[]{1,2});
model.batch("sweep1").feature().create("sol", "Solutionseq");
model.batch("sweep1").feature("sol").set("seq", "sol3");
model.batch().create("batch1", "Batch");
model.batch("batch1").feature().create("task", "Jobseq");
model.batch("batch1").feature("task").set("seq", "sweep1");
model.batch().create("sweep2", "Parametric");
model.batch("sweep2").set("pname", "b");
model.batch("sweep2").set("plist", new double[]{1,2,3});
model.batch("sweep2").feature().create("gtask", "Geomseq");
model.batch("sweep2").feature("gtask").set("seq", "geom1");
model.batch("sweep2").feature().create("task", "Jobseq");
model.batch("sweep2").feature("task").set("seq", "batch1");
model.batch("sweep2").run();
```

Determine the parameter names and values from a parametric sweep that has already been run.

```
model.batch(pname).feature(fname).getString('psol')
```

where *pname* is the name of the parametric sweep feature that ran and *fname* is the name of the solution feature that stored the solutions. Use

model.batch()

```
model.sol(sname).feature().tags()
```

to find out the tags of the stored solutions. Use

```
model.sol(sname).feature(fname).getString('sol')
```

to find the solver sequence for a parameter. Use

```
model.sol(sname).getParamNames()
```

and

```
model.sol(sname).getParamVals()
```

See Also

[model.sol\(\)](#), [model.study\(\)](#)

Purpose	Manipulate Cape-Open settings.
Syntax	<code>model.capeopen().create(<tag>)</code> <code>model.capeopen().feature().create(<tag>)</code> <code>model.capeopen().feature(<tag>).set(prop,value)</code>
Description	<code>model.capeopen().create(<tag>)</code> creates a Cape-Open entity. <code>model.capeopen().feature().create(<cotag>)</code> creates a Cape-Open feature. <code>model.capeopen().feature(<tag>).set(prop,<value>)</code> sets property <i>prop</i> to value <i><value></i> .
See Also	model.func()

Purpose	Manipulate coefficient form contributions.
Syntax	<pre>model.coeff().create(<tag>,<fields>); model.coeff(<tag>).field(<fields>); model.coeff(<tag>).field(<pos>,<fields>); model.coeff(<tag>).intRule(<irlist>); model.coeff(<tag>).intRule(<pos>,<irule>); model.coeff(<tag>).feature().create(<ftag>); model.coeff(<tag>).feature(<ftag>).set(ctype,<cvalue>); model.coeff(<tag>).feature(<ftag>).selection().named(<seltag>); model.coeff(<tag>).feature(<ftag>).selection().set(...); model.coeff(<tag>).field(); model.coeff(<tag>).intRule(); model.coeff(<tag>).feature(<ftag>).getType(ctype); model.coeff(<tag>).feature(<ftag>).selection().named(); model.coeff(<tag>).feature(<ftag>).selection().getType();</pre>
Description	<p><code>model.coeff(<tag>)</code> is coefficient form entity with tag <code><tag></code>.</p> <p><code>model.coeff().create(<tag>,<fields>)</code> creates a new coefficient form entity using the fields <code><fields></code>. The field tags refer to the fields defined by the <code>model.field()</code> entity. The shape entities referred to by the fields are internally also used to find the derivatives of the field variables if converting the coefficient features to weak form. By default, all coefficients are designed to be non-contributing to the equation under consideration. For example, <code>model.coeff().create("foo",new String[]{"u","v"})</code>.</p> <p><code>model.coeff(<tag>).field(<fields>)</code> sets the coefficient form field variables. <code><fields></code> is a string with a field tag or a vector of field tags, for example <code>new String[]{"u","v"}</code>. Reassigning the fields has the side effect that the size of the coefficients change if the number of field variables changes.</p> <p><code>model.coeff(<tag>).field(<pos>,<fields>)</code> edits the field at position <code><pos></code> in the field vector <code><fields></code>.</p> <p><code>model.coeff(<tag>).intRule(<irlist>)</code> assigns integration rules to the coefficient form entity. The list must have the same length as the number of field variables defined by the fields, or have length 1. In the latter case all equations use the same integration rule. The number of field variables is not necessarily the same as the number of strings specified in <code>model.coeff(<tag>).field()</code>.</p> <p><code>model.coeff(<tag>).intRule(<pos>,<irule>)</code> edits the integration rule at position <code><pos></code> in the vector <code><irule></code>.</p>

`model.coeff(<tag>).feature(<ftag>)` is a coefficient form feature with tag `<ftag>` in the coefficient form entity with tag `<tag>`.

`model.coeff(<tag>).feature().create(<ftag>)` creates a new coefficient form feature with tag `<ftag>`.

`model.coeff(<tag>).feature(<ftag>).set(ctype,<cvalue>)` sets the value of the coefficient of type `ctype` to `<cvalue>`. All string data types that are listed in [Table 2-2](#) are supported; which argument types are applicable depends on the coefficient. `ctype` is one of `c`, `al`, `ga`, `be`, `a`, `f`, `da`, `ea`, `q`, and `g`. These coefficients are available at all dimensions. In addition at level `edim=sdim-1`, the coefficients `q` and `g` are allowed, corresponding to `a` and `f` respectively. All coefficients have a default 0 contribution.

`model.coeff(<tag>).feature(<ftag>).selection().named(<seltag>)` or, alternatively `model.coeff(<tag>).feature(<ftag>).selection().set(...)` assigns the coefficient form contribution to geometric entities. For a complete list of methods available under `selection()`, see [model.selection\(\)](#). Only selections at a single geometry level is allowed in the selection.

`model.coeff(<tag>).field()` returns the fields as a string array.

`model.coeff(<tag>).intRule()` returns the integration rule tags as a string array.

`model.coeff(<tag>).feature(<ftag>).getType(ctype)` returns the coefficient value. See the section [getType\(\)](#) for available methods.

`model.coeff(<tag>).feature(<ftag>).selection().named()` returns the selection tag as a string.

`model.coeff(<tag>).feature(<ftag>).selection().getType()` returns domain information. See [model.selection\(\)](#) for available methods.

Example

Define two uncoupled Poisson-like equations on the domain `dtag`.

```
model.coeff().create("c1",new String[]{"u","v"});
model.coeff("c1").intRule(new String[]{"gp1","gp1"});
CoeffFeature f1 = model.coeff("c1").feature().create("f1");
f1.set("c",1,new String[]{"1","0.1","2"});
f1.set("c",2,"3");
f1.set("f",new String[]{"2","1"});
f1.selection().geom("g1",2);
f1.selection().set(new int[]{1});
```

See Also

[model.shape\(\)](#), [model.weak\(\)](#)

Purpose	Manipulate constraints.
Syntax	<pre>model.constr().create(<tag>, <shtags>); model.constr(<tag>).shape(<shtags>); model.constr(<tag>).shape(<pos>, <shtags>); model.constr(<tag>).feature().create(<ftag>); model.constr(<tag>).feature(<ftag>).set(ctype, <value>); model.constr(<tag>).feature(<ftag>).selection().named(<seltag>); model.constr(<tag>).feature(<ftag>).selection().set(...); model.constr(<tag>).shape(); model.constr(<tag>).feature(<ftag>).getType(ctype); model.constr(<tag>).feature(<ftag>).selection().named(); model.constr(<tag>).feature(<ftag>).selection().getType();</pre>
Description	<p><code>model.constr(<tag>)</code> is a constraint entity with tag <code><tag></code>.</p> <p><code>model.constr().create(<tag>, <shtags>)</code> creates a constraint entity with tag <code><tag></code> using the shape functions <code><shtags></code>.</p> <p><code>model.constr(<tag>).shape(<shtags>)</code> points to the shape functions associated with the constraint object. Reassigning the shape functions can have the side effect of modifying the constraints since the number of constraints can change as the size of each constraint vector can change.</p> <p><code>model.constr(<tag>).feature(<ftag>)</code> is a feature in the constraint object <code><tag></code>.</p> <p><code>model.constr(<tag>).feature().create(<ftag>)</code> creates a constraint feature.</p> <p><code>model.constr(<tag>).feature(<ftag>).set(ctype, <value>)</code> sets the parameter <code>ctype</code> to <code><value></code>, where <code>ctype</code> is either <code>constr</code> or <code>constrf</code>, and <code><value></code> is a single constraint expression or a list of constraint expressions. The number of elements in the constraint expression depends on the shape function. A Lagrange shape function requires a single item, whereas a vector shape function requires one item for each space dimension. The supported <code>set</code> methods are the ones for double string arrays defined in Table 2-2.</p> <p><code>model.constr(<tag>).feature(<ftag>).selection().named(<seltag>)</code> assigns the constraint to the selection <code><seltag></code>. Only selections at a single geometry level is allowed in the selection.</p> <p><code>model.constr(<tag>).shape()</code> returns the shape function tags as a string array.</p>

`model.constr(<tag>).feature(<ftag>).getType(ctype)` returns the constraint or constraint force value. For available methods, see [getType\(\)](#).

`model.constr(<tag>).feature(<ftag>).selection().named()` returns the selection tag as a string.

`model.constr(<tag>).feature(<ftag>).selection().getType()` returns domain information. For available methods, see [Selections](#).

Examples

Set several constraint by using multiple constr entities:

```
Model model = ModelUtil.create("Model");
model.constr().create("c1", new String[]{"shu", "shv"});
ConstrFeature f = model.constr("c1").feature().create("f1");
f.set("constr", new String[]{"u-1", "v"});
f.selection().geom("geom1", 1);
f.selection().all();
```

Vector elements need a set of constraints:

```
Model model = ModelUtil.create("Model");
model.constr().create("c2", new String[]{"shE"});
ConstrFeature f = model.constr("c2").feature().create("f1");
f.set("constr", new String[]{"Ex-1", "Ey-0", "Ez-0"});
f.selection().geom("geom1", 1);
f.selection().all();
```

See Also

[model.shape\(\)](#)

Purpose Manipulate coordinate systems.

Syntax

```
model.coordSystem().create(<tag>, <gtag>, type);  
model.coordSystem(<tag>).set(property, <value>);  
model.coordSystem(<tag>).setIndex(property, <value>, row);  
model.coordSystem(<tag>).setIndex(property, <value>, row, col);  
  
model.coordSystem(<tag>).coord()  
model.coordSystem(<tag>).isOrthonormal()  
model.coordSystem(<tag>).isLinear()
```

Description `model.coordSystem().create(<tag>, <gtag>, type)` creates a coordinate system with tag `<tag>` on geometry `<gtag>` of type `type`. There are currently five types of systems, mapped system (`Mapping`), base-vector system (`VectorBase`), rotated system (`Rotated`), boundary system (`Boundary`), and cylindrical system (`Cylindrical`). The boundary system only applies to boundaries.

`model.coordSystem(<tag>).set("orthonormal", "on")` specifies that this is a orthonormal system. This affects the internal calculation of systems, so some simplifications on expressions can be made. It is recommended to use this option when possible. Boundary systems, rotated systems, and cylindrical system are always orthonormal.

MAPPED SYSTEM

`model.coordSystem().create(<tag1>, <gtag>, "Mapping")` creates a mapped system. In a mapped system you specify the coordinate mapping given in some of the available frame coordinates (usually x, y, z).

TABLE 2-7: PROPERTIES FOR MAPPING SYSTEM

PROPERTY	VALUE	DEFAULT	DESCRIPTION
coord	String matrix	[(x1,x2,x3)]	Coordinate names
map	String array	(x,y,z)	The map
orthonormal	String (on off)	off	If the system is orthonormal
frametype	String (mesh material spatial)	spatial	The frame type

`model.coordSystem(<tag1>).setIndex("map", "x+1", 0)` sets the mapping of the first coordinate system coordinate to be a function of the first frame coordinate, x.

`model.coordSystem(<tag1>).setIndex("map", "y+1", 2)` sets the mapping of the third coordinate system coordinate to be a function of the second frame coordinate `y`.

BASE VECTOR SYSTEM

`model.coordSystem().create(<tag2>, "VectorBase")` creates a base-vector system. In a base-vector system you specify the base vectors given in components of a frame system. If the components are independent of frame coordinates this is a linear system and can be applied for any frame.

TABLE 2-8: PROPERTIES FOR BASE VECTOR SYSTEM

PROPERTY	VALUE	DEFAULT	DESCRIPTION
coord	String matrix	[(x1,x2,x3)]	Coordinate names
base	String matrix	[(1,0,0)(0,1,0)(0,0,1)]	Base vectors
orthonormal	String (on off)	off	If the system is orthonormal or not
outofplane	String	"2" in 2D, "1,2" in 1D	Out of plane index

`model.coordSystem(<tag2>).setIndex("base", "1", 0, 1)` sets the first base vector's second component to one. As an alternative, it is possible to specify the full base-vector matrix using the following syntax:

`model.coordSystem(<tag2>).set("base", new String[][]{{"0", "1", "0"}, {"0", "0", "1"}, {"1", "0", "0"}})` sets the base vector matrix so the first base vector is equal to the y-axis of the frame system, the second is the z-axis, and so on. In 2D, you only use a two rows and two columns from the full base vector matrix for the in plane base vectors. As an option, it is therefore possible to specify which of the coordinate system base vectors that corresponds to the out-of-plane axis in the frame system. Internally, this base vector always gets the components {"0", "0", "1"}. The third column is also set using these components. To make a general 3D system in 2D, you have to use the mapped system.

`model.coordSystem(<tag2>).set("outofplane", "2")` sets the third base vector to represent the out-of-plane vector (z-axis in 2D). The value is zero based. In 1D the out-of-plane index is set using the syntax "1,2" to set second and third base vectors to represent the out-of-plane vector.

ROTATED SYSTEM

model.coordSystem().create(<tag3>, "Rotated") creates a rotated system. In 3D you specify the Z-X-Z Euler angles, which corresponds to sequential rotation first about the z-axis, then the x-axis, and finally the z-axis again. In 2D you can only rotate about the out-of-plane axis.

TABLE 2-9: PROPERTIES FOR ROTATED SYSTEM

PROPERTY	VALUE	DEFAULT	DESCRIPTION
coord	String matrix	[(x1,x2,x3)]	Coordinate names
angle	String array	(0,0,0)	Rotation angles
outofplane	String	"2" in 2D, "1,2" in 1D	Out of plane index

model.coordSystem(<tag3>).setIndex("angle", "12[deg]", 0) sets the first rotation about the z-axis to 12 degrees. The default unit for angles are radians.

BOUNDARY SYSTEM

model.coordSystem().create(<tag4>, <gttag>, "Boundary") creates a new boundary system. There is always one boundary system added by default for each geometry.

TABLE 2-10: PROPERTIES FOR BOUNDARY SYSTEM

PROPERTY	VALUE	DEFAULT	DESCRIPTION
coord	String matrix	[(x1,x2,x3)]	Coordinate names
frametype	String (mesh material spatial)	spatial	Frame type
reversenormal	String (on off)	off	Reverse normal direction
tangent	String array		Tangent direction
mastersystem	String (manual globalCartesian <tag>)	globalCartesian	Which system to create first tangential direction from
mastercoordsyscomp	String	"2" in axisymmetry, "3" otherwise	Which axis to create first tangential direction from

`model.coordSystem(<tag4>.set("reversenormal", "on")` flips the normal direction for this system, so it is opposite to the normal direction given by the geometry.

`model.coordSystem(<tag4>.set("mastersystemcomp", "2")` sets the first tangential direction from the second axis of the specified master system.

`model.coordSystem(<tag4>.set("mastersystem", "manual")` specifies that no master system is used and that the tangential direction must be entered by the user.

`model.coordSystem(<tag4>.setIndex("tangent", "1")` sets the first component of the first tangential direction.

CYLINDRICAL SYSTEM

`model.coordSystem().create(<tag5>, <gtag>, "Cylindrical")` creates a cylindrical system. You can specify the origin, axis direction and radial base vector.

TABLE 2-11: PROPERTIES FOR CYLINDRICAL SYSTEM

PROPERTY	VALUE	DEFAULT	DESCRIPTION
coord	String matrix	[(r, phi, a)]	Coordinate names
origin	String array	(0,0,0)	Origin of system
axis	String array	(0,0,1)	Axis direction
radialbasevector	String array	(1,0,0)	Radial base vector direction a j=0

`model.coordSystem(<tag5>.set("origin", new String[]{"1", "0", "0"})` sets the origin to (1,0,0).

Purpose	Manipulate coupling operators.
Syntax	<pre> model.cpl().create(<tag>,type,<gtag>); model.cpl(<tag>).selection().named(<seltag>); model.cpl(<tag>).selection().set(...); model.cpl(<tag>).set(property,<value>); model.cpl(<tag>).set("opname",<opname>) model.cpl(<tag>).selection(property).named(<seltag>); model.cpl(<tag>).selection(property).set(...); model.cpl(<tag>).feature().create(<subtag>,subtype); model.cpl(<tag>).feature(<subtag>).set(property,<value>); model.cpl(<tag>).feature(<subtag>).selection().named(<seltag>); model.cpl(<tag>).feature(<subtag>).selection().set(...); model.cpl(<tag>).feature(<subtag>).selection(property). named(<seltag>); model.cpl(<tag>).feature(<subtag>).selection(property).set(...); model.cpl(<tag>).selection().named(); model.cpl(<tag>).selection().getType(...); model.cpl(<tag>).properties(); model.cpl(<tag>).getType(property,<value>); model.cpl(<tag>).selection(property).named(); model.cpl(<tag>).selection(property).getType(...); model.cpl(<tag>).feature(<subtag>).selection().named(); model.cpl(<tag>).feature(<subtag>).selection().getType(...); model.cpl(<tag>).feature(<subtag>).properties(); model.cpl(<tag>).feature(<subtag>).getType(property,<value>); </pre>
Description	<p>model.cpl().create(<tag>,type,<gtag>) creates a coupling operator entity of type <i>type</i> on the geometry <gtag>. The supported types are GeneralExtrusion, LinearExtrusion, BoundarySimilarity, IdentityMapping, GeneralProjection, LinearProjection, Integration, Average, Maximum, and Minimum.</p> <p>model.cpl(<tag>).selection().named(<seltag>) or, alternatively, model.cpl(<tag>).selection().set(...) specifies source geometric entities for all types of coupling operators. For a complete list of methods available under selection(), see Selections.</p> <p>model.cpl(<tag>).set(property,<value>) specifies properties relevant for the selected coupling operator type, see below.</p> <p>model.cpl(<tag>).set("opname",<opname>) sets the operator name of the coupling operator. The default operator name is <tag>.</p> <p>model.cpl(<tag>).selection(property).named(<seltag>) or, alternatively, model.cpl(<tag>).selection(property).set(...) specifies the entities in a</p>

selection property for certain types of coupling operators. For a complete list of methods available under `selection(property)`, see [Selections](#).

`model.cpl(<tag>).feature().create(<subtag>, subtype)` creates a sub feature of type `subtype`. This can only be done when `type` is `BoundarySimilarity`.

`model.cpl(<tag>).selection().named()` returns the source selection of the coupling.

`model.cpl(<tag>).selection().getType(...)` queries the source selection.

`model.cpl(<tag>).properties()` returns the list of assigned properties as a string array.

`model.cpl(<tag>).getType(property)` returns the value of a specified property.

`model.cpl(<tag>).selection(property).named()` returns the tag of a selection property.

`model.cpl(<tag>).selection(property).getType(...)` queries a selection property.

Notation: `srcedim` = dimension of source selection, `srcsdim` = space dimension of source geometry.

Extrusion Coupling Operators

An extrusion coupling operator `oper` maps an expression `e` defined on (a part of) the source selection to an expression `oper(e)` that can be evaluated on (a part of) the destination geometry/geometries. For each point p_s in the source selection, there can be zero, one or several corresponding points p_d in the destination. The inverse mapping $p_s = m(p_d)$ is always one-to-one. The value of `oper(e)` at the point p_d is defined as the value of `e` at the point p_s .

The inverse mapping m is specified as the composition of a *destination map* m_d and the inverse of a *source map* m_s : $p_s = m(p_d) = m_s^{-1}(m_d(p_d))$. In other words, $m_s(p_s) = m_d(p_d)$ —both the destination map and the source map into the same *intermediate space*. For all operator types except `GeneralExtrusion`, the intermediate space coincides with the source geometry. The source map is always one-to-one. By default, the source map is the identity.

The operator type determines the type of destination map:

TABLE 2-12: EXTRUSION COUPLING OPERATOR TYPES

OPERATOR TYPE	DESTINATION MAP
GeneralExtrusion	Nonlinear map described by expressions
LinearExtrusion	Linear map described by vertex mapping
BoundarySimilarity	Similarity transformation described by mapping of boundaries. Also used by copy mesh.
IdentityMapping	Identity map

For most of these operator types, a source map described by (possibly nonlinear) expressions can be used.

TABLE 2-13: EXTRUSION COUPLING OPERATOR PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
exttol	double	0.3	Extrapolation tolerance in mesh search
method	usetol closest	usetol	Mesh search method
usenan	on off	off	Use NaN instead of error message when source point is outside selection.

If `method=usetol`, `oper(e)` is defined when the source point p_s is within the source selection, or if it is slightly outside. The tolerance is given in the property `exttol`, which is a distance in mesh element local coordinates; that is, it is a measure relative to the mesh element size. If `oper(e)` is not defined, an error message is given (if `usenan=off`), or the value NaN is returned (if `usenan=on`).

If `method=closest`, a brute force search method is used, which makes `oper(e)` defined everywhere (the nearest point to p_s in the source selection is used).

Depending on the operator type, additional properties are available (see below).

GENERAL EXTRUSION MAP

TABLE 2-14: GENERAL EXTRUSION MAP PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
dstmap	string array	spatial coordinates	Expressions for destination map $m_d(p_d)$
srcframe	mesh material spatial	spatial	Frame for source mesh
usesrcmap	on off	off	Use source map
srcmap	string array	spatial coordinates	Expressions for source map $m_s(p_s)$

Trailing empty expressions in the properties `dstmap` and `srcmap` are ignored. The remaining expressions must be equal in number, and this determines the dimension `idim` of the intermediate space. Requirement: `srcdim ≤ idim ≤ srcsdm`. Changing the source selection has the side effect of changing `dstmap` and `srcmap` so that this requirement is satisfied. By default, `idim=srcsdm`.

The source mesh is viewed in the frame `srcframe`. The source mapping is taken to be linear within each source mesh element.

If `usesrcmap=off`, the `srcmap` property is not used. In this case, `dstmap` is a mapping from the destination to the source (viewed in the frame `srcframe`), and `idim=srcsdm`.

LINEAR EXTRUSION MAP

TABLE 2-15: LINEAR EXTRUSION MAP PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
srcvertexN	Selection		Source vertex number N
dstgeom	String	source geometry	Destination geometry
dstvertexN	Selection		Destination vertex number N
srcframe	mesh material spatial	spatial	Frame for evaluation of source vertex coordinates
dstframe	mesh material spatial	spatial	Frame for evaluation of destination vertex coordinates
usesrcmap	on off	off	Use source map
srcmap	String[srcsdim]	spatial coordinates	Expressions for source map $m_s(p_s)$

The number of selections `srcvertexN` and `dstvertexN` is 4. These are used only for $1 \leq N \leq \dim + 1$, where `dim` is a number less than or equal to $\min(\text{srcsdim}, \text{dstsdim})$. The remaining $4 - \dim$ selections should be empty.

The destination map is the following linear (affine) map from the destination geometry to the source geometry:

- 1 First, if $\dim < \text{dstsdim}$, an orthogonal projection onto the affine space spanned by the destination vertices. The number of destination vertices is $\dim + 1$. Thus, $\dim = 2$ gives a plane, and $\dim = 1$ gives a line.
- 2 Then, a linear (affine) map mapping the destination vertices onto the source vertices.

BOUNDARY SIMILARITY (3D)

TABLE 2-16: BOUNDARY SIMILARITY PROPERTIES IN 3D

PROPERTY	VALUE	DEFAULT	DESCRIPTION
destination	Selection		Destination face
usesrcmap	on off	off	Use source map
srcmap	String[srcsdim]	spatial coordinates	Expressions for source map $m_s(p_s)$.

The destination transformation is a similarity transformation that maps a destination face (`destination`) onto a set of source faces (the source selection). The mesh is always viewed in the mesh frame.

By default, the algorithm automatically chooses a transformation when symmetries make several transformations possible. To control this choice, one of the following subfeatures can be added.

TABLE 2-17: SUBFEATURE TYPES

SUB FEATURE	REMARKS
EdgeMap	Specify how one source edge is mapped.
OnePointMap	Specify how one source vertex is mapped.
TwoPointMap	Specify how two source vertices are mapped.

EdgeMap Subfeature

You specify that a certain destination edge should be mapped onto a certain source edge. Their relative direction is given by the property `direction`. The edges must be adjacent to the given faces.

TABLE 2-18: PROPERTIES FOR EDGEMAP SUBFEATURE

PROPERTY	VALUE	DEFAULT	DESCRIPTION
<code>srcedge</code>	Selection		Source edge
<code>dstedge</code>	Selection		Destination edge
<code>direction</code>	auto same opposite	auto	Edge direction

OnePointMap Subfeature

You specify that a certain destination vertex should be mapped onto a certain source vertex.

TABLE 2-19: PROPERTIES FOR ONEPOINTMAP SUBFEATURE

PROPERTY	VALUE	DEFAULT	DESCRIPTION
<code>srcpoint1</code>	Selection		Vertex on source face
<code>dstpoint1</code>	Selection		Vertex on destination face

TwoPointMap Subfeature

You specify that two destination vertices should be mapped onto two source vertices.

TABLE 2-20: PROPERTIES FOR ONEPOINTMAP SUBFEATURE

PROPERTY	VALUE	DEFAULT	DESCRIPTION
<code>srcpoint1</code>	Selection		Vertex 1 on source face
<code>srcpoint2</code>	Selection		Vertex 2 on source face

TABLE 2-20: PROPERTIES FOR ONEPOINTMAP SUBFEATURE

PROPERTY	VALUE	DEFAULT	DESCRIPTION
dstpoint1	Selection		Vertex 1 on destination face
dstpoint2	Selection		Vertex 2 on destination face

BOUNDARY SIMILARITY (2D)

TABLE 2-21: BOUNDARY SIMILARITY PROPERTIES IN 2D

PROPERTY	VALUE	DEFAULT	DESCRIPTION
destination	Selection		Destination edge
direction	auto same opposite	auto	Edge direction
usesrcmap	on off	off	Use source map
srcmap	String[srcsdim]	spatial coordinates	Expressions for source map $m_s(p_s)$

The destination transformation is a similarity transformation that maps a destination edge (`destination`) onto a set of source edges (the source selection). Their relative direction is given by the property `direction`. The mesh is always viewed in the mesh frame.

IDENTITY MAP

The destination transformation is an identity mapping between the given frames.

TABLE 2-22: NORMAL EXTRUSION MAP PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
dstframe	mesh material spatial	spatial	Frame for evaluation of destination coordinates
srcframe	mesh material spatial	spatial	Frame for evaluation of source coordinates

Projection Coupling Operators

A projection coupling operator `oper` maps an expression `e` defined on (a part of) the source selection to an expression `oper(e)` that can be evaluated on (a part of) the destination geometries. It does so by performing integration along curves in the source selection. These curves correspond to lines in an *intermediate space*, whose dimension is equal to `srcdim`. There is a *source map* m_s mapping the source selection into the intermediate space, and a *destination map* m_d mapping the

destination geometries into the subspace of intermediate space where the last coordinate is zero. The source map is always one-to-one. The value of `oper(e)` at a destination point p_d is defined as follows:

- 1 In the intermediate space, consider the line that is parallel to the last coordinate axis, and goes through the point $m_d(p_d)$.
- 2 Map this line to a curve in the source selection using the inverse of the source map.
- 3 Integrate the expression `e` over this curve.

This implies that the value of `oper(e)` at the destination point p_d is the integral of `e` along a curve through the source point $p_s = m_s^{-1}(m_d(p_d))$.

The operator type determines the type of the maps:

TABLE 2-23: PROJECTION COUPLING OPERATOR TYPES

OPERATOR TYPE	MAP TYPES
GeneralProjection	Nonlinear map described by expressions
LinearProjection	Linear map described by vertex mapping

TABLE 2-24: PROJECTION COUPLING OPERATOR PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
intorder	int	4	Order of integration formula

Additional properties are available depending on the operator type, see below.

GENERAL PROJECTION MAP

TABLE 2-25: GENERAL PROJECTION COUPLING OPERATOR PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
dstmap	String[srcedim-1]	spatial coordinates	Expressions for destination map $m_d(p_d)$
srcframe	mesh material spatial	spatial	Frame for source mesh.
srcmap	String[srcedim]	spatial coordinates	Expressions for source map $m_s(p_s)$

LINEAR PROJECTION MAP

The mapping between destination and source is given by a linear map defined by vertices. Let v be the vector from the first source vertex to the last source vertex.

The value of `oper(e)` at a point p_d is equal to the integral of e over the line through the point $p_s = m_s^{-1}(m_d(p_d))$ with direction vector v .

TABLE 2-26: LINEAR PROJECTION COUPLING OPERATOR PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
<code>srcvertexN</code>	Selection		Source vertex number N
<code>dstgeom</code>	String	source geometry	Destination geometry
<code>dstvertexN</code>	Selection		Destination vertex number N
<code>srcframe</code>	mesh material spatial	spatial	Frame for evaluation of source vertex coordinates
<code>dstframe</code>	mesh material spatial	spatial	Frame for evaluation of destination vertex coordinates

The number of selections `srcvertexN` is 4. These are used only for $1 \leq N \leq \text{srcdim} + 1$. The remaining selections should be empty. The number of source vertices is `srcdim`. The source map is a linear (affine) map that maps the source vertices onto the points $0, e_1, e_2, \dots, e_{\text{srcdim}}$ in the intermediate space, where e_i is the i th unit vector.

The number of selections `dstvertexN` is 4. These are used only for $1 \leq N \leq \text{srcdim}$. The remaining selections should be empty. The number of destination vertices is `srcdim`. The destination map is the following linear (affine) map from the destination geometry to the intermediate space:

- 1 First, if $\text{srcdim} - 1 < \text{dstdim}$, an orthogonal projection onto the affine space spanned by the destination vertices. Thus, `srcdim`=3 gives a plane, and `srcdim`=2 gives a line.
- 2 Then, a linear (affine) map mapping the destination vertices onto the points $0, e_1, e_2, \dots, e_{\text{srcdim}-1}$ in the intermediate space, where e_i is the i th unit vector.

Integration Coupling Operators

By default, an integration coupling operator `oper` integrates an expression e over the source selection. The resulting value `oper(e)` can be used anywhere. If

method=summation, the expression is instead summed over the nodes in the source selection.

TABLE 2-27: INTEGRATION COUPLING OPERATOR PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
intorder	String	4	Integration order
frame	mesh material spatial	spatial	Frame to integrate in (determines volume element)
method	integration summation	integration	Method of computation

Average Coupling Operators

An average coupling operator `oper` integrates an expression `e` over the source selection, and divides with the measure of the source selection. The resulting value `oper(e)` can be used anywhere.

TABLE 2-28: AVERAGE COUPLING OPERATOR PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
intorder	String	4	Integration order
frame	mesh material spatial	spatial	Frame to integrate in (determines volume element)

Maximum/Minimum Coupling Operators

A maximum or minimum coupling operator `oper` finds the maximum/minimum of an expression `e` over the source selection. The resulting value `oper(e)` can be used anywhere. An optional second argument is evaluated at the point where the first argument has its maximum or minimum. Use `x`, `y`, or `z`, for example, to get the coordinate location of the maximum or minimum.

TABLE 2-29: MAXIMUM/MINIMUM COUPLING OPERATOR PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
intorder	String	4	Integration rule
points	node integration lagrange	node	Type of point

TABLE 2-29: MAXIMUM/MINIMUM COUPLING OPERATOR PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
intorder	String	4	Integration order
lagrange	String	2	Lagrange order

The maximum/minimum is approximated by evaluating the expression in the specified points.

Purpose	Manipulate elements.
Syntax	<pre> model.elem().create(<tag>,eltype); model.elem(<tag>).set(<ftag>,value); model.elem(<tag>).field().create(<ftag>,"record"); model.elem(<tag>).field(<ftag>).set(<ftag>,value); model.elem(<tag>).field().create(<atag>,"array"); model.elem(<tag>).field(<atag>).pos().create("string",value); model.elem(<tag>).field(<atag>).pos().create("array"); model.elem(<tag>).field(<atag>).pos(pos).create("string",value); model.elem(<tag>).src().create(<fttag>); model.elem(<tag>).src(<fttag>).set(<ftag>,value); model.elem(<tag>).src(<fttag>).selection().named(<stag>); model.elem(<tag>).src(<fttag>).selection().set(...); model.elem(<tag>).src(<fttag>).field().create(<ftag>,"array"); model.elem(<tag>).geomdim().create(<fttag>); </pre>
Description	<p>Externally generated element syntax contributions. These element syntax contributions are also be used by, for example, the far-field feature and the <code>elpric</code> element. The syntax is not specific to a certain type of element but works for all types of elements. As a result, the syntax can be rather lengthy in some cases.</p> <p><code>model.elem().create(<tag>,eltype)</code> creates a new element of type <code>eltype</code>, for example <code>elinterp</code>, <code>elpric</code>, <code>elvar</code>, <code>elode</code>, and so on.</p> <p><code>model.elem(<tag>).set(<ftag>,value)</code> sets the field tagged <code><ftag></code> to <code>value</code>. Examples of fields and values are, <code>file</code> and <code>solution_interp.txt</code>, <code>global</code> and <code>1</code>, and so on.</p> <p><code>model.elem(<tag>).field().create(<ftag>,"record")</code> creates a new field tagged <code><ftag></code> of type <code>record</code> under the element tagged <code><tag></code>.</p> <p><code>model.elem(<tag>).field(<ftag>).set(sname,value)</code> sets the field tagged <code>sname</code> to <code>value</code>. The field is located under the record field tagged <code><ftag></code>.</p> <p><code>model.elem(<tag>).field(<ftag>).field().create(<rtag>,"record")</code> creates a new record field tagged <code><rtag></code> that is a field under the record field <code><ftag></code>.</p> <p><code>model.elem(<tag>).field().create(<atag>,"array")</code> creates a new array field tagged <code><atag></code>.</p> <p><code>model.elem(<tag>).field(<atag>).pos().create("array")</code> adds a new element of type <code>array</code> to the array tagged <code><atag></code>.</p>

`model...field(<atag>).pos(1).pos().create("string", "1")` adds a new array element of type string with value 1 to the first array element of the array stored in the field <atag>.

In the text below, all occurrences of `src` can be replaced with `geomdim`.

`model.elem(<tag>).src().create(<fttag>)` creates a `src` feature tagged <fttag> under the element. A feature must have a domain selection.

`model.elem(<tag>).src(<fttag>).selection().dim(2).set(gname)` assigns all domains of dimension 2 from geometry `gname` to the selection of feature <fttag>.

`model.elem(<tag>).src(<fttag>).set(<fttag>, value)` sets the field <fttag> to `value` under the feature <fttag>.

`model.elem(<tag>).src(<fttag>).field().create(rname, "record")` adds a new record field `rname` under the feature <fttag>.

Examples

Specifies an interpolation element that takes its data from a file named `solution_data.txt`.

```
Model model = ModelUtil.create("Model");
model.elem().create("fun1", "elinterp");
model.elem("fun1").set("name", new String[]{"sol"});
model.elem("fun1").set("file", "solution_data.txt");
model.elem("fun1").set("fileindex", new String[]{"1"});
model.elem("fun1").set("defvars", new String[]{"true"});
model.elem("fun1").set("method", new String[]{"linear"});
model.elem("fun1").set("extmethod", new String[]{"const"});
```

The example below creates two integration coupling operators.

```
model.elem().create("elem1", "elcplscalar");
model.elem("elem1").set("var", new String[]{"aa", "bb"});
model.elem("elem1").set("global", new String[]{"1", "2"});
model.elem("elem1").src().create("feat1");
model.elem("elem1").src("feat1").selection().geom("g", 2)
.set(new int[]{1});
model.elem("elem1").src("feat1")
.set("expr", new String[][]{{"1"}, {"2"}}
model.elem("elem1").src("feat1")
.set("ipoints", new String[][]{{"2"}, {"2"}}
model.elem("elem1").src("feat1")
.set("frame", new String[][]{{"spatial"}, {"spatial"}});
```

This complicated example creates a `constr` element with two constraints (usually done with constraint features).

```

model.elem().create("elem1", "elsconstr");
feat = model.elem("elem1").geomdim().create("feat1");
feat.selection().geom("g", 2).set(new int[] {1});
feat.set("constr", new String[][][] {{"Ex", "Ey", "Ez"}});
feat.set("cshape", new String[] {"1"});
feat.field().create("shelem", "record");
feat.field("shelem").set("case", new String[0]);
feat.field("shelem").set("mind", new String[0]);
feat.field("shelem").field().create("default", "array");
feat.field("shelem").field("default").pos().create("array");
feat.field("shelem").field("default").pos(1).pos()
.create("array");
feat.field("shelem").field("default").pos(1).pos(1).pos()
.create("string", "edg");
feat.field("shelem").field("default").pos(1).pos(1).pos()
.create("string", "shcurl");
feat.field("shelem").field("default").pos(1).pos(1).pos()
.create("record");
feat.field("shelem").field("default").pos(1).pos(1).pos(3)
.set("order", "2");
feat.field("shelem").field("default").pos(1).pos(1).pos(3)
.set("comnames", new String[] {"Ex", "Ey", "Ez"});
feat.field("shelem").field("default").pos(1).pos(1).pos(3)
.set("frame", "ref");
feat.field("shelem").field("default").pos(1).pos(1).pos()
.create("string", "edg2");
feat.field("shelem").field("default").pos(1).pos(1).pos()
.create("string", "shcurl");
feat.field("shelem").field("default").pos(1).pos(1).pos()
.create("record");
feat.field("shelem").field("default").pos(1).pos(1).pos(6)
.set("order", "2");
feat.field("shelem").field("default").pos(1).pos(1).pos(6)
.set("comnames", new String[] {"Ex", "Ey", "Ez"});
feat.field("shelem").field("default").pos(1).pos(1).pos(6)
.set("frame", "ref");

```

For all records, the statement

```
model...set("frame", "ref");
```

is the equivalent to

```
model...field().create("frame", "string", "ref");
```

The statement

```
model...set("expr", new String[][]{{"1"}, {"2"}});
```

is equivalent to

```
model...field().create("expr", "array");
```

model.elem()

```
model...field("expr").pos().create("array").  
model...field("expr").pos(1).create("string","1");  
model...field("expr").pos().create("array").  
model...field("expr").pos(2).create("string","1");
```

so the `set` method is often a much more convenient way to create simple fields.

Purpose	Manipulate events.
Syntax	<pre> model.solverEvent().create(<tag>, evtype); model.solverEvent(<tag>).start(expr); model.solverEvent(<tag>).start(); model.solverEvent(<tag>).period(expr); model.solverEvent(<tag>).period(); model.solverEvent(<tag>).condition(expr); model.solverEvent(<tag>).condition(); model.solverEvent(<tag>).reinit(); model.solverEvent(<tag>).reinit().create(<tag>); model.solverEvent(<tag>).reinit(<tag>).set(<var>, expr); </pre>
Description	<p>Create events and manipulate event settings. There are two types of events; Explicit and Implicit.</p> <p><code>model.solverEvent().create(<tag>, evtype)</code> creates a new event of type <code>evtype</code>, either Explicit and Implicit.</p> <p>EXPLICIT EVENTS</p> <p>Explicit events triggers on a predefined timing.</p> <p><code>model.solverEvent(<tag>).start(expr)</code> sets the start time for an explicit event.</p> <p><code>model.solverEvent(<tag>).period(expr)</code> sets the period for an explicit event. After the start time, the event then triggers after each period.</p> <p>IMPLICIT EVENTS</p> <p>Implicit events trigger when a condition goes from false to true.</p> <p><code>model.solverEvent(<tag>).condition(expr)</code> sets the condition for an implicit event.</p> <p>RE-INITIALIZATION</p> <p>When an event is triggered, any degree of freedom may be re-initialized. This typically means that they get a new value. You specify these values with a re-initialization entity that has the same syntax as an <code>init</code> entity.</p> <p><code>model.solverEvent(<tag>).reinit().create(<tag>)</code> adds a new reinit feature to the event. In most cases you only need one, but you need more when you have re-initialization conditions on several geometric entity levels, for example on a global selection and a domain selection.</p>

EVENT STATE VARIABLES

An event needs state variables in most cases. There are discrete states and indicator states. Discrete states are just ODE states that only change during re-initialization, and can only have a zero-valued equation (or no equation). The indicator states are needed for implicit events, and are ode states with non-zero equations.

`model.ode().create(<tag>).type(<ode type>)` creates a new ODE entity that contains event state variables if you set the ode type to `discrete` for discrete states and `quadrature` for indicator states.

`model.ode(<tag>).state(<states>)` adds a new discrete states to the ode feature.

`model.ode(<tag>).ode(<state>, "sin(2*pi*t)")` adds a new indicator state and its right-hand-side to the ODE entity. The left-hand side of the equation is the state variable, so the full equation for the indicator state becomes `nojac(sin(2*pi*t))-<state>`.

Examples

Example of an idealized bouncing ball using implicit events.

```
Model model = ModelUtil.create("Model");
model.study().create("std1");
model.study("std1").feature().create("time1", "Transient");
model.study("std1").feature("time1").set("tlist", "0 10");
model.study("std1").feature("time1").set("rtol", 1e-6);
// Non-discrete states
model.ode().create("ode1");
model.ode("ode1").ode("y", "-2*y-ytt");
model.init().create("ode1");
model.init("ode1").selection().global();
model.init("ode1").set("y", "1");
// Discrete states
model.ode().create("ode2").type("quadrature");
model.ode("ode2").ode("z1", "y");
// Implicit event
model.solverEvent().create("impl1", "Implicit");
model.solverEvent("impl1").condition("!(z1>=0)");
model.solverEvent("impl1").reinit().create("reinit");
model.solverEvent("impl1").reinit("reinit").selection().global();
model.solverEvent("impl1").reinit("reinit").set("y", "y");
// Bounce reverts velocity
model.solverEvent("impl1").reinit("reinit").set("yt", "-yt");
model.sol().create("sol1");
model.sol("sol1").createAutoSequence("std1");
// Special solver settings for events
model.sol("sol1").feature("t1").set("tout", "tsteps");
```



```
model.sol("sol1").feature("t1").set("atolglobal", "1e-6");
model.sol("sol1").feature("t1").set("initialstepbdfactive",
"on");
model.sol("sol1").feature("t1").set("initialstepbdf", "1e-6");
model.sol("sol1").feature("t1").set("eventtol", "2e-6");
model.sol("sol1").feature("t1").set("ewtrescale", "off");
model.sol("sol1").runAll();
```

See Also[model.ode\(\)](#), [model.init\(\)](#)

model.field()

Purpose	Manipulate fields.
Syntax	<pre>model.field().create(<tag>,<fname>); model.field(<tag>).field(<fname>); model.field(<tag>).shape(<shlist>); model.field(<tag>).field(); model.field(<tag>).shape(); model.field(<tag>).geom();</pre>
Description	<p><code>model.field(<tag>)</code> is a field entity with tag <code><tag></code>.</p> <p><code>model.field().create(<tag>,<fname>)</code> creates a field entity with tag <code><tag></code> with the field name <code><fname></code>.</p> <p><code>model.field(<tag>).field(<fname>)</code> sets the field name.</p> <p><code>model.field(<tag>).shape(<shlist>)</code> sets the shape functions defining the field variables. <code><shlist></code> is a list of shape entities. Each shape function defines one or more field variables. Together the shape functions specify which field variables there are in the field.</p> <p><code>model.field(<tag>).field()</code> returns the field name as a string.</p> <p><code>model.field(<tag>).shape()</code> returns the shape entity tags as a string array.</p> <p><code>model.field(<tag>).geom()</code> returns the geometry associated with the field.</p>
See Also	model.shape() , model.coeff()

Purpose	Manipulate frames.
Syntax	<pre> model.frame().create(<tag>,<gtag>); model.frame(<tag>).coord(<coordlist>); model.frame(<tag>).coord(<pos>,<coord>); model.frame(<tag>).meshFrame(); model.frame(<tag>).materialFrame(); model.frame(<tag>).geometryFrame(); model.frame(<tag>).spatialFrame(); model.frame(<tag>).sorder(order); model.frame(<tag>).sshape.create(<stag>,type); model.frame(<tag>).sshape(<stag>).type(type); model.frame(<tag>).sshape(<stag>).sorder(order); model.frame(<tag>).sshape(<stag>).coorddof(<dofs>); model.frame(<tag>).sshape(<stag>).coorddof(<pos>,<dof>); model.frame(<tag>).sshape(<stag>).refframe(<ftag>); model.frame(<tag>).sshape(<stag>).coordexpr(<exprs>); model.frame(<tag>).sshape(<stag>).coordexpr(<pos>,<expr>); model.frame(<tag>).sshape(<stag>).selection().named(<seltag>); model.frame(<tag>).sshape(<stag>).selection().set(...); model.frame(<tag>).coord(); model.frame(<tag>).identifier(); model.frame(<tag>).varNameSuffix(); model.frame(<tag>).geom(); model.frame(<tag>).isMeshFrame(); model.frame(<tag>).isGeometryFrame(); model.frame(<tag>).isMaterialFrame(); model.frame(<tag>).isSpatialFrame(); model.frame(<tag>).sorder(); model.frame(<tag>).sshape(<stag>).type(); model.frame(<tag>).sshape(<stag>).sorder(); model.frame(<tag>).sshape(<stag>).coorddof(); model.frame(<tag>).sshape(<stag>).refframe(); model.frame(<tag>).sshape(<stag>).coordexpr(); model.frame(<tag>).sshape(<stag>).selection().named(); model.frame(<tag>).sshape(<stag>).selection().getType(); </pre>
Description	<p><code>model.frame().create(<tag>,<gtag>)</code> creates a new frame and assigns it to geometry <code><gtag></code>.</p> <p><code>model.frame(<tag>).coord(<coordlist>)</code> defines <code><coordlist></code> as a list of independent variables. (Formerly <code>sdim</code>.)</p> <p><code>model.frame(<tag>).coord(<pos>,<coord>)</code> edits the coordinate at position <code><pos></code> in the coordinate list.</p> <p><code>model.frame(<tag>).meshFrame()</code> sets this frame to be the mesh frame. Each geometry requires exactly one mesh frame. The first one added becomes the mesh</p>

frame. When assigning one frame to be the mesh frame, this flag is cleared in the previous frame being the mesh frame.

`model.frame(<tag>).geometryFrame()` sets this frame to be the geometry frame. Each geometry requires exactly one geometry frame. The first one added becomes the geometry frame. When assigning one frame to be the geometry frame, this flag is cleared in the previous frame being the geometry frame.

`model.frame(<tag>).materialFrame()` sets this frame to be the material frame. Each geometry requires exactly one material frame. The first one added becomes the material frame. When assigning one frame to be the material frame, this flag is cleared in the previous frame being the material frame.

`model.frame(<tag>).spatialFrame()` sets this frame to be the spatial frame. Each geometry requires exactly one spatial frame. The first one added becomes the spatial frame. When assigning one frame to be the spatial frame, this flag is cleared in the previous frame being the spatial frame.

`model.frame(<tag>).sorder(order)` sets the geometrical shape order. This value is used if the frame is the reference frame. The reference frame ignores all sshape features.

`model.frame(<tag>).sshape().create(<stag>, type)` creates a spatial shape feature of the given type. Possible types are `fixed` (default), `moving_abs`, `moving_rel`, and `moving_expr`.

`model.frame(<tag>).sshape(<stag>).type(type)` sets the type of the spatial shape feature.

`model.frame(<tag>).sshape(<stag>).sorder(order)` sets the spatial approximation order for `<stag>` to `order`.

`model.frame(<tag>).sshape(<stag>).oorddof(<dofs>)` sets the spatial coordinates for `<stag>` when the `moving_rel` type is used.

`model.frame(<tag>).sshape(<stag>).oorddof(<pos>, <dof>)` edits the coordinate name at position `<pos>` in the degree of freedom list.

`model.frame(<tag>).sshape(<stag>).refframe(<ftag>)` sets the reference frame for `<stag>` when the `moving_rel` type is used.

`model.frame(<tag>).sshape(<stag>).coordexpr(<exprs>)` sets the expressions for the mesh displacement for `<stag>`.

`model.frame(<tag>).sshape(<stag>).coordexpr(<pos>,<expr>)` edits the expression at position `<pos>` in the expression list.

`model.frame(<tag>).sshape(<stag>).selection().named(<seltag>)` or, alternatively, `model.frame(<tag>).sshape(<stag>).selection().set(...)` sets the domains for `<stag>`. For a complete list of methods available under `selection()`, see [model.selection\(\)](#). All types of selections are supported except the global one and selections containing interior mesh boundaries.

`model.frame(<tag>).coord()` returns the coordinate names as a string array.

`model.frame(<tag>).identifier()` returns the frame's identifier as a string.

`model.frame(<tag>).varNameSuffix()` returns the variable name suffix as a string.

`model.frame(<tag>).geom()` returns the geometry name as a string.

`model.frame(<tag>).isMeshFrame()` returns true if this frame is the mesh frame.

`model.frame(<tag>).isGeometryFrame()` returns true if this frame is the geometry frame.

`model.frame(<tag>).isMaterialFrame()` returns true if this frame is the material frame.

`model.frame(<tag>).isSpatialFrame()` returns true if this frame is the spatial frame.

`model.frame(<tag>).sorder()` returns the geometrical shape order.

`model.frame(<tag>).sshape(<stag>).type()` returns the type as a string.

`model.frame(<tag>).sshape(<stag>).sorder()` returns the spatial approximation order as an integer.

`model.frame(<tag>).sshape(<stag>).coorddof()` returns the spatial coordinates as a string array.

`model.frame(<tag>).sshape(<stag>).refframe()` returns the reference frame as a string.

`model.frame(<tag>).sshape(<stag>).coordexpr()` returns the spatial coordinate expressions as a string array.

model.frame()

`model.frame(<tag>).sshape(<stag>).selection().named()` returns the selection tag as a string.

`model.frame(<tag>).sshape(<stag>).selection().getType()` returns domain information. For available methods, see [model.selection\(\)](#).

See Also

[model.shape\(\)](#)

Purpose Manipulate functions.

Syntax

```

model.func().create(<tag>,<type>);
model.func(<tag>).model(<mtag>)
model.func(<tag>).set(property,<value>);
model.func(<tag>).set("funcname",<funcname>)
model.func(<tag>).importData()

model.func(<tag>).model()
model.func(<tag>).getType(property);
    
```

Description

`model.func().create(<tag>,<type>)` creates a new function object of type `<type>` with the tag `<tag>`.

`model.func(<tag>).model(<mtag>)` sets the model of the function.

`model.func(<tag>).set(property,<value>)` sets the value of a property of the function.

`model.func(<tag>).set("funcname",<funcname>)` sets the operator name of the function. The default function name is `<tag>`.

`model.func(<tag>).model()` returns the model.

`model.func(<tag>).getType(property)` retrieves a value of a property of the function.

`model.func(<tag>).importData()` imports the file that the function references into the model. This is possible for interpolation, elevation, and image function.

What properties are available depends on the type of function. The following function types are available:

Analytic Generate function using an analytic expression.

TABLE 2-30: ANALYTIC PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
argders	Nx2 String array	{ }	(argument, partial derivative) pairs if dermethod is manual
args	String array	{ }	The arguments to the function
complex	boolean	false	True if the function can produce complex results for real inputs

TABLE 2-30: ANALYTIC PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
dermethod	automatic manual	Automatic	Automatic differentiation or manual control over the derivatives
expr	String	None	The expression defining the function
funcname	String	The tag name.	The name of the function
periodic	boolean	false	True if the function should be extended to a periodic function
periodiclower	String	0	The lower limit of the interval that is extended periodically
periodicupper	String	1	The upper limit of the interval that is extended periodically
argunit	String		A comma separated list of required units for each argument
fununit	String		The unit of the function's result

Interpolation Generate interpolation function.

TABLE 2-31: INTERPOLATION PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
defineinv	on off	off	If source is table: Whether to define the inverse function.
defvars	boolean	false	If source is file and defvars is set, the space variables are used as default arguments to the function if no arguments are supplied in a call to it.
extrap	const interior linear value	const	The extrapolation method
extrapvalue	double	0	The extrapolation value if extrap is value
filename	String		The file that contains the data if source is file.

TABLE 2-31: INTERPOLATION PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
funcinvname	String		If source is table and defineinv is on: The name of the inverse function.
funcname	String	The tag name.	The name of the function if source is table
funcs	String matrix		Used source is file; the first column contains function names and the second column contains the positions in the file where the corresponding function is defined
interp	neighbor linear piecewisecubic cubicspline	piecewisecubic	The interpolation method
modelres	String		If sourcetype is model, specifies the model resource in model.file() that contains the interpolation data
nargs	integer (1-3)	1	The number of function arguments if struct is spreadsheet.
source	table file	table	If sourcetype is user, specifies whether the data is entered in a table or read from a file
sourcetype	model user	user	Specifies if the data for the function is stored in the model or provided by the user
struct	sectionwise spreadsheet	spreadsheet	The data format if source is file
table	Nx2 String array	Empty	Contains the point/value pairs if the source is table
argunit	String		A comma separated list of required units for each argument
fununit	String		The unit of the function's result

Piecewise Generate piecewise interpolation function

TABLE 2-32: PIECEWISE PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
arg	String	x	The argument to the function
extrap	const interior none periodic value	const	The extrapolation method
extrapvalue	double	0	The extrapolation value if extrap is value
funcname	String	The tag name.	The name of the function
pieces	Nx3 String array	Empty	(left, right, expression) for each interval
smooth	none cont contd1 contd2	none	The type of smoothing
smoothzone	double	0.1	The relative size of the smoothing zone if smoothing is enabled
argunit	String		A comma separated list of required units for each argument
fununit	String		The unit of the function's result

Gaussian Pulse Generate Gaussian pulse function.

TABLE 2-33: GAUSSIAN PULSE PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
funcname	String	The tag name.	The name of the function
location	String	0	Where the pulse peaks.
sigma	String	1	The standard deviation of the underlying normal distribution.

Ramp Generate ramp function.

TABLE 2-34: RAMP PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
cutoffactive	boolean	false	If true, then the ramp ends when it reaches the cutoff value
cutoff	double	1	If cutoffactive is true, the level where the ramp ends
funcname	String	The tag name.	The name of the function
location	String	0	Where the ramp starts
slope	String	1	The slope of the ramp
smoothcutoff	boolean	false	Smooth the transition where the ramp ends at the cutoff?
smoothloc	boolean	false	Smooth the transition where the ramp starts?
smoothzone	double	0.1	The relative size of the smoothing zone if smoothing is enabled

Random Generate random function.

TABLE 2-35: RANDOM PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
funcname	String	The tag name.	The name of the function
mean	String	0	The average value
nargs	integer	1	The number of arguments
normalsigma	String	1	The standard deviation if type is Normal
type	uniform normal	Uniform	The distribution type
uniformrange	String	1	The range if type is Uniform

Rectangle Generate rectangle-shaped function.

TABLE 2-36: RECTANGLE PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
funcname	String	The tag name.	The name of the function
lower	String	-0.5	Where the high zone begins

TABLE 2-36: RECTANGLE PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
smooth	boolean	true	Smooth the transitions?
smoothzone	String	0.1	The size of the smoothing zone on both sides of the transitions
upper	String	0.5	Where the high zone ends

Step Generate step function.

TABLE 2-37: STEP PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
from	String	0	The value to the left of the location
funcname	String	The tag name.	The name of the function
location	String	0	Where the step is located
smooth	boolean	true	Smooth the transition?
smoothzone	String	0.1	The size of the smoothing zone on both sides of location
to	String	1	The value to the right of the location

Triangle Generate triangle-shaped function.

TABLE 2-38: TRIANGLE PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
funcname	String	The tag name.	The name of the function
lower	String	-0.5	Where the high zone begins
smooth	boolean	true	Smooth the transitions?
smoothzone	String	0.1	Size of smoothing zone on both sides of the transitions
upper	String	0.5	Where the high zone ends

External Generate external function.

TABLE 2-39: EXTERNAL PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
ders	Nx3 String array		(function name, argument, partial derivative) triplets
funcs	String array		The functions defined by the library.

TABLE 2-39: EXTERNAL PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
init	String		The string that is sent to the library when the function feature is initialized.
path	String		The path to the shared library that defines the functions.

An external function is a function defined in a shared library written by the user. The shared library must define the following three functions with C linkage:

- `int init(const char *str)` is called when the function is initialized with the string from the **Initialization data** field. It returns a nonzero value in case of success and zero in case of failure. This function might be called several times; it is always called before solving a model that uses the function.
- `int eval(const char *func, int nArgs, const double **inReal, const double **inImag, int blockSize, double *outReal, double *outImag)` is called for elementwise evaluation of the function `func` called with `nArgs` arguments of length `blockSize`. The array `inReal` contains the real parts of the arguments; it has length `nArgs`, and each element has length `blockSize`. If the arguments are all-real, then `inImag` is null, otherwise it contains the imaginary parts of the arguments. If the function evaluation is successful, 1 is returned if it resulted in an all-real array and 2 is returned if it resulted in a complex array. The function should return 0 in case of error. In case of a real result, the function values should be written to the array `outReal`. In case of a complex result, the real parts of the function should be written to `outReal` and the imaginary parts to `outImag`. The `outReal` and `outImag` arrays both have length `blockSize`. All matrices are allocated and deallocated by COMSOL.
- `const char *getLastError()` returns the last error that has occurred. A null or empty string is returned if no error has occurred. Calling `init()` or `eval()` must set the last error string to "" or null. All memory allocation of this string is handled by the shared library. There is no localization of the error messages.

If you are using Microsoft Visual Studio to compile your library, you can declare the functions as `__declspec(dllexport)` to export them from the DLL.

An example of a library that defines a function called `extsinc` that computes the `sinc` function ($\sin(x)/x$):

```
#include <math.h>
#include <stdlib.h>
```

```
#include <string.h>

static const char *error = NULL;

int init(const char *str) {
    return 1;
}

const char * getLastError() {
    return error;
}

int eval(const char *func,
        int nArgs,
        const double **inReal,
        const double **inImag,
        int blockSize,
        double *outReal,
        double *outImag) {
    int i, j;

    if (strcmp("extsinc", func) == 0) {
        if (nArgs != 1) {
            error = "One argument expected";
            return 0;
        }
        for (i = 0; i < blockSize; i++) {
            double x = inReal[0][i];
            outReal[i] = (x == 0) ? 1 : sin(x) / x;
        }
        return 1;
    }
    else {
        error = "Unknown function";
        return 0;
    }
}
```

External MATLAB. Declare use of function in MATLAB. This requires the LiveLink for MATLAB.

TABLE 2-40: MATLAB PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
ders	Nx3 String array		(function name, argument, partial derivative) triplets
funcs	String array		The functions defined by MATLAB.

TABLE 2-40: MATLAB PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
manpath	String		If pathtype is manual, this MATLAB path is used.
pathtype	auto manual	auto	If auto, COMSOL tries to determine the MATLAB path.

Wave Generate wave-shaped function.

TABLE 2-41: WAVE PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
amplitude	String	1	The amplitude
freq	String	1	The angular frequency
funcname	String	The tag name.	The name of the function
phase	String	0	The phase
smooth	boolean	true	Smooth the transitions? (Only used for wave forms with discontinuous function values or derivatives.)
smoothzone	String	0.1	The size of smoothing zone on both sides of the transitions
type	sawtooth sine square triangle	sine	The type of wave form

Elevation: Generate Elevation function from a DEM file.

TABLE 2-42: ELEVATION PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
extrap	const interior linear value	const	The extrapolation method
extrapvalue	double	0	The extrapolation value if extrap is value
filename	String		The name of the DEM file.
funcname	String	The tag name.	The name of the function
interp	neighbor linear	linear	The interpolation method

Image Generate Image function from a BMP, GIF, JPEG, or PNG file.

TABLE 2-43: IMAGE PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
argunit	string		The unit of the function arguments.
clipmaxx	double	1000	If clipping is manual: The maximum pixel x-coordinate that is kept.
clipminx	double	0	If clipping is manual: The minimum pixel x-coordinate that is kept.
clipmaxy	double	1000	If clipping is manual: The maximum pixel y-coordinate that is kept.
clipminy	double	0	If clipping is manual: The minimum pixel y-coordinate that is kept.
clipping	none manual	none	The clipping method.
extrap	const interior linear value	const	The extrapolation method
extrapvalue	double	0	The extrapolation value if extrap is value
fununit	string		The unit of the function value.
filename	String		The name of the DEM file.
flipx	boolean	false	If inplace is false: Whether to flip the image horizontally when mapping it to the xy-plane.
flipy	boolean	false	If inplace is false: Whether to flip the image vertically when mapping it to the xy-plane.
funcname	String	The tag name.	The name of the function
inplace	boolean	false	If true, the image is mapped to the xy-plane without scaling; l length unit corresponds to l pixel.
interp	neighbor linear	linear	The interpolation method

TABLE 2-43: IMAGE PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
manualexpr	String	$(r+g+b)/3$	If scaling is manual: The scaling function expressed in terms of the red (r), green (g), and blue (b) pixel intensities.
scaling	automatic manual	automatic	The method used for computing function values from pixel colors.
xmax	double	1	If inplace is false: The maximum x-coordinate of the region to which the image is mapped.
xmin	double	0	If inplace is false: The minimum x-coordinate of the region to which the image is mapped.
ymax	double	1	If inplace is false: The maximum y-coordinate of the region to which the image is mapped.
ymin	double	0	If inplace is false: The minimum y-coordinate of the region to which the image is mapped.

See Also[model.material\(\)](#)

model.geom()

Purpose

Manipulate geometry.

Syntax

```

model.geom().create(<tag>,<sdim>);
model.geom().create(<tag>,<meshtag>,<filename>);
model.geom(<tag>).model(<mtag>);
model.geom(<tag>).model();
model.geom(<tag>).axisymmetric(boolean);
model.geom(<tag>).isAxisymmetric();
model.geom(<tag>).lengthUnit(<unit>);
model.geom(<tag>).lengthUnit();
model.geom(<tag>).angularUnit(<unit>);
model.geom(<tag>).angularUnit();
model.geom(<tag>).scaleUnitValue(boolean);
model.geom(<tag>).scaleUnitValue();
model.geom(<tag>).repairTol(<reITol>);
model.geom(<tag>).repairTol();
model.geom(<tag>).geomRep(geomrep);
model.geom(<tag>).geomRep();
model.geom().remove(<tag>);

model.geom(<tag>).feature().create(<ftag>,type);
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
model.geom(<tag>).feature(<ftag>).selection(property).selMethod;
model.geom(<tag>).feature(<ftag>).geom().geomMethod;
model.geom(<tag>).feature(<ftag>).active(boolean);
model.geom(<tag>).feature(<ftag>).isActive();
model.geom(<tag>).feature().move(<ftag>,<position>);
model.geom(<tag>).feature().remove(<ftag>);

model.geom(<tag>).run(<ftag>);
model.geom(<tag>).runPre(<ftag>);
model.geom(<tag>).runCurrent();
model.geom(<tag>).runAll();
model.geom(<tag>).run();
model.geom().run();

model.geom(<tag>).current();
model.geom(<tag>).feature(<ftag>).status();
model.geom(<tag>).feature(<ftag>).message();

model.geom(<tag>).objectNames();
model.geom(<tag>).feature(<ftag>).objectNames();
model.geom(<tag>).object(<objname>).geomInfoMethod
model.geom(<tag>).geomInfoMethod

model.geom(<tag>).measure().selection().selMethod;
model.geom(<tag>).measure().geomMeasurementMethod;
model.geom(<tag>).measureFinal().selection().selMethod;
model.geom(<tag>).measureFinal().geomMeasurementMethod;

model.geom(<tag>).export().selection().selMethod;;

```

```
model.geom(<tag>).export(<filename>);  
model.geom(<tag>).exportFinal(<filename>);
```

```
model.geom(<tag>).defeaturing(<tag>).defeaturingMethod;  
model.geom(<tag>).feature(<ftag>).find();  
model.geom(<tag>).feature(<ftag>).detail().selMethod;
```

Description

CREATING AND DELETING A GEOMETRY SEQUENCE

`model.geom().create(<tag>,<sdim>)` creates a geometry of space dimension `<sdim>` and assigns it the tag `<tag>`.

`model.geom().create(<tag>,<meshtag>,<filename>)` creates a geometry sequence tagged `<tag>` and a corresponding meshing sequence tagged `<meshtag>`. The parameter `<filename>` specifies a file that contains a geometry or a mesh, and an import feature is inserted into the geometry or mesh sequence.

`model.geom(<tag>).feature().move(<ftag>,<position>)` moves the feature `<ftag>` to the zero indexed position `<position>` in the sequence.

`model.geom().remove(<tag>)` deletes the geometry tagged `<tag>`.

GENERAL GEOMETRY SETTINGS

`model.geom(<tag>).model(<mtag>)` sets the model of the geometry `<tag>` to `<mtag>`.

`String mtag = model.geom(<tag>).model()` returns the model tag of the geometry.

`model.geom(<tag>).axisymmetric(boolean)` indicates if the geometry is axisymmetric. This is only applicable for 1D and 2D geometries.

`model.geom(<tag>).isAxisymmetric()` returns true if the geometry is axisymmetric and false otherwise.

`model.geom(<tag>).lengthUnit(<unit>)` sets the length unit.

`String unit = model.geom(<tag>).lengthUnit()` returns the length unit.

`model.geom(<tag>).angularUnit(<unit>)` sets the angular unit.

`String unit = model.geom(<tag>).angularUnit()` returns the angular unit.

`model.geom(<tag>).scaleUnitValue(boolean)` sets the geometry to scale property values when units are changed.

`model.geom(<tag>).scaleUnitValue()` returns true if the geometry is set to scale property values when units are changed.

`model.geom(<tag>).repairTol(<relTol>)` sets the default relative repair tolerance to use when creating new features.

`double relTol = model.geom(<tag>).repairTol()` returns the default relative repair tolerance.

`model.geom(<tag>).geomRep(<geomrep>)` sets the geometry representation to use in a 3D geometry. The *geomrep* string can be `bezier`, meaning the COMSOL kernel, `cadps`, meaning the CAD Import Module kernel (Parasolid), or `auto`, meaning an automatic choice of kernel.

`String geomrep = model.geom(<tag>).geomRep()` returns the geometry representation.

CREATING, EDITING, DISABLING, AND DELETING FEATURES

`model.geom(<tag>).feature().create(<ftag>, <type>)` adds a geometry feature *<ftag>* of type *<type>* to the geometry *<tag>*, after the current feature.

`model.geom(<tag>).feature(<ftag>).set(<property>, <value>)` sets a property in the geometry feature *<ftag>*. All data types listed in [Table 2-2](#) are supported; the applicable data types differ between the properties. String expressions can use parameters from `model.param()`.

`model.geom(<tag>).feature(<ftag>).getType(<property>)` returns the value of a property in the geometry feature *<ftag>*.

`model.geom(<tag>).feature(<ftag>).selection(<property>).selMethod` manipulates the geometry object selection property *<property>*. The available selection methods are described in [Geometry Object Selection Methods](#).

`model.geom(<tag>).feature(<ftag>).geom().geomMethod` manipulates the 2D geometry sequence corresponding to the work plane feature *<ftag>*. The available methods are the same as for a 2D geometry `model.geom(<gtag>)`.

`model.geom(<tag>).feature(<ftag>).active(false)` disables the feature *<ftag>*.

`model.geom(<tag>).feature(<ftag>).active(true)` enables the feature *<ftag>*.

`model.geom(<tag>).feature(<ftag>).isActive()` returns true if the feature <ftag> is enabled, and false otherwise.

`model.geom(<tag>).feature().remove(<ftag>)` removes the feature <ftag>.

BUILDING FEATURES

After each build operation, the current feature is set as the last of the active features that were built. The current state contains all objects that are generated by these features.

`model.geom(<tag>).run(<ftag>)` builds all features up to (and including) the feature <ftag>.

`model.geom(<tag>).runPre(<ftag>)` builds all features preceding the feature <ftag>.

`model.geom(<tag>).runCurrent()` builds all features up to (and including) the current feature.

`model.geom(<tag>).runAll()` builds all features preceding the `Finalize` feature.

`model.geom(<tag>).run()` builds all features, including the `Finalize` feature. The finalized geometry and all selections are also updated.

`model.geom().run()` builds the finalized geometry in all geometries.

GETTING BUILD STATUS

`String fTag = model.geom(<tag>).current()` returns the tag of the current feature. If the current state is before the first feature, the empty string "" is returned.

`String status = model.geom(<tag>).feature(<ftag>).status()` returns the status of the feature <ftag>. The status is `built`, `warning`, `needs_rebuild`, `edited`, or `error`.

`String msg = model.geom(<tag>).feature(<ftag>).message()` returns the warning/error message of the feature <ftag>.

GETTING INFORMATION ABOUT GEOMETRY OBJECTS

`String[] n = model.geom(<tag>).objectNames()` returns the names of all objects that exist in the current state.

`String[] n = model.geom(<tag>).feature(<ftag>).objectNames()` returns the names of the output object generated by the feature <ftag>.

`model.geom(<tag>).object(<objname>).geomInfoMethod` returns information about the object `<objname>`. The available methods are described in [Geometry Object Information](#).

`model.geom(<tag>).geomInfoMethod` returns information about the finalized geometry of geometry `<tag>`.

GEOMETRIC MEASUREMENTS

Use `model.geom(<tag>).measure().selection().selMethod` to specify the domains, boundaries, or edges in geometry objects that you want to measure. You can also specify one vertex or two vertices to get the coordinates of the vertex or the distance between the two vertices, respectively. The available selection methods are described in [Geometry Object Selection Methods](#).

`model.geom(<tag>).measure().geomMeasurementMethod` returns the volume, area, length, vertex coordinates, or distance between two vertices according to the selection. The available measurement methods are described in [Geometry Object Information](#).

Use `model.geom(<tag>).measureFinal().selection().selMethod` to specify the domains, boundaries, or edges in the finalized geometry that you want to measure. You can also specify one vertex or two vertices to get the coordinates of the vertex or the distance between the two vertices, respectively. The available selection methods are described in [model.selection\(\)](#).

`model.geom(<tag>).measureFinal().geomMeasurementMethod` returns the volume, area, length, vertex coordinates, or distance between two vertices according to the selection. The available measurement methods are described in [Measurements](#).

EXPORTING GEOMETRY OBJECTS

`model.geom(<tag>).export().selection().selMethod` can be used to select a number of geometry objects to export to file. The available selection methods are described in [Geometry Object Selection Methods](#).

`model.geom(<tag>).export(<filename>)` exports the selected objects to a file.

`model.geom(<tag>).exportFinal(<filename>)` exports the finalized geometry to a file.

CAD DEFEATURING

If you have a licence for the CAD Import Module, or a LiveLink product for CAD software, the following functionality is available. For details, see [Defeaturing Tools](#) in the *CAD Import Module User's Guide*.

`model.geom(<tag>).defeaturing(tooltag).defeaturingMethod` uses a defeaturing tool to create a feature that deletes small details. Available tools are listed in the *CAD Import Module User's Guide*.

`model.geom(<tag>).feature(<ftag>).find()` searches for small details, for a defeaturing feature `<ftag>`.

`model.geom(<tag>).feature(<ftag>).detail().selMethod` manipulates the selection of details to remove, for a defeaturing feature `<ftag>`.

GEOMETRY OBJECT SELECTION METHODS

For a geometry object selection `sel`, the following methods are available.

`sel.init()` sets the selection to be a selection of whole geometry objects. Subsequent calls to `set`, `add`, and `remove` select objects.

`sel.init(dim)` sets the selection property to be a selection of geometric entities of dimension `dim`. Subsequent calls to `all`, `set`, `add`, `remove`, and `clear` select entities.

The following three methods are applicable when the selection consists of whole objects. The argument `<onames>` can be an array of strings, or several string arguments.

`sel.set(<onames>)` sets the selection to be the objects `<onames>`.

`sel.add(<onames>)` adds the objects `<onames>` to the selection.

`sel.remove(<onames>)` removes the objects `<onames>` from the selection.

The following five methods are applicable when the selection consists of geometric entities. The argument `<entities>` can be an array of integers, or several integer arguments.

`sel.all(<oname>)` sets the selection to be all the entities of object `<oname>`. The selections on other objects are not affected.

`sel.set(<oname>, <entities>)` sets the selection on object `<oname>` to be `<entities>`. The selections on other objects are not affected.

`sel.add(<oname>, <entities>)` adds the entities *<entities>* to the selection on object *<oname>*. The selections on other objects are not affected.

`sel.remove(<oname>, <entities>)` removes the entities *<entities>* from the selection on object *<oname>*. The selections on other objects are not affected.

`sel.clear(<oname>)` clears the selection on object *<oname>*. The selections on other objects are not affected.

To get information about the selection, use:

`String[] onames = sel.object()` returns the names of the selected objects.

`int dim = sel.dimension()` returns the dimension for the entities in the selection if the selection consists of geometric entities.

`int[] ent = sel.entities(<oname>, dim)` returns the entities in the selection on object *<oname>* if the selection consists of geometric entities.

Example

Create a 2D geometry model as the union of a circle and rectangle

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1",2);
model.geom("geom1").feature().create("r1","Rectangle");
model.geom("geom1").feature("r1").set("size",
    new double[]{0.5,1});
model.geom("geom1").feature("r1").set("pos",
    new double[]{-1,0});
model.geom("geom1").feature().create("c1","Circle");
model.geom("geom1").feature("c1").set("r",0.5);
model.geom("geom1").feature("c1").set("pos",
    new double[]{0.5,0});
model.geom("geom1").run();
```

Compatibility

The following COMSOL 3.5a commands correspond to the above example:

```
r1 = rect2(0.5,1,'pos',[-1,0]);
c1 = circ2(0.5,'pos',[0.5,0]);
clear s
s.objs = {r1,c1};
s.name = {'R1','C1'};
s.tags = {'r1','c1'};
fem.draw = struct('s',s);
fem.geom = geomcsg(fem);
```

See Also

[model.mesh\(\)](#)

model.group()

Purpose	Define group identifiers.
Syntax	<pre>model.group().create(<tag>, type); model.group(<tag>).identifier(<id>); model.group(<tag>).type(); model.group(<tag>).identifier();</pre>
Description	<p><code>model.group().create(<tag>, type)</code> creates a new group of the specified type, which can be either <code>LoadGroup</code> or <code>ConstraintGroup</code>.</p> <p><code>model.group(<tag>).identifier(<id>)</code> sets the group identifier, which is used for defining a parameter called <code>group.<id></code>.</p> <p><code>model.group(<tag>).type()</code> returns the group type as a string.</p> <p><code>model.group(<tag>).identifier()</code> returns the group identifier.</p>

Purpose	Manipulate initial values.
Syntax	<pre> model.init().create(<tag>); model.init(<tag>).set(<fieldname>,<expr>); model.init(<tag>).remove(<fieldname>); model.init(<tag>).selection().named(<seltag>); model.init(<tag>).selection().set(...); model.init(<tag>).varnames(); model.init(<tag>).get(<fieldname>); model.init(<tag>).selection().named(); model.init(<tag>).selection().getType(); </pre>
Description	<p><code>model.init(<tag>).set(<fieldname>,<expr>)</code> defines the expression <code><expr></code> as the initial value for the dependent variable (field variable) <code><fieldname></code>.</p> <p><code>model.init(<tag>).remove(<fieldname>)</code> removes the field variable <code><fieldname></code> from the <code>init</code> entity <code><tag></code>.</p> <p><code>model.init(<tag>).selection().named(<seltag>)</code> or, alternatively, <code>model.init(<tag>).selection().set(...)</code> sets the domains to the initial value entity. For a complete list of methods available under <code>selection()</code>, see Selections. Only selections at a single geometry level is allowed except for ODE states which require the global selection.</p> <p><code>model.init(<tag>).varnames()</code> returns the names of the variables for the <code>init</code> entity <code><tag></code> as a string array.</p> <p><code>model.init(<tag>).get(<fieldname>)</code> returns the initial value for the field variable <code><fieldname></code> as a string.</p> <p><code>model.init(<tag>).selection().named()</code> returns the selection name for the <code>init</code> entity <code><tag></code> as a string.</p> <p><code>model.init(<tag>).selection().getType()</code> returns domain information for the <code>init</code> entity <code><tag></code>; see Selections for available methods.</p>

model.intRule()

Purpose	Manipulate integration rules.
Syntax	<pre>model.intRule().create(<tag>,<ftag>); model.intRule(<tag>).frame(<ftag>); model.intRule(<tag>).feature().create(<ftag>); model.intRule(<tag>).feature(<ftag>).order(gporder); model.intRule(<tag>).frame();</pre>
Description	<p><code>model.intRule().create(<tag>,<ftag>)</code> creates an integration rule for the frame <code><ftag></code>.</p> <p><code>model.intRule(<tag>).frame(<ftag>)</code> sets the frame for the integration rule.</p> <p><code>model.intRule(<tag>).feature().create(<ftag>)</code> creates an integration rule feature.</p> <p><code>model.intRule(<tag>).feature(<ftag>).order(gporder)</code> specifies the integration order of the integration rule.</p> <p><code>model.intRule(<tag>).frame()</code> returns the frame as a string.</p>
Examples	<p>Specify two integration rules, one with the integration order 2 and one with the integration order 4.</p> <pre>Model model = ModelUtil.create("Model"); model.intRule().create("ir1","f"); model.intRule("ir1").feature().create("ir1").order(2); model.intRule("ir1").feature().create("ir2").order(4);</pre>
See Also	model.shape()

Purpose	Manipulate materials and material models.
Syntax	<pre> model.material().create(<tag>); model.material(<tag>).info(<itag>); model.material(<tag>).info(); model.material(<tag>).materialModel(<mtag>); model.material(<tag>).materialModel(); model.material(<tag>).prefix(<prefix>); model.material(<tag>).prefix(); model.material(<tag>).selection(); model.material().move(<tag>,<position>); MaterialModel mm = model.material(<tag>).materialModel(). create(<mtag>,<descr>); mm.addInput(<quantity>); mm.func(); mm.func(<ftag>); mm.getString(<pname>); mm.getStringArray(<pname>); mm.hasParam(<pname>); mm.info(<itag>); mm.info(); mm.input(); mm.isOutput(<pname>); mm.params(); mm.removeInput(<quantity>); mm.set(<pname>,<expr>); mm.size(<pname>); mm.suffix(<suffix>); mm.suffix(); mm.info().create(<itag>,<descr>); mm.info(<itag>).title(<title>); mm.info(<itag>).title(); mm.info(<itag>).body(<body>); mm.info(<itag>).body(); </pre>
Description	<p>A Material is a collection of material models, where each material model defines a set of material properties, material functions, and model inputs. A material property can either be a visible output property or a local parameter. The output property is visible for physics interfaces and local parameters are only visible inside the material model. If two material models define the same output property, the last material model determines the value of the output property. The material function is used by the material model to calculate a property or parameter value as a function of other variables, usually model inputs. The model input is a quantity that the material model recognizes as an input variable (temperature, for example). The actual</p>

variable that represents the model input is not known until the model is solved, and it can also be different between physics interfaces.

There are two types of material models, user defined and specialized. When a material is created, there is always one default user-defined material model present. To this material model it is possible to add output properties from a predefined list of quantities. These quantities are recognized by all physics interfaces as material properties—for example, thermal conductivity, electric conductivity, and density. The full list is presented in the user interface for the default material model. The specialized material models are built in and usually define few output properties that only some physics interfaces can access. These output properties are not necessarily part of the allowed properties for the default material model. An example of such specialized model is the refractive index material model, which defines the real and imaginary part of the refractive index as output properties. These properties can only be accessed by the Electromagnetic Waves physics interface.

`model.material().create(<tag>)` creates a new material for the current geometry.

`model.material(<tag>).info(<itag>)` returns an information item for a material.

`model.material(<tag>).input()` returns the list of model inputs.

`model.material(<tag>).materialModel(<mtag>)` gets the material model named `<mtag>` for the material.

`model.material(<tag>).identifier(<identifier>)` changes the identifier of the material. The default is `mat<num>`.

`model.material(<tag>).selection()` returns the selection of the material. The selection determines which geometry the material belongs to.

`model.material().move(<tag>, <position>)` moves the material `<tag>` to the zero indexed position `<position>` in the list.

`mm = model.material(<tag>).materialModel().create(<tag>, <descr>)` creates a new material model and stores it in the variable `mm`.

`mm.addInput(<quantity>)` adds a new model input to the material model of the given quantity.

`mm.func(<ftag>)` returns the function object named `<ftag>`. For information about how to add and modify functions, see [model.func\(\)](#).

`mm.getString(<pname>)` Returns the string value of the given parameter. If it is a vector or matrix quantity, the first value is returned.

`mm.getStringArray(<pname>)` Returns the string array value of the given parameter. Matrix values are returned in a columnwise order.

`mm.hasparam(<pname>)` Returns true if the parameter is defined by the material model.

`mm.info(<itag>)` Returns the information object for the material model.

`mm.isOutput(<pname>)` Returns true if the given parameter is an output property. For user-defined material models the method returns true for all predefined material properties known to all physics interfaces. For the specialized material models, it can also return true for other properties.

`mm.params()` Returns a list of all parameters stored in the material model.

`mm.removeInput(<quantity>)` Removes the given quantity from the list of model inputs.

`mm.set(<pname>, <expr>)` sets the expression for the given property. The expression can use local names for the properties, parameters, and model inputs. For vector and matrix properties, the expression can be string arrays of varying size. Isotropic matrices only require one element or a string, diagonal matrices require three elements, and so forth. Vectors always require three elements.

`mm.size(<pname>)` Returns the size of the stored parameter, which usually is 1-by-1, 3-by-1 or 3-by-3, but other sizes are supported.

`mm.identifier(<identifier>)` sets the identifier for local model parameters. The default is `mod<num>` for new property groups.

`mm.identifier()` Returns the identifier that are prepended to all items declared by the material model. The prefix of the material is also used. The parameter values are not stored outside the material unless it is used by a physics interface. The reason is that such parameters cannot be evaluated if it uses a model input, which is unknown to the material but not the physics interface.

`model.material(<tag>).materialModel()` returns a list of all material models in the material.

`model.material(<tag>).materialModel(<tag>).info()`.

`create(<tag>, <descr>)` creates a new information entity that can contain

detailed information about this material model. This could, for example, be used by the Material Library to define the **Phase/Condition** and **Orientation/Condition** fields.

`mm.info(<itag>).title(<title>)` Sets the title of the info object.

`mm.info(<itag>).title()` Returns the title.

`mm.info(<itag>).body(<body>)` Sets the body text of the information object.

`mm.info(<itag>).body()` Returns the body text.

Note

The term material model used in this context is the same thing as property group in the graphical user interface.

See Also

[model.func\(\)](#), [model.physics\(\)](#)

Purpose	Manipulate meshes.
Syntax	<pre> model.mesh().create(<tag>,<gtag>); model.mesh().remove(<tag>); model.mesh(<tag>).feature().create(<ftag>,operation); model.mesh(<tag>).feature(<ftag>).set(property,<value>); model.mesh(<tag>).feature(<ftag>).getType(property); model.mesh(<tag>).feature(<ftag>).selection().selMethod model.mesh(<tag>).feature(<ftag>).selection(property).selMethod model.mesh(<tag>).feature(<ftag>).feature().meshMethod model.mesh(<tag>).current(<ftag>); model.mesh(<tag>).feature(<ftag>).active(boolean); model.mesh(<tag>).feature(<ftag>).isActive(); model.mesh(<tag>).feature().move(<ftag>,<position>); model.mesh(<tag>).feature().remove(<ftag>); model.mesh(<tag>).clear(); model.mesh(<tag>).run(<ftag>); model.mesh(<tag>).run(); model.mesh().run(); model.mesh(<tag>).current(); model.mesh(<tag>).feature(<ftag>).status(); model.mesh(<tag>).feature(<ftag>).message(); model.mesh(<tag>).meshGetMethod model.mesh(<tag>).data().meshModificationMethod model.mesh(<tag>).stat().meshStatisticsMethod model.mesh(<tag>).export(<filename>); </pre>
Description	<p>Creating and Deleting a Meshing Sequence</p> <p><code>model.mesh().create(<tag>,<gtag>)</code> creates a meshing sequence for the geometry <code><gtag></code> and assigns it the tag <code><tag></code>.</p> <p><code>model.mesh().remove(<tag>)</code> removes the meshing sequence <code><tag></code>.</p> <p>CREATING, EDITING, AND DELETING FEATURES</p> <p><code>model.mesh(<tag>).feature().create(<ftag>,operation)</code> adds a feature <code><ftag></code> of type <code>operation</code> to the meshing sequence <code><tag></code>, after the current feature.</p> <p><code>model.mesh(<tag>).feature(<ftag>).set(property,<value>)</code> sets the property <code>property</code> defined for the feature <code><ftag></code> to the value <code><value></code>. All data types listed in Table 2-2 are supported; the applicable data types differ between the properties. String expressions can use parameters from <code>model.param()</code>.</p>

`model.mesh(<tag>).feature(<ftag>).getType(property)` returns the value of a property in the feature `<ftag>`.

`model.mesh(<tag>).feature(<ftag>).selection().selMethod` manipulates the selection of the feature `<ftag>`. The available selection methods are described in [Selection Methods](#).

`model.mesh(<tag>).feature(<ftag>).selection(property).selMethod` manipulates the selection of the property `property`. The available selection methods are described in [Selection Methods](#).

`model.mesh(<tag>).feature(<ftag>).feature().meshMethod` manipulates the entity list for the feature `<ftag>`.

`model.mesh(<tag>).current(<ftag>)` sets the current feature to be `<ftag>`.

`model.mesh(<tag>).feature(<ftag>).active(false)` disables the feature `<ftag>`.

`model.mesh(<tag>).feature(<ftag>).active(true)` enables the feature `<ftag>`.

`model.mesh(<tag>).feature(<ftag>).isActive()` returns `true` if the feature `<ftag>` is enabled, and `false` otherwise.

`model.mesh(<tag>).feature().move(<ftag>,<position>)` moves the feature `<ftag>` to the zero indexed position `<position>` in the sequence.

`model.mesh(<tag>).feature().remove(<ftag>)` removes the feature `<ftag>`.

`model.mesh(<tag>).clear()` removes all features from the sequence and clears the mesh.

BUILDING FEATURES

After each build operation, the current feature is set as the last of features that were built. The mesh is updated to be the mesh generated by these features.

`model.mesh(<tag>).run(<ftag>)` builds all features up to (and including) the feature `<ftag>`.

`model.mesh(<tag>).run()` builds all features.

`model.mesh().run()` builds all meshing sequences.

GETTING BUILD STATUS

`String fTag = model.mesh(<tag>).current()` returns the tag of the current feature. If the current state is before the first feature, the empty string "" is returned.

`String status = model.mesh(<tag>).feature(<ftag>).status()` returns the status of the feature <ftag>. The status is built, warning, needs_rebuild, edited, or error.

`String msg = model.mesh(<tag>).feature(<ftag>).message()` returns the warning/error message of the feature <ftag>.

GETTING AND SETTING MESH DATA

`model.mesh(<tag>).meshGetMethod` gets mesh data from the mesh <tag>. The available methods are described in [Accessing Mesh Data](#).

`model.mesh(<tag>).data().meshModificationMethods` are used to modify mesh data on a low level. You can access and modify individual elements. The available methods are described in [Accessing Mesh Data](#).

`model.mesh(<tag>).data().createMesh()` transfers the manipulated data into to the mesh <tag>.

MESH STATISTICS

`model.mesh(<tag>).stat().selection().selMethod` can be used to select a number of geometric entities for which statistics is wanted. The available selection methods are described in [Selection Methods](#).

`model.geom(<tag>).stat().meshStatisticsMethod` returns mesh statistics about the selected geometric entities. The available methods are described in [Information and Statistics](#).

EXPORTING A MESH TO FILE

`model.mesh(<tag>).export(<filename>)` exports the mesh <tag> to an mphbin or mphtxt file.

SELECTION METHODS

`selection.allGeom()` sets the selection to be the entire geometry (that is, all geometric entities).

`selection.remaining()` sets the selection to be the geometric entities that remains to be meshed when the feature is about to be built.

`selection.geom(<dim>).all()` sets all geometric entities in dimension `<dim>`.

`selection.geom(<dim>).set(<entities>)` sets the selection to be the geometric entities specified in the integer array `<entities>` in dimension `<dim>`.

`selection.geom(<dim>).add(<entities>)` adds the geometric entities specified in the integer array `<entities>` in dimension `<dim>` to the selection.

`selection.geom(<dim>).remove(<entities>)` removes the geometric entities specified in the integer array `<entities>` in dimension `<dim>` from the selection.

`selection.geom(<dim>).clear()` clears the selection.

To access the selections use:

`int[] dims = selection.dimension()` returns the geometric entity level in `dims[0]` for the entities in the selection. If `dims` is empty the selection defines the entire geometry.

`selection.isRemaining()` returns true if the selection specifies the remaining entities, otherwise false.

`selection.dom(<dim>)` returns the geometric entities in dimension `<dim>` for the selection.

Example

Create a 2D geometry by the union of a circle and square. Build a triangle mesh with `hmax = 0.1` in domains 1 and 3, and `hmax = 0.01` in domain 2.

```
Model model = ModelUtil.create("Model");
model.modelNode().create("mod1");
model.geom().create("geom1", 2);
model.mesh().create("mesh1", "geom1");

model.geom("geom1").feature().create("c1", "Circle");
model.geom("geom1").feature().create("sq1", "Square");
model.geom("geom1").feature().create("uni1", "Union");
model.geom("geom1").feature("uni1").selection("input")
    .set(new String[]{"c1", "sq1"});

model.mesh("mesh1").feature().create("size1", "Size");
model.mesh("mesh1").feature("size1").selection().
    geom(2).set(new int[]{1, 3});
model.mesh("mesh1").feature("size1").set("hmax", "0.1");
model.mesh("mesh1").feature().create("size2", "Size");
model.mesh("mesh1").feature("size2").selection().
    geom(2).set(new int[]{2});
model.mesh("mesh1").feature("size2").set("hmax", "0.025");
model.mesh("mesh1").feature().create("ftri1", "FreeTri");
model.mesh("mesh1").run();
```

See Also

[model.geom\(\)](#)

model.modelNode()

Purpose	Manipulate model nodes.
Syntax	<pre>model.modelNode().create(<tag>); model.modelNode(<tag>).identifier(<scopename>); model.modelNode(<tag>).identifier(); model.modelNode(<tag>).scope(); model.modelNode(<tag>).baseSystem(); model.modelNode(<tag>).baseSystem(<system>); model.modelNode(<tag>).sorder(); model.modelNode(<tag>).sorder(<stype>);</pre>
Description	<p><code>model.modelNode(<tag>)</code> represents a model node in the model tree.</p> <p><code>model.modelNode().create(<tag>)</code> creates a <code>modelNode</code> with the given tag.</p> <p><code>model.modelNode(<tag>).identifier(<scopename>)</code> sets the scope name of the model node.</p> <p><code>model.modelNode(<tag>).identifier()</code> returns the scope name of the model node.</p> <p><code>model.modelNode(<tag>).scope()</code> returns the fully qualified scope name.</p> <p><code>model.modelNode(<tag>).baseSystem(<system>)</code> use the given base system as unit system for the model node. This overrides the global unit system specified for the entire model object. To use global system again, set the base system of the model node to <code>null</code>.</p> <p><code>model.modelNode(<tag>).sorder()</code> returns the geometry shape order used for the model node and it's descendants.</p> <p><code>model.modelNode(<tag>).sorder(<stype>)</code> Sets the geometry shape order. Allowed values are automatic, linear, quadratic, cubic, quartic, and quintic, and the default is automatic. With automatic shape order the physics interfaces under the model node decide the most optimum shape order.</p>
Note	<p>You assign a model node to a physics interface, a geometry and so forth by using the methods</p> <pre>model.geom(<tag>).model(<mtag>); model.physics(<tag>).model(<mtag>);</pre> <p>The methods</p> <pre>model.geom(<tag>).model(); model.physics(<tag>).model();</pre>

return the tag of the current model node.

The last created model node is the default model node for any geometry or physics interface that you create. If no model node exists when you create a geometry or a physics interface, a default model node with tag `mod1` is automatically created for you.

Examples

```
model.modelNode().create("mod1");

model.geom().create("geom1", 3);
model.geom("geom1").model("mod1");

model.func().create("an1", "Analytic");
model.func("an1").model("mod1");
```

Purpose	Manipulate global equations.
Syntax	<pre>model.ode().create(<tag>); model.ode(<tag>).state(<statelist>); model.ode(<tag>).state(<pos>,<state>); model.ode(<tag>).ode(<state>,<equation>); model.ode(<tag>).descr(<state>,<descr>); model.ode(<tag>).weak(<wlist>); model.ode(<tag>).weak(<pos>,<wexpr>); model.ode(<tag>).discrete(<boolean>); model.ode(<tag>).state(); model.ode(<tag>).ode(<state>); model.ode(<tag>).descr(<state>); model.ode(<tag>).weak(); model.ode(<tag>).discrete();</pre>
Description	<p><code>model.ode(<tag>)</code> is an ODE entity with tag <code><tag></code>.</p> <p><code>model.ode().create(<tag>)</code> creates an ODE entity and assigns it the name <code><tag></code>.</p> <p><code>model.ode(<tag>).state(<statelist>)</code> sets the states of the ODE entity tagged <code><tag></code> according to the list <code><statelist></code>.</p> <p><code>model.ode(<tag>).state(<pos>,<state>)</code> edits the state at position <code><pos></code> in the state vector for the ODE entity <code><tag></code>.</p> <p><code>model.ode(<tag>).ode(<state>,<equation>)</code> sets the equation for the state <code><state></code>. If the state variable has not previously been added using <code>model.ode(<tag>).state(<statelist>)</code> then <code><state></code> is appended to the list of state variables.</p> <p><code>model.ode(<tag>).descr(<state>,<descr>)</code> adds a description for the state <code><state></code>.</p> <p><code>model.ode(<tag>).weak(<wlist>)</code> adds weak equations.</p> <p><code>model.ode(<tag>).weak(<pos>,<wexpr>)</code> edits the weak expression at position <code><pos></code> in the weak list.</p> <p><code>model.ode(<tag>).state()</code> returns the state variables as a string array.</p> <p><code>model.ode(<tag>).ode(<state>)</code> returns the ODE equation for the state variable <code><state></code> as a string.</p>

`model.ode(<tag>).descr(<state>)` returns the description of the state variable `<state>` as a string.

`model.ode(<tag>).weak()` returns the weak equations as a string array.

`model.ode(<tag>).discrete(true)` specifies that the an ODE entity contains event states.

Examples

```
Model model = ModelUtil.create("Model");
model.ode().create("ode1");
model.ode("ode1").ode("u", "ut+1");
model.ode("ode1").ode("v", "vt-1");
model.ode("ode1").weak(new String[]{"u_test*v"});
```

See Also

[model.init\(\)](#), [model.solverEvent\(\)](#)

Purpose	Manipulate objective functions, variables, and constraints
Syntax	<pre>model.opt().objective().create(<tag>, type) model.opt().objective(<tag>).set(property, <value>) model.opt().objective(<tag>).selection().set(...) model.opt().constr().create(<tag>) model.opt().constr(<tag>).etc model.opt().gconstr().create(<tag>) model.opt().gconstr(<tag>).constr(<constrExpr>) model.opt().gconstr(<tag>).lbound(<lboundExpr>) model.opt().gconstr(<tag>).ubound(<uboundExpr>)</pre>
Description	<p>The purpose of <code>model.opt</code> is to manage information relating to optimization and sensitivity analysis. Most of the fields under <code>model.opt</code> are read and interpreted directly by the optimization and sensitivity solvers. They never affect the result of other solvers.</p> <p><code>model.opt().objective().create(<tag>, type)</code> adds an objective function of the specified type. The supported types are <code>Global</code> and <code>LeastSquares</code>.</p> <p><code>model.opt().objective(<tag>).set(property, <value>)</code> sets an objective function property. Objective functions of type <code>Global</code> support the single property <code>expr</code>, which takes a globally defined expression as value. Allowed properties for objectives of type <code>LeastSquares</code> are described below.</p> <p><code>model.opt().objective(<tag>).selection().named(<seltag>)</code> or, alternatively, <code>model.opt().objective(<tag>).selection().set(...)</code> specifies a selection for the objective function. For a complete list of methods available under <code>selection()</code>, see model.selection(). Only objective functions of type <code>LeastSquares</code> require a selection. See further below.</p> <p><code>model.opt().constr().create(<tag>)</code> adds a pointwise (mesh-based) constraint on the control variables. The syntax is shared with model.constr() with the exception that the <code>cType</code> parameter expects values <code>constr</code>, <code>lbound</code>, and <code>ubound</code> for constraint, lower bound, and upper bound, respectively.</p> <p><code>model.opt().gconstr().create(<tag>)</code> registers a global constraint with the optimization solvers. Such constraints consist of a globally available expression, which can depend both on optimization variables and on the forward PDE solution, together with likewise global expressions for lower and upper bound.</p>

`model.opt().gconstr(<tag>).constr(<constrExpr>)` specifies a global constraint expression.

`model.opt().gconstr(<tag>).lbound(<lboundExpr>)` sets lower bound for the constraint.

`model.opt().gconstr(<tag>).ubound(<lboundExpr>)` sets upper bound for the constraint.

Least-Squares Objective Functions

Least-squares objective functions are specified in terms of measured values, stored on file, together with information about how corresponding expressions can be evaluated for the current control variable values. An overview of the allowed properties is given in the table below.

TABLE 2-44: PROPERTIES FOR OBJECTIVE FUNCTION TYPE LEASTSQUARES

PROPERTY	VALUE	DESCRIPTION
<code>filename</code>	String	Full path of the measurement data file
<code>paramnames</code>	String[]	Parameters used in the experiment
<code>paramexprs</code>	String[]	Values of the given parameters
<code>columnntypes</code>	String[]	List of column type indicators
<code>columnexprsweights</code>	String[]	Column contribution weights
<code>columnexprs</code>	String[]	Measurement expressions

In principle, you must specify the following for each measured value:

- To which experiment the value belongs and parameters for that experiment
- Which expression to evaluate
- Where the expression must be evaluated
- For which time or parameter value the evaluation must be performed

Each *experiment* corresponds to a solution of the forward problem with a given set of parameter values. In practice, measurements for each experiment must be stored in a separate file, and specified as a separate `LeastSquares` objective feature where you give the full path of the measurement data file in the `filename` property.

Parameters specified in the `paramnames` property will be given the values specified using `paramexprs` property during the forward solution. One forward solution will be performed for each unique set of parameter names and values.

The required measurement data file format is row- and column-oriented. Entries on each row must be separated by commas or semicolons, while rows are separated by line feeds. Use the `columntypes` property to specify the content of each column, in the order that they appear in the data file, according to the following table:

TABLE 2-45: ALLOWED COLUMN TYPES

TYPE	COLUMN CONTENTS
<code>time</code>	Actual measurement times
<code>param</code>	Actual parameter values
<code>coord</code>	Actual measurement coordinates
<code>value</code>	Measured values
<code>none</code>	Ignored column

Columns of type `time` are only allowed for transient problems. The measurements on the same row are assumed to be made at the specified time. Forward model values are interpolated to the given times. There must only be one column of type `time`, and it requires no further parameters.

Columns of type `param` contain parameter values for which the measurements on the same row have been made, and for which the forward problem must be solved. A data file may contain multiple parameter columns. Corresponding parameter names must be given in the `columnnames` property.

Columns of type `coord` contain global coordinates where the measurements on the same row have been made. The coordinate columns must be coupled to a coordinate variable by specifying the coordinate variable name in the `columnnames` property for the given column and the frame tag `spatial`, `material` or `mesh` in the `columnexprs` property. For example, in a 3D model, you will need three columns of type `coord` with `columnnames` entries `x`, `y` and `z`, respectively.

A `value` column contains measured data. For each `value` column, a corresponding expression to be evaluated must be specified in the `columnexprs` property. Entries in `value` columns will be interpreted as real numbers when possible. Anything else, including for example hash marks (`#`) and the literal strings `nan`, `Nan`, `NaN` and `NAN` is interpreted as an illegal value which will be excluded from the least squares objective function evaluation. A weight for the objective contribution from a column, multiplying the squared difference between the measured value and the expression, can be specified as a positive globally expression that can be evaluated using the `columnexprsweights` property. To exclude a measurement from a comma-separated file, you can also simply leave a value column empty.

Columns of type `none` can be used to exclude columns from the data file.

Coordinates are interpreted as global in the context of the objective feature's selection. This means that the value column expressions will be evaluated at the points within the selection that best match the given coordinates. If the interpolation fails for some point because its coordinates lie too far outside the selection, the corresponding value will be ignored.

Purpose	Manipulate pairs.
Syntax	<pre>model.pair().create(<tag>,type,<gtag>); model.pair(<tag>).type(type); model.pair(<tag>).type(); model.pair(<tag>).pairName(<pname>); model.pair(<tag>).pairName(); model.pair(<tag>).source().selMethod; model.pair(<tag>).source().named(<seltag>); model.pair(<tag>).source().named(); model.pair(<tag>).destination().selMethod; model.pair(<tag>).destination().named(<seltag>); model.pair(<tag>).destination().named(); model.pair(<tag>).swap(); model.pair(<tag>).srcFrame(<frame>); model.pair(<tag>).srcFrame(); model.pair(<tag>).dstFrame(<frame>); model.pair(<tag>).dstFrame(); model.pair(<tag>).hasAutoSelection(); model.pair(<tag>).manualSelection(manual); model.pair(<tag>).manualSelection(); model.pair(<tag>).searchMethod(method); model.pair(<tag>).searchMethod(); model.pair(<tag>).manualDist(manual); model.pair(<tag>).manualDist(); model.pair(<tag>).searchDist(<dist>); model.pair(<tag>).searchDist(); model.pair(<tag>).opName(src2dst); model.pair(<tag>).mphOpName(src2dst); model.pair(<tag>).gapName(src2dst); model.pair(<tag>).active(boolean); model.pair(<tag>).isActive(); model.pair().remove(<tag>);</pre>
Description	<p><code>model.pair().create(<tag>,type,<gtag>)</code> creates a boundary pair with tag <code><tag></code> in the geometry with tag <code><gtag></code>. The type <code>type</code> is either <code>Contact</code> or <code>Identity</code>. <code>model.pair(<tag>).type()</code> returns the pair type as a string. <code>model.pair(<tag>).type(type)</code> changes the pair type.</p> <p><code>model.pair(<tag>).pairName(<pname>)</code> sets the pair name, which is used as a suffix in operator names and variable names. By default, the pair name is the same as the tag. <code>model.pair(<tag>).pairName()</code> returns the pair name.</p> <p><code>model.pair(<tag>).source().named(<seltag>)</code> or, alternatively, <code>model.pair(<tag>).source().set(...)</code> specifies the source boundaries. <code>model.pair(<tag>).source().named()</code> returns the source selection tag as a</p>

string. See `model.selection()` for additional methods that can be applied on `model.pair(<tag>).source()`.

`model.pair(<tag>).destination().named(<seltag>)` or, alternatively, `model.pair(<tag>).destination().set(...)` specifies the destination boundaries. `model.pair(<tag>).destination().named()` returns the destination selection tag as a string. See `model.selection()` for additional methods that can be applied on `model.pair(<tag>).destination()`.

`model.pair(<tag>).swap()` swaps the source and destination selections.

`model.pair(<tag>).srcFrame(<frame>)` and `model.pair(<tag>).dstFrame(<frame>)` sets the source and destination frames for the identity mapping. The argument `<frame>` can have the values `spatial`, `material`, or `mesh`. The default is `spatial`. These frames are only used for identity pairs. `model.pair(<tag>).srcFrame()` and `model.pair(<tag>).dstFrame()` returns the frame tags.

`model.pair(<tag>).hasAutoSelection()` returns true if the contact pair was created automatically, using the create pairs check box in the finalize geometry node.

`model.pair(<tag>).manualSelection(manual)` enables or disables manual control of the selections for a pair that was created automatically.

`model.pair(<tag>).manualSelection()` returns true if manual control of selections is enabled, and false otherwise.

`model.pair(<tag>).searchMethod(method)` sets the search method for a contact pair. The argument `method` can be `fast` or `direct`. The default is `fast`.

`model.pair(<tag>).searchMethod()` returns the search method

`model.pair(<tag>).manualDist(manual)` enables or disables manual control of the search distance for a contact pair. The argument `manual` is boolean. The default value `false` means that the search distance is automatically computed based on the size of the geometry. `model.pair(<tag>).manualDist()` returns true if manual control of search distance is enabled, and false otherwise.

`model.pair(<tag>).searchDist(<dist>)` sets the search distance for a contact pair, when manual control of the search distance is enabled. The argument `<dist>` is a string whose default unit is the geometry's length unit. The default is `1e-2`.

`model.pair(<tag>).searchDist()` returns the search distance as a string.

`model.pair(<tag>).opName(src2dst)` returns the name of the operator transferring an expression from source to destination (if `src2dst=true`) or from destination to source (if `src2dst=false`).

`model.pair(<tag>).mphOpName(src2dst)` returns the name of the multiphysics operator transferring an expression from source to destination (if `src2dst=true`) or from destination to source (if `src2dst=false`). When the test operator is applied on this operator, it does not give any contribution (reaction force) on the SME interface's degrees of freedom due to the variable point mapping. These operators are available only for contact pairs.

`model.pair(<tag>).gapName(src2dst)` returns the name of the geometric gap variable seen from the destination (if `src2dst=true`) or seen from the source (if `src2dst=false`). These variables are available only for contact pairs.

`model.pair(<tag>).active(boolean)` enables or disables the pair.

`boolean enabled = model.pair(<tag>).isActive()` returns `true` if the pair is enabled, and `false` otherwise.

`model.pair().remove(<tag>)` deletes the pair.

Example

Create a contact pair in the geometry `geom1` with source boundaries 4 and 6 and destination boundaries 10 and 12.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 3);
model.geom("geom1").feature().create("blk1", "Block");
model.geom("geom1").feature().create("blk2", "Block");
model.geom("geom1").feature("blk2")
    .set("pos", new String[]{"0.5", "0.5", "1"});
model.geom("geom1").feature("fin").name("Form Assembly");
model.geom("geom1").feature("fin").set("action", "assembly");
model.geom("geom1").feature("fin").set("imprint", true);
model.geom("geom1").feature("fin").set("createpairs", false);
model.geom("geom1").run();

model.pair().create("p1", "Contact", "geom1");
model.pair("p1").source().set(new int[]{4, 6});
model.pair("p1").destination().set(new int[]{10, 12});
```

Purpose	Manipulate model parameters.
Syntax	<pre>model.param().set(<param>, <expr>); model.param().set(<param>, <expr>, <descr>); model.param().descr(<param>, <descr>); model.param().remove(<param>); model.param().varnames(); model.param().get(<param>); model.param().descr(<param>);</pre>
Description	<p>model.param() is a collection of model parameters.</p> <p>model.param().set(<param>, <expr>) defines the parameter <param> as <expr>.</p> <p>model.param().set(<param>, <expr>, <descr>) defines the parameter <param> as <expr> and assigns it the description <descr>.</p> <p>model.param().descr(<param>, <descr>) sets the description for the parameter <param>.</p> <p>model.param().remove(<param>) removes the parameter <param>.</p> <p>model.param().varnames() returns the names of all parameters as a string array.</p> <p>model.param().get(<param>) returns the parameter value as a string.</p> <p>model.param().descr(<param>) returns the parameter description as a string.</p>
Example	<p>Define the parameter c in terms of another parameter a and then remove c.</p> <pre>Model model = ModelUtil.create("Model"); model.param().set("c", "1+a"); model.param().remove("c");</pre>
See Also	model.variable()

Purpose	Manipulate physics interfaces.
Syntax	<pre>model.physics().create(<tag>,physint); model.physics().create(<tag>,physint,<geomtag>); model.physics().create(<tag>,physint,<geomtag>,<varnames>); model.physics(<tag>).model(<mtag>); model.physics(<tag>).field(fieldname).fieldname(<namelist>); model.physics(<tag>).field(fieldname).fieldname(<pos>,<name>); model.physics(<tag>).identifier(<scopename>); model.physics(<tag>).selection().named(<seltag>); model.physics(<tag>).selection().set(...); model.physics(<tag>).prop(propname).set(property,<value>); model.physics(<tag>).feature().create(<ftag>,feature); model.physics(<tag>).feature().create(<ftag>,feature,<dim>); model.physics(<tag>).feature(<ftag>).set(property,<value>); model.physics(<tag>).feature(<ftag>).selection().named(<seltag>); model.physics(<tag>).feature(<ftag>).selection().set(...); model.physics(<tag>).feature().move(<ftag>,<position>); model.physics(<tag>).feature(<ftag>).feature(); model.physics(<tag>).feature(<ftag>).feature(<ftag2>); model.physics(<tag>).feature(<ftag>).featureInfo(); model.physics(<tag>).feature(<ftag>).featureInfo("info"); feature = model.physics(<tag>).feature(<ftag>); feature.featureInfo("info").lock(variable,<value>); feature.featureInfo("info").getInfoTable(id); model.physics(<tag>).model(); model.physics(<tag>).field(fieldname).fieldname(); model.physics(<tag>).identifier(); model.physics(<tag>).scope(); model.physics(<tag>).geom(); model.physics(<tag>).selection().named(); model.physics(<tag>).selection().getType(); model.physics(<tag>).prop(propname).getType(<pname>); model.physics(<tag>).prop(propname).param(); model.physics(<tag>).feature(<ftag>).getType(<pname>); model.physics(<tag>).feature(<ftag>).param(); model.physics(<tag>).feature(<ftag>).selection().named(); model.physics(<tag>).feature(<ftag>).selection().getType();</pre>
Description	<p>model.physics(<tag>) is a physics interface.</p> <p>model.physics().create(<tag>,physint) or model.physics().create(<tag>,physint,<geomtag>) adds a physics interface to the model and initializes it with defaults. The <i>physint</i> argument specifies which physics interface to create. There can be several different values of <i>physint</i> which create the same internal physics interface class, but which set different defaults. The</p>

constructor without the `<geomtag>` argument can only be used (and should be used) by 0D physics interfaces.

`model.physics().create(<tag>, physint, <geomtag>, <varnames>)` adds a physics interface with the field variable names `<varnames>`. Only physics interfaces supporting a varying number of field variables considers this argument. Providing the variable names in the `create` method rather than changes them afterwards using `model.physics(<tag>).field(fieldname).fieldname(<namelist>)` ensures that the default features are correct.

`model.physics(<tag>).model(<mtag>)` sets the model of a 0D physics interface. For interfaces with a geometry, the model is deduced from the geometry.

`model.physics(<tag>).field(fieldname).fieldname(<namelist>)` sets a name of a dependent variable. The entity `fieldname` (which could be, for example, temperature, x-velocity, electric field) specifies which dependent variable to set the name for. The available fields are provided by the physics interface. The argument `<namelist>` can be a list of names for physics interfaces supporting an arbitrary number of dependent variables. The physics interfaces provide default names for the dependent variables.

`model.physics(<tag>).field(fieldname).fieldname(<pos>, <name>)` changes the name at position `<pos>` in the list of field names.

`model.physics(<tag>).identifier(<scopename>)` sets the scope name of the physics interface. The `create()` method provides a default value for the identifier. It has to be unique within the model.

`model.physics(<tag>).selection().named(<seltag>)` or, alternatively, `model.physics(<tag>).selection().set(...)` specifies where the physics interface is active. For a complete list of methods available under `selection()`, see [Selections](#). The selection must apply to the physics interface's maximum geometry level. The `create()` method sets a default that the physics interface is active in all domains. 0D physics interfaces are always active globally and do not support these methods.

`model.physics(<tag>).prop(propname).set(pname, <value>)` sets the value of some property parameter. All string types listed in [Table 2-2](#) are supported.

`model.physics(<tag>).feature().create(<ftag>, feature)` adds a new feature instance to the physics interface and initializes the feature with defaults. The available features are given by the physics interface.

`model.physics(<tag>).feature().create(<ftag>,feature,<dim>)` adds a new feature instance to the physics interface and initializes the feature with defaults. The feature is assigned to the domain level `<dim>`. Use this constructor for features which can be applied to more than one domain level. The constructor without the `<dim>` argument assigns the feature to the highest domain level, which the feature supports.

`model.physics(<tag>).feature(<ftag>).set(pname,<value>)` sets a parameter value. All string types listed in the section [Table 2-2](#) are supported.

`model.physics(<tag>).feature(<ftag>).selection().named(<seltag>)` or, alternatively,

`model.physics(<tag>).feature(<ftag>).selection().set(...)` assigns the feature to the domains. For a complete list of methods available under `selection()`, see [Selections](#). 0D features need no domain selection.

`model.physics(<tag>).feature().move(<ftag>,<position>)` moves the feature `<ftag>` to the zero indexed position `<position>` in the list. A feature cannot be moved before a default feature and the default features cannot be moved.

`model.physics(<tag>).feature().create(<itag>,"init")` creates an initial value feature, using the reserved feature ID `init`.

`model.physics(<tag>).feature(<itag>).set(varname,<value>)` specifies an initial value. The variable names are the field variables. For wave problems, the time derivatives of the field variables are also included in the list of variables.

`model.physics(<tag>).model()` returns the model of the interface.

`model.physics(<tag>).field(fieldname).fieldname()` returns the field names as a string array.

`model.physics(<tag>).identifier()` returns the scope name of the interface.

`model.physics(<tag>).scope()` returns the fully qualified scope name.

`model.physics(<tag>).geom()` returns the geometry tag as a string.

`model.physics(<tag>).selection().named()` returns the selection tag as a string.

`model.physics(<tag>).selection().getType()` returns domain information. See [Selections](#) for available methods.

`model.physics(<tag>).prop(propname).getType(pname)` returns the parameter value. See [getType\(\)](#) for available methods.

`model.physics(<tag>).prop(propname).param()` returns the parameter names as a string array.

`model.physics(<tag>).feature(<ftag>).getType(pname)` returns the parameter value. See [getType\(\)](#) for available methods.

`model.physics(<tag>).feature(<ftag>).param()` returns the parameter names as a string array.

`model.physics(<tag>).feature(<ftag>).selection().named()` returns the selection tag as a string array.

`model.physics(<tag>).feature(<ftag>).feature()` returns the list of feature attributes. This list supports the same methods as `model.physics(<tag>).feature()`.

`model.physics(<tag>).feature(<ftag>).feature(<ftag2>)` returns the feature attribute `<ftag2>`. The feature attributes support the same methods as `model.physics(<tag>).feature(<ftag>)`.

`model.physics(<tag>).feature(<ftag>).featureInfo()` returns a list of info objects.

`model.physics(<tag>).feature(<ftag>).featureInfo("info")` returns the info object that contains information about the variables, weak expressions, and constraints that a feature generates. The `model.physics(<tag>)` and `model.coordSystem(<tag>)` objects also have this list that you access with `model.physics(<tag>).featureInfo("info")`. These objects do not support the `lock` method, which only works for the object `model.physics(<tag>).feature(<ftag>)`.

`feature.featureInfo("info").lock(variable, <value>)` locks the named variable to the given expression. The expression must be given as a string array.

`feature.featureInfo("info").getInfoTable(id)` returns a table that lists all information about a certain table id. The supported id:s are `Expression`, `Shape`, `Weak`, and `Constraint`.

Examples

This example creates an Electrostatics physics interface. It sets boundaries 3 and 8 to the ground potential and assigns the electric potential of 1 V at boundary 4.

When the physics interface is created a couple of default features are automatically added. One of them is the Charge Conservation feature, which has the tag `ccn1`. The relative permittivity of this feature is set to 1.

```
model.physics().create("es", "Electrostatics", "geom1");
model.physics("es").feature().create("gnd1", "Ground", 2);
model.physics("es").feature("gnd1").selection().set(new int[]{3, 8});
model.physics("es").feature().create("pot1", "ElectricPotential", 2);
model.physics("es").feature("pot1").selection().set(new int[]{4});
model.physics("es").feature("pot1").set("V0", "1");
model.physics("es").feature("ccn1").set("epsilon_r_mat", "userdef");
model.physics("es").feature("ccn1").set("epsilon_r", "1");
```

Compatibility

From version 4.3 the methods

```
model.physics(<tag>).feature(<ftag>).params();
model.physics(<tag>).prop(propname).params();
```

are deprecated and replaced by the methods

```
model.physics(<tag>).feature(<ftag>).param();
model.physics(<tag>).prop(propname).param();
```

See Also

[model.material\(\)](#), [model.study\(\)](#)

Purpose Manipulate probe objects.

Syntax

```
model.probe().create(<tag>, type);
model.probe(<tag>).model(<mtag>);
model.probe(<tag>).set(property,<value>);
model.probe(<tag>).feature().create(<etag>, etype);
model.probe(<tag>).feature(<etag>).set(eproperty,<evaluate>);
```

Description

`model.probe().create(<tag>, type)` creates a probe of type `type` with tag `<tag>`.

`model.probe(<tag>).model(<mtag>)` sets the model to `<mtag>`.

`model.probe(<tag>).set(property,<value>)` set `property` to `<value>`.

`model.probe(<tag>).selection(...)` set the selection for the probe. This is possible for the probes of the types Domain, Boundary and Edge.

`model.probe(<tag>).feature().create(<etag>, etype)` creates a point probe expression of type `etype` and tag `<tag>`.

`model.probe(<tag>).feature(<etag>).set(eproperty,<evaluate>)` sets the property `eproperty` on the point probe expression `<etag>`.

Probes can be of the following types:

TABLE 2-46: PROBE TYPES

TYPE	DESCRIPTION
Boundary	Probe that defines a value as an integral, maximum, minimum or average over boundaries.
Domain	Probe that defines a value as an integral, maximum, minimum or average over domains.
Edge	Probe that defines a value as an integral, maximum, minimum or average over edges (in 3D).
GlobalVariable	Probe that defines a value using a global variable.
PointExpr	Probe that defines a value by interpolation of an expression in a probe point. The probe point is defined by the parent, a DomainPoint or a BoundaryPoint.

Probe points can be of the following types:

TABLE 2-47: PROBE POINT TYPES

TYPE	DESCRIPTION
BoundaryPoint	Defines a probe coordinate on a boundary in 3D.
DomainPoint	Defines a probe coordinate in a domain.

Probes takes the following properties:

TABLE 2-48: PROBE PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
descr	String		Description of the probe. Used for model.result().
descractive	on off	off	Manual control of description.
expr	String		The expression defining the probe.
frame	String	spatial frame	Frame used for defining the probe.
intorder	Integer	4	Integration order (DomainProbe and BoundaryProbe).
method	integration summation	integration	Method used (DomainProbe and BoundaryProbe).
probename	String	probe tag	Probe variable name.
table	String	default	Table to use for probe evaluation.
type	average maximum minimum integral	average	Type of probe (DomainProbe and BoundaryProbe).
unit	String	unit of expr	Unit for the probe. Used for model.result().
window	String	default	The plot window to use for the probe.

A probe point of the type DomainPoint takes the following properties:

TABLE 2-49: PROBE PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
bndsnap1	on off	off	Snap to nearest point (1D).
bndsnap2	on off	off	Snap to nearest boundary point (2D).
bndsnap3	on off	off	Snap to nearest boundary point (3D).
coords	Matrix of doubles		Probe coordinates.

TABLE 2-49: PROBE PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
depthpointnormal	Double	0	Depth along line defined by the pointnormal method.
depthpointdirection	Double	0	Depth along line defined by the pointdirection method.
depthtwopoints	Double	0	Depth along line defined by the twopoints method.
dimension	1 2 3	3	The spatial dimension in which the point resides.
first	Double array		The coordinates of the first point on the probe line.
method	pointnormal pointdirection twopoints none	pointnormal	Line entry method.
second	Double array		The coordinates of the second point (for method=twopoints)
twopointscurrent	first second	first	Point selector (for method=twopoints)

A probe point of BoundaryPoint types take the following properties:

TABLE 2-50: PROBE PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
coords	Double array	0, 0, 0	Probe coordinates.
rawcoords	Double array	0, 0, 0	Full precision probe coordinates.
snapcoords	Double array	0, 0, 0	The boundary-snapped coordinates.

model.result()

Purpose

Manipulate result objects.

Syntax

```
model.result().create(<pgtag>,dim);
model.result().create(<pgtag>,ftype);
model.result().autoplot();
model.result().autoplot(<value>);
model.result(<pgtag>).set(property,<value>);
model.result(<pgtag>).run();

model.result(<pgtag>).feature().create(<ftag>,ftype);
model.result(<pgtag>).feature(<ftag>).getType();
model.result(<pgtag>).feature(<ftag>).selection(...);
model.result(<pgtag>).feature(<ftag>).set(property,<value>);
model.result(<pgtag>).feature(<ftag>).run();

model.result(<pgtag>).feature(<ftag>)
    .create(<attrtag>, attrtype);
model.result(<pgtag>).feature(<ftag>)
    .feature(<attrtag>).set(property,<value>);

model.result().dataset().create(<dtag>,dtype);
model.result().dataset(<dtag>).selection(...);
model.result().dataset(<dtag>).set(property,<value>);

model.result().export().create(<etag>,<pgtag>,ctype);
model.result().export(<etag>).set(property,<value>);
model.result().export(<etag>).run();

model.result().numerical().create(<ntag>,ntype);
model.result().numerical(<ntag>).selection(...);
model.result().numerical(<ntag>).set(property,<value>);
model.result().numerical(<ntag>).run();

model.result().table().create(<ftag>,ntype);
model.result().table(<ftag>).setColumnHeaders(<headers>);
model.result().table(<ftag>).setTableData(<realData>,<imagData>);
model.result().table(<ftag>).getColumnHeaders();
model.result().table(<ftag>).getReal();
model.result().table(<ftag>).getImag();
model.result().table(<ftag>).isComplex();
model.result().table(<ftag>).clearTableData();
model.result().table(<ftag>).save(<filename>);
```

```

model.result().report().create(<rtag>);
model.result().report(<rtag>).set(rprop,<value>);
model.result().report(<rtag>).feature().create(<r2tag>,frtype);
model.result().report(<rtag>).feature(<r2tag>)...
    .set(rprop,<value>);
model.result().report(<rtag>).feature(<r2tag>)...
    .feature().create(<r3tag>,frtype);
model.result().report(<rtag>).feature(<r2tag>)...
    .feature(<r3tag>)set(rprop,<value>);
model.result().report(<rtag>).run();

```

Description

`model.result().create(<pgtag>,dim)` creates a plot group with the tag `<pgtag>`, of dimension `dim`, where `dim` can be 1, 2, or 3.

`model.result().create(<pgtag>,frtype)` creates a plot group of type `frtype`.

`model.result().autoplot()` returns true if plot features are plotted automatically when selected. `model.result().autoplot(true)` and `model.result().autoplot(false)` enable and disable automatic plotting, respectively.

`model.result(<pgtag>).feature().create(<ftag>,frtype)` creates a plot feature of type `frtype` tagged `<ftag>` belonging to the plot group `<pgtag>`.

`model.result(<pgtag>).feature(<ftag>).getType()` returns the type of the feature `<ftag>`. This is the same string `frtype` that was used to create the feature.

`model.result(<pgtag>).feature(<ftag>).create(<attrtag>, attrtype)` creates an attribute feature with the tag `<attrtag>` of type `attrtype`, belonging to the feature `<ftag>`.

`model.result(<pgtag>).run()` plots the plot group.

`model.result().dataset().create(<dtag>,dtype)` creates a data set feature with the tag `<dtag>` and the type `dtype`.

`model.result().export().create(<etag>,<pgtag>,etype)` creates an export feature with the tag `<etag>`, belonging to plot group `<pgtag>` and of export feature type `etype`.

`model.result().numerical().create(<ntag>, ntype)` creates a numerical results feature with the tag `<ntag>` of the numerical feature type `ntype`.

`model.result().numerical(<ntag>).run()` evaluates the numerical feature.

`model.result().table().create(<ftag>, ntype)` creates a table feature with the tag `<ftag>`. The set and get methods used to manipulate tables are described in [Table](#).

The data extraction methods used to retrieve plot or numerical data are described in [Results](#).

`model.result().report().create(<rtag>, "Report")` creates a report with tag `<rtag>`.

`report.feature().create(<tptag>, "TitlePage")` adds a title page to the report `report`. Only one title-page feature can be added.

`report.feature("<tptag>").set(prop, value)` sets the title-page property `prop` to the value `value`.

`report().feature().create(<toctag>, "TableOfContents")` adds a table of contents to the report `report`. Only one table-of-contents feature can be added.

`report.feature().create(<stag>, "Section")` adds an additional section level to a report.

`report.feature(<stag>).set(prop, value)`

`report.feature(<stag>).feature().create(<ftag>, feature)`

`report.feature(<stag>).feature(<ftag>).set(prop, value)`

To add a report contents feature—that is, a feature corresponding to content in the report—to a report section feature `section`, type,

`section.feature().create(<frtag>, frtype, ...)`. Depending on the report feature type `frtype`, the create operation includes zero, one or two tags that refer to the model feature to report about. The tags must refer to an existing feature of the correct type. The following report feature types are available:

REPORT FEATURES	DESCRIPTION
Model	Prints information about the model root, such as model file.
ModelNode	Prints information about a model, its identifier.
Parameter	Reports on the global model parameters.
Variables	Reports on a variables feature.
Functions	Reports on a function feature.
Probe	Reports on a probe feature.
ModelCoupling	Reports on a model-coupling feature.

REPORT FEATURES	DESCRIPTION
Selection	Reports on a selection feature.
CoordinateSystem	Reports on a coordinate system feature.
PML	Reports on a PML feature.
InfiniteElements	Reports on an infinite elements feature.
Pair	Reports on a pair feature.
Geometry	Reports on a geometry.
Material	Reports on a material feature.
Physics	Reports on a physics interface and its features.
Mesh	Reports on a mesh.
Study	Reports on a study.
Solver	Reports on a solver.
DataSet	Reports on a data-set feature.
DerivedValues	Reports on a derived-values feature.
Table	Includes a results table in the report.
PlotGroup	Includes a plot group in the report.
Export	Includes an export feature in the report.

To point a report feature `rFeature` to another feature with tag `<ftag>` in the tree, use the method `rFeature.set("noderef", <ftag>)` method. A report contents feature must point to a feature of the type it is designed to report on; see the table above. Instead of a feature tag, set "noderef" to "none" to clear a reference.

```
model.result().report(<rtag>).feature(<stag>).feature(<frtag>).set(frprop, <value>)
```

to set a property in a report feature.

Examples

Create a solution data set and set it to point to the tagged solution `sol1` from a solver sequence:

```
model.result().dataset().create("dset", "Solution");
model.result().dataset("dset").set("solution", "Sol1");
```

Create 3D plot group containing a streamline plot and a plane with a contour plot on:

```
result().create("pg1", 3);
result("pg1").set("data", "dset");
result("pg1").feature().create("stream", "Streamline");
model.result("pg1").feature("stream").set("expr",
```

model.result()

```
        new String[]{"2-x", "0", "z"});
model.result("pg1").feature("stream").
    selection().set(new int[]{2});
result().dataset().create("cutp1", "CutPlane");
result("pg1").feature().create("cont1", "Contour");
result("pg1").feature("cont1").set("data", "cutp1");
result("pg1").run();
```

See Also

Purpose	Manipulate selections and hide features used by result features.
Syntax	<pre>model.savePoint(<tag>).geom(<gtag>) model.savePoint(<tag>).geom(<gtag>).selection(<stag>) model.savePoint(<tag>).geom(<gtag>).view(<vtag>)</pre>
Description	<p><code>model.savePoint(<tag>)</code> is a container of selections and hide features used by result features. When solving, a copy of the model is made—a save point model—which is used in results and analysis. The selections and hide features contained in <code>model.savePoint(<tag>)</code> refer to the geometry in this copy.</p> <p>Editing the data in <code>model.savePoint(<tag>)</code> may only be done in the following circumstances.</p> <ul style="list-style-type: none">• The geometry on which the analysis is done has been modified after solving. In this case the selections and hide feature may be edited but not created or removed.• The geometry on which the analysis is done has been removed. In this case the selections and hide features may be both edited, created, and deleted. <p>In all other circumstances, edit the selections in <code>model.selection()</code>, and the hide features in <code>model.view()</code>. Changes there are synchronized with the data in <code>model.savePoint()</code>.</p> <p><code>model.savePoint(<tag>).geom(<gtag>)</code> returns a container with selections and views with hide features for a geometry in the save point model.</p> <p><code>model.savePoint(<tag>).geom(<gtag>).selection(<stag>)</code> returns a selection.</p> <p><code>model.savePoint(<tag>).geom(<gtag>).view(<vtag>)</code> returns a view. Contrary to the views in <code>model.view()</code>, only the hide features in <code>view.hideEntities()</code> can be edited.</p>
See also	model.selection() , model.weak()

Purpose	Manipulate tagged selections.
Syntax	<pre>model.selection().create(<tag>); model.selection().create(<tag>,<type>); model.selection(<tag>).model(<mtag>); model.selection(<tag>).set(property,<value>); model.selection(<tag>).geom(<gtag>,dim); model.selection(<tag>).geom(<gtag>,highdim,lowdim,typelist); model.selection(<tag>).geom(dim); model.selection(<tag>).all(); model.selection(<tag>).set(<domlist>); model.selection(<tag>).add(<domlist>); model.selection(<tag>).remove(<domlist>); model.selection(<tag>).inherit(bool); model.selection(<tag>).model(); model.selection(<tag>).isGeom(); model.selection(<tag>).geom(); model.selection(<tag>).dimension(); model.selection(<tag>).entities(dim); model.selection(<tag>).interiorEntities(dim); model.selection(<tag>).isInheriting(); model.selection(<tag>).inputDimension(); model.selection(<tag>).inputEntities();</pre>
Description	<p><code>model.selection(<tag>)</code> is a tagged domain selection.</p> <p><code>model.selection().create(<tag>)</code> creates a selection of type <code>explicit</code>.</p> <p><code>model.selection().create(<tag>,<type>)</code> creates a selection of type <code><type></code>.</p> <p><code>model.selection(<tag>).model(<mtag>)</code> sets the model of the selection. Only geometries in the model can be used in selections.</p> <p><code>model.selection(<tag>).model()</code> returns the model of the selection.</p> <p><code>model.selection(<tag>).set(property,<value>)</code> sets a property value for the selection. Which properties are available for the different selection types are listed on the following pages. All other assignment methods are only supported by the <code>Explicit</code> selection type.</p> <p>All other methods are explained in the section Selections.</p> <p>Other entities can use any of the selections in <code>model.selection()</code> when defining its selection. For example, create a selection <code>sel1</code>:</p> <pre>model.selection().create("sel1"); model.selection("sel1").model("mod1");</pre>

Then, for example, a variable entities can use this selection:

```
model.variable().create("var1");
model.variable("var1").model("mod1");
model.variable("var1").selection().named("sel1");
```

What properties are available depends on the type of selection. The following selection types are available:

Explicit Selection defined by an explicit set of entities.

Explicit selections do not have any properties.

Ball Selection of entities in a ball.

NAME	VALUE	DEFAULT	DESCRIPTION
entitydim	0 1 2 3	sdim	Dimension of entities to select
inputent	all selections	all	Use all entities or entities defined by input property
input	String[]	{}	Input selections
condition	intersects inside somevertex allvertices	intersects	Condition for inclusion of an entity
posx	double	0	Center of ball, first coordinate
posy	double	0	Center of ball, second coordinate
posz	double	0	Center of ball, third coordinate
r	double	0	Radius

The posx, posy and posz properties define the center of the ball, and r defines the radius. These properties take their units from the corresponding geometry sequence.

When condition is intersects, all entities that intersect the ball are included in the selection. The rendering mesh is used for the calculation. The accuracy of the rendering mesh can be set in Options > Preferences > Graphics > Detail.

When condition is inside, all entities that are completely inside the ball are included in the selection. The rendering mesh is used for the calculation.

When condition is somevertex, all entities that have at least one adjacent vertex inside the ball are included in the selection.

When condition is allvertices, all entities that have all adjacent vertices inside the ball are included in the selection.

When inputent is selections, the selection is restricted to the entities in the selections defined by the input property. When inputent is all, all entities in the geometry are considered.

Box Selection of entities in a box.

NAME	VALUE	DEFAULT	DESCRIPTION
entitydim	0 1 2 3	sdim	Dimension of entities to select
inputent	all selections	all	Use all entities or entities defined by input property
input	String[]	{}	Input selections
condition	intersects inside somevertex allvertices	intersects	Condition for inclusion of an entity
xmax	double	inf	Maximum x-coordinate of box
xmin	double	-inf	Minimum x-coordinate of box
ymax	double	inf	Maximum y-coordinate of box
ymin	double	-inf	Minimum y-coordinate of box
zmax	double	inf	Maximum z-coordinate of box
zmin	double	-inf	Minimum z-coordinate of box

The xmax, xmin, ymax, ymin, zmax and zmin properties define the box. These properties take their units from the corresponding geometry sequence.

When condition is intersects, all entities that intersect the box are included in the selection. The rendering mesh is used for the calculation. The accuracy of the rendering mesh can be set in Options > Preferences > Graphics > Detail.

When condition is inside, all entities that are completely inside the box are included in the selection. The rendering mesh is used for the calculation.

When condition is somevertex, all entities that have at least one adjacent vertex inside the box are included in the selection.

When condition is allvertices, all entities that have all adjacent vertices inside the box are included in the selection.

When input is selections, the selection is restricted to the entities in the selections defined by the input property. When input is all, all entities in the geometry are considered.

Union Selection defined by the union of a set of selections.

NAME	VALUE	DEFAULT	DESCRIPTION
entitydim	0 1 2 3	sdim	Dimension of entities to select
input	String[]	{}	Selections to add

Intersection Selection defined by the intersection of a set of selections.

NAME	VALUE	DEFAULT	DESCRIPTION
entitydim	0 1 2 3	sdim	Dimension of entities to select
input	String[]	{}	Selections to intersect

Difference Selection defined by the difference between two sets of selections.

NAME	VALUE	DEFAULT	DESCRIPTION
entitydim	0 1 2 3	sdim	Dimension of entities to select
add	String[]	{}	Selections to add
subtract	String[]	{}	Selections to subtract

Complement Selection defined by the complement of a set of selections.

NAME	VALUE	DEFAULT	DESCRIPTION
entitydim	0 1 2 3	sdim	Dimension of entities to select
input	String[]	{}	Selections to invert

Adjacent Selection of entities adjacent to entities in another selection.

NAME	VALUE	DEFAULT	DESCRIPTION
entitydim	0 1 2 3	sdim	Dimension of entities to select
input	String[]	{}	Input selections
outputdim	0 1 2 3	sdim-1	Dimension of output entities
exterior	on off	on	Include exterior boundaries/edges
interior	on off	off	Include interior boundaries/edges.

Examples

Define the selection `equ1` as the domain of a rectangle and the selection `bnd1` as the boundary of the rectangle.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1",2);
model.geom("geom1").feature().create("f1","Rectangle");
model.geom("geom1").runAll();
model.selection().create("equ1").geom(2);
model.selection("equ1").all();
model.selection().create("bnd1").geom(1);
model.selection("bnd1").all();
```

Create a selection for all interior mesh boundary boundaries and all internal boundaries of the union of a `Circle` and a `Rectangle`:

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1",2);
model.geom("geom1").feature().create("r1","Rectangle");
model.geom("geom1").feature().create("c1","Circle");
model.geom("geom1").runAll();
model.selection().create("ultra").geom("geom1",2,1,
    new String[]{"interior","meshinterior"});
model.selection("ultra").all();
```

The above selection is typically used in very weak formulations to include all internal mesh boundaries and the internal boundaries in a single expression.

The (outer) boundaries for the model can be set with the selection

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1",2);
model.geom("geom1").feature().create("r1","Rectangle");
model.selection().create("outer").geom("geom1",2,1,
    new String[]{"exterior"});
```

```
model.selection("outer").all();
```

Create a selection for all boundaries of a block intersecting a ball with radius 0.5 and center (1,1,1):

```
Model model = ModelUtil.create("Model");
model.geom().create("g1",3).feature().create("blk1","Block");
model.geom("g1").run();
model.selection().create("ball1", "Ball");
model.selection("ball1").set("entitydim", "2");
model.selection("ball1").set("posx", "1");
model.selection("ball1").set("posy", "1");
model.selection("ball1").set("posz", "1");
model.selection("ball1").set("r", "0.5");
```

Create a selection of all edges adjacent to the boundaries in the ball selection:

```
model.selection().create("adj1", "Adjacent");
model.selection("adj1").set("entitydim", "2");
model.selection("adj1").set("outputdim", "1");
model.selection("adj1").set("input", new String[]{"ball1"});
```

See Also

[Selections](#)

Purpose	Manipulate shape functions.
Syntax	<pre>model.shape().create(<tag>,<frame>); model.shape(<tag>).elementSet(<condition>); model.shape(<tag>).frame(<ftag>); model.shape(<tag>).feature().create(<ftag>,<func>); model.shape(<tag>).feature(<ftag>).shape(<func>); model.shape(<tag>).feature(<ftag>).set(property,<value>); model.shape(<tag>).selection().named(<seltag>); model.shape(<tag>).selection().set(...); model.shape(<tag>).slits().named(<seltag>); model.shape(<tag>).slits().set(...); model.shape(<tag>).upFlux(<varName>); model.shape(<tag>).downFlux(<varName>); model.shape(<tag>).domainFlux(<expressions>,<frame>); model.shape(<tag>).elementSet(); model.shape(<tag>).frame(); model.shape(<tag>).feature(<ftag>).shape(); model.shape(<tag>).feature(<ftag>).getType(property); model.shape(<tag>).feature(<ftag>).properties; model.shape(<tag>).fieldVariable(); model.shape(<tag>).selection().named(); model.shape(<tag>).selection().getType(); model.shape(<tag>).slits().named(); model.shape(<tag>).slits().getType(); model.shape(<tag>).upFlux(); model.shape(<tag>).downFlux();</pre>
Description	<p><code>model.shape(<tag>)</code> is a shape entity.</p> <p><code>model.shape().create(<tag>,<frame>)</code> creates a shape entity with tag <code><tag></code> and assigns the frame <code><frame></code> to it.</p> <p><code>model.shape(<tag>).frame(<ftag>)</code> assigns frame <code><ftag></code> to the shape function. See model.frame() for a discussion on the default frame.</p> <p><code>model.shape(<tag>).feature().create(<ftag>,<func>)</code> creates a shape feature with the shape function <code>func</code>. <code>func</code> can be a shape function name, for example <code>shlag</code>, or a shape function with arguments, for example, <code>shlag(2,u)</code>. The latter is interpreted as an assignment of some property values.</p> <p><code>model.shape(<tag>).feature(<ftag>).shape(<func>)</code> sets the shape function.</p> <p><code>model.shape(<tag>).feature(<ftag>).set(property,<value>)</code> sets a property for the shape function. Of the data types listed in Table 2-2, the ones</p>

supported are those for integers, strings, and string arrays. Which ones are applicable differs for each property.

`model.shape(<tag>).selection().named(<seltag>)` or, alternatively, `model.shape(<tag>).selection().set(...)` assigns the shape function to the specified domains. For a complete list of methods available under `selection()`, see [Selections](#).

`model.shape(<tag>).upFlux(<varName>)` and `model.shape(<tag>).downFlux(<varName>)` set the names of the up and down boundary flux variables.

`model.shape(<tag>).domainFlux(<expressions>,<frame>)` sets expressions for the domain flux in a given frame. This is required to make the boundary flux variables produce accurate results. Only Lagrange shape functions support boundary flux variables.

`model.shape(<tag>).frame()` returns the frame tag as a string.

`model.shape(<tag>).feature(<ftag>).shape()` returns the shape function as a string.

`model.shape(<tag>).feature(<ftag>).getType(property)` returns a property value. For available data types, see [getType\(\)](#).

`model.shape(<tag>).feature(<ftag>).properties()` returns the names of the properties as a string array.

`model.shape(<tag>).fieldVariable()` returns the field variables which the shape functions define.

`model.shape(<tag>).selection().named()` returns the selection tag as a string.

`model.shape(<tag>).elementSet()` returns the element set condition, empty string means no condition.

`model.shape(<tag>).elementSet(<condition>)` sets the element set condition to the given string.

`model.shape(<tag>).selection().getType()` returns domain information. For available methods, see [model.selection\(\)](#).

`model.shape(<tag>).slits()` returns a selection used to generate a slit on the shape. Works exactly as selections.

model.shape()

`model.shape(<tag>).upFlux()` and `model.shape(<tag>).downFlux()` return the names of the up and down flux variables (an empty string if the variable names have not been set.)

Examples

Define the shape function `shlag(2, "u")`.

```
model.shape().create("shu", "f");
model.shape("shu").feature().create("f1", "shlag");
model.shape("shu").feature("f1").set("order", 2);
model.shape("shu").feature("f1").set("basename", "u");
model.shape("shu").selection().named("equ1");
```

See Also

[model.coeff\(\)](#), [model.intRule\(\)](#), [model.weak\(\)](#)

Purpose	Manipulate solutions.
Syntax	<pre> model.sol().create(<tag>) model.sol().create(<tag>,<studytag>) model.sol().create(<tag>,<studytag>,<varstag>) model.sol().remove(<tag>) model.sol(<tag>).feature().create(<ftag>,<oper>) model.sol(<tag>).feature().remove(<ftag>) model.sol(<tag>).feature(<ftag>).set(property,<value>) model.sol(<tag>).clearSolution() model.sol(<tag>).copySolution(<ctag>) model.sol(<tag>).createAutoSequence(<stag>) model.sol(<tag>).createSolution() model.sol(<tag>).updateSolution() model.sol(<tag>).run(<ftag>) model.sol(<tag>).runFrom(<ftag>) model.sol(<tag>).runAll() model.sol(<tag>).run() model.sol(<tag>).continueCun() </pre>
Description	<p><code>model.sol().create(<tag>)</code> adds a solution to the model.</p> <p><code>model.sol().create(<tag>,<studytag>)</code> adds a solution to the model. The constructor adds one feature of the type <code>StudyStep</code> to the solver sequence with the tag <code><studytag></code>. This <code>StudyStep</code> feature is connected to a study step (see model.study()).</p> <p><code>model.sol().create(<tag>,<studytag>,<varstag>)</code> adds a solution to the model. The constructor adds one feature of the type <code>StudyStep</code> with the tag <code><studytag></code> and one feature of the type <code>Variables</code> with the tag <code><varstag></code> to the solver sequence.</p> <p><code>model.sol().remove(<tag>)</code> removes a solution object from the model.</p> <p><code>sol(<tag>).feature().create(<ftag>,<oper>)</code> creates a solution operation feature.</p> <p><code>model.sol(<tag>).feature().remove(<ftag>)</code> removes the feature <code><ftag></code>.</p> <p><code>model.sol(<tag>).feature(<ftag>).set(property,<value>)</code> sets the property <code>property</code> for the feature <code><ftag></code>.</p> <p><code>model.sol(<tag>).clearSolution()</code> clears the solution data associated with the solution <code><tag></code>. The features are not changed.</p>

`model.sol(<tag>).copySolution(<ctag>)` copies the solution data associated with the solution `<tag>` to a new solution `<ctag>`. The features are not copied.

`model.sol(<tag>).createAutoSequence(<stag>)` creates a sequence of features automatically from the study `<stag>`. The sequence of study steps are used as input to the sequence generation algorithm but also the physics used in the study steps are used to automatically adopt the solver settings.

`model.sol(<tag>).createSolution()` creates a solution object from one or more set operations (`setU(. . .)`, ...), see [Solution Creation](#) for details.

`model.sol(<tag>).updateSolution()` updates a solution object to make it consistent with the current model.

`model.sol(<tag>).run(<ftag>)` runs the features for a solution object up to and including the feature `<ftag>`.

`model.sol(<tag>).runFrom(<ftag>)` runs the features for a solution object from and including the feature `<ftag>`.

`model.sol(<tag>).runAll()` and `model.sol(<tag>).run()` run all the features for a solution object.

`model.sol(<tag>).continueRun()` continues to run a solver sequence.

Examples

Assume that a study `st1` represents one stationary study step with the tag `stat1` for some equations.

```
model.sol().create("s", "step1", "vars1");
model.sol("s").feature("step1").set("study", "st1");
model.sol("s").feature("step1").set("studystep", "stat1");
model.sol("s").feature().create("solver1", "Stationary");
```

Assume that a second study step with frequency response is added to the study with tag `freq1` and that we want to make a frequency sweep from 10 to 1000 using the parametric solver and the solution above as the linearization point (bias solution).

```
model.sol("s").feature().create("step2", "StudyStep");
model.sol("s").feature("step2").set("study", "st1");
model.sol("s").feature("step2").set("studystep", "freq1");
model.sol("s").feature().create("vars2", "Variables");
SolverFeature s2 = (SolverFeature)
    model.sol("s").feature().create("solver2", "Stationary");
s2.set("nonlin", "linper");    (*)
s2.set("linpmethod", "sol");
s2.set("linpsol", "s");
s2.set("storelinpoint", "on");
```

```
s2.feature().create("par","Parametric");
s2.feature("par").set("pname","freq");
s2.feature("par").set("plist",new double[] {10,1000});
s2.runAll();
```

At this point the solution `s` is associated to the study step `freq1` (but it depends indirectly on the bias study step `stat1` as well).

(*) Uses the new small signal study functionality, which makes it possible to access also the linearization point for postprocessing together with the small signal solution. Here it is assumed that the bias problem and the small signal problem can be setup independently for the two study steps.

See Also

[model.study\(\)](#)

Purpose	Manage studies.
Syntax	<pre>model.study().create(<tag>); model.study(<tag>).feature().create(<ftag>, type); model.study(<tag>).feature().move(<ftag>, position); model.study(<tag>).run() model.study(<tag>).runNoGen() model.study(<tag>).createAutoSequences(type) model.study(<tag>).showAutoSequences(type) step = model.study(<tag>).feature(<ftag>); step.mesh(<geom>, <mesh>); step.activate(<physpath>, <bool>); step.discretization(<physpath>, <discr>); step.mglevel.create(<mglevel>); step.mglevel(<mglevel>).mesh(<geom>, <mesh>); step.mglevel(<mglevel>).discretization(<physpath>, <discr>); step.type(); step.activate(<physpath>); step.discretization(<physpath>); step.mesh(<geom>); step.mglevel(<mglevel>).mesh(<geom>); step.mglevel(<mglevel>).discretization(<physpath>);</pre>
Description	<p>The entity <code>model.study</code> stores a list of studies, each of which consists of a number of study steps. Each study step, in turn, defines a solver-ready problem. This means that a study step can be turned into an extended mesh, and a basic solver (Stationary, Time, Eigenvalue, Modal, AWE, Optimization) can be applied, resulting in a solution object.</p> <p>The central property of a study step is its <i>study type</i>, which on one hand controls the equations generated by physics interfaces, and on the other hand triggers automatic selection of a suitable solver. Another important property of a study step is which mesh to use (for each geometry in the model). Other fundamental simulation parameters can also be found among the study step settings, like the time span for a Time Dependent study type and frequency range for a Frequency Domain type.</p> <p>Under a study step, you can add <i>multigrid levels</i>. The parent node still defines the problem to be solved (for example, the study type and the mesh). Therefore, the added multigrid levels must necessarily be coarser than the parent study step.</p>

Most physics interface features and also some other parts of the model object (for example expression features) must support a `step` member, which (in analogy to the spatial `selection`) controls for which study steps the feature is active. In many ways, the study selection can be seen as a fourth, discrete, dimension.

`model.study().create(<tag>)` creates a new study sequence.

`model.study(<tag>).run()` computes study.

`model.study(<tag>).runNoGen()` runs the attached solver sequence without regenerating it.

`model.study(<tag>).createAutoSequences(type)` creates an attached solver sequence and/or job using default solver settings. The argument *type* is one of `all`, `jobs`, or `sol`, corresponding to creating both jobs and solver sequences or one of them.

`model.study(<tag>).showAutoSequences(type)` generates a new attached solver sequence and/or job using default solver settings. The previous item describes the *type* argument.

`model.study(<tag>).feature().create(<ftag>, type)` creates a new study step of the given type within the specified sequence. The set of allowed values should be limited to study types supported by at least one physics interface present in the model (Stationary, Time, Frequency, and Eigenvalue should always be allowed).

`model.study(<tag>).feature().move(<ftag>, position)` moves the feature *<ftag>* to the zero indexed position *<position>* in the list.

`step = model.study(<tag>).feature(<ftag>)` obtains a reference to a specified study step.

`step.mesh(<geom>, <mesh>)` specifies which mesh to use for geometry *<geom>* in the model.

`step.activate(<physpath>, <bool>)` activates or deactivates a physics interface or a physics feature. The string *<physpath>* is a path to a node in a physics interface. Currently only the tag of the physics interface tag itself is supported.

`step.discretization(<physpath>, <discr>)` assigns discretization for a physics interface. The string *<physpath>* is the path of a physics interface. The string *<discr>* is a tag of a discretization feature under a physics mode. The default *<discr>* the physics interface tag. It can be changed to the tag of a discretization node under a physics interface.

`step.mglevel.create(<mglevel>)` adds a (coarser) multigrid level to a study.

`step.mglevel(<mglevel>).mesh(<geom>, <mesh>)` specifies a mesh for the multigrid level. The set of allowed values must, in addition to the actual meshes, include an option “from parent”. This should be the default choice and indicates that the multigrid level uses the same mesh as the parent study.

`step.mglevel(<mglevel>).discretization(<physpath>, <discr>)` assigns discretization for a multigrid level. The string `<physpath>` is the path of a physics interface. The string `<discr>` is a tag of a discretization feature under a physics mode. The default `<discr>` the physics interface tag. It can be changed to the tag of a discretization node under a physics interface.

`step.type()` returns the study type.

`step.mesh(<geom>)` returns the mesh selected for the given geometry.

`step.activate(<physpath>)` returns activation status of a physics interface or a physics interface feature. Currently only the tag of the physics interface tag itself is supported.

`step.mglevel(<mglevel>).mesh(<geom>)` returns the mesh for the selected multigrid level and geometry.

`step.mglevel(<mglevel>).discretization(<discpath>)` returns activation status of a discretization feature.

Examples

The following code sets up a study sequence to analyze the influence of structural deformation on a waveguide with a numerical port boundary condition. It consists of three steps: stationary structural mechanics followed by an eigenvalue study for the port and finally a wave propagation problem solved with manual multigrid levels (to get nested meshes).

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 3);
model.geom("geom1").feature().create("blk1", "Block");
model.geom().run();
model.mesh().create("mesh1", "geom1");
model.mesh().create("mesh2", "geom1");
model.mesh().create("mesh3", "geom1");

model.physics().create("rfw1", "ElectromagneticWaves", "geom1");
model.study().create("seq1");
Study s1 = model.study("seq1");
s1.feature().create("struct", "Stationary");
s1.feature("struct").mesh("geom1", "mesh1");
```

```
s1.feature().create("port","BoundaryModeAnalysis");
s1.feature("port").set("PortName","port1");
s1.feature("port").mesh("geom1","mesh2");
s1.feature().create("wave","Frequency");
s1.feature("wave").mesh("geom1","mesh2");
s1.feature("wave").mglevel().create("mgl1");
s1.feature("wave").mglevel().create("mgl2");
s1.feature("wave").mglevel("mgl2").mesh("geom1","mesh3");
model.physics("rfw1").feature().
    create("mgl1","Discretization");
model.physics("rfw1").feature("mgl1").set("order","1");
```

In this case, the only settings that must be applied in the study members of other features are the ones relating to multigrid levels. The physics interfaces' equation form is by default set to automatic, which means that they respond suitably to the study type each time an xmesh is created.

See Also

[model.batch\(\)](#), [model.physics\(\)](#), [model.sol\(\)](#)

model.unitSystem()

Purpose	Manipulate unit systems.
Syntax	<pre>UnitSystem us = model.unitSystem().create(<tag>); us.baseUnit().create(<tag>,<symbol>,<quantity>) us.derivedUnit().create(<tag>,<units>,<powers>); us.additionalUnit().create(<tag>,<dim>); model.unitSystem().builtInTags(); us.baseUnit(<tag>); us.derivedUnit(<tag>); us.additionalUnit(<tag>) us.derivedUnit(<tag>).aliases(); us.baseUnit(<tag>).dimension(); us.derivedUnit(<tag>).quantity(); us.derivedUnit(<tag>).offset(); us.derivedUnit(<tag>).scale(); us.derivedUnit(<tag>).symbol(); us.derivedUnit(<tag>).definition(<units>,<powers>); us.additionalUnit(<tag>).aliases(<aliases>); us.additionalUnit(<tag>).quantity(<quantity>); us.additionalUnit(<tag>).offset(<offset>); us.additionalUnit(<tag>).scale(<scale>); us.additionalUnit(<tag>).offset(<offset>); us.additionalUnit(<tag>).symbol(<symbol>);</pre>
Description	<p><code>model.unitSystem().create(<uname>)</code> creates a unit system <code><uname></code>.</p> <p><code>us.baseUnit().create(<tag>,<symbol>,<quantity>)</code> creates a base unit for the quantity <code><quantity></code>, tagged <code><tag></code> with the symbol <code><symbol></code>. The quantity is any of the 7 base dimensions (length, mass, time, current, temperature, substance, and intensity).</p> <p><code>us.derivedUnit().create(<tag>,<units>,<powers>)</code> creates a new derived dimension tagged <code><tag></code> and derived from the units in <code><units></code> each to the power of the powers in <code><powers></code>.</p> <p><code>us.derivedUnit(<tag>).definition(<units>,<powers>)</code> sets the definition of a derived unit in powers of other units. The resulting dimension must agree with any previously specified dimension for this unit. Use the <code>create</code> method to define a dimension from the derived units.</p> <p><code>us.additionalUnit().create(<tag>,<dim>)</code> creates a new additional unit.</p> <p>All methods below are valid for all units, no matter what unit list they belong to. Furthermore, only the set methods are described here, but there is also a corresponding get method.</p>

`model.unitSystem().builtInTags()` returns the tags of the built-in unit systems. The method `model.unitSystem().tags()` returns the tags of the user defined unit systems. Both sets of tags can be used to retrieve the unit system using `model.unitSystem(<tag>)`.

`us.additionalUnit(<tag>).aliases(<aliases>)` sets alternate names for the unit that can be used in unit expressions.

`us.additionalUnit(<tag>).quantity(<quantity>)` assigns a physical quantity to the given unit.

`us.additionalUnit(<tag>).scale(<scale>)` sets the scale of the additional unit.

`us.derivedUnit(<tag>).symbol(<symbol>)` sets the symbol of the derived unit.

`us.derivedUnit(<tag>).offset(<offset>)` sets the offset of the derived unit.

Notes

There is only one unit system per model object, but it is possible to use all units defined by the unit systems in the list. The SI-system is read only and always created by default.

Examples

```
Model model = ModelUtil.create("Model");
UnitSystem us = model.unitSystem().create("cgs2");
model.baseSystem("cgs2");
us.baseUnit().create("centimeter", "cm", "length");
us.derivedUnit().create("meter_per_second",
    new int[]{1,0,-1,0,0,0,0,0});
Unit du = us.derivedUnit("meter_per_second");
du.definition(new String[]{"meter", "second"},
    new int[]{1,-1,0,0,0,0,0,0});
Unit au = us.additionalUnit().create("celsius",
    new int[]{0,0,0,0,1,0,0,0});
au.offset(273.15);
```

See Also

[model.physics\(\)](#)

Purpose	Manipulate variables.
Syntax	<pre>model.variable().create(<tag>); model.variable(<tag>).set(<var>,<expr>); model.variable(<tag>).set(<var>,<expr>,<descr>); model.variable(<tag>).descr(<var>,<descr>); model.variable(<tag>).remove(<var>); model.variable(<tag>).model(<mtag>); model.variable(<tag>).selection().named(<seltag>); model.variable(<tag>).selection().set(...); model.variable(<tag>).varnames(); model.variable(<tag>).get(<var>); model.variable(<tag>).descr(<var>); model.variable(<tag>).model(); model.variable(<tag>).scope(); model.variable(<tag>).selection().named(); model.variable(<tag>).selection().getType();</pre>
Description	<p><code>model.variable(<tag>)</code> is a tagged variable entity. It can contain several variables, but only one selection.</p> <p><code>model.variable(<tag>).set(<var>,<expr>)</code> defines the variable <code><var></code> by the expression <code><expr></code>.</p> <p><code>model.variable(<tag>).set(<var>,<expr>,<descr>)</code> defines a variable and gives it a description.</p> <p><code>model.variable(<tag>).descr(<var>,<descr>)</code> defines a description for the variable <code><var></code>.</p> <p><code>model.variable(<tag>).model(<mtag>)</code> sets the model.</p> <p><code>model.variable(<tag>).selection().named(<seltag>)</code> or, alternatively, <code>model.variable(<tag>).selection().set(...)</code> assigns the variable entity with tag <code><tag></code> to the specified domains. Before assigning a selection, the variable's model must be set using <code>model.variable(<tag>).model(<mtag>)</code>. Only the global selection and selections on a geometry in the model can be used. For a complete list of methods available under <code>selection()</code>, see Selections.</p> <p><code>model.variable(<tag>).remove(<var>)</code> removes a variable from the tagged variable entity.</p> <p><code>model.variable(<tag>).varnames()</code> returns the names of all expressions as a string array.</p> <p><code>model.variable(<tag>).get(<var>)</code> returns the variable value as a string.</p>

`model.variable(<tag>).descr(<var>)` returns the variable description as a string.

`model.variable(<tag>).model()` returns the model.

`model.variable(<tag>).scope()` returns the fully qualified scope name.

`model.variable(<tag>).selection().named()` returns the selection tag as a string.

`model.variable(<tag>).selection().getType()` returns domain information.

For available methods, see [model.selection\(\)](#).

Examples

Define the expression e as $x+1$ in Domains 1 and 2 and as $x-1$ in Domain 3.

```
Model model = ModelUtil.create("Model");
model.modelNode().create("mod1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("blk1", "Block");
model.geom("geom1").run();
model.variable().create("e1").set("e", "x+1");
model.variable("e1").model("mod1");
model.variable("e1").selection().geom("geom1",2);
model.variable("e1").selection().set(new int[]{1,2});
model.variable().create("e2").set("e", "x-1");
model.variable("e2").model("mod1");
model.variable("e2").selection().geom("geom1",2);
model.variable("e2").selection().set(3);
```

See Also

[model.selection\(\)](#)

Purpose	Manipulate views.
Syntax	<pre>model.view().create(<vtag>,<gtag>) model.view().create(<vtag>,<viewdim>) model.view().create(<vtag>,<gtag>,<workplane>) model.view(<vtag>).set(<pname>,<pvalue>) model.view(<vtag>).getType(<pname>) model.view(<vtag>).axis().set(<pname>,<pvalue>) model.view(<vtag>).axis().getType(<pname>) model.view(<vtag>).camera().set(<pname>,<pvalue>) model.view(<vtag>).camera().getType(<pname>) model.view(<vtag>).light().create(<ltag>,<ltype>) model.view(<vtag>).light(<ltag>).set(<pname>,<pvalue>) model.view(<vtag>).light(<ltag>).getType(<pname>) model.view(<vtag>).hideObjects().create(<htag>) model.view(<vtag>).hideObjects(<htag>).set(<pname>,<pvalue>) model.view(<vtag>).hideObjects(<htag>).getType(<pname>) model.view(<vtag>).hideEntities().create(<htag>) model.view(<vtag>).hideEntities(<htag>).set(<pname>,<pvalue>) model.view(<vtag>).hideEntities(<htag>).getType(<pname>)</pre>
Description	<p><code>model.view()</code> is a list of views that can be used when viewing geometry/mesh and plot groups. Each view has an axis and some properties on the top level. In 3D a view also has a camera and a list of lights. All views also have a list of hide features.</p> <p><code>model.view().create(<vtag>,<gtag>)</code> creates a view tied to the geometry with the given tag. The dimension of the view will be the same as the dimension for the geometry.</p> <p><code>model.view().create(<vtag>,<viewdim>)</code> creates a view with the given tag for the given dimension (1, 2 or 3). These views are not tied to any geometry and will show up under the Views node under Results.</p> <p><code>model.view().create(<vtag>,<gtag>,<workplane>)</code> creates a view tied to the work plane with the given tag in the geometry sequence with the given tag. The dimension of the view will be 2.</p> <p><code>model.view(<vtag>).set(<pname>,<pvalue>)</code> sets the given property to the given value.</p>

`model.view(<vtag>).getType(<pname>)` returns the property with the given name of type *Type*.

TABLE 2-51: VIEW PROPERTIES

NAME	VALUE	DIMENSIONS	DESCRIPTION
default	on off	1, 2, 3	If this is the default view to use when viewing the geometry and mesh.
headlight	on off	3	If the light in the camera should be turned on.
locked	on off	1, 2, 3	If the settings should be updated from interactive changes or not.
scenelight	on off	3	If the background lights as specified by the added lights should be turned on.
wireframe	on off	3	If wireframe rendering should be used.

`model.view(<vtag>).axis().set(<pname>, <pvalue>)` sets the given axis property to the given value. Which axis properties that are available in the different dimensions are given in the table below.

`model.view(<vtag>).axis().getType(<pname>)` returns the axis property with the given name.

TABLE 2-52: AXIS PROPERTIES

NAME	VALUE	DIMENSIONS	DESCRIPTION
auto	on off	1, 2, 3	Set if axis settings should be automatically stored and updated from interactive changes using mouse and toolbar buttons.
equal	on off	2, 3	Should the same scaling be used for all directions
extrax	double array	2	An array with extra x grid lines
extray	double array	2	An array with extra y grid lines
logx	on off	1	Should log scale be used for the x-axis
logy	on off	1	Should log scale be used for the y-axis
manualspacing	on off	2	Should manual spacing be used for x and y grid lines.
manuallimits	on off	1, 2, 3	Should manual axis limits be used. If not a zoom extents is performed each time something is plotted into the axis.
xmin	double	1, 2, 3	The minimum x-coordinate

TABLE 2-52: AXIS PROPERTIES

NAME	VALUE	DIMENSIONS	DESCRIPTION
xmax	double	1, 2, 3	The maximum <i>x</i> -coordinate
xspacing	double	2	Manual spacing for <i>x</i> grid lines
ymin	double	2, 3	The minimum <i>y</i> -coordinate
ymax	double	2, 3	The maximum <i>y</i> -coordinate
yspacing	double	2	Manual spacing for <i>y</i> grid lines
zmin	double	3	The minimum <i>z</i> -coordinate
zmax	double	3	The maximum <i>z</i> -coordinate

`model.view(<vtag>).camera().set(<pname>, <pvalue>)` sets the given camera property to the given value.

`model.view(<vtag>).camera().getType(<pname>)` returns the camera property with the given name.

TABLE 2-53: CAMERA PROPERTIES

NAME	VALUE	DESCRIPTION
auto	on off	Set if camera settings should be automatically stored and updated from interactive changes using the mouse.
position	double array	The position of the camera
target	double array	The point the camera looks at
up	double array	The up direction
viewangle	double	The view angle of the camera

`model.view(<vtag>).light().create(<ltag>, <ltype>)` creates a light with the given tag and type. `<ltype>` can be any of 'Direction', 'Point' and 'Spot'.

`model.view(<vtag>).light(<ltag>).set(<pname>, <pvalue>)` sets the given light property to the given value. Different properties are available for the different types of lights according to the table below.

`model.view(<vtag>).light(<ltag>).getType(<pname>)` returns the light property with the given name.

TABLE 2-54: LIGHT PROPERTIES

NAME	VALUE	LIGHT TYPES	DESCRIPTION
color	String or RGB-triplet	all	The color of the light.
cameracoord	on off	all	If the light should be defined in the camera coordinate system or the world coordinate system.
direction	double array	Direction Spot	The direction from which the light shines or is directed at.
position	double array	Point, Spot	The position from which the light shines.
spreadangle	double	Spot	The spread angle for the light.

`model.view(<vtag>).hideObjects().create(<htag>)` creates a hide feature of geometric objects.

`model.view(<vtag>).hideEntities().create(<htag>)` creates a hide feature of geometric entities.

The API for manipulating them are similar to the API for selections.

See Also

[model.result\(\)](#)

Purpose

Add and manipulate weak form contributions.

Syntax

```
model.weak().create(<tag>);
model.weak(<tag>).weak(<wlist>);
model.weak(<tag>).weak(<pos>,<wexpr>);
model.weak(<tag>).intRule(<irlist>);
model.weak(<tag>).intRule(<pos>,<irule>);
model.weak(<tag>).condition(<condition>);
model.weak(<tag>).selection().named(<seltag>);
model.weak(<tag>).selection().set(...);

model.weak(<tag>).weak();
model.weak(<tag>).intRule();
model.weak(<tag>).condition();
model.weak(<tag>).selection().named();
model.weak(<tag>).selection().getType();
```

Description

`model.weak(<tag>)` is a weak form entity with tag `<tag>`.

`model.weak().create(<tag>)` creates a weak form entity with tag `<tag>`.

`model.weak(<tag>).weak(<wlist>)` sets the weak equations. You can supply a single weak expression or a list of weak expressions. `<wlist>` is a string or a string array.

`model.weak(<tag>).weak(<pos>,<wexpr>)` sets the weak equations at position `<pos>` in the weak list.

`model.weak(<tag>).intRule(<irlist>)` assigns the integration rules to the weak form feature. The list of integration rules must have the same length as the list of weak expressions, or be of length 1. In the latter case all weak expressions use the same integration rule.

`model.weak(<tag>).intRule(<pos>,<irule>)` sets the integration rule at position `<pos>` in the integration rule list.

`model.weak(<tag>).condition(<condition>)` introduces conditional assembly. The feature is assembled if `<condition>` is true.

`model.weak(<tag>).selection().named(<seltag>)` or, alternatively, `model.weak(<tag>).selection().set(...)` assigns the weak form feature to the domain selection. For a complete list of methods available under `selection()`, see [Selections](#). Only selections at a single geometry level is allowed in the selection.

`model.weak(<tag>).weak()` returns the weak equations as a string array.

`model.weak(<tag>).intRule()` returns the integration rule tags as a string array.

`model.weak(<tag>).condition()` returns the condition as a string.

`model.weak(<tag>).selection().named()` returns the selection tag as a string.

`model.weak(<tag>).selection().getType()` returns domain information. See [Selections](#) for available methods.

Examples

Define the weak expressions $u*u_test$ and $v*v_test$ on the selection `dom1`, integration rule `gp1` and frame ref.

```
model.weak().create("w1").selection().named("dom1");
model.weak("w1").intRule("gp1");
model.weak("w1").weak(new String[]{"u*u_test", "v*v_test"});
```

See Also

[model.coeff\(\)](#), [model.shape\(\)](#)

Geometry

This chapter includes reference information about the geometry commands and how to work with a geometry sequence and the geometry objects to create the model geometry.

In this chapter:

- [About Geometry Commands](#)
- [Working with a Geometry Sequence](#)
- [Geometry Settings](#)
- [Work Planes](#)
- [Virtual Operations](#)
- [Geometry Object Information](#)
- [Measurements](#)
- [Inserting a Geometry Sequence from a File](#)
- [Exporting Geometry to File](#)
- [Geometry Commands](#)

About Geometry Commands

The following list includes the geometry commands that are documented in this chapter:

- `Array`
- `BezierPolygon`
- `Block`
- `Chamfer`
- `Circle`
- `CollapseEdges`
- `Compose, Union, Intersection, Difference`
- `CompositeDomains`
- `CompositeEdges`
- `CompositeFaces`
- `Cone`
- `ConvertToSolid, ConvertToSurface, ConvertToCurve, ConvertToPoint`
- `Cylinder`
- `Delete`
- `ECone`
- `EditObject`
- `Ellipse`
- `Ellipsoid`
- `Extrude`
- `Fillet`
- `Finalize`
- `FromMesh`
- `Helix`
- `Hexahedron`
- `IgnoreEdges`
- `IgnoreFaces`

- IgnoreVertices
- Import DXF
- Import ECAD
- Import geometry sequence
- Import mphbin/mphtxt
- Import STL/VRML
- Interpolation Curve
- Interval
- MeshControlDomains
- MeshControlEdges
- MeshControlFaces
- MeshControlVertices
- MergeVertices
- Mirror
- Move, Copy
- ParametricCurve
- ParametricSurface
- Point
- Polygon
- Pyramid
- Rectangle
- Revolve
- Rotate
- Scale
- Selection
- Sphere
- Split
- Square
- Sweep
- Tangent
- Tetrahedron

- [Torus](#)
- [WorkPlane](#)



See Also

- [Features for Creating Geometric Primitives](#)
- [Features for Geometric Operations](#)
- [Features for Virtual Operations](#)
- [Features for Mesh Control](#)
- [Geometry Object Information Methods](#)

Features for Creating Geometric Primitives

[Table 3-1](#) is an overview of the features for creating 3D geometric primitives:

TABLE 3-1: 3D GEOMETRIC PRIMITIVES

NAME	DESCRIPTION
BezierPolygon	Chain of connected line segments, quadratic or cubic curves
Block	Right-angled parallelepiped (box)
Cone	Right circular cone or cone frustum
Cylinder	Right circular cylinder
ECone	Oblique cone or cone frustum with elliptic base
Ellipsoid	Ellipsoid
Helix	Helix solid, surface, or curve
Hexahedron	Hexahedron bounded by bilinear faces
ParametricCurve	Curve defined by coordinate expressions
ParametricSurface	Surface defined by coordinate expressions
Point	One or several points
Polygon	Chain of connected line segments
Pyramid	Rectangular pyramid
Sphere	Sphere or ball
Tetrahedron	Tetrahedron
Torus	Torus

Table 3-2 is an overview of the features for creating 2D geometric primitives:

TABLE 3-2: 2D GEOMETRIC PRIMITIVES

NAME	DESCRIPTION
BezierPolygon	Chain of connected line segments, quadratic or cubic curves
Circle	Circle or disc
Ellipse	Ellipse
ParametricCurve	Curve defined by coordinate expressions
Point	One or several points
Polygon	Chain of connected line segments
Rectangle	Rectangle
Square	Square

Table 3-3 is an overview of the features for creating 1D geometric primitives:

TABLE 3-3: 1D GEOMETRIC PRIMITIVES

NAME	DESCRIPTION
Interval	One interval, or a chain of connected intervals
Point	One or several points

Features for Geometric Operations

The `Import` feature imports geometry objects from a file or from another geometry. The `FromMesh` feature constructs a geometry object from a (deformed) mesh.

Table 3-4 through Table 3-8 list the features that create new geometric objects from existing ones:

TABLE 3-4: WORK-PLANE RELATED FEATURES (ONLY 3D)

NAME	DESCRIPTION
WorkPlane	Create a work plane for drawing 2D objects that are embedded into 3D
Extrude	Extrude planar objects into 3D
Revolve	Revolve planar objects into 3D
Sweep	Sweep a face along a spine curve to create a solid in 3D

TABLE 3-5: BOOLEAN OPERATIONS

NAME	DESCRIPTION
Compose, Union, Intersection, Difference	
Compose	Compose solids using a set formula
Difference	Subtract solids from solids
Intersection	Intersect solids
Union	Unite geometry objects

TABLE 3-6: LINEAR TRANSFORMATIONS

NAME	DESCRIPTION
Array	Rectangular or linear array of geometry objects
Mirror	Reflect objects in a plane (3D), a line (2D), or a point (1D)
Rotate	Rotate geometry objects about a center point
Scale	Scale geometric objects about a center point
Move, Copy	
Move	Translate geometry objects
Copy	Make a displaced copy of geometry objects

TABLE 3-7: OBJECT TYPE CONVERSIONS

NAME	DESCRIPTION
ConvertToSolid, ConvertToSurface, ConvertToCurve, ConvertToPoint	
ConvertToSolid	Unite and convert objects to a single solid object
ConvertToSurface	Unite and convert 3D objects to a single surface object
ConvertToCurve	Unite and convert 2D or 3D objects to a single curve object
ConvertToPoint	Unite and convert objects to a single point object

TABLE 3-8: OTHER OPERATIONS

NAME	DESCRIPTION
Chamfer	Chamfer corners in 2D geometry objects
Fillet	Fillet corners in 2D geometry objects
Tangent	Line segment tangent to an edge in 2D

TABLE 3-8: OTHER OPERATIONS

NAME	DESCRIPTION
Delete	Delete entities (domains, boundaries, edges, or points) from objects, or delete entire geometry objects
Split	Split geometry objects into their constituent entities
Finalize	Finalize geometry by uniting all geometry objects to a single one

Features for Virtual Operations

Table 3-9 lists the features that correspond to virtual operations:

TABLE 3-9: VIRTUAL GEOMETRY RELATED FEATURES (ONLY 2D AND 3D)

NAME	DESCRIPTION
IgnoreVertices	Virtually remove isolated vertices or vertices adjacent to two edges only
IgnoreEdges	Virtually remove isolated edges or edges adjacent to precisely two faces or between two domains
IgnoreFaces	Virtually remove isolated faces or faces between two domains
CompositeEdges	Form virtual composite edges from sets of connected edges by ignoring the vertices between the edges in each set
CompositeFaces	Form virtual composite faces from sets of connected faces by ignoring the edges between the faces in each set
CompositeDomains	Form virtual composite domains from sets of connected domains by ignoring the boundaries between the domains in each set
CollapseEdges	Virtually collapse each edge into a vertex by merging its adjacent vertices
MergeVertices	Virtually merge one adjacent vertex of an edge with the other adjacent vertex

Features for Mesh Control

Table 3-10 lists the features that correspond to mesh control operations:

TABLE 3-10: MESH CONTROL RELATED FEATURES (ONLY 2D AND 3D)

NAME	DESCRIPTION
MeshControlVertices	Use vertices for mesh control only
MeshControlEdges	Use edges for mesh control only

TABLE 3-10: MESH CONTROL RELATED FEATURES (ONLY 2D AND 3D)

NAME	DESCRIPTION
MeshControlFaces	Use faces for mesh control only
MeshControlDomains	Use domains for mesh control only

Geometry Object Information Methods

GENERAL INFORMATION

TABLE 3-11: GENERAL GEOMETRY INFORMATION METHODS

METHOD	DESCRIPTION
check	Check object for errors
getBoundingBox	Get bounding box around object
getSDim	Get space dimension
getType	Get object type (solid, surface, curve, point, mixed, empty)
hasCadRep	Is represented using CAD Import Module kernel

GEOMETRIC ENTITY COUNTERS

TABLE 3-12: GEOMETRIC ENTITY COUNTERS

METHOD	DESCRIPTION
getNEntities	Get number of entities of different dimensions
getNVertices	Get number of vertices
getNEdges	Get number of edges
getNFaces	Get number of faces
getNBoundaries	Get number of boundaries
getNDomains	Get number of domains
getNEntitiesMesh	Get number of entities of different dimensions in the geometry used for meshing

ADJACENCY

TABLE 3-13: ADJACENCY BETWEEN GEOMETRIC ENTITIES

METHOD	DESCRIPTION
getStartEnd	Get start and end vertices of edges
getUpDown	Get up and down domain indices
getVertexDomain	Get domain index for isolated vertices
getSD	Get domain index for isolated vertices
getAdj	Get adjacency matrices
getAdjOrient	Get adjacency orientation
getAdjSparse	Get adjacency matrix in sparse format

EDGE EVALUATION

TABLE 3-14: EDGE EVALUATION METHODS

METHOD	DESCRIPTION
edgeParamRange	Get parameter range of edge
edgeX	Evaluate coordinates
edgeDX	Evaluate first derivative
edgeDDX	Evaluate second derivative
edgeNormal	Evaluate normal vector in 2D
edgeCurvature	Evaluate curvature
edgeTorsion	Evaluate torsion in 3D

FACE EVALUATION

TABLE 3-15: FACE EVALUATION METHODS

METHOD	DESCRIPTION
faceParamRange	Get parameter ranges of face
faceX	Evaluate coordinates
faceDX	Evaluate first derivatives
faceDDX	Evaluate second derivatives
faceNormal	Evaluate normal vector
faceFF1	Evaluate first fundamental form
faceFF2	Evaluate second fundamental form
faceGaussCurvature	Evaluate Gauss curvature
faceMeanCurvature	Evaluate mean curvature

GEOMETRY REPRESENTATION ARRAYS

TABLE 3-16: GET ARRAYS IN GEOMETRY REPRESENTATION

METHOD	DESCRIPTION
getVertex	Get vertex matrix
getEdges	Get edge matrix
getFaces	Get face matrix
getPVertex	Get parameter vertices (embeddings of vertices in faces)
getPEdge	Get parameter edges (embeddings of edges in faces)
getVertexCoord	Get vertex coordinates

Working with a Geometry Sequence

This section describes how to construct geometries using Java methods. A *geometry* is defined by a *geometry sequence* consisting of *geometry features*. Each feature generates a set of *output geometry objects* when you *build* the feature. An *operation feature* takes previously generated geometry objects as input and usually deletes them. Each geometry sequence in 1D ends with a `Finalize` feature that forms a single output object by uniting all existing geometry objects. A geometry sequence in 2D or 3D also contains a `Finalize` feature, but in 2D and 3D it is possible to add features corresponding to *virtual operations* after the `Finalize` feature (see [Virtual Operations](#) for more information). The output object of the last feature of a sequence is referred to as the *finalized geometry*. The finalized geometry is used for meshing and physics modeling.

In this section:

- [Adding a Model \(Geometry\)](#)
- [Adding a Geometry Feature](#)
- [Editing a Geometry Feature](#)
- [Building Geometry Features](#)
- [Feature Status](#)
- [Accessing Geometry Object Names](#)
- [Deleting and Disabling Geometry Features](#)
- [Deleting Geometry Objects](#)



- [Geometry Modeling Features](#) in the *COMSOL Multiphysics Reference Guide*
 - [Geometry Modeling and CAD Tools](#) in the *COMSOL Multiphysics User's Guide*
-

Adding a Model (Geometry)

To add a new geometry to the model object `model`, enter

```
model.geom().create(<tag>,sDim);
```

where `<tag>` is the geometry's tag (an identifier of your choice), and `sDim` is its space dimension (1, 2, or 3).

The geometry is added to the last created model node. If no model node exists in the model, a model node tagged `mod1` is automatically created for you. A physics interface using the geometry must belong to the same model node as the geometry.

You can change the model of a geometry by entering

```
model.geom(<tag>).model(<mtag>);
```

where `<mtag>` is the tag of a model node.



See Also

`model.modelNode()`

Adding a Geometry Feature

To add a feature to a geometry tagged `<tag>`, enter

```
model.geom(<tag>).feature().create(<ftag>, ftype);
```

where `<ftag>` is the feature's tag (an identifier of your choice), and `ftype` is the feature's type. Feature types are capitalized and case-sensitive, for example `Rectangle`.

When you add a feature, it is inserted after the *current feature*. You can get the tag of the current feature type by entering

```
String ftag = model.geom(<tag>).current();
```

If `ftag` is the empty string, the current feature is the beginning of the geometry sequence, that is, the empty state before all features. When the feature has been added, it automatically becomes current, but it is not built automatically.

All properties in a new feature get a default value.

Editing a Geometry Feature

To change a property value in a feature, enter

```
model.geom(<tag>).feature(<ftag>).set(property, <value>);
```

where `property` is a property name and `<value>` is a property value.

All numeric properties can be given either as a numeric value or as a string expression that can contain parameters defined in `model.param()`. When building the feature, the string expressions are evaluated using the current values of the parameters.



Note

Behavior has changed since version 3.5a. String expression arguments are retained and not converted to numeric values.

To get the value of a property, enter one of the following, depending on the type of the property:

```
double d = model.geom(<tag>).feature(<ftag>).getDouble(property);
String s = model.geom(<tag>).feature(<ftag>).getString(property);
double[] da =
    model.geom(<tag>).feature(<ftag>).getDoubleArray(property);
String[] sa =
    model.geom(<tag>).feature(<ftag>).getStringArray(property);
double[][] dm =
    model.geom(<tag>).feature(<ftag>).getDoubleMatrix(property);
String[][] sm =
    model.geom(<tag>).feature(<ftag>).getStringMatrix(property);
```

If you request a numerical value for a string property, it is evaluated using the current values of the parameters in `model.param()`.



See Also

- [getType\(\)](#)
 - [set\(\)](#)
-

SELECTIONS

There are primitive features and operation features. Operations features take existing geometry objects as input and create new geometry objects from them. The input objects are usually specified in the `input` selection:

```
model.geom(<tag>).feature(<ftag>).selection("input")
    set(inputObjects);
```

where `inputObjects` is a string array with object or feature names. If `inputObjects` contains a feature name, it refers to all objects generated by this feature.



See Also

Geometry Object Selection Methods

Usually, the input objects of an operation feature is removed when building the feature. To change this behavior, a property `keep` is available for many operations features. If `keep` is set to on, the input objects are kept when building the feature.

Building Geometry Features

To generate the output objects of a feature, you must *build* the feature. Enter

```
model.geom(<tag>).run(<ftag>);
```

to build the feature `<ftag>` and all its preceding features (the features are built in the order from the first to the last). When the build has completed, the feature `<ftag>` becomes current.

To build all preceding features of the feature `<ftag>`, enter

```
model.geom(<tag>).runPre(<ftag>);
```

To build all features preceding the `Finalize` feature, enter

```
model.geom(<tag>).runAll();
```

To build all features, including the `Finalize` feature, enter

```
model.geom(<tag>).run();
```

ERRORS

If an error occurs when building a feature, the build stops, and the feature before the failing feature becomes current. The failing feature gets a *error feature* appended, which contains the error message. To access the error message, enter

```
String msg = model.geom(<tag>).feature(<ftag>).message();
```

To access the error feature, its message and detailed message, enter

```
String msg = model.geom(<tag>).feature(<ftag>).problem("error").  
    getString("message");  
String det = model.geom(<tag>).feature(<ftag>).problem("error").  
    getString("details");
```


WARNINGS

After a successful build, a feature can get warning features appended, which contain warning messages. To access the first warning message, enter

```
String msg = model.geom(<tag>).feature(<ftag>).message();
```

To access the warning features, their messages and detailed messages, enter

```
String msg = model.geom(<tag>).feature(<ftag>).problem(<wtag>).  
    getString("message");  
String det = model.geom(<tag>).feature(<ftag>).problem(<wtag>).  
    getString("details");
```

where *<wtag>* is *warning1*, *warning2*, and so on.

Feature Status

The *status* of a feature can be one of the following:

- *Built* or *warning*. This means that the none of the feature's properties have changed since the feature was last built, and the features of the input objects are all built. If the status is *warning*, the feature contains warning messages.
- *Edited*. This means that some of the feature's properties have changed since the feature was last built.
- *Needs rebuild*. This means that the feature generating some input object is not built.
- *Error*. This means that the feature contains an error message.

You can examine the status of a feature by entering

```
String status = model.geom(<tag>).feature(<ftag>).status();
```

Accessing Geometry Object Names

Each feature produces one or several output geometry objects. To get the names of these objects, enter

```
String[] oNames = model.geom(<tag>).feature(<ftag>).objectNames();
```

To get the names of all currently existing geometry objects (the geometry objects that were generated by the last build), enter

```
String[] oNames = model.geom(<tag>).objectNames();
```

To access one of these objects, you can enter

```
GeomObject go = model.geom(<tag>).object(<objname>);
```

where the string *<objname>* is an object name. If *<objname>* does not exist in the current state, you get an error message. You can get information about the geometry object go by using the *geometry information methods*, for example

```
int numberOfFaces = go.getNFaces();
```



See Also

Geometry Object Information

To access the finalized geometry (the output of the last feature), use

```
model.geom(<tag>)
```

NAMING OF GEOMETRY OBJECTS

The names of the output objects of a feature are formed by appending characters after the feature's tag, in one of the following ways:

- `ftag(index)`, for example `split1(1)`, `split1(2)`, `split1(3)` if the feature tagged `split1` has three output objects. This method is used for most features.
- `ftag(i1, i2, ...)`, for example `arr1(1,1)`, `arr1(1,2)`, `arr(2,1)`, `arr1(2,2)` for a 2-by-2 array feature tagged `arr1`. This method is only used for the Array feature.
- `ftag.objectNameIn2D`, for example `wp1.r1`, `wp1.pt1(1)`, `wp1.pt1(2)` if the work plane feature `wp1` contains the 2D objects `r1`, `pt1(1)`, and `pt1(2)`. This method is only used for the `WorkPlane` feature.
- `ftag.objectName`. This method can be used for the `Import` feature, and then `objectName` is taken from the CAD file.

Deleting and Disabling Geometry Features

To delete a feature, enter

```
model.geom(<tag>).feature().remove(<ftag>);
```

To disable a feature, enter

```
model.geom(<tag>).feature(<ftag>).active(false);
```

The disabled feature does not affect the finalized geometry—its output is empty. To enable a disabled feature, enter

```
model.geom(<tag>).feature(<ftag>).active(true);
```

You can get the enabled/disabled status of a feature by entering

```
boolean isEnabled = model.geom(<tag>).feature(<ftag>).active();
```

Deleting Geometry Objects

You can use the following operation to delete objects from the geometry sequence.

```
model.geom(<tag>).delete(String[]);
```

In the input string array you specify the names of the objects to delete. The operation deletes objects that correspond to primitive geometry features by removing these features from the sequence. The operation then deletes the remaining objects by adding and building a `Delete` feature with the objects in its selection.



Note

When using the delete operation the status of the current feature and all its preceding features must be built.

Geometry Settings

You can control the following general settings for a geometry:

- [Length Unit](#)
- [Angular Unit](#)
- [Scale Values When Changing Unit](#)
- [Geometry Representation in 3D](#)
- [Default Relative Repair Tolerance](#)
- [Automatic Rebuild](#)

Length Unit

The default length unit is meter. To change the length unit, enter

```
model.geom(<tag>).lengthUnit(newLengthUnit);
```

where *newLengthUnit* is a string like "mm", "in", or "ft".

To get the current length unit, enter

```
String currentUnit = model.geom(<tag>).lengthUnit();
```

The length unit is used in fields for lengths, and for visualization of the geometry. In fields you can override the unit, for example by entering 13[mm]. When solving the model, all lengths are converted to meters.

Angular Unit

The default angular unit is degrees. To change the angular unit, enter

```
model.geom(<tag>).angularUnit(newAngularUnit);
```

where *newAngularUnit* is deg or rad.

To get the current angular unit, enter

```
String currentUnit = model.geom(<tag>).angularUnit();
```

The angular is used in fields for angles. You can override the unit, for example by entering 0.3[rad]. Numeric inputs and outputs of trigonometric functions are always assumed to be in radians, though.

Scale Values When Changing Unit

When you change the length unit or angular unit there are two possibilities to interpret pure numeric values in the geometry and meshing sequences. The first possibility is to reinterpret the numeric value in the new unit; a circle of radius 1.0 (meter) becomes a circle of radius 1.0 (millimeter), assuming the length unit changes from meter to millimeter.

The other possibility is to scale the numbers; a circle of radius 1.0 (meter) becomes a circle of radius 1000.0 (millimeter). To control the behavior, use

```
model.geom(<tag>).scaleUnitValue(newScaleValue);
```

where *newScaleValue* is `true` if you want values to be scaled, and `false` otherwise. The default value is `false`.

To get the currently used method, enter

```
boolean currentScaleValue = model.geom(<tag>).scaleUnitValue();
```

Geometry Representation in 3D

This setting controls which kernel (modeler) is used to represent and operate on the geometry objects, COMSOL Multiphysics' own kernel or the CAD Import Module's kernel (Parasolid). To change the geometry representation, enter

```
model.geom(<tag>).geomrep(newGeomRep);
```

where *newGeomRep* is `comsol` or `cadps`.

- If you choose `comsol`, all objects are represented using COMSOL's kernel.
- If you choose `cadps`, all features that support this use the CAD Import Module's kernel. For example, the Work Plane, Extrude, and Revolve features currently do not support this kernel. This alternative requires that you have license for the CAD Import Module.

The default geometry representation is controlled by the preference setting **Geometry > Default Geometry representation**. To change or read this preference setting, enter

```
ModelUtil.setDefaultGeometryKernel(defaultGeomRep);  
ModelUtil.getDefaultGeometryKernel();
```

If the chosen geometry representation cannot be used (for example, because a feature requires the CAD Import Module's kernel or because no CAD license is available), the behavior is controlled by the preference setting **Geometry > Switch kernel automatically**. To change or read this preference setting, enter

```
ModelUtil.setAutoSwitchGeometryKernel(auto);
ModelUtil.getAutoSwitchGeometryKernel();
```

If automatic switching is enabled, the geometry kernel will automatically be switched when needed. If automatic switching is disabled, an error message will be generated if the selected kernel cannot be used.

When you change the geometry representation setting, all features that support the CAD Import Module's kernel get *edited* status. To rebuild the geometry using the new kernel, use the `run` or `runAll` methods.

Default Relative Repair Tolerance

The *default relative repair tolerance* is $1e-6$ by default. You can change it by entering `model.geom(<tag>).repairTol(<newDefaultRepairTol>);`

To get the current default relative repair tolerance, enter

```
double reptol = model.geom(<tag>).repairTol();
```

The default relative repair tolerance is the default value that is used when you add a new feature that has a `repairTol` property, for example Boolean operations and conversions. Changing the default relative repair tolerance does not affect the tolerances in existing features. Adjust the relative repair tolerance if you experience problems with a Boolean operation. The absolute repair tolerance is the relative repair tolerance times the maximum coordinate of the input objects. Geometric entities that have a distance less than the absolute repair tolerance is merged.

Automatic Rebuild

This setting controls if the geometry sequence is automatically rebuilt when clicking on a node in the model tree outside the geometry sequence. You can change it by entering:

```
model.geom(<tag>).autoRebuild(<newAutoRebuild>);
```

where `<newAutoRebuild>` is either `on` or `off`.

The default geometry representation is controlled by the preference setting **Geometry > Automatic rebuild > Default in new geometries**.

Work Planes

In 3D, you can create 3D objects by defining 2D objects in *work planes* and then *extruding* and *revolving* these into 3D objects.

To add a WorkPlane feature, use

```
model.geom(<tag>).feature().create(<ftag>, "WorkPlane");
```

You access a work planes 2D geometry sequence by the `geom()` method. To add a 2D feature to a work plane, use

```
model.geom(<tag>).feature(<ftag>).geom().feature().  
create(<ftag1>, ftype);
```

where `<ftag>` refers to a WorkPlane feature and `ftype` refers to a 2D feature type.



Note

A work plane's geometry sequence does not contain a `Finalize` feature.

A work plane's geometry sequence inherits its settings from its 3D sequence.



See Also

For more information on the settings for a geometry sequence see [Geometry Settings](#).

When you build a work plane feature its corresponding 2D sequence builds automatically and the geometry objects defined by the 2D sequence *embed* into 3D geometry objects in the 3D sequence. You can then extrude or revolve these embedded point, curve, or surface objects into curve, surface, or solid objects, respectively, by `Extrude` or `Revolve` features, respectively.

Virtual Operations

In this section:

- [About Virtual Operations](#)
- [Mesh Control Entities](#)

About Virtual Operations

In 2D and 3D it is possible to reduce the number of vertices, edges, faces, and domains of the geometry by using *virtual operation features*. To add the first virtual operation feature to a sequence you need to build the finalize feature by entering

```
model.geom(<tag>).run("fin");
```

You can then add the virtual operation feature by entering

```
model.geom(<tag>).feature().create(<ftag>,ftype);
```

where *<ftag>* is the feature's tag (an identifier of your choice), and *ftype* is the feature's type. To build the feature, enter

```
model.geom(<tag>).run(<ftag>);
```

To build all features, including the finalize feature and all virtual operation features, and to create the finalized geometry, enter

```
model.geom(<tag>).run();
```

The finalized geometry of a sequence that contains virtual operation features is referred to as a *virtual geometry*. If you form a composite edge, face, or domain by using either a [CompositeEdges](#), [CompositeFaces](#), or a [CompositeDomains](#) feature, respectively (or the analogues [IgnoreVertices](#), [IgnoreEdges](#), or [IgnoreFaces](#) features) the resulting edge, face, or domain is referred to as a *virtual composite edge*, *virtual composite face*, or *virtual composite domain*, respectively, or more generally, a *virtual composite entity*.

Mesh Control Entities

Sometimes it is desirable to use certain geometric entities only when constructing the mesh. For example, you can add a curve inside a domain to control mesh element size there. If you mark this curve as a *mesh control entity*, it is not included in the geometry

used when defining the physics. An advantage is that the final mesh need not respect this curve exactly; it is used only to control element size.

You can use the `keepformesh` property of the Composite and Ignore features described above to define mesh control entities. Alternatively, you can use the `MeshControlDomains`, `MeshControlVertices`, `MeshControlEdges`, or `MeshControlFaces` features.

Geometry Object Information

You can get the geometry object named `<objname>` via

```
model.geom(<tag>).object(<objname>)
```



See Also

Accessing Geometry Object Names

The geometry itself,

```
model.geom(<tag>)
```

works as an object, namely the final geometry resulting from the sequence. To get information about these objects, you can apply the methods described in this section.

The corresponding COMSOL 3.5a functionality is also indicated in the tables below. This functionality existed in three forms: as options to the function `geominfo`, as `get` methods on geometry objects, and as utility functions starting with `flgeom`.

In this section:

- [General Information](#)
- [Geometric Entity Counters](#)
- [Adjacency](#)
- [Evaluation on an Edge](#)
- [Evaluation on a Face](#)
- [Geometry Representation Arrays](#)

General Information

TABLE 3-17: GENERAL GEOMETRY INFORMATION METHODS

METHOD	OUTPUT TYPE
<code>check()</code>	boolean
<code>exists()</code>	boolean
<code>getBoundingBox()</code>	double[sdim*2]
<code>getSDim()</code>	int
<code>getType()</code>	String
<code>hasCadRep()</code>	boolean

- `check()` returns true if the object is valid, and false if it contains errors.
- `exists()` returns true if an object exists.
- `getBoundingBox()` returns a bounding box for the object in the order `xmin`, `xmax`, `ymin`, `ymax`, `zmin`, `zmax`.
- `getSDim()` returns the space dimension of the geometry.
- `getType()` returns the object type: `solid`, `surface`, `curve`, `point`, `mixed`, or `empty`.
- `hasCadRep()` returns true if the object is represented using the CAD Import Module's geometry kernel (Parasolid).

Geometric Entity Counters

The following geometric entity counter methods are available:

TABLE 3-18: GEOMETRIC ENTITY COUNTER METHODS

METHOD	1D	2D	3D	OUTPUT TYPE	3.5A NAME
<code>getNEntities()</code>	√	√	√	int[]	
<code>getNVertices()</code>	√	√	√	int	<code>nv</code> , <code>flgeomnv</code>
<code>getNEdges()</code>	√	√	√	int	<code>ne</code> , <code>flgeomnes</code>
<code>getNFaces()</code>			√	int	<code>nf</code>
<code>getNBoundaries()</code>	√	√	√	int	<code>nbs</code> , <code>flgeomnbs</code>
<code>getNDomains()</code>	√	√	√	int	<code>ns</code> , <code>flgeomnmr</code>
<code>getNEntitiesMesh()</code>	√	√	√	int[]	

- `getNEntities` returns a vector of length 2 in 1D, length 3 in 2D, and length 4 in 3D. The vectors contain the number of geometric entities for each entity dimension.

The methods `getNVertices`, `getNEdges`, `getNFaces`, `getNBoundaries`, and `getNDomains` return the number of entities of the specified type.

- `getNEntitiesMesh` returns a vector of length 2 in 1D, length 3 in 2D, and length 4 in 3D. The vectors contain the number of geometric entities for each entity dimension in the geometry used for meshing. If there are no mesh control entities in the geometry, the output is identical to that of `getNEntities`.

Adjacency

The following geometry adjacency information methods are available:

TABLE 3-19: GEOMETRY ADJACENCY INFORMATION METHODS

METHOD	1D	2D	3D	OUTPUT TYPE	3.5A NAME
<code>getStartEnd()</code>	√	√	√	<code>int[2][]</code>	<code>se, flgeomse</code>
<code>getUpDown()</code>	√	√	√	<code>int[2][]</code>	<code>ud, flgeomud</code>
<code>getVertexDomain()</code>		√	√	<code>int[]</code>	<code>sd, flgeomsd</code>
<code>getSD()</code>		√	√	<code>double[]</code>	<code>sd, flgeomsd</code>
<code>getAdj(int, int)</code>	√	√	√	<code>int[][]</code>	<code>adj, flgeomadj</code>
<code>getAdj(int, int, int)</code>	√	√	√	<code>int[]</code>	<code>adj, flgeomadj</code>
<code>getAdjOrient(int, int)</code>	√	√	√	<code>int[][]</code>	<code>adj, flgeomadj</code>
<code>getAdjOrient(int, int, int)</code>	√	√	√	<code>int[][]</code>	<code>adj, flgeomadj</code>
<code>getAdjSparse(int, int)</code>	√	√	√	<code>int[3][]</code>	<code>adj, flgeomadj</code>

- `getStartEnd` returns the start and end vertices of all edges in the first and second row of the returned matrix.
- `getUpDown` returns the up and down domain number for all boundaries in the first and second row of the returned matrix.
- `getVertexDomain` returns the domain index for each vertex. For non-isolated vertices, the domain index is -1.
- `getSD` returns the domain index for each vertex. For non-isolated vertices, the domain index is NaN.
- `a = getAdj(fromDim, toDim)` returns a matrix where `a[fromIdx]=getAdj(fromDim, toDim, fromIdx)` contains the entities in dimension `toDim` that are adjacent to entity `fromIdx` in dimension `fromDim`.
- `ao = getAdjOrient(fromDim, toDim)` returns a matrix where `ao[fromIdx]=getAdjOrient(fromDim, toDim, fromIdx)` contains the

orientation flag for the entities in `getAdj(fromDim, toDim, fromIdx)`. The orientation flag is 1 if the adjacent entities have the same orientation, and -1 if they have the opposite orientation, and 2 if the relative orientation cannot be determined (for instance, for an edge interior to a face).

- `as = getAdjSparse(fromDim, toDim)` returns the adjacency matrix from entities in dimension `fromDim` to entities in dimension `toDim` on a sparse format, that is, `as[0]` are the entity numbers in dimension `fromDim`, `as[1]` are the entity numbers in dimension `toDim`, and `as[2]` are the corresponding orientation flags.

Evaluation on an Edge

The following edge evaluation methods are available in 2D and 3D:

TABLE 3-20: EDGE EVALUATION METHODS IN 2D AND 3D

METHOD	2D	3D	OUTPUT TYPE	3.5A NAME
<code>edgeParamRange(int)</code>	√	√	<code>double[2]</code>	<code>rng</code>
<code>edgeX(int, double[])</code>	√	√	<code>double[][D]</code>	<code>xx</code>
<code>edgeDX(int, double[])</code>	√	√	<code>double[][D]</code>	<code>dxx</code>
<code>edgeDDX(int, double[])</code>	√	√	<code>double[][D]</code>	<code>ddx</code>
<code>edgeNormal(int, double[])</code>	√		<code>double[][D]</code>	<code>nor</code>
<code>edgeCurvature(int, double[])</code>	√	√	<code>double[]</code>	<code>crv</code>
<code>edgeTorsion(int, double[])</code>		√	<code>double[]</code>	<code>crv</code>

The first input argument of all methods is the edge number. The second input argument, when it exists, is an array of parameter values for which to perform evaluation on the edge. For all but the first method, the first index in the output corresponds to the different parameter values, and the second index corresponds to the spatial coordinates.

- `edgeParamRange` returns the parameter range for evaluation on the edge.
- `edgeX` evaluates the parameters to coordinate values.
- `edgeDX` evaluates the parameters to first order derivative values.
- `edgeDDX` evaluates the parameters to second order derivative values.
- `edgeNormal` evaluates the parameters to normal vector values.
- `edgeCurvature` evaluates the parameters to curvature values.
- `edgeTorsion` evaluates the parameters to torsion values.

Evaluation on a Face

Use the following method for face evaluation in 3D. They do not work on virtual geometry objects.

TABLE 3-21: FACE EVALUATION METHODS IN 3D

METHOD	OUTPUT TYPE	3.5A NAME
<code>faceParamRange(int)</code>	<code>double[4]</code>	<code>rng, flgeomfs</code>
<code>faceX(int, double[][2])</code>	<code>double[][3]</code>	<code>xx</code>
<code>faceDX(int, double[][2])</code>	<code>double[][3][2]</code>	<code>dx</code>
<code>faceDDX(int, double[][2])</code>	<code>double[][3][2][2]</code>	<code>ddx</code>
<code>faceNormal(int, double[][2])</code>	<code>double[][3]</code>	<code>nor</code>
<code>faceFF1(int, double[][2])</code>	<code>double[][2]</code>	<code>ff1</code>
<code>faceFF2(int, double[][2])</code>	<code>double[][2]</code>	<code>ff2</code>
<code>faceGaussCurvature(int, double[][2])</code>	<code>double[]</code>	<code>crv</code>
<code>faceMeanCurvature(int, double[][2])</code>	<code>double[]</code>	<code>crv</code>

The first input argument of all methods is the face number. The second input argument, when it exists, is a matrix of parameter points, for which to perform evaluation. For all but the first method, the first index in the output corresponds to the different parameter points.

- `faceParamRange` returns two parameter ranges for evaluation on the face.
- `faceX` evaluates the parameters to coordinate values.
- `faceDX` evaluates the parameters to first order derivative values.
- `faceDDX` evaluates the parameters to second order derivative values.
- `faceNormal` evaluates the parameters to normal vector values.
- `faceFF1` evaluates the parameters to the first fundamental form values.
- `faceFF2` evaluates the parameters to the second fundamental form values.
- `faceGaussCurvature` evaluates the parameters to Gauss curvature values.
- `faceMeanCurvature` evaluates the parameters to mean curvature values.

Geometry Representation Arrays

Use the following methods to access the arrays in the internal representation of COMSOL geometry objects. They do not work on objects represented using the CAD Import Module's kernel, assembly geometries, or virtual geometries.

TABLE 3-22: GET ARRAYS IN GEOMETRY REPRESENTATION

METHOD	1D	2D	3D	OUTPUT TYPE	3.5A NAME
<code>getVertex()</code>	√	√	√	<code>double[][]</code>	vertex
<code>getEdge()</code>		√	√	<code>double[][]</code>	edge
<code>getFace()</code>			√	<code>double[][]</code>	face
<code>getPVertex()</code>			√	<code>double[][]</code>	pvertex
<code>getPEdge()</code>			√	<code>double[][]</code>	pedge
<code>getVertexCoord()</code>	√	√	√	<code>double[][]</code>	mp, flgeomvtx
<code>voidsAreLabeled()</code>	√	√	√	boolean	



Note

In version 4.2a, a possibility to represent void regions with negative domain labels was introduced. This can affect the methods `getVertex`, `getEdge`, and `getFace`. If the method `voidsAreLabeled()` returns `true`, the geometry object uses such domain labels. If `voidsAreLabeled()` returns `false`, all void regions are represented with the domain label 0, like in version 4.2.

- In 2D and 3D, `getVertex` returns $(sdim+2)$ -by- nv matrix representing the vertices of the object. The first $sdim$ rows are the coordinates of the vertices. Row $sdim+1$ contains the domain number if the vertex is isolated and is unspecified otherwise. The last row contains a relative local tolerance for the vertex. For nontolerant vertices the tolerance is NaN. This method does not work on virtual geometry objects.
- In 1D, `getVertex` returns a 3-by- $nvtx$ matrix representing the vertices of the 1D object. Row 1 provides the coordinates of the vertices. Rows 2 and 3 provide the up and down domain numbers, respectively.
- `getPVertex` returns a 6-by- npv matrix containing embeddings of vertices in faces. Row 1 contains the vertex index (that is, column from `getVertex`), rows 2 and 3 contain (s, t) coordinates of the vertex on the face, row 4 contains a face index, and row 5 contains the manifold index into the manifolds. Row 6 contains a relative local tolerance for the vertex. This method does not work on virtual geometry objects.

- In 3D, `getEdge` returns a 7-by-`ne` matrix representing the edges of the 3D object. Rows 1 and 2 contain the start and end vertex indices of the edge (0 if they do not exist), respectively. Rows 3 and 4 give the parameter values of these vertices. Row 5 gives the index of a domain if the edge is not adjacent to a face, and is unspecified otherwise. Row 6 gives a sign and an index to the underlying manifold. The sign indicates the direction of the edge relative the curve. Finally, row 7 contains a relative local tolerance for the edge. This method does not work on virtual geometry objects.
- In 2D, `getEdge` returns a 8-by-`ne` matrix representing the edges of the 2D object. Rows 1 and 2 contain the start and end vertex indices of the edge, respectively (0 if they do not exist). Rows 3 and 4 give the parameter values of these vertices. Rows 5 and 6 contain the left and right domain number of the edge, respectively. Row 7 gives a sign and an index to the array of underlying curves. The sign indicates the direction of the edge relative the curve. Row 8 contains a relative local tolerance for the edge.
- `getPEdge` returns a 10-by-`npe` matrix representing the embeddings of the edges in faces. The first row gives the index of the edge in `getEdge`. Rows 2 and 3 contain the start and end vertex indices from `getPVertex`, respectively. Rows 4 and 5 give the parameter values of these vertices. Row 6 and 7 give the indices of the faces to the left and right of the edge, respectively. Row 8 gives a sign and index to the parameter curve (if any), and row 9 gives the index to the surface. Row 10 contains a relative local tolerance for the edge. This method does not work on virtual geometry objects.
- `getFace` returns a 4-by-`nf` matrix representing the faces of the 3D geometry. Rows 1 and 2 contain the up and down domain index of the face, respectively, and row 3 contains the manifold index of the face. Row 4 contains a relative local tolerance for the face. This method does not work on virtual geometry objects.
- `getVertexCoord` returns a matrix with the vertex coordinates. Its dimension is the space dimension times the number of vertices.

Measurements

Geometric measurements is a tool to measure geometric entities and objects. You access it by entering

```
model.geom(<tag>).measure()
```

In this section:

- [Measuring Geometric Entities in Objects](#)
- [Measuring Objects](#)

Measuring Geometric Entities in Objects

To select entities you want to measure, enter

```
model.geom(<tag>).measure().selection().init(entDim);  
model.geom(<tag>).measure().selection().set(<objname>,entities);
```

where *entDim* is the dimension of the entities, *<objname>* is the object name, and *entities* is an integer array containing the entity numbers.

To get the volume/area/length of the selected entities, enter

```
double vol = model.geom(<tag>).measure().getVolume();
```

To get the area/length of the boundary of the selected entities, enter

```
double bndVol = model.geom(<tag>).measure().getBoundaryVolume();
```

If you have selected two vertices, you can get their distance by entering

```
double[] d = model.geom(<tag>).measure().getVtxDistance();
```

d[0] is the distance, and *d*[*i*] is the distance in the *i*th coordinate (*i* = 1, 2, 3).

If you have selected one vertex, you can get its coordinates by entering

```
double[] coord = model.geom(<tag>).measure().getVtxCoord();
```

Measuring Objects

To select objects you want to measure, enter

```
model.geom(<tag>).measure().selection().init();  
model.geom(<tag>).measure().selection().set(<objnames>);
```

where *<objnames>* is a string array containing the object names.

To get the total number of entities in the selected objects, enter

```
int[] entitiesPerDimension =  
    model.geom(<tag>).measure().getNEntities();
```

Inserting a Geometry Sequence from a File

To insert a geometry sequence from an MPH-file, enter

```
model.geom(<tag>).insertFile(<filename>, <sequencename>);
```

where *<filename>* and *<sequencename>* are strings.

To insert a geometry sequence from a different model, enter

```
model.geom(<tag>).insertSequence(<modeltag>, <sequencename>);
```

where *<modeltag>* and *<sequencename>* are strings.

E The following sequence imports three different geometry sequences from two different files.

```
x  
a  
m Model model = ModelUtil.create("Model");  
p model.geom().create("g", 2);  
l model.geom("g").insertFile("filename", "geom1");  
e ModelUtil.load("Model2", "filename2");  
model.geom("g").insertSequence("Model2", "geom1/wp1");  
model.geom("g").insertSequence("Model2", "geom1/wp2");
```

Exporting Geometry to File

In this section:

- [How to Export the Finalized Geometry](#)
- [Exporting to an STL File](#)
- [Exporting to a Parasolid File](#)
- [Compatibility in 3D](#)

How to Export the Finalized Geometry

To export the finalized geometry to a file, enter

```
model.geom(<tag>).exportFinal(<filename>);
```

where *<filename>* is a string.

To export selected geometry objects to a file, first select the objects to export using

```
model.geom(<tag>).export().selection().set(<objnames>);
```

where *<objnames>* is a string array of object names. Then export them by entering

```
model.geom(<tag>).export(<filename>);
```

The file can be any of the following formats:

TABLE 3-23: VALID FILE FORMATS

FILE FORMAT	NOTE	FILE EXTENSIONS
COMSOL Multiphysics Binary		.mphbin
COMSOL Multiphysics Text		.mphtxt
Parasolid Binary (3D)	1	.x_b
Parasolid Text (3D)	1	.x_t
STL Binary (3D)	2	.x_b
STL Text (3D)	2	.x_t
DXF (2D)		.dxf

¹ This format requires a license for the COMSOL CAD Import Module.

² Use `model.geom(<tag>).export().setSTLFormat(<format>)` to specify the STL file format (“binary” or “text”)

Exporting to an STL File

To export to an STL file, start with specifying a file format using

```
model.geom(<tag>).export().setSTLFormat(<format>);
```

where *<format>* is string with only two allowed values: **binary** and **text**

Use the following methods to select domains or boundaries to export:

```
model.geom(<tag>).export().selection().init(<edim>);  
model.geom(<tag>).export().selection().set(<objnames>, <entlst>);
```

Use the following methods to select objects to export:

```
model.geom(<tag>).export().selection().init();  
model.geom(<tag>).export().selection().set(<objnames>);
```

Finish the export by using the following line

```
model.geom(<tag>).export(<filename>);
```

Exporting to a Parasolid File

When exporting to Parasolid text or binary format, a unit conversion can optionally be performed during export. Use the following method to select the export length unit:

```
model.geom(<tag>).export().setLengthUnit(<unit>);
```

where *<unit>* is either **fromgeom** to disable unit conversion, or a COMSOL length unit, such as **m** for meters or **in** for inches.

Compatibility in 3D

If you want to open a COMSOL Multiphysics 3D geometry file in the 3.5a version of COMSOL, you need to set the **compat** property to **3.5a** using

```
model.geom(<tag>).export().set("compat", "3.5a");
```

Geometry Commands

- Array
- BezierPolygon
- Block
- Chamfer
- Circle
- CollapseEdges
- Compose, Union, Intersection, Difference
- CompositeDomains
- CompositeEdges
- CompositeFaces
- Cone
- ConvertToSolid, ConvertToSurface, ConvertToCurve, ConvertToPoint
- Cylinder
- Delete
- ECone
- EditObject
- Ellipse
- Ellipsoid
- Extrude
- Fillet
- Finalize
- FromMesh
- Helix
- Hexahedron
- IgnoreEdges
- IgnoreFaces
- IgnoreVertices
- Import DXF

- Import ECAD
- Import geometry sequence
- Import mphbin/mphtxt
- Import STL/VRML
- Interpolation Curve
- Interval
- MergeVertices
- MeshControlEdges
- MeshControlFaces
- MeshControlVertices
- Mirror
- Move, Copy
- ParametricCurve
- ParametricSurface
- Point
- Polygon
- Pyramid
- Rectangle
- Revolve
- Rotate
- Scale
- Selection
- Sphere
- Split
- Square
- Sweep
- Tangent
- Tetrahedron
- Torus
- WorkPlane

Purpose Create block shaped (3D), rectangular (2D, 3D) or linear array of geometry objects

Syntax

```
model.geom(<tag>).feature().create(<ftag>, "Array");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property, <value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

Description Use `model.geom(<tag>).feature().create(<ftag>, "Array")` to create an array of geometry objects.

Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the objects to array. The default selection is empty.

The following properties are available:

TABLE 3-24: VALID PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
input	Selection		Objects to array
displ	double[sdim]	1	Displacements in axis directions
size	int int[sdim]	1	Array size
createselection	on off	off	Create selections

If `size` is a scalar, a linear (oblique) array with `size` copies of the input objects is constructed. The displacement between two consecutive copies is given by the vector `displ`. The names of the output objects are `ftag(i)`, where `ftag` is the tag of the feature, and `i` is a 1-based index. If there are more than one input object, the output objects are named `ftag(i, in)`, where `in` is a 1-based index corresponding to the input objects.

2D: If `size` is an array of length 2, a rectangular array with `size[0]`-by-`size[1]` copies of the input object is constructed. The *x*- and *y*-displacements are `displ[0]` and `displ[1]`, respectively. The names of the output objects are `ftag(i1, i2)`, where `ftag` is the name of the feature, and `i1` and `i2` are 1-based indices. If there are more than one input object, the output objects are named `ftag(i1, i2, in)`, where `in` is a 1-based index corresponding to the input objects.

3D: If `size` is an array of length 3, a three-dimensional (block shaped) array with `size[0]`-by-`size[1]`-by-`size[2]` copies of the input object is constructed. The *x*-, *y*-, and *z*-displacements are `displ[0]`, `displ[1]`, and `displ[2]`, respectively. The names of the output objects are `ftag(i1, i2, i3)`, where `ftag` is the name of the feature, and `i1`, `i2`, and `i3` are 1-based indices. If there are more than one input

object, the output objects are named `ftag(i1, i2, i3, in)`, where `in` is a 1-based index corresponding to the input objects.

The input object is deleted and an identical object is constructed as a part of the array.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `wnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

Compatibility

In COMSOL version 3.5a it was possible to use `geomarrayr` to copy an object to an arbitrary set of positions. Now, use the Copy feature to do this.

`model.geom(<tag>).feature().create(<ftag>, "arrayr")` constructs an Array feature

Example

The following sequence creates a block with four equally sized holes.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1", 3);
model.geom("geom1").feature().create("cyl1", "Cylinder");
model.geom("geom1").feature().create("arr1", "Array");
model.geom("geom1").feature("arr1").
    selection("input").set("cyl1");
model.geom("geom1").feature("arr1").set("displ", "4 4 0");
model.geom("geom1").feature("arr1").set("size", "2 2 1");
model.geom("geom1").feature().create("blk1", "Block");
model.geom("geom1").feature("blk1").set("size", "10 14 5");
model.geom("geom1").feature("blk1").set("pos", "-3 -5 -4");
model.geom("geom1").feature().create("dif1", "Difference");
model.geom("geom1").feature("dif1").
    selection("input").set("blk1");
model.geom("geom1").feature("dif1").
    selection("input2").set("arr1");
model.geom("geom1").runAll();
```

See Also

[Move](#), [Copy](#)

Purpose	Create curve or solid polygon consisting of Bézier segments in 2D or 3D
Syntax	<pre>model.geom(<tag>).feature().create(<ftag>, "BezierPolygon"); model.geom(<tag>).feature(<ftag>).set(property, <value>); model.geom(<tag>).feature(<ftag>).getType(property);</pre>
Description	Use <code>model.geom(<tag>).feature().create(<ftag>, "BezierPolygon")</code> to create a Bézier polygon or a line segment. The following properties are available

TABLE 3-25: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
degree	int[] int	1	Degree of Bézier segments
p	double[][]		Control points
type	solid open closed	solid (2D) open (3D)	Object type. solid is not available in 3D.
w	double[]		Weights
createselection	on off	off	Create selections

If `type` is `open` or `closed`, a curve consisting of line, quadratic, or cubic rational Bézier segments is constructed. If `type` is `solid`, the solid enclosed by such a closed polygon is constructed. If `type` is `closed` or `solid`, but the first and last control points are different, an extra linear segment is added to close the curve.

The degree of the n th segment is `degree[n]`, and it must be 1 (linear), 2 (quadratic), or 3 (cubic). The n th segment has `degree[n]+1` control points and weights. The weights are stored consecutively in the array `w`, which has length `degree[0]+...+degree[N-1]+N`, where N is the number of segments. The i th coordinates of the control points are stored consecutively in the array `p[i]`. Adjacent segments share the common control point, which means that `p[i]` has length `degree[0]+...+degree[N-1]+1`.

For a linear or cubic segment, the default weights are 1. For a quadratic segment, the default weights are $1, 1/\sqrt{2}, 1$.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges, and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, or `pnt`. The `createselection` property is not available in work-plane geometries.

Examples	Construct a solid triangle <code>b1</code> , and an elliptic arc <code>b2</code> :
-----------------	--

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",2);
model.geom("geom1").feature().create("b1","BezierPolygon");
model.geom("geom1").feature("b1").set("p",
    new double[][]{{0, 0, 2}, {1, 0 ,0}});

model.geom("geom1").feature().create("b2","BezierPolygon");
model.geom("geom1").feature("b2").set("type","open");
model.geom("geom1").feature("b2").set("degree",2);
model.geom("geom1").feature("b2").set("p",
    new double[][]{{0, 0, 1}, {0, 1, 1}});
model.geom("geom1").runAll();
```

See Also[Polygon](#)

- Purpose** Create a right-angled solid or surface block in 3D
- Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Block");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```
- Description** Use `model.geom(<tag>).feature().create(<ftag>,"Block")` to create a block. The following properties are available:

TABLE 3-26: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
axis	double[]	{0,0,1}	Direction of the edge on the local z-axis. Vector has length 3 if <code>axistype</code> is cartesian, and length 2 if <code>axistype</code> is spherical.
axistype	cartesian spherical	cartesian	Coordinate system used for axis. The value is synchronized with <code>axis</code> .
base	corner center	corner	Positions the object either centered about <code>pos</code> or with one corner in <code>pos</code> .
layer	double[]		Thicknesses of layers
layertop	on off	off	Apply layers on top
layerbottom	on off	on	Apply layers on bottom
layerleft	on off	off	Apply layers to the left
layerright	on off	off	Apply layers to the right
layerfront	on off	off	Apply layers on front
layerback	on off	off	Apply layers on back
size	double[]	{1,1,1}	Edge lengths.
pos	double[]	{0,0,0}	Position of the object.
rot	double	0	Rotational angle about axis.
type	solid surface	solid	Object type.
createselection	on off	off	Create selections

If `createselection` is set to on, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>`

is the geometry tag, *<ftag>* the feature tag and *<lvl>* is one of dom, bnd, edg, pnt. The `createselection` property is not available in work-plane geometries.

Compatibility

`model.geom(<tag>).feature().create(<ftag>,"block2")` constructs a solid block.

`model.geom(<tag>).feature().create(<ftag>,"block3")` constructs a surface block.

The following properties are also available:

TABLE 3-27: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
ax2	double[]	{0,0}	Alias for axis when axistype is spherical
ax3	double[]	{0,0,1}	Alias for axis when axistype is cartesian
lx, ly, lz	double	1	Alias for size
x, y, z	double	0	Alias for pos

The property `const` is no longer available.

Examples

The following commands create a solid and surface block, where the position is defined in the two alternative ways.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("b1","Block");
model.geom("geom1").feature("b1").set("size","1 2.1 0.5");
model.geom("geom1").feature("b1").set("base","center");
model.geom("geom1").feature("b1").set("pos","1 0 1");
model.geom("geom1").feature("b1").set("axis","1 0 0");
model.geom("geom1").feature("b1").set("rot",30);
double[] a = model.geom("geom1").feature("b1").
    getDoubleArray("pos");
model.geom("geom1").feature().create("b2","Block");
model.geom("geom1").feature("b2").set("type","surface");
model.geom("geom1").feature("b2").set("size","1 2.1 0.5");
model.geom("geom1").feature("b2").set("pos",a);
String b = model.geom("geom1").feature("b2").
    getString("pos");
```

See Also

[Hexahedron](#)

- Purpose** Create flattened corners in 2D objects
- Syntax**
`model.geom(<tag>).feature().create(<ftag>,"Chamfer");`
`model.geom(<tag>).feature(<ftag>).selection(property);`
`model.geom(<tag>).feature(<ftag>).set(property,<value>);`
`model.geom(<tag>).feature(<ftag>).getType(property);`
- Description**
Use `model.geom(<tag>).feature().create(<ftag>,"Chamfer")` to chamfer corners in 2D.
Use `model.geom(<tag>).feature(<ftag>).selection("point")` to select the corners to chamfer. The default selection is empty.

PROPERTY	VALUE	DEFAULT	DESCRIPTION
dist	double	0	Distance from vertex to chamfer
point	Selection		Vertices to chamfer
createselection	on off	off	Create selections

If `createselection` is set to on, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

- Compatibility** In version 3.5a, the default was to chamfer all vertices in the input objects. The 3.5a properties `angles`, `dist1`, `dist2`, `edges`, `length`, and `out` are no longer available.

- Example** Chamfer a rectangle.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",2);
model.geom("geom1").feature().create("r1","Rectangle");
model.geom("geom1").feature().create("cha1","Chamfer");
model.geom("geom1").feature("cha1").selection("point").
    set("r1(1)",new int[] {1,2,3,4});
model.geom("geom1").feature("cha1").set("dist",0.1);
model.geom("geom1").run();
```

- Diagnostics** If a chamfer cannot be created according to the specified properties this vertex is ignored. When the chamfers generate intersections with other edges in the geometry, an error message is given.

- See Also** [Fillet](#)

Purpose Create circle or disk in 2D

Syntax

```
model.geom(<tag>).feature().create(<ftag>,"Circle");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

Description Use `model.geom(<tag>).feature().create(<ftag>,"Circle")` to create a disk in 2D. The following properties are available:

TABLE 3-28: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
base	corner center	center	Positions the object either centered about pos or with the lower left corner of a surrounding box in pos
layer	double[]		Thicknesses of layers
pos	double[]	{0,0}	Position of the object
r	double	1	Radius
rot	double	0	Rotational angle about pos
type	solid curve	solid	Object type
createselection	on off	off	Create selections

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

Compatibility

`model.geom(<tag>).feature().create(<ftag>,"circ2")` creates a solid disk.

`model.geom(<tag>).feature().create(<ftag>,"circ1")` creates a circle curve.

The following properties are also available:

TABLE 3-29: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
x, y	double	0	Alias for pos

The property `const` is no longer available.

Example The sequence below creates a unit disk (solid circle object).

Circle

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",2);
model.geom("geom1").feature().create("c1","Circle");
model.geom("geom1").feature("c1").set("pos",new double[]{2,3});
String base = model.geom("geom1").feature("c1").
    getString("base");
```

See Also

[Ellipse](#)

Purpose	Collapse edges
Syntax	<pre>model.geom(<tag>).feature().create(<ftag>,"CollapseEdges"); model.geom(<tag>).feature(<ftag>).selection(property); model.geom(<tag>).feature(<ftag>).set(property,<value>); model.geom(<tag>).feature(<ftag>).getType(property);</pre>
Description	<p>Use <code>model.geom(<tag>).feature().create(<ftag>,"CollapseEdges")</code> to collapse edges.</p> <p>Use <code>model.geom(<tag>).feature(<ftag>).selection("input")</code> to select the edges to collapse. The default selection is empty.</p> <p>The feature collapses an edge by removing it, merging its adjacent vertices to the vertex with lowest index, and re-connecting the adjacent edges to the merged vertex.</p> <p>The output object is a virtual geometry.</p> <p>The following properties are available:</p>

TABLE 3-30: VALID PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
input	Selection		Edges to collapse

See Also[MergeVertices](#)

Purpose	Compose objects using a boolean set formula.
Syntax	<pre>model.geom(<tag>).feature().create(<ftag>,"Compose"); model.geom(<tag>).feature().create(<ftag>,"Union"); model.geom(<tag>).feature().create(<ftag>,"Intersection"); model.geom(<tag>).feature().create(<ftag>,"Difference"); model.geom(<tag>).feature(<ftag>).selection(property); model.geom(<tag>).feature(<ftag>).set(property,<value>); model.geom(<tag>).feature(<ftag>).getType(property);</pre>
Description	<p>Use <code>model.geom(<tag>).feature().create(<ftag>,operationName)</code> to combine geometric objects in different ways.</p> <p>Use <code>model.geom(<tag>).feature(<ftag>).selection(property)</code> to select the objects to combine. The default selection is empty.</p>

The following properties are available:

TABLE 3-31: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
formula	String		Set formula (only for Compose feature)
input	Selection		Objects to compose
input2	Selection		Objects to subtract (only for Difference feature)
intbnd	on off	on	Keep interior boundaries.
keep	on off	off	Keep input objects
repairtol	double	1e-6	Repair tolerance, relative to size of union of inputs
createselection	on off	off	Create selections

For the features `Compose`, `Intersection`, and `Difference`, the input objects must be solids. For the `Union` feature, the input objects can be of arbitrary type.

The following boolean operation is performed:

- For `Compose`, the input objects are combined using the set formula in the property `formula`. The operators `+`, `*`, and `-` correspond to the set operations union, intersection, and difference. The precedence of the operators `+` and `-` are the same. `*` has higher precedence.
- For `Union`, the objects in `input` are united.

- For **Intersection**, the objects in `input` are intersected.
- For **Difference**, the objects in `input2` are subtracted from the union of the objects in `input`.

If `createselection` is set to on, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

Compatibility

The following properties are also supported, see the [Delete](#) feature:

TABLE 3-32: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
edge	all none	none	Delete isolated edges on a face (3D) Delete interior edges and edges not adjacent to a domain (2D, alias for <code>indbnd</code>)
face	all none	none	Delete interior faces (3D, alias for <code>intbnd</code>)
point	all none	none	Delete isolated vertices on a face (3D). Delete isolated vertices in a domain (2D)

The property `out` is no longer available.

See Also

[ConvertToSolid](#), [ConvertToSurface](#), [ConvertToCurve](#), [ConvertToPoint](#), [Finalize](#)

- Purpose** Form composite domains.
- Syntax**
`model.geom(<tag>).feature().create(<ftag>,"CompositeDomains");`
`model.geom(<tag>).feature(<ftag>).selection(property);`
`model.geom(<tag>).feature(<ftag>).set(property,<value>);`
`model.geom(<tag>).feature(<ftag>).getType(property);`
- Description**
Use `model.geom(<tag>).feature().create(<ftag>,"CompositeDomains")` to form composite domains.
- Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the domains to composite. The default selection is empty.
- The feature forms a composite domain for each connected domain component of the selected domains by ignoring the boundaries between the domains. The output object is a virtual geometry.

The following properties are available:

TABLE 3-33: VALID PROPERTIES

NAME	VALUE	DEFAULT	DESCRIPTION
<code>ignoreadj</code>	<code>on off</code>	<code>on</code>	Ignore edges (3D only) and vertices on boundary
<code>input</code>	Selection		Edges to composite
<code>keepformesh</code>	<code>on off</code>	<code>off</code>	Keep input domains for mesh control

Use `ignoreadj` to specify if the feature also removes the ignorable edges (3D only) and vertices on the boundary of each resulting composite domain.

Use `keepformesh` to keep the input domains while meshing, to help you in constructing the mesh.

- Example** Create a composite domain of domain 2 and 3.
- ```
Model model = ModelUtil.create("Model");
model.geom().create("geom", 2);
model.geom("geom").feature().create("r1", "Rectangle");
model.geom("geom").feature().create("c1", "Circle");
model.geom("geom").run("fin");
model.geom("geom").feature().create("cmd1", "CompositeDomains");
model.geom("geom").feature("cmd1").selection("input").
 set("fin", 2, 3);
model.geom("geom").run();
```

**See Also** [CompositeEdges](#), [CompositeFaces](#), [IgnoreEdges](#), [IgnoreFaces](#)

**Purpose** Form composite edges.

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>, "CompositeEdges");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property, <value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>, "CompositeEdges")` to form composite edges.

Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the edges to concatenate. The default selection is empty.

The feature forms a composite edge for each connected edge component (of manifold type) of the selected edges by ignoring the vertices between the edges. The output object is a virtual geometry.

The following properties are available:

TABLE 3-34: VALID PROPERTIES

| NAME        | VALUE     | DEFAULT | DESCRIPTION                       |
|-------------|-----------|---------|-----------------------------------|
| input       | Selection |         | Edges to composite                |
| keepformesh | on   off  | off     | Keep input edges for mesh control |

Use `keepformesh` to keep the input edges while meshing, to help you in constructing the mesh.

Note that the operation will never form composite edges that are closed loops or periodic, that is, every resulting edge will have distinct start and end vertices.

**Example** Compose edges 2 and 4 of a circle into one edge.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 2);
model.geom("geom1").feature().create("c1", "Circle");
model.geom("geom1").run("fin");
model.geom("geom1").feature().create("cme1", "CompositeEdges");
model.geom("geom1").feature("cme1").selection("input").
 set("fin", 2, 4);
model.geom("geom1").run();
```

**See Also** [CompositeDomains](#), [CompositeFaces](#), [IgnoreVertices](#)

- Purpose** Form composite faces
- Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"CompositeFaces");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```
- Description** Use `model.geom(<tag>).feature().create(<ftag>,"CompositeFaces")` to form composite faces.
- Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the faces to concatenate. The default selection is empty.
- The feature forms a composite face for each connected face component (of manifold type) of the selected faces by ignoring the edges between the faces. The output object is a virtual geometry.

The following properties are available:

TABLE 3-35: VALID PROPERTIES

| NAME        | VALUE     | DEFAULT | DESCRIPTION                       |
|-------------|-----------|---------|-----------------------------------|
| input       | Selection |         | Faces to composite                |
| ignorevtx   | on   off  | on      | Ignore vertices on boundary       |
| keepformesh | on   off  | off     | Keep input faces for mesh control |

Use `ignorevtx` to specify if the feature also removes the ignorable vertices on the boundary of each resulting composite face.

Use `keepformesh` to keep the input faces while meshing, to help you in constructing the mesh.

- Example** A COMSOL standard cone has six faces. Using the following composite face operation, the result is a cone with three faces: top, bottom and side.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 3);
model.geom("geom1").feature().create("cone1", "Cone");
model.geom("geom1").run("fin");
model.geom("geom1").feature().create("cmf1", "CompositeFaces");
model.geom("geom1").feature("cmf1").selection("input").
 set("fin", 1, 2, 5, 6);
model.geom("geom1").run();
```

- See Also** [CompositeDomains](#), [CompositeEdges](#), [IgnoreEdges](#)

**Purpose** Create a solid or surface circular right cone or frustum in 3D

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Cone");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Cone")` to create a cone. The following properties are available:

TABLE 3-36: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE                 | DEFAULT     | DESCRIPTION                                                                                                                                                         |
|-----------------|-----------------------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ang             | double                | arctan(1/2) | Semi-angle, that is, the angle between the axis and a generator of the conical surface                                                                              |
| axis            | double[]              | {0,0,1}     | Direction of the axis. Vector has length 3 if axistype is cartesian, and length 2 if axistype is spherical.                                                         |
| axistype        | cartesian   spherical | cartesian   | Coordinate system used for axis. The value is synchronized with axis.                                                                                               |
| h               | double                | 1           | Height                                                                                                                                                              |
| layer           | double[]              |             | Thicknesses of layers                                                                                                                                               |
| layertop        | on   off              | off         | Apply layers on top                                                                                                                                                 |
| layerbottom     | on   off              | off         | Apply layers on bottom                                                                                                                                              |
| layerside       | on   off              | on          | Apply layers on side                                                                                                                                                |
| pos             | double[]              | {0,0,0}     | Center of the bottom circle                                                                                                                                         |
| r               | double                | 1           | Radius of bottom circle                                                                                                                                             |
| rot             | double                | 0           | Rotational angle about axis                                                                                                                                         |
| rtop            | double                | 0.5         | Radius of top circle                                                                                                                                                |
| specifytop      | angle   radius        | angle       | If axistype is angle, the radius of the top circle is given by the ang property. If axistype is radius, the radius of the top circle is given by the rtop property. |
| type            | solid   surface       | solid       | Object type                                                                                                                                                         |
| createselection | on   off              | off         | Create selections                                                                                                                                                   |

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

### Compatibility

`model.geom(<tag>).feature().create(<ftag>, "cone3")` creates a solid cone.

`model.geom(<tag>).feature().create(<ftag>, "cone2")` creates a surface cone.

The following properties are also available:

TABLE 3-37: VALID PROPERTY/VALUE PAIRS

| PROPERTY             | VALUE                 | DEFAULT              | DESCRIPTION                                            |
|----------------------|-----------------------|----------------------|--------------------------------------------------------|
| <code>ax2</code>     | <code>double[]</code> | <code>{0,0}</code>   | Alias for axis when <code>axistype</code> is spherical |
| <code>ax3</code>     | <code>double[]</code> | <code>{0,0,1}</code> | Alias for axis when <code>axistype</code> is cartesian |
| <code>x, y, z</code> | <code>double</code>   | <code>0</code>       | Alias for <code>pos</code>                             |

The property `const` is no longer available.

### Examples

Create a cone with an apex.

```
double r = 2;
double h = 3;
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").angularUnit("rad");
model.geom("geom1").feature().create("c1", "Cone");
model.geom("geom1").feature("c1").set("r",r);
model.geom("geom1").feature("c1").set("h",h);
model.geom("geom1").feature("c1").set("ang", Math.atan(r/h));
double ang = model.geom("geom1").feature("c1").getDouble("ang");
```

Created a truncated and rotated cone.

```
model.geom("geom1").feature().create("c2", "Cone");
model.geom("geom1").feature("c2").set("pos", "1 -2 4");
model.geom("geom1").feature("c2").set("axis", "1 -1 0.3");
model.geom("geom1").feature("c2").set("rot",Math.PI/3);

model.geom("geom1").runAll();
```



**See Also**

[Cylinder](#), [ECone](#)

## ConvertToSolid, ConvertToSurface, ConvertToCurve, ConvertToPoint

---

**Purpose** Unite and convert objects to a solid, surface, curve, or point object.

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"ConvertToSolid");
model.geom(<tag>).feature().create(<ftag>,"ConvertToSurface");
model.geom(<tag>).feature().create(<ftag>,"ConvertToCurve");
model.geom(<tag>).feature().create(<ftag>,"ConvertToPoint");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,convertOperation)` to reduce or extend the topological dimension of objects.

Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the objects to convert. The default selection is empty.

The following properties are available:

TABLE 3-38: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE     | DEFAULT | DESCRIPTION                                           |
|-----------------|-----------|---------|-------------------------------------------------------|
| input           | Selection |         | Objects to convert                                    |
| keep            | on   off  | off     | Keep input objects                                    |
| repairtol       | double    | 1e-6    | Repair tolerance, relative to size of union of inputs |
| createselection | on   off  | off     | Create selections                                     |

The input objects are united, and the resulting object is converted to the requested type.

If `createselection` is set to on, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Compatibility** The object type Surface was called Face in version 3.5a.

**See Also** [Compose](#), [Union](#), [Intersection](#), [Difference](#)

**Purpose** Create a solid or surface right circular cylinder in 3D

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Cylinder");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Cylinder")` to create a cylinder. The following properties are available:

TABLE 3-39: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE               | DEFAULT   | DESCRIPTION                                                                                                                           |
|-----------------|---------------------|-----------|---------------------------------------------------------------------------------------------------------------------------------------|
| axis            | double[]            | {0,0,1}   | Direction of the axis. Vector has length 3 if <code>axistype</code> is cartesian, and length 2 if <code>axistype</code> is spherical. |
| axistype        | cartesian spherical | cartesian | Coordinate system used for axis. The value is synchronized with <code>axis</code> .                                                   |
| layer           | double[]            |           | Thicknesses of layers                                                                                                                 |
| layertop        | on   off            | off       | Apply layers on top                                                                                                                   |
| layerbottom     | on   off            | off       | Apply layers on bottom                                                                                                                |
| layerside       | on   off            | on        | Apply layers on side                                                                                                                  |
| h               | double              | 1         | Height                                                                                                                                |
| pos             | double[]            | {0,0,0}   | Center of the bottom circle                                                                                                           |
| r               | double              | 1         | Radius of bottom circle                                                                                                               |
| rot             | double              | 0         | Rotational angle about axis                                                                                                           |
| type            | solid   surface     | solid     | Object type                                                                                                                           |
| createselection | on   off            | off       | Create selections                                                                                                                     |

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Compatibility** `model.geom(<tag>).feature().create(<ftag>,"cylinder3")` creates a solid cylinder.

`model.geom(<tag>).feature().create(<ftag>,"cylinder2")` creates a surface cylinder.

The following properties are also available:

TABLE 3-40: VALID PROPERTY/VALUE PAIRS

| PROPERTY | VALUE    | DEFAULT | DESCRIPTION                               |
|----------|----------|---------|-------------------------------------------|
| ax2      | double[] | {0,0}   | Alias for axis when axistype is spherical |
| ax3      | double[] | {0,0,1} | Alias for axis when axistype is cartesian |
| x, y, z  | double   | 0       | Alias for pos                             |

The property `const` is no longer available.

### Examples

The following commands generate a surface cylinder and a solid cylinder.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").angularUnit("rad");
model.geom("geom1").feature().create("c2","Cylinder");
model.geom("geom1").feature("c2").set("type","surface");
model.geom("geom1").feature("c2").set("r",0.5);
model.geom("geom1").feature("c2").set("h",4);
model.geom("geom1").feature("c2").set("pos","1 1 0");
model.geom("geom1").feature("c2").set("axis","pi/2 0");
model.geom("geom1").feature().create("c3","Cylinder");
model.geom("geom1").feature("c3").set("r",20);
model.geom("geom1").feature("c3").set("h",40);
model.geom("geom1").feature("c3").set("pos","0 0 -100");
model.geom("geom1").feature("c3").set("axis","1 1 1");
model.geom("geom1").run();
```

### See Also

[Cone](#), [ECone](#)

**Purpose** Delete vertices, edges, faces, domains, or objects

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Delete");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Delete")` to delete geometric entities.

Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the entities to delete. The default selection is empty.

TABLE 3-41: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE      | DEFAULT | DESCRIPTION                                           |
|-----------------|------------|---------|-------------------------------------------------------|
| input           | Selection  |         | Vertices, edges, faces, domains, or objects to delete |
| compat          | 4.2a   4.3 | 4.3     | Algorithm version                                     |
| createselection | on   off   | off     | Create selections                                     |

Deleting a domain, face, or edge automatically deletes all lower-dimensional adjacent entities, except those needed to bound surviving entities.

In 2D and 3D, vertices that are adjacent to an edge can not be deleted.

In 3D, an edge can be deleted if it has no adjacent faces, or if it is interior to a face.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Compatibility**

In version 4.3, the algorithm was changed slightly. The main difference is that the old algorithm preserved the object type for solid, surface, and curve objects. To get the old behavior, set `compat` to 4.2a.

`model.geom(<tag>).feature().create(<ftag>,"del")` creates a Delete feature.

In 3D, the default value for edge and point was `all` in version 3.5a. Now the default is empty (corresponds to `none` in 3.5a). The value `all` for `subdomain`, `face`, `edge`, `point` is no longer available. The property `out` is no longer available.

**Example**

Delete face 5 from a surface block:

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("blk1","Block");
model.geom("geom1").feature("blk1").set("type", "surface");
model.geom("geom1").run("blk1");
model.geom("geom1").feature().create("del1","Delete");
model.geom("geom1").feature("del1").selection("input").
 set("blk1",5);
model.geom("geom1").runAll();
```

**See Also**

[Compose](#), [Union](#), [Intersection](#), [Difference](#)

**Purpose** Create solid or surface eccentric oblique cone or frustum in 3D

**Syntax**  

```
model.geom(<tag>).feature().create(<ftag>,"ECone");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"ECone")` to create an eccentric oblique cone. The following properties are available:

TABLE 3-42: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE                 | DEFAULT   | DESCRIPTION                                                                                                                         |
|-----------------|-----------------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------|
| axis            | double[]              | {0,0,1}   | Direction of the normal to the bottom ellipse. Vector has length 3 if axistype is cartesian, and length 2 if axistype is spherical. |
| axistype        | cartesian   spherical | cartesian | Coordinate system used for axis. The value is synchronized with axis.                                                               |
| displ           | double[2]             | {0,0}     | Displacement of top ellipse relative to bottom ellipse, in local coordinate system                                                  |
| h               | double                | 1         | Height                                                                                                                              |
| pos             | double[3]             | {0,0,0}   | Center of the bottom ellipse                                                                                                        |
| r               | double                | 1         | Radius of bottom ellipse                                                                                                            |
| rat             | double                | 0.5       | Ratio between perimeter for top ellipse and bottom ellipse                                                                          |
| rot             | double                | 0         | Rotational angle about axis.                                                                                                        |
| semiaxes        | double[2]             | {1,1}     | Semi-axes of bottom ellipse                                                                                                         |
| type            | solid   surface       | solid     | Object type                                                                                                                         |
| createselection | on   off              | off       | Create selections                                                                                                                   |

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Compatibility**

`model.geom(<tag>).feature().create(<ftag>, "econe3")` creates a solid eccentric cone.

`model.geom(<tag>).feature().create(<ftag>, "econe2")` creates a surface eccentric cone.

The following properties are also available:

TABLE 3-43: VALID PROPERTY/VALUE PAIRS

| PROPERTY | VALUE    | DEFAULT | DESCRIPTION                               |
|----------|----------|---------|-------------------------------------------|
| a, b     | double   | 1       | Alias for semiaxes                        |
| ax2      | double[] | {0,0}   | Alias for axis when axistype is spherical |
| ax3      | double[] | {0,0,1} | Alias for axis when axistype is cartesian |
| x, y, z  | double   | 0       | Alias for pos                             |

The property `const` is no longer available.

**Examples**

Create a truncated eccentric cone with the base face in the *xy*-plane.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("e1", "ECone");
model.geom("geom1").feature("e1").set("semiaxes", "10 40");
model.geom("geom1").feature("e1").set("h",20);
```

Create an eccentric cone with an apex, that is, a singular patch, on top.

```
model.geom("geom1").feature().create("e2", "ECone");
model.geom("geom1").feature("e2").set("semiaxes", "1 2");
model.geom("geom1").feature("e2").set("h",4);
model.geom("geom1").feature("e2").set("rat",0);
model.geom("geom1").feature("e2").set("displ", "1 1");
model.geom("geom1").feature("e2").set("pos", "100 100 100");
model.geom("geom1").feature("e2").set("axis", "0 1 4");
model.geom("geom1").feature("e2").set("rot",45);
model.geom("geom1").runAll();
```

**See Also**

[Cone](#), [Cylinder](#)



**Purpose** Create an Edit object feature in 2D

**Syntax**

```

model.geom(<tag>).feature().create(<ftag>,"EditObject");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
model.geom(<tag>).feature(<ftag>).vertexNew();
model.geom(<tag>).feature(<ftag>).vertexDelete(<vertex>);
model.geom(<tag>).feature(<ftag>).vertexSnap(<vertex>);
model.geom(<tag>).feature(<ftag>).startVertexDisconnect(<edge>);
model.geom(<tag>).feature(<ftag>).endVertexDisconnect(<edge>);
model.geom(<tag>).feature(<ftag>).edgeNew();
model.geom(<tag>).feature(<ftag>).edgeDelete(<edge>);

```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"EditObject")` to create an edit object feature.

Use `model.geom(<tag>).feature(<ftag>).vertexNew()` to add a new vertex to the object.

Use `model.geom(<tag>).feature(<ftag>).vertexDelete(<vertex>)` to delete `<vertex>` from the object.

Use `model.geom(<tag>).feature(<ftag>).vertexSnap(<vertex>)` to delete `<vertex>` from the object, and move any adjacent edges to the closest remaining vertex.

Use `model.geom(<tag>).feature(<ftag>).startVertexDisconnect(<edge>)` to create a new vertex and use this vertex as the start vertex for `<edge>`.

Use `model.geom(<tag>).feature(<ftag>).endVertexDisconnect(<edge>)` to create a new vertex and use this vertex as the end vertex for `<edge>`.

Use `model.geom(<tag>).feature(<ftag>).edgeNew()` to add a new edge to the object.

Use `model.geom(<tag>).feature(<ftag>).edgeDelete(<edge>)` to delete `<edge>` from the object.

The following properties are available:

TABLE 3-44: VALID PROPERTY/VALUE PAIRS

| PROPERTY | VALUE        | DEFAULT | DESCRIPTION             |
|----------|--------------|---------|-------------------------|
| input    | Selection    |         | Geometry object to edit |
| vertex   | integer   "" |         | Vertex to edit          |

TABLE 3-44: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE        | DEFAULT | DESCRIPTION                                          |
|-----------------|--------------|---------|------------------------------------------------------|
| xvertex         | double       | 0       | x-coordinate of vertex being edited                  |
| yvertex         | double       | 0       | y-coordinate of vertex being edited                  |
| edge            | integer   "" |         | Edge to edit                                         |
| x               | double[]     |         | x-coordinates of control points of edge being edited |
| y               | double[]     |         | y-coordinates of control points of edge being edited |
| weights         | double[]     |         | Weights of control points of edge being edited       |
| knots           | double[]     |         | Knots of NURBS curve for edge being edited           |
| degree          | 1   2   3    |         | Degree of edge being edited                          |
| start           | integer   "" |         | Start vertex of edge being edited                    |
| end             | integer   "" |         | End vertex of edge being edited                      |
| createselection | on   off     | off     | Create selections                                    |

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

## Example

The sequence below edits a circle, setting the degree of one edge to one to create a straight edge.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 2);
model.geom("geom1").feature().create("c1", "Circle");
model.geom("geom1").run("c1");
model.geom("geom1").feature().create("edo1", "EditObject");
model.geom("geom1").feature("edo1").selection("input").set(new
 String[]{"c1"});
model.geom("geom1").feature("edo1").set("edge", "1");
model.geom("geom1").feature("edo1").set("degree", "1");
model.geom("geom1").run("edo1");
```

## See Also

[BezierPolygon](#)

**Purpose** Create a solid or curved ellipse in 2D

**Syntax**  
`model.geom(<tag>).feature().create(<ftag>, "Ellipse");`  
`model.geom(<tag>).feature(<ftag>).set(property, <value>);`  
`model.geom(<tag>).feature(<ftag>).getType(property);`

**Description** Use `model.geom(<tag>).feature().create(<ftag>, "Ellipse")` to create an ellipse. The following properties are available:

TABLE 3-45: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE           | DEFAULT | DESCRIPTION                                                                                            |
|-----------------|-----------------|---------|--------------------------------------------------------------------------------------------------------|
| base            | corner   center | center  | Positions the object either centered about pos or with the lower left corner of surrounding box in pos |
| layer           | double[]        |         | Thicknesses of layers                                                                                  |
| pos             | double[]        | {0,0}   | Position of the object                                                                                 |
| rot             | double          | 0       | Rotational angle about pos                                                                             |
| semiaxes        | double[]        | {1,1}   | Semi-axes                                                                                              |
| type            | solid   curve   | solid   | Object type                                                                                            |
| createselection | on   off        | off     | Create selections                                                                                      |

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Compatibility** `model.geom(<tag>).feature().create(<ftag>, "ellip2")` is a solid ellipse.

`model.geom(<tag>).feature().create(<ftag>, "ellip1")` is an ellipse curve.

The following properties are also available:

TABLE 3-46: VALID PROPERTY/VALUE PAIRS

| PROPERTY | VALUE  | DEFAULT | DESCRIPTION        |
|----------|--------|---------|--------------------|
| a, b     | double | 1       | Alias for semiaxes |
| x, y     | double | 0       | Alias for pos      |

The property `const` is no longer available.

**Example** The sequence below creates a solid ellipse.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",2);
model.geom("geom1").feature().create("e1","Ellipse");
model.geom("geom1").feature("e1").set("semiaxes","1 0.3");
model.geom("geom1").feature("e1").set("rot",45);
model.geom("geom1").run();
```

**See Also**

[Circle](#)

**Purpose** Create a solid or surface ellipsoid in 3D.

**Syntax**  
`model.geom(<tag>).feature().create(<ftag>,"Ellipsoid");`  
`model.geom(<tag>).feature(<ftag>).set(property,<value>);`  
`model.geom(<tag>).feature(<ftag>).getType(property);`

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Ellipsoid")` to create an ellipsoid. The following properties are available:

TABLE 3-47: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE                 | DEFAULT   | DESCRIPTION                                                                                                                       |
|-----------------|-----------------------|-----------|-----------------------------------------------------------------------------------------------------------------------------------|
| axis            | double[]              | {0,0,1}   | Direction of the local z-axis. Vector has length 3 if <i>axistype</i> is cartesian, and length 2 if <i>axistype</i> is spherical. |
| axistype        | cartesian   spherical | cartesian | Coordinate system used for axis. The value is synchronized with <i>axis</i> .                                                     |
| layer           | double[]              |           | Thicknesses of layers                                                                                                             |
| pos             | double[]              | {0,0,0}   | Center                                                                                                                            |
| rot             | double                | 0         | Rotational angle about axis                                                                                                       |
| semiaxes        | double[3]             | {1,1,1}   | Semi-axes                                                                                                                         |
| type            | solid   surface       | solid     | Object type                                                                                                                       |
| createselection | on   off              | off       | Create selections                                                                                                                 |

If *createselection* is set to on, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where *<tag>* is the geometry tag, *<ftag>* the feature tag and *<lvl>* is one of *dom*, *bnd*, *edg*, *pnt*. The *createselection* property is not available in work-plane geometries.

**Compatibility** `model.geom(<tag>).feature().create(<ftag>,"ellipsoid3")` creates a solid ellipsoid.

`model.geom(<tag>).feature().create(<ftag>,"ellipsoid2")` creates a surface ellipsoid.

The following properties are also available:

TABLE 3-48: VALID PROPERTY/VALUE PAIRS

| PROPERTY | VALUE    | DEFAULT | DESCRIPTION                               |
|----------|----------|---------|-------------------------------------------|
| a, b, c  | double   | 1       | Alias for semiaxes                        |
| ax2      | double[] | {0,0}   | Alias for axis when axistype is spherical |
| ax3      | double[] | {0,0,1} | Alias for axis when axistype is cartesian |
| x, y, z  | double   | 0       | Alias for pos                             |

The property `const` is no longer available.

### Examples

The following commands create a surface and solid ellipsoid, where the position and semi-axes are defined in the two alternative ways.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("e2","Ellipsoid");
model.geom("geom1").feature("e2").set("type","surface");
model.geom("geom1").feature("e2").set("pos","0 1 0");

model.geom("geom1").feature().create("e3","Ellipsoid");
model.geom("geom1").feature("e3").set("semiaxes","12 10 8");

model.geom().run();
```

### See Also

[Sphere](#)

**Purpose** Extrude planar objects into 3D

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Extrude");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Extrude")` to extrude objects from a work plane or planar faces from the 3D geometry.

Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the work plane objects to extrude. The default selection is all available objects from the last preceding work plane.

Use `model.geom(<tag>).feature(<ftag>).selection("inputface")` to select the faces to extrude. Faces are extruded when the `workplane` property is none, otherwise work plane objects are extruded.

The following properties are available:

TABLE 3-49: VALID PROPERTY/VALUE PAIRS

| PROPERTY    | VALUES                           | DEFAULT     | DESCRIPTION                                                                                       |
|-------------|----------------------------------|-------------|---------------------------------------------------------------------------------------------------|
| crossfaces  | on   off                         | on          | Keep cross-sectional faces                                                                        |
| displ       | double[n <sub>d</sub> ][2]       | {{0,0}}     | Displacement (parallel to work plane) of extrusion top (of each layer) in local coordinate system |
| distance    | double   double[n <sub>d</sub> ] | 1           | Extrusion distance(s), that is, local z-coordinate for the top (of each layer)                    |
| extrudefrom | workplane   faces                |             | Extrude work plane objects or faces from 3D objects                                               |
| input       | Selection                        | all objects | Objects to extrude                                                                                |
| inputface   | Selection                        |             | Faces to extrude                                                                                  |
| polres      | double                           | 50          | Polygon resolution of edges                                                                       |
| reverse     | on   off                         | off         | Reverse the extrude direction                                                                     |
| scale       | double[n <sub>d</sub> ][2]       | {{1,1}}     | Scale of extrusion top (of each layer)                                                            |
| twist       | double   double[n <sub>d</sub> ] | 0           | Twist angle (of each layer)                                                                       |
| unite       | on   off                         | on          | Unite extruded objects with input objects                                                         |

TABLE 3-49: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUES   | DEFAULT | DESCRIPTION           |
|-----------------|----------|---------|-----------------------|
| workplane       | String   |         | Work plane to extrude |
| createselection | on   off | off     | Create selections     |

Each planar input is extruded in  $n_d$  layers defined by a local coordinate system. By default,  $n_d=1$ . The property `distance` is the extrusion distance (of each layer) in the z-axis direction of the local system. The properties `displ`, `scale`, and `twist` define the translation displacements, scale factors and rotation of the top (of each layer) with respect to the bottom of the extruded object. The last array dimension in the properties `displ`, `scale`, and `twist` can be omitted if the same value is desired for all layers.

When extruding work plane objects, the local system is defined as the local system of the work plane. When extruding faces, the local system is defined by the face with the smallest face number in the object that comes first in the geometry sequence. The local z-axis is parallel to the face normal and located at the center of the face. The local x-axis is defined by the tangent direction corresponding to the first parameter in the surface representation for the face.

When `unite` is set to `on`, the input objects are united with the corresponding extruded objects, after which the input objects are removed. When extruding from work plane object, this has the same effect as deleting the input objects. When `unite` is set to `off`, the extruded objects remain separate from the input objects and the input objects are kept.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Compatibility**

The cubic interpolated extrusion is no longer supported.

The following property is also supported:

TABLE 3-50: VALID PROPERTY/VALUE PAIRS

| PROPERTY | VALUES     | DEFAULT | DESCRIPTION                                                        |
|----------|------------|---------|--------------------------------------------------------------------|
| face     | all   none | all     | Cross-sectional faces to delete, alias for <code>crossfaces</code> |
| keep     | on   off   | off     | Alias for <code>unite</code> property with opposite value          |



**Example**

Creation of a cylinder of height 1.3.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("wp1","WorkPlane");
model.geom("geom1").feature("wp1").geom().
 feature().create("c1","Circle");
model.geom("geom1").run("wp1");
model.geom("geom1").feature().create("e1","Extrude");
model.geom("geom1").feature("e1").set("distance",1.3);
model.geom("geom1").run();
```

**See Also**

[Revolve](#), [WorkPlane](#)

- Purpose** Create circular rounded corners in 2D geometry objects
- Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Fillet");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```
- Description**

Use `model.geom(<tag>).feature().create(<ftag>,"Fillet")` to round corners in 2D.

Use `model.geom(<tag>).feature(<ftag>).selection("point")` to select which corners to round. The default selection is empty.

TABLE 3-51: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE     | DEFAULT | DESCRIPTION        |
|-----------------|-----------|---------|--------------------|
| point           | Selection |         | Vertices to fillet |
| radius          | double    | 0       | Radius of fillet   |
| createselection | on   off  | off     | Create selections  |

If `createselection` is set to on, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

- Compatibility** In version 3.5a, the default was to fillet all vertices in the input objects.  
The properties `edges`, `out`, and `radii` are no longer available.

- Examples** Fillet a rectangle object:

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",2);
model.geom("geom1").feature().create("r1","Rectangle");
model.geom("geom1").feature().create("fil1","Fillet");
model.geom("geom1").feature("fil1").selection("point").
 set("r1(1)",new int[]{1,2,3,4});
model.geom("geom1").feature("fil1").set("radius",0.1);
model.geom("geom1").run();
```

- Diagnostics** If `Fillet` does not succeed in creating a rounded corner according to the specified radius, the vertex is skipped. When a fillet intersects another edge, the function generates an error message.

- See Also** [Chamfer](#)

**Purpose** Create finalized geometry.

**Syntax** `model.geom(<tag>).feature(<ftag>).set(property,<value>);`  
`model.geom(<tag>).feature(<ftag>).getType(property);`

**Description** The finalize features combines all available geometry objects in the sequence to form a single geometry object. In 3D, you can modify this object by using virtual operations. The output of the last geometry feature is the *finalized geometry* used when meshing and when setting up physics. If the property `action` is set to `union`, and multiple geometry objects are present in the geometry sequence, the objects are combined into a single object with multiple domains corresponding to the input objects and eventual overlaps between these.

Set the property `action` to `assembly` to keep multiple objects in the finalized geometry. Use this option when modeling physics that needs separate geometry objects, for example when modeling mechanical contact.

TABLE 3-52: VALID PROPERTIES

| NAME                     | VALUE                           | DEFAULT               | DESCRIPTION                                             |
|--------------------------|---------------------------------|-----------------------|---------------------------------------------------------|
| <code>action</code>      | <code>union   assembly</code>   | <code>union</code>    | Handling of multiple objects                            |
| <code>createpairs</code> | <code>on   off</code>           | <code>on</code>       | Create pairs (used if <code>action=assembly</code> )    |
| <code>imprint</code>     | <code>on   off</code>           | <code>off</code>      | Create imprints (used if <code>action=assembly</code> ) |
| <code>repairtol</code>   | <code>double</code>             | <code>1e-6</code>     | Repair tolerance, relative to size of union of inputs   |
| <code>pairtype</code>    | <code>identity   contact</code> | <code>identity</code> | Type of pairs to create                                 |

**See Also** [Compose](#), [Union](#), [Intersection](#), [Difference](#)

**Purpose** Create geometry (deformed configuration) from a (deformed) mesh.

**Syntax** `model.geom(<tag>).feature(<ftag>).set(property,<value>);`  
`model.geom(<tag>).feature(<ftag>).getType(property);`  
`model.geom(<tag>).feature(<ftag>).importData();`

**Description** To create a geometry sequence from a deformed mesh, use the `createDeformedConfig` method on a solution dataset, see [Solution](#). Such a geometry sequence contains a `FromMesh` feature. This feature has the following properties

TABLE 3-53: VALID PROPERTIES

| NAME                | VALUE                | DEFAULT       | DESCRIPTION                       |
|---------------------|----------------------|---------------|-----------------------------------|
| <code>solnum</code> | non-negative integer | Last solution | The index of the solution to use. |

`model.geom(<tag>).feature(<ftag>).importData()` updates the geometry based on the current value of the solution in the feature's corresponding solver sequence.

**Purpose** Create a solid, surface or curve helix in 3D

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Helix");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Helix")` to create a helix. The following properties are available:

TABLE 3-54: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE                           | DEFAULT   | DESCRIPTION                                                                                                                                 |
|-----------------|---------------------------------|-----------|---------------------------------------------------------------------------------------------------------------------------------------------|
| axialpitch      | double                          | 0.3       | Axial pitch                                                                                                                                 |
| axis            | double[]                        | {0,0,1}   | Direction of the helix axis. Vector has length 3 if <code>axistype</code> is cartesian, and length 2 if <code>axistype</code> is spherical. |
| axistype        | cartesian   spherical           | cartesian | Coordinate system used for axis. The value is synchronized with <code>axis</code> .                                                         |
| chirality       | right   left                    | right     | Chirality                                                                                                                                   |
| endcaps         | paraaxis   perpaxis   perpspine | paraaxis  | Direction of end caps                                                                                                                       |
| grep            | bezier   spline                 | spline    | Geometry representation                                                                                                                     |
| pos             | double[]                        | {0,0,0}   | Position of the object                                                                                                                      |
| radialpitch     | double                          | 0         | Radial pitch                                                                                                                                |
| rmaj            | double                          | 1         | Major radius                                                                                                                                |
| rmin            | double                          | 0.1       | Minor radius                                                                                                                                |
| rot             | double                          | 0         | Rotational angle about axis                                                                                                                 |
| rtol            | double                          | 1e-4      | Relative tolerance                                                                                                                          |
| turns           | double                          | 3         | Number of turns                                                                                                                             |
| type            | solid   surface                 | solid     | Object type                                                                                                                                 |
| twistcomp       | on   off                        | on        | Twist compensation                                                                                                                          |
| createselection | on   off                        | off       | Create selections                                                                                                                           |

If `createselection` is set to on, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To

access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

### Examples

The following sequence generates a surface helix and a solid helix.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("h1","Helix");
model.geom("geom1").feature("h1").set("type","surface");
model.geom("geom1").feature("h1").set("rmaj",2);
model.geom("geom1").feature("h1").set("rmin",0.3);
model.geom("geom1").feature("h1").set("axialpitch",1);

model.geom("geom1").feature().create("h2","Helix");
model.geom("geom1").feature("h2").set("rmaj",10);
model.geom("geom1").feature("h2").set("rmin",2);
model.geom("geom1").feature("h2").set("axialpitch",1);
model.geom("geom1").feature("h2").set("pos","0,0,-100");
model.geom("geom1").feature("h2").set("axis","1,1,1");
model.geom("geom1").feature("h2").set("rot",60);
model.geom("geom1").run();
```

### See Also

[Torus, Sweep](#)

**Purpose** Create solid or surface hexahedron bounded by bilinear faces

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Hexahedron");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Hexahedron")` to create a general hexahedron. The following properties are available:

TABLE 3-55: VALID PROPERTY/VALUE PAIR

| PROPERTY NAME   | PROPERTY VALUE  | DEFAULT                                                        | DESCRIPTION        |
|-----------------|-----------------|----------------------------------------------------------------|--------------------|
| p               | double[3][8]    | {0,0,1,1,0,0,1,1},<br>{0,1,1,0,0,1,1,0},<br>{0,0,0,0,1,1,1,1}} | Corner coordinates |
| type            | solid   surface | solid                                                          | Object type        |
| createselection | on   off        | off                                                            | Create selections  |

For a hexahedron approximately aligned to the coordinate planes, the points in p are ordered as follows. The first four points and the last four points projected down to the (x, y)-plane defines two negatively oriented quadrangles. The corresponding plane for the second quadrangle must lie above the plane of the first quadrant in the z direction. Generally oriented hexahedra have the points of p ordered in a similar way, except for a rigid transformation of the defining point set.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bn`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Example** The following command generates a solid hexahedron object.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("h1","Hexahedron");
model.geom("geom1").feature("h1").set("p",new double[][]
 {{0,0.0,1,1.0,0,0,1.0,1},
 {0,0.8,1,0.0,0,1,1.2,0},
 {0,0.1,0,0.2,1,1,2.0,1}});
model.geom("geom1").run();
```

**See Also** [Block](#), [Pyramid](#), [Tetrahedron](#)

**Purpose** Ignore edges

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>, "IgnoreEdges");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property, <value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>, "IgnoreEdges")` to ignore edges.

Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the edges to ignore. The default selection is empty.

The feature removes the selected edges that are isolated, that are adjacent to precisely two faces, or that are between two domains. If an edge is adjacent to two faces in 3D, the operations forms a composite face, if an edge is between two domains in 2D, the operation forms composite domain. The output object is a virtual geometry.

The following properties are available:

TABLE 3-56: VALID PROPERTIES

| NAME        | VALUE     | DEFAULT | DESCRIPTION                 |
|-------------|-----------|---------|-----------------------------|
| input       | Selection |         | Edges to ignore             |
| ignorevtx   | on   off  | on      | Ignore vertices on boundary |
| keepformesh | on   off  | off     | Keep edges for mesh control |

Use `ignorevtx` to specify if the feature also removes the ignorable vertices on the boundary of each resulting composite face.

Use `keepformesh` to keep the ignored edges while meshing, to help you in constructing the mesh.

**Example** Create a sphere and ignore all edges and, implicitly, all vertices.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 3);
model.geom("geom1").feature().create("sph1", "Sphere");
model.geom("geom1").feature().create("ige1", "IgnoreEdges");
model.geom("geom1").feature("ige1").selection("input").
 set("fin(1)", 1,2,3,4,5,6,7,8,9,10,11,12);
model.geom("geom1").run("ige1");
```

**See Also** [CompositeFaces](#), [IgnoreFaces](#), [IgnoreVertices](#), [MeshControlEdges](#)



|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Ignore faces                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Syntax</b>      | <pre>model.geom(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"IgnoreFaces"); model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).selection(property); model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).set(property,&lt;value&gt;); model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).getType(property);</pre>                                                                                                                                                                                   |
| <b>Description</b> | <p>Use <code>model.geom(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"IgnoreFaces")</code> to ignore faces in 3D.</p> <p>Use <code>model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).selection("input")</code> to select the faces to ignore. The default selection is empty.</p> <p>The feature removes the selected faces that are isolated or that are between two domains. In the latter case, the operation forms a composite domain. The output object is a virtual geometry.</p> |

The following properties are available:

TABLE 3-57: VALID PROPERTIES

| NAME        | VALUE     | DEFAULT | DESCRIPTION                           |
|-------------|-----------|---------|---------------------------------------|
| input       | Selection |         | Faces to ignore                       |
| ignoreadj   | on   off  | on      | Ignore edges and vertices on boundary |
| keepformesh | on   off  | off     | Keep faces for mesh control           |

Use `ignoreadj` to specify if the feature also removes the ignorable edges and vertices on the boundary of each resulting composite domain.

Use `keepformesh` to keep the ignored faces while meshing, to help you in constructing the mesh.

|                |                                                                                                                |
|----------------|----------------------------------------------------------------------------------------------------------------|
| <b>Example</b> | Ignore faces to form one composite domain. The operation will also create composite faces and composite edges. |
|----------------|----------------------------------------------------------------------------------------------------------------|

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 3);
model.geom("geom1").feature().create("blk1", "Block");
model.geom("geom1").feature().create("cyl1", "Cylinder");
model.geom("geom1").run("fin");
model.geom("geom1").feature().create("igf1", "IgnoreFaces");
model.geom("geom1").feature("igf1").selection("input").
 set("fin", 6, 7, 10);
model.geom("geom1").run("igf1");
```

|                 |                                                                                                                                    |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------|
| <b>See Also</b> | <a href="#">CompositeDomains</a> , <a href="#">IgnoreEdges</a> , <a href="#">IgnoreVertices</a> , <a href="#">MeshControlFaces</a> |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------|

- Purpose** Ignore vertices
- Syntax**  
`model.geom(<tag>).feature().create(<ftag>, "IgnoreVertices");`  
`model.geom(<tag>).feature(<ftag>).selection(property);`  
`model.geom(<tag>).feature(<ftag>).set(property, <value>);`  
`model.geom(<tag>).feature(<ftag>).getType(property);`
- Description**
- Use `model.geom(<tag>).feature().create(<ftag>, "IgnoreVertices")` to ignore vertices.
- Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the vertices to ignore. The default selection is empty.
- The feature removes the selected vertices that are isolated or that are adjacent to precisely two edges. If a vertex is adjacent to two edges, the operation forms a composite edge. The output object is a virtual geometry.
- The following properties are available:

TABLE 3-58: VALID PROPERTIES

| NAME        | VALUE     | DEFAULT | DESCRIPTION                    |
|-------------|-----------|---------|--------------------------------|
| input       | Selection |         | Vertices to ignore             |
| keepformesh | on   off  | off     | Keep vertices for mesh control |

Use `keepformesh` to keep the ignored vertices while meshing, to help you in constructing the mesh.

- Example** Create an ellipse and ignore vertices 1 and 3, which gives you two remaining edges in the final geometry.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 2);
model.mesh().create("mesh1", "geom1");
model.geom("geom1").feature().create("e1", "Ellipse");
model.geom("geom1").run("fin");
model.geom("geom1").feature().create("igv1", "IgnoreVertices");
model.geom("geom1").feature("igv1").selection("input").
 set("fin", 1, 3);
model.geom("geom1").run();
```

- See Also** [CompositeEdges](#), [IgnoreEdges](#), [IgnoreFaces](#), [MeshControlVertices](#)

**Purpose** Import geometry objects from a DXF file to 2D

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Import");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
model.geom(<tag>).feature(<ftag>).getLayers();
model.geom(<tag>).feature(<ftag>).importData();
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Import")` to create a geometry import feature. When the property `filename` is set to a file recognized as a DXF CAD drawing, the property `type` is set to `dxf` and the following properties are available:

TABLE 3-59: VALID PROPERTY/VALUE PAIRS

| PROPERTY                     | VALUE                            | DEFAULT                 | DESCRIPTION                                                                |
|------------------------------|----------------------------------|-------------------------|----------------------------------------------------------------------------|
| <code>convert</code>         | <code>solid   curve   off</code> | <code>solid</code>      | Unite all objects in each layer, and convert it to a solid or curve object |
| <code>filename</code>        | String                           |                         | File name                                                                  |
| <code>layers</code>          | String[]                         | <code>all layers</code> | Layers to import                                                           |
| <code>repairgeom</code>      | <code>on   off</code>            | <code>on</code>         | Repair geometry                                                            |
| <code>repairtol</code>       | double                           | <code>1e-5</code>       | Repair tolerance, relative to size of union of imported objects            |
| <code>type</code>            | <code>dxf</code>                 |                         | Type of import                                                             |
| <code>createselection</code> | <code>on   off</code>            | <code>off</code>        | Create selections                                                          |

The file specified by `filename` can be of any of the following formats:

TABLE 3-60: SUPPORTED FILE FORMATS

| FILE FORMAT | FILE EXTENSIONS   |
|-------------|-------------------|
| DXF         | <code>.dxf</code> |

The imported objects are represented using COMSOL's geometry modeler.

The property `layers` controls which DXF layers are imported. The value is an array of strings containing the names of the layers that are to be imported. The layers found in the file defined by the property `filename` can be retrieved by the command

```
model.geom(<tag>).feature(<ftag>).getLayers()
```

The method

```
model.geom(<tag>).feature(<ftag>).importData()
```

imports the file again.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. If more than one object is imported, additional selections are created for each imported object. To access the selections, use

`model.selection(<tag>_<otag>_<lvl>)`, where `<otag>` is a tag derived from the name of the imported object. For standard object names of the form `<ftag>(<n>)`, where `<n>` is an object number, the corresponding `<otag>` is `<ftag>_<n>`. For non-standard object names derived from CAD files, `<otag>` is derived by replacing space and dot characters with underscore characters, and removing other characters that are not numbers or upper- or lowercase English characters (a-z). Additionally, if required to make `<otag>` unique, `_<m>` is appended, where `<m>` is an integer. The `createselection` property is not available in work-plane geometries.

### Compatibility

The following property is also supported:

| PROPERTY              | VALUE                                   | DEFAULT            | DESCRIPTION                                                                                        |
|-----------------------|-----------------------------------------|--------------------|----------------------------------------------------------------------------------------------------|
| <code>coercion</code> | <code>solid   face   curve   off</code> | <code>solid</code> | Alias for <code>convert</code> . The value <code>face</code> is equivalent to <code>solid</code> . |

**Purpose** Import geometry objects from an ECAD file in 2D and 3D

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Import");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
model.geom(<tag>).feature(<ftag>).getLayers();
model.geom(<tag>).feature(<ftag>).importData();
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Import")` to create a geometry import feature.

---

**Note:** ECAD import requires a license for any of the following modules: AC/DC Module, MEMS Module, or RF Module.

---

When the property `filename` is set to a file recognized as an ECAD file, the property `type` is set to `ecad` or `odb` and the following properties are available:

TABLE 3-61: VALID PROPERTY/VALUE PAIRS

| PROPERTY                     | VALUE      | DEFAULT | DESCRIPTION                                                     |
|------------------------------|------------|---------|-----------------------------------------------------------------|
| <code>filename</code>        | String     |         | File name                                                       |
| <code>elevation</code>       | String[]   |         | Z-position of layers                                            |
| <code>height</code>          | String[]   |         | Height of layers                                                |
| <code>importlayer</code>     | String[]   |         | Layers to import                                                |
| <code>manualelevation</code> | on   off   | off     | Manual control of elevations                                    |
| <code>repairgeom</code>      | on   off   | on      | Repair imported objects                                         |
| <code>repairtol</code>       | double     | 1e-5    | Repair tolerance, relative to size of union of imported objects |
| <code>type</code>            | ecad   odb |         | Type of import                                                  |
| <code>createselection</code> | on   off   | off     | Create selections                                               |

The file specified by `filename` can be of any of the following formats:

TABLE 3-62: SUPPORTED FILE FORMATS

| FILE FORMAT | FILE EXTENSIONS |
|-------------|-----------------|
| GDS         | .gds            |
| NETEX-G     | .asc            |
| ODB++(X)    | .xml            |

The imported objects are represented using COMSOL’s geometry modeler.

The property `type` determines which properties are available. To import a GDS or NETEX-G file, `type` must be `ecad`. To import an ODB++ file, `type` must be `odb`. The property `type` is automatically initialized from the property `filename`, according to the table above.

The property `importlayer` determines which layers to import. It is a string array of the same length as the number of layers, holding the strings `on` or `off`. The property is initialized with a valid default when setting the property `filename`. To inspect available layers, use the method

```
model.geom(<tag>).feature(<ftag>).getLayers();
```

The property `height` determines the height of all layers. It is a string array of the same length as the number of layers, holding string representations of the layer height, for example `1[mm]`. The property is initialized with a valid default when setting the property `filename`.

The property `manualelevation` controls how imported layers are positioned in the Z direction. When `manualelevation` is `off`, the imported layers are stacked on top of each other with no gaps, so the Z positions are computed from the `height` property. When `manualelevation` is `on` and `grouping` is set to `layer` or `none`, the imported layers are positioned in the Z direction as specified by the `elevation` property.

The property `elevation` determines the Z-position of all layers. It is a string array of the same length as the number of layers, holding string representations of the layer elevation. The property is initialized with a valid default when setting the property `filename`.

Additional properties available when `type` is `ecad` or `odb`.

TABLE 3-63: VALID PROPERTY/VALUE PAIRS FOR ECAD IMPORT

| PROPERTY NAME           | PROPERTY VALUE                  | DEFAULT             | DESCRIPTION                                                                                                                                                                                                |
|-------------------------|---------------------------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>grouping</code>   | <code>all   layer   none</code> | <code>all</code>    | The grouping of the imported layers, where <code>all</code> returns one single object, and <code>layers</code> gives you one object per layer. In 2D, <code>all</code> is the same as <code>layer</code> . |
| <code>importtype</code> | <code>full3d   shell</code>     | <code>full3d</code> | Determine if metal layers are imported as solid or faces in 3D                                                                                                                                             |
| <code>intbnd</code>     | <code>on   off</code>           | <code>on</code>     | Keep interior boundaries of nets                                                                                                                                                                           |

Properties that are only available when type is `ecad`.

TABLE 3-64: VALID PROPERTY/VALUE PAIRS FOR GDS AND NETEX-G

| PROPERTY NAME               | PROPERTY VALUE                       | DEFAULT              | DESCRIPTION                                                                                         |
|-----------------------------|--------------------------------------|----------------------|-----------------------------------------------------------------------------------------------------|
| <code>arcdistancetol</code> | <code>double</code>                  | 0.3                  | Tolerance for segment length deviation                                                              |
| <code>arcmaxangle</code>    | <code>double</code>                  | 36                   | Maximum angle for segments                                                                          |
| <code>arcminangle</code>    | <code>double</code>                  | 3.6                  | Minimum angle for segments to part of an arc                                                        |
| <code>arcradiustol</code>   | <code>double</code>                  | 0.4                  | Tolerance for arc curvature                                                                         |
| <code>bondtype</code>       | <code>edge   block   cylinder</code> | <code>edge</code>    | Specify how bond wires are modeled for NETEX-G files                                                |
| <code>bottommargin</code>   | <code>double</code>                  | 0                    | Distance to the bottom edge of the dielectric region                                                |
| <code>cell</code>           | <code>String</code>                  | <code>top net</code> | Name of top net or cell to import                                                                   |
| <code>dielectric</code>     | <code>on   off</code>                | <code>on</code>      | Import dielectric regions                                                                           |
| <code>findarcs</code>       | <code>auto   manual   off</code>     | <code>auto</code>    | Control arc recognition                                                                             |
| <code>findlines</code>      | <code>on   off</code>                | <code>on</code>      | Turn on straight line recognition. Only available when <code>findarcs</code> is <code>manual</code> |
| <code>leftmargin</code>     | <code>double</code>                  | 0                    | See <code>bottommargin</code>                                                                       |
| <code>rightmargin</code>    | <code>double</code>                  | 0                    | See <code>bottommargin</code>                                                                       |
| <code>topmargin</code>      | <code>double</code>                  | 0                    | See <code>bottommargin</code>                                                                       |

When `findarcs` is `auto` or `manual`, line segments are combined to form arcs. If `findarcs` is `manual`, the properties `arcdistancetol`, `arcradiustol`, `arcminangle`, `arcmaxangle`, and `findlines` can be used to tune the arc recognition algorithm, otherwise the algorithm tries to determine optimal parameters.

TABLE 3-65: VALID PROPERTY/VALUE PAIRS FOR ODB++

| PROPERTY NAME           | PROPERTY VALUE        | DEFAULT         | DESCRIPTION                                  |
|-------------------------|-----------------------|-----------------|----------------------------------------------|
| <code>ignoretext</code> | <code>on   off</code> | <code>on</code> | Ignore objects marked as text in ODB++ files |

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where

`<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. If more than one layer is imported, additional selections are created for each imported layer. To access the selections, use `model.selection(<tag>_<ftag>_<otag>_<dom>)`, where `<otag>` is a tag derived from the name of the imported layer. `<otag>` is derived by replacing space and dot characters with underscore characters, and removing other characters that are not numbers or upper- or lowercase English characters (a-z). Additionally, if required to make `<otag>` unique, `_<m>` is appended, where `<m>` is an integer. The `createselection` property is not available in work-plane geometries.



**Purpose** Import geometry objects from another geometry sequence

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Import");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
model.geom(<tag>).feature(<ftag>).importData();
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Import")` to create a geometry import feature. Set the property sequence to the tag of another geometry sequence in the model.

| PROPERTY        | VALUE    | DEFAULT | DESCRIPTION                    |
|-----------------|----------|---------|--------------------------------|
| sequence        | String   |         | Tag of other geometry sequence |
| type            | sequence |         | Type of import                 |
| createselection | on   off | off     | Create selections              |

When building, the import feature takes all the existing objects in the specified sequence and imports them into the feature’s sequence.

The method

```
model.geom(<tag>).feature(<ftag>).importData()
```

imports the sequence again. The imported objects are represented using COMSOL’s geometry modeler, or the CAD Import Module’s geometry modeler (Parasolid).

If `createselection` is set to on, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. If more than one object is imported, additional selections are created for each imported object. To access the selections, use `model.selection(<tag>_<otag>_<lvl>)`, where `<otag>` is a tag derived from the name of the imported object. For standard object names of the form `<ftag>(<n>)`, where `<n>` is an object number, the corresponding `<otag>` is `<ftag>_<n>`. For non-standard object names derived from CAD files, `<otag>` is derived by replacing space and dot characters with underscore characters, and removing other characters that are not numbers or upper- or lowercase English characters (a-z). Additionally, if required to make `<otag>` unique, `_<m>` is appended, where `<m>` is an integer. The `createselection` property is not available in work-plane geometries.

|                    |                                                                                                                                                                                                                                                                                                                                              |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Import geometry objects from a file using COMSOL's geometry formats                                                                                                                                                                                                                                                                          |
| <b>Syntax</b>      | <pre>model.geom(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"Import"); model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).set(property,&lt;value&gt;); model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).getType(property); model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).importData();</pre>                                                          |
| <b>Description</b> | Use <code>model.geom(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"Import")</code> to create a geometry import feature. When the property <code>filename</code> is set to a file recognized as an <code>mphbin</code> or <code>mphtxt</code> file, the property type is set to <code>native</code> and the following properties are available: |

TABLE 3-66: VALID PROPERTY/VALUE PAIRS

| PROPERTY                     | VALUE                              | DEFAULT          | DESCRIPTION       |
|------------------------------|------------------------------------|------------------|-------------------|
| <code>filename</code>        | String                             |                  | File name         |
| <code>type</code>            | <code>native</code>                |                  | Type of import    |
| <code>createselection</code> | <code>on</code>   <code>off</code> | <code>off</code> | Create selections |

The file specified by `filename` can be of any of the following formats:

TABLE 3-67: SUPPORTED FILE FORMATS

| FILE FORMAT                | FILE EXTENSIONS      |
|----------------------------|----------------------|
| COMSOL Multiphysics Binary | <code>.mphbin</code> |
| COMSOL Multiphysics Text   | <code>.mphtxt</code> |

The imported objects are represented using COMSOL's geometry modeler, or the CAD Import Module's geometry modeler (Parasolid).

The method

```
model.geom(<tag>).feature(<ftag>).importData()
```

imports the file again.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. If more than one object is imported, additional selections are created for each imported object. To access the selections, use `model.selection(<tag>_<otag>_<lvl>)`, where `<otag>` is a tag derived from the name of the imported object. For standard object names of the form `<ftag>(<n>)`, where `<n>` is an object number, the corresponding `<otag>` is `<ftag>_<n>`. For non-standard object names derived from CAD files, `<otag>` is

derived by replacing space and dot characters with underscore characters, and removing other characters that are not numbers or upper- or lowercase English characters (a-z). Additionally, if required to make `<otag>` unique, `_m` is appended, where `<i>` is an integer. The `createselection` property is not available in work-plane geometries.

**Purpose** Import geometry objects from a STL or VRML file containing a surface mesh

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Import");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
model.geom(<tag>).feature(<ftag>).importData();
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Import")` to create a geometry import feature. When the property `filename` is set to a file recognized as an STL or VRML file, the property type is set to `stlvrml` and the following properties are available:

TABLE 3-68: VALID PROPERTY/VALUE PAIRS

| PROPERTY      | VALUE         | DEFAULT     | DESCRIPTION                                                                                                                             |
|---------------|---------------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| curvedface    | auto   manual | auto        | Control parameters for partitioning of curved faces.                                                                                    |
| extrangle     | double        | 0.6 degrees | Maximum angle between boundary element normal and extrusion plane that causes the element to be a part the extruded face if possible    |
| faceangle     | double        | 110 degrees | Maximum angle between any two boundary elements in the same face                                                                        |
| facecleanup   | double        | 0.01        | Avoid creating small faces. Faces with an area less than <code>facecleanup * the mean face area</code> , are merged with adjacent faces |
| facecurv      | double        | 10 degrees  | Maximum relative curvature deviation between any two boundary elements in the same face                                                 |
| facepartition | auto   manual | auto        | Manual or automatic face partitioning                                                                                                   |
| filename      | String        |             | File name                                                                                                                               |
| minareacurv   | double        | 1           | Minimum relative area of face to be considered as a face with constant curvature                                                        |

TABLE 3-68: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE    | DEFAULT     | DESCRIPTION                                                                                                                         |
|-----------------|----------|-------------|-------------------------------------------------------------------------------------------------------------------------------------|
| minareaextr     | double   | 0.05        | Minimum relative area of face to be considered extruded                                                                             |
| minareaplane    | double   | 0.005       | Minimum relative area of face to be considered planar                                                                               |
| neighangle      | double   | 20 degrees  | Maximum angle between a boundary element and a neighbor that causes the elements to be part of the same boundary domain if possible |
| planar          | on   off | on          | Detect planar faces                                                                                                                 |
| planarangle     | double   | 0.6 degrees | Maximum angle between boundary element normal and a neighbor that causes the element to be a part the planar face if possible       |
| report          | on   off | on          | Display a progress window                                                                                                           |
| type            | stlvrml  |             | Type of import                                                                                                                      |
| createselection | on   off | off         | Create selections                                                                                                                   |

The file specified by filename can be of any of the following formats:

TABLE 3-69: SUPPORTED FILE FORMATS

| FILE FORMAT | FILE EXTENSIONS |
|-------------|-----------------|
| STL         | .stl            |
| VRML        | .wr1, .vrml     |

The imported objects are represented using COMSOL's geometry modeler.

The method

```
model.geom(<tag>).feature(<ftag>).importData()
```

imports the file again.

If createselection is set to on, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of dom, bnd, edg, pnt. If more than one object is imported, additional selections are created for

each imported object. To access the selections, use `model.selection(<tag>_<otag>_<lvl>)`, where `<otag>` is a tag derived from the name of the imported object. For standard object names of the form `<ftag>(<n>)`, where `<n>` is an object number, the corresponding `<otag>` is `<ftag>_<n>`. For non-standard object names derived from CAD files, `<otag>` is derived by replacing space and dot characters with underscore characters, and removing other characters that are not numbers or upper- or lowercase English characters (a-z). Additionally, if required to make `<otag>` unique, `_<m>` is appended, where `<m>` is an integer. The `createselection` property is not available in work-plane geometries.

**Purpose** Create a curve interpolating or approximating a sequence of points in 2D or 3D

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"InterpolationCurve");
model.geom(<tag>).feature(<ftag>).importToTable();
model.geom(<tag>).feature(<ftag>).importData();
```

**Description** To create an interpolation curve use

```
model.geom(<tag>).feature().create(<ftag>,"InterpolationCurve")
```

The following properties are available:

TABLE 3-70: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE                 | DEFAULT | DESCRIPTION                                                   |
|-----------------|-----------------------|---------|---------------------------------------------------------------|
| filename        | String                |         | If source is file, the file that contains the data            |
| source          | table   file          | table   | Specifies whether data is entered in table or read from file. |
| table           | double[][]            |         | Data points, size N*sdim.                                     |
| rtol            | double                | 0       | Maximum relative error. 0 implies interpolation.              |
| type            | open   closed   solid | open    | Type of curve                                                 |
| createselection | on   off              | off     | Create selections                                             |

Use `model.geom(<tag>).feature(<ftag>).importToTable()` to read data from the file defined by the `filename` property and store the data in the `table` property. The `source` property is also changed to `table`.

If `source` is `file`, the interpolation curve is not automatically rebuilt when the data in the file changes. Use `model.geom(<tag>).feature(<ftag>).importData()` to rebuild the interpolation curve after such a change.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Example** The commands below create a curve interpolating four points.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 2);
model.geom("geom1").feature().create("ic1",
```

```
 "InterpolationCurve");
model.geom("geom1").feature("ic1").set("table",
 new double[][]{{0,0}, {1,0}, {1,1}, {0,1}});
model.geom("geom1").run();
```

**See Also**

[BezierPolygon](#)



**Purpose** Create one or several connected intervals in 1D

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Interval");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Interval")` to create one or more intervals. The following properties are available:

TABLE 3-71: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE      | DEFAULT | DESCRIPTION                    |
|-----------------|------------|---------|--------------------------------|
| intervals       | one   many | one     | Use properties p1 and p2, or p |
| p               | double[]   | {0, 1}  | Vertex coordinates             |
| p1              | double     | 0       | Left endpoint                  |
| p2              | double     | 1       | Right endpoint                 |
| createselection | on   off   | off     | Create selections              |

To specify one interval, set the properties p1 and p2. Then, `intervals` is automatically set to `one`.

To specify a sequence of connected intervals, set the property p. Then, `intervals` is automatically set to `many`.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Compatibility** `model.geom(<tag>).feature().create(<ftag>,"solid1")` creates an interval.

**Example** The commands below create a solid consisting of two intervals.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",1);
model.geom("geom1").feature().create("i1","Interval");
model.geom("geom1").feature("i1").set("p","0 1 3");
model.geom("geom1").runAll();
```

**See Also** [BezierPolygon](#)

## MergeVertices

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Merge two vertices                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Syntax</b>      | <pre>model.geom(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"MergeVertices"); model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).selection(property); model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).set(property,&lt;value&gt;); model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).getType(property);</pre>                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Description</b> | <p>Use <code>model.geom(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"MergeVertices")</code> to merge two vertices.</p> <p>Use <code>model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).selection("keepvtx")</code> to select the vertex to keep. The default selection is empty.</p> <p>Use <code>model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).selection("removevtx")</code> to select the vertex to remove. The default selection is empty.</p> <p>The feature merges the two vertices by collapsing the edge between the vertices and re-connecting the edges adjacent to the removed vertex to the resulting merged vertex.</p> <p>The output object is a virtual geometry.</p> <p>The following properties are available:</p> |

TABLE 3-72: VALID PROPERTIES

| NAME      | VALUE     | DEFAULT | DESCRIPTION      |
|-----------|-----------|---------|------------------|
| keepvtx   | Selection |         | Vertex to keep   |
| removevtx | Selection |         | Vertex to remove |

**See Also** [CollapseEdges](#)

**Purpose** Define mesh control domains

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"MeshControlDomains");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description**

Use `model.geom(<tag>).feature().create(<ftag>,"MeshControlDomains")` to define mesh control domains.

Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the domains to include. The default selection is empty.

The feature creates a composite domain by removing all faces (in 3D) or edges (in 2D) between the selected domains and adjacent domains. The removed entities are kept for mesh control.

The following property is available:

TABLE 3-73: VALID PROPERTIES

| NAME  | VALUE     | DEFAULT | DESCRIPTION     |
|-------|-----------|---------|-----------------|
| input | Selection |         | Edges to ignore |

**See Also** [MeshControlFaces](#), [MeshControlEdges](#)

- Purpose** Define mesh control edges
- Syntax**  

```
model.geom(<tag>).feature().create(<ftag>,"MeshControlEdges");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```
- Description**  
Use `model.geom(<tag>).feature().create(<ftag>,"MeshControlEdges")` to define mesh control edges.
- Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the edges to include. The default selection is empty.
- The feature removes the selected edges that are isolated, that are adjacent to precisely two faces (in 3D), or that are between two domains (in 2D). The edges are kept for mesh control.

The following properties are available:

TABLE 3-74: VALID PROPERTIES

| NAME       | VALUE     | DEFAULT | DESCRIPTION                    |
|------------|-----------|---------|--------------------------------|
| input      | Selection |         | Edges to ignore                |
| includevtx | on   off  | on      | Include start and end vertices |

Use `includevtx` to specify if the feature also removes the ignorable start and end vertices of the edge.

- See Also** [IgnoreEdges](#), [MeshControlDomains](#), [MeshControlFaces](#), [MeshControlVertices](#)

|                    |                                                                                                                                                                                                                                                                                                      |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Define mesh control faces                                                                                                                                                                                                                                                                            |
| <b>Syntax</b>      | <pre>model.geom(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"MeshControlFaces"); model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).selection(property); model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).set(property,&lt;value&gt;); model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).getType(property);</pre> |
| <b>Description</b> | <p>Use <code>model.geom(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"MeshControlFaces")</code> to define mesh control faces in 3D.</p> <p>Use <code>model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).selection("input")</code> to select the faces to include. The default selection is empty.</p>       |

The feature removes the selected faces that are isolated or that are between two domains. The faces are kept for mesh control.

The following properties are available:

TABLE 3-75: VALID PROPERTIES

| NAME       | VALUE     | DEFAULT | DESCRIPTION                            |
|------------|-----------|---------|----------------------------------------|
| input      | Selection |         | Faces to include                       |
| includeadj | on   off  | on      | Include edges and vertices on boundary |

Use `includeadj` to specify if the feature also includes the ignorable edges and vertices on the boundary of each resulting composite domain.

**See Also** [IgnoreFaces](#), [MeshControlDomains](#), [MeshControlEdges](#), [MeshControlVertices](#)

**Purpose** Define mesh control vertices

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"MeshControlVertices");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description**

Use `model.geom(<tag>).feature().create(<ftag>,"MeshControlVertices")` to define mesh control vertices.

Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the vertices to include. The default selection is empty.

The feature removes the selected vertices that are isolated or that are adjacent to precisely two edges. The vertices are kept for mesh control.

The following properties are available:

TABLE 3-76: VALID PROPERTIES

| NAME  | VALUE     | DEFAULT | DESCRIPTION         |
|-------|-----------|---------|---------------------|
| input | Selection |         | Vertices to include |

**See Also** [IgnoreVertices](#), [MeshControlFaces](#), [MeshControlEdges](#)

- Purpose** Reflect objects in a plane (3D), a line (2D), or a point (1D)
- Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Mirror");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```
- Description** Use `model.geom(<tag>).feature().create(<ftag>,"Mirror")` to mirror geometry objects.
- Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the objects to mirror. The default selection is empty.

The following properties are available:

TABLE 3-77: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE     | DEFAULT                                | DESCRIPTION                           |
|-----------------|-----------|----------------------------------------|---------------------------------------|
| input           | Selection |                                        | Objects to reflect                    |
| keep            | on   off  | off                                    | Keep input objects                    |
| pos             | double[]  | 0                                      | A point to be fixed during reflection |
| axis            | double[]  | {0 0 1} (3D)<br>{1 0} (2D)<br>{1} (1D) | Vector in the direction to reflect    |
| createselection | on   off  | off                                    | Create selections                     |

In 3D, the input objects are reflected in the plane through `pos` with normal vector `axis`. In 2D, the input objects are reflected in the line through `pos` with normal vector `axis`. In 1D, the input objects are reflected in the point `pos`.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Compatibility** The property `out` is no longer available.

**Examples** In 2D:

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",2);
model.geom("geom1").feature().create("r1","Rectangle");
model.geom("geom1").feature().create("m1","Mirror");
```

```
model.geom("geom1").feature("m1").selection("input").set("r1");
model.geom("geom1").feature("m1").set("pos","2 2");
model.geom("geom1").feature("m1").set("axis","1 1");
model.geom("geom1").run();
```

In 3D:

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("blk1","Block");
model.geom("geom1").feature().create("m1","Mirror");
model.geom("geom1").feature("m1").
 selection("input").set("blk1");
model.geom("geom1").feature("m1").set("pos","2 2 2");
model.geom("geom1").feature("m1").set("axis","1 1 1");
model.geom("geom1").run();
```

**See Also**

[Move](#), [Copy](#), [Rotate](#), [Scale](#)



**Purpose** Move or copy geometry object(s) by translation

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Move");
model.geom(<tag>).feature().create(<ftag>,"Copy");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Move")` to move geometry objects.

Use `model.geom(<tag>).feature().create(<ftag>,"Copy")` to move a copy of geometry objects.

Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the objects to move or copy. The default selection is empty.

The following properties are available:

TABLE 3-78: VALID PROPERTIES

| NAME            | VALUE                 | DEFAULT                 | DESCRIPTION             |
|-----------------|-----------------------|-------------------------|-------------------------|
| input           | Selection             |                         | Objects to move or copy |
| keep            | on   off              | off (Move)<br>on (Copy) | Keep input objects      |
| displ           | double[]   double[][] | 0                       | Displacement vector(s)  |
| createselection | on   off              | off                     | Create selections       |

If `displ` is a one-dimensional array, a single copy of each input object is created using the translation vector `displ`. If `displ` is a two-dimensional array, several copies can be created, where the `n`th copy has translation `displ[i][n]` in the `i`th coordinate.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Example** The sequence below moves a circle from the origin to (2,3).

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",2);
model.geom("geom1").feature().create("c1","Circle");
```

## Move, Copy

---

```
model.geom("geom1").feature().create("m1","Move");
model.geom("geom1").feature("m1").selection("input").set("c1");
model.geom("geom1").feature("m1").
 set("displ", new double[][]{{2},{3}});
model.geom("geom1").run();
```

### See Also

[Array](#), [Mirror](#), [Rotate](#), [Scale](#)

**Purpose** Create a parametric curve defined by coordinate expressions in 2D or 3D

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>, "ParametricCurve");
model.geom(<tag>).feature(<ftag>).set(property, <value>);
model.geom(<tag>).feature(<ftag>).getType(property);
model.geom(<tag>).feature(<ftag>).importData();
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>, "ParametericCurve")` to create a parametric curve. Self-intersecting curves are not supported, except the case of a closed curve (that is, when the start and end points coincide). The following properties are available:

TABLE 3-79: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE                 | DEFAULT   | DESCRIPTION                                                                                                                                                            |
|-----------------|-----------------------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| axis            | double[]              | {0, 0, 1} | Direction of the z-axis of the local coordinate system. Vector has length 3 if <code>axistype</code> is cartesian, and length 2 if <code>axistype</code> is spherical. |
| axistype        | cartesian   spherical | cartesian | Coordinate system used for axis. The value is synchronized with <code>axis</code> .                                                                                    |
| coord           | String[2]   String[3] | empty     | Coordinates of parametric curve as function of parameter                                                                                                               |
| maxknots        | int                   | 1000      | Maximum number of knots                                                                                                                                                |
| parname         | String                | s         | Parameter name                                                                                                                                                         |
| parmax          | double                | 1         | Maximum parameter value                                                                                                                                                |
| parmin          | double                | 0         | Minimum parameter value                                                                                                                                                |
| pos             | double[]              | {0, 0, 0} | Position of the object                                                                                                                                                 |
| rot             | double                | 0         | Rotational angle about axis                                                                                                                                            |
| rtol            | double                | 1e-6      | Relative tolerance                                                                                                                                                     |
| createselection | on   off              | off       | Create selections                                                                                                                                                      |

The expressions in `coord` can contain functions defined in the model. If the definition of such a function is changed, the parametric curve is not automatically rebuilt. Use `model.geom(<tag>).feature(<ftag>).importData()` to rebuild the parametric curve after such a change.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>`

is the geometry tag, *<ftag>* the feature tag and *<lvl>* is one of dom, bnd, edg, pnt. The `createselection` property is not available in work-plane geometries.

### Examples

The following commands create a parametric curve in 3D with the shape of a helix.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("pc1","ParametricCurve");
model.geom("geom1").feature("pc1").set("parmax","2*pi");
model.geom("geom1").feature("pc1").set("coord",
 new String[]{"cos(s)","sin(s)","s*0.2"});
model.geom("geom1").run();
```

### See Also

[BezierPolygon](#), [ParametricSurface](#)

**Purpose** Create a parametric surface defined by coordinate expressions in 3D

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"ParametricSurface");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
model.geom(<tag>).feature(<ftag>).importData();
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"ParametericSurface")` to create a parametric surface. Self-intersecting surfaces are not supported. The following properties are available:

TABLE 3-80: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE                 | DEFAULT   | DESCRIPTION                                                                                                                                                            |
|-----------------|-----------------------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| axis            | double[]              | {0,0,1}   | Direction of the z-axis of the local coordinate system. Vector has length 3 if <code>axistype</code> is cartesian, and length 2 if <code>axistype</code> is spherical. |
| axistype        | cartesian   spherical | cartesian | Coordinate system used for axis. The value is synchronized with <code>axis</code> .                                                                                    |
| coord           | String[3]             | empty     | Coordinates of parametric surface as function of parameters                                                                                                            |
| maxknots        | int                   | 10        | Maximum number of knots in each parameter coordinate                                                                                                                   |
| parname1        | String                | s1        | First parameter name                                                                                                                                                   |
| parname2        | String                | s2        | Second parameter name                                                                                                                                                  |
| parmax1         | double                | 1         | Maximum value of first parameter                                                                                                                                       |
| parmax2         | double                | 1         | Maximum value of second parameter                                                                                                                                      |
| parmin1         | double                | 0         | Minimum value of first parameter                                                                                                                                       |
| parmin2         | double                | 0         | Minimum value of second parameter                                                                                                                                      |
| pos             | double[]              | {0,0,0}   | Position of the object                                                                                                                                                 |
| rot             | double                | 0         | Rotational angle about axis                                                                                                                                            |
| rto1            | double                | 1e-6      | Relative tolerance                                                                                                                                                     |
| createselection | on   off              | off       | Create selections                                                                                                                                                      |

The expressions in `coord` can contain functions defined in the model. If the definition of such a function is changed, the parametric surface is not automatically rebuilt. Use `model.geom(<tag>).feature(<ftag>).importData()` to rebuild the parametric surface after such a change.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

### Examples

The following commands create a parametric surface in 3D with the shape of a twisted rectangle.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1", 3);
model.geom("geom1").feature().create("ps1", "ParametricSurface");
;
model.geom("geom1").feature("ps1").set("parmin1", "-1");
model.geom("geom1").feature("ps1").set("parmax2", "pi");
model.geom("geom1").feature("ps1").set("coord",
 new String[]{"s1*cos(s2)", "s1*sin(s2)", "s2"});
model.geom("geom1").run();
```

### See Also

[ParametricCurve](#)

**Purpose** Create point object.

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Point");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Point")` to create one or more points. The following property is available:

TABLE 3-81: VALID PROPERTY/VALUE PAIR

| PROPERTY NAME   | PROPERTY VALUE           | DEFAULT | DESCRIPTION       |
|-----------------|--------------------------|---------|-------------------|
| p               | double[]  <br>double[][] | 0       | Coordinates       |
| createselection | on   off                 | off     | Create selections |

If `p` is a one-dimensional array, a single point with these coordinates is constructed. If `p` is a two-dimensional array, a point object containing several points is constructed, where the `n`th point has `i`th coordinate `p[i][n]`.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Compatibility** The following aliases work in 1D, 2D, and 3D, respectively:

```
model.geom(<tag>).feature().create(<ftag>,"point1");
model.geom(<tag>).feature().create(<ftag>,"point2");
model.geom(<tag>).feature().create(<ftag>,"point3");
```

**Example** The following commands generate a point at (1,2).

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",2);
model.geom("geom1").feature().create("p1","Point");
model.geom("geom1").feature("p1").
 set("p",new double[][]{{1},{2}});
model.geom("geom1").run();
```

- Purpose** Create curve or solid polygon consisting of line segments in 2D or 3D
- Syntax**

```
model.geom(<tag>).feature().create(<ftag>, "Polygon");
model.geom(<tag>).feature(<ftag>).set(property, <value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```
- Description** Use `model.geom(<tag>).feature().create(<ftag>, "Polygon")` to create a polygon or a line segment. The following properties are available

TABLE 3-82: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE                     | DEFAULT                 | DESCRIPTION                                                                        |
|-----------------|---------------------------|-------------------------|------------------------------------------------------------------------------------|
| filename        | String                    |                         | If source is file, the file that contains the vertex coordinates                   |
| source          | table   file<br>  vectors | vectors                 | Whether vertex coordinates are specified as vectors, a table, or read from a file. |
| table           | double[][]                |                         | The vertex coordinates when source is table, size N*sdim.                          |
| type            | solid   open   closed     | solid (2D)<br>open (3D) | Object type. solid is not available in 3D.                                         |
| x               | double[]                  | {}                      | x-coordinates for vertices                                                         |
| y               | double[]                  | {}                      | y-coordinates for vertices                                                         |
| z               | double[]                  | {}                      | z-coordinates for vertices                                                         |
| createselection | on   off                  | off                     | Create selections                                                                  |

If `type` is `open` or `closed`, a curve consisting of line segments is constructed. If `type` is `solid`, the solid enclosed by such a closed polygon is constructed. If `type` is `closed` or `solid`, but the first and last control points are different, an extra segment is added to close the curve.

Use `model.geom(<tag>).feature(<ftag>).importToTable()` to read data from the file defined by the `filename` property and store the data in the `table` property. The `source` property is also changed to `table`.

If `source` is `file`, the polygon is not automatically rebuilt when the data in the file changes. Use `model.geom(<tag>).feature(<ftag>).importData()` to rebuild the polygon after such a change.



If `createselection` is set to on, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Compatibility**

`model.geom(<tag>).feature().create(<ftag>,"line1")` constructs an open polygon.

`model.geom(<tag>).feature().create(<ftag>,"poly1")` constructs a closed polygon.

`model.geom(<tag>).feature().create(<ftag>,"line2")` or  
`model.geom(<tag>).feature().create(<ftag>,"poly2")` constructs a solid polygon.

**Examples**

Construct a solid triangle `po11`:

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",2);
model.geom("geom1").feature().create("po11","Polygon");
model.geom("geom1").feature("po11").set("x","0,0,2")
 .set("y","1,0,0");
model.geom("geom1").runAll();
```

**See Also**

[BezierPolygon](#)

- Purpose** Create solid or surface rectangular pyramid or frustum in 3D
- Syntax**

```
model.geom(<tag>).feature().create(<ftag>, "Pyramid");
model.geom(<tag>).feature(<ftag>).set(property, <value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```
- Description** Use `model.geom(<tag>).feature().create(<ftag>, "Pyramid")` to create a pyramid. The following properties are available:

TABLE 3-83: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE                       | DEFAULT   | DESCRIPTION                                                                                                                                                              |
|-----------------|-----------------------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| a, b            | double                      | 1         | Side lengths for bottom rectangle                                                                                                                                        |
| axis            | double[]                    | {0, 0, 1} | Direction of the axis orthogonal to the bottom rectangle. Vector has length 3 if <code>axistype</code> is cartesian, and length 2 if <code>axistype</code> is spherical. |
| axistype        | cartesian<br> <br>spherical | cartesian | Coordinate system used for axis. The value is synchronized with <code>axis</code> .                                                                                      |
| h               | double                      | 1         | Height                                                                                                                                                                   |
| pos             | double[]                    | {0, 0, 0} | Center of the bottom rectangle                                                                                                                                           |
| rat             | double                      | 0.5       | Ratio of perimeter of top rectangle and bottom rectangle                                                                                                                 |
| rot             | double                      | 0         | Rotational angle about <code>axis</code>                                                                                                                                 |
| type            | solid  <br>surface          | solid     | Object type                                                                                                                                                              |
| createselection | on   off                    | off       | Create selections                                                                                                                                                        |

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

- Compatibility** `model.geom(<tag>).feature().create(<ftag>, "pyramid3")` creates a solid pyramid.

`model.geom(<tag>).feature().create(<ftag>,"pyramid2")` creates a surface pyramid.

The following properties are also available:

TABLE 3-84: VALID PROPERTY/VALUE PAIRS

| PROPERTY | VALUE    | DEFAULT | DESCRIPTION                               |
|----------|----------|---------|-------------------------------------------|
| ax2      | double[] | {0,0}   | Alias for axis when axistype is spherical |
| ax3      | double[] | {0,0,1} | Alias for axis when axistype is cartesian |
| x, y, z  | double   | 0       | Alias for pos                             |

The property `const` is no longer available.

### Examples

Create a pyramid frustum with the base face in the *xy*-plane.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("e1","Pyramid");
model.geom("geom1").feature("e1").set("a",10).set("b",40);
model.geom("geom1").feature("e1").set("h",20);
```

Create a pyramid with an apex.

```
model.geom("geom1").feature().create("e2","Pyramid");
model.geom("geom1").feature("e2").set("a",1).set("b",2);
model.geom("geom1").feature("e2").set("h",4);
model.geom("geom1").feature("e2").set("rat",0);
model.geom("geom1").feature("e2").set("pos","100 100 100");
model.geom("geom1").feature("e2").set("axis","0 1 4");
model.geom("geom1").feature("e2").set("rot",45);
model.geom("geom1").run();
```

### See Also

[Cone](#), [ECone](#)

**Purpose** Create solid or curve rectangle in 2D

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Rectangle");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Rectangle")` to create a rectangle. The following properties are available:

TABLE 3-85: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE           | DEFAULT | DESCRIPTION                                                                         |
|-----------------|-----------------|---------|-------------------------------------------------------------------------------------|
| base            | corner   center | corner  | Positions the object either centered about pos or with the lower left corner in pos |
| layer           | double[]        |         | Thicknesses of layers                                                               |
| layerleft       | on   off        | off     | Apply layers to the left                                                            |
| layerright      | on   off        | off     | Apply layers to the right                                                           |
| layertop        | on   off        | off     | Apply layers on top                                                                 |
| layerbottom     | on   off        | on      | Apply layers on bottom                                                              |
| pos             | double[]        | {0,0}   | Position of the object                                                              |
| rot             | double          | 0       | Rotational angle about pos                                                          |
| size            | double[]        | {1,1}   | Side lengths                                                                        |
| type            | solid   curve   | solid   | Object type                                                                         |
| createselection | on   off        | off     | Create selections                                                                   |

If `createselection` is set to on, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of dom, bnd, edg, pnt. The `createselection` property is not available in work-plane geometries.

**Compatibility** `model.geom(<tag>).feature().create(<ftag>,"rect2")` creates a solid rectangle.

`model.geom(<tag>).feature().create(<ftag>,"rect1")` creates a curve rectangle.

The following properties are also available:

TABLE 3-86: VALID PROPERTY/VALUE PAIRS

| PROPERTY | VALUE  | DEFAULT | DESCRIPTION    |
|----------|--------|---------|----------------|
| lx, ly   | double | 1       | Alias for size |
| x, y     | double | 0       | Alias for pos  |

The property `const` is no longer available.

- Purpose** Revolve planar objects into 3D
- Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Revolve");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```
- Description**

Use `model.geom(<tag>).feature().create(<ftag>,"Revolve")` to revolve objects from a work plane.

Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the work plane objects to revolve. The default selection is all available objects from the last preceding work plane.

Use `model.geom(<tag>).feature(<ftag>).selection("inputface")` to select the faces to revolve. Faces are revolved when the `workplane` property is none, otherwise work plane objects are revolved.

The following properties are available:

TABLE 3-87: VALID PROPERTY/VALUE PAIRS

| PROPERTY  | VALUES         | DEFAULT     | DESCRIPTION                                                           |
|-----------|----------------|-------------|-----------------------------------------------------------------------|
| angle1    | double         | 0           | Start revolution angle                                                |
| angle2    | double         | 0           | End revolution angle                                                  |
| angtype   | specang   full | specang     | Type of specification                                                 |
| axis      | double[2]      | {0, 1}      | Direction of axis of revolution (in local coordinate system)          |
| axis3     | double[3]      | {0, 1, 0}   | Direction of axis of revolution (in 3D coordinate system)             |
| axistype  | 2d   3d        | 2d          | Type of revolution axis                                               |
| input     | Selection      | all objects | Objects to revolve                                                    |
| inputface | Selection      |             | Faces to revolve                                                      |
| origfaces | off   on       | on          | Keep original faces                                                   |
| polres    | double         | 50          | Polygon resolution of edges                                           |
| pos       | double[2]      | {0, 0}      | A point on the axis of revolution (in work plane's coordinate system) |
| pos3      | double[3]      | {0, 0, 0}   | A point on the axis of revolution (in 3D coordinate system)           |

TABLE 3-87: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUES            | DEFAULT | DESCRIPTION                                         |
|-----------------|-------------------|---------|-----------------------------------------------------|
| revolvefrom     | workplane   faces |         | Revolve work plane objects or faces from 3D objects |
| unite           | on   off          | on      | Unite revolved objects with input objects           |
| workplane       | String            |         | Work plane to revolve or none to revolve faces      |
| createselection | on   off          | off     | Create selections                                   |

Each 2D object in `input` or planar face in `inputface` is revolved about the revolution axis. The range of angles is given by the properties `angle1` and `angle2`. If `axistype` is `2d`, the revolution axis is defined in a local coordinate system. The revolution axis goes through `pos` with direction `axis`. If `axistype` is `3d`, the revolution axis is defined in the 3D coordinate system. The revolution axis goes through `pos3` with direction `axis3`.

When revolving work plane objects, the local system is defined as the local system of the work plane. When revolving faces, the local system is defined by the face with the smallest face number in the object that comes first in the geometry sequence. The local z-axis is parallel to the face normal and located at the center of the face. The local x-axis is defined by the tangent direction corresponding to the first parameter in the surface representation for the face.

When `unite` is set to `on`, the input objects are united with the corresponding revolved objects, after which the input objects are removed. When revolving from work plane object, this has the same effect as deleting the input objects. When `unite` is set to `off`, the revolved objects remain separate from the input objects and the input objects are kept.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

## Compatibility

Additional properties:

TABLE 3-88: VALID PROPERTY/VALUE PAIRS

| PROPERTY | VALUES             | DEFAULT           | DESCRIPTION                                           |
|----------|--------------------|-------------------|-------------------------------------------------------|
| angles   | double   double[2] | 2*pi              | Alias for angle1 and angle2                           |
| keep     | on   off           | off               | Alias for unite property with opposite value          |
| revaxis  | double[2][2]       | {{0,0},<br>{0,1}} | Alias for pos (first column) and axis (second column) |

## Example

Create torus about the y-axis:

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("wp1", "WorkPlane");
model.geom("geom1").feature("wp1").geom().
 feature().create("c1", "Circle");
model.geom("geom1").feature("wp1").geom().
 feature("c1").set("pos", "2 0");
model.geom("geom1").run("wp1");
model.geom("geom1").feature().create("r1", "Revolve");
model.geom("geom1").run();
```

## See Also

[Extrude](#), [WorkPlane](#)



**Purpose** Rotate objects about a point in 2D or an axis in 3D.

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Rotate");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Rotate")` to rotate geometry objects.

Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the objects to rotate. The default selection is empty.

The following properties are available:

TABLE 3-89: VALID PROPERTIES

| NAME            | VALUE                 | DEFAULT   | DESCRIPTION                                                                                               |
|-----------------|-----------------------|-----------|-----------------------------------------------------------------------------------------------------------|
| axis            | double[]              | {0,0,1}   | Rotation axis in 3D. Vector has length 3 if axistype is cartesian, and length 2 if axistype is spherical. |
| axistype        | cartesian   spherical | cartesian | Coordinate system used for axis. The value is synchronized with axis.                                     |
| input           | Selection             |           | Objects to rotate                                                                                         |
| keep            | on   off              | off       | Keep input objects                                                                                        |
| pos             | double[]              |           | Center of rotation                                                                                        |
| rot             | double                | 0         | Rotation angle                                                                                            |
| createselection | on   off              | off       | Create selections                                                                                         |

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Compatibility** The possibility to set and get a rotation matrix has been removed.

The property `out` is no longer available.

**Example** The command below rotates an ellipse by 10 degrees about (2,3).

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",2);
```

## Rotate

---

```
model.geom("geom1").feature().create("e1", "Ellipse");
model.geom("geom1").feature("e1").set("semiaxes", "1 3");
model.geom("geom1").feature().create("r1", "Rotate");

model.geom("geom1").feature("r1").selection("input").set("e1");
model.geom("geom1").feature("r1").set("rot", 10);
model.geom("geom1").feature("r1").set("pos", "2 3");
model.geom("geom1").run();
```

### See Also

[Mirror](#), [Move](#), [Copy](#), [Scale](#)

**Purpose** Scale objects around a point.

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Scale");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Scale")` to scale geometry objects.

Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the objects scale. The default selection is empty.

The following properties are available:

TABLE 3-90: VALID PROPERTIES

| NAME            | VALUE             | DEFAULT | DESCRIPTION        |
|-----------------|-------------------|---------|--------------------|
| factor          | double   double[] | 1       | Scale factor(s)    |
| input           | Selection         |         | Objects to scale   |
| keep            | on   off          | off     | Keep input objects |
| pos             | double[]          | 0       | Center of scaling  |
| createselection | on   off          | off     | Create selections  |

If `factor` is an array, the inputs are scaled by the `factor[i]` in the *i*th coordinate. If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Example** The sequence below scales the unit circle by (1,2) about (2,3).

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",2);
model.geom("geom1").feature().create("c1","Circle");
model.geom("geom1").feature().create("s1","Scale");

model.geom("geom1").feature("s1").selection("input").set("c1");
model.geom("geom1").feature("s1").set("factor", "1,2");
model.geom("geom1").feature("s1").set("pos",new double[]{2,3});
model.geom("geom1").run();
```

**Compatibility** The property `out` is no longer available.

**See Also** [Mirror](#), [Move](#), [Copy](#), [Rotate](#)

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Create selections for objects in the geometry sequence.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Syntax</b>      | <pre>model.geom(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"Selection"); model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).selection(property);</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Description</b> | <p>Use <code>model.geom(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"Selection")</code> to create selections for geometric entities in the geometry sequence.</p> <p>Use <code>model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).selection("selection")</code> to select the entities to create selections for. The default selection is empty.</p> <p>Use <code>model.selection(&lt;tag&gt;_&lt;ftag&gt;)</code> to access the corresponding selections in the finalized geometry.</p>                                                                                                                           |
| <b>Example</b>     | <p>The sequence below creates a block and a cylinder and creates a selection on the block domain.</p> <pre>Model model = ModelUtil.create("Model"); model.geom().create("geom1", 3); model.geom("geom1").feature().create("blk1", "Block"); model.geom("geom1").run("blk1"); model.geom("geom1").feature().create("sel1", "Selection"); model.geom("geom1").feature("sel1").selection("selection")     .set("blk1", new int[]{1}); model.geom("geom1").feature().create("cyl1", "Cylinder"); model.geom("geom1").run(); int[] domains = model.selection("geom1_sel1").entities(3); // domains == {2,3}</pre> |

**Purpose** Create a solid ball or surface sphere in 3D.

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Sphere");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Sphere")` to create a sphere. The following properties are available:

TABLE 3-91: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE                       | DEFAULT   | DESCRIPTION                                                                                                                                   |
|-----------------|-----------------------------|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| axis            | double[]                    | {0,0,1}   | Direction of the local z-axis. Vector has length 3 if <code>axistype</code> is cartesian, and length 2 if <code>axistype</code> is spherical. |
| axistype        | cartesian<br> <br>spherical | cartesian | Coordinate system used for axis. The value is synchronized with axis.                                                                         |
| layer           | double[]                    |           | Thicknesses of layers                                                                                                                         |
| pos             | double[]                    | {0,0,0}   | Center                                                                                                                                        |
| r               | double                      | 1         | Radius                                                                                                                                        |
| rot             | double                      | 0         | Rotational angle about axis                                                                                                                   |
| type            | solid  <br>surface          | solid     | Object type                                                                                                                                   |
| createselection | on   off                    | off       | Create selections                                                                                                                             |

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges, and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, and `pnt`. The `createselection` property is not available in work-plane geometries.

**Compatibility** `model.geom(<tag>).feature().create(<ftag>,"sphere3")` creates a solid sphere.

`model.geom(<tag>).feature().create(<ftag>,"sphere2")` creates a surface sphere.

The following properties are also available:

TABLE 3-92: VALID PROPERTY/VALUE PAIRS

| PROPERTY | VALUE    | DEFAULT | DESCRIPTION                               |
|----------|----------|---------|-------------------------------------------|
| ax2      | double[] | {0,0}   | Alias for axis when axistype is spherical |
| ax3      | double[] | {0,0,1} | Alias for axis when axistype is cartesian |
| x, y, z  | double   | 0       | Alias for pos                             |

The property `const` is no longer available.

## Examples

The following commands create a surface and solid sphere, where the position and radius are defined differently.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("s2","Sphere");
model.geom("geom1").feature("s2").set("type","surface");
model.geom("geom1").feature("s2").set("pos","0 1 0");
model.geom("geom1").feature().create("s3","Sphere");
model.geom("geom1").feature("s3").set("r",4);
model.geom("geom1").run();
```

## See Also

[Ellipsoid](#)

**Purpose** Split (explode) objects into their domains, faces, edges, or vertices.

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Split");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Split")` to split geometry objects.

Use `model.geom(<tag>).feature(<ftag>).selection("input")` to select the objects to split. The default selection is empty.

TABLE 3-93: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE     | DEFAULT | DESCRIPTION        |
|-----------------|-----------|---------|--------------------|
| input           | Selection |         | Objects to split   |
| keep            | on   off  | off     | Keep input objects |
| createselection | on   off  | off     | Create selections  |

A solid object is split into solids corresponding to its domains.

A surface object is split into surface objects corresponding to its faces.

A curve object is split into curve objects corresponding to its edges.

A point object is split into point objects corresponding to its vertices.

A general (mixed) object is split into solids (corresponding to the domains), surface objects (corresponding to faces not adjacent to a domain), curve objects (corresponding to edges not adjacent to a face or domain), and point objects (corresponding to vertices not adjacent to an edge, face, or domain).

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges, and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, and `pnt`. The `createselection` property is not available in work-plane geometries.

**Example** Split union of a solid circle and a solid rectangle.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",2);
model.geom("geom1").feature().create("r1","Rectangle");
model.geom("geom1").feature().create("c1","Circle");
model.geom("geom1").feature().create("u1","Union");
model.geom("geom1").feature("u1").selection("input").
```

## Split

---

```
 set(new String[]{"r1", "c1"});
model.geom("geom1").feature().create("spl1", "Split");
model.geom("geom1").feature("spl1").selection("input").
 set("u1");
model.geom("geom1").run();
```

### See Also

[Compose](#), [Union](#), [Intersection](#), [Difference](#), [Delete](#)



**Purpose** Create solid or curve square in 2D

**Syntax**  
`model.geom(<tag>).feature().create(<ftag>,"Square");`  
`model.geom(<tag>).feature(<ftag>).set(property,<value>);`  
`model.geom(<tag>).feature(<ftag>).getType(property);`

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Square")` to create a square. The following properties are available:

TABLE 3-94: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE           | DEFAULT | DESCRIPTION                                                                         |
|-----------------|-----------------|---------|-------------------------------------------------------------------------------------|
| base            | corner   center | corner  | Positions the object either centered about pos or with the lower left corner in pos |
| layer           | double[]        |         | Thicknesses of layers                                                               |
| layerleft       | on   off        | off     | Apply layers to the left                                                            |
| layerright      | on   off        | off     | Apply layers to the right                                                           |
| layertop        | on   off        | off     | Apply layers on top                                                                 |
| layerbottom     | on   off        | on      | Apply layers on bottom                                                              |
| pos             | double[]        | {0,0}   | Position of the object                                                              |
| rot             | double          | 0       | Rotational angle about pos                                                          |
| size            | double          | 1       | Side length                                                                         |
| type            | solid   curve   | solid   | Object type                                                                         |
| createselection | on   off        | off     | Create selections                                                                   |

If `createselection` is set to on, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Compatibility** `model.geom(<tag>).feature().create(<ftag>,"square2")` creates a solid square.

`model.geom(<tag>).feature().create(<ftag>,"square1")` creates a curve square.

The following properties are also available:

TABLE 3-95: VALID PROPERTY/VALUE PAIRS

| PROPERTY | VALUE  | DEFAULT | DESCRIPTION    |
|----------|--------|---------|----------------|
| l        | double | 1       | Alias for size |
| x, y     | double | 0       | Alias for pos  |

The property `const` is no longer available.

### Example

The sequence below creates a unit solid square.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1", 2);
model.geom("geom1").feature().create("sq1", "Square");
model.geom("geom1").run();
```

### See Also

[Rectangle](#)

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Sweep a face along a spine curve into a solid in 3D                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Syntax</b>      | <pre>model.geom(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"Sweep"); model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).selection(property); model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).set(property,&lt;value&gt;); model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).getType(property);</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Description</b> | <p>Use <code>model.geom(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"Sweep")</code> to sweep a face along a spine curve.</p> <p>Use <code>model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).selection("face")</code> to select the face to sweep.</p> <p>Use <code>model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).selection("edge")</code> to select the edges to sweep along.</p> <p>Use <code>model.geom(&lt;tag&gt;).feature(&lt;ftag&gt;).selection("diredge")</code> to select the edge whose direction defines the positive sweep direction. If this selection is empty, it is automatically set when the <code>edge</code> selection is set. The <code>diredge</code> selection can be empty if the <code>edge</code> selection contains a single edge.</p> |

The following properties are available:

TABLE 3-96: VALID PROPERTY/VALUE PAIRS

| PROPERTY                  | VALUES                                                                   | DEFAULT               | DESCRIPTION                                                                                          |
|---------------------------|--------------------------------------------------------------------------|-----------------------|------------------------------------------------------------------------------------------------------|
| <code>adjustlen</code>    | double                                                                   | 0                     | Spine adjustment parameter length. Used when <code>align</code> is set to <code>adjustspine</code> . |
| <code>align</code>        | <code>noadjust</code>   <code>adjustspine</code>   <code>moveface</code> | <code>noadjust</code> | Type of alignment between face and spine curve                                                       |
| <code>diredge</code>      | Selection                                                                |                       | Direction-defining edge                                                                              |
| <code>edge</code>         | Selection                                                                |                       | Edges that form spine curve                                                                          |
| <code>face</code>         | Selection                                                                |                       | Face to sweep                                                                                        |
| <code>grep</code>         | <code>bezier</code>   <code>spline</code>                                | <code>spline</code>   | Geometry representation                                                                              |
| <code>includefinal</code> | <code>on</code>   <code>off</code>                                       | <code>off</code>      | Include all used input objects in <code>finalize</code> operation                                    |
| <code>keep</code>         | <code>on</code>   <code>off</code>                                       | <code>on</code>       | Keep input objects                                                                                   |
| <code>maxknots</code>     | int                                                                      | 1000                  | Maximum number of knots                                                                              |
| <code>parname</code>      | String                                                                   | <code>s</code>        | Parameter name                                                                                       |
| <code>reversedir</code>   | <code>on</code>   <code>off</code>                                       | <code>off</code>      | Reverse sweep direction                                                                              |
| <code>rtol</code>         | double                                                                   | <code>1e-4</code>     | Relative tolerance                                                                                   |

TABLE 3-96: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUES   | DEFAULT | DESCRIPTION                    |
|-----------------|----------|---------|--------------------------------|
| scale           | String   | 1       | Scale factor for cross section |
| twist           | String   | 0       | Twist angle for cross section  |
| twistcomp       | on   off | on      | Twist compensation             |
| createselection | on   off | off     | Create selections              |

The expressions in `scale` and `twist` can contain functions defined in the model. If the definition of such a function is changed, the swept object is not automatically rebuilt. Use `model.geom(<tag>).feature(<ftag>).importData()` to rebuild the swept object after such a change.

If `includefinal` is `off`, input objects are automatically removed in the finalize operation, if they are completely used by this feature. Objects used in `face` are considered completely used if they contain a single face. Objects used in `edge` are considered completely used if they contain no faces and all their edges are included in `edge`. If an object is considered completely used by one property but not completely used by another property, the object will not be removed in the finalize operation. If `includefinal` is `on`, input objects are not removed in the finalize operation.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges, and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, or `pnt`. The `createselection` property is not available in work-plane geometries.

### Compatibility

In COMSOL 4.2a and earlier versions, the positive sweep direction was defined as the curve direction instead of the edge direction.

### Example

Create a half torus about the *y*-axis:

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("wp1","WorkPlane");
model.geom("geom1").feature("wp1").geom().
 feature().create("c1","Circle");
model.geom("geom1").feature().create("pc1","ParametricCurve");
model.geom("geom1").feature().create("swe1","Sweep");
model.geom("geom1").feature("pc1").set("parmax","pi");
model.geom("geom1").feature("pc1").
 set("coord",new String[]{"(cos(s)-1)*3","0","sin(s)*3"});
model.geom("geom1").feature("swe1").selection("face").
```

```
 set("wp1.c1", new int[]{1});
model.geom("geom1").feature("swe1").selection("edge").
 set("pc1(1)", new int[]{1});
model.geom("geom1").run();
```

**See Also**

[Extrude](#), [Helix](#), [Revolve](#), [WorkPlane](#)

**Purpose** Create a tangent line segment to one or two 2D edges.

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Tangent");
model.geom(<tag>).feature(<ftag>).selection(property);
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Tangent")` to create a line segment tangent to two edges or tangent to one edge with a fixed end point. The following properties are available:

TABLE 3-97: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE                   | DEFAULT | DESCRIPTION                                          |
|-----------------|-------------------------|---------|------------------------------------------------------|
| edge            | Selection               |         | Edge in an geometry object to find tangent to        |
| start           | double                  | 0.5     | Start guess for parameter value of point of tangency |
| type            | edge   point<br>  coord | edge    | Type of tangent                                      |
| createselection | on   off                | off     | Create selections                                    |

If `type` is `edge` a common tangent line to two edges are constructed. Then, the following additional properties are available:

TABLE 3-98: VALID PROPERTY/VALUE PAIRS

| PROPERTY | VALUE     | DEFAULT | DESCRIPTION                                            |
|----------|-----------|---------|--------------------------------------------------------|
| edge2    | Selection |         | Second edge in some geometry object to find tangent to |
| start2   | double    | 0.5     | Start guess for parameter value of point of tangency   |

If `type` is `point` a tangent line through a given point is constructed. Then, the following additional property is available:

TABLE 3-99: VALID PROPERTY/VALUE PAIRS

| PROPERTY | VALUE     | DEFAULT | DESCRIPTION                   |
|----------|-----------|---------|-------------------------------|
| point    | Selection |         | Point in some geometry object |

If `type` is `coord` a tangent line through a point with given coordinates are constructed. Then, the following additional property is available:

TABLE 3-100: VALID PROPERTY/VALUE PAIRS

| PROPERTY           | VALUE                 | DEFAULT            | DESCRIPTION |
|--------------------|-----------------------|--------------------|-------------|
| <code>coord</code> | <code>double[]</code> | <code>{0,0}</code> | Coordinates |

If a tangent cannot be found, a tangent to some adjacent edge is constructed, if possible.

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bn`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

### Compatibility

`model.geom(gname).feature().create(fname, "tangent")` creates a Tangent feature.

The following properties are no longer supported:

TABLE 3-101: OBSOLETE PROPERTY/VALUE PAIRS

| PROPERTY NAME       | PROPERTY VALUE                     | DEFAULT            | DESCRIPTION                                                |
|---------------------|------------------------------------|--------------------|------------------------------------------------------------|
| <code>edim1</code>  | <code>0   1</code>                 | geometry dependent | Starting point element dimension: 0 for vertex, 1 for edge |
| <code>edim2</code>  | <code>0   1</code>                 | geometry dependent | Ending point element dimension: 0 for vertex, 1 for edge   |
| <code>dom1</code>   | <code>integer</code>               | <code>1</code>     | Starting point entity number                               |
| <code>dom2</code>   | <code>integer</code>               | <code>1</code>     | Ending point entity number                                 |
| <code>out</code>    | <code>cell array of strings</code> | <code>{}</code>    | Additional output data                                     |
| <code>start1</code> | <code>double</code>                | <code>0.5</code>   | Starting point parameter value on specified edge           |

### Examples

The following sequence generates a tangent from the unit circle to the point (2, 0).

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",2);
model.geom("geom1").feature().create("c1", "Circle");
model.geom("geom1").run("c1");
model.geom("geom1").feature().create("tan1", "Tangent");
```

```
model.geom("geom1").feature("tan1").set("type", "coord");
model.geom("geom1").feature("tan1").selection("edge").
 set("c1", 3);
model.geom("geom1").feature("tan1").set("coord", "2 0");
model.geom("geom1").run();
```

The following sequence generates a common tangent between two circles.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1", 2);
model.geom("geom1").feature().create("c1", "Circle");
model.geom("geom1").feature().create("c2", "Circle");
model.geom("geom1").feature("c2").set("pos", "2 2");
model.geom("geom1").run("c2");
model.geom("geom1").feature().create("tan1", "Tangent");
model.geom("geom1").feature("tan1").selection("edge").
 set("c1", 4);
model.geom("geom1").feature("tan1").selection("edge2").
 set("c2", 4);
model.geom("geom1").run();
```

**See Also**

[BezierPolygon](#)



**Purpose** Create solid or surface tetrahedron in 3D.

**Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Tetrahedron");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```

**Description** Use `model.geom(<tag>).feature().create(<ftag>,"Tetrahedron")` to create a tetrahedron. The following properties are available:

TABLE 3-102: VALID PROPERTY/VALUE PAIR

| PROPERTY NAME   | PROPERTY VALUE  | DEFAULT                               | DESCRIPTION        |
|-----------------|-----------------|---------------------------------------|--------------------|
| p               | double[3][4]    | {0,0,1,0},<br>{0,1,0,0},<br>{0,0,0,1} | Corner coordinates |
| type            | solid   surface | solid                                 | Object type        |
| createselection | on   off        | off                                   | Create selections  |

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

**Compatibility** `model.geom(<tag>).feature().create(<ftag>,"tetrahedron3")` creates a solid tetrahedron.

`model.geom(<tag>).feature().create(<ftag>,"tetrahedron2")` creates a surface tetrahedron.

**Example** The following command generate a solid tetrahedron object.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("t1","Tetrahedron");
model.geom("geom1").feature("t1").set("p",
 new double[][]{{0,0,1,0},{0,0.8,1,0},{0,0.1,0,0.2}});
model.geom("geom1").run();
```

**See Also** [Hexahedron](#), [Pyramid](#)

- Purpose** Create a solid or surface torus in 3D
- Syntax**

```
model.geom(<tag>).feature().create(<ftag>,"Torus");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
```
- Description** Use `model.geom(<tag>).feature().create(<ftag>,"Torus")` to create a torus. The following properties are available:

TABLE 3-103: VALID PROPERTY/VALUE PAIRS

| PROPERTY        | VALUE                 | DEFAULT   | DESCRIPTION                                                                                                                                      |
|-----------------|-----------------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| angle           | double                | 360       | Revolution angle                                                                                                                                 |
| axis            | double[]              | {0,0,1}   | Direction of the revolution axis. Vector has length 3 if <code>axistype</code> is cartesian, and length 2 if <code>axistype</code> is spherical. |
| axistype        | cartesian   spherical | cartesian | Coordinate system used for axis. The value is synchronized with <code>axis</code> .                                                              |
| intfaces        | on   off              | off       | Create cross section faces inside the torus.                                                                                                     |
| pos             | double[]              | {0,0,0}   | Center coordinates                                                                                                                               |
| rma             | double                | 1         | Directrix radius                                                                                                                                 |
| rmi             | double                | 0.5       | Generatrix radius                                                                                                                                |
| rot             | double                | 0         | Rotational angle about axis                                                                                                                      |
| type            | solid   surface       | solid     | Object type                                                                                                                                      |
| createselection | on   off              | off       | Create selections                                                                                                                                |

If `createselection` is set to on, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`. The `createselection` property is not available in work-plane geometries.

- Compatibility**
- `model.geom(<tag>).feature().create(<ftag>,"torus3")` creates a solid torus.
- `model.geom(<tag>).feature().create(<ftag>,"torus2")` creates a surface torus.

The following properties are also available:

TABLE 3-104: VALID PROPERTY/VALUE PAIRS

| PROPERTY | VALUE    | DEFAULT | DESCRIPTION                                |
|----------|----------|---------|--------------------------------------------|
| ax2      | double[] | {0,0}   | Alias for axis when axistype is spherical. |
| ax3      | double[] | {0,0,1} | Alias for axis when axistype is cartesian. |
| x, y, z  | double   | 0       | Alias for pos.                             |

The property const is no longer available.

### Examples

The following sequence generates a surface torus and a solid torus.

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("t2","Torus");
model.geom("geom1").feature("t2").set("type","surface");
model.geom("geom1").feature("t2").set("rmaj",2);
model.geom("geom1").feature("t2").set("rmin",1);

model.geom("geom1").feature().create("t3","Torus");
model.geom("geom1").feature("t3").set("rmaj",10);
model.geom("geom1").feature("t3").set("rmin",2);
model.geom("geom1").feature("t3").set("pos","0,0,-100");
model.geom("geom1").feature("t3").set("axis","1,1,1");
model.geom("geom1").feature("t3").set("rot",60);
model.geom("geom1").run();
```

### See Also

[Cylinder](#)

- Purpose** Create a work plane in 3D for drawing 2D objects that can be extruded or revolved.
- Syntax**
- ```
model.geom(<tag>).feature().create(<ftag>,"WorkPlane");
model.geom(<tag>).feature(<ftag>).set(property,<value>);
model.geom(<tag>).feature(<ftag>).getType(property);
model.geom(<tag>).feature(<ftag>).geom().geomSequenceMethod
model.geom(<tag>).feature(<ftag>).geom().feature();
```
- Description** A work plane embeds 2D objects in 3D. The sections below describe how to define the location of the work plane, and how to create 2D objects in it.

DEFINING THE LOCATION OF THE WORK PLANE

A work plane has a local coordinate system that is orthonormal and positively oriented (right-handed). The work plane coincides with the *xy*-plane in the local coordinate system. The following properties control how the work plane is defined.

TABLE 3-105: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
planetype	quick faceparallel edgeangle vertices general	quick	Type of data defining the work plane
createselection	on off	off	Create selections

If `createselection` is set to `on`, predefined selections for all entities (all or some of domains, boundaries, edges and points) in the finalized geometry are created. To access the selections, use `model.selection(<tag>_<ftag>_<lvl>)`, where `<tag>` is the geometry tag, `<ftag>` the feature tag and `<lvl>` is one of `dom`, `bnd`, `edg`, `pnt`.

Depending on `planetype`, additional properties are available.

Quick

This creates a work plane parallel to one of the coordinate planes.

TABLE 3-106: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
quickplane	xy yz zx yx zy xz	xy	Coordinate plane
quickx	double	0	x-coordinate for work plane (used when plane is yz or zy).

TABLE 3-106: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
quicky	double	0	y-coordinate for work plane (used when plane is xz or zx).
quickz	double	0	z-coordinate for work plane (used when plane is xy or yx).

Face Parallel

This creates a work plane that is parallel to a planar face in a geometry object. Use the `origin` property to specify if the origin of the local coordinate system is set in the center of the face (`origin=center`) or as the projection onto the face of the minimum parameter coordinates of the face's parameter space bounding box (`origin=boxcorner`). The local *x*-axis is in the direction of the face's first parameter. The local *z*-axis is in the direction of the surface normal or its opposite.

TABLE 3-107: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
face	Selection		Planar face
offset	double	0	Signed offset in the direction of the local z-axis
origin	facecenter boxcorner	facecenter	Origin of local coordinate system
reverse	on off	off	Reverse direction of local z-axis

Edge Angle

This creates a work plane through a straight edge of a geometry object. The work plane makes a given angle with the tangent plane of a face in the same geometry object. The face must be adjacent to the edge, and its tangent plane must be the same at all points on the edge. The origin of the local coordinate system coincides with the start vertex (if `reverse` is `off`) or end vertex (if `reverse` is `on`) of the edge. The direction of the local *x*-axis coincides with the direction of the edge (if `reverse` is `off`) or its opposite (if `reverse` is `on`). If the property `angle` is zero, the direction

of the local *y*-axis points into the face. In general, the local coordinate system is rotated by *angle* about the local *x*-axis.

TABLE 3-108: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
angle	double	0	Angle between face and work plane
edge	Selection		Straight edge
adj face	Selection		Face adjacent to edge in the same object
reverse	on off	off	Reverse direction of local <i>x</i> -axis

Vertices

This creates a work plane parallel to a plane through three vertices *v1*, *v2*, *v3*. When *offset*=0, the origin of the local coordinate system coincides with the first vertex *v1*. The *x*-axis of the local coordinate system is in the direction *v2* - *v1*. The direction of the local *z*-axis is given by $(v2 - v1) \times (v3 - v1)$ or its opposite (if *reverse* is on).

TABLE 3-109: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
offset	double	0	Signed offset in the direction of the local <i>z</i> -axis
reverse	on off	off	Reverse direction of local <i>z</i> -axis
vertex1	Selection		First vertex
vertex2	Selection		Second vertex
vertex3	Selection		Third vertex

General

This creates a work plane through three points *p1*, *p2*, *p3*. The origin of the local coordinate system coincides with the first point *p1*. The *x*-axis of the local coordinate system is in the direction *p2* - *p1*. The direction of the local *z*-axis is given by $(p2 - p1) \times (p3 - p1)$.

TABLE 3-110: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
genpoints	double[3][3]	{ {0,0,0}, {1,0,0}, {0,1,0} }	Points

`genpoints[n][i]` is the *i*th coordinate of the *n*th point.

CREATING 2D OBJECTS IN THE WORK PLANE

The work plane owns a geometry sequence that contains the features that define the 2D objects you draw in the work plane. You access this geometry sequence by

```
model.geom(<tag>).feature(<ftag>).geom()
```

where *<ftag>* is the name of the work plane feature. You can add geometry features in this 2D sequence as usual.

Example

Create a work plane with a rectangle. When the work plane is built, the rectangle is embedded in the space of the 3D sequence

```
Model model = ModelUtil.create("Model1");
model.geom().create("geom1",3);
model.geom("geom1").feature().create("wp1", "WorkPlane");
model.geom("geom1").feature("wp1").set("quickplane", "yz");
model.geom("geom1").feature("wp1").geom().
    feature().create("r1", "Rectangle");
model.geom("geom1").feature("wp1").geom().
    feature("r1").set("pos", "1 1");
model.geom("geom1").runAll();
```

See Also

[Extrude](#), [Revolve](#)

4

Mesh

Details include reference information about the mesh commands and utility methods.

In this chapter:

- [About Mesh Commands](#)
- [Working with a Meshing Sequence](#)
- [Physics-Controlled Meshing](#)
- [Information and Statistics](#)
- [Getting and Setting Mesh Data](#)
- [Errors and Warnings](#)
- [Exporting Mesh to File](#)
- [Mesh Commands](#)

About Mesh Commands

The following list includes the mesh commands that are documented in this chapter:

- [BndLayer](#)
- [BndLayerProp](#)
- [Convert](#)
- [CopyEdge](#)
- [CopyFace](#)
- [Delete](#)
- [Distribution](#)
- [Edge](#)
- [EdgeGroup](#)
- [EdgeMap](#)
- [FreeQuad](#)
- [FreeTet](#)
- [FreeTri](#)
- [Import](#)
- [Map](#)
- [OnePointMap](#)
- [Point](#)
- [Reference](#)
- [Refine](#)
- [Scale](#)
- [Size](#)
- [Sweep](#)
- [TwoPointMap](#)



- [Operation Features](#)
 - [Attribute Features](#)
-

Operation Features

Table 4-1 is an overview of the features that create or modify the mesh.

TABLE 4-1: MESH OPERATION FEATURES

FEATURE TYPE	LOCALIZED TYPE DESCRIPTION IN GUI	DEFAULT NAME IN GUI
BndLayer	Boundary Layers	bl
Convert	Convert	conv
CopyEdge	Copy Edge	cpe
CopyFace	Copy Face	cpf
CopyDomain	Copy Domain	cpd
Delete	Delete	del
Edge	Edge	edg
FreeQuad	Free Quad	fq
FreeTet	Free Tetrahedral	ftet
FreeTri	Free Triangle	ftri
Import	Import	imp
Map	Mapped	map
Reference	Reference	rf
Refine	Refine	ref
Sweep	Swept	swe

Attribute Features

Table 4-2 is an overview of the features that contain properties used by operation features to build the mesh.

TABLE 4-2: MESH ATTRIBUTE FEATURES

FEATURE TYPE	LOCALIZED TYPE DESCRIPTION IN GUI	DEFAULT NAME IN GUI
BndLayerProp	Boundary Layer Properties	blp
Distribution	Distribution	dis
EdgeGroup	Edge Groups	eg
EdgeMap	Edge Map	em
OnePointMap	One-Point Map	pm
Scale	Scale	sca

TABLE 4-2: MESH ATTRIBUTE FEATURES

FEATURE TYPE	LOCALIZED TYPE DESCRIPTION IN GUI	DEFAULT NAME IN GUI
Size	Size	size
TwoPointMap	Two-Point Map	ppm

Features for Imported Meshes

Table 4-3 is an overview of the features that deals with imported meshes.

TABLE 4-3: FEATURES FOR IMPORTED MESHES

FEATURE TYPE	LOCALIZED TYPE DESCRIPTION IN GUI	DEFAULT NAME IN GUI
Ball	Ball	ball
Box	Box	box
CreateVertex	Create Vertex	vtx
DeleteEntities	Delete Entities	dele
Import	Import	imp
JoinEntities	Join Entities	join

Working with a Meshing Sequence

This section describes how to build meshes using Java methods. A *mesh* is defined by a *meshing sequence* consisting of *mesh features*. A meshing feature is either an *attribute feature* or an *operation feature*. Each operation feature modifies the mesh when you *build* the feature using properties defined by attribute features.

An attribute feature is defined on a geometric entity selection and has a set of properties. Running an attribute feature does not change the mesh, but affects the subsequent operation features in the sequence. For example, the `FreeTet` operation feature, that creates a tetrahedral mesh, uses properties from the `Distribution`, `Scale`, and `Size` attribute features, that define the size and distribution of the mesh elements. You can add an attribute feature directly to the meshing sequence, this is referred to as a *global attribute feature*, or add it to an operation feature, this is referred to as a *local attribute feature*. Properties defined in local attribute features of an operation feature overrides corresponding properties defined in preceding global feature properties (on the same selection).

An operation features makes operations on the mesh as defined by the meshing sequence. Some operation features, like `FreeTet` and `Sweep` *generate* new mesh. Other operation features, like `Refine` and `Convert` *modify* existing mesh.

In this section:

- [Adding a Meshing Sequence](#)
- [Adding a Mesh Feature](#)
- [Editing a Mesh Feature](#)
- [Building Mesh Features](#)
- [Feature Status](#)
- [Deleting Mesh Features](#)
- [Disabling Mesh Features](#)
- [Clearing Meshes](#)

- [Units](#)
- [Selections](#)



- [Meshing Features](#) in the *COMSOL Multiphysics Reference Guide*
- [Meshing](#) in the *COMSOL Multiphysics User's Guide*

Adding a Meshing Sequence

To add a new meshing sequence to a model object `model`, enter

```
model.mesh().create(<mtag>,<gtag>);
```

where `mTag` is the mesh's tag (an identifier of your choice) and `gTag` is the tag of the associated geometry. If you want to import a mesh, you must specify an empty geometry sequence; the geometry is then defined by the mesh.

Adding a Mesh Feature

To add a feature to a mesh with tag `<tag>`, enter

```
model.mesh(<tag>).feature().create(<ftag>,ftype);
```

where `<ftag>` is the feature's tag (an identifier of your choice), and `ftype` is the feature's type. Feature types are capitalized and case-sensitive, for example `FreeTet`.

When you add a feature, it is inserted after the *current feature*. You can get the tag of the current feature type by entering

```
String ftag = model.mesh(<tag>).current();
```

If `ftag` is the empty string, the current feature is the beginning of the meshing sequence, that is, the empty state before all features. Adding a meshing feature, it automatically becomes current, but it is not built automatically.

For some operation features it is possible to add attribute features. To add an attribute feature to an operation feature, enter

```
model.mesh(<tag>).feature(<ftag>).feature().  
create(<ftag1>,ftype);
```

where `<ftag1>` is the attribute feature's tag (an identifier of your choice), and `ftype` is the attribute feature's type.

All properties in a new feature get a default value.

Editing a Mesh Feature

To change a property value in a feature, enter

```
model.mesh(<tag>).feature(<ftag>).set(property,<value>);
```

where *property* is a property name and *<value>* is a property value.

All numeric properties can be given either as a numeric value or as a string expression that can contain parameters defined in `model.param()`. When building the feature, the string expressions are evaluated using the current values of the parameters.



Behavior has changed since COMSOL version 3.5a. String expression arguments are retained and not converted to numeric values.

To get the value of a property, enter one of the following, depending on the property type:

```
double d = model.mesh(<tag>).feature(<ftag>).getDouble(property);
String s = model.mesh(<tag>).feature(<ftag>).getString(property);
double[] da =
    model.mesh(<mtag>).feature(<ftag>).getDoubleArray(property);
String[] sa =
    model.mesh(<tag>).feature(<ftag>).getStringArray(property);
```

If you request a numerical value for a string property, it is evaluated using the current values of the parameters in `model.param()`.

Building Mesh Features

To modify the mesh, you must *build* an operation feature. Enter

```
model.mesh(<tag>).run(<ftag>);
```

to build the feature *<ftag>* and all its preceding features (the features are built in the order from the first to the last). When the build has completed, the feature *<ftag>* becomes the current feature.

To build all features, enter

```
model.mesh(<tag>).run();
```

Feature Status

The *status* of a feature can be one of the following:

- *Built*. This means that the none of the feature's properties have changed since the feature was last built, and the features of the input objects are all built. The feature may contain warning messages.
- *Edited*. This means that some of the feature's properties have changed since the feature was last built.
- *Needs rebuild*. This means that any of the preceding features is edited.
- *Error*. This means that the feature contains an error message.
- *Warning*. This means that the feature contains a warning message.

You can examine the status of a feature by entering

```
boolean built = model.mesh(<tag>).feature(<ftag>).isBuilt();
boolean edited = model.mesh(<tag>).feature(<ftag>).isEdited();
boolean hasError = model.mesh(<tag>).feature(<ftag>).hasError();
boolean hasWarning =
    model.mesh(<tag>).feature(<ftag>).hasWarning();
boolean needsRebuild = !(built || edited || hasError ||
    hasWarning);
```

Deleting Mesh Features

To delete a feature, enter

```
model.mesh(<tag>).feature().remove(<ftag>);
```

Disabling Mesh Features

To disable a feature, enter

```
model.mesh(<tag>).feature(<ftag>).active(false);
```

To enable a disabled feature, enter

```
model.mesh(<tag>).feature(<ftag>).active(true);
```

You can get the enabled/disabled status of a feature by entering

```
boolean isEnabled = model.mesh(<tag>).feature(<ftag>).active();
```


Clearing Meshes

To clear the mesh of a sequence, enter

```
model.mesh(<tag>).clearMesh();
```

To clear the mesh and remove all features in a sequence, enter

```
model.mesh(<tag>).feature().clear();
```

To clear all meshes for all geometries in a model, enter

```
model.mesh().clearMeshes();
```

Units

The meshing sequence uses the same base unit system as the geometry sequence. The string versions of setters and getters support units and unit conversion using the standard machinery.

Selections

Most mesh features have selections, to specify where they operate. To access a feature's selection, use the syntax

```
model.mesh(<tag>).feature(<ftag>).selection();
```

To specify the entire geometry, write

```
model.mesh(<tag>).feature(<ftag>).selection().allgeom();
```

To specify all geometric entities in dimension *<dim>*, write

```
model.mesh(<tag>).feature(<ftag>).selection().geom(<dim>).all();
```

To specify the geometric entities that remains to be meshed when the feature is about to be built, use

```
model.mesh(<tag>).feature(<ftag>).selection().remaining();
```

It is not possible to retrieve the geometric entities of this selection, unless the feature is built.

If *entities* is an integer array of geometric entities in dimension *dim*, use the following syntax to select these entities

```
model.mesh(<tag>).feature(<ftag>).selection().  
    geom(dim).set(entities);
```

For example, to selection domain 1 and 2 in a 3D geometry, write

```
model.mesh(<tag>).feature(<ftag>).selection().  
    geom(3).set(new int[]{1,2});
```

To add the geometric entities specified in the integer array *<entities>* in dimension *<dim>* to the selection, write

```
model.mesh(<tag>).feature(<ftag>).selection().  
    geom(<dim>).add(<entities>);
```

To remove the geometric entities specified in the integer array *<entities>* in dimension *<dim>* from the selection, write

```
model.mesh(<tag>).feature(<ftag>).selection().  
    geom(<dim>).remove(<entities>);
```

To clear the selection in dimension *<dim>*, write

```
model.mesh(<tag>).feature(<ftag>).selection().  
    geom(<dim>).clear();
```

Some features have more than one selection, for example *sweep*, where it is possible to specify *source* and *destination* faces. Use the following syntax to access these selections.

```
model.mesh(<tag>).feature(<ftag>).selection(<property>);
```

Thus, to specify boundary 5 as source face on the sweep feature *swe1*, write

```
model.mesh(<tag>).feature(<ftag>).selection("sourceface").  
    geom(2).set(5);
```

Physics-Controlled Meshing



Caution

When a physics-controlled sequence is built, a sequence of ordinary meshing features is created. This sequence can be customized by editing these features. However, do not assume the existence of a certain feature in a java program designed to run with future versions of COMSOL Multiphysics. The actual contents of the sequence might change.

A physics-controlled meshing sequence examines the physics to automatically determine size attributes and sequence operations needed to create a mesh adapted to the problem. The physics-controlled sequence is based on heuristics and knowledge built-in by application experts. It is not adapted by numerical error estimates—that type of adaptation is provided by mesh adaptation in the solver sequence.

When a mesh is built or a problem solved, the physics-controlled sequence is updated to match the currently active physics. If the sequence is in any other state than physics-controlled, it is not updated or modified before it is built.

By default, a meshing sequence is in the physics-controlled state. If you manually add a feature to the sequence or edit a feature, the sequence automatically switches to the user-controlled state. It is also possible to explicitly switch to user-controlled state by entering

```
model.mesh(<tag>).automatic(false);
```

To switch back to physics-controlled mesh, enter

```
model.mesh(<tag>).automatic(true);
```

The current sequence is then modified or overwritten next time the sequence is built or the problem is solved.

Use `model.mesh(<tag>).isAutomatic()` to determine in which state the sequence is.

You can adjust the overall size of a physics-induced mesh by using the method

```
model.mesh(<tag>).autoMeshSize(<size>);
```

The value 5 of `<size>` corresponds to the default size, the values 4, 3, 2, and 1, gives you (increasingly) finer mesh, whereas the values 6, 7, 8, and 9 gives you a coarser mesh. The method `model.mesh(<tag>).autoMeshSize()` returns the current size adjustment.

Information and Statistics

In this section:

- [Statistics](#)
- [Number and Types of Elements](#)
- [Quality of Elements](#)
- [Volume of Elements and Mesh](#)
- [Mesh Status](#)

Statistics

Use the `stat()` method on the meshing sequence to determine the number of elements of different types and the quality of elements. Use the `info()` method to obtain topological information, the number of geometric entities and so forth. When importing mesh, use `infoCurrent()` to obtain topological information about the current (last built) mesh feature, and `info()` to obtain this information about the finalized mesh. See [Geometry Object Information Methods](#) for a list of available methods.

The `stat()` method returns an object with a collection of methods that can be queried for statistical information about the current mesh. There is also a selection,

```
model.mesh(<tag>).stat().selection()
```

which is used to select geometric entities for which the statistics is calculated. The default selection is the entire geometry. The methods described below also exist directly on the meshing sequence. These methods always return statistics for the entire geometry.

Statistics can be requested per element type. The type is given as a string, denoted `type`, and the possible types is given in the following table.

TABLE 4-4:

STRING	ELEMENT	ELEMENT DIMENSION
vtx	Vertex element	0
edg	Edge element	1
tri	Triangular element	2
quad	Quadrilateral element	2

TABLE 4-4:

STRING	ELEMENT	ELEMENT DIMENSION
tet	Tetrahedral element	3
pyr	Pyramid element	3
prism	Prism element	3
hex	Hexahedral element	3
all	All elements of maximal dimension in the selection	

The parameter string `all` gives statistics for all elements with the same dimension as the maximal dimension of the current selection. For example, if the entire geometry is selected in 2D, the parameter `all` provides combined statistics for triangular and quadrilateral elements.



See Also

- [Geometry Object Information](#)
- [Selections](#)

Number and Types of Elements

To determine the number of elements of a certain type, use

```
int model.mesh(<tag>).stat().getNumElem(type);
```

To get the number of elements of all types, use

```
int model.mesh(<tag>).stat().getNumElem();
```

To determine the element types, use

```
String[] model.mesh(<tag>).stat().getTypes();
```

If the current selection is not the entire geometry, only elements and types in the current selection is returned. You can also use the methods

```
int model.mesh(<tag>).getNumElem(type);
int model.mesh(<tag>).getNumElem();
String[] model.mesh(<tag>).getTypes();
```

to obtain information about the entire geometry.

Quality of Elements

The quality of an element is a double between 0 and 1, where 0.0 represents a degenerated element and 1.0 represents a completely symmetric element.

To retrieve the minimal quality, use

```
double model.mesh(<tag>).stat().getMinQuality(type);
double model.mesh(<tag>).stat().getMinQuality();
```

To retrieve the mean quality, use

```
double model.mesh(<tag>).stat().getMeanQuality(type);
double model.mesh(<tag>).stat().getMeanQuality();
```

To calculate a distribution of qualities, use the `getQualityDistr` method.

```
int[] model.mesh(<tag>).stat().getQualityDistr(type, <size>);
int[] model.mesh(<tag>).stat().getQualityDistr(<size>);
```

The size parameter is a positive integer determining how detailed the distribution is, and equals the size of the output array. The distribution can be used to plot a histogram of the element quality. For example, if size equals 10, the first entry in the returned array is the number of elements with quality less than 0.1 and the last entry is the number of elements with quality better than 0.9.

The following methods are available directly on the sequence, and provide statistics for the entire geometry.

```
double model.mesh(<tag>).getMinQuality(type);
double model.mesh(<tag>).getMinQuality();
double model.mesh(<tag>).getMeanQuality(type);
double model.mesh(<tag>).getMeanQuality();
int[] model.mesh(<tag>).getQualityDistr(type, <size>);
int[] model.mesh(<tag>).getQualityDistr(<size>);
```

Volume of Elements and Mesh

To determine minimum element volume, area, or length of a certain type, use the method `getMinVolume`.

```
double model.mesh(<tag>).stat().getMinVolume(type);
double model.mesh(<tag>).stat().getMinVolume();
```

To determine maximum element volume, area, or length of a certain type, use the method `getMaxVolume`.

```
double model.mesh(<tag>).stat().getMaxVolume(type);
double model.mesh(<tag>).stat().getMaxVolume();
```

To determine the volume, area, or length of the mesh, use the method `getVolume`.

```
double model.mesh(<tag>).stat().getVolume(type);  
double model.mesh(<tag>).stat().getVolume();
```

The following methods are available directly on the sequence, and provide volume information about the entire geometry.

```
double model.mesh(<tag>).getMinVolume(type);  
double model.mesh(<tag>).getMinVolume();  
double model.mesh(<tag>).getMaxVolume(type);  
double model.mesh(<tag>).getMaxVolume();  
double model.mesh(<tag>).getVolume(type);  
double model.mesh(<tag>).getVolume();
```

Growth Rate in Mesh

The growth rate value is a local measure greater than or equal to 1 indicating the maximum element size growth rate between two neighboring elements.

To retrieve the maximal growth rate value for a selection, use

```
double model.mesh(<tag>).stat().getMaxGrowthRate();
```

To retrieve the average growth rate for a selection, use

```
double model.mesh(<tag>).stat().getMeanGrowthRate();
```

The following methods are available directly on the sequence, and provide statistics for the entire geometry.

```
double model.mesh(<tag>).getMaxGrowthRate();  
double model.mesh(<tag>).getMeanGrowthRate();
```

Mesh Status

You can check if the entire selected geometry has a mesh by calling the `isComplete` method.

```
boolean model.mesh(<tag>).stat().isComplete();
```

To check if the entire geometry is meshed, use

```
boolean model.mesh(<tag>).isComplete();
```

You can also check if the selected geometry has an empty mesh by calling the `isEmpty` method.

```
boolean model.mesh(<tag>).stat().isEmpty();
```

To check if the entire geometry has an empty mesh, use

```
boolean model.mesh(<tag>).isEmpty();
```


Getting and Setting Mesh Data

The data in the mesh object can be accessed and manipulated via *getters and setters*. You can get vertex coordinates, elements, and for each element the number of its geometric entity. The element matrix consist of indexes into the vertex list. The entity list contains the entity number of each element. There is one element matrix and one entity number list for each type.

In this section:

- [Accessing Mesh Data](#)
- [Setting or Modifying Mesh Data](#)
- [Block Versions](#)
- [Element Numbering Conventions](#)

Accessing Mesh Data

To get the number of mesh vertices, use

```
int model.mesh(<tag>).getNumVertex();
```

To get the coordinates of the mesh vertices, use

```
double[][] model.mesh(<tag>).getVertex();
```

which gives you a matrix where each column corresponds to a mesh vertex.

To get the element types in the mesh, use

```
String[] model.mesh(<tag>).getTypes();
```

The possible types are given by the following table. See [Element Numbering Conventions](#) for an explanation of each type.

STRING	ELEMENT	DIMENSION	NUMBER OF NODES
vtx	Vertex element	0	1
edg	Edge element	1	2
tri	Triangular element	2	3
quad	Quadrilateral element	2	4
tet	Tetrahedral element	3	4
pyr	Pyramid element	3	5

STRING	ELEMENT	DIMENSION	NUMBER OF NODES
prism	Prism element	3	6
hex	Hexahedral element	3	8

To get the number of elements of a specific type, use

```
int model.mesh(<tag>).getNumElem(type);
```

To get the elements for a specific type, use

```
int[][] model.mesh(<tag>).getElem(type);
```

which gives you a matrix where each column contains the mesh vertex indices of an element's corners.

To get the geometric entity number for the elements of a specific type, use

```
int[] model.mesh(<tag>).getElemEntity(type);
```



See Also

[Information and Statistics](#)

Setting or Modifying Mesh Data

You can manipulate the mesh object of a meshing sequence via the `data()` method. Using this method you access a temporary object (`MeshData`) storing mesh data. When you use the `data()` method the first time the `MeshData` object is empty. You can fill it with mesh data either by using various set methods or by transferring mesh data from the mesh of the meshing sequence. Call the method `data().createMesh` to construct a complete mesh from the `MeshData` object and store it in the meshing sequence. If the geometry is not empty, the new mesh is checked to ensure that it matches the geometry. Thus, to create an arbitrary mesh, you need to create an empty geometry sequence and a corresponding empty meshing sequence and construct the mesh on the empty meshing sequence.

To set the mesh vertices, use

```
model.mesh(<tag>).data().setVertex(double[][]);
```

where each column of the input matrix contains the coordinates of a mesh vertex.

To set the elements of a specific type, use

```
model.mesh(<tag>).data().setElem(type, int[][]);
```

where each column of input element matrix contains the mesh vertex indices of an element's corners.

If you want to specify the geometric entity number for the elements of a specific type, use

```
model.mesh(<tag>).data().setElemEntity(type, int[]);
```

The MeshData object has the same access methods as the meshing sequence.

```
int model.mesh(<tag>).data().getNumVertex();
double[][] model.mesh(<tag>).data().getVertex();
String[] model.mesh(<tag>).data().getTypes();
int model.mesh(<tag>).data().getNumElem(type);
int[][] model.mesh(<tag>).data().getElem(type);
int[] model.mesh(<tag>).data().getElemEntity(type);
```



See Also

Accessing Mesh Data

It is also possible to fill the MeshData object with mesh data from the mesh of a meshing sequence. To transfer the mesh from the current meshing sequence into the MeshData object, use

```
model.mesh(<tag>).data().transferMesh();
```

To transfer the mesh from another meshing sequence, specified by *mtag*, into the MeshData object, use

```
model.mesh(<tag>).data().transferMesh(mtag);
```

To clear the MeshData object, use

```
model.mesh(<tag>).data().clearData();
```

To create a complete mesh from the MeshData object and store it in the sequence, use

```
model.mesh(<tag>).data().createMesh();
```

This method uses several properties when creating a complete mesh from the specified mesh data. To set a property, use

```
model.mesh(<tag>).data().set(property, <value>);
```

To get a property, use

```
model.mesh(<tag>).data().getType(property);
```

The following properties are available.

TABLE 4-5: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	2D	3D	DESCRIPTION
extrangle	double	0.6 degrees		√	Maximum angle between boundary element normal and extrusion plane that causes the element to be a part the extruded face if possible
faceangle	double	360 degrees		√	Maximum angle between any two boundary elements in the same face
facecleanup	double	0.01		√	Avoid creating small faces. Faces with an area less than Facecleanup * the mean face area, are merged with adjacent faces
facecurv	double	10 degrees		√	Maximum relative angle deviation between any two boundary elements in the same face
faceparam	on/off	on		√	Parameterize faces
minareacurv	double	1		√	Minimum relative area of face to be considered as a face with constant curvature
minareaextr	double	0.05		√	Minimum relative area of face to be considered extruded
minareaeplane	double	0.005	√	√	Minimum relative area of face to be considered planar

TABLE 4-5: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	2D	3D	DESCRIPTION
neighangle	double	20 degrees	√	√	Maximum angle between a boundary element and a neighbor that causes the elements to be part of the same boundary domain if possible
planarangle	double	0.6 degrees	√	√	Maximum angle between boundary element normal and a neighbor that causes the element to be a part the planar face if possible

EXAMPLES OF SETTING OR MODIFYING MESH DATA

The following examples create a triangular mesh on a square, extracts the vertices and the triangles. Then the vertices are transformed and inserted into a new meshing sequence.

```

Model model = ModelUtil.create("Model");

model.geom().create("geom1", 2);
model.mesh().create("mesh1", "geom1");

// Create a rectangle and a mesh
model.geom("geom1").feature().create("r1", "Rectangle");
model.mesh("mesh1").feature().create("ftri1", "FreeTri");
model.mesh("mesh1").run();

double[][] vtx = model.mesh("mesh1").getVertex();
int[][] tri = model.mesh("mesh1").getElem("tri");

// Transform x coordinates
for (int k=0; k<vtx[0].length; k++)
    vtx[0][k] *= 0.5;

// Create a new geometry and mesh
model.geom().create("geom2", 2);
model.mesh().create("mesh2", "geom2");

// Insert vertices and triangles and create mesh
model.mesh("mesh2").data().setElem("tri", tri);
model.mesh("mesh2").data().setVertex(vtx);
model.mesh("mesh2").data().createMesh();

```

Block Versions

Since the amount of available Java memory might be limited, there are block versions of the mesh setters and getters, which sets or gets a subset of the data. The getters take a *position* argument, which specifies the first item to get, and a *number* argument, which specifies the number of items to get. The setters takes only the position argument; the number of items is determined by the size of the provided data. When working with the setters, remember that it is more efficient to set the data at the last position first, since sufficient space is then allocated directly and no copying and reallocation is needed.

```
double[][] model.mesh(<tag>).getVertex(int position, int number);
int[][] model.mesh(<tag>).getElem(type, int position, int number);
int[] model.mesh(<tag>).getGeomEntity(type, int position,
                                     int number);
```

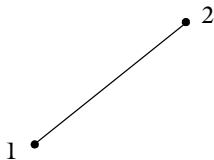
```
model.mesh(<tag>).data().setVertex(double[][] , int position);
model.mesh(<tag>).data().setElem(type, int[][], int position);
model.mesh(<tag>).data().setGeomEntity(type, int[],
                                       int position);
```

```
double[][] model.mesh(<tag>).data().getVertex(int position,
                                              int number);
int[][] model.mesh(<tag>).data().getElem(type, int position,
                                       int number);
int[] model.mesh(<tag>).data().getGeomEntity(type, int position,
                                           int number);
```

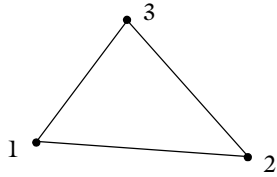
Element Numbering Conventions

The (local) numbering of the corners of an element is defined according to the following.

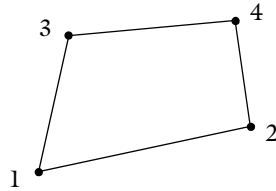
Edge element (edg):



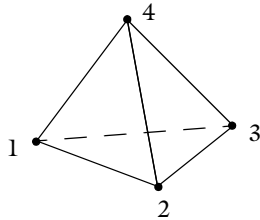
Triangular element (tri):



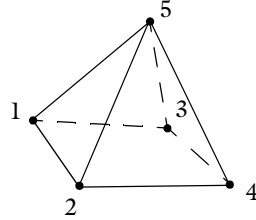
Quadrilateral element (quad):



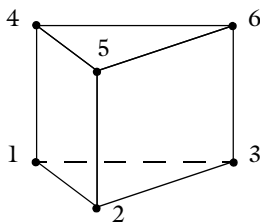
Tetrahedral element (tet):



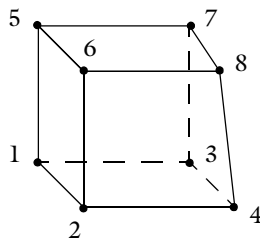
Pyramid element (pyr):



Prism element (prism):



Hexahedral element (hex):



Errors and Warnings

COMSOL Multiphysics treats problems encountered when building a meshing feature in two different ways depending on if it is possible to avoid the problem and continue the operation or if the operation must be stopped.

In this section:

- [Continuing Operations](#)
- [Stopping Operations](#)
- [The MeshError Feature](#)
- [The MeshWarning Feature](#)
- [Retrieving Problem Information](#)

Continuing Operations

When you build `FreeTri`, `FreeQuad`, or `FreeTet` features all problems related to meshing of faces and domains are avoided by leaving the corresponding faces and domains unmeshed. The operation continues meshing the remaining entities and stores information on the encountered problems in the feature. A feature that encountered this type of problems during the build gets a warning status. If you build several features in a sequence the build is not stopped by a feature that gets a warning status.

The information on the encountered problems for a feature with warning status is contained in `MeshError` and `MeshWarning` features stored in the feature. There is one `MeshError` feature for each geometric entity that failed to be meshed and one `MeshWarning` feature for each dimension where there exists an entity that could not be meshed due to failures meshing any of its boundary entities.

You can control whether a free meshing feature should avoid encountered problems and continue to mesh or if it should stop at the first encountered problem by the `continue` property.

Stopping Operations

When you build other operation features than the `FreeTri`, `FreeQuad`, or `FreeTet` features the operations stops if a problem is encountered. This means that no changes

are made to the mesh. The feature gets an error status and if it is part of a sequence build the build stops and the preceding feature becomes the current feature. Information on the error is contained in a `MeshError` feature stored in the feature.

The MeshError Feature

A `MeshError` feature contains an error message and can be equipped with a selection defining the failed entity, or a coordinate value specifying a position related to the error. It can also be equipped with details about the error. A `MeshError` feature can have a children feature of `MeshError` type that contains low-level error information. This means that an error can be represented by a stack of `MeshError` features that reflects the stack trace of the error.

The MeshWarning Feature

One `MeshWarning` feature is generated for each dimension where there are entities that cannot be meshed due to previous errors. For example, if there are edges that fail to be meshed for a `FreeTet` feature operating on the entire geometry there is one `MeshWarning` feature for the adjacent faces and one `MeshWarning` feature for the adjacent domains.

The `MeshWarning` feature contains a selection defining the entities that could not be meshed and a message describing the cause for this.

Retrieving Problem Information

Build a geometry.

```
Model mdl = com.comsol.model.util.ModelUtil.create("Model1");
mdl.geom().create("g",3);
mdl.geom("g").feature().create("cyl1","Cylinder").set("h",3.0);
mdl.geom("g").feature().create("cyl2","Cylinder").set("h",3.0).
set("r",0.95);
mdl.geom("g").feature().create("co1","Difference");
mdl.geom("g").feature("co1").selection("input").set("cyl1");
mdl.geom("g").feature("co1").selection("input2").set("cyl2");
```

Build a mesh.

```
MeshSequence ms = mdl.mesh().create("m", "g");
ms.feature("size").set("hauto", 9);
ms.feature().create("ftri1","FreeTri");
ms.feature("ftri1").selection().geom(2).set(1, 2, 7, 10);
```

```

ms.feature().create("ftet1", "FreeTet");
ms.feature("ftet1").feature().create("ms1", "Size");
ms.run();

```

Check if the mesh was built with problems.

```

boolean problem = ms.hasProblems();

```

Get the names of the features with problems. In this case the feature `ftet1`.

```

String[] problemNames = ms.feature().problemNames();

```

Get error information.

```

String[] errorNames = ms.feature(problemNames[0]).problem().
errorNames();
for (String errorName : errorNames) {
    int errorDepth = ms.feature(problemNames[0]).
    problem(errorName).depth();
    for (int i=0; i<errorDepth; ++i) {
        MeshFeature errorFeature = ms.feature(problemNames[0]).
        problem(errorName).get(i);
        String errorMessage = errorFeature.getString("message");
        MeshSelection sel = null;
        if (errorFeature.hasSelection())
            sel = errorFeature.selection();
    }
}

```

Get warning information.

```

String[] warningNames = ms.feature(problemNames[0]).problem().
warningNames();
MeshFeature warningFeature = ms.feature(problemNames[0]).
problem(warningNames[0]);
String warningMessage = warningFeature.getString("message");
MeshSelection sel = warningFeature.selection();

```

Exporting Mesh to File

To export a mesh to a file, enter

```
model.mesh(<tag>).export(<filename>);
```

where *<filename>* is a string. The file can be any of the following formats.

TABLE 4-6: VALID FILE FORMATS

FILE FORMAT	NOTE	FILE EXTENSIONS
COMSOL Multiphysics Binary		.mphbin
COMSOL Multiphysics Text		.mphtxt
STL Binary (3D)	1	.stl
STL Text (3D)	1	.stl

¹ Use `model.mesh(<tag>).export().setSTLFormat(<format>)` to specify the STL file format (“binary” or “text”)

Mesh Commands

The following list includes the available commands for creating and modifying meshes:

- `Ball`
- `BndLayer`
- `BndLayerProp`
- `Box`
- `Convert`
- `CopyEdge`
- `CopyFace`
- `CopyDomain`
- `CreateVertex`
- `Delete`
- `DeleteEntities`
- `Distribution`
- `Edge`
- `EdgeGroup`
- `EdgeMap`
- `FreeQuad`
- `FreeTet`
- `FreeTri`
- `Import`
- `JoinEntities`
- `Map`
- `OnePointMap`
- `Point`
- `Reference`
- `Refine`
- `Scale`
- `Size`

- Sweep
- TwoPointMap

Purpose Split geometric entities of an imported mesh by a ball.

Syntax

```
model.mesh(<tag>).feature().create(<ftag>,"Ball");
model.mesh(<tag>).feature(<ftag>).selection();
model.mesh(<tag>).feature(<ftag>).set(property,<value>);
model.mesh(<tag>).feature(<ftag>).getType(property);
model.mesh(<tag>).feature(<ftag>).feature().
    create(<ftag1>,"Ball");
```

Description Use `model.mesh(<tag>).feature().create(<ftag>,"Ball")` to split geometric entities of an imported 2D or 3D mesh by an element set defined by a ball.

Use `model.mesh(<tag>).feature(<ftag>).selection()` to specify geometric entities to split. If you do not specify the selection, the feature operates on the entire geometry.

The following properties are available:

TABLE 4-7: AVAILABLE PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
posx	double	0	Center, first coordinate
posy	double	0	Center, second coordinate
posz	double	0	Center, third coordinate
r	double	1	Radius
condition	allvertices somevertex	allvertices	Condition for inclusion of an element

See Also [Import](#), [Box](#)

Purpose Create boundary layer mesh.

Syntax

```
model.mesh(<tag>).feature().create(<ftag>,"BndLayer");
model.mesh(<tag>).feature(<ftag>).selection();
model.mesh(<tag>).feature(<ftag>).set(property,<value>);
model.mesh(<tag>).feature(<ftag>).getType(property);
model.mesh(<tag>).feature(<ftag>).feature().
    create(<ftag1>,"BndLayerProp");
```

Description Use `model.mesh(<tag>).feature().create(<ftag>,"BndLayer")` to create a boundary layer mesh in 2D or 3D.

Use `model.mesh(<tag>).feature(<ftag>).selection()` to specify the domain selection. If you do not specify the selection, the feature operates on all domains.

Use

`model.mesh(<tag>).feature(<ftag>).feature().create(<ftag1>,"BndLayerProp")` to add a BndLayerProp attribute feature defining the locations and properties of the boundary layers.

The feature reads properties from the BndLayerProp attribute feature.

The following properties are available:

TABLE 4-8: AVAILABLE PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
sharpcorners	none split trim	split	Specifies the handling of sharp corners in 2D and sharp edges in 3D.
splitangle	double	240 [deg]	Minimum angle between boundary layer boundaries to introduce a boundary layer split.
splitdivangle	double	100 [deg]	Maximum angle per split
trimmaxangle	double	20 [deg]	Maximum angle between boundary layer boundaries for boundary layer trimming.
trimminangle	double	240 [deg]	Minimum angle between boundary layer boundaries for boundary layer trimming.
layerdec	integer	2	Maximum difference in number of boundary layers between neighboring points on boundary layer boundaries.

TABLE 4-8: AVAILABLE PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
smoothtransition	on off	on	Specifies if the operation smoothes the transition to interior mesh.
smoothmaxiter	integer	8 in 2D, 4 in 3D	Specifies the number of smoothing iterations.
smoothmaxdepth	integer	16 in 2D, 6 in 3D	Specifies the maximum element smoothing depth.

Compatibility

The following properties from the corresponding COMSOL 3.5a command, meshbndlayer, have been removed:

TABLE 4-9: REMOVED PROPERTIES

PROPERTY	REASON
blbnd	Defined by the selection of BndLayerProp
hauto	Input mesh provided by meshing sequence
mcase	Defined by meshing sequence
meshstart	Input mesh provided by meshing sequence
out	Output mesh provided by meshing sequence
subdomain	Defined by the selection

Examples

Insert boundary layers to an existing mesh containing both quadrilateral elements and triangular elements.

```

Model model = ModelUtil.create("Model");
model.geom().create("geom1", 2);
model.mesh().create("mesh1", "geom1");

model.geom("geom1").feature().create("sq1", "Square");
model.geom("geom1").feature().create("sq2", "Square");
model.geom("geom1").feature("sq2").setIndex("pos", "1", 0);
model.geom("geom1").feature().create("c1", "Circle");
model.geom("geom1").feature("c1").set("r", "0.2");
model.geom("geom1").feature("c1").setIndex("pos", "1.5", 0);
model.geom("geom1").feature("c1").setIndex("pos", "0.5", 1);
model.geom("geom1").feature().create("co1", "Compose");
model.geom("geom1").feature("co1").selection("input").
    init().set(new String[]{"c1", "sq1", "sq2"});
model.geom("geom1").feature("co1").
    set("formula", "sq1+sq2-c1");
model.geom("geom1").run();

model.mesh("mesh1").feature().create("map1", "Map");
    
```



```

model.mesh("mesh1").feature("map1").selection().
    geom("geom1", 2);
model.mesh("mesh1").feature("map1").selection().
    set(new int[]{1});
model.mesh("mesh1").feature().create("ftri1", "FreeTri");
model.mesh("mesh1").feature().create("b1", "BndLayer");
model.mesh("mesh1").feature("b1").feature().
    create("blp", "BndLayerProp");
model.mesh("mesh1").feature("b1").feature("blp").selection().
    set(new int[]{2, 3, 5, 6, 8, 9, 10, 11});
model.mesh("mesh1").run();

```

Create a boundary layer mesh consisting of prism elements along the boundary layer boundaries and tetrahedral elements in the interior.

```

Model model = ModelUtil.create("Model");
model.geom().create("geom1", 3);
model.mesh().create("mesh1", "geom1");

model.geom("geom1").feature().create("blk1", "Block");
model.geom("geom1").feature("blk1").setIndex("size", "10", 0);
model.geom("geom1").feature("blk1").setIndex("size", "5", 1);
model.geom("geom1").feature("blk1").setIndex("size", "5", 2);
model.geom("geom1").feature().create("sph1", "Sphere");
model.geom("geom1").feature("sph1").setIndex("pos", "3", 0);
model.geom("geom1").feature("sph1").setIndex("pos", "2.5", 1);
model.geom("geom1").feature("sph1").setIndex("pos", "2.5", 2);
model.geom("geom1").feature().create("dif1", "Difference");
model.geom("geom1").feature("dif1").selection("input").
    init().set(new String[]{"blk1"});
model.geom("geom1").feature("dif1").selection("input2").
    init().set(new String[]{"sph1"});
model.geom("geom1").run();

model.mesh("mesh1").feature().create("ftet1", "FreeTet");
model.mesh("mesh1").feature().create("b1", "BndLayer");
model.mesh("mesh1").feature("b1").feature().
    create("blp", "BndLayerProp");
model.mesh("mesh1").feature("b1").feature("blp").selection().
    set(new int[]{2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13});
model.mesh("mesh1").run();

```

See Also

[BndLayerProp](#), [Map](#), [Sweep](#)

Purpose Boundary layer meshing properties.

Syntax

```
model.mesh(<tag>).feature(<ftag>).feature().
    create(<ftag1>, "BndLayerProp");
model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).selection();
model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).
    set(property, <value>);
model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).
    getType(property);
```

Description Use

```
model.mesh(<tag>).feature(<ftag>).feature().create(<ftag1>, "BndLayerProp")
```

to define boundary layer properties for the BndLayer feature <ftag>.

Use `model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).selection()` to specify the boundary selection. If you do not specify the selection, it is empty.

The following properties are available:

TABLE 4-10: AVAILABLE PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
blhminfact	String double	1	Factor used to adjust the default thickness
blhmin	String double		Manual initial boundary layer thickness
blnlayers	String integer	8	Number of boundary layers
blstretch	String double	1.2	Boundary layer stretching factor
inittype	blhminfact blhmin	blhminfact	Selects whether blhmin or blhminfact is used.

Use the properties `blhmin`, `blstretch`, and `blnlayers` to specify the distribution of the boundary layers. `blhmin` specifies the thickness of the initial boundary layer, `blstretch` a stretching factor, and `blnlayers` the number of boundary layers. This means that the thickness of the m th boundary layer ($m=1$ to `blnlayers`) is $\text{blstretch}^{(m-1)}\text{blhmin}$. The number of boundary layers and the thickness of the boundary layers might be automatically reduced in thin regions.

It is also possible to specify the thickness of the initial layer by using the `blhminfact` property. Then, the thickness of the first layer is $1/20$ of the local domain element height. Use the `blhminfact` property to specify a scaling factor that multiplies this default size.

The property `inittype` determines which of `blhminfact` or `blhmin` that is used. You do not need to set it explicitly, since the feature automatically changes it when you set one of `blhmin` or `blhminfact`.

The values of `blhmin`, `blhminfact`, and `blstretch` are positive real scalars, or strings that evaluate to positive real scalars, given the evaluation context provided by the property `const`.

The value of `blnlayers` is a positive integer scalar, or a string that evaluates to a positive integer, given the evaluation context provided by the property `const`.

See Also

[BndLayer](#), [Scale](#), [Size](#)

Purpose

Split geometric entities of an imported mesh by a box.

Syntax

```
model.mesh(<tag>).feature().create(<ftag>, "Box");  
model.mesh(<tag>).feature(<ftag>).selection();  
model.mesh(<tag>).feature(<ftag>).set(property, <value>);  
model.mesh(<tag>).feature(<ftag>).getType(property);  
model.mesh(<tag>).feature(<ftag>).feature().  
    create(<ftag1>, "Box");
```

Description

Use `model.mesh(<tag>).feature().create(<ftag>, "Box")` to split geometric entities of an imported 2D or 3D mesh by an element set defined by a box.

Use `model.mesh(<tag>).feature(<ftag>).selection()` to specify geometric entities to split. If you do not specify the selection, the feature operates on the entire geometry.

The following properties are available:

TABLE 4-11: AVAILABLE PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
xmin	double	-inf	Minimum x-coordinate of box
xmax	double	inf	Maximum x-coordinate of box
ymin	double	-inf	Minimum y-coordinate of box
ymax	double	inf	Maximum y-coordinate of box
zmin	double	-inf	Minimum z-coordinate of box
zmax	double	inf	Maximum z-coordinate of box
condition	allvertices somevertex	allvertices	Condition for inclusion of an element

See Also

[Import, Ball](#)

Purpose Convert to simplex mesh.

Syntax

```
model.mesh(<tag>).feature().create(<ftag>,"Convert");
model.mesh(<tag>).feature(<ftag>).selection();
model.mesh(<tag>).feature(<ftag>).set(property,<value>);
model.mesh(<tag>).feature(<ftag>).getType(property);
```

Description Use `model.mesh(<tag>).feature().create(<ftag>,"Convert")` to convert non-simplex elements in a mesh to simplex elements, that is, triangles and tetrahedra.

Use `model.mesh(<tag>).feature(<ftag>).selection()` to specify the domain or face selection. If you do not specify the selection the feature converts all quadrilateral, pyramidal, prismatic, and hexahedral elements in the mesh.

The following properties are available:

TABLE 4-12: AVAILABLE PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
splitmethod	diagonal center	diagonal	Split method for quadrilateral and hexahedral elements

Use the property `splitmethod` to specify how to split quadrilateral and hexahedral elements into triangular and tetrahedral elements, respectively. Use the `diagonal` option to split each quadrilateral element into two triangular elements and each hexahedral element into five tetrahedral element. Use the `center` option to split each quadrilateral element into four triangular elements and each hexahedral element into 28 tetrahedral elements. The conversion also affects quadrilateral elements on the boundaries of the specified domains in 3D, which are converted into two triangular elements (when the option `diagonal` is used) or four triangular elements (when the option `center` is used).

Compatibility The following properties from the corresponding COMSOL 3.5a command, `meshconvert`, have been removed:

TABLE 4-13: REMOVED PROPERTIES

PROPERTY	REASON
face	Defined by the selection
out	Output mesh provided by meshing sequence
domain	Defined by the selection

Examples Create a mapped quad mesh on a unit rectangle and convert each quadrilateral element into four triangular elements:

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 2);
model.mesh().create("mesh1", "geom1");

model.geom("geom1").feature().create("r1", "Rectangle");
model.geom("geom1").run();

model.mesh("mesh1").feature().create("map1", "Map");
model.mesh("mesh1").feature().create("conv1", "Convert");
model.mesh("mesh1").run();
```

Create a prism mesh and convert each prism into three tetrahedral elements.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 3);
model.mesh().create("mesh1", "geom1");

model.geom("geom1").feature().create("blk1", "Block");
model.geom("geom1").run();

model.mesh("mesh1").feature().create("ftri1", "FreeTri");
model.mesh("mesh1").feature("ftri1").selection().
    set(new int[]{1});
model.mesh("mesh1").feature().create("swe1", "Sweep");
model.mesh("mesh1").feature().create("conv1", "Convert");
model.mesh("mesh1").run();
```

See Also

[BndLayer](#), [Map](#), [Refine](#), [Sweep](#)

Purpose Copy edge mesh.

Syntax

```
model.mesh(<tag>).feature().create(<ftag>,"CopyEdge");
model.mesh(<tag>).feature(<ftag>).selection(property);
model.mesh(<tag>).feature(<ftag>).set(property,<value>);
model.mesh(<tag>).feature(<ftag>).getType(property);
```

Description Use `model.mesh(<tag>).feature().create(<ftag>,"CopyEdge")` to copy mesh between edges in a 2D or 3D geometry.

The following properties are available:

TABLE 4-14: AVAILABLE PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
direction	auto same opposite	auto	Direction of the copied mesh
copymethod	auto singlecopy arraycopy	auto	Type of copy operation
source	Selection	Empty	Source edges
destination	Selection	Empty	Destination edges
smoothcontrol	on off	on	Specifies if the operation smooths the mesh across removed control entities.
smoothmaxiter	integer	8 in 2D, 4 in 3D	Specifies the number of smoothing iterations.
smoothmaxdepth	integer	8 in 2D, 4 in 3D	Specifies the maximum element smoothing depth.

Use the properties `source` and `destination` to specify the source and destination edges. The `copymethod` property determines if many-to-one or many-to-many copying is used. The `direction` property controls the orientation of the copied mesh, and is relative the direction of the source edge with smallest number and the direction of the destination edge.

Copying a mesh is only possible if the destination edge is not adjacent to a meshed domain. The `copy` feature overwrites any existing mesh on the destination edge.

Compatibility

The following properties from the corresponding COMSOL 3.5a command, `meshcopy`, have been removed:

TABLE 4-15: REMOVED PROPERTIES

PROPERTY	REASON
<code>mcase</code>	Defined by the meshing sequence

Example

Mesh Edge 1 and copy the mesh to Edges 2, 3, and 4.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 2);
model.mesh().create("mesh1", "geom1");

model.geom("geom1").feature().create("sq1", "Square");
model.geom("geom1").run();

model.mesh("mesh1").feature().create("edg1", "Edge");
model.mesh("mesh1").feature("edg1").selection().
    set(new int[]{1});
model.mesh("mesh1").feature().create("cpe1", "CopyEdge");
model.mesh("mesh1").feature("cpe1").
    selection("source").set(new int[]{1});
model.mesh("mesh1").feature("cpe1").
    selection("destination").set(new int[]{2, 3, 4});
model.mesh("mesh1").run();
```

See Also

[CopyFace](#), [CopyDomain](#)

Purpose	Copy face mesh.
Syntax	<pre>model.mesh(<tag>).feature().create(<ftag>,"CopyFace"); model.mesh(<tag>).feature(<ftag>).selection(property); model.mesh(<tag>).feature(<ftag>).feature(). create(<ftag1>,ftype);</pre>
Description	<p>Use <code>model.mesh(<tag>).feature().create(<ftag>,"CopyFace")</code> to copy mesh between faces in a 3D geometry.</p> <p>If you want to specify the orientation of the source mesh on the destination, use <code>model.mesh(<tag>).feature(<ftag>).feature().create(<ftag1>,ftype)</code> to add an <code>EdgeMap</code>, a <code>OnePointMap</code>, or a <code>TwoPointMap</code> attribute feature.</p>

The following properties are available:

TABLE 4-16: AVAILABLE PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
copymethod	auto singlecopy arraycopy	auto	Type of copy operation
source	Selection	Empty	Source boundaries
destination	Selection	Empty	Destination boundary
smoothcontrol	on off	on	Specifies if the operation smooths the mesh across removed control entities.
smoothmaxiter	integer	8 in 2D, 4 in 3D	Specifies the number of smoothing iterations.
smoothmaxdepth	integer	8 in 2D, 4 in 3D	Specifies the maximum element smoothing depth.

Use the properties `source` and `destination` to specify the source and destination boundaries. The `copymethod` property determines if many-to-one or many-to-many copying is used.

Compatibility	The following properties from the corresponding COMSOL 3.5a command, <code>meshcopy</code> , have been removed:
----------------------	---

TABLE 4-17: REMOVED PROPERTIES

PROPERTY	REASON
direction	Defined by the attribute feature <code>EdgeMap</code>
mcase	Defined by the meshing sequence

TABLE 4-17: REMOVED PROPERTIES

PROPERTY	REASON
sourceedg	Defined by the attribute feature EdgeMap
targetedg	Defined by the attribute feature EdgeMap

Example

Mesh Face 1 of a block and copy the mesh to the opposite Face 6.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 3);
model.mesh().create("mesh1", "geom1");

model.geom("geom1").feature().create("blk1", "Block");
model.geom("geom1").run();

model.mesh("mesh1").feature().create("ftri1", "FreeTri");
model.mesh("mesh1").feature("ftri1").selection().
    set(new int[]{1});
model.mesh("mesh1").feature().create("cpf1", "CopyFace");
model.mesh("mesh1").feature("cpf1").
    selection("source").set(new int[]{1});
model.mesh("mesh1").feature("cpf1").
    selection("destination").set(new int[]{6});
model.mesh("mesh1").run();
```

See Also

[CopyEdge](#), [CopyDomain](#), [EdgeMap](#), [OnePointMap](#), [TwoPointMap](#)

Purpose Copy Domain mesh.

Syntax

```
model.mesh(<tag>).feature().create(<ftag>,"CopyDomain");
model.mesh(<tag>).feature(<ftag>).selection(property);
model.mesh(<tag>).feature(<ftag>).feature().
    create(<ftag1>,ftype);
```

Description Use `model.mesh(<tag>).feature().create(<ftag>,"CopyDomain")` to copy mesh between domains in a 2D or 3D geometry.

If you want to specify the orientation of the source mesh on the destination, use `model.mesh(<tag>).feature(<ftag>).feature().create(<ftag1>,ftype)` to add an `EdgeMap`, a `OnePointMap`, or a `TwoPointMap` attribute feature.

The following properties are available:

TABLE 4-18: AVAILABLE PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
copymethod	auto singlecopy arraycopy	auto	Type of copy operation
source	Selection	Empty	Source domains
destination	Selection	Empty	Destination domains
smoothcontrol	on off	on	Specifies if the operation smooths the mesh across removed control entities.
smoothmaxiter	integer	8 in 2D, 4 in 3D	Specifies the number of smoothing iterations.
smoothmaxdepth	integer	8 in 2D, 4 in 3D	Specifies the maximum element smoothing depth.

Use the properties `source` and `destination` to specify the source and destination boundaries. The `copymethod` property determines if many-to-one or many-to-many copying is used.

Example Mesh block 1 and copy the mesh to the block 2.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 3);
model.mesh().create("mesh1", "geom1");

model.geom("geom1").feature().create("blk1", "Block");
model.geom("geom1").feature().create("blk2", "Block");
model.geom("geom1").feature("blk2").setIndex("pos", "2", 0);
model.geom("geom1").run();
```

```
model.mesh("mesh1").feature().create("ftet1", "FreeTet");
model.mesh("mesh1").feature("ftet1").selection().
    set(new int[]{1});
model.mesh("mesh1").feature().create("cpd1", "CopyDomain");
model.mesh("mesh1").feature("cpd1").
    selection("source").set(new int[]{1});
model.mesh("mesh1").feature("cpd1").
    selection("destination").set(new int[]{2});
model.mesh("mesh1").run();
```

See Also

[CopyEdge](#), [CopyFace](#), [EdgeMap](#), [OnePointMap](#), [TwoPointMap](#)

Purpose Create an additional vertex in an imported mesh.

Syntax

```
model.mesh(<tag>).feature().create(<ftag>,"CreateVertex");
model.mesh(<tag>).feature(<ftag>).set(property,<value>);
model.mesh(<tag>).feature(<ftag>).getType(property);
model.mesh(<tag>).feature(<ftag>).feature().
    create(<ftag1>,"CreateVertex");
```

Description Use `model.mesh(<tag>).feature().create(<ftag>,"CreateVertex")` to create an additional vertex in the mesh point closest to a specified position.

The following properties are available:

TABLE 4-19: AVAILABLE PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
x	double	0	x-coordinate
y	double	0	y-coordinate
z	double	0	z-coordinate

See Also [Import](#)

Purpose	Delete elements from mesh.
Syntax	<pre>model.mesh(<tag>).feature().create(<ftag>,"Delete"); model.mesh(<tag>).feature(<ftag>).selection(); model.mesh(<tag>).feature(<ftag>).set(property,<value>); model.mesh(<tag>).feature(<ftag>).getType(property);</pre>
Description	<p>Use <code>model.mesh(<tag>).feature().create(<ftag>,"Delete")</code> to delete elements from the mesh.</p> <p>Use <code>model.mesh(<tag>).feature(<ftag>).selection()</code> to specify the geometric entity selection. Allowed selections are meshed geometric entities of any dimension and the entire geometry, which can be partially meshed.</p>

The following properties are available:

TABLE 4-20: AVAILABLE PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
deladj	on off	on	Specifies if elements belonging to adjacent domains of lower dimensions are deleted as well

Deleting elements corresponding to a specific domain, all elements on adjacent domains of higher dimension are deleted as well.

Compatibility	The following properties from the corresponding COMSOL 3.5a command, <code>meshdel</code> , have been removed:
----------------------	--

TABLE 4-21: REMOVED PROPERTIES

PROPERTY	REASON
out	Output mesh provided by meshing sequence
edge	Defined by the selection
face	Defined by the selection
point	Defined by the selection
domain	Defined by the selection

Examples	<p>Create a mesh of a 2D geometry with 3 domains. First, delete the elements belonging to Domain 3 only. Then delete the elements belonging to Domain 1 and all adjacent domains of lower dimensions that can be deleted. At last, delete the edge elements belonging to Edge 1. The elements belonging to the adjacent domain (Domain 2) are deleted as well.</p>
-----------------	--

```
Model model = ModelUtil.create("Model");
model.modelNode().create("mod1");
```

```
model.geom().create("geom1", 2);
model.mesh().create("mesh1", "geom1");

model.geom("geom1").feature().create("R1", "Rectangle");
model.geom("geom1").feature().create("C1", "Circle");
model.geom("geom1").run();

model.mesh("mesh1").feature().create("ftri1", "FreeTri");

model.mesh("mesh1").feature().create("del1", "Delete");
model.mesh("mesh1").feature("del1").selection().geom(2).set(3);
model.mesh("mesh1").feature("del1").set("deladj", "off");

model.mesh("mesh1").feature().create("del2", "Delete");
model.mesh("mesh1").feature("del2").selection().geom(2).set(1);
model.mesh("mesh1").feature("del2").set("deladj", "on");

model.mesh("mesh1").feature().create("del3", "Delete");
model.mesh("mesh1").feature("del3").selection().geom(1).set(1);

model.mesh("mesh1").run();
```

See Also[FreeTet](#), [Map](#), [Sweep](#)

DeleteEntities

- Purpose** Delete geometric entities from an imported mesh.
- Syntax**
- ```
model.mesh(<tag>).feature().create(<ftag>,"DeleteEntities");
model.mesh(<tag>).feature(<ftag>).selection();
model.mesh(<tag>).feature(<ftag>).set(property,<value>);
model.mesh(<tag>).feature(<ftag>).getType(property);
model.mesh(<tag>).feature(<ftag>).feature().
 create(<ftag1>,"DeleteEntities");
```
- Description**
- Use `model.mesh(<tag>).feature().create(<ftag>,"DeleteEntities")` to delete geometric entities from an imported 2D or 3D mesh.
- Use `model.mesh(<tag>).feature(<ftag>).selection()` to specify geometric entities to delete.

The following properties are available:

TABLE 4-22: AVAILABLE PROPERTIES

| PROPERTY  | VALUE   | DEFAULT | DESCRIPTION                                                            |
|-----------|---------|---------|------------------------------------------------------------------------|
| deleteadj | boolean | true    | Specifies if the operation removes lower dimensional adjacent entities |

**See Also** [Import](#), [JoinEntities](#)



**Purpose** Mesh element distribution properties.

**Syntax**

```
model.mesh(<tag>).feature().create(<ftag>,"Distribution");
model.mesh(<tag>).feature(<ftag>).selection();
model.mesh(<tag>).feature(<ftag>).set(property,<value>);
model.mesh(<tag>).feature(<ftag>).getType(property);
model.mesh(<tag>).feature(<ftag>).feature().
 create(<ftag1>,"Distribution");
model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).selection();
model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).
 set(property,<value>);
model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).
 getType(property);
```

**Description** Use `model.mesh(<tag>).feature().create(<ftag>,"Distribution")` to specify element distribution properties in the sequence. Use `model.mesh(<tag>).feature(<ftag>).feature().create(<ftag1>,"Distribution")` to specify element distribution properties for the feature `<ftag>` that can be any of the types `Edge`, `FreeQuad`, `FreeTri`, `FreeTet`, `Map`, or `Sweep`.

Use `model.mesh(<tag>).feature(<ftag>).selection()` or `model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).selection()` to specify the edge or domain selection.

You can specify a mesh element distribution in three different ways; by specifying the number of elements only, by specifying the number of elements together with properties determining the distribution of the elements, or by specifying the element distribution explicitly. The property `type` determines which of the three alternatives you want to use. However, you need not set `type` manually since it is automatically updated when you set a property from one of the three groups below.

The following group of properties are available:

TABLE 4-23: AVAILABLE PROPERTIES WHEN TYPE IS NUMBER

| PROPERTY             | VALUE                | DEFAULT | DESCRIPTION        |
|----------------------|----------------------|---------|--------------------|
| <code>numelem</code> | <code>integer</code> |         | Number of elements |

Use the property `numelem` to specify the number of elements, but let the algorithm determine a suitable distribution, taking geometry and surrounding mesh into account.

TABLE 4-24: AVAILABLE PROPERTIES WHEN TYPE IS EXPLICIT

| PROPERTY              | VALUE                 | DEFAULT | DESCRIPTION                             |
|-----------------------|-----------------------|---------|-----------------------------------------|
| <code>explicit</code> | <code>double[]</code> |         | Explicitly defined element distribution |

Use the `explicit` property to specify an explicit element distribution. The value of this property is an array with increasing values starting at 0.

TABLE 4-25: AVAILABLE PROPERTIES WHEN TYPE IS PREDEFINED

| PROPERTY               | VALUE                                                               | DEFAULT                 | DESCRIPTION                                                                                                              |
|------------------------|---------------------------------------------------------------------|-------------------------|--------------------------------------------------------------------------------------------------------------------------|
| <code>elemcount</code> | <code>integer</code>                                                |                         | Number of elements                                                                                                       |
| <code>elemratio</code> | <code>double</code>                                                 | 1                       | Specifies the ratio in size between the last element and first element along the edge.                                   |
| <code>method</code>    | <code>arithmetic</code><br><code> </code><br><code>geometric</code> | <code>arithmetic</code> | Specifies if the element distribution is an arithmetic or a geometric sequence.                                          |
| <code>reverse</code>   | <code>on</code>   <code>off</code>                                  | <code>off</code>        | Specifies if the distribution is defined in the opposite edge direction for the edge in the selection with lowest index. |
| <code>symmetric</code> | <code>on</code>   <code>off</code>                                  | <code>off</code>        | Specifies if the distribution is made symmetric.                                                                         |

When the type is predefined, the distribution as calculated from the parameters given above.

This `Distribution` feature can be assigned to edges in 2D and 3D, domains in 3D or the entire geometry. The `FreeTet`, `FreeTri`, `FreeQuad`, `Edge`, and `Map` features use this property on when defined on edges, the `Sweep` feature uses this property defined on domains.

**See Also**

[Scale](#), [Size](#)

**Purpose** Create edge mesh.

**Syntax**

```
model.mesh(<tag>).feature().create(<ftag>,"Edge");
model.mesh(<tag>).feature(<ftag>).selection();
model.mesh(<tag>).feature(<ftag>).set(property,<value>);
model.mesh(<tag>).feature(<ftag>).getType(property);
model.mesh(<tag>).feature(<ftag>).feature().
 create(<ftag1>,ftype);
```

**Description** Use `model.mesh(<tag>).feature().create(<ftag>,"Edge")` to create an edge mesh.

Use `model.mesh(<tag>).feature(<ftag>).selection()` to specify the edge selection. If you do not specify any selection, the feature creates a mesh on the remaining entities in 1D. In 3D and 2D, the default selection is empty.

Use

```
model.mesh(<tag>).feature(<ftag>).feature().create(<ftag1>,ftype)
```

to add `Size` or `Distribution` attribute features.

The following properties are available:

TABLE 4-26: AVAILABLE PROPERTIES

| PROPERTY       | VALUE    | DEFAULT             | DESCRIPTION                                                                  |
|----------------|----------|---------------------|------------------------------------------------------------------------------|
| smoothcontrol  | on   off | on                  | Specifies if the operation smooths the mesh across removed control entities. |
| smoothmaxiter  | integer  | 8 in 2D,<br>4 in 3D | Specifies the number of smoothing iterations.                                |
| smoothmaxdepth | integer  | 8 in 2D,<br>4 in 3D | Specifies the maximum element smoothing depth.                               |

**See Also** [Distribution](#), [Point](#), [Size](#)

**Purpose** Define edge groups for mapped meshes.

**Syntax**

```
model.mesh(<tag>).feature(<ftag>).feature().
 create(<ftag1>, "EdgeGroup");
model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).selection();
model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).
 selection(property);
```

**Description** Use `model.mesh(<tag>).feature(<ftag>).feature().create(<ftag1>, "EdgeGroup")` to define edge groups for the Map feature `<ftag>`.

Use `model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).selection()` to specify the domain.

The following properties are available:

TABLE 4-27: AVAILABLE PROPERTIES

| PROPERTY | VALUE     | DEFAULT | DESCRIPTION          |
|----------|-----------|---------|----------------------|
| edge1    | Selection |         | First group of edges |
| edge2    | Selection |         | Second group of edge |
| edge3    | Selection |         | Third group of edge  |
| edge4    | Selection |         | Fourth group of edge |

The value of each property is an edge selection that combines edges to defines a logical side of the corresponding domain (in 2D) or boundary (in 3D). No specific ordering of the edges is required.

**See Also** [Distribution, Map, Size](#)

**Purpose** Specify an edge map for a face copy or a domain copy operation.

**Syntax**

```
model.mesh(<tag>).feature(<ftag>).create(<ftag1>,"EdgeMap");
model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).
 selection(property);
model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).
 set(property,<value>);
model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).
 getType(property);
```

**Description** Use `model.mesh(<tag>).feature(<ftag>).feature().create(<ftag1>,"EdgeMap")` to define an edge mapping for CopyFace or CopyDomain feature <ftag>.

The following properties are available:

TABLE 4-28: AVAILABLE PROPERTIES

| PROPERTY  | VALUE                     | DEFAULT | DESCRIPTION                                |
|-----------|---------------------------|---------|--------------------------------------------|
| direction | auto   same<br>  opposite | auto    | The direction of dstedge relative srcedge. |
| dstedge   | Selection                 |         | Edge on destination face/domain            |
| srcedge   | Selection                 |         | Edge on source face/domain                 |

Use the EdgeMap feature if you need to control how the source and destination faces/domains are matched in a copy face or a copy domain mesh operation. When this feature is present, the source mesh is transformed so that `srcedge` is mapped onto `dstedge`. The relative orientation of the edges is specified by the `direction` property.

**Example** Create a block and mesh Face 1 with a fine mesh on Edge 1. Copy this mesh to face 6 and ensure that the fine mesh of Edge 1 ends up on Edge 12.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 3);
model.mesh().create("mesh1", "geom1");

model.geom("geom1").feature().create("blk1", "Block");
model.geom("geom1").run();

model.mesh("mesh1").feature().create("ftri1", "FreeTri");
model.mesh("mesh1").feature("ftri1").selection().
 set(new int[]{1});
model.mesh("mesh1").feature("ftri1").feature().
 create("size1", "Size");
model.mesh("mesh1").feature("ftri1").feature("size1").
 selection().geom("geom1", 1).set(new int[]{1});
```

```
model.mesh("mesh1").feature("ftri1").feature("size1").
 set("hmax", "0.01");

model.mesh("mesh1").feature().create("cpf1", "CopyFace");
model.mesh("mesh1").feature("cpf1").
 selection("source").set(new int[]{1});
model.mesh("mesh1").feature("cpf1").
 selection("destination").set(new int[]{6});
model.mesh("mesh1").feature("cpf1").feature().
 create("em1", "EdgeMap");
model.mesh("mesh1").feature("cpf1").feature("em1").
 selection("dstedge").set(new int[]{1});
model.mesh("mesh1").feature("cpf1").feature("em1").
 selection("dstedge").set(new int[]{12});

model.mesh("mesh1").run();
```

### See Also

[CopyFace](#), [CopyDomain](#), [OnePointMap](#), [TwoPointMap](#)

**Purpose** Create unstructured quadrilateral mesh.

**Syntax**

```
model.mesh(<tag>).feature().create(<ftag>,"FreeQuad");
model.mesh(<tag>).feature(<ftag>).selection();
model.mesh(<tag>).feature(<ftag>).set(property,<value>);
model.mesh(<tag>).feature(<ftag>).getType(property);
model.mesh(<tag>).feature(<ftag>).feature().
 create(<ftag1>,ftype);
```

**Description** Use `model.mesh(<tag>).feature().create(<ftag>,"FreeQuad")` to create an unstructured quadrilateral mesh.

Use `model.mesh(<tag>).feature(<ftag>).selection()` to specify the domain (boundary in 3D) selection. If you do not specify any selection the feature creates a mesh on the remaining geometric entities in 2D. In 3D, the default selection is empty.

Use

```
model.mesh(<tag>).feature(<ftag>).feature().create(<ftag1>,ftype)
```

to add `Size` or `Distribution` attribute features.

The following properties are available:

TABLE 4-29: AVAILABLE PROPERTIES

| PROPERTY       | VALUE    | DEFAULT             | DESCRIPTION                                                                  |
|----------------|----------|---------------------|------------------------------------------------------------------------------|
| continue       | on   off | on                  | When enabled, the mesher does not stop if there is an error                  |
| xscale         | double   | 1                   | Scale geometry in x direction before meshing                                 |
| yscale         | double   | 1                   | Scale geometry in y direction before meshing                                 |
| zscale         | double   | 1                   | Scale geometry in z direction before meshing                                 |
| smoothcontrol  | on   off | on                  | Specifies if the operation smooths the mesh across removed control entities. |
| smoothmaxiter  | integer  | 8 in 2D,<br>4 in 3D | Specifies the number of smoothing iterations.                                |
| smoothmaxdepth | integer  | 8 in 2D,<br>4 in 3D | Specifies the maximum element smoothing depth.                               |

See the `FreeTet` feature for more information on the properties.

This feature uses the same attribute feature as the `FreeTet` feature.

## FreeQuad

---

**Compatibility**

See FreeTet.

**See Also**

[Distribution](#), [FreeTri](#), [Size](#)



|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Create free tetrahedral mesh.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Syntax</b>      | <pre> model.mesh(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"FreeTet"); model.mesh(&lt;tag&gt;).feature(&lt;ftag&gt;).selection(); model.mesh(&lt;tag&gt;).feature(&lt;ftag&gt;).set(property,&lt;value&gt;); model.mesh(&lt;tag&gt;).feature(&lt;ftag&gt;).getType(property); model.mesh(&lt;tag&gt;).feature(&lt;ftag&gt;).feature().     create(&lt;ftag1&gt;,ftype); </pre>                                                                                                                                         |
| <b>Description</b> | <p>Use <code>model.mesh(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"FreeTet")</code> to create an unstructured tetrahedral mesh.</p> <p>Use <code>model.mesh(&lt;tag&gt;).feature(&lt;ftag&gt;).selection()</code> to specify the domain selection. If you do not specify any selection the feature creates a mesh on the remaining geometric entities.</p> <p>Use <code>model.mesh(&lt;tag&gt;).feature(&lt;ftag&gt;).feature().create(&lt;ftag1&gt;,ftype)</code> to add Size or Distribution attribute features.</p> |

The following properties are available:

TABLE 4-30: AVAILABLE PROPERTIES

| PROPERTY       | VALUE    | DEFAULT             | DESCRIPTION                                                                  |
|----------------|----------|---------------------|------------------------------------------------------------------------------|
| continue       | on   off | on                  | When enabled, the mesher does not stop if there is an error                  |
| xscale         | double   | 1                   | Scale geometry in x direction before meshing                                 |
| yscale         | double   | 1                   | Scale geometry in y direction before meshing                                 |
| zscale         | double   | 1                   | Scale geometry in z direction before meshing                                 |
| smoothcontrol  | on   off | on                  | Specifies if the operation smooths the mesh across removed control entities. |
| smoothmaxiter  | integer  | 8 in 2D,<br>4 in 3D | Specifies the number of smoothing iterations.                                |
| smoothmaxdepth | integer  | 8 in 2D,<br>4 in 3D | Specifies the maximum element smoothing depth.                               |

If `continue` is on, the mesher does not stop if it encounters an error. Instead, it continues to mesh remaining entities. Before finishing, all errors are collected and reported as feature problems. You can use the output to visually examine the partial

mesh; this can help you understand what the problems are and how they can be fixed.

The properties `xscale`, `yscale`, and `zscale` specify scalar factors in each axis direction that the geometry is scaled by before meshing. The resulting mesh is then scaled back to fit the original geometry. The values of other properties correspond to the scaled geometry. By default, no scaling is done.

The following attribute features are used:

TABLE 4-31: ATTRIBUTE FEATURES USED

| FEATURE      | REMARKS                      |
|--------------|------------------------------|
| Distribution | Used when defined on edges   |
| Scale        | Scales Size and Distribution |
| Size         | All properties are used      |

### Compatibility

The following properties from the corresponding COMSOL 3.5a command, `meshinit`, have been removed:

TABLE 4-32: REMOVED PROPERTIES

| PROPERTY                | REASON                                                   |
|-------------------------|----------------------------------------------------------|
| <code>edge</code>       | Defined by the selection                                 |
| <code>edgelem</code>    | Defined by the attribute feature Distribution            |
| <code>face</code>       | Defined by the selection                                 |
| <code>hauto</code>      | Defined by attribute feature Size                        |
| <code>hcurveedg</code>  | Defined by the selection for <code>hcurve</code> in Size |
| <code>hcurvefac</code>  | Defined by the selection for <code>hcurve</code> in Size |
| <code>hcutoffedg</code> | Defined by the selection for <code>hmin</code> in Size   |
| <code>hcutofffac</code> | Defined by the selection for <code>hmin</code> in Size   |
| <code>hgradvtx</code>   | Defined by the selection for <code>hgrad</code> in Size  |
| <code>hgradedg</code>   | Defined by the selection for <code>hgrad</code> in Size  |
| <code>hgradfac</code>   | Defined by the selection for <code>hgrad</code> in Size  |
| <code>hgradsub</code>   | Defined by the selection for <code>hgrad</code> in Size  |
| <code>hmaxvtx</code>    | Defined by the selection for <code>hmax</code> in Size   |
| <code>hmaxedg</code>    | Defined by the selection for <code>hmax</code> in Size   |
| <code>hmaxfac</code>    | Defined by the selection for <code>hmax</code> in Size   |
| <code>hmaxfact</code>   | Defined by the selection for <code>hmax</code> in Size   |
| <code>hmaxsub</code>    | Defined by the selection for <code>hmax</code> in Size   |

TABLE 4-32: REMOVED PROPERTIES

| PROPERTY  | REASON                                                         |
|-----------|----------------------------------------------------------------|
| hnumedg   | Defined by the selection for hnum in Distribution              |
| hnumsub   | Defined by the selection for hnum in Distribution              |
| hpntedg   | No longer supported                                            |
| hpnt      | No longer supported                                            |
| hpntfac   | No longer supported                                            |
| jiggle    | No longer supported. Mesh quality improvements is always done. |
| mcase     | Defined by meshing sequence                                    |
| meshstart | Input mesh provided by meshing sequence                        |
| minit     | No longer supported                                            |
| mlevel    | Defined by the selection                                       |
| point     | Defined by the selection                                       |
| out       | Output mesh provided by meshing sequence                       |
| subdomain | Defined by the selection                                       |

**See Also**[Distribution](#), [FreeTri](#), [Size](#)

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Create unstructured triangular mesh.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Syntax</b>      | <pre>model.mesh(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"FreeTri"); model.mesh(&lt;tag&gt;).feature(&lt;ftag&gt;).selection(); model.mesh(&lt;tag&gt;).feature(&lt;ftag&gt;).set(property,&lt;value&gt;); model.mesh(&lt;tag&gt;).feature(&lt;ftag&gt;).getType(property); model.mesh(&lt;tag&gt;).feature(&lt;ftag&gt;).feature().     create(&lt;ftag1&gt;,&lt;ftype&gt;);</pre>                                                                                                                                                                                                        |
| <b>Description</b> | <p>Use <code>model.mesh(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"FreeTri")</code> to create an unstructured triangular mesh.</p> <p>Use <code>model.mesh(&lt;tag&gt;).feature(&lt;ftag&gt;).selection()</code> to specify the domain (boundary in 3D) selection. If you do not specify any selection the feature creates a mesh on the remaining geometric entities in 2D. In 3D, the default selection is empty.</p> <p>Use <code>model.mesh(&lt;tag&gt;).feature(&lt;ftag&gt;).feature().create(&lt;ftag1&gt;,&lt;ftype&gt;)</code> to add Size or Distribution attribute features.</p> |

The following properties are available:

TABLE 4-33: AVAILABLE PROPERTIES

| PROPERTY       | VALUE              | DEFAULT             | DESCRIPTION                                                                  |
|----------------|--------------------|---------------------|------------------------------------------------------------------------------|
| continue       | on   off           | on                  | When enabled, the mesher does not stop if there is an error                  |
| method         | auto   af<br>  del | auto                | Triangulation method                                                         |
| xscale         | double             | 1                   | Scale geometry in x direction before meshing                                 |
| yscale         | double             | 1                   | Scale geometry in y direction before meshing                                 |
| zscale         | double             | 1                   | Scale geometry in z direction before meshing                                 |
| smoothcontrol  | on   off           | on                  | Specifies if the operation smooths the mesh across removed control entities. |
| smoothmaxiter  | integer            | 8 in 2D,<br>4 in 3D | Specifies the number of smoothing iterations.                                |
| smoothmaxdepth | integer            | 8 in 2D,<br>4 in 3D | Specifies the maximum element smoothing depth.                               |

Use the property `method` to specify the method used to triangulate domains in 2D and faces in 3D. A Delaunay based method is used if the property is set to `de1` and an advancing front method is used if the property is set to `af`. If `method` is set to `auto`, the program tries to choose the best method for each geometric entity.

**Compatibility**

See `FreeTet`.

**See Also**

[Distribution](#), [FreeTet](#), [FreeQuad](#), [Size](#)

- Purpose** Import mesh from file or other meshing sequence.
- Syntax**

```
model.mesh(<tag>).feature().create(<ftag>,"Import");
model.mesh(<tag>).feature(<ftag>).set(property,<value>);
model.mesh(<tag>).feature(<ftag>).getType(property);
model.mesh(<tag>).feature(<ftag>).importData();
```
- Description** Use `model.mesh(<tag>).feature().create(<ftag>,"Import")` to import a mesh into a sequence without a corresponding geometry. It is only possible to use this feature when the geometry sequence is empty. If the sequence already contains a mesh, the imported mesh is added to the existing mesh.
- Use `model.mesh(<tag>).feature(<ftag>).importData()` to import the file again.

The following mesh formats are supported:

| FORMAT                          | FILE EXTENSION     |
|---------------------------------|--------------------|
| COMSOL Multiphysics text file   | .mpltxt            |
| COMSOL Multiphysics binary file | .mpltbin           |
| NASTRAN file                    | .nas   .bdf   .dat |

The following properties are available:

| PROPERTY         | VALUES        | DEFAULT | DESCRIPTION                                                                                                         |
|------------------|---------------|---------|---------------------------------------------------------------------------------------------------------------------|
| elemsplit        | on   off      | off     | Specifies if mesh elements of different element forms get different domain labels when importing a NASTRAN file.    |
| facepartition    | auto   manual | auto    | Manual or automatic face partitioning in 3D                                                                         |
| filename         | String        |         | File name                                                                                                           |
| linearelem       | on   off      | off     | Specifies if extended node points in the NASTRAN file are ignored.                                                  |
| materialsplitted | on   off      | on      | Specifies if material data in the NASTRAN file is used to determine the domain partitioning of the domain elements. |
| data             | all   mesh    | all     | Specifies the data to import from the NASTRAN file.                                                                 |

| PROPERTY | VALUES                                                | DEFAULT | DESCRIPTION           |
|----------|-------------------------------------------------------|---------|-----------------------|
| sequence | String                                                |         | Meshing sequence name |
| source   | file   sequence<br>  native  <br>nastran  <br>stlvrml | file    | Source for the import |

The properties `elemsplit`, `linearelem`, `materialsplitsplit`, and `data` are only used for import of NASTRAN files.

`elemsplit` specifies if mesh elements of different element forms—that is, tetrahedral, pyramid, prism, or hexahedral—get different domain labels. The default value is `off`.

`linearelem` determines if extended node points are ignored. If the value is `on` all imported elements are linear. Otherwise, the order of the imported elements is determined from the order of the elements in the file. The default value is `on`.

`materialsplitsplit` determines if material data in the file is used (if available) to determine the domain partitioning of the domain elements. If the value is `off` all domain elements in the imported mesh belongs to the same domain if possible. The default value is `on`.

If `facepartition` is set to `manual` in 3D, the following properties are available. If any of these properties are set explicitly, `facepartition` is automatically switched to `manual`

TABLE 4-34: VALID PROPERTY/VALUE PAIRS

| PROPERTY   | VALUE         | DEFAULT     | DESCRIPTION                                                                                                                          |
|------------|---------------|-------------|--------------------------------------------------------------------------------------------------------------------------------------|
| curvedface | auto   manual | auto        | Control parameters for partitioning of curved faces.                                                                                 |
| extrangle  | double        | 0.6 degrees | Maximum angle between boundary element normal and extrusion plane that causes the element to be a part the extruded face if possible |
| faceangle  | double        | 360 degrees | Maximum angle between any two boundary elements in the same face                                                                     |

TABLE 4-34: VALID PROPERTY/VALUE PAIRS

| PROPERTY      | VALUE    | DEFAULT     | DESCRIPTION                                                                                                                         |
|---------------|----------|-------------|-------------------------------------------------------------------------------------------------------------------------------------|
| facecleanup   | double   | 0.01        | Avoid creating small faces. Faces with an area less than Facecleanup * the mean face area, are merged with adjacent faces           |
| facecurv      | double   | 10 degrees  | Maximum relative angle deviation between any two boundary elements in the same face                                                 |
| minareacurv   | double   | 1           | Minimum relative area of face to be considered as a face with constant curvature                                                    |
| minareaextr   | double   | 0.05        | Minimum relative area of face to be considered extruded                                                                             |
| minareaeplane | double   | 0.005       | Minimum relative area of face to be considered planar                                                                               |
| neighangle    | double   | 20 degrees  | Maximum angle between a boundary element and a neighbor that causes the elements to be part of the same boundary domain if possible |
| planar        | on   off | on          | Detect planar faces                                                                                                                 |
| planarangle   | double   | 0.6 degrees | Maximum angle between boundary element normal and a neighbor that causes the element to be a part the planar face if possible       |

The table below specifies the supported NASTRAN bulk data entries.

| BULK DATA ENTRY |        |        |        |
|-----------------|--------|--------|--------|
| CBAR            | CORD2C | CQUAD4 | GRID   |
| CHEXA           | CORD2R | CQUAD8 | MAT1   |
| CORDIC          | CORD2S | CTETRA | MAT10  |
| CORDIR          | CPENTA | CTRIA3 | PSHELL |
| CORDIS          | CPYRAM | CTRIA6 | PSOLID |



The NASTRAN bulk data format uses reduced second-order elements; that is, the center node on quadrilateral mesh faces (`quadNode`) and the center node of hexahedral elements (`hexNode`) are missing. Importing a NASTRAN mesh with second-order elements, COMSOL Multiphysics interpolates the coordinates of these missing node points from the surrounding node points using the following formulas:  $\text{quadNode} = 0.5 \cdot \text{quadEdgeNodes} - 0.25 \cdot \text{quadCornerNodes}$ , where `quadEdgeNodes` is the sum of the coordinates of the surrounding 4 edge nodes and `quadCornerNodes` is the sum of the coordinates of the surrounding 4 corner nodes, and  $\text{hexNode} = 0.25 \cdot \text{hexEdgeNodes} - 0.25 \cdot \text{hexCornerNodes}$ , where `hexEdgeNodes` is the sum of the coordinates of the surrounding 12 edge nodes and `hexCornerNodes` is the sum of the coordinates of the surrounding 8 corner nodes.

**Cautionary**

The `Import` feature does not handle NASTRAN files in free field format where the data fields are separated by blanks.

**Compatibility**

The following properties from the corresponding COMSOL 3.5a command, `meshimport`, have been removed:

TABLE 4-35: REMOVED PROPERTIES

| PROPERTY           | REASON                                   |
|--------------------|------------------------------------------|
| <code>mcase</code> | Defined by meshing sequence              |
| <code>out</code>   | Output mesh provided by meshing sequence |

**See Also**

[Ball](#), [Box](#), [CreateVertex](#), [DeleteEntities](#), [JoinEntities](#)

**Purpose** Join geometric entities of an imported mesh.

**Syntax**

```
model.mesh(<tag>).feature().create(<ftag>,"JoinEntities");
model.mesh(<tag>).feature(<ftag>).selection();
model.mesh(<tag>).feature(<ftag>).set(property,<value>);
model.mesh(<tag>).feature(<ftag>).getType(property);
model.mesh(<tag>).feature(<ftag>).feature().
 create(<ftag1>,"JoinEntities");
```

**Description** Use `model.mesh(<tag>).feature().create(<ftag>,"JoinEntities")` to join adjacent geometric entities of an imported 2D or 3D mesh.

Use `model.mesh(<tag>).feature(<ftag>).selection()` to specify geometric entities to join.

The following properties are available:

TABLE 4-36: AVAILABLE PROPERTIES

| PROPERTY | VALUE   | DEFAULT | DESCRIPTION                                                          |
|----------|---------|---------|----------------------------------------------------------------------|
| joinadj  | boolean | true    | Specifies if the operation joins lower dimensional adjacent entities |

**See Also** [Import](#), [DeleteEntities](#)

**Purpose** Create structured quadrilateral mesh.

**Syntax**

```
model.mesh(<tag>).feature().create(<ftag>,"Map");
model.mesh(<tag>).feature(<ftag>).selection();
model.mesh(<tag>).feature(<ftag>).set(property,<value>);
model.mesh(<tag>).feature(<ftag>).getType(property);
model.mesh(<tag>).feature(<ftag>).feature().
 create(<ftag1>,ftype);
```

**Description** Use `model.mesh(<tag>).feature().create(<ftag>,"Map")` to create a structured quadrilateral mesh.

Use `model.mesh(<tag>).feature(<ftag>).selection()` to specify the domain (boundary in 3D) selection. If you do not specify any selection the feature creates a mesh on the remaining domains in 2D. In 3D, the default selection is empty.

Use

```
model.mesh(<tag>).feature(<ftag>).feature().create(<ftag1>,ftype)
```

to add a Size, Distribution, or EdgeGroup attribute feature.

The following properties are available:

TABLE 4-37: AVAILABLE PROPERTIES

| PROPERTY       | VALUE                                      | DEFAULT             | DESCRIPTION                                                                  |
|----------------|--------------------------------------------|---------------------|------------------------------------------------------------------------------|
| adjustedgdistr | on   off                                   | off                 | When enabled, the mapped mesher adjusts evenly distributed edge mesh.        |
| interpmethod   | auto  <br>transfinite2D  <br>transfinite3D | auto                | Interpolation method                                                         |
| smoothcontrol  | on   off                                   | on                  | Specifies if the operation smooths the mesh across removed control entities. |
| smoothmaxiter  | integer                                    | 8 in 2D,<br>4 in 3D | Specifies the number of smoothing iterations.                                |
| smoothmaxdepth | integer                                    | 8 in 2D,<br>4 in 3D | Specifies the maximum element smoothing depth.                               |

The following attribute features are used:

TABLE 4-38: ATTRIBUTE FEATURES USED

| FEATURE      | REMARKS                                 |
|--------------|-----------------------------------------|
| EdgeGroup    | Defined on the domain/face to be meshed |
| Distribution | Used when defined on edges              |

TABLE 4-38: ATTRIBUTE FEATURES USED

| FEATURE | REMARKS                                           |
|---------|---------------------------------------------------|
| Scale   | Scales Size and Distribution                      |
| Size    | Defined on domain/face. Uses only hauto and hmax. |

**Compatibility**

The following properties from the corresponding COMSOL 3.5a command, meshmap, have been removed:

TABLE 4-39: REMOVED PROPERTIES

| PROPERTY  | REASON                                   |
|-----------|------------------------------------------|
| edgelem   | Defined by the Distribution              |
| face      | Defined by the selection                 |
| mcase     | Defined by the meshing sequence          |
| meshstart | Input mesh provided by meshing sequence  |
| out       | Output mesh provided by meshing sequence |
| domain    | Defined by the selection                 |

**See Also**

[Distribution](#), [FreeTri](#)

- Purpose** Specify a one point map for a face copy or a domain copy operation.
- Syntax** `model.mesh(<tag>).feature(<ftag>).create(<ftag1>,"OnePointMap");`  
`model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).`  
`selection(property);`
- Description** Use `model.mesh(<tag>).feature(<ftag>).feature().create(<ftag1>,"OnePointMap")` to define a one-point map for CopyFace or CopyDomain feature `<ftag>`.

The following properties are available:

TABLE 4-40: AVAILABLE PROPERTIES

| PROPERTY  | VALUE     | DEFAULT | DESCRIPTION                      |
|-----------|-----------|---------|----------------------------------|
| srcpoint1 | Selection |         | Point on source face/domain      |
| dstpoint1 | Selection |         | Point on destination face/domain |

Use the OnePointMap feature if you need to control how the source and destination faces/domains are matched in a copy face or a copy domain mesh operation. When this feature is present, the source mesh is transformed so that srcpoint1 is mapped to dstpoint1.

- Example** Create a block and mesh face 4 with a fine mesh near Point 8. Copy this mesh onto Face 3 and ensure that the fine mesh near Point 8 ends up near Point 3.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 3);
model.mesh().create("mesh1", "geom1");

model.geom("geom1").feature().create("blk1", "Block");
model.geom("geom1").run();

model.mesh("mesh1").feature().create("ftri1", "FreeTri");
model.mesh("mesh1").feature("ftri1").selection().
 set(new int[]{4});
model.mesh("mesh1").feature("ftri1").feature().
 create("size1", "Size");
model.mesh("mesh1").feature("ftri1").feature("size1").
 selection().geom("geom1", 0).set(new int[]{8});
model.mesh("mesh1").feature("ftri1").feature("size1").
 set("hmax", "0.01");
model.mesh("mesh1").feature().create("cpf1", "CopyFace");
model.mesh("mesh1").feature("cpf1").selection("source").
 geom("geom1", 2).set(new int[]{4});
model.mesh("mesh1").feature("cpf1").selection("destination").
 geom("geom1", 2).set(new int[]{3});
model.mesh("mesh1").feature("cpf1").feature().
```

```
create("pm1", "OnePointMap");
model.mesh("mesh1").feature("cpf1").feature("pm1").
 selection("srcpoint1").set(new int[]{8});
model.mesh("mesh1").feature("cpf1").feature("pm1").
 selection("dstpoint1").set(new int[]{3});
model.mesh("mesh1").run();
```

**See Also**

[CopyFace](#), [CopyDomain](#), [EdgeMap](#), [TwoPointMap](#)

|                    |                                                                                                                                                                                                                                                                                                                             |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Create point mesh.                                                                                                                                                                                                                                                                                                          |
| <b>Syntax</b>      | <pre>model.mesh(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"Point");<br/>model.mesh(&lt;tag&gt;).feature(&lt;ftag&gt;).selection();</pre>                                                                                                                                                                                   |
| <b>Description</b> | <p>Use <code>model.mesh(&lt;tag&gt;).feature().create(&lt;ftag&gt;,"Point")</code> to mesh geometry vertices.</p> <p>Use <code>model.mesh(&lt;tag&gt;).feature(&lt;ftag&gt;).selection()</code> to specify the point selection. If you do not specify any selection the feature creates a mesh on the remaining points.</p> |
| <b>See Also</b>    | <a href="#">Edge</a>                                                                                                                                                                                                                                                                                                        |

- Purpose** Refer to a meshing sequence.
- Syntax**
- ```
model.mesh(<tag>).feature().create(<ftag>, "Reference");
model.mesh(<tag>).feature(<ftag>).set(property, <value>);
model.mesh(<tag>).feature(<ftag>).getType(property);
model.mesh(<tag>).feature(<ftag>).expand();
model.mesh(<tag>).feature(<ftag>).feature().
    create(<ftag1>, ftype);
```
- Description**
- Use `model.mesh(<tag>).feature().create(<ftag>, "Reference")` to refer to another meshing sequence. Use `model.mesh(<tag>).feature(<ftag>).feature().create(<ftag1>, ftype)` to add Scale attribute features.
- Use `model.mesh(<tag>).feature(<ftag>).expand()` to replace the reference with a copy of the referred sequence, where the attributes have been scaled with the scale attribute features of the reference.

The following properties are available:

TABLE 4-41: AVAILABLE PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
sequence	String		Tag of referred sequence.

Use the `sequence` property to specify another meshing sequence on the same geometry. When running the feature, all features of the specified sequence are run in the current context.

It is not allowed to introduce circular references.

- Examples**
- Create a mixed mesh with quads and triangles on a geometry. Create a second meshing sequence with a `scale` feature and a reference to the first meshing sequence. The result is a coarser version of the first mesh.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 2);
model.mesh().create("mesh1", "geom1");

model.geom("geom1").feature().create("sq1", "Square");
model.geom("geom1").feature().create("sq2", "Square");
model.geom("geom1").feature("sq2").set("size", "0.5");
model.geom("geom1").run();

model.mesh("mesh1").feature().create("map1", "Map");
model.mesh("mesh1").feature("map1").selection().
    geom("geom1", 2).set(new int[] {1});
model.mesh("mesh1").feature().create("ftri1", "FreeTri");
model.mesh("mesh1").feature("ftri1").selection();
```



```
    geom("geom1", 2).set(new int[]{2});
    model.mesh("mesh1").run();

    model.mesh().create("mesh2", "geom1");
    model.mesh("mesh2").feature().create("sca1", "Scale");
    model.mesh("mesh2").feature("sca1").set("scale", "2");
    model.mesh("mesh2").feature().create("rf1", "Reference");
    model.mesh("mesh2").feature("rf1").set("sequence", "mesh1");
    model.mesh("mesh2").run();
```

See Also

[Scale](#)

Purpose	Refine mesh.
Syntax	<pre>model.mesh(<tag>).feature().create(<ftag>,"Refine"); model.mesh(<tag>).feature(<ftag>).selection(); model.mesh(<tag>).feature(<ftag>).set(property,<value>); model.mesh(<tag>).feature(<ftag>).getType(property);</pre>
Description	<p>Use <code>model.mesh(<tag>).feature().create(<ftag>,"Refine")</code> to refine the mesh.</p> <p>Use <code>model.mesh(<tag>).feature(<ftag>).selection()</code> to specify the domain selection or the entire geometry. If you do not specify any selection the feature refines all triangular and tetrahedral elements in the mesh.</p>

The following properties are available:

PROPERTY	VALUE	DEFAULT	DESCRIPTION
boxcoord	on off	off	Use coordinates of a bounding box to determine the elements to refine
rmethod	longest regular	see below	Refinement method
element	int[]	all	List of elements to refine
numrefine	int or int[]	1	Number of refinements
xmax, xmin, ymax, ymin, zmax, zmin	double		Coordinates of bounding box

Use the `boxcoord` property to refine elements inside a bounding box. To define the bounding box, set the properties `xmin`, `xmax`, `ymin`, `ymax`, `zmax`, and `zmin` on the feature, where `(xmin,ymin,zmin)` defines the lower-left corner and `(xmax,ymax,zmax)` defines the upper-right corner of the bounding box. The elements that have all its corner points in the bounding box are refined once. `boxcoord` is automatically set to `on` if one of the coordinates are set.

The default refinement method in 2D is regular refinement, where all of the specified triangles are divided into four triangles of the same shape. Longest edge refinement, where the longest edge of each specified triangle is bisected, can be selected by giving `longest` as `rmethod`. Using `regular` as `rmethod` results in regular refinement. Some triangles outside of the specified set may also be refined, in order to preserve the triangulation and its quality.

In 3D, the default refinement method is `longest`. The regular refinement method is only implemented for uniform refinements (that is, when all elements are refined).

In 1D, regular refinement, where each element is divided into two elements of the same shape, is always used.

By default, all elements are refined once. By using the `element` property, you can specify which elements are refined and the `numrefine` property specifies how many times the elements is refined. If `numrefine` is an integer, all refined elements are refined `numrefine` times. If `numrefine` is a vector, it must have the same length as the `element` vector, and gives the number of refinements for each element.

Compatibility

The following properties from the corresponding COMSOL 3.5a command, `meshrefine`, have been removed:

TABLE 4-42: REMOVED PROPERTIES

PROPERTY	REASON
<code>mcase</code>	Defined by meshing sequence
<code>out</code>	Output mesh provided by meshing sequence
<code>domain</code>	Defined by the selection
<code>tri</code> , <code>tet</code>	Replaced by <code>element</code> and <code>numrefine</code>

Examples

Mesh two squares with free mesh. Refine the mesh on `sq2` once and refine the elements inside a box in `sq1` twice.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 2);
model.mesh().create("mesh1", "geom1");

model.geom("geom1").feature().create("sq1", "Square");
model.geom("geom1").feature().create("sq2", "Square");
model.geom("geom1").feature("sq2").setIndex("pos", "1", 0);
model.geom("geom1").run();

model.mesh("mesh1").feature().create("ftri1", "FreeTri");
model.mesh("mesh1").feature().create("ref1", "Refine");
model.mesh("mesh1").feature("ref1").selection().
    geom("geom1", 2).set(new int[] {2});
model.mesh("mesh1").feature().create("ref2", "Refine");
model.mesh("mesh1").feature("ref2").set("xmin", "0.2");
model.mesh("mesh1").feature("ref2").set("xmax", "0.8");
model.mesh("mesh1").feature("ref2").set("ymin", "0.2");
model.mesh("mesh1").feature("ref2").set("ymax", "0.6");
model.mesh("mesh1").run();
```

See Also

[Convert](#)

Purpose Scale size properties.

Syntax

```
model.mesh(<tag>).feature().create(<ftag>,"Scale");
model.mesh(<tag>).feature(<ftag>).selection();
model.mesh(<tag>).feature(<ftag>).set(property,<value>);
model.mesh(<tag>).feature(<ftag>).getType(property);
model.mesh(<tag>).feature(<ftag>).feature().
    create(<ftag1>,"Scale");
model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).selection();
model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).
    set(property,<value>);
model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).
    getType(property);
```

Description

Use `model.mesh(<tag>).feature().create(<ftag>,"Scale")` to scale size properties defined in the sequence and use `model.mesh(<tag>).feature(<ftag>).feature(<ftag1>,"Scale")` to scale size properties defined in the sequence referred to by the Reference feature `<ftag>`.

Use `model.mesh(<tag>).feature(<ftag>).selection()` or `model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).selection()` to specify the geometric entity selection or the entire geometry (which is default).

The following properties are available:

TABLE 4-43: FEATURE PROPERTIES DEFINED

PROPERTY	VALUE	DEFAULT	DESCRIPTION
scale	double	1	Scale factor

Scale is a positive number. The feature scales mesh size properties, distribution properties and boundary layer properties affecting mesh elements generated by features following the scale feature. The scale feature also affects size properties defined by Size, Distribution, and BndLayerProp features occurring later in the sequence.

A scale less than 1 gives smaller (more) elements; a scale greater than 1 gives larger (fewer) elements. The scale feature has no effect on mesh generated earlier in the sequence.

If two or more scale features exist on the same selection, the resulting scale on that selection is the product of the given scales.

Example

Create a block and mesh it with 10-by-10-by-10 hexahedra. Setting `scale` to 2 gives you a block with 5-by-5-by-5 hexahedra and setting the `scale` to 0.5 gives you a block with 20-by-20-by-20 hexahedra.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 3);
model.mesh().create("mesh1", "geom1");

model.geom("geom1").feature().create("blk1", "Block");
model.geom("geom1").run();

model.mesh("mesh1").feature().create("sca1", "Scale");
model.mesh("mesh1").feature().create("map1", "Map");
model.mesh("mesh1").feature("map1").selection().
    set(new int[]{1});
model.mesh("mesh1").feature().create("swe1", "Sweep");
model.mesh("mesh1").run();

model.mesh("mesh1").feature("sca1").set("scale", "2");
model.mesh("mesh1").run();

model.mesh("mesh1").feature("sca1").set("scale", "0.5");
model.mesh("mesh1").run();
```

See Also

[BndLayerProp](#), [Distribution](#), [Size](#)

Purpose	Mesh size properties.
Syntax	<pre> model.mesh(<tag>).feature().create(<ftag>,"Size"); model.mesh(<tag>).feature(<ftag>).selection(); model.mesh(<tag>).feature(<ftag>).set(property,<value>); model.mesh(<tag>).feature(<ftag>).getType(property); model.mesh(<tag>).feature(<ftag>).feature(). create(<ftag1>,"Size"); model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).selection(); model.mesh(<tag>).feature(<ftag>).feature(<ftag1>). set(property,<value>); model.mesh(<tag>).feature(<ftag>).feature(<ftag1>). getType(property); </pre>
Description	<p>Use <code>model.mesh(<tag>).feature().create(<ftag>,"Size")</code> to specify element size properties in the sequence. Use <code>model.mesh(<tag>).feature(<ftag>).feature().create(<ftag1>,"Size")</code> to specify element size properties for the feature <code><ftag></code> that can be any of the types <code>Edge</code>, <code>FreeQuad</code>, <code>FreeTri</code>, <code>FreeTet</code>, <code>Map</code>, or <code>Sweep</code>.</p> <p>Use <code>model.mesh(<tag>).feature(<ftag>).selection()</code> or <code>model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).selection()</code> to specify the geometric entity selection. If you do not specify any selection the size feature is defined on all geometric entities. The selection is not available for the <i>default size feature</i>, tagged size.</p>

The following properties are available:

TABLE 4-44: FEATURE PROPERTIES DEFINED

PROPERTY	VALUE	DEFAULT	DESCRIPTION
custom	on off	off	Setting custom to on deactivates all mesh parameters.
hauto	double	5	Automatic settings for all mesh parameters.
hcurve	double	0.3 0.6	Curvature mesh size
hcurveactive	on off	on	Specifies if hcurve is used
hgrad	double	1.3 1.5	Element growth rate
hgradactive	on off	on	Specifies if hgrad is used
hmax	double	geometry dependent	Maximum element size
hmaxactive	on off	on	Specifies if hmax is used

TABLE 4-44: FEATURE PROPERTIES DEFINED

PROPERTY	VALUE	DEFAULT	DESCRIPTION
hmin	double	geometry dependent	Minimum element size
hminactive	on off	on	Specifies if hmin is used
hnarrow	double	0.5	Resolution of narrow regions
hnarrowactive	on off	on	Specifies if hnarrow is used
table	cfD default plasma	default	Specifies for which physics the element size is calibrated

Note: The properties with names ending in `active` are not available for the default size feature.

The property `table` is either `cfD`, `default`, or `plasma` and specifies the physics for which the element size is calibrated.

`Hauto` is a positive scalar. This value is used to set several mesh parameters in order to get a mesh of desired size. Smaller values of `hauto` generate finer meshes with more elements. The integers between 1 and 9 has a special interpretation; they correspond to the mesh settings **Normal**, **Fine**, **Coarse** and so forth in COMSOL Multiphysics. The value 5 correspond to **Normal**. When you set the property `hauto`, all other properties are set to their default value, according to the following tables (for `table` set to `default`).

TABLE 4-45: MESH PARAMETERS SET BY THE PROPERTY HAUTO IN 2D (FOR DEFAULT TABLE)

HAUTO	HMAXFACT	HCURVE	HGRAD	HMINFACT	HNARROW
1	0.01	0.2	1.1	2e-5	1
2	0.02	0.25	1.2	7.5e-5	1
3	0.037	0.25	1.25	1.25e-4	1
4	0.053	0.3	1.3	3e-4	1
5	0.067	0.3	1.3	3e-4	1
6	0.1	0.4	1.4	0.002	1
7	0.13	0.6	1.5	0.006	1
8	0.2	0.8	1.8	0.016	1
9	0.33	1	2	0.05	0.9

mesh parameters set by the property `hauto` in 3d (for default table)

HAUTO	HMAXFACT	HCURVE	HGRAD	HMINFACT	HNARROW
1	0.02	0.2	1.3	2e-4	1
2	0.035	0.3	1.35	0.0015	0.85
3	0.055	0.4	1.4	0.004	0.7
4	0.08	0.5	1.45	0.01	0.6
5	0.1	0.6	1.5	0.018	0.5
6	0.15	0.7	1.6	0.028	0.4
7	0.19	0.8	1.7	0.04	0.3
8	0.3	0.9	1.85	0.054	0.2
9	0.5	1	2	0.07	0.1

The property `hcurve` is a real value that relates the mesh size to the curvature of the geometry boundaries. The gaussian radius of curvature is multiplied by the `hcurve` factor to obtain the mesh size along the boundary. The specified `hcurve` is only used if `hcurveactive` is on, otherwise `hcurve` is taken from a preceding size feature in the sequence. In the default size feature, tagged `size`, `hcurve` is always active and there is no `hcurveactive` property.

The property `hgrad` tells how fast the element size—measured as the length of the longest edge of the element—can grow from a region with small elements to a region with larger elements. If two elements lie one unit length apart, the difference in element size can be at most `hgrad`. The specified `hgrad` is only used if `hgradactive` is on, otherwise `hgrad` is taken from a preceding size feature in the sequence. In the default size feature, `hgrad` is always active and there is no `hcurvegrad` property.

The `hmax` parameter controls the size of the elements in the mesh. The algorithm aims at creating a mesh where no element size exceeds `hmax`. The default `hmax` value is `hmaxfact * maxdist`, where `maxdist` is the longest axis parallel distance in the geometry. The specified `hmax` is only used if `hmaxactive` is on, otherwise `hmax` is taken from a preceding size feature in the sequence. In the default size feature, `hmax` is always active and there is no `hmaxactive` property.

You can use `hmin` to control the minimum size of the elements. The main purpose of this parameter is to prevent the generation of many small elements near small curved parts of the geometry. The default `hmin` value is `hminfact * maxdist`, where `maxdist` is the longest axis parallel distance in the geometry. The specified `hmin` is only used if `hminactive` is on, otherwise `hmin` is taken from a preceding size feature

in the sequence. In the default size feature, `hmin` is always active and there is no `hminactive` property.

The `hnarrow` parameter controls the size of the elements in narrow regions. Increasing values of this property decrease the size of the elements in narrow regions. If the value of `hnarrow` is less than one, elements that are anisotropic in size might be generated in narrow regions. The specified `hnarrow` is only used if `hnarrowactive` is on, otherwise `hnarrow` is taken from a preceding size feature in the sequence. In the default size feature, `hnarrow` is always active and there is no `hnarrowactive` property.

The values of `hauto`, `hcurve`, `hgrad`, `hmax`, `hmin`, and `hnarrow` are positive real scalars, or strings that evaluate to positive real scalars, given the evaluation context provided by `model.param()`.

It is not possible to specify coarser size settings on the boundary of a domain than on the domain. The finer settings on the domain is inherited by its boundaries and, in 3D, edges. A warning is issued when settings are overwritten by inheritance. If you need to create coarser mesh on a boundary, you should first mesh the boundary then add the finer size settings on the domain and a corresponding free mesh operation.

Compatibility

The following size control properties from the COMSOL 3.5a command, `meshinit`, have been removed:

TABLE 4-46: REMOVED PROPERTIES

PROPERTY	REASON
<code>hcutoff</code>	Replaced by <code>hmin</code> . The relation is given by $hmin = hcutoff \cdot hcurve \cdot maxdist$, where <code>maxdist</code> is the maximal axis parallel distance in the geometry.
<code>hmaxfact</code>	Replaced by <code>hmax</code> . The relation is given by $hmax = hmaxfact \cdot maxdist / 10$ in 3D and $hmax = hmaxfact \cdot maxdist / 15$ in 2D and 1D, where <code>maxdist</code> is defined as above.
<code>hmesh</code>	No longer supported
<code>mesh</code>	No longer supported

See Also

[Distribution](#), [Scale](#)

Purpose	Create swept mesh.
Syntax	<pre> model.mesh(<tag>).feature().create(<ftag>,"Sweep"); model.mesh(<tag>).feature(<ftag>).selection(); model.mesh(<tag>).feature(<ftag>).selection(property); model.mesh(<tag>).feature(<ftag>).set(property,<value>); model.mesh(<tag>).feature(<ftag>).getType(property); model.mesh(<tag>).feature(<ftag>).feature(). create(<ftag1>,<ftype>); </pre>
Description	<p>Use <code>model.mesh(<tag>).feature().create(<ftag>,"Sweep")</code> to create a swept mesh in 3D.</p> <p>Use <code>model.mesh(<tag>).feature(<ftag>).selection()</code> to specify the domain selection. If you do not specify any selection the feature creates a mesh on the remaining domains.</p> <p>Use <code>model.mesh(<tag>).feature(<ftag>).feature().create(<ftag1>,<ftype>)</code> to add a Size or Distribution attribute feature.</p> <p>Use <code>model.mesh(<tag>).feature(<ftag>).selection()</code> to specify the 3D domain selection. If you do not specify any selection the feature creates a mesh on the remaining domains.</p> <p>The following properties are available:</p>

TABLE 4-47: AVAILABLE PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
facemethod	tri quad	quad	Face meshing method
sourceface	Selection		Source faces selection
sweepath	String	auto	Sweep path
targetface	Selection		Destination face selection
targetmesh	String	auto	Destination mesh method
smoothcontrol	on off	on	Specifies if the operation smooths the mesh across removed control entities.
smoothmaxiter	integer	8 in 2D, 4 in 3D	Specifies the number of smoothing iterations.
smoothmaxdepth	integer	8 in 2D, 4 in 3D	Specifies the maximum element smoothing depth.

Use the property `sourceface` and `targetface` to specify the source faces and the destination faces of the sweep, respectively. For domains in the feature selection

where none of the surrounding faces are specified as either a source or a destination face, the software automatically tries to determine these faces.

Use the property `sweepPath` if you want to specify the shape of the sweep path. The string is either `auto`, `straight`, `circular`, or `general`. `straight` means that all interior mesh points are located on straight lines between the corresponding source and destination points. `circular` means that all interior mesh points are located on circular arcs between the corresponding source and destination points. `general` means that the positions of the interior mesh points are determined by a general interpolation procedure. `auto`, which is default, means that the sweeping algorithm automatically tries to determine if the sweep path is straight or circular. If this is the case `sweepPath` is set to `straight` or `circular`, respectively. Otherwise, `sweepPath` is set to `general`.

Any source face that is not meshed, is meshed automatically. The property `faceMethod` controls which face meshing method is used. If `faceMethod` is `quad`, you get quadrilateral face mesh and therefore hexahedral domain mesh. If `faceMethod` is `tri`, you get triangular face mesh and prism elements in the domain.

Use the property `targetMesh` if you want to specify the method to be used for transferring the source mesh to the destination face. The string is either `auto`, `morph`, or `rigid`. `morph` means that the destination mesh is created from the source mesh by a morphing technique, and `rigid` means that the destination mesh is created by a rigid transformation of the source mesh. The value `auto`, which is default, means that the sweeping algorithm automatically tries to determine a suitable method for creating the destination mesh.

The following attribute features are used:

TABLE 4-48: ATTRIBUTE FEATURES USED

FEATURE	REMARKS
Distribution	Used when defined on domains
Scale	Scales Size and Distribution
Size	Defined on domain.

If a Distribution feature is defined on a domain, it is used to determine the distribution of element layer in the sweep direction. Otherwise, if `haut0` or `hmax` is specified, equidistant element layers are generated.

Compatibility

The following properties from the corresponding COMSOL 3.5a command, `meshsweep`, have been removed:

TABLE 4-49: REMOVED PROPERTIES

PROPERTY	REASON
<code>elsweeplayers</code>	Defined by the property <code>elemdistr</code> in <code>Distribution</code>
<code>meshstart</code>	Input mesh provided by meshing sequence
<code>out</code>	Output mesh provided by meshing sequence
<code>domain</code>	Defined by the selection

See Also

[Distribution](#), [FreeQuad](#), [FreeTri](#), [Map](#)

- Purpose** Specify a two point map for a face copy or a domain copy operation.
- Syntax** `model.mesh(<tag>).feature(<ftag>).create(<ftag1>,"TwoPointMap")`
`model.mesh(<tag>).feature(<ftag>).feature(<ftag1>).selection(property)`
- Description** Use `model.mesh(<tag>).feature(<ftag>).feature().create(<ftag1>,"TwoPointMap")` to define a two-point map for the CopyFace or CopyDomain feature `<ftag>`.

The following properties are available:

TABLE 4-50: AVAILABLE PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
srcpoint1	Selection		First point on source face/domain
srcpoint2	Selection		Second point on source face/domain
dstpoint1	Selection		First point on destination face/domain
dstpoint2	Selection		Second point on destination face/domain

Use the TwoPointMap feature if you need to control how the source and destination faces/domains are matched in a copy face or a copy domain mesh operation. When this feature is present, the source mesh is transformed so that srcpoint1 is mapped to dstpoint1 and srcpoint2 is mapped to dstpoint2.

- Example** Create a block and mesh face 2. Copy this mesh onto the opposite Face 5 and ensure that Point 6 is mapped to Point 4 and Point 5 is mapped to Point 8.

```
Model model = ModelUtil.create("Model");
model.geom().create("geom1", 3);
model.mesh().create("mesh1", "geom1");

model.geom("geom1").feature().create("blk1", "Block");
model.geom("geom1").run();

model.mesh("mesh1").feature().create("ftri1", "FreeTri");
model.mesh("mesh1").feature("ftri1").selection().
    set(new int[]{2});
model.mesh("mesh1").feature("ftri1").feature().
    create("size1", "Size");
model.mesh("mesh1").feature("ftri1").feature("size1").
    selection().geom("geom1", 1).set(new int[]{9});
model.mesh("mesh1").feature("ftri1").feature("size1").
    set("hmax", "0.01");
model.mesh("mesh1").feature().create("cpf1", "CopyFace");
model.mesh("mesh1").feature("cpf1").
    selection("source").geom("geom1", 2).set(new int[]{2});
```

```
model.mesh("mesh1").feature("cpf1").
    selection("destination").geom("geom1", 2).set(new int[]{5});
model.mesh("mesh1").feature("cpf1").feature().
    create("ppm1", "TwoPointMap");
model.mesh("mesh1").feature("cpf1").feature("ppm1").
    selection("srcpoint1").set(new int[]{6});
model.mesh("mesh1").feature("cpf1").feature("ppm1").
    selection("dstpoint1").set(new int[]{4});
model.mesh("mesh1").feature("cpf1").feature("ppm1").
    selection("srcpoint2").set(new int[]{5});
model.mesh("mesh1").feature("cpf1").feature("ppm1").
    selection("dstpoint2").set(new int[]{8});
model.mesh("mesh1").run();
```

See Also

[CopyFace](#), [CopyDomain](#), [EdgeMap](#), [OnePointMap](#)

5

Solver

This chapter contains reference information about the solver command and utility commands for producing and handling solutions.

In this chapter:

- [About Solver Commands](#)
- [Solution Object Data](#)

About Solver Commands

The following list includes the solver commands that are documented in this chapter:

- [Adaption](#)
- [Advanced](#)
- [Assemble](#)
- [AutoRemesh](#)
- [AWE](#)
- [Eigenvalue](#)
- [FullyCoupled](#)
- [Linear](#)
- [Modal](#)
- [Optimization](#)
- [Parametric](#)
- [PlotWhileSolving](#)
- [PreviousSolution](#)
- [Segregated](#)
- [SegregatedStep](#)
- [Sensitivity](#)
- [StateSpace](#)
- [Stationary](#)
- [StopCondition](#)
- [StoreSolution](#)
- [StudyStep](#)
- [Time](#)
- [TimeDiscrete](#)
- [TimeExplicit](#)

- [Variables](#)
- [XmeshInfo](#)



See Also

- [Features Producing and Manipulating Solutions](#)
- [Features with Solver Settings](#)
- [Solution Object Information Methods](#)
- [Solution Feature Information Methods](#)

In the *COMSOL Multiphysics Reference Guide*:

- [Solver Features](#)
- [Advanced Solver Topics](#)

In the *COMSOL Multiphysics User's Guide*:

- [Solvers and Study Types](#)

Features Producing and Manipulating Solutions

Table 5-1 is an overview of the available features for producing and manipulating solution objects.

TABLE 5-1: SOLUTION OBJECT FEATURES

FEATURE	PURPOSE
Assemble	Assembles and stores the matrices generated during assembly
AWE	Solve parametric problem with asymptotic waveform evaluation
Eigenvalue	Solve eigenvalue problem
Modal	Solve time-dependent or parametric problem with modal analysis
Optimization	Solve optimization problem
StateSpace	Assembles and stores matrices that describe a model as a dynamic system
Stationary	Solve stationary problem
StudyStep	Specifies which PDE problem to compile
Time	Solve time-dependent problem with implicit time-stepping
TimeDiscrete	Solve time-dependent problem with user's own time-stepping

TABLE 5-1: SOLUTION OBJECT FEATURES

FEATURE	PURPOSE
TimeExplicit	Solve time-dependent problem with explicit time-stepping
Variables	Handle variables solved for (initial values, scaling) and not solved for (prescribed values)

Features with Solver Settings

[Table 5-2](#) is an overview of the available features for solver settings.

TABLE 5-2: SOLVER SETTING FEATURES

FEATURE	SETTINGS HANDLED
Adaption	Solve with adaptive mesh refinement
Advanced	Advanced general settings
AutoRemesh	Automatically remesh deformed geometries
ControlField	Control fields (a set of control variables)
ControlState	Set of global control variables
Direct	Direct linear system solvers
Field	Fields (a set of dependent variables)
FullyCoupled	Fully coupled nonlinear solution approach
IncompleteLU	Incomplete factorization preconditioners
Iterative	Iterative linear system solvers
Jacobi	Jacobi linear system preconditioners
KrylovPreconditioner	Krylov linear system preconditioners
Multigrid	Multigrid linear system preconditioners
Parametric	Parameter stepping
PreviousSolution	Previous solution solvers
Segregated	Segregated nonlinear solution approach
SegregatedStep	Segregated steps
Sensitivity	Sensitivity analysis
SOR	SOR linear system preconditioners
SORGauge	SOR Gauge linear system preconditioners
SORLine	SOR Line linear system preconditioners
SORVector	SOR Vector linear system preconditioners
State	Sets of global dependent variables

TABLE 5-2: SOLVER SETTING FEATURES

FEATURE	SETTINGS HANDLED
StopCondition	Stop conditions
Vanka	Vanka linear system preconditioners

Solution Object Information Methods

The following tables are an overview of the solution object information methods.

GENERAL INFORMATION

TABLE 5-3: GENERAL SOLUTION INFORMATION METHODS

METHOD	DESCRIPTION
getType	Get object type ()
getSize	Get number of dynamic solutions and length of solution vector
getSizeMulti	Get number of local solution objects and total number of solutions
getMesh	Get mesh name associated with solution and geometry
getNU	Get number of solutions of a certain solution data type
getPNames	Get parameter names
getParamName	Get parameter names for parametric sweep
getParamVals	Get parameter values for parametric sweep

SOLUTION DATA

TABLE 5-4: SOLUTION DATA ACCESS METHODS

METHOD	DESCRIPTION
getU	Get real part of solution vector
getUDot	Get real part of the first time-derivative solution vector
getUImag	Get imaginary part of solution vector
getUDotImag	Get imaginary part of first time-derivative solution vector
getPVals	Get the real part of the parameter values
getPValsImag	Get the imaginary part of the parameter values
getUBlock	A blocked version of the getU method
getUDotBlock	A blocked version of the getUDot method
getUImagBlock	A blocked version of the getUImag method
getUDotImagBlock	A blocked version of the getUDotImag method

SOLUTION CREATION

TABLE 5-5: SOLUTION CREATION METHODS

METHOD	DESCRIPTION
setU	Set real part of solution vector
setUDot	Set real part of the first time-derivative solution vector
setUImag	Set imaginary part of solution vector

TABLE 5-5: SOLUTION CREATION METHODS

METHOD	DESCRIPTION
setUDotImag	Set imaginary part of first time-derivative solution vector
setPVals	Set the real part of the parameter values
setPValsImag	Set the imaginary part of the parameter values
setUBlock	A blocked version of the setU method
setUDotBlock	A blocked version of the setUDot method
setUImagBlock	A blocked version of the setUImag method
setUDotImagBlock	A blocked version of the setUDotImag method

GENERAL INFORMATION

TABLE 5-6: GENERAL MATRIX INFORMATION METHODS

METHOD	DESCRIPTION
isReal	Check if matrix is real
getM	Get number of rows
getN	Get number of columns
getNnz	Get number of nonzeros in sparse matrix

MATRIX DATA

TABLE 5-7: MATRIX ACCESS METHODS

METHOD	DESCRIPTION
getSparseMatrixVal	Get matrix values
getSparseMatrixValImag	Get the imaginary matrix values
getSparseMatrixCol	Get column numbers of matrix values
getSparseMatrixRow	Get row numbers of matrix values
getVector	Get the vector associated with the matrix type
getVectorImag	Get the imaginary part of the vector associated with the matrix type
getSparseMatrixValBlock	A blocked version of getSparseMatrixVal
getSparseMatrixValImagBlock	A blocked version of getSparseMatrixValImag
getSparseMatrixColBlock	A blocked version of getSparseMatrixCol
getSparseMatrixRowBlock	A blocked version of getSparseMatrixRow
getVectorBlock	A blocked version of getVector
getVectorImagBlock	A blocked version of getVectorImag

Solution Object Data

The solver sequence works as a solution object itself. The solution object data produced by running the sequence (partially or in whole) can be obtained by a number of access methods on the sequence. See [Table 5-3](#) and [Table 5-5](#) for an overview.

In this section:

- [General Information](#)
- [Solution Data](#)
- [Solution Creation](#)
- [General Matrix Information](#)
- [Matrix Data](#)

General Information

TABLE 5-8: GENERAL SOLUTION OBJECT INFORMATION METHODS

METHOD	OUTPUT TYPE
<code>isRealU()</code>	Boolean
<code>isRealU(int)</code>	Boolean
<code>isRealU(int, string)</code>	Boolean
<code>isRealU(int, string, int)</code>	Boolean
<code>isRealUDot()</code>	Boolean
<code>isRealUDot(int)</code>	Boolean
<code>isRealPVals()</code>	Boolean
<code>getType()</code>	String
<code>getSize()</code>	int[2]
<code>getSize(int)</code>	int[2]
<code>getSizeMulti()</code>	int[2]
<code>getMesh(string)</code>	String
<code>getMesh(string, int)</code>	String
<code>getNU(String)</code>	int
<code>getPNames()</code>	String[]
<code>getPVals()</code>	double[]
<code>getParamNames()</code>	String[]
<code>getParamVals()</code>	double[]

- `model.sol(<tag>).isRealU()` returns true if the solution is real.
- `model.sol(<tag>).isRealU(<solnum>)` returns true if solution `<solnum>` is real.
- `model.sol(<tag>).isRealU(<solnum>, <uType>)` returns true if the solution `<solnum>` of type `<uType>` is real.
- `model.sol(<tag>).isRealU(<solnum>, <uType>, <uNum>)` returns true if the solution `<solnum>` of type `<uType>` and solution index `<uNum>` is real.
- `model.sol(<tag>).isRealUDot()` returns true if the first time-derivative is real.
- `model.sol(<tag>).isRealUDot(<solnum>)` returns true if first time-derivative `<solnum>` is real.
- `model.sol(<tag>).isRealPVals()` returns true if the parameter values are real.
- `model.sol(<tag>).isRealU()` returns true if the solution vector is real.

- `model.sol(<tag>).getType()` returns a string for the solution type which can be any of the strings; **Stationary**, **Parametric**, **Time** and **Eigenvalue**.
- `model.sol(<tag>).getSize()` returns an array of sizes for the solution data. The number of degrees of freedoms is stored in the first position and the number of solutions (`solnums`) in the second.
- `model.sol(<tag>).getSize(<iMulti>)` returns an array of sizes for the solution number `<iMulti>` of the multi solution. The number of degrees of freedoms is stored in the first position and the number of solutions (`solnums`) in the second.
- `model.sol(<tag>).getSizeMulti()` returns an array of sizes for the multi solution. The number of local solution objects is stored in the first position and the total number of solutions (`solnums`) in the second.
- `model.sol(<tag>).getMesh(<geom>)` returns the mesh name associated with the solution and the geometry `<geom>`.
- `model.sol(<tag>).getMesh(<geom>,<iMulti>)` returns the mesh name associated with the solution number `<iMulti>` of the multi solution and the geometry `<geom>`.
- `model.sol(<tag>).getNU(<uType>)` returns the number of solutions stored of the type `<uType>`. Here `<uType>` is the solution type as a string; **Sol** (main solution), **Reacf** (reaction force), **Adj** (adjoint solution), **Fsens** (functional sensitivity) and **Sens** (forward sensitivity).
- `model.sol(<tag>).getPNames()` returns the parameter names from continuation solver as an array of strings.
- `model.sol(<tag>).getParamNames()` returns the parameter names from parametric sweep as an array of strings.
- `model.sol(<tag>).getParamVals()` returns the parameter values from parametric sweep as an array of double.

Solution Data

TABLE 5-9: SOLUTION DATA ACCESS METHODS, REAL PART

METHOD	OUTPUT TYPE
<code>getU(int, string, int)</code>	<code>double[]</code>
<code>getU(int, string)</code>	<code>double[]</code>
<code>getU(int)</code>	<code>double[]</code>
<code>getU()</code>	<code>double[]</code>
<code>getUDot()</code>	<code>double[]</code>
<code>getUDot(int)</code>	<code>double[]</code>
<code>getPVals()</code>	<code>double[]</code>
<code>getPVals(int)</code>	<code>double[]</code>

- `model.sol(<tag>).getU(<solnum>, <uType>, <uNum>)` returns the real part of the solution vector for solution number `<solnum>`, the solution type `<uType>` and the 1-based solution index `<uNum>`. Here, $1 \leq <uNum> \leq N$, where $N = \text{model.sol}(<tag>).getNU(<uType>)$.
- `model.sol(<tag>).getU(<solnum>, <uType>)` returns the real part of the solution vector for the solution number `<solnum>` and the solution data type `<uType>`. The solution index `<uNum>=1`.
- `model.sol(<tag>).getU(<solnum>)` returns the real part of the solution vector for solution number `<solnum>`. The solution data type `<uType>=Sol` and the solution index `<uNum>=1`.
- `model.sol(<tag>).getU()` returns the real part of the solution vector. For a Time-dependent and Parametric type, the last solution number is used, and for a Eigenvalue type the first solution number. The solution data type `<uType>=Sol` and the solution index `<uNum>=1`.
- `model.sol(<tag>).getUDot()` returns the real part of the first time-derivative solution vector for a Time-dependent type and if the time-derivatives have been stored. The last solution number is used. For other types and if the time-derivatives have not been stored, an error message is given.
- `model.sol(<tag>).getUDot(<solnum>)` returns the real part of the first time-derivative solution vector for the solution number `<solnum>`.
- `model.sol(<tag>).getPVals()` returns for a solution of Parametric type the real part of all the parameter values stored. For multiple parameters all the parameter tuples are concatenated. For a solution of Time type, this is the times for which

solution data is stored. For a solution of **Eigenvalue** type, this is the real part of the eigenvalues stored. For a **Time-dependent** and **Parametric** type, the last solution number is used, and for a **Eigenvalue** type the first solution number.

- `model.sol(<tag>).getPVals(<solnum>)` returns for a solution of **Parametric** type the real part of the parameter tuples stored for solution number `<solnum>`. For a solution of **Time** type, this is the time for solution number `<solnum>`. For a solution of **Eigenvalue** type, this is the real part of the eigenvalue stored at solution number `<solnum>`.

TABLE 5-10: SOLUTION DATA ACCESS METHODS, IMAGINARY PART

METHOD	OUTPUT TYPE
<code>getUImag()</code>	<code>double[]</code>
<code>getUImag(int)</code>	<code>double[]</code>
<code>getUImag(int,string)</code>	<code>double[]</code>
<code>getUImag(int,string,int)</code>	<code>double[]</code>
<code>getUDotImag()</code>	<code>double[]</code>
<code>getUDotImag(int)</code>	<code>double[]</code>
<code>getPValsImag()</code>	<code>double[]</code>
<code>getPValsImag(int)</code>	<code>double[]</code>

- `model.sol(<tag>).getUImag()` returns the imaginary part of the solution vector. The same `<solnum>`, `<uType>` and `<uNum>` is used as for the method `getU()`. And similarly for the other `Imag` methods.

TABLE 5-11: SOLUTION DATA ACCESS METHODS, BLOCKED VERSIONS

METHOD	OUTPUT TYPE
<code>getUBlock(int,int)</code>	<code>double[]</code>
<code>getUBlock(int,int,int)</code>	<code>double[]</code>
<code>getUBlock(int,string,int,int)</code>	<code>double[]</code>
<code>getUBlock(int,string,int,int,int)</code>	<code>double[]</code>
<code>getUDotBlock(int,int)</code>	<code>double[]</code>
<code>getUDotBlock(int,int,int)</code>	<code>double[]</code>
<code>getUImagBlock(int,int)</code>	<code>double[]</code>
<code>getUImagBlock(int,int,int)</code>	<code>double[]</code>
<code>getUImagBlock(int,string,int,int)</code>	<code>double[]</code>
<code>getUImagBlock(int,string,int,int,int)</code>	<code>double[]</code>
<code>getUDotImagBlock(int,int)</code>	<code>double[]</code>
<code>getUDotImagBlock(int,int,int)</code>	<code>double[]</code>

- `model.sol(<tag>).getUBlock(<startpos>,<endpos>)` returns a subset of the vector returned by `getU()`, the sub-array from position `<startpos>` to the position `<endpos>`. And similarly for the other `Block` methods.

Solution Creation

TABLE 5-12: SOLUTION CREATION METHODS, REAL PART

METHOD	OUTPUT TYPE
<code>setU(double[])</code>	
<code>setU(int,double[])</code>	
<code>setPNames(String[])</code>	
<code>setPVals(double[])</code>	
<code>setPVals(int,double[])</code>	
<code>createSolution()</code>	

- `model.sol(<tag>).setU(<vals>)` sets the real part of the solution vector to `<vals>`
- `model.sol(<tag>).setU(<solnum>,<vals>)` sets the real part of solution vector `<solnum>`, to `<vals>`.
- `model.sol(<tag>).setPNames(<pnames>)` sets parameter names of the solution vectors to `<pnames>`.
- `model.sol(<tag>).setPVals(<vals>)` sets the parameter values to `<vals>`.
- `model.sol(<tag>).setPVals(<solnum>,<vals>)` sets the parameter values `<solnum>` to `<vals>`.
- `model.sol(<tag>).createSolution()` creates solutions based on the input from the vectors previously set. The solution is created at this stage. Afterwards the user input is cleared. If a created solution is used before this function is run the result is unpredictable.

TABLE 5-13: SOLUTION CREATION METHODS, IMAGINARY PART

METHOD	OUTPUT TYPE
<code>setUImag(double[])</code>	
<code>setUImag(int,double[])</code>	
<code>setPValsImag(double[])</code>	
<code>setPValsImag(int,double[])</code>	

- `model.sol(<tag>).setUImag(<solnum>,<vals>)` sets the imaginary part of solution vector `<solnum>` to `<vals>` (and similarly for the other `Imag` methods).

TABLE 5-14: SOLUTION CREATION METHODS, REAL PART

METHOD	OUTPUT TYPE
<code>setUBlock(double[],int)</code>	
<code>setUBlock(int,double[],int)</code>	
<code>setUImagBlock(double[],int)</code>	
<code>setUImagBlock(int,double[],int)</code>	
<code>setUDotBlock(double[],int)</code>	
<code>setUDotBlock(int,double[],int)</code>	
<code>setUImagBlock(double[],int)</code>	
<code>setUImagBlock(int,double[],int)</code>	

- `model.sol(<tag>).setUBlock(<solnum>,<vals>,<start>)` sets the real part of solution vector `<solnum>`, the sub-array from position `<start>` to position `<start>+<vals>.length-1` to `<vals>` (and similarly for the other `Imag` methods).

General Matrix Information

TABLE 5-15: GENERAL MATRIX OBJECT INFORMATION METHODS

METHOD	OUTPUT TYPE
<code>isReal(String)</code>	Boolean
<code>getM(String)</code>	int
<code>getN(String)</code>	int
<code>getNnz(String)</code>	int

- `model.sol(<tag>).feature(<ftag>).isReal(<mname>)` returns true if the matrix `<mname>` is real.
- `model.sol(<tag>).feature(<ftag>).getM(<mname>)` returns number of rows in the matrix `<mname>`.
- `model.sol(<tag>).feature(<ftag>).getN(<mname>)` returns number of columns in the matrix `<mname>`.
- `model.sol(<tag>).feature(<ftag>).getNnz(<mname>)` returns number of nonzero entries in the matrix `<mname>`.

Matrix Data

TABLE 5-16: MATRIX DATA ACCESS METHODS, REAL PART

METHOD	OUTPUT TYPE
<code>getSparseMatrixVal(String)</code>	<code>double[]</code>
<code>getSparseMatrixCol(String)</code>	<code>int[]</code>
<code>getSparseMatrixRow(String)</code>	<code>int[]</code>
<code>getVector(String)</code>	<code>double[]</code>

- `model.sol(<tag>).feature(<ftag>).getSparseMatrixVal(<mname>)` returns the real part of the sparse matrix values of matrix `<mname>` stored in feature `<ftag>`. Here, `<mname>`, is one of “K”, “D”, “E”, “N”, “NF”, “NP”, “Kc”, “Dc”, “Ec”, “Null”, “Nullf”, “Mc”, “MA”, “MB”, “C”.
- `model.sol(<tag>).feature(<ftag>).getSparseMatrixCol(<mname>)` returns the column numbers of the sparse matrix values of matrix `<mname>` stored in feature `<ftag>`. Here, `<mname>`, is one of “K”, “D”, “E”, “N”, “NF”, “NP”, “Kc”, “Dc”, “Ec”, “Null”, “Nullf”, “Mc”, “MA”, “MB”, “C”.
- `model.sol(<tag>).feature(<ftag>).getSparseMatrixRow(<mname>)` returns the row numbers of the sparse matrix values of matrix `<mname>` stored in feature `<ftag>`. Here, `<mname>`, is one of “K”, “D”, “E”, “N”, “NF”, “NP”, “Kc”, “Dc”, “Ec”, “Null”, “Nullf”, “Mc”, “MA”, “MB”, “C”.
- `model.sol(<tag>).feature(<ftag>).getVector(<mname>)` returns the real part of the vector `<mname>` stored in feature `<ftag>`. Here, `<mname>`, is one of “L”, “M”, “MP”, “MLB”, “MUB”, “ud”, “uscale”, “x0”.

TABLE 5-17: MATRIX DATA ACCESS METHODS, IMAGINARY PART

METHOD	OUTPUT TYPE
<code>getSparseMatrixValImag(String)</code>	<code>double[]</code>
<code>getVectorImag(String)</code>	<code>double[]</code>

- `model.sol(<tag>).feature(<ftag>).getSparseMatrixValImag(<mname>)` returns the imaginary part of the sparse matrix values of matrix `<mname>` stored in feature `<ftag>`. Here, `<mname>`, is one of “K”, “D”, “E”, “N”, “NF”, “NP”, “Kc”, “Dc”, “Ec”, “Null”, “Nullf”, “Mc”, “MA”, “MB”, “C”.

- `model.sol(<tag>).feature(<ftag>).getVectorImag(<mname>)` returns the imaginary part of the vector `<mname>` stored in feature `<ftag>`. Here, `<mname>`, is one of “L”, “M”, “MP”, “MLB”, “MUB”, “ud”, “uscale”, “x0”.

TABLE 5-18: MATRIX DATA ACCESS METHODS, BLOCKED VERSIONS

METHOD	OUTPUT TYPE
<code>getSparseMatrixValBlock(String,int,int)</code>	<code>double[]</code>
<code>getSparseMatrixColBlock(String,int,int)</code>	<code>int[]</code>
<code>getSparseMatrixRowBlock(String,int,int)</code>	<code>int[]</code>
<code>getVectorBlock(String,int,int)</code>	<code>double[]</code>
<code>getSparseMatrixValImagBlock(String,int,int)</code>	<code>double[]</code>
<code>getVectorImagBlock(String,int,int)</code>	<code>double[]</code>

- `model.sol(<tag>).feature(<ftag>).getSparseMatrixValBlock(<mname>, <startpos>,<endpos>)` returns a subset of the real part of the sparse matrix values returned by `getSparseMatrixVal(<mname>)`, the sub-array from the position `<startpos>` to the position `<endpos>`. And similarly for the other `Block` methods.
- `model.sol(<tag>).feature(<ftag>).getVectorBlock(<mname>,<vals>)` returns a subset of the real part of the vector values returned by `getVector(<mname>)`, the sub-vector from the position `<startpos>` to the position `<endpos>`. Here, `<mname>`, is one of “L”, “M”.

Purpose	Handle adaptive mesh refinement parameters.
Syntax	<pre> model.sol(sname).feature(solv).feature().create(fname, 'Adaption') model.sol(sname).feature(solv).feature(). create(fname, 'TimeAdaption') model.sol(sname).feature(solv).feature(fname).set(pname, value) </pre>
Description	<p>Handles settings for adaptive mesh refinement. There are two sorts of adaption features, of the type <code>Adaption</code>, which can be added to solvers of <code>Eigenvalue</code> or <code>Stationary</code> type and of the type <code>TimeAdaption</code> which can be added to a solver of <code>Time-dependent</code> type.</p> <p>The <code>Adaption</code> feature runs an overall adaption iteration a number of steps, and in each iteration a new mesh is generated and solved for. The last mesh generated and the solution on this mesh is added to the model.</p> <p>The <code>TimeAdaption</code> feature splits the overall time range into subintervals and in each interval an adapted mesh is generated and used. The meshes for these intervals as well as the solutions are added to the model. The solutions are stored in one container node (<code>model.sol()</code>) to facilitate the result processing.</p> <p>The feature <code>Adaption</code> accepts the following property/value pairs</p>

TABLE 5-19: VALID ADAPTION PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
<code>adjppr</code>	<code>auto on off</code>	<code>auto</code>	Use recovery for adjoint solution error estimate
<code>eefun</code>	<code>l2 func</code>	<code>l2</code>	Error estimation function
<code>eefunc</code>	string		Error estimate functional name (<code>eefun=func</code>)
<code>eigselect</code>	vector of positive scalars	<code>1</code>	Weights for eigenmodes
<code>elementspar</code>	positive scalar		Controls refinement if <code>elselect=elements</code>
<code>elselect</code>	<code>globalmin worst elements</code>		Method for selecting elements to refine.
<code>geomnum</code>	string		Name of geometry sequence
<code>globalminpar</code>	positive scalar		Controls refinement if <code>elselect=globalmin</code>
<code>l2scale</code>	vector of positive scalars	<code>1</code>	Scale factors for the L2 error norm
<code>l2staborder</code>	vector of positive integers	<code>2</code>	Orders in the stability estimate for the L2 error estimate
<code>maxt</code>	positive scalar	<code>Inf</code>	Maximum number of mesh elements

TABLE 5-19: VALID ADAPTION PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
ngen	scalar integer	5 (1D) 2 (2D) 1 (3D)	Maximum number of refinements
plot	on off	off	Plot while solving
plotgroup	string	default	Plot group to use for plot while solving
resorder	auto scalar vector	auto	Order of decrease of equation residuals
resorderactive			
rmethod	regular longest meshinit	longest	Refinement method
worstpar	positive scalar		Controls refinement if <code>elselect=worst</code>

The feature TimeAdaption accepts the following property/value pairs

TABLE 5-20: VALID TIMEADAPTION PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
consistentrestart	on off	off	Consistent initialization after restart
convertmesh	on off	on	Convert to simplex mesh
eefuntime	user	user	Error indicator function
eefuntime	string		Error indicator name (eefuntime=user)
elfrac	positive scalar	0.2	Fraction of maximum refinement if <code>tauto=automatic</code>
elselect	globalmin worst elements		Method for selecting elements to refine.
elselectauto	globalmin		Method for selecting elements to refine if <code>tauto=automatic</code> .
gf	positive scalar	2	Interval growth factor
globalminpar	positive scalar		Controls refinement if <code>elselect=globalmin</code>
globalminparauto	positive scalar		Controls refinement if <code>elselectauto=globalmin</code>
initialsteprestart	positive scalar	0.001	Initial time step size after restart
initialsteprestartactive			
minti	positive scalar	0.01	Minimal length of adaption time intervals
ngenlocal	scalar integer	2	Maximum number of element refinements
rf	positive scalar	0.5	Interval reduction factor

TABLE 5-20: VALID TIMEADAPTION PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
rmethod	regular longest	longest	Refinement method
samplepts	scalar numeric vector	range(0, 0.1, 1)	Where to check the error in next subinterval
tauto	manual automatic	manual	Time interval control
tfrac	positive scalar	0.1	Length of adaption time intervals
tfracauto	positive scalar	0.1	Length of initial adaption time interval if tauto=automatic
timeadapgeom	string		Name of geometry sequence
worstpar	positive scalar		Controls refinement if elselect=worst

The Adaption algorithm solves a sequence of PDE problems using a sequence of refined meshes. The first mesh is obtained from the mesh sequence. The following generations of meshes are obtained by solving the PDE problem, computing a mesh element error indicator based on the error estimate function, selecting a set of elements based on the element pick function, and then finally refining these elements. The solution to the PDE problem is then recomputed. The loop continues until the maximum number of element generations has been reached or until the maximum number of elements is obtained.

The adaptive solver works in one geometry at a time. You specify the name of the geometry sequence in the property geomnum. The solver only supports simplex meshes.

Error Estimation

Then, the residuals in the equations are computed for all mesh elements. The *error estimation function* is given by the property eefun. For solver type stationary there are two functions available: l2 and func. The function l2 computes the error indicator using the L^2 norm, and the function func computes the error indicator using a functional. For the solver type eigenvalue only the l2 function is available.

If the error estimate function functional is used, you must provide a functional variable name using the property eefunc. This variable must have global scope. The algorithm computes the adjoint solution related to the functional and estimates the error in this solution. This error estimate is used for the selection of elements to refine. Two methods are supported to estimate the error in the adjoint solution: a recovery technique and a gradient-based method. By selecting adjppr=on you can enforce using the recovery technique, and with adjppr=off the adaptive solver uses the gradient method. When using the auto option, the algorithm automatically

detects if the model uses only Lagrange basis function. If so, the recovery technique is used. Otherwise, the algorithm chooses the gradient-based method. In the Solver Log you can inspect which method is selected. See [The Adaptive Solver Algorithm](#) in the *COMSOL Multiphysics Reference Guide* for more information.

The error estimator gives local error indicators $(f(i,j)h(j))^{\beta(i)}\alpha\text{Vol}(j)$, where i is the equation number, j is the mesh element number, h is the mesh element size, and Vol is the mesh element volume. $f(i,j)$ is the scaled absolute value of the i th equation residual on the j th mesh element. The mesh element error indicator is the sum of these local error indicators over the equation index i . The global error indicator is the α root of the sum of the mesh element error indicators over the mesh element index j .

If the eigenvalue solver is used, you can specify the weighting of the error indicators for the different eigenfunctions using the property `Eigselect`. The n th component of the `Eigselect` vector is the weight for the error indicator of the n th eigenfunction.

Mesh Refinement

Then, a refinement of the mesh is generated based on the local error indicators. The aim is to refine the mesh most where the errors are largest. The mesh refinement ratios are determined by the property `elselect`, and depending on the value of `elselect` on one of the parameters `globalminpar`, `worstpar`, and `elementspar`. If `elselect=globalmin`, the solver tries to minimize the total error for a prescribed mesh size, namely `globalminpar` times the current number of mesh elements. Each element can be refined several times. Otherwise, each element is refined at most once. If `elselect=worst`, the solver refines the elements with an error greater than a fraction `worstpar` of the worst error, whereas if `elselect=elements` the solver refines a given fraction of the elements, given in the property `elementspar`.

The property `resorder` is a scalar or vector that gives the order of decrease of the equation residuals as the mesh size h tends to 0. If it is a vector, the residual of the n th equation is $O(h^{\text{Resorder}(n)})$. If `resorder` equals `auto`, the software determines the order of decrease in equation residuals on the basis of the shape function orders in the model. Roughly speaking, the order is one less than the shape function order for the corresponding equation.

Once the mesh refinement ratios have been determined, the mesh is refined using the method given in the property `rmethod`, and the algorithm starts a new iteration. The refinement method is either `longest`, `regular`, or `meshinit`. Details on the first two refinement methods can be found in the entry on `meshrefine`. `Meshinit`

means that a new mesh is generated through a call to `meshinit` using the `Hmesh` property to control the element sizes.

Convergence Control

No more than `ngen` successive refinements are attempted. Refinement is also stopped when the number of elements in the mesh exceeds `maxt`.

TIME ADAPTION

The `TimeAdaption` algorithm solves a sequence of PDE problems on a sequence of adapted meshes. The first mesh, the base mesh, is obtained from the mesh sequence. The new adapted mesh is obtained by evaluating the mesh element error indicator, selecting a set of elements based on the element pick function, and then finally refining these elements. The solution to the PDE problem on the previous mesh is then mapped to the new mesh and time integration continues until the next mesh adaption takes place. The time of mesh adaption can be determined manually or automatically.

The time adaptive solver works in one geometry at a time. You specify the name of the geometry sequence in the property `timeadapgeom`. The solver only supports simplex meshes, and if the base mesh is not simplex it can be converted by using the property `convertmesh`.

The length of the time interval using a fixed adapted spatial mesh can be controlled manually or automatically by the property `tauto`. If the time integrator runs into problems the computation is restarted at the beginning of the previous time interval. The length of the new interval will be reduced to a fraction of the current interval length. This fraction is specified by the property `rf`. In the `tauto=manual` case the time interval length is given by property `tfrac`; if `tauto=automatic` the property `tfracauto` controls the initial interval length. For both cases the shortest possible interval length is given by the property `minti`.

If the property `tauto` is set to `automatic` the `TimeAdaption` algorithm tries to determine the length of the time interval according to the requested fraction of maximum refinement. The fraction is given by the value of the property `e1frac`. A value of zero means no refinement of the base mesh and a value of one means refinement everywhere with maximum element refinements (set through property `ngenlocal`). The algorithm strives to assume the given value of `e1frac` by controlling the size of the time interval. The shortening and lengthening of the interval is determined by the interval reduction and growth factors. These are the properties `rf` and `gf` respectively.

The error indicator is specified using the property `eefunction`. A solution on the coarse base mesh is computed in the next time interval and the error indicator is evaluated at the points given by property `samplepts`. In this way a new adapted mesh appropriate for the next time interval can be generated and the computation on this new mesh is then started. The sample points must be specified as a number between 0 and 1 because they are interpreted as being relative to the time interval under consideration. Entering a scalar value of 0.5 means that the error indicator is evaluated at the midpoint of the interval.

After each mesh adaptation the time integration is restarted and you can control the time stepping by the Time type analogous properties `consistentrestart` and `initialsteprestart`.

Purpose	Handle advanced general solver parameters.
Syntax	<code>model.sol(sname).feature(solv).feature().create(fname, 'Advanced')</code> <code>model.sol(sname).feature(solv).feature(fname).set(pname, value)</code>
Description	Advanced feature.

TABLE 5-21: VALID GENERAL PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
autorescale	§on off	on	Automatic rescaling of linear equations (for the Stationary solver)
blocksize	positive integer auto	auto	Assembly block size
complexfun	on off	off	Use complex-valued functions with real input
convinfo	on detailed off	on	Print info to log
D, E, K, L, M, N	on off		Manual control of reassembly
keep	on off		Manual control of reassembly
matherr	on off	on	Error for undefined operations
nullfun	f1nullorth flspnull auto	auto	Null-space function
rowscale	on off	on	Equilibrate rows
symmetric	symmetric hermitian nonsymmetric auto	auto	Symmetric matrices

The [Advanced](#) section in the *COMSOL Multiphysics Reference Guide*, describes the functionality corresponding to the properties `blocksize`, `complexfun`, `nullfun`, and `rowscale`.

You can use the property `symmetric` to tell the solver that the model is symmetric/hermitian or you can use the automatic feature to find out (see [Which Problems are Symmetric?](#) in the *COMSOL Multiphysics Reference Guide*).

You can set `convinfo=detailed` to print more detailed information about the solver process in the log window. For example information about individual linear iterations or the scales per field computed by the automatic scaling algorithm. When `convinfo=off` only minimal information about the solution process is printed.

By default, COMSOL Multiphysics gives an error message if the solver encounters an undefined mathematical operation when solving the model, for instance `0/0` or `log(0)`. If you instead want the solver to proceed, put the property `matherr=off`. Then `0/0=NaN` (not a number) and `log(0)=-Inf`.

The properties `keep` and `D`, `E`, `K`, `L`, `M`, and `N` allow manual control of reassembly. If `keep=on`, each of the other properties controls reassembly of a specific matrix or vector. Setting the property value to `on`, means that the quantity is constant, and therefore can be assembled once and then kept. The letters have the following meaning: `E`=constant mass, `D`=constant damping, `K`=constant Jacobian, `L`=constant load, `M`=constant constraint, `N`=constant constraint Jacobian.

The `autorescale` property control if the automatically computed scales should be recomputed. This property only affects stationary nonlinear problems and fields that are using the automatic scaling method and for the constant damping technique. The initially computed scales are based on the initial assembled matrix. When `autorescale=on` the scales are recomputed in each nonlinear iteration based on the current solution.

Purpose Assembles and stores the matrices generated during assembly.

Syntax

```

model.sol(sname).feature().create(fname, 'Assemble')
model.sol(sname).feature(fname).set(pname, value)
model.sol(sname).feature(fname).getSparseMatrixVal(mname)
model.sol(sname).feature(fname).getSparseMatrixValImag(mname)
model.sol(sname).feature(fname).getSparseMatrixRow(mname)
model.sol(sname).feature(fname).getSparseMatrixCol(mname)
model.sol(sname).feature(fname).getVector(vname)
model.sol(sname).feature(fname).getVectorImag(vname)
model.sol(sname).feature(fname).getSparseMatrixValBlock(mname,
    start, stop)
model.sol(sname).feature(fname).getSparseMatrixValImagBlock
    (mname, start, stop)
model.sol(sname).feature(fname).getSparseMatrixRowBlock(mname,
    start, stop)
model.sol(sname).feature(fname).getSparseMatrixColBlock(mname,
    start, stop)
model.sol(sname).feature(fname).getVectorBlock(vname, start, stop)
model.sol(sname).feature(fname).getVectorImagBlock(vname, start,
    stop)
model.sol(sname).feature(fname).isReal(mname)
model.sol(sname).feature(fname).getM(mname)
model.sol(sname).feature(fname).getN(mname)
    
```

Description Assemble feature.

TABLE 5-22: VALID GENERAL PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
K	on off	off	Assemble the stiffness matrix
L	on off	off	Assemble the load vector
M	on off	off	Assemble the constraint vector
N	on off	off	Assemble the constraint Jacobian
D	on off	off	Assemble the damping matrix
E	on off	off	Assemble the mass matrix
NF	on off	off	Assemble the constraint force Jacobian
NP	on off	off	Assemble the optimization constraint Jacobian
MP	on off	off	Assemble the optimization constraint vector
MLB	on off	off	Assemble the lower bound constraint vector

TABLE 5-22: VALID GENERAL PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
MUB	on off	off	Assemble the upper bound constraint vector
Kc	on off	off	Assemble the eliminated stiffness matrix
Lc	on off	off	Assemble the eliminated load vector
Dc	on off	off	Assemble the eliminated damping matrix
Ec	on off	off	Assemble the eliminated mass matrix
Null	on off	off	Assemble the constraint null-space basis
Nullf	on off	off	Assemble the constraint force null-space basis
ud	on off	off	Assemble the particular solution ud
uscale	on off	off	Assemble the scale vector

The assemble feature assembles the matrices specified as output matrices and stores them in the feature. The output is stored in the feature. You can access the result using the matrix and vector access methods. The linearization point is the solution stored in the sequence when the assemble feature is called. The linearization point is stored in the sequence after the run. For information about the eliminated system, see [Elimination Constraint Handling](#) in the *COMSOL Multiphysics Reference Guide*.

Purpose Iteratively and automatically create deformed geometries and remesh these geometries. In each step, map the solution and restart the simulation.

Syntax `model.sol(sname).feature(tname).create(fname, 'AutoRemesh')`
`model.sol(sname).feature(tname).feature(fname).set(pname,pvalue)`

Description Operation feature. The following property/values are accepted:

TABLE 5-23: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
autoremeshgeom	string		Name of geometry sequence
consistentremesh	on off	off	Consistent initialization after remesh
initialstepremesh	positive scalar	0.001	Initial time step size after remesh
initialstepremeshactive	on off	off	Use initialstepremesh
stopexpr	string		Mesh quality expression
stopval	string	0.2	Minimal mesh quality

The automatic remeshing solver works in one geometry at a time. You specify the name of the geometry sequence in the property `autoremeshgeom`. Automatic remeshing is available for Time-Dependent studies and is intended for usage with the Moving Mesh and Deformed Geometry interfaces.

The property `stopexpr` is the expression governing the mesh quality. If it becomes smaller than `stopval` the solver stops, remeshes and maps the solution at previously stored solution time. The simulation is then automatically restarted on the new mesh.

After each remeshing the time integration is restarted and you can control the time stepping by the Time type analogous properties `consistentremesh` and `initialstepremesh`.

If the time integrator runs into problems the computation is restarted at the beginning of the previous time interval using stricter time stepping controls.

Purpose Solve a parametric PDE problem with asymptotic waveform evaluation (AWE).

Syntax `model.sol(sname).feature().create(fname, 'AWE')`
`model.sol(sname).feature(fname).set(pname, pvalue)`

Description Operation feature. The following property/values are accepted:

TABLE 5-24: VALID AWE PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
acceptshort	on off	on	If on, the solver accepts short intervals unconditionally
atol	scalar	0.001	Absolute tolerance for parameter sweep
aweassemble	all one	all	Either assemble all the needed matrices at once, or one at a time
awefunc	string vector of strings		Expression(s) used in the search algorithm
expeval	scalar numeric vector	range(0.1, 0.1, 0.9)	Where to check the error in each subinterval
expsize	scalar	3	Number of terms in expansion
exptype	pade taylor	pade	Use Padé or Taylor expansions to approximate the unknown
minint	scalar	0	The shortest allowed subinterval length
minintactive	on off	off	If off, rtol times the parameter span is used. If on, minint is used
plist	scalar numeric vector		Parameter list
plot	on off	off	Plot while solving
plotgroup	string	default	Plot group to use for plot while solving
pname	vector of strings		Parameter names
pout	plist psteps	plist	Output either the parameters in plist or the solution at the expansion points
probesel	all manual	all	Probe selector
probes	vector of strings		Probes to use when probesel=manual
rtol	scalar	0.01	Relative tolerance for parameter sweep

The AWE solver computes expansions of an underlying problem around certain parameter values. In the first step the largest and smallest values of `plist` are used as expansion points. Using these expansions, the values of one or more functions at intermediate parameter values are computed. If the two expansions give similar

enough functional values at these internal points, the interval is accepted and no subdivisions of that particular interval are deemed necessary.

The property `awefunc` is used to specify the functionals of interest and the property `expeval` determines at which internal points these functionals are to be evaluated. The values for `expeval` are given relative the interval. That is, a value of 0.5 means that the functionals are evaluated at the midpoint of each interval. When the functional-values from the two expansions are compared, a check is performed to see if they fulfill the specified tolerances `atol` and `rtol`. If neither of the tolerances are fulfilled, the interval is bisected and the process is repeated for each subinterval. Before a bisection is performed a check is made to make sure that the new intervals are not shorter than the shortest allowed. By default the shortest allowed interval is given by the relative tolerance times the length of the interval defined by `plist` (when `mininactive` is set to `off`). If `mininactive` has been set to `on` the value of `minint` is the shortest interval allowed. If `minint` has been specified, the value of `mininactive` is `on` by default. The property `acceptshort` determines how to handle too short intervals. If `acceptshort` is set to `off` and a short interval is detected, the solver is interrupted with an error/warning. If `acceptshort` is set to `on` and a short interval is detected, the solver accepts the interval even if the tolerances have not been fulfilled.

In AWE several matrices are needed to compute each expansion. There are two options when it comes to assembling these matrices: With `aweassemble` set to `all` everything is assembled in a single call to the `Xmesh`. With `aweassemble` set to `one`, the matrices are assembled one at a time. The first option is faster but requires more memory.

Purpose Solve PDE eigenvalue problem

Syntax

```
model.sol(sname).feature().create(fname, 'Eigenvalue')
model.sol(sname).feature(fname).set(pname, value)

model.sol(sname).feature(fname).feature()
    .create(fname2, LinearType)

model.sol(sname).feature(fname).feature()
    .create(fname2, 'Advanced')
```

Here `LinearType` is any of the allowed linear solver feature types.

Description Operation feature.

For both linear and nonlinear PDE problems, the eigenvalue problem is that of the linearization about a solution U_0 . If the eigenvalue appears nonlinearly, COMSOL Multiphysics reduces the problem to a quadratic approximation around a value λ_0 specified by the property `eigref`. The discretized form of the problem reads

$$KU - (\lambda - \lambda_0)DU + (\lambda - \lambda_0)^2EU = -N_F\Lambda$$

$$NU = M$$

where K , D , E , N , and N_F are evaluated for $U = U_0$ and $\lambda = \lambda_0$. Λ is the Lagrange multiplier vector, λ is the eigenvalue. The eigenvalue name can be given by the property `eigname`. The linearization point U_0 can be given with the property `U`. The shift, described below, is compensated according to the linearization point for the eigenvalue. Therefore, changing the linearization point has no effect at all for linear or quadratic eigenvalue problems.

The feature `eigenvalue` accepts the following property/value pairs:

TABLE 5-25: VALID EIGENVALUE PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
<code>control</code>	string	user	Name of controlling study
<code>eigfunscale</code>			
<code>eigname</code>	string	lambda	Name of eigenvalue variable
<code>eigref</code>	string	0	Linearization point for the eigenvalue
<code>krylovdim</code>	positive integer		Dimension of Krylov space

TABLE 5-25: VALID EIGENVALUE PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
linpmethod	init solution	init	Method used for linearization point
linpsol	zero solution object	zero	Linearization point solution
linpsoluse	current solution store	current	
maxeigit	positive integer		
neigs	positive integer	6	Number of eigenvalues sought
rtol	scalar	1e-4	Relative tolerance
shift	scalar	0	Eigenvalue search location
solfile	off on	off	Store solution on file
solfileblock	positive scalar	16	Max size of solution block (MB)
solnum	auto all positive integer	auto	
transform			
transformdescr			
transformval			
transinfo			

Specify where to look for the desired eigenvalues with the property `shift`. Enter a real or complex scalar; the default value is 0, meaning that the solver tries to find eigenvalues close to 0.

For more information about the eigenvalue solver, see [Eigenvalue Solver](#) in the *COMSOL Multiphysics Reference Guide*.

If `Solfile` is on, the solution is stored on a temporary file. The temporary file is stored in the temporary directory created at startup. You can decide the temporary directory with the `-tmpdir` switch; see the section [Options](#) in the *COMSOL Installation and Operations Guide* for further details. A part of the solution is stored in memory in a few *blocks* (usually 1–5 blocks reside in memory). The

maximum block size (in megabytes) can be controlled with the property `Solfileblock`.

TABLE 5-26: REMOVED FEMEIG PROPERTIES

PROPERTY	REASON
In	Matrix import not supported
Out	Solution object should be exported

Purpose	Handle the fully coupled nonlinear solution approach.
Syntax	<pre> model.sol(sname).feature(solv).feature() .create(fname, 'FullyCoupled') model.sol(sname).feature(solv).feature(fname).set(pname, value) model.sol(sname).feature(fname).feature(sname).set(pname, value) </pre>
Description	This feature can be used as an attribute to the Time and Stationary features. The nonlinear solver is an affine invariant form of the damped Newton method.

TABLE 5-27: VALID FULLY COUPLED PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
damp	positive real	1	Damping factor for the damped Newton method
ddoginitdamp	non-negative scalar	1	Initial damping factor for dtech set to ddog
dtech	const auto hnlin ddog	auto const (Time)	Damping technique
initstep	non-negative scalar	1	Initial damping factor for dtech set to auto
initsteph	non-negative scalar	1e-4	Initial damping factor for dtech set of hnlin
jtech	minimal once onevery	onevery minimal (Time)	Jacobian update technique for dtech set to const
maxiter	positive integer	25 4 (Time)	Maximum number of Newton iterations
minstep	positive scalar	1	Minimum damping factor for dtech set to auto
minsteph	positive scalar	1e-4	Minimum damping factor for dtech set to hnlin
niter	positive integer	1	Fixed number of iterations
ntermauto	tol itertol	tol	Termination techniques for dtech set to auto/hnlin
ntermconst	iter tol itertol	tol	Termination techniques for dtech set to const
ntolfact	positive scalar	1	Tolerance factor
ratelimit	positive scalar	0.9 (dtech set to const)	Limit on nonlinear convergence rate
plot	on off	off	Plot while solving
plotgroup	string	default	Plot group to use for plot while solving
probesel	all manual	all	Probe selector

TABLE 5-27: VALID FULLY COUPLED PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
probes	vector of strings		Probes to use when probesel=manual
resscale	scalefieldwise scaleuniform	scalefieldwise	Residual scaling technique for dtech set to ddog
rstep	positive scalar	10	Restrictions for step-size update
useratelimit	on off	off on (Time)	Use limit on nonlinear convergence rate

The property `dtech` controls which damping factor to use in the damped Newton iterations.

For `dtech` set to `auto`, the solver determines an appropriate damping factor automatically. For this method the initial and minimally allowed damping factors are controlled by the properties `initstep` and `minstep` respectively. The termination technique is controlled by the property `ntermauto`.

For `dtech` set to `hnlm`, the solver determines an appropriate damping factor automatically but treat the problem as being highly nonlinear. This option can be tried if there is no convergence with `dtech` set to `auto`. For this method the initial and minimally allowed damping factors are controlled by the properties `initsteph` and `minsteph` respectively. Moreover, certain internal control structures are adapted. Especially, the error control is biased from a more absolute norm towards a relative norm. So this parameter is also useful if a solution with components of highly varying orders of magnitudes are present. In the context of parameter stepping, you can also try this option if the step sizes in the parameter seem to be too small.

When `dtech=const`, the constant damping factor specified in the property `damp` is used. For this method the termination technique is controlled by the property `ntermconst`. Furthermore, the property `jtech` can be used to control how often the Jacobian is updated. With `jtech=minimal`, the Jacobian is updated as seldom as possible (only once for a stationary problem and at most once per time step for a time-dependent problem). For time-dependent problems, the choice `jtech=once` makes the solver update the Jacobian once per time step. With `jtech=onevery`, the Jacobian is updated on every Newton iteration. The default is `onevery` for stationary problems and `minimal` for time-dependent problems.

When `dtech` is set to `ddog` (stationary problems), the double dogleg solver is used. The initial damping factor is controlled by the property `ddoginitdamp` and the property `resscale` controls the residual scaling. The option `resscale=scalefieldwise` scales the equations based on the field-wise sizes of

the initial residual. When the option `resscale=scaleuniform` is selected the algorithm terminates on the relative residual based on the initial residual.

The tolerance `ntol` gives the criterion for convergence for a stationary problem; see [The Nonlinear Solver Algorithm](#) in the *COMSOL Multiphysics Reference Guide*.

The property `ntolfact` controls how accurately the nonlinear system of equations is solved. The value given in `ntolfact` is multiplied with the main solver tolerance and used in the convergence criteria. Also, the solution process is interrupted (and the Jacobian updated or the time step reduced) if the convergence is too slow. This can be disabled by setting `useratelimit=off`. When `useratelimit=on`, what is to be considered as too slow convergence can be controlled through the property `ratelimit`. The solution process is interrupted if the estimated linear convergence rate (of all steps, when the segregated solver is used) becomes larger than the value given in `ratelimit`.

Purpose Handle linear system solvers with three different attribute features: Direct, Iterative, and Multigrid.

Syntax

```
sol.feature(fname).create(lname, 'Direct')
sol.feature(fname).feature(lname).set(pname, value)

sol.feature(fname).create(lname, 'Iterative')
sol.feature(fname).feature(lname).set(pname, value)
sol.feature(fname).feature(lname).create(pcname, PType);
sol.feature(fname).feature(lname).feature(pcname).
    set(pname, value)

sol.feature(fname).create(lname, 'Multigrid')
sol.feature(fname).feature(lname).feature('presmooth').
    create(prename, SType)
sol.feature(fname).feature(lname).feature('postsmooth').
    create(postname, SType)
sol.feature(fname).feature(lname).feature('csolver').
    create(cname, CType)
sol.feature(fname).feature(lname).feature('presmooth').
    feature(prename).set(pname, value)
sol.feature(fname).feature(lname).feature('postsmooth').
    feature(postname).set(pname, value)
sol.feature(fname).feature(lname).feature('csolver').
    feature(cname).set(pname, value)
```

PType is any of the allowed preconditioner feature types. These types are SOR, SOR Gauge, SOR Vector, Vanka, SOR Line, Incomplete LU, Krylov preconditioners. SType is any of the allowed smoother types. These are the same as the PType. CType is any of the allowed coarse grid solver types; Direct, Incomplete LU, Krylov Preconditioners.

Description Three attribute features for linear system solvers.

Examples:

I GMRES with ILU as preconditioner:

```
solver = sol.feature(fname).create('iter1', 'Iterative')
solver.set('solver', 'gmres')
solver.create('ilu', 'IncompleteLU')
```

2 Change preconditioner to GMG/SORVector/SPOOLES:

```

solver.create('gmg', 'Multigrid')
solver('gmg').set('solver', 'gmg')
solver('gmg').feature('presmooth').create('p1', 'SorVec')
solver('gmg').feature('postsmooth').create('p1', 'SorVec')
csolver = solver('gmg').feature('csolver').create('c1', 'Direct')
csolver.set('solver', 'spooles')
csolver.set('errorchkd', 'on')
    
```

3 Use Conjugate Gradients instead of GMRES:

```

solver.set('solver', 'cg')
    
```

DIRECT PROPERTIES

TABLE 5-28: VALID DIRECT PROPERTY/VALUE PAIRS (FOR ALL SOLVER)

PROPERTY	VALUES	DEFAULT	DESCRIPTION
errorchk	on off auto	auto	Check error estimate
linolver	mumps pardiso spooles	mumps	Method to use
rhob	scalar > 1	400 1 (coarse solver)	Factor in linear error estimate

TABLE 5-29: OPTIONAL DIRECT PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
droptol	scalar between 0 and 1	0.01 when used as pre- conditioner or smoother, 0 when used as solver	Drop tolerance (SPOOLES, MUMPS)
mumpsreorder	auto amd amf qamd nd	auto	Preordering algorithm (MUMPS)
mumpsrreorder	on off	on	Row preordering (MUMPS)
ooc	on off	off	Use out-of-core (PARDISO, MUMPS)

TABLE 5-29: OPTIONAL DIRECT PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
oocmemory	positive real	512.0	Out-of-core memory (PARDISO, MUMPS)
pivotenable	on off	on	Use pivoting (MUMPS)
pivotperturb	scalar between 0 and 1	1e-8	Pivot perturbation threshold (PARDISO, MUMPS)
pivotrefines	non-negative integer	0	Number of forced iterative refinements (PARDISO, MUMPS)
pivotstrategy	on off	on	Use 2-by-2 Bunch-Kaufmann pivoting (PARDISO)
preorder	mmd nd ms bestof	nd	Preordering algorithm (SPOOLES)
pardmtsolve	on off	off	Multithreaded forward and backward solve (PARDISO)
pardreorder	mmd nd ndmt	nd	Preordering algorithm (PARDSIO)
pardrreorder	on off	on	Row preordering algorithm (PARDISO)
pardschedule	auto one two	auto	Scheduling method (PARDISO)
thresh	scalar between 0 and 1	0.1	Pivot threshold (MUMPS, SPOOLES)

ITERATIVE PROPERTIES

TABLE 5-30: VALID ITERATIVE PROPERTY/VALUE PAIRS (FOR ALL SOLVERS)

PROPERTY	VALUES	DEFAULT	DESCRIPTION
maxlinit	positive integer	10000 500 (coarse solver)	Maximum number of linear iterations (when used with a tolerance)
rhob	scalar > 1	400 1 (coarse solver)	Factor in linear error estimate
linsolver	ilu gmres fgmres bicgstab sor sorline sorvec sorgauge vanka	gmres, ilu (precond)	Method to use
errorchk	on off auto	auto	Validate error estimate

TABLE 5-31: OPTIONAL ITERATIVE PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
iluiter	non-negative integer	1	Fixed number of iterations (when used as preconditioner, smoother, or coarse solver) (ILU)
iter	non-negative integer	2	Fixed number of iterations (when used as preconditioner, smoother, or coarse solver) (all except ILU)
itrestart	positive integer	50	Number of iterations before restart (gmres, fgmres)
prefuntype	left right	left	Left or right preconditioning (gmres, cg, bicgstab)
relax	scalar between 0 and 2	1	Relaxation factor (Jacobi, SOR-based algorithms, ILU, and Vanka)
seconditer	nonnegative integer	1	Number of secondary iterations (SOR vector and SOR gauge algorithms), number of SSOR updates (vanka)

TABLE 5-31: OPTIONAL ITERATIVE PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
sorblocked	on off	on	Blocked SOR method
sorvecdof	vector of strings		Vector element variables (SOR vector and SOR gauge algorithms)
symmetric	on off	off	Use symmetric form; ssor instead of sor, and so forth. (SOR, SORVector, SORGauge, SORLine)
transpose	on off	off	Use transposed form; soru instead of sor and so forth. (SOR, SORVector, SORGauge, SORLine)
vankablocked	on off	on	Blocked Vanka method
vankarelay	scalar between 0 and 2	0.8	Relaxation factor for Vanka update
vankarestart	positive integer	100	GMRES restart value (vanka)
vankasolv	gmres direct	gmres	Local block solver (vanka)
vankatol	positive scalar	0.02	GMRES tolerance (vanka)
vankavars	vector of strings	{}	Lagrange multiplier variables (vanka)

The property `divcleantol` is used in the inequality $|T^T b| < \text{divcleantol} \cdot |b|$ to ensure that the numerical divergence after divergence cleaning is small enough; see [The SSOR Gauge, SOR Gauge, and SORU Gauge Algorithms](#) in the *COMSOL Multiphysics Reference Guide*.

MULTIGRID PROPERTIES

TABLE 5-32: VALID MULTIGRID PROPERTIES

PROPERTY	VALUES	DEFAULT	DESCRIPTION
gmglevels	positive integer	1	Maximum number of geometric multigrid levels
iter	integer	2	Fixed number of iterations (when used as preconditioner, smoother, or coarse solver)
linsolver	gmg amg	gmg	Method to use
maxlinit	positive integer	10000, 500 (coarse solver)	Maximum number of linear iterations (when used with a tolerance)
mgcycle	v w f	v	Cycle type
mglevels	positve integer	5	Maximum number of algebraic multigrid levels
rhob	scalar > 1	400 1 (coarse solver)	Factor in linear error estimate

TABLE 5-33: OPTIONAL MULTIGRID PROPERTITES

PROPERTY	VALUES	DEFAULT	DESCRIPTION
amgauto	integer from 1 to 10	3	Quality of multigrid hierarchy (amg)
geomuse	vector of strings		Geometries for geometric multigrid hierarchy
massem	on off	on	Assemble on multigrid levels (gmg)
maxcoarsedof	positive integer	5000	Maximum number of DOFs at coarsest level (amg)
mcaseassem	vector of strings		Multigrid levels where assemble should be performed (gmg, mcasegen=manual)
mcasegen	manual all any coarse coarseorder refine refineany refineall	any	Hierarchy generation method (gmg)

TABLE 5-33: OPTIONAL MULTIGRID PROPERTIES

PROPERTY	VALUES	DEFAULT	DESCRIPTION
mcasuse	vector of strings		Multigrid levels which should be used (gmg, mcasuse=manual)
mkeep	on off	off	Keep generated mesh cases (gmg)
rmethod	regular longest	regular	Mesh refinement method (gmg)
scale	vector of positive numbers	2	Mesh scale factor (gmg)

For the geometric multigrid solver/preconditioners, the multigrid hierarchy is controlled in the following way (see also [Geometric Multigrid](#) in the *COMSOL Multiphysics Reference Guide*):

- If `mcasuse=all`, `any`, or `coarse`, `coarseorder`, then the multigrid hierarchy is automatically constructed starting from the mesh and discretization set by the study. The number of multigrid levels generated is given in the property `gmglevels`. The method `all` and `any` first tries to lower the discretization order for the shape functions used, and secondly coarsens the mesh. The method `all` lowers the order (by one) if all used shape functions can be lowered. The method `any` lowers the order (by one) if at least one shape function can be lowered. The method `coarse` does not lower the order, it only coarsens the mesh. The method `coarseorder` both lowers the order (for any shape functions that can be lowered by one) and coarsen the mesh, at the same time.
- If `mcasuse=refine`, `refineany`, or `refineall` then the multigrid hierarchy is automatically constructed by a combination of refining the mesh given by the study and changing the discretization. The number of multigrid levels generated is given in the property `gmglevels`. The refinement method can be specified using the property `rmethod`. The originally selected mesh for the study will in the case of refining the mesh be used in a multigridlevel and the finest multigrid level generated will be used for the study (solved for). The generated multigrid levels will be kept in the model and the `mcasuse` property will be changed into `manual`. The method `refine` will only refine the mesh and not change the shape function order. The method `refineany` and `refineall` will first try to lower the order, and secondly refine the mesh. The method `refineany` will construct a multigrid level by lower the order (by one) if at least on shape function can be

lowered. The method `refineall` will generate multigrid levels by lowering the order (by one) if all used shape function can be lowered.

- If `mcasegen=manual`, then the existing multigrid levels (children to the current study) can be used. The subset to use is selected by giving their tags to the `mcaseuse` property.

The construction of coarse level matrices is controlled by the property `massem` and `mcaseassem`. The first property controls if the matrices should be assembled for the automatically generated levels. If set to `off` prolongation and restriction matrices are used to project the matrices from the top level in the hierarchy. The second property controls which multigrid levels that should use the assemble technique in the `mcasegen=manual` case.

When an iterative solver is used as preconditioner, smoother, or coarse solver you can choose whether to solve using a tolerance or to perform a fixed number of iterations. When used as a coarse solver the default is to solve using a tolerance. When used as a preconditioner or smoother the default is to perform a fixed number of iterations. If both properties `itol` and `iter` (or `iluiter` for ILU) are given, the program solves using a tolerance.

Purpose Solve parametric or time dependent PDE problem with the eigenmodal method.

Syntax `model.sol(sname).feature().create(fname, 'Modal')`
`model.sol(sname).feature(fname).set(pname, pvalue)`

Description Operation feature. The following property/values are accepted:

TABLE 5-34: VALID MODAL PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
analysistype	frequency transient	frequency	Solve for frequency response or transient response
control	string	user	Name of controlling study
dampratio	scalar numeric vector	0	Damping ratios for participating modes
eigsol	solution object		Pre-computed eigenpairs (or other vectors) to be used in the modal analysis
loadfact	string vector of strings	empty	Scalar function(s) for time and/or parameter dependent boundary conditions
modes	integer vector	all	Participating modes
plist	scalar numeric vector		Frequency list. Only applicable when analysistype has been set to frequency
pname	vector of strings		Parameter names
pout	plist fraction spread	plist	Use plist as it stands or modify in relation to the participating modes
rtol	scalar	0.01	Relative tolerance. Only applicable when analysistype has been set to transient
tlist	scalar numeric vector		Time list. Only applicable when analysistype has been set to transient

For frequency response analysis non-constant Neumann boundary conditions and constant Dirichlet boundary conditions are supported. The only allowed type of parameter dependent Dirichlet boundary condition are those that can be written as a constant vector times a scalar function. The scalar function is specified via the

property `loadfact`. For transient response analysis only constant Dirichlet boundary conditions are supported. Neumann conditions that can be written as a constant vector times a scalar function (which is specified via the property `loadfact`) are supported for transient response.

The property `modes` is index 0 based.

If `pout` is set to `fraction` the output frequencies are the ones in `plist` multiplied by the absolute value of the largest eigenvalue in `eigsol` (or some other fraction of the largest participating eigenvalue of `eigsol`). The purpose of this property is to be able to automatically compute the frequency response for reasonable frequencies. If `pout` is set to `spread` then `plist` is interpreted as an interval around each participating eigenvalue. For example, if `plist` is set to `range(0.9,0.04,1.1)` then each participating eigenvalue is multiplied by this list and the resulting lists are concatenated into the `plist` that is used.

Removed Properties

TABLE 5-35: REMOVED PROPERTIES FOR THE MODAL SOLVER SEQUENCE FEATURE

PROPERTY	REASON
<code>Callblevel</code>	Given by the solver sequence attribute feature

Purpose	Handle optimization solver parameters.
Syntax	<pre>model.sol(sname).feature().create(fname, 'Optimization') model.sol(sname).feature(fname).set(pname, value) model.sol(sname).feature(fname).feature() .create(aname, SolverAttribute)</pre>
Description	<p>Operation feature. When this feature is used, a PDE-constrained optimization problem is solved. The computed solution object contains the PDE solution evaluated for the optimal set of design variables. When the gradient-evaluation method is analytic, it also returns the adjoint solution.</p>

The two optimization-solvers SNOPT and Levenberg-Marquardt are available in COMSOL. Levenberg-Marquardt can only be used to solve problems with objective functions of a least-squares type. SNOPT can be used to solve any type of optimization problem. Another difference is that SNOPT supports constraints. Any constraints present are disregarded by Levenberg-Marquardt.

Choosing solver is done with the following property

TABLE 5-36: PROPERTY/VALUE PAIR TO SELECT OPTIMIZATION SOLVER

PROPERTY	VALUE	DEFAULT	DESCRIPTION
optsolver	snopt lm	snopt	Optimization solver

When the optimization solver is set to SNOPT (snopt), the following property/value pairs are accepted:

TABLE 5-37: VALID PROPERTY/VALUE PAIRS FOR OPTSOLVER SNOPT

PROPERTY	VALUE	DEFAULT	DESCRIPTION
feastol	real scalar	1e-6	Linear constraint tolerance
funcprec	real scalar	3.8e-11	Function precision
gradientsnopt	analytic numeric	analytic	Gradient/Jacobian evaluation method
hessupd	integer	10	Hessian updates
majfeastol	real scalar	1e-6	Nonlinear constraint tolerance
manualhessupd	on off	off	Whether to use property hessupd
manualstepcond	on off	off	Whether to use manual step condition
nsolvemax	positive integer	10000	Maximum number of objective evaluations

TABLE 5-37: VALID PROPERTY/VALUE PAIRS FOR OPTSOLVER SNOPT

PROPERTY	VALUE	DEFAULT	DESCRIPTION
objcontrib	all manual	all	Whether to use all objective contributions present or specify manually.
optobj	string		Objective function that is minimized when objcontrib>manual
opttol	real scalar	1e-6	Tolerance
plot	on off	off	Whether to plot while solving
plotgroup	string	default	Name of plot group for plot while solving
probes	vector of strings		Probes to use if probese1>manual
probese1	all manual	all	All probes or manual selection
qpsolver	cholesky cg qn	cholesky	QP subproblem algorithm
stepcond	string	empty	Manual step condition

The property `gradientsnopt` is used to control if the gradient should be computed analytically (by solving the adjoint problem) or numerically. If the number of design variables is large, numerical computation of the gradient can be very time consuming. Analytic gradient is only supported when the underlying PDE-problem is stationary.

If `manualstepcond` is set to `on`, the expression in the property `stepcond` is evaluated when new values for the design variables have been computed. If the expression becomes negative, the new values are discarded and the optimization solver reduces the step length in the current line search.

When the optimization solver is set to Levenberg-Marquardt (`lm`), the following property/value pairs are accepted:

TABLE 5-38: VALID PROPERTY/VALUE PAIRS FOR OPTSOLVER LM

PROPERTY	VALUE	DEFAULT	DESCRIPTION
gradientlm	numeric	numeric	Gradient/Jacobian evaluation method
gradorder	first second	first	Approximation order of the gradient
lmfact	real scalar	1e-3	Initial Levenberg-Marquardt factor

TABLE 5-38: VALID PROPERTY/VALUE PAIRS FOR OPTSOLVER LM

PROPERTY	VALUE	DEFAULT	DESCRIPTION
nsolvemax	positive integer	10000	Maximum number of objective evaluations
opttol	real scalar	1e-6	Tolerance
plot	on off	off	Whether to plot while solving
plotgroup	string	default	Name of plot group for plot while solving
probes	vector of strings		Probes to use if probesel=manual
probesel	all manual	all	All probes or manual selection

For a description of the optimization properties, see [Optimization Solver Properties](#) in the *COMSOL Optimization Module User's Guide*.

TABLE 5-39: REMOVED FEMOPTIM PROPERTIES

PROPERTY	REASON
Callblevel	Handled by attribute features
Solprop	Handled by stationary or time
Solcomp	Handled by variables
Report	Handled by variables
Out	Solution should be exported

Purpose Handle parameters for parameter stepping for stationary problems.

Syntax

```
model.sol(sname).feature().create(fname, 'Stationary')
model.sol(sname).feature(fname).feature()
    .create(parname, 'Parametric')
model.sol(sname).feature(fname).feature(parname)
    .set(pname, pvalue)
```

Description Attribute feature.

TABLE 5-40: PARAMETRIC PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
control	string	user	Name of controlling study
paramtuning	on off	off	Setting this property to on enables the use of the properties <code>pinitstep</code> , <code>pmaxstep</code> , and <code>pminstep</code>
pdistrib	on off	off	If the solver should distribute the parameter sweep
pinitstep	positive real		Initial step size for parameter. See <code>paramtuning</code>
plist	real array		List of parameter values. Obsolete, use <code>plistarr</code> instead.
plistarr	real matrix		Lists of parameter values. One row of values for each parameter name.
pmaxstep	positive real		Maximum step size for parameter. See <code>paramtuning</code>
pminstep	positive real		Minimum step size for parameter. See <code>paramtuning</code>
pname	vector of strings		Parameter names
porder	constant linear	linear	Predictor order for parameter stepping
pout	plist psteps	plist	Output either the parameters in <code>plist</code> or the solution at the expansion points
plot	on off	off	Plot while solving
plotgroup	string	default	Plot group to use for plot while solving
probesel	all manual	all	All probes or manual selection
probes	array of strings		Probes to use when <code>probesel=manual</code>
pwork	integer	1	Maximum number of distributed groups

TABLE 5-40: PARAMETRIC PROPERTIES

rstep	real scalar > 1	10	Restriction for step size update
sweepstype	sparse filled	sparse	Method for doing the parameter variation. For sweepstype=sparse, the parameter tuples defined by the columns in plistarr will be solved for. This method requires equal length for the rows. For sweepstype=filled, all parameter combinations given by plistarr will be solved for.

Purpose Makes it possible, through a callback, to display plots during the solution process.

Syntax
`model.sol(sname).feature().create(fname, 'PlotWhileSolving')`
`model.sol(sname).feature(fname).set(pname, pvalue)`

Description Attribute feature.

TABLE 5-41: VALID PLOT WHILE SOLVING PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
Postfeature	string		Name of postprocessing feature to update at each callback
Callbfreq	tout tsteps	tout	Callback frequency
Callblevel	nonlin refine time param optim	nonlin	Solver level for the callback

PreviousSolution

Purpose	Previous parametric solution parameters
Syntax	<pre>model.sol(sname).feature().create(fname, 'Stationary') model.sol(sname).feature(fname).feature() .create(parname, 'Parametric') model.sol(sname).feature(fname).feature(parname).feature() .create(psname, 'PreviousSolution') model.sol(sname).feature(fname).feature(parname).feature(psname) .set(pname, pvalue)</pre>
Description	Attribute feature. After the solver has converged for a parameter step, the previous components are solved for in a separate solver step. These components are held fixed (not solved for) during the normal solver procedure.

Purpose Handle the segregated solution approach.

Syntax

```
model.sol(sname).feature(solv).feature()
    .create(fname, 'Segregated')
model.sol(sname).feature(solv).feature(fname).set(pname, value)
model.sol(sname).feature(solv).feature(fname)
    .feature(fname2).set(pname, value)
```

Description This feature can be used as an attribute for the Time and Stationary features. The approach taken is nonlinear Uzawa iterations in which user defined groups of variables are solved for separately (a segregated step) while other variables are held fixed. The segregated steps for the segregated solver is handled by sub-attributes of the sort SegregatedStep.

The Segregated attribute supports the following properties;

TABLE 5-42: VALID SEGREGATED PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
maxsegiter	positive integer	100, 25 (Time)	Maximum number of segregated iterations
ntolfact	positive scalar	1	Tolerance factor
plot	on off	off	Plot while solving
plotgroup	string	default	Plot group to use for plot while solving
probesel	all manual	all	All probes or manual selection
probes	array of strings		Probes to use when probesel>manual
ratelimit	positive scalar	1	Limit on nonlinear convergence rate
segiter	positive integer	1	Fixed number of segregated iterations
segterm	iter tol itertol	tol	Segregated solver termination technique
useratelimit	on off	off, on (time)	Use limit on nonlinear convergence rate

Termination of the segregated solver is controlled by the property segterm. The default setting is tol, in which case the segregated iterations are terminated when, for each group, the estimated error is below the corresponding tolerance set by the main tolerance for the parent solver multiplied with the nonlinear tolerance factor

`ntolfact`. However, a maximum number of allowed segregated iterations is chosen through the property `maxsegiter`; if the maximum is reached, the iterations are terminated and an error message is displayed. Termination after a fixed number of segregated iterations is achieved by instead choosing `iter`. The number of segregated iterations is controlled by the property `segiter`. The third available option for `segterm` is `itertol`, which is a combination of the other two options; the segregated iterations are terminated when one of the two convergence criteria of `tol` and `iter` is met. The property `maxsegiter` is only supported when `tol` is used for termination. For both the settings `iter` and `itertol`, the number of iterations is controlled by the property `segiter`.

The nonlinear solver uses an adaptive tolerance for termination of iterative linear system solvers. This adaptive tolerance is based on the maximum of `ntol` and `itol`. During the nonlinear iterations, it can, however, be larger or smaller than this number. The segregated solver uses the same tolerance as the linear solver when constant damping is used. However, when automatically adjusted damping is used, the adaptive tolerance of the nonlinear solver is used. The parametric solver uses the same tolerance as the corresponding stationary solver.

Purpose	Handle a segregated solution step.
Syntax	<pre>model.sol(sname).feature().create(fname, 'SegregatedStep') model.sol(sname).feature(fname).set(pname, value) model.sol(sname).feature(fname).feature(sname).set(pname, value)</pre>
Description	This feature controls one segregated solution step.

TABLE 5-43: VALID SEGREGATED STEP PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
maxsubiter	integer	20	Maximum number of substep iterations
segcomp	vector of strings		Field/State components in step if segvarspec=manual
segvar	vector of strings		Fields/States in step
segvarspec	all manual	all	Include all components or specify which manually
subdamp	real	1.0	Substep damping factor
subdtech	const auto hnl ddog	const	Substep damping technique
subddoginitdamp	non-negative scalar	1	Initial damping factor for subdtech set to ddog
subinitstep	real	1	Substep initial damping factor for subdtech=auto
subinitsteph	real	1e-4	Substep initial damping factor for subdtech=hnlin
subiter	integer	1	Substep iterations
subjtech	minimal once onfirst onevery	see below	Substep Jacobian update technique for subdtech=const
subminstep	real	1e-4	Substep minimum damping factor for subdtech=auto
subminsteph	real	1e-8	Substep minimum damping factor for subdtech=hnlin
subntolfact	real	10	Substep tolerance factor
subressscale	scalefieldwise scaleuniform	scalefieldwise	JResidual scaling technique for subdtech set to ddog
subrstep	real	10	Substep restrictions for step-size update
subtermconst	iter tol itertol	iter	Substep termination technique for subdtech=const
subtermauto	tol itertol	itertol	Substep termination technique for subdtech=auto/hnlin

The fields/states to include in the step is defined through the property `segvar`. The property `segvarspec` controls which components of the fields/states in `segvar` to include in the step. By default `segvarspec` is `all`, in which case all components in

the fields/states of `segvar` are included. By setting `segvarspec` to `manual`, a subset of the fields/states of `segvar` can be included in the step. The components to include in the step are then defined through the property `segcomp`.

Analogously, the property `subterm` controls how each substep is terminated through the properties `maxsubiter`, `subiter`, and `subntol/subntolfact` for a stationary or time-dependent problem.

The damping technique used in each substep is controlled by the property `subdtech`. The default setting is `const`, which means that damped Newton iterations with a fixed damping factor is used. The damping factor is set in the property `subdamp`. The other available damping technique is `autodamp` in which case the damping factor is automatically adjusted. For substeps which uses `autodamp`, four other properties are supported: `subhnl`, `subinitstep`, `subminstep`, and `subrstep`. For each substep, these properties set the properties `hnl`, `initstep`, `minstep`, and `rstep` supported by the nonlinear solver, see `FullyCoupled`.

In substeps with `subdtech=const`, how often the Jacobian is updated is controlled by the property `subjtech`. The values `minimal`, `once`, and `onevery` give the same Jacobian update techniques as they do when applied to the coupled solver through the property `jtech`; see `FullyCoupled`. The value `onfirst` makes the solver update the Jacobian of the substep on the first subiteration each time the substep is solved for. Default value is `onevery` for stationary problems and `minimal` for time-dependent problems.

When `subdtech` is set to `ddog` (stationary problems), the double dogleg solver is used. The initial damping factor is controlled by the property `subddoginitdamp` and the property `subresscale` controls the residual scaling. The option `resscale=scalefieldwise` scales the equations based on the field-wise sizes of the initial residual. When the option `subresscale=scaleuniform` is selected the algorithm terminates on the relative residual based on the initial residual.

Purpose	Handle sensitivity solver parameters.
Syntax	<pre>model.sol(sname).feature(solv).feature() .create(fname, 'Sensitivity') model.sol(sname).feature(solv).feature(fname).set(pname, value)</pre>
Description	Attribute feature. This feature can be used to make analytic forward or backward sensitivity analysis. This analysis is done after the main problem has converged. The solution approach (coupled or segregated, Jacobians, and so on) for the main problem is reused.

TABLE 5-44: VALID SENSITIVITY PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
sensfunc	string		Sensitivity functional variable name
sensmethod	none adjoint forward	none	Sensitivity analysis

Purpose Assembles and stores matrices that describe a model as a dynamic system.

Syntax

```

model.sol(sname).feature().create(fname, 'StateSpace')
model.sol(sname).feature(fname).set(pname, value)
model.sol(sname).feature(fname).getSparseMatrixVal(mname)
model.sol(sname).feature(fname).getSparseMatrixValImag(mname)
model.sol(sname).feature(fname).getSparseMatrixRow(mname)
model.sol(sname).feature(fname).getSparseMatrixCol(mname)
model.sol(sname).feature(fname).getVector(vname)
model.sol(sname).feature(fname).getVectorImag(vname)
model.sol(sname).feature(fname).getSparseMatrixValBlock(mname,
    start, stop)
model.sol(sname).feature(fname).getSparseMatrixValImagBlock
    (mname, start, stop)
model.sol(sname).feature(fname).getSparseMatrixRowBlock(mname,
    start, stop)
model.sol(sname).feature(fname).getSparseMatrixColBlock(mname,
    start, stop)
model.sol(sname).feature(fname).getVectorBlock(vname, start, stop)
model.sol(sname).feature(fname).getVectorImagBlock(vname, start,
    stop)
model.sol(sname).feature(fname).isReal(mname)
model.sol(sname).feature(fname).getM(mname)
model.sol(sname).feature(fname).getN(mname)
    
```

Description State-space feature.

TABLE 5-45: VALID GENERAL PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
input	string array		The input parameters that affect the model
output	string array		The output expressions
static	on off	on	Static linearized model
Mc	on off	off	Assemble the Mc matrix
MA	on off	off	Assemble the McA matrix
MB	on off	off	Assemble the McB matrix
C	on off	off	Assemble the C matrix
D	on off	off	Assemble the D matrix
Null	on off	off	Assemble the Null matrix

TABLE 5-45: VALID GENERAL PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
ud	on off	off	Assemble the ud vector
x0	on off	off	Assemble the initial data

The state-space feature assembles matrices that describe a model as a dynamic system when `Static` is `off`

$$\begin{aligned} Mc\dot{x} &= McAx + McBu \\ y &= Cx + Du \end{aligned}$$

In the case when `Static` is on a static linearized model of the system is described by

$$y = (D - C(McA)^{-1}McB)u$$

Let *Null* be the PDE constraint null-space matrix and *ud* a particular solution fulfilling the constraints. The solution vector *U* for the PDE problem can then be written

$$U = \text{Null}x + ud + u0$$

where *u0* is the linearization point, which is the solution stored in the sequence once the state-space export feature is run. The input linearization point is stored in the sequence after the state-space feature is run.

The input parameters `input` should contain all parameters that are of interest as input to the model. The output expressions `output` should contain a list of all expressions that are to be evaluated as output from the model.

Purpose Solve stationary PDE problem with or without parameters, adaption, sensitivity, or optimization.

Syntax `model.sol(sname).feature().create(fname, 'Stationary')`
`model.sol(sname).feature(fname).set(pname, value)`

Description Operation feature.
 The following (intrinsic) properties are available.

TABLE 5-46: STATIONARY PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
control	string	user	Name of controlling study
nonlin	auto on off linper	auto	Use the nonlinear solver
linpmethod	init sol	init	Method used for linearization point
linpsol	zero solution object	zero	Linearization point solution
linpsoluse	current solution store	current	
reactf	on off	on	Compute reaction forces
solnum	auto all positive integer	auto	Which solnums from another solution to use as linearization point
stol	positive real	1e-3	Relative tolerance
storelinpoint	on off	off	Whether to store the linearization point

This solver uses a nonlinear solver if `nonlin` is on, and it uses the linear solver if `nonlin` is on or `linper`. If `nonlin` is set to `auto` an analysis is performed to automatically detect if the problem can be solved with a linear solver approach. For a description of the nonlinear solver see the entry under `coupling`.

The automatic nonlinear/linear detection works in the following way. The linear solver is called if the residual Jacobian matrix (the stiffness matrix, \mathbf{K}) and the constraint Jacobian matrix (the constraint matrix, \mathbf{N}) are both found not solution dependent and if these matrices are detected as complete. In all other situations the nonlinear solver is used. The analysis is performed by a symbolic analysis of the expressions contributing to these matrices. Complete here means that in the residual

and constraint vectors, only expressions were found for which COMSOL Multiphysics computes the correct Jacobian contribution.

Therefore, if you want to solve a linearized (nonlinear) problem, you must set `nonlin` to `off` or `linper`. The `off` option uses the linearization point for both the residual computation and for the Jacobian and the solution to the linear problem is added to the linearization point. This corresponds to one step in the Newton method. For `linper`, the linearization point is used for the Jacobian, the zero solution is used for the assembly of the residual and the solution to the linear problem is returned as the solution. Furthermore, the residual assembled for `linper` is computed using loads marked with the `linper` operator.

There are variables for which COMSOL Multiphysics is conservative and therefore flags these, and their Jacobian contribution, as solution dependent even though they not always are. For these situations, the nonlinear solver is used even though the linear solver could be used. This should only result in some extra computational effort, and should not influence the result. The opposite situation however, where the linear solver is used for a nonlinear problem is more dangerous. So, select `nonlin` to `off` with great care.

The property `react` controls the computation and storage of constraint reaction forces. The value `react=on` (default) means that the solver stores the FEM residual vector L in the solution object `fem.sol`. Because $L = N_F \Lambda$ for a converged solution, the residual is the same as the constraint force. Only the components of L that correspond to nonzero rows of N_F are stored. The value `react=off` gives no computation or storage of the reaction force and saves some memory.

The linear solver uses the property `it01` for termination of iterative linear system solvers and for error checking for direct solvers (if enabled).

StopCondition

Purpose Handle stop conditions for time-dependent and parametric solver processes.

Syntax

```
model.sol(sname).feature().create(fname, 'Stationary')
model.sol(sname).feature(fname).feature()
    .create(pname, Parametric)
model.sol(sname).feature(fname).feature(pname).feature()
    .create(ocname, StopCondition)
model.sol(sname).feature(fname).feature(pname).feature(ocname)
    .set(pname, pvalue)
```

Description Attribute feature. Use the property `Stopcond` feature to make sure the solver stops when a specified condition is fulfilled. When you provide a scalar expression, then the expression is evaluated after each time or parameter step. The stepping is stopped if the real part of the expression is evaluated to something negative. The corresponding solution, for which the expression is negative is not returned. When you provide an integer the solver stops when the corresponding implicit event is triggered.

TABLE 5-47: VALID STOPCONDITION PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
stopcondition	String		Stop condition expression

Purpose A place holder for a solver sequence that is used to store a computed solution.

Syntax `model.sol(sname).feature().create(fname, 'StoreSolution')`
`model.sol(sname).feature(fname).getString('sol')`

Description The store solution feature stores a reference to a computed solution. Use the sol property to find out the name of the referenced solution.

TABLE 5-48: VALID STORESOLUTION PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
sol	String	A solver sequence	Name of solver sequence that stores the solution

In the case of a parametric sweep you can use the StoreSolution features to find the solutions created during the sweep. You first find out the solver sequence that holds the stored solutions

```
model.batch(pname).feature(fname).getString('psol')
```

where `pname` is the name of the parametric sweep feature that ran and `fname` is the name of the solution feature that stored the solutions. Use

```
model.sol(sname).feature().tags()
```

to find out the tags of the stored solutions. Use

```
model.sol(sname).feature(fname).getString('sol')
```

to find the solver sequence for a parameter. Use

```
model.sol(sname).getParamNames()
```

and

```
model.sol(sname).getParamVals()
```

to find the parameter values that created the solution object.

StudyStep

Purpose	Specify which PDE problem to use for subsequent solver operations.
Syntax	<pre>model.sol(sname).feature().create(fname, 'StudyStep') model.sol(sname).feature(fname).set(pname, pvalue)</pre>
Description	Utility feature. This feature determines which PDE problem to use for subsequent solver operations. It contains a reference to a study and a reference to a study step within that study. When run the corresponding low-level PDE representation is compiled.

TABLE 5-49: VALID CONFIGURATION PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
study	String		Name of study to use
studystep	String		Name of study step to use
splitcomplex	on off	off	Represent complex variables by separate degrees of freedom for real and imaginary parts

Purpose	Solve a time-dependent PDE problem.
Syntax	<code>model.sol(sname).feature().create(fname, 'Time')</code> <code>model.sol(sname).feature(fname).set(pname, value)</code>
Description	Operation feature. The time interval and possible intermediate time values are given in the property Tlist. The output times are controlled by the property Tout. The feature Time accepts the following property/values:

TABLE 5-50: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
atol	string	empty	Absolute tolerance per field. See below
atolmethod	string	empty	How to interpret the atolfields value. See below
atolglobal	positive scalar	1e-3	Global absolute tolerance
atolglobalmethod	scaled unscaled	scaled	How to interpret the atolglobal value
atoludot	string	empty	Absolute tolerance for time derivatives per field. Only applicable if atoludotactive is on. See below
atoludotactive	string	empty	Used to activate manual specification of absolute tolerance for time derivatives. See below
complex	on off	off	Complex numbers
consistent	off on bweuler	bweuler	Consistent initialization of DAE systems
control	string	user	Name of controlling study
estrat	include exclude	include	Error estimation strategy
ewtrescale	on off	on	Update scaled absolute tolerance for BDF
incrdelay	positive integer	15	Number of time steps to delay a time step increase
incrdelayactive	on off	off	Use delay in time step increase
initialstepbdf	positive scalar	1e-3	Initial time step for BDF
initialstepgenal pha	positive scalar	1e-3	Initial time step for generalized alpha
masssingular	yes maybe	maybe	Singular mass matrix
maxorder	integer between 1 and 5	5	Maximum BDF order
maxstepbdf	positive scalar	1e-1	Maximum time step BDF

TABLE 5-50: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
maxstepgenalpha	positive scalar	1e - 1	Maximum time step generalized alpha
minorder	1 2	1	Minimum BDF order
nlsolver	automatic manual	manual	Nonlinear solver settings
plot	on off	off	Plot while solving
plotfreq	tsteps tout	tout	Times to update plot
plotgroup	string		Name of plot group for plot while solving
probefreq	tsteps tout	tsteps	Times to update probe
probes	vector of strings		Probed to use if probesel=manual
probese1	all manual	all	All probes or manual selection
predictor	linear constant	linear	Predictor
reacf	on off	on	Compute reaction forces
rhoinf	numeric	0.75	Amplification factor for high frequencies
rtol	numeric	0.01	Relative tolerance
solfile	on off	off	Store solution on file
solfileblock	positive scalar	16	Max size of solution block (MB)
storeudot	on off	on	Store time derivatives
timemethod	bdf genalpha init	bdf	Time-stepping method
timestepgenalpha	numeric scalar numeric vector string with expression	0.01	Time step when manual time stepping
tlist	numeric vector		Time list
tout	tlist tsteps	tlist	Output times
tstepsbdf	free intermediate strict	free	Time-stepping mode when Timemethod is set to bdf
tstepsgenalpha	free intermediate strict manual	free	Time-stepping mode when Timemethod is set to genalpha

By default, you can control the process of solving the linear or nonlinear system of equations in each time step manually. For a coupled problem, this is done through the properties `Damp`, `Dtech`, `Hnlin`, `Initstep`, `Jtech`, `Maxiter`, `Minstep`, and `Rstep` listed under `femnl`. For a segregated problem, the properties listed under `femstatic` that are related to the segregated solver are available. When `Timemethod` is set to `bdf` it is possible to use the internal nonlinear solver of the time integrator. This can be achieved by setting `Nlsolver` to `automatic`.

The properties `atol`, `atolmethod`, `atolglobal`, `atolglobalmethod`, `atoludot`, and `atoludotactive` require some additional explanation. The default value of the absolute tolerance for all fields is given by the property `atolglobal`. The modifier `atolglobalmethod` specifies whether the given value of `atolglobal` should be applied to scaled or unscaled variables. For variables where the automatic scaling does a good job, or where a manual scaling has been used, specifying the absolute tolerance in scaled variables is much easier. If either a different absolute value or scaling method than dictated by `atolglobal` and `atolglobalmethod` is wanted for one or several variables you can use the properties `atol` and `atolmethod`. Enter `atol` as a space separated string with alternating field names and tolerances (for example, "u 1e-3 v 1e-6"). Enter `atolmethod` as a space-separated string with alternating field names and one of the strings `global`, `scaled`, or `unscaled` (for example, "u unscaled v scaled"). By default `atolmethod` is equal to `global` for all fields. The lists `atol` and `atolmethod` do not have to contain all fields. The ones not present get absolute tolerances as specified by `atolglobal` and `atolglobalmethod`. When solving wave-type equations with `timemethod` set to `bdf` the time-derivatives of all fields are also treated as unknowns and therefore absolute tolerances have to be specified also for these components. By default these tolerances are chosen automatically. In some situations it might be necessary to specify them manually with the properties `atoludot` and `atoludotactive`. To turn on manual specification for, say, the two fields `u` and `v` set the property `atoludotactive` to the string "u on v on". If `atoludot` is not specified these two time-derivatives get the default absolute tolerance `1e-3`. To specify other absolute tolerances set `atoludot` to, for instance, the string "u 1e-4 v 1e-7". The absolute tolerance method for all time-derivatives is the same as the method specified for the field itself.

The maximum allowed relative error in each time step (the local error) is specified using `rtol`. However, for small components of the solution vector U , the algorithm tries only to reduce the absolute local error in U below the given absolute tolerance.

There is no guarantee that the error tolerances are met strictly, that is, for hard problems they can be exceeded.

For the tolerance parameter in the convergence criterion for linear systems, the maximum of the numbers `rtol` and `itol` is used.

Use `complex=on` if complex numbers occur in the solution process.

The property `Consistent` controls the consistent initialization of a *differential algebraic equation* (DAE) system. The value `Consistent=off` means that the

initial values are consistent (this is seldom the case, because the initial value of the time derivative is 0). Otherwise, the solver tries to modify the initial values so that they become consistent. The value `consistent=on` can be used (when `timemethod=bdf` and `nlsolver=automatic`) for index-1 DAEs. Then the solver fixes the values of the differential DOFs, and solve for the initial values of the algebraic DOFs and the time derivative of the differential DOFs. The value `consistent=bweuler` can be used for both index-1 and index-2 DAEs. Then the solver perturbs the initial values of all DOFs by taking a backward Euler step.

For a DAE system, if `Estrat=exclude`, then the algebraic DOFs are excluded from the error norm of the time discretization error.

You can suggest a size of the initial time step using the property `initialstepbdf` when `timemethod` is set to `bdf` and the property `initialstepgenalpha` when `timemethod` is set to `genalpha`. You also have to set one of the properties `initialstepbdfactive` or `initialstepgenalphaactive` to `on` for the specified initial step to be active.

By default, the solver determines whether the system is differential-algebraic by looking after zero rows or columns in the mass matrix. If you have a DAE where the mass matrix has no zero rows or columns, put `masssingular=yes`.

The property `maxorder` gives the maximum degree of the interpolating polynomial in the BDF method (when `timemethod=bdf`).

The properties `maxstepbdf` (for `timemethod=bdf`) and `maxstepgenalpha` (for `timemethod=genalpha`) put an upper limit on the time step size (this property is not allowed when `tstepsgenalpha>manual`). You also have to set one of the properties `maxstepbdfactive` or `maxstepgenalphaactive` to `on` for the specified maximal step to be active.

The property `timemethod` is used to select which time-stepping method to use. With `timemethod=bdf`, the solver IDA (which uses variable order backward differentiation formula) is used. With `timemethod=genalpha`, the method generalized- α is used. With generalized- α , the numerical damping can be controlled by giving a value, $0 \leq \rho_\infty \leq 1$, by which the amplitude of the highest possible frequency is multiplied each time step (hence, a small value corresponds to large damping while a value close to 1 corresponds to little damping). This is done through the property `rhoinf`. Also, the initial guess for the solution at the next time step (needed by the nonlinear solver) can be controlled through the property `predictor` when generalized- α is used. With `predictor=linear`, linear extrapolation using the current solution and time-derivative is used. With

`predictor=constant`, the current solution is used as initial guess. When `timemethod` is set to `init` the solver computes consistent initial values (for the start time, as defined by the property `tlist`) for the system and then stop. Time derivatives of algebraic variables and indicator functions might still be uninitialized after this operation. Such uninitialized quantities are represented by NaN (not a number) in the solution object.

The property `react` controls the computation and storage of the constraint reaction force. The value `react=on` (default) means that the solver stores the FEM residual vector L in the solution object. Because $L = N_F \Lambda$ for a converged solution, the residual is the same as the constraint force. Only the components of L that correspond to nonzero rows of N_F are stored. For each time for which the solution is requested an extra residual vector assembly is performed. The value `react=off` gives no computation or storage of the reaction force and can therefore save some computational time.

The property `tlist` must be a strictly monotone vector of real numbers. Commonly, the vector consists of a start time and a stop time. If more than two numbers are given, the intermediate times can be used as output times, or to control the size of the time steps (see below). If just a single number is given, it represents the stop time, and the start time is 0.

The property `tout` determines the times that occur in the output. If `tout=tsteps`, then the output contains the time steps actually taken by the solver. If `tout=tlist`, then the output contains interpolated solutions for the times in the `tlist` property. The default is `tout=tlist`.

The properties `tstepsbdf` (applicable when `timemethod=bdf`) and `tstepsgenalpha` (applicable when `timemethod=genalpha`) control the selection of time steps. If either of these two properties is set to `free`, then the solver selects the time steps according to its own logic, disregarding the intermediate times in the `tlist` vector. If either of the properties is set to `strict`, then time steps taken by the solver contain the times in `tlist`. If either of the properties is set to `intermediate`, then there is at least one time step in each interval of the `tlist` vector. If `tstepsgenalpha` has been set to `manual`, the solver follows the time step specified in the property `timestepgenalpha`. If `timestepgenalpha` is a scalar value, this time step is taken in the entire simulation. When `timestepgenalpha` is a (strictly monotone) numeric vector, the solver computes the solution at the times in the vector. The start time and stop time is still obtained from `tlist`; the vector given in `timestepgenalpha` is truncated and/or expanded using the first and/or

last time step in the vector so that the start time and stop time agrees with the values in `tlist`. Finally, an expression using variables with global scope and which results in a scalar can be used as `timestepgenalpha`.

For problems of wave-type, the logic by which the solver selects the time step can sometimes result in a time step which oscillates in an inefficient manner. When `timemethod=genalpha` (the solver typically used for problems of wave-type), such oscillations in the time step can be avoided through the properties `incrdelay` and `incrdelayactive`. When `incrdelayactive=on`, a counter keeps track of the number of consecutive time steps for which a time step increase has been warranted. When this counter exceeds the number given in the property `incrdelay`, the time step is increased and the counter is set to zero.

For more information about the time-dependent solver; see [Time-Dependent Solver](#) in the *COMSOL Multiphysics Reference Guide*.

Caution

In structural mechanics models, the displacements are often quite small, and it is critical that the absolute tolerance is chosen to be smaller than the actual displacements.

Removed Properties

TABLE 5-51: REMOVED FEMTIME PROPERTIES

PROPERTY	REASON
Callblevel	Callback
Callback	Callback
Callbfreq	Callback
Ntolfact	Handled by Coupled
Out	The solution is exported in the solver sequence
Keep	Handled by Advanced
Ratelimit	Handled by Coupled
Useratelimit	Handled by Coupled

- Purpose** Solve a time-discretized PDE problem.
- Syntax** `model.sol(sname).feature().create(fname,"TimeDiscrete")`
`model.sol(sname).feature(fname).set(pname,value)`
- Description** Operation feature.

The time interval and possible intermediate time values are given in the property `tlist`. The output times are controlled by the property `tout`.

The feature `TimeDiscrete` accepts the following property/values:

TABLE 5-52: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
<code>atol</code>	string	empty	Absolute tolerance per field. See below
<code>atolmethod</code>	string	empty	How to interpret the <code>atolfields</code> value. See below
<code>atolglobal</code>	positive scalar	1e-3	Global absolute tolerance
<code>atolglobalmethod</code>	scaled unscaled	scaled	How to interpret the <code>atolglobal</code> value
<code>control</code>	string	user	Name of controlling study
<code>plot</code>	on off	off	Plot while solving
<code>plotfreq</code>	tsteps tout	tout	Times to update plot
<code>plotgroup</code>	string		Name of plot group for plot while solving
<code>prevlevels</code>	positive integer	2	Number of previous time levels to store.
<code>probefreq</code>	tsteps tout	tsteps	Times to update probe
<code>probes</code>	vector of strings		Probed to use if <code>probesel=manual</code>
<code>probesel</code>	all manual	all	All probes or manual selection
<code>rto1</code>	numeric	0.01	Relative tolerance
<code>solfile</code>	on off	off	Store solution on file
<code>solfileblock</code>	positive scalar	16	Max size of solution block (MB)

TABLE 5-52: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
<code>timestepdiscrete</code>	numeric scalar numeric vector string with expression	0.01	Time step when manual time stepping
<code>tlist</code>	numeric vector		Time list
<code>tout</code>	<code>tlist</code> <code>tsteps</code>	<code>tlist</code>	Output times

The `TimeDiscrete` solver is used for solving time-dependent PDEs that have already been discretized in time using, for example, the `prev` operator or the `bdf` operator. Such discretization requires the solution at previous time steps. Different discretizations require different number of previous time steps. For example, the first order accurate `bdf` method requires the solution at the previous time step, while the second-order accurate `bdf`-method requires the solution at the two preceding time steps. How many previous time steps should be accessible to the solver is controlled through the property `prevlevels`.

You can control the process of solving the linear or nonlinear system of equations in each time step manually. For a coupled problem, this is done through the properties `Damp`, `Dtech`, `Hnlin`, `Initstep`, `Jtech`, `Maxiter`, `Minstep`, and `Rstep` listed under `femnl`. For a segregated problem, the properties listed under `femstatic` that are related to the segregated solver are available.

Because only manual time stepping is available, there is no estimation of the error made in a time step. However, the tolerances, specified through the properties `rtol`, `atol`, `atolmethod`, `atolglobal`, and `atolglobalmethod` are still important as tolerances when solving the nonlinear system of equations in each time step. For a description of these properties, see [Time](#). They should in general be set to the desired accuracy in the final solution.

The property `tlist` must be a strictly monotone vector of real numbers. Commonly, the vector consists of a start time and a stop time. If more than two numbers are given, the intermediate times can be used as output times, or to control the size of the time-steps (see below). If just a single number is given, it represents the stop time, and the start time is 0.

The property `tout` determines the times that occur in the output. If `tout=tsteps`, then the output contains the time steps actually taken by the solver. If `tout=tlist`, then the output contains interpolated solutions for the times in the `tlist` property. The default is `tout=tlist`.

The size of the time step is controlled through the property `timestepdiscrete`. If `timestepdiscrete` is a scalar value, this time step is taken in the entire simulation. When `timestepdiscrete` is a (strictly monotone) numeric vector, the solver computes the solution at the times in the vector. The start time and stop time is still obtained from `tlist`; the vector given in `timestepdiscrete` is truncated and/or expanded using the first and/or last time step in the vector so that the start time and stop time agrees with the values in `tlist`. Finally, an expression using variables with global scope and which results in a scalar can be used as `timestepdiscrete`.

For more information about the time discrete solver; see [Time Discrete Solver](#) in the *COMSOL Multiphysics Reference Guide*.

TimeExplicit

Purpose

Solve time-dependent problem with explicit time stepping.

Syntax

```
model.sol(sname).feature().create(fname, 'TimeExplicit')
model.sol(sname).feature(fname).set(pname, pvalue)
```

Description

Operation feature. The `TimeExplicit` solver is used for solving time-dependent PDEs using the classic Runge-Kutta explicit time-stepping scheme.

TABLE 5-53: VALID TIMEEXPLICIT PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
control	string	user	Name of controlling study
erkorder	integer between 1 and 4	4	Runge-Kutta order
linsolver			Linear solver
plot	on off	off	Plot while solving
plotfreq	tsteps tout	tout	Times to update plot
plotgroup	string		Name of plot group for plot while solving
probefreq	tsteps tout	tsteps	Times to update probe
probes	vector of strings		Probed to use if probesel=manual
probesel	all manual	all	All probes or manual selection
rktimestep	positive scalar	1e-3	Time step
solfile	on off	on	Store solution out-of-core
storeudot	on off	on	Store time-derivatives
tlist	vector of strings		Specified time list
tout	tsteps tlist	tlist	Times to store in solution

The order of the Runge-Kutta method can be set by the `erkorder` property. The size of the time step is controlled through the property `rktimestep` and can be given as a single scalar value, a (strictly monotone) numeric vector, or an expression using variables with global scope, which results in a scalar.

Purpose	Handle parameters for parameter stepping for a time-dependent problem.
Syntax	<pre> model.sol(sname).feature().create(fname, 'Time') model.sol(sname).feature(fname).feature() .create(parname, 'TimeParametric') model.sol(sname).feature(fname).feature(parname) .set(pname, pvalue) </pre>
Description	Attribute feature.

TABLE 5-54: PARAMETRIC PROPERTIES

PROPERTY	VALUE	DEFAULT	DESCRIPTION
control	string	user	Name of controlling study
pdistrib	on off	off	If the solver should distribute the parameter sweep
plist	real array		List of parameter values. Obsolete, use plistarr instead.
plistarr	real matrix		Lists of parameter values. One row of values for each parameter name.
pname	vector of strings		Parameter names
pwork	integer	1	Maximum number of distributed groups
sweeptype	sparse filled	sparse	Method for doing the parameter variation. For sweeptype=sparse, the parameter tuples defined by the columns in plistarr will be solved for. This method requires equal length for the rows. For sweeptype=filled, all parameter combinations given by plistarr will be solved for.

Purpose Handles initial data and scaling for variables solved, as well as how variables not solved for are computed. The methods are applied for the dependent variables present as Field or State subattributes. These attributes are automatically created and updated by this feature. So, if the Analysis (for the solver sequence) is altered or if a different Analysis is used in the sequence, then the Field attributes are changed accordingly.

Syntax

```
model.sol(sname).feature().create(fname, 'Variables')
model.sol(sname).feature(fname).set(pname, pval)
model.sol(sname).feature(fname).feature(varname).set(pname, pval)
```

Description Operation feature. Computes the initial values for the variables that are solved for and how the variables not solved for are computed. The variables handled are the ones present as Field or State attributes. The feature also handles scaling and which variables to store in output.

Attribute feature.

TABLE 5-55: VALID VARIABLE PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
control	string	user	Name of controlling study
initmethod	init sol	init	Method used for initial value computation
initsol	zero solution object	zero	Initial value solution object
initsoluse	current solution store	current	
notsol	zero solution object	zero	Solution object for variables not solved for
notsolmethod	init sol	init	Method used for variables not solved for
notsolnum	auto all positive integer	auto	Which solnums from other solution to use for variables not solved for.
notsoluse	current solution store	current	
scalemethod	auto init none manual	auto	Method used for scaling of variables

TABLE 5-55: VALID VARIABLE PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
scaleval	scalar	1	Global scaling value
storesol	init u		

TABLE 5-56: VALID VARIABLE SUB-ATTRIBUTE FIELD/STATE PROPERTY/VALUE PAIRS

PROPERTY	VALUES	DEFAULT	DESCRIPTION
comp	vector of strings		Field/State components
out	on off	on	Store Field/State in output
scalemethod	auto init none manual parent	parent	Method used for scaling of variables
scaleval	scalar	1	Scaling value
solvefor	on off	on	Solve for this Field/State

The properties `initmethod`, `initsol`, and `initsoluse` determine the initial value for the solution components you solve for.

The properties `notsolmethod`, `notsol`, `notsoluse`, and `notsolnum` determine the value of solution components you do not solve.

Which variables to solve for, and which variables to store in the solution is controlled by the properties `solvefor` and `out` in the Field or State attributes.

The properties `scalemethod` and `scaleval` determine a scaling of the degrees of freedom that is applied in order to get a more well-conditioned system. The possible values of `scalemethod` are:

TABLE 5-57: VALUES FOR THE PROPERTY SCALEMETHOD

VALUE	MEANING
auto	The scaling is automatically determined
init	The scaling is determined from the initial value. Use this if the sizes of the components of the initial value give a good estimate of the order of magnitude of the solution
none	No scaling is applied
manual	The scaling is user controlled by setting the property <code>scaleval</code>
parent	Scaling method is inherited from the parent Variables feature (only for subattributes).

Purpose	Get extended mesh information.
Syntax	<pre>SolverFeature step = model.sol(seqTag).feature(studyStepTag); XmeshInfo xmi = step.xmeshInfo(); XmeshInfo xmi = step.xmeshInfo(meshCase); SolverFeature var = model.sol(seqTag).feature(variablesTag); XmeshInfo xmi = var.xmeshInfo(); XmeshInfo xmi = var.xmeshInfo(meshCase); XmeshInfo xmi = model.sol(seqTag).xmeshInfo(); XmeshInfo xmi = model.sol(seqTag).xmeshInfo(meshCase); String[] mcases = xmi.meshCases(); int nDofs = xmi.nDofs(); String[] fieldNames = xmi.fieldNames(); int[] fieldNDofs = xmi.fieldNDofs(); String[] geomTags = xmi.geoms(); String[] meshTypes = xmi.meshTypes(); String[] meshTypes = xmi.meshTypes(geomTag); XmeshInfoDofs dofs = xmi.dofs(); int[] dofs.geomNums() int[] dofs.nodes() double[][] dofs.coords() String[] dofs.dofNames() int[] dofs.nameInds() XmeshInfoNodes nodes = xmi.nodes(); XmeshInfoNodes nodes = xmi.nodes(geomTag); double[][] nodes.coords() String[] nodes.dofNames() int[][] nodes.dofs() XmeshInfoElements elems = xmi.elements(meshType); XmeshInfoElements elems = xmi.elements(meshType,geomTag); double[][] elems.localCoords() int[][] elems.nodes() String[] elems.localDofNames() double[][] elems.localDofCoords() int[][] elems.dofs() model.sol(seqTag).feature(studyStepTag).clearXmesh(); model.sol(seqTag).feature(variablesTag).clearXmesh();</pre>
Description	The Xmesh information methods provide information about the numbering of elements, nodes, and degrees of freedom (DOFs) in the extended mesh and in the matrices returned by <code>Assemble</code> and the solvers.

```
SolverFeature step = model.sol(seqTag).feature(studyStepTag);
XmeshInfo xmi = step.xmeshInfo();
```

returns information about all degrees of freedom in the given study step, for the main mesh case.

```
XmeshInfo xmi = step.xmeshInfo(meshCase);
```

returns information about the given mesh case. The string `meshCase` can be `main`, `adaptionresidual`, or a multigrid level tag.

```
SolverFeature var = model.sol(seqTag).feature(variablesTag);
XmeshInfo xmi = var.xmeshInfo();
XmeshInfo xmi = var.xmeshInfo(meshCase);
```

returns information about the degrees of freedom solved for in the given variables feature. That is, the numbering of the degrees of freedom span over the DOFs solved for.

```
XmeshInfo xmi = model.sol(seqTag).xmeshInfo();
XmeshInfo xmi = model.sol(seqTag).xmeshInfo(meshCase);
```

is equivalent to calling `xmeshInfo` on the last study step feature in the sequence.

```
model.sol(seqTag).feature(studyStepTag).clearXmesh();
model.sol(seqTag).feature(variablesTag).clearXmes();
```

clears out the `Xmesh` object created by the call to `xmeshInfo`. After the required information has been obtained from the `XmeshInfo` object, this function should be called to release memory. When `xmeshInfo` is called on a solver sequence, an already existing `Xmesh` object is used, so there is no need to call `clearXmesh`.

GENERAL INFORMATION

`String[] mcases = xmi.meshCases()` returns a string vector containing tags of all mesh cases.

`int nDofs = xmi.nDofs()` returns the total number of DOFs.

`String[] fieldNames = xmi.fieldNames()` returns the field names, or the field names solved for.

`int[] fieldNDofs = xmi.fieldNDofs()` returns the number of DOFs for each field.

`String[] geomTags = xmi.geoms()` returns the tags of all geometries that exist in the `xmesh`.

`String[] meshTypes = xmi.meshTypes()` returns all mesh types.

`String[] meshTypes = xmi.meshTypes(geomTag)` returns all mesh types in geometry `geomTag` (a string). Possible mesh types are `vtx`, `edg`, `tri`, `quad`, `tet`, `hex`, `prism`, and `pyr`.

INFORMATION ABOUT EACH DOF

`XmeshInfoDofs dofs = xmi.dofs()` returns information about each DOF.

The class `XmeshInfoDofs` has the following methods:

TABLE 5-58: XMESHINFODOFS METHODS

FIELD	CONTENTS
<code>int[] geomNums()</code>	1-based geometry numbers for all DOFs
<code>int[] nodes()</code>	0-based node numbers for all DOFs. Note: Was 1-based in 3.5a.
<code>double[][] coords()</code>	Global coordinates for all DOFs in the model length unit. The <i>k</i> th column of this matrix contains the coordinates of DOF number <i>k</i> .
<code>double[][] gCoords()</code>	Same as <code>coords()</code> except that coordinates are given in the geometry length unit. If there is more than one geometry, the coordinates of each DOF are given in the length unit of the geometry of that DOF.
<code>String[] dofNames()</code>	DOF names
<code>int[] nameInds()</code>	0-based indices into <code>dofNames()</code> for all DOFs. Note: Was 1-based in 3.5a.

INFORMATION ABOUT EACH NODE POINT

`XmeshInfoNodes nodes = xmesh.nodes()` returns information about nodes. This method throws an error if there is more than one geometry.

`XmeshInfoNodes nodes = xmesh.nodes(geomTag)` returns information about nodes in geometry `geomTag` (a string).

The class `XmeshInfoNodes` has the following methods:

TABLE 5-59: XMESHINFONODES CLASS METHODS

FIELD	CONTENTS
<code>double[][] coords()</code>	Global coordinates for all nodes. The <i>n</i> th column of the matrix <code>coords</code> contains the coordinates of node point number <i>n</i>
<code>double[][] gCoords()</code>	Same as <code>coords()</code> except that coordinates are given in the geometry length unit.

TABLE 5-59: XMESHINFONODES CLASS METHODS

FIELD	CONTENTS
String[] dofNames()	DOF names in this geometry
int[][] dofs()	0-based DOF numbers for all nodes in this geometry. <code>dofs()[k][n]</code> is the DOF number for DOF name <code>dofNames()[k]</code> at node point <code>n</code> . A value of -1 means that there is no DOF with this name at the node. Note: If there is a slit, only one of the DOFs is given for each node point.

INFORMATION ABOUT EACH MESH ELEMENT

XmeshInfoElements `elems = xmesh.elements(meshType)` returns information about mesh elements of type `meshType` (a string). This method throws an error if there is more than one geometry.

XmeshInfoElements `elems = xmesh.elements(meshType, geomTag)` returns information about mesh elements of type `meshType` in geometry `geomTag`. Possible mesh types are `vtx`, `edg`, `tri`, `quad`, `tet`, `hex`, `prism`, and `pyr`. The XmeshInfoElements class has the following methods:

TABLE 5-60: XMESHINFOELEMENTS CLASS METHODS

FIELD	CONTENTS
double[][] localCoords()	Local coordinates of nodes. The <code>k</code> th column of the matrix <code>localCoords()</code> contains the coordinates of local node point number <code>k</code> .
int[][] nodes()	0-based node point indices for all mesh elements of type <code>type()</code> . <code>nodes()[k][e1]</code> is the node point number within geometry <code>geomNum()</code> (see the output <code>xmi.nodes()</code>) for local node point <code>k</code> within mesh element <code>e1</code> . A value of -1 means that there is no node point at this location.
String[] localDofNames()	The name for each local DOF.
double[][] localDofCoords()	The local coordinates for each local DOF (one column for each local DOF).
int[][] dofs()	0-based DOF numbers for all mesh elements of type <code>type()</code> . <code>dofs()[k][e1]</code> is the DOF number for local DOF <code>k</code> within mesh element <code>e1</code> . A value of -1 means that there is no DOF at this location.

6

Results

Detailed COMSOL Java API reference information is included for the result features and utility methods.

In this chapter:

- [About Results Commands](#)
- [Use of Data Sets](#)
- [Extracting Data](#)
- [Solution Selection](#)

About Results Commands

The following list includes the available commands for results evaluation and visualization:

- Animation
- ArrowVolume, ArrowSurface, ArrowLine
- AvVolume, AvSurface, AvLine
- Average, Integral, Maximum, Minimum
- Color
- Contour
- Contour (data set)
- CoordSysLine, CoordSysSurface, CoordSysVolume
- CutLine2D, CutLine3D
- CutPlane
- CutPoint1D, CutPoint2D, CutPoint3D
- Data
- Deform
- Edge2D, Edge3D
- Eval
- EvalGlobal
- EvalGlobalMatrix
- EvalPoint
- FarField
- Filter
- Function1D, Function2D, Function3D
- Global (numerical)
- Global (plot)
- Height
- Histogram
- HistogramHeight

- Image1D, Image2D, Image3D
- Interp
- IntVolume, IntSurface, IntLine
- Isosurface
- Isosurface (data set)
- Join
- Line
- LineGraph
- MaxMinVolume, MaxMinSurface, MaxMinLine
- MaxVolume, MaxSurface, MaxLine, MinVolume, MinSurface, MinLine
- Mesh
- Mesh (data set)
- Mesh (export)
- Mirror2D, Mirror3D
- Multislice
- Nyquist
- Parametric
- ParCurve2D, ParCurve3D
- ParSurface
- Particle
- Particle (evaluation)
- ParticleMass
- Player
- Plot
- PlotGroup1D, PlotGroup2D, PlotGroup3D
- PointGraph
- PolarGroup
- PrincipalSurface, PrincipalVolume
- Revolve1D, Revolve2D
- ScatterVolume, ScatterSurface
- Sector2D, Sector3D

- `Slice`
- `Solution`
- `Streamline`
- `Surface`
- `Surface (data set)`
- `Table`
- `Table (plot)`
- `TableHeight`
- `TableSurface`
- `Volume`

Commands Grouped by Function

ATTRIBUTES

FUNCTION	PURPOSE
Color	Color expression
Deform	Deformation
Filter	Filter
Height	Height
HistogramHeight	Height for histogram plots
TableHeight	Height for table plots

DATA SETS

FUNCTION	PURPOSE
Average , Integral , Maximum , Minimum	Evaluation data sets
Contour (data set)	Contour data set
CutLine2D , CutLine3D	Cut line data sets
CutPlane	Cut plane data set
CutPoint1D , CutPoint2D , CutPoint3D	Cut point data sets
Edge2D , Edge3D	Edge data sets.
Function1D , Function2D , Function3D	Function data set
Isosurface (data set)	Isosurface data set
Join	Join data set
Mesh (data set)	Mesh data set
Mirror2D , Mirror3D	Mirror data set
Parametric	Extends another data set by using a parameter as dimension
ParCurve2D , ParCurve3D	Parameterized curve data set
ParSurface	Parameterized face data set
Revolve1D , Revolve2D	Revolution data set
Sector2D , Sector3D	Sector symmetry data set
Solution	Solution data set
Surface (data set)	Surface data set

EXPORT FEATURES

FUNCTION	PURPOSE
Animation	Animation export
Data	Data export from data sets
Mesh (export)	Mesh export from data sets
Image1D , Image2D , Image3D	Image export
Player	Animation player
Plot	Plot export

NUMERICAL RESULTS

FUNCTION	PURPOSE
AvVolume , AvSurface , AvLine	Average
Eval	Generic evaluation
EvalGlobal	Global evaluation
EvalGlobalMatrix	Global matrix evaluation
EvalPoint	Evaluation in points
Global (numerical)	Generic evaluation
Interp	Interpolation
IntVolume , IntSurface , IntLine	Integration
MaxVolume , MaxSurface , MaxLine , MinVolume , MinSurface , MinLine	Maximum and minimum
Particle (evaluation)	Evaluation on particle trajectories

PLOTS

FUNCTION	PURPOSE
ArrowVolume , ArrowSurface , ArrowLine	Arrow plots
Contour	Contour plot
CoordSysLine , CoordSysSurface , CoordSysVolume	Coordinate system plot
FarField	Far-field plot
Global (plot)	Global plot
Histogram	Histogram plot

FUNCTION	PURPOSE
Isosurface	Isosurface plot
Line	Line plot
LineGraph	Line graph plot
MaxMinVolume, MaxMinSurface, MaxMinLine	Max/min marker plots
Mesh	Mesh plot
Multislice	Multislice plot
Nyquist	Nyquist plot.
Particle	Massless particle tracing plot
ParticleMass	Particle tracing plot with mass
PointGraph	Point graph plot
PrincipalSurface, PrincipalVolume	Principal stress/strain plots
ScatterVolume, ScatterSurface	Scatter plot
Slice	Slice plot
Streamline	Streamline plot
Surface	Surface plot
Table (plot)	Table plot
TableSurface	Table surface plot
Volume	Volume plot

TABLES

FUNCTION	PURPOSE
Table	Table containing real and imaginary data.



See Also

- [Results Analysis and Plots](#) in the *COMSOL Multiphysics Reference Guide*
- [Results Evaluation and Visualization](#) in the *COMSOL Multiphysics User's Guide*

Use of Data Sets

Table 6-1 shows applicability of data set output as data sets input. Rows correspond to data set output and columns to data set input. Check marks appear if the row data set output is accepted by the column data set. Evaluation indicates Average, Integral, Maximum, and Minimum data sets

TABLE 6-1: DATA SET INPUT VERSUS OUTPUT

DATA SETS output versus input	CONTOUR	CUTLINE2D	CUTLINE3D	CUTPLANE	CUTPOINT1D	CUTPOINT2D	CUTPOINT3D	EVALUATION	ISOSURFACE	JOIN	MESH	PARCURVE2D	PARCURVE3D	PARFACE	REVOLVE1D	REVOLVE2D	SOLUTION
Contour								√									
CutLine2D					√			√							√		
CutLine3D					√			√									
CutPlane	√	√				√		√				√				√	
CutPoint1D								√									
CutPoint2D								√									
CutPoint3D								√									
Edge2D																	√
Edge3D																	√
Evaluation								√									
Isosurface	√							√									
Join																	
Mesh	√	√	√	√	√	√	√	√	√			√	√	√	√	√	√
ParCurve2D				√	√			√	√								
ParCurve3D					√			√									
ParFace	√	√				√		√				√					
Revolve1D	√	√				√		√				√					
Revolve2D			√	√			√	√	√				√	√			
Sector2D		√		√						√	√				√		√
Sector3D			√	√					√	√	√					√	√
Solution	√	√	√	√	√	√	√	√	√			√	√	√	√	√	√
Surface	√																

Table 6-2 shows applicability of data set output as input to plot features. Rows correspond to data set output and columns to plot features. Checks appear if the data set output is accepted by the plot feature.

TABLE 6-2: DATA SET OUTPUT AS INPUT TO PLOT FEATURES

DATA SET OUTPUT versus	ARROW	CONTOUR	FARFIELD	GLOBAL	ISOSURFACE	LINE	LINEGRAPH	MESH	MULTISLICE	PARTICLETRACING	POINTGRAPH	SCATTER	SLICE	STREAMLINE	SURFACE	VOLUME
Contour	√					√										
CutLine2D	√					√	√					√				
CutLine3D	√					√	√					√				
CutPlane	√	√				√						√		√	√	
CutPoint1D											√					
CutPoint2D											√					
CutPoint3D											√					
Edge2D						√	√									
Edge3D						√	√									
Evaluation				√							√					
Isosurface	√	√				√										√
Join	√	√			√	√	√		√		√	√	√	√	√	√
Mesh	√	√			√	√	√	√	√		√	√	√	√	√	√
ParCurve2D	√					√	√									
ParCurve3D	√					√	√									
ParSurface	√	√				√						√		√	√	
Revolve1D	√	√				√						√		√	√	
Revolve2D	√	√			√	√			√			√	√	√	√	√
Sector2D	√	√				√						√		√	√	
Sector3D	√	√			√	√			√			√		√	√	√
Solution	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√
Surface	√	√				√						√	√		√	

Extracting Data

This section describes how to retrieve results or plot data directly through the Java API.

- [Retrieving Plot Data](#)
- [Retrieving Numerical Results](#)

Retrieving Plot Data

Each plot is made up of one or more *groups* or parts. Most plots contain only one group, such as [Surface](#) or [Line](#) plots, whereas for example [Slice](#) plots contain one group per slice. Retrieve the number of groups with the method

```
plot.getGroups(<renderIndex>)
```

where `plot` is any plot feature.

Retrieving the groups requires that you specify a *render index* for which you want the number of groups. Each plot is made up of one or more internal, or rendering, plot types. For example, particle tracing can contain both lines and spheres, which are separate rendering types. Most plot have only a single rendering type, in which case you can safely use 0 as the render index.

Extract the data contained in any plot feature using the following methods:

`p = plot.getVertices(<renderIndex>, <groupIndex>)` returns a float matrix containing one row for each dimension and one column for each vertex.

`t = getElements(<renderIndex>, <groupIndex>)` returns the indices to columns in `p` of a simplex mesh, each column in `t` representing a simplex.

`d = getData(<renderIndex>, <groupIndex>, <dataType>)` returns a float array containing the data for each point in `p`. The type of data to retrieve is given by the String `<dataType>: "Color", "Height",` and so forth.

To retrieve the available data types, use:

```
types = getDataTypes(<renderIndex>)
```

which returns a string array with the data types currently present in the plot.

EXAMPLE

```

int renderDataGroups = plot.getRenderGroups();

for (int ri = 0; ri < renderDataGroups; ri++) {

    String[] dataTypes = plot.getDataTypes(ri);
    int plotDataGroups = plot.getGroups(ri);
    for (int gi = 0; gi < plotDataGroups; gi++) {
        p = plot.getVertices(ri,gi);
        t = plot.getElements(ri,gi);
        //d = plot.getData(ri, gi, "Color");
        d = plot.getData(ri, gi, dataTypes[0]);
    }
}

```

Retrieving Numerical Results

It is possible to retrieve numerical results from any numerical feature, but there are a number of features especially designed for the Java API that are not present in the COMSOL Multiphysics GUI. These functions support multiple expressions, as well as some additional advanced properties, and a more convenient way to extract interpolated data. These two groups have slightly different access methods.

API-ONLY NUMERICAL FEATURES

TABLE 6-3: API-ONLY NUMERICAL FEATURE

FUNCTION	PURPOSE
Eval	Generic evaluation
Global (numerical)	Generic evaluation
Interp	Interpolation

`result = model.result().numerical(<ftag>).getData()` returns the real part of the result, recomputing the feature if necessary. `result` is a three-dimensional double matrix ordered `result[expression][solnum][coordinates]`.

`model.result().numerical(<ftag>).getData(<expressionIndex>)` returns the real part of the result for one expression, equivalent to `result[expressionIndex]`.

`result = model.result().numerical(<ftag>).getImagData()` returns the imaginary part of the result, recomputing the feature if necessary. `result` is a three-dimensional double matrix ordered `result[expression][solnum][coordinates]`.

`model.result().numerical(<ftag>).getImagData(<expressionIndex>)`
returns the imaginary part of the result for one expression, equivalent to
`result[expressionIndex]`.

`model.result().numerical(<ftag>).isComplex()` returns true if the result is complex. For models with outer solutions, `isComplex()` returns true if the result for the current value of `outersolnum` is complex.

`model.result().numerical(<ftag>).isComplex(<outersolnum>)` returns true if the result is complex for the given outer solution.

`model.result().numerical(<ftag>).getNData()` returns the number of data vectors in the result.

`model.result().numerical(<ftag>).getCoordinates()` returns the coordinates of the evaluation or interpolation.

`model.result().numerical(<ftag>).getElements()` returns indices to columns in `p` of a simplex mesh.

`model.result().numerical(<ftag>).getVertexElements()` returns indices to mesh elements for each point.

More details can be found in the documentation for each feature type.

STANDARD NUMERICAL FEATURES

TABLE 6-4: STANDARD NUMERICAL FEATURES, ALSO PRESENT IN THE COMSOL MULTIPHYSICS GUI

FUNCTION	PURPOSE
EvalGlobal	Global evaluation
EvalPoint	Evaluation in points
IntVolume , IntSurface , IntLine	Integration

`model.result().numerical(<ftag>).getReal()` returns the real result, recomputing the feature if necessary. Data is ordered such that one row contains data for all solution numbers. This is identical to (`<columnwise>`) when `<columnwise>` is `false`. If `<columnwise>` is `true`, the ordering is the opposite: each *column* contains the values for all solution numbers.

`model.result().numerical(<ftag>).getImag(<allocate>, <columnwise>)`
returns the imaginary part of complex result, recomputing the feature if necessary. If

`<allocate>` is `true`, a zero-valued matrix is allocated even when the result is real. `getImag()` uses `<allocate> true` and `<columnwise> false`.

`model.result().numerical(<ftag>).isComplex()` returns `true` if the result is complex. For models with outer solutions, `isComplex()` returns `true` if the result is complex for any of the currently set `outersolnum`.

`model.result().numerical(<ftag>).isComplex(<outersolnum>)` returns `true` if the result is complex for the given outer solution.

More details can be found in the documentation for each feature type.

Solution Selection

In this section:

- [About Selecting Solutions](#)
- [Selecting Solutions by Solution Number](#)
- [Selecting Solutions by Solution Level](#)
- [Choosing Solution Selection Method](#)

About Selecting Solutions

During the solution of, for example, time-dependent models or parametric sweep models, more than one solution is generated, and in order to do relevant postprocessing the correct set of solutions needs to be selected among them. How many solutions the result features can display vary, the main difference being between single-select and multi-select features. Single solution selection is available when only one solution at a time can be visualized, for example in 2D and 3D plots. In numerical features and 1D plots multi-select is used to be able to display plots relating to more than one parameter value at a time.

There are two ways to select solutions:

- by solution number
- by solution level

COMSOL keeps them synchronized as far as possible.

Selecting solutions by solution number is a method that is tightly linked to the solution representation used by the solvers. The solution level method is structurally similar to the set up of the studies. Setting any one property belonging to either method triggers a synchronisation in which all properties of that method are mapped to those of the other method. Mapping to the solution number method will always work, since that case is the more general. If, on the other hand, mapping to the solution level method fails, its properties are set to their default settings.

The `solrepresentation` property is set to "solnum" automatically if the solution number method is the only one able to represent the selection made. On solving it is set to "solutioninfo" if the solution level method can be used to represent the

previous selection. The `solutionrepresentation` property also decides which method is visible in the GUI.

Selecting Solutions by Solution Number

In the solution number method, the solutions are selected as a collection of inner and outer solutions. Inner solutions are generated by the solvers in one step. Outer solutions are generated by parametric sweeps wrapping the inner solutions. If there are more than one inner or outer parameter, they will be represented and selected as tuples, that is, combinations of values of the different parameters. Depending on the setup of the studies the parameters can be either filled (all combinations) or sparse (a selection of combinations). In the single-selection case the properties used are `solnum`, `t` and `outersolnum`. In the multi-selection case the valid properties are `innerinput`, `solnum`, `solnumindices`, `t`, `outerinput`, `outersolnum`, and `outerindices`.

Selecting Solutions by Solution Level

In contrast, the solution level method handles all filled parameters, that is, parameters defined individually in the studies, in one level each, up to a maximum of three levels. If more levels than that exist in the study the outermost levels are combined in the third level. Parameters that together form sparse tuples in the studies are always presented on the same level. In the single-selection case the properties used are `looplevel` and `interp`. In the multi-selection case the valid properties are `looplevelinput`, `looplevel`, `looplevelindices`, and `interp`.

Choosing Solution Selection Method

Whether selection is made using the solution level method or the solution number method, the ways of selecting solutions are the same. In the single-selection case, solutions are selected by parameter index or, if the solution is time dependent, by value. In the multiselection case there are a number of selection input options all, first, last, by index from existing values, by manual indices, or, in time-dependent cases, by time.

Which method to use is not self-evident. The solution level method is perhaps the more intuitive of the two because it attempts to treat each individual level separately. The solution number method, however, is more general, and can pin-point which tuples to use with more precision. The recommendation is to use the solution level

method wherever possible, and resort to the solution number method only if its special characteristics are needed.

Synopsis Animate plots.

Syntax

```
model.result().export().create(<ftag>,"Animation");
model.result().export(<ftag>).set(property, <value>);
model.result().export(<ftag>).run();
```

Description `model.result().export().create(<ftag>,"Animation")` creates an animation feature with the name `<ftag>`.

`result().export(<ftag>).set("plotgroup", <ptag>)` changes the source of the animation to the plot group named `<ptag>`.

The following properties are available:

TABLE 6-5: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
antialias	on off	on	Enable/disable antialiasing.
avifilename	string		The name of the AVI file produced if movietype is avi.
aviqual	double in [0,1]	0.75	The quality of the AVI file if movietype is avi; higher is better.
axes	on off	on	If options is on; enable/disable display of the coordinate axes. Used for 1D and 2D animations.
axisorientation	on off	on	If options is on; enable/disable display of the axis orientation indicator. Used for 3D animations.
background	current color	color	The background color.
bmpfilename	string		The name of the output file if imagetype is bmp.
customcolor	double array	{1, 1, 1}	If background is color; the red, green, and blue components of the background color.
cycletype	fullharm halfharm linear	fullharm	The transformation of the solution that is performed if sweeptype is dde.
flashfilename	string		The name of the Flash file produced if movietype is flash.
flashinterp	on off	on	Enable/disable interpolation between frames in the generated Flash file if movietype is flash.
flashopen	on off	off	Enable/disable opening of the generated Flash file in a browser if movietype is flash.
fontsize	integer	9	The font size.

TABLE 6-5: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
fps	positive integer	10	The number of frames per second.
giffilename	string		The name of the GIF file produced if movietype is gif.
gifopen	on off	off	Enable/disable opening of the generated GIF file in a browser if movietype is gif.
grid	on off	on	If options is on; enable/disable display of the coordinate grid. Used for 3D animations.
height	integer	480	The height in pixels of the frames of the animation.
imagefilename	string		The base name of generated images if type is movieseq; the generated images have names of the form base1.ext, base2.ext, ...
legend	on off	on	If options is on; enable/disable display of the legend.
logo	on off	on	If options is on; enable/disable display of the logotype.
movietype	gif flash avi	gif	The movie format to use if type is movie.
options	on off	off	Enable/disable optional components of the image.
outerinnertype	first last all	last	When solnumtype is outer, outerinnertype controls whether to plot all, the first or the last inner solution. Applicable only for parametric sweep models.
outersolnumarray	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models when solnumtype is outer.
outersolnumsingle	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models when solnumtype is inner.
parameter	string		The model parameter that varies if sweeptype is parameter.
pframes	positive integer	11	The number of frames if sweeptype is parameter.
plotgroup	string		The name of the plot group to animate.
pstart	double	0	The start parameter if sweeptype is parameter.

TABLE 6-5: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
pstop	double	1	The stop parameter if sweeptype is parameter.
resolution	integer	96	The frame resolution in dots per inch.
reverse	on off	off	Enable/disable reversal in time of the animation.
solnumtype	inner outer	inner	Whether to sweep over inner or outer solutions in a parametric sweep model.
solnum	integer array	all	The solutions to animate if sweeptype is solutions
staticframes	positive integer	11	The number of frames if sweeptype is dde.
sweeptype	solutions parameter dde	solutions	The parameter that varies during animation.
timeinterp	on off	off	Enable/disable sweep over interpolated times if sweeptype is solutions.
tint	double array		The interpolated times to animate if timeinterp is on.
title	on off	on	If options is on; enable/disable display of the title.
type	imageseq movie	movie	The kind of output that is produced.
width	integer	640	The width in pixels of the frames of the animation.

Example

Create a 2D animation of a surface and contour plot:

```
model.result().export().create("c2", "pg1", "Animation");
model.result().export("c2").set("plotgroup", "pg1");
```

Create animation:

```
model.result().export("c2").run();
```

See Also

[Image1D](#), [Image2D](#), [Image3D](#)

Synopsis	Arrow plots.
Syntax	<pre>model.result(<pgtag>).feature().create(<ftag>,"ArrowVolume"); model.result(<pgtag>).feature().create(<ftag>,"ArrowSurface"); model.result(<pgtag>).feature().create(<ftag>,"ArrowLine"); model.result(<pgtag>).feature(<ftag>).set(property, <value>); model.result(<pgtag>).feature(<ftag>).run();</pre>
Description	<p>model.result(<pgtag>).feature().create(<ftag>,"Arrow...") creates an arrow plot feature named <ftag>.</p>

Arrow plots are available in 2D and 3D. ArrowLine plots arrows on lines in 2D or 3D such as geometry boundaries in 2D or cut plane edges in 3D. ArrowSurface plots arrows on surfaces in 2D or 3D. ArrowVolume plots arrows in a 3D volume.

The following properties are available:

TABLE 6-6: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
arrowcount	positive integer	200	If placement is uniform: The approximate number of arrows. Available for ArrowEdge in 2D and 3D and for ArrowSurface in 3D.
arrowlength	normalized proportional logarithmic	proportional	The arrow scaling: Proportional uses the actual arrow length, normalized a unit length, and logarithmic a length proportional to the logarithm of the arrow length.
arrowtype	arrow cone	arrow	The type of arrow to draw.
arrowxmethod	number coord	number	Indicates whether the x-coordinates of the arrows should be specified by number of points to distribute evenly across the data or by coordinates. Available for ArrowSurface in 2D and ArrowVolume in 3D.
arrowymethod	number coord	number	Indicates whether the y-coordinates of the arrows should be specified by number of points to distribute evenly across the data or by coordinates. Available for ArrowSurface in 2D and ArrowVolume in 3D.
arrowzmethod	number coord	number	Indicates whether the z-coordinates of the arrows should be specified by number of points to distribute evenly across the data or by coordinates. Available for ArrowVolume in 3D.

TABLE 6-6: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
color	custom black blue cyan green magenta red white yellow	red	The color to use.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
customcolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use. Active when color is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
descr	string	Model-dependent	The description of the expressions in expr. Is used in the automatic title.
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string array of length 2 in 2D and 3 in 3D	Mode-dependent	The components to plot.
inheritarrow scale	boolean	true	If inheritplot is not none: Determines if arrow scale is inherited.
inheritcolor	boolean	true	If inheritplot is not none: Determines if the color is inherited.
inheritplot	none plot name	none	The plot that arrow scale, color, and deformation scale is inherited from.

TABLE 6-6: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
interp	double array	Time corresponding to last selected solnum for transient levels.	The time to use, for transient levels. Available when data is not parent and the underlying data is transient.
logrange	double > 1	100	If arrowlength is logarithmic: The ratio between the maximum arrow length and the arrow length below which no arrow is drawn.
looplevel	array of non-negative integers and strings	Last solution for transient or parametric solution for each level. Otherwise first solution for each level.	The index of the solution to use, per level, or interp, but only for transient solutions. Available when data is not parent and the underlying data has multiple solutions.
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
placement	elements uniform uniformanis	uniform	If uniform, then the arrows are distributed uniformly. If uniformanisotropic, then the arrows are distributed uniformly with weights taken from the weight property. If elements, then arrows are drawn in each element. Available for ArrowEdge in 2D and 3D and for ArrowSurface in 3D.
prefixintitle	string	Empty	Added prefix to contribution to title.
scale	positive double	1	If scaleactive is true: The length scale factor.
scaleactive	boolean	false	Whether to use manual scaling.
solnum	non-negative integer	Last solution for transient or parametric solution. Otherwise first solution.	The index of the solution to use. Available when data is not parent and the underlying data has multiple solutions.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
suffixintitle	string	Empty	Added suffix to contribution to title.

TABLE 6-6: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
t	double	Time corresponding to last selected solnum.	The time to use, for transient problems. Available when data is not parent and the underlying data is transient.
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when titletype is custom.
weight	double array	1	If placement is uniformani: The weights given to the different axis directions.
xnumber	non-negative integer	15 (3D), 7 (2D)	Number of points in the x-direction. Active when arrowxmethod is set to number. Available for ArrowSurface in 2D and ArrowVolume in 3D.
xcoord	double array	Empty	Absolute coordinates in the x-direction, active when arrowxmethod is set to coord. Available for ArrowSurface in 2D and ArrowVolume in 3D.
ynumber	integer	15 (3D), 7 (2D)	Number of points in the y-direction. Active when arrowymethod is set to number. Available for ArrowSurface in 2D and ArrowVolume in 3D.
ycoord	double array	Empty	Absolute coordinates in the z-direction, active when arrowymethod is set to coord. Available for ArrowSurface in 2D and ArrowVolume in 3D.
znumber	integer	15 (3D), 7 (2D)	Number of points in the z-direction. Active when arrowzmethod is set to number. Available for ArrowVolume in 3D.
zcoord	double array	Empty	Absolute coordinates in the z-direction, active when arrowzmethod is set to coord. Available for ArrowVolume in 3D.

Attributes [Color](#), [Deform](#), [Filter](#)

See Also [Line](#), [ScatterVolume](#), [ScatterSurface](#), [Surface](#), [Volume](#)

Synopsis

Averaging.

Syntax

```
model.result().numerical().create(<ftag>,"AvVolume");
model.result().numerical().create(<ftag>,"AvSurface");
model.result().numerical().create(<ftag>,"AvLine");
model.result().numerical(<ftag>).selection(...);
model.result().numerical(<ftag>).set(property, <value>);
model.result().numerical(<ftag>).getReal();
model.result().numerical(<ftag>).getReal(<columnwise>);
model.result().numerical(<ftag>).getReal(<outersolnum>);
model.result().numerical(<ftag>).getReal(<columnwise>,
    <outersolnum>);
model.result().numerical(<ftag>).getImag();
model.result().numerical(<ftag>).getImag(<allocate>,
    <columnwise>);
model.result().numerical(<ftag>).getImag(<outersolnum>);
model.result().numerical(<ftag>).getImag(<allocate>, <columnwise>,
    <outersolnum>);
model.result().numerical(<ftag>).isComplex();
model.result().numerical(<ftag>).isComplex(<outersolnum>);
model.result().numerical(<ftag>).setResult();
model.result().numerical(<ftag>).appendResult();
```

Description

`model.result().numerical().create(<ftag>,"AvVolume")` creates a volume average feature with the name `<ftag>`.

`model.result().numerical().create(<ftag>,"AvSurface")` creates a surface average feature with the name `<ftag>`.

`model.result().numerical().create(<ftag>,"AvLine")` creates a line average feature with the name `<ftag>`.

`model.result().numerical(<ftag>).getReal()` returns the real result, recomputing the feature if necessary. Data is ordered such that one row contains data for all solution numbers. This is identical to `(columnwise)` when `columnwise` is `false`. If `columnwise` is `true`, the ordering is the opposite: each `column` contains the values for all solution numbers.

`model.result().numerical(<ftag>).getImag(allocate, columnwise)` returns the imaginary part of complex result, recomputing the feature if necessary. If `allocate` is `true`, a zero-valued matrix is allocated even when the result is real. `getImag()` uses `allocate true` and `columnwise false`.

`model.result().numerical(<ftag>).isComplex()` returns `true` if the result is complex.

`<outersolnum>` is applicable only for parametric sweep solutions and is the index of each outer parametric solution.

`model.result().numerical(<ftag>).setResult()` and `model.result().numerical(<ftag>).appendResult()` evaluates the feature and set or append the result in the table indicated by the `table` property.

The following properties are available:

TABLE 6-7: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
<code>data</code>	<code>none</code> data set name	First compatible data set	The data set this feature refers to.
<code>dataseries</code>	<code>average</code> <code>integral</code> <code>maximum</code> <code>minimum</code> <code>none</code> <code>rms</code> <code>stddev</code> <code>variance</code>	<code>none</code>	The operation that is applied to the data series formed by the evaluation.
<code>const</code>	String array of property/value pairs	Empty	Parameters to use in the expressions.
<code>descr</code>	string	Model-dependent	The description of the expression in <code>expr</code> . Is used in the automatic title.
<code>differential</code>	<code>on</code> <code>off</code>	<code>on</code>	Whether the expression should be linearized at the linearization point. Applicable only if <code>evalmethod</code> is <code>harmonic</code>
<code>evalmethod</code>	<code>linpoint</code> <code>harmonic</code> <code>lintotal</code> <code>lintotalavg</code> <code>lintotalrms</code> <code>lintotalpeak</code>	<code>harmonic</code>	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
<code>expr</code>	string	Model-dependent	The expression to plot.
<code>innerinput</code>	<code>all</code> <code>first</code> <code>last</code> <code>manual</code> <code>manualindices</code> <code>interp</code>	<code>all</code>	How to input the solution to use. <code>manual</code> indicates that <code>solnum</code> is used. <code>manualindices</code> indicates that <code>solnumindices</code> is used. <code>interp</code> indicates that <code>t</code> is used.

TABLE 6-7: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
interp	double row matrix	Empty on all levels.	The times to use, for transient levels. Available when data is not parent and the underlying data is transient.
intorder	positive integer	4	The integration order.
intorderactive	on off	off	Whether to use manually specified integration order.
intsurface	on off	off	Compute surface integral. Available for line integration features of axisymmetric models.
intvolume	on off	off	Compute volume integral. Available for surface integration features of axisymmetric models.
looplevel	integer row matrix	All solutions on all levels	The solutions to use, per level.
looplevelindices	integer row matrix	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range (1, 1, 20). Applicable when looplevelinput is manualindices on a level.
looplevelinput	String array with all first last manual manualindices interp on each level	all on all levels	How to input the solution to use, per level. manual on a level indicates that looplevel is used on that level. manualindices on a level indicates that looplevelindices is used on that level. interp on a level indicates that interp is used on that level.
maximumobj	abs real	real	The value being maximized if dataseries is maximum.
method	auto integration summation	auto	The integration method.
minimumobj	abs real	real	The value being minimized if dataseries is minimum.
outerinput	all first last manual manualindices	all	How to input the outer solutions to use. Applicable only for parametric sweep models. manual indicates that outersolnum is used. manualindices indicates that outersolnumindices is used.
outersolnum	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models. Since the various outer solutions can have different number of solnum, the solnum property is not used.

TABLE 6-7: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
outersolnumindices	string or integer array	Empty	An alternate way to specify the outer solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when outerinput is manualindices.
solnum	non-negative integer array	All solutions	The solutions to use.
solnumindices	string or integer array	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when innerinput is manualindices.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
t	double array	Empty	The times to use. Available when the underlying solution is transient.
table	new table name	new	The table to use when calling setResult() or appendResult(). new indicates that a new table is created.
tablecols	inner outer data level1	data	Whether to use inner or outer solutions as columns in the table when calling setResult() or appendResult(). Applicable only for parametric sweep models. The level values (level1, level2, and so on) are the levels in the parametric sweep.
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.
unit	string	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.

See Also [IntVolume](#), [IntSurface](#), [IntLine](#)

Average, Integral, Maximum, Minimum

Purpose	Evaluation data sets.
Syntax	<pre> model.result().dataset().create(<dtag>, "Average"); model.result().dataset().create(<dtag>, "Integral"); model.result().dataset().create(<dtag>, "Maximum"); model.result().dataset().create(<dtag>, "Minimum"); model.result().dataset(<dtag>).set(property, <value>); model.result().dataset(<dtag>).selection(...); </pre>
Description	<p><code>model.result().dataset().create(<dtag>, "Average")</code> creates a data set named <code><dtag></code> that computes the average of another data set.</p> <p><code>model.result().dataset().create(<dtag>, "Integral")</code> creates a data set named <code><dtag></code> that computes the average of another data set.</p> <p><code>model.result().dataset().create(<dtag>, "Maximum")</code> creates a data set named <code><dtag></code> that computes the maximum of another data set.</p> <p><code>model.result().dataset().create(<dtag>, "Minimum")</code> creates a data set named <code><dtag></code> that computes the minimum of another data set.</p> <p>The following properties are available:</p>

TABLE 6-8: COMMON PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
name	String	None	The name of this feature
data	None data set name	First compatible data set	The data set this feature refers to.
level	fromdataset volume surface edge point	fromdataset	The element dimension; if fromdataset, then the highest dimension supported by the data set is used.
descr	string	Model-dependent.	The description of the expression in expr. Is used in the automatic title.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic

TABLE 6-8: COMMON PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent.	The expression to plot.

The following properties are available:

TABLE 6-9: ADDITIONAL PROPERTY/VALUE PAIRS FOR AVERAGE AND INTEGRAL

PROPERTY	VALUE	DEFAULT	DESCRIPTION
intmethod	auto integration summation	auto	The integration method.
intorderactive	on off	off	Whether to use manually specified integration order.
intorder	Positive integer	4	The manually set integration order.

Purpose Color expression attribute.

Syntax `model.result(<pgtag>).feature(<ftag>).feature().create(<atag>, "Color");`
`model.result(<pgtag>).feature(<ftag>).feature(<atag>).set(property, <value>);`

Description `model.result(<pgtag>).feature(<ftag>).feature().create(<atag>, "Color")` creates a color expression attribute named <atag> belonging to the plot feature <ftag>.

Use color expressions to add a coloring to the shapes defined by a plot. Color expressions can be added to surface plots, line plots, volume plots, arrow plots, contour plots, isosurface plots, particle tracing plots, and streamline plots.

The following properties are available:

TABLE 6-10: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
color	custom black blue cyan green magenta red white yellow	red	The uniform color to use. Active when coloring is uniform.
coloring	colortable uniform	colortable	How to color the parent plot.
colorlegend	on off	on	Whether to show color legend, when coloring is set to colortable.
colortable	colortable name	Rainbow	The color table to use when colormethod is set to colortable.
colortablerev	on off	off	Whether to reverse to color table when colormethod is set to colortable.
colortablesym	on off	off	Whether to symmetrize the color range around 0 when colormethod is set to colortable.
customcolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use. Active when color is set to custom.
descr	string	Model-dependent.	The description of the expression in expr. Is used in the automatic title.
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.

TABLE 6-10: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent.	The expression to plot.
expressionintitle	on off	off	Whether the title contribution should contain the expression when titletype is custom.
prefixintitle	string	Empty	Added prefix to contribution to title.
rangecoloractive	on off	off	Whether to use the manual color range specified in rangecolormin and rangecolormax. The color range specifies the minimum and maximum value in the plotted colors. Default is the minimum and maximum data values.
rangecolormax	double	Plot-dependent	The maximum color range value. Active when rangecoloractive is on.
rangecolormin	double	Plot-dependent	The minimum color range value. Active when rangecoloractive is on.
rangedataactive	on off	off	Whether to use the manual data range specified in rangedatamin and rangedatamax. Values outside the data range are not plotted.
rangedatamax	double	Plot-dependent	The maximum data value. Active when rangedataactive is on.
rangedatamin	double	Plot-dependent	The minimum data value. Active when rangedataactive is on.
suffixintitle	string	Empty	Added suffix to contribution to title.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.

TABLE 6-10: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
typeintitle	on off	on	Whether the title contribution should contain the type when titletype is custom.
unit	string	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.
unitintitle	on off	on	Whether the title contribution should contain the unit when titletype is custom.

See Also

[Deform](#), [Height](#), [ArrowVolume](#), [ArrowSurface](#), [ArrowLine](#), [Contour](#), [Isosurface](#), [Particle](#), [ParticleMass](#), [Streamline](#)

Synopsis Contour plot.

Syntax

```
model.result(<pgtag>).feature().create(<ftag>, "Contour");
model.result(<pgtag>).feature(<ftag>).set(property, <value>);
model.result(<pgtag>).feature(<ftag>).run();
```

Description `model.result(<pgtag>).feature().create(<ftag>, "Contour")` creates a contour plot feature named `<ftag>` belonging to the plot group `<pgtag>`. Contour plots are available in 2D and 3D plot groups. Contour lines are colored by their level. Add a color expression attribute to color them by an arbitrary expression.

The following properties are available:

TABLE 6-11: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
color	custom black blue cyan green magenta red white yellow	red	The uniform color to use. Active when coloring is uniform.
coloring	colortable uniform	colortable	How to color the contours.
colorlegend	on off	on	Whether to show color legend, when coloring is set to colortable.
colortable	colortable name	Rainbow	The color table to use when colormethod is set to colortable.
colortablerev	on off	off	Whether to reverse to color table when colormethod is set to colortable.
colortablesym	on off	off	Whether to symmetrize the color range around 0 when colormethod is set to colortable.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
contourlabels	on off	off	Whether to display labels next to the contour lines. Only applicable if contourtype is lines.
contourtype	lines filled	lines	Whether to display lines for each level or a surface with bands of color.
customcolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use. Active when color is set to custom.

TABLE 6-11: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
customlabelcolor	RGB-triplet	{1,0,0} or last used color.	If contourlabels is on and labelcolor is custom: The label color to use.
data	none parent data set name	parent	The data set this feature refers to.
descr	string	Model-dependent.	The description of the expression in expr. Is used in the automatic title.
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent.	The expression to plot.
expressionintitle	on off	off	Whether the title contribution should contain the expression when titletype is custom.
inheritcolor	boolean	true	If inheritplot is not none: Determines if the color is inherited.
inheritdeformscale	boolean	true	If inheritplot is not none: Determines if the deformation scale is inherited.
inheritplot	none plot name	none	The plot that color and deformation scale is inherited from.
interp	double array	Time corresponding to last selected solnum for transient levels.	The time to use, for transient levels. Available when data is not parent and the underlying data is transient.
levelmethod	number levels	number	How to specify contour levels.

TABLE 6-11: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
labelcolor	custom black blue cyan green magenta red white yellow	red	If <code>contourlabels</code> is on: The label color to use.
labelprec	positive	integer	If <code>contourlabels</code> is on: The number of significant digits in the labels.
levels	double array		The specific levels to plot. Active when <code>levelmethod</code> equals <code>levels</code> .
looplevel	array of non-negative integers and strings	Last solution for transient or parametric solution for each level. Otherwise first solution for each level.	The index of the solution to use, per level, or <code>interp</code> , but only for transient solutions. Available when data is not parent and the underlying data has multiple solutions.
number	positive integer	20	Total number of contour levels. Active when <code>levelmethod</code> equals <code>number</code> .
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
prefixintitle	string	Empty	Added prefix to contribution to title.
rangecoloractive	on off	off	Whether to use the manual color range specified in <code>rangecolormin</code> and <code>rangecolormax</code> . The color range specifies the minimum and maximum value in the plotted colors. Default is the minimum and maximum data values.
rangecolormax	double	Plot-dependent	The maximum color range value. Active when <code>rangecoloractive</code> is on.
rangecolormin	double	Plot-dependent	The minimum color range value. Active when <code>rangecoloractive</code> is on.
rangedataactive	on off	off	Whether to use the manual data range specified in <code>rangedatamin</code> and <code>rangedatamax</code> . Values outside the data range are not plotted.
rangedatamax	double	Plot-dependent	The maximum data value. Active when <code>rangedataactive</code> is on.

TABLE 6-11: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
rangedatamin	double	Plot-dependent	The minimum data value. Active when rangedataactive is on.
recover	off pprint ppr	off	The derivative recovery method.
refine	non-negative integer	1	The element refinement to use, if resolution is set to manual. Bear in mind that this is the refinement used for the base data set, so the number of elements in the model can increase radically if the plot uses, for example, a revolve data set.
resolution	norefine coarse normal fine finer extrafine custom	normal	Controls the plot's resolution. A finer setting results in a higher resolution by modifying the internally computed default refinement. Use custom to enter your own refinement in the refine property.
smooth	none internal everywhere	internal	Smoothing settings.
solnum	Non-negative integer	Last solution for transient or parametric solution. Otherwise first solution.	The index of the solution to use. Available when data is not parent and the underlying data has multiple solutions.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
suffixintitle	string	Empty	Added suffix to contribution to title.
t	double	Time corresponding to last selected solnum.	The time to use, for transient problems. Available when data is not parent and the underlying data is transient.
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.
title	string	The auto-title.	The title to use when titletype is manual.

TABLE 6-11: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
<code>titletype</code>	<code>auto</code> <code>custom</code> <code>manual</code> <code>none</code>	<code>auto</code>	<code>auto</code> if the title contribution should be computed automatically, possibly using the group's customization. <code>custom</code> if the title contribution should be computed automatically, but customized. <code>manual</code> if the manual title contribution should be used (the <code>title</code> property). <code>none</code> if no title contribution should be used.
<code>typeintitle</code>	<code>on</code> <code>off</code>	<code>on</code>	Whether the title contribution should contain the <code>type</code> when <code>titletype</code> is <code>custom</code> .
<code>unit</code>	<code>string</code>	Model-dependent	The unit to use for the expression in <code>expr</code> . If the old unit is not valid when the expression changes, the <code>unit</code> property is reset to default.
<code>unitintitle</code>	<code>on</code> <code>off</code>	<code>on</code>	Whether the title contribution should contain the <code>unit</code> when <code>titletype</code> is <code>custom</code> .
<code>wireframe</code>	<code>on</code> <code>off</code>	<code>off</code>	Whether to plot filled elements or only their edges.

Attributes [Color](#), [Deform](#), [Filter](#)

See Also [Contour \(data set\)](#), [Surface](#)

Contour (data set)

Synopsis	Contour data set.
Syntax	<pre>model.result().dataset().create(<dtag>, "Contour"); model.result().dataset(<dtag>).set(property, <value>);</pre>
Description	<p><code>model.result().dataset().create(<dtag>, "Contour")</code> creates a contour data set feature named <code><dtag></code>.</p> <p>Contour lines are in general not parametrizable, and this limits the set of plots and transformations that can applied to them.</p> <p>The following properties are available:</p>

TABLE 6-12: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
data	none data set name	First compatible data set	The data set this feature refers to.
descr	string		Description of expr.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if <code>evalmethod</code> is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	u	Expression to find constant level for.
level	double	0	Level that defines the data set. Active when <code>levelmethod</code> is level.
levelmethod	number levels	number	How to specify contour levels.
number	positive integer	20	Total number of contour levels. Active when <code>levelmethod</code> is number.
unit	string		Unit of expr. If the old unit is not valid when the expression changes, the unit property is reset to default.

See Also [Contour](#)

Synopsis Coordinate system plot.

Syntax

```
model.result(<pgtag>).feature().create(<ftag>, "CoordSysVolume");
model.result(<pgtag>).feature().create(<ftag>, "CoordSysSurface");
model.result(<pgtag>).feature().create(<ftag>, "CoordSysLine");

model.result(<pgtag>).feature(<ftag>).set(property, <value>);
model.result(<pgtag>).feature(<ftag>).run();
```

Description

model.result(<pgtag>).feature().create(<ftag>, "CoordSysVolume") creates a coordinate system plot named <ftag> belonging to the plot group <pgtag>.

The following properties are available:

TABLE 6-13: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
arrowcount	positive integer	200	If placement is uniform: The approximate number of points to display coordinate systems in. Available for CoordSysLine in 2D and 3D and for CoordSysSurface 3D.
arrowlength	normalized proportional logarithmic	proportional	The arrow scaling: Proportional uses the actual arrow length, normalized a unit length, and logarithmic a length proportional to the logarithm of the arrow length.
arrowtype	arrow cone	arrow	The type of arrow to draw.
arrowxmethod	number coord	number	Indicates whether the x-coordinates of the arrows should be specified by number of points to distribute evenly across the data or by coordinates. Available for CoordSysSurface in 2D and CoordSysVolume in 3D.
arrowymethod	number coord	number	Indicates whether the y-coordinates of the arrows should be specified by number of points to distribute evenly across the data or by coordinates. Available for CoordSysSurface in 2D and CoordSysVolume in 3D.
arrowzmethod	number coord	number	Indicates whether the z-coordinates of the arrows should be specified by number of points to distribute evenly across the data or by coordinates. Available for CoordSysVolume in 3D.
data	none parent data set name	parent	The data set this feature refers to.

TABLE 6-13: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
descr	string		If mode is matrix: The description of the matrix expression to plot. Available for CoordSysSurface in 2D and CoordSysVolume in 3D.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string		If mode is matrix: The matrix expression to plot. Available for CoordSysSurface in 2D and CoordSysVolume in 3D.
inheritarrow scale	boolean	true	If inheritplot is not none: Determines if arrow scale is inherited.
inherit color	boolean	true	If inheritplot is not none: Determines if the color is inherited.
inheritplot	none plot name	none	The plot that arrow scale, color, and deformation scale is inherited from.
interp	double array	Time corresponding to last selected solnum for transient levels.	The time to use, for transient levels. Available when data is not parent and the underlying data is transient.
logrange	double > 1	100	If arrowlength is logarithmic: The ratio between the maximum arrow length and the arrow length below which no arrow is drawn.
looplevel	array of non-negative integers and strings	Last solution for transient or parametric solution for each level. Otherwise first solution for each level.	The index of the solution to use, per level, or interp, but only for transient solutions. Available when data is not parent and the underlying data has multiple solutions.
mode	system matrix	system	Chooses whether what's plotted is taken from a coordinate system or a matrix variable. Available for CoordSysSurface in 2D and CoordSysVolume in 3D.

TABLE 6-13: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
placement	elements uniform uniformani	uniform	If uniform, then the arrows are distributed uniformly. If uniformanisotropic, then the arrows are distributed uniformly with weights taken from the weight property. If elements, then arrows are drawn in each element. Available for CoordSysLine in 2D and 3D and for CoordSysSurface 3D.
scale	positive double	1	If scaleactive is true: The length scale factor.
scaleactive	boolean	false	Whether to use manual scaling.
solnum	non-negative integer	Last solution for transient or parametric solution. Otherwise first solution.	The index of the solution to use. Available when data is not parent and the underlying data has multiple solutions.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
sys	none coordinate system name	none	The coordinate system to plot.
t	double	Time corresponding to last selected solnum.	The time to use, for transient problems. Available when data is not parent and the underlying data is transient.
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. manual if the manual title should be used (the title property). none if no title should be displayed.
type	stress strain	stress	Selection between principal stress and principal strain plot.
weight	double array	1	If placement is uniformani: The weights given to the different axis directions.

TABLE 6-13: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
xnumber	non-negative integer	15 (3D), 7 (2D)	Number of points in the x-direction. Active when arrowxmethod is set to number. Available for CoordSysSurface in 2D and CoordSysVolume in 3D.
xcoord	double array	Empty	Absolute coordinates in the x-direction, active when arrowxmethod is set to coord. Available for CoordSysSurface in 2D and CoordSysVolume in 3D.
ynumber	integer	15 (3D), 7 (2D)	Number of points in the y-direction. Active when arrowymethod is set to number. Available for CoordSysSurface in 2D and CoordSysVolume in 3D.
ycoord	double array	Empty	Absolute coordinates in the z-direction, active when arrowymethod is set to coord. Available for CoordSysSurface in 2D and CoordSysVolume in 3D.
znumber	integer	15 (3D), 7 (2D)	Number of points in the z-direction. Active when arrowzmethod is set to number. Available for CoordSysVolume in 3D.
zcoord	double array	Empty	Absolute coordinates in the z-direction, active when arrowzmethod is set to coord. Available for CoordSysVolume in 3D.

Synopsis	Cut line data set
Syntax	<pre>model.result().dataset().create(<dtag>, "CutLine2D"); model.result().dataset().create(<dtag>, "CutLine3D"); model.result().dataset(<dtag>).set(property, <value>);</pre>
Description	<p><code>model.result().dataset().create(<dtag>, "CutLine2D")</code> creates a 2D cut line data set feature named <code><dtag></code>.</p> <p><code>model.result().dataset().create(<dtag>, "CutLine3D")</code> creates a 3D cut line data set feature named <code><dtag></code>.</p> <p>The following properties are available:</p>

TABLE 6-14: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
bndsnap	boolean	false	If true, each point is snapped to the closest boundary.
bounded	on off	on	Active when method equals twopoint, this property specifies if the line should be bounded by the two points or extend infinitely.
data	none data set name	First compatible data set	The data set this feature refers to.
genparaactive	on off	off	Decides if parallel lines should be drawn.
genparadist	double array	{ }	Active when genparaactive is on, this property contains the distances from the extra parallel lines to the base line.
genpoints	double matrix	{{0, 0, 0}, {1,0,0}}	Active when method equals twopoint, this property contains the coordinates of the two points in the two rows of the matrix.
method	twopoint pointdir	twopoint	Decides if the line should be specified by two points or through one point and a direction.
pddir	double array	Zero vector	Active when method equals pointdir, this property contains the direction.
pdpoint	double array	Zero vector	Active when method equals pointdir, this property contains the coordinates of the point.
spacevars	String array of length 1	Created from the feature tag.	The name of the variable that evaluates to the line's parameterization.

See Also [LineGraph](#)

- Synopsis** Cut plane data set.
- Syntax** `model.result().dataset().create(<dtag>, "CutPlane");`
`model.result().dataset(<dtag>).set(property, <value>);`
- Description** `model.result().dataset().create(<dtag>, "CutPlane")` creates a cut plane data set with the name `<dtag>`.

The following properties are available:

TABLE 6-15: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
data	none data set name	First compatible data set	The data set this feature refers to.
genparaactive	on off	off	Decides if parallel lines should be drawn.
genparadist	double array	{}	Active when genparaactive is on, this property contains the distances from the extra parallel planes to the base plane.
genmethod	threepoint pointnormal	threepoint	Active when planetype equals general, this property indicates whether the plane should be specified by three points or through one point and a normal.
genpoints	double matrix	{{0, 0, 0}, {1, 0, 0}, {0, 1, 0}}	Active when method equals threepoint, this property contains the coordinates of the three points in the rows of the matrix.
genpnpoint	double array of length three	Zero vector	Active when genmethod equals pointnormal, this property contains the coordinates of the point.
hasnormal	on off	off	Decides if variables for the plane's normal component are defined.
genpnvec	double array of length three	Zero vector	Active when genmethod equals pointnormal, this property contains the normal vector.
normal	String array of length three	Created from the feature tag.	If hasnormal is on: The names of the variables that can be used to evaluate the plane's normal.
planetype	quick general	quick	Specify plane type.
quickplane	xy yz zx yx zy xz	yz	Specify quick plane type. Active when planetype is quick.
quickx	double	0	x-coordinate if planetype is yz or zy.
quicky	double	0	y-coordinate if planetype is zx or xz.

TABLE 6-15: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
quickz	double	0	z-coordinate if planetype is xy or yx.
spacevars	String array of length 2	Created from the feature tag.	The names of the variables that evaluate to the plane's parameterization.

Examples

This example creates a cut plane and plots a surface plot and a contour plot on it.

Create a solution data set and set it to point to the named solution Sol1 from a solver sequence:

```
model.result().dataset().create("dset1", "Solution");
model.result().dataset("dset1").set("solution", "sol1");
```

Create 3D plot group:

```
result().create("pg1", 3);
result().dataset().create("cutp1", "CutPlane");
result().dataset("cutp1").set("data", "dset1");

result("pg1").feature().create("surf1", "Surface");
result("pg1").feature("surf1").set("data", "cutp1");

result("pg1").feature().create("cont1", "Contour");
result("pg1").feature("cont1").set("data", "cutp1");
```

See Also

[Surface](#)

Synopsis	Cut point data set.
Syntax	<pre>model.result().dataset().create(<dtag>, "CutPoint1D"); model.result().dataset().create(<dtag>, "CutPoint2D"); model.result().dataset().create(<dtag>, "CutPoint3D"); model.result().dataset(<dtag>).set(property, <value>);</pre>
Description	<p><code>model.result().dataset().create(<dtag>, "CutPoint1D")</code> creates a 1D cut point data set with the name <code><dtag></code>.</p> <p><code>model.result().dataset().create(<dtag>, "CutPoint2D")</code> creates a 2D cut point data set with the name <code><dtag></code>.</p> <p><code>model.result().dataset().create(<dtag>, "CutPoint3D")</code> creates a 3D cut point data set with the name <code><dtag></code>.</p> <p>A cut point is the 0D analog of cut lines and cut planes. A difference compared to cut lines and cut planes is that a cut point feature can contain an arbitrary number of points. Cut points can exist in 1D, 2D, and 3D.</p>

The following properties are available:

TABLE 6-16:

NAME	VALUE	DEFAULT	DESCRIPTION
<code>bndsnap</code>	boolean	false	If true, each point is snapped to the closest boundary.
<code>data</code>	none data set name	First compatible data set	The data set this feature refers to.
<code>gridx</code>	double array		If method is grid: The grid x-coordinates.
<code>filename</code>	string		If method is file: The file that contains the point coordinates in a spreadsheet format.
<code>gridy</code>	double array		If method is grid: The grid y-coordinates. (Only for CutPoint2D and CutPoint3D)
<code>gridz</code>	double array		If method is grid: The grid z-coordinates. (Only for CutPoint3D)
<code>method</code>	coords file grid regulargrid	coords	The method used for defining the points.
<code>pointx</code>	double array	[]	If method is coords: The point x-coordinates.
<code>pointy</code>	double array	[]	If method is coords: The point y-coordinates. (Only for CutPoint2D and CutPoint3D)

TABLE 6-16:

NAME	VALUE	DEFAULT	DESCRIPTION
pointz	double array	[]	If method is coords: The point z-coordinates. (Only for CutPoint3D)
regulargridx	integer	10	If method is regulargrid: The number of grid points in the x-direction.
regulargridy	integer	10	If method is regulargrid: The number of grid points in the y-direction. (Only for CutPoint2D and CutPoint3D)
regulargridz	integer	10	If method is regulargrid: The number of grid points in the z-direction. (Only for CutPoint3D)

See Also[PointGraph](#)

Synopsis Data export.

Syntax

```
model.result().export().create(<ftag>, "Data");
model.result().export().create(<ftag>, <dtag>, "Data");
model.result().export(<ftag>).set(property, <value>);
model.result().export(<ftag>).run();
```

Description

model.result().export().create(<ftag>, "Data") creates a data export feature with the name <ftag>.

model.result().export().create(<ftag>, <dtag>, "Data") creates a data export feature with the name <ftag> for the data set <dtag>.

The following properties are available:

TABLE 6-17: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
coordfilename	string		If location is file: The file that contains coordinates to evaluate in.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
data	string		The name of the data set to export.
descr	string array		Descriptions of the expressions in expr.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string array		The expressions to evaluate and export.
filename	string		The output file.
fullprec	on off	on	If on, floating-point numbers are written in full precision, otherwise they are written with six significant digits.
gporder	poitive integer	1	If pattern is gauss: The Gauss point order.
gridstruct	grid spreadsheet	spreadsheet	If location is grid or regulargrid: The format of the exported data.

TABLE 6-17: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
gridx1	double array		If location is grid and the data set is 1D: x-coordinates to evaluate in.
gridx2	double array		If location is grid and the data set is 2D: x-coordinates to evaluate in.
gridy2	double array		If location is grid and the data set is 2D: y-coordinates to evaluate in.
gridx3	double array		If location is grid and the data set is 3D: x-coordinates to evaluate in.
gridy3	double array		If location is grid and the data set is 3D: y-coordinates to evaluate in.
gridz3	double array		If location is grid and the data set is 3D: z-coordinates to evaluate in.
header	on off	off	Enable/disable a data header in the output file.
lagorder	integer	1	The Lagrange point order to use if resolution is custom
level	fromdataset volume surface line point	fromdataset	The geometry level to evaluate on.
location	fromdataset file grid regulargrid	fromdataset	The points evaluated in.
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
pattern	gauss lagrange	lagrange	If the data set is a solution: Specifies if evaluation takes place in Lagrange points or in Gauss points.
regulargridx 1	positive integer	10	If location is regulargrid and the data set is 1D: The number of grid points along the x-axis.
regulargridx 2	positive integer	10	If location is regulargrid and the data set is 2D: The number of grid points along the x-axis.
regulargridy 2	positive integer	10	If location is regulargrid and the data set is 2D: The number of grid points along the y-axis.
regulargridx 3	positive integer	10	If location is regulargrid and the data set is 3D: The number of grid points along the x-axis.
regulargridy 3	positive integer	10	If location is regulargrid and the data set is 3D: The number of grid points along the y-axis.

TABLE 6-17: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
regulargridz 3	positive integer	10	If location is regulargrid and the data set is 3D: The number of grid points along the z-axis.
resolution	normal fine finer custom		The evaluation resolution.
sdim	fromdataset 0 1 2 3	fromdataset	The space dimension to evaluate the underlying data set in.
solnum	integer array		Solution number to take values from.
sort	on off	off	Enable/disable sorting of the points with respect to the coordinates.
struct	sectionwise spreadsheet		If location is fromdataset: Format of the exported data.
t	String		Time to evaluate in if timeinterp is on.
timeinterp	on off	off	Enable/disable explicit time to evaluate in.

See Also

[HistogramHeight](#)

Synopsis	Deformation attribute.
Syntax	<pre>model.result(<pgtag>).feature(<ftag>).feature().create(<atag>, "Deform"); model.result(<pgtag>).feature(<ftag>).feature(<atag>).set(property, <value>);</pre>
Description	<pre>model.result(<pgtag>).feature(<ftag>).feature().create(<atag>, "Deform")</pre> <p>creates a deformation attribute feature with the name <code><atag></code>, belonging to the feature <code><ftag></code>.</p>

Deformation attributes deform the coordinates of a plot feature according to an expression. The deformation attribute can be added to arrow plots, contour plots, isosurface plots, particle plots, slice plots, streamline plots, surface plots, volume plots, and mesh plots.

The following properties are available:

TABLE 6-18: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
descr	string	Model-dependent	The description of the expression in <code>expr</code> . Is used in the automatic title.
description intitle	on off	on	Whether the title contribution should contain the description when <code>titletype</code> is <code>custom</code> .
differentia l	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if <code>evalmethod</code> is <code>harmonic</code>
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent	The expression to plot.
prefixintitle	string	Empty	Added prefix to contribution to title.
scale	positive double	Model-dependent	The scale factor for the deformation.
scaleactive	on off	off	Whether to use the automatically computed scale, or the scale in the <code>scale</code> property.

TABLE 6-18: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
suffixintitle	string	Empty	Added suffix to contribution to title.
title	string	The auto-title.	The title to use when <code>titletype</code> is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the <code>title</code> property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when <code>titletype</code> is custom.
unit	string	Model-dependent	The unit to use for the expression in <code>expr</code> . If the old unit is not valid when the expression changes, the <code>unit</code> property is reset to default.

See Also

[Color](#), [Height](#), [ArrowVolume](#), [ArrowSurface](#), [ArrowLine](#), [Contour](#), [Contour](#), [Isosurface](#), [Line](#), [Mesh](#), [Particle](#), [ParticleMass](#), [ScatterVolume](#), [ScatterSurface](#), [Slice](#), [Streamline](#), [Surface](#), [Volume](#).

Synopsis Edge data set.

Syntax

```
model.result().dataset().create(<dtag>, "Edge2D");
model.result().dataset().create(<dtag>, "Edge3D");

model.result().dataset(<dtag>).set(property, <value>);
```

Description `model.result().dataset().create(<dtag>, "Edge2D")` creates a 2D edge data set with the name `<dtag>`.

The edge data set makes it possible to evaluate edge of a model in 1D or the model's dimension.

The following properties are available:

TABLE 6-19: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
data	none data set name	First compatible data set	The solution data set this feature refers to.

Synopsis	Evaluate expressions in domains.
Syntax	<pre>model.result().numerical().create(<ftag>,"Eval"); model.result().numerical(<ftag>).selection(...); model.result().numerical(<ftag>).set(property, <value>); model.result().numerical(<ftag>).getData(); model.result().numerical(<ftag>).getData(<expressionIndex>); model.result().numerical(<ftag>).getImagData(); model.result().numerical(<ftag>).getImagData(<expressionIndex>); model.result().numerical(<ftag>).isComplex(); model.result().numerical(<ftag>).isComplex(<outersolnum>); model.result().numerical(<ftag>).getNData(); model.result().numerical(<ftag>).getCoordinates(); model.result().numerical(<ftag>).getElements(); model.result().numerical(<ftag>).getVertexElements(); model.result().numerical(<ftag>).run();</pre>
Description	<p><code>model.result().numerical().create(<ftag>,"Eval")</code> creates an evaluation feature with the name <code><ftag></code>.</p> <p><code>Eval</code> is a feature made specifically for users of the COMSOL Java API and does not appear in the COMSOL Multiphysics GUI. <code>Interp</code> combines cut points and evaluation features, as well as allowing evaluation of arbitrary data sets. It supports multiple expressions and some additional advanced properties not available when using cut points and EvalPoint features.</p> <p><code>result = model.result().numerical(<ftag>).getData()</code> returns the real part of the result, recomputing the feature if necessary. <code>result</code> is a three-dimensional double matrix ordered <code>result[expression][solnum][coordinates]</code>.</p> <p><code>model.result().numerical(<ftag>).getData(<expressionIndex>)</code> returns the real part of the result for one expression, equivalent to <code>result[expressionIndex]</code>.</p> <p><code>result = model.result().numerical(<ftag>).getImagData()</code> returns the imaginary part of the result, recomputing the feature if necessary. <code>result</code> is a three-dimensional double matrix ordered <code>result[expression][solnum][coordinates]</code>.</p> <p><code>model.result().numerical(<ftag>).getImagData(<expressionIndex>)</code> returns the imaginary result for one expression, equivalent to <code>result[expressionIndex]</code>.</p>

`model.result().numerical(<ftag>).isComplex()` returns true if the result is complex.

`<outersolnum>` is applicable only for parametric sweep solutions and is the index of each outer parametric solution.

`model.result().numerical(<ftag>).getNData()` returns the number of data vectors in the result.

`model.result().numerical(<ftag>).getCoordinates()` returns node point coordinates.

`model.result().numerical(<ftag>).getElements()` returns indices to columns in `p` of a simplex mesh.

`model.result().numerical(<ftag>).getVertexElements()` returns indices to mesh elements for each point.

The following properties are available:

TABLE 6-20: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
data	none data set name	First compatible data set	The data set this feature refers to.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string array	Model-dependent	The expressions to evaluate.
complexfun	on off	on	Use complex-valued functions with real input
gporder	poitive integer	1	If pattern is gauss: The Gauss point order.
matherr	on off	off	Error for undefined operation or variable

TABLE 6-20: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
refine	auto integer	auto	Refinement of elements for evaluation points
recover	off pprint ppr	off	The derivative recovery method.
pattern	gauss lagrange	lagrange	Specifies if evaluation takes place in Lagrange points or in Gauss points.
phase	double	0	Evaluate solution at this angle, given in degrees.
smooth	none internal everywhere	internal	Smoothing settings.
solnum	non-negative integer array	All solutions	The solutions to use.
t	double array	Empty	The times to use. Available when the underlying solution is transient.
phase	double	0	Evaluate solution at this angle, given in degrees.
unit	String	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.

See Also

[Interp](#), [Global \(numerical\)](#), [EvalPoint](#), [EvalGlobal](#)

Synopsis

Evaluate quantities.

Syntax

```
model.result().numerical().create(<ftag>, "EvalGlobal");
model.result().numerical(<ftag>).set(property, <value>);
model.result().numerical(<ftag>).getReal();
model.result().numerical(<ftag>).getReal(<columnwise>);
model.result().numerical(<ftag>).getReal(<outersolnum>);
model.result().numerical(<ftag>).getReal(<columnwise>,
    <outersolnum>);
model.result().numerical(<ftag>).getImag();
model.result().numerical(<ftag>).getImag(<allocate>,
    <columnwise>);
model.result().numerical(<ftag>).getImag(<outersolnum>);
model.result().numerical(<ftag>).getImag(<allocate>, <columnwise>,
    <outersolnum>);
model.result().numerical(<ftag>).isComplex();
model.result().numerical(<ftag>).isComplex(<outersolnum>);
model.result().numerical(<ftag>).setResult();
model.result().numerical(<ftag>).appendResult();
```

Description

`model.result().numerical().create(<ftag>, "EvalGlobal")` creates an evaluation feature with the name `<ftag>`.

`model.result().numerical(<ftag>).getReal()` returns the real result, recomputing the feature if necessary. Data is ordered such that one row contains data for all solution numbers. This is identical to `(<columnwise>)` when `columnwise` is `false`. If `columnwise` is `true`, the ordering is the opposite: each *column* contains the values for all solution numbers.

`model.result().numerical(<ftag>).getImag(<allocate>, <columnwise>)` returns the imaginary part of complex result, recomputing the feature if necessary. If `allocate` is `true`, a zero-valued matrix is allocated even when the result is real. `getImag()` uses `<allocate>` `true` and `<columnwise>` `false`.

`model.result().numerical(<ftag>).isComplex()` returns `true` if the result is complex.

`<outersolnum>` is applicable only for parametric sweep solutions and is the index of each outer parametric solution.

`model.result().numerical(<ftag>).setResult()` and `model.result().numerical(<ftag>).appendResult()` evaluates the feature and set or append the result in the table indicated by the `table` property.

The following properties are available:

TABLE 6-21: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
data	none data set name	First compatible data set	The data set this feature refers to.
dataseries	average integral maximum minimum none rms stddev variance	none	The operation that is applied to the data series formed by the evaluation.
descr	string	Model-dependent	The description of the expression in expr. Is used in the automatic title.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent	The expression to plot.
innerinput	all first last manual manualindices interp	all	How to input the solution to use. manual indicates that solnum is used. manualindices indicates that solnumindices is used. interp indicates that t is used.
interp	double row matrix	Empty on all levels.	The times to use, for transient levels. Available when data is not parent and the underlying data is transient.
looplevel	integer row matrix	All solutions on all levels	The solutions to use, per level.
looplevelindices	integer row matrix	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when looplevelinput is manualindices on a level.

TABLE 6-21: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
looplevelinput	String array with all first last manual manualindices interp on each level	all on all levels	How to input the solution to use, per level. manual on a level indicates that looplevel is used on that level. manualindices on a level indicates that looplevelindices is used on that level. interp on a level indicates that interp is used on that level.
maximumobj	abs real	real	The value being maximized if dataseries is maximum.
minimumobj	abs real	real	The value being minimized if dataseries is minimum.
outerinput	all first last manual manualindices	all	How to input the outer solutions to use. Applicable only for parametric sweep models. manual indicates that outersolnum is used. manualindices indicates that outersolnumindices is used.
outersolnum	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models. Since the various outer solutions can have different number of solnum, the solnum property is not used.
outersolnumindices	string or integer array	Empty	An alternate way to specify the outer solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when outerinput is manualindices.
solnum	non-negative integer array	All solutions	The solutions to use.
solnumindices	string or integer array	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when innerinput is manualindices.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
t	double array	Empty	The times to use. Available when the underlying solution is transient.
table	new table name	new	The table to use when calling setResult() or appendResult(). new indicates that a new table is created.

TABLE 6-21: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
tablecols	inner outer data level1	data	Whether to use inner or outer solutions as columns in the table when calling <code>setResult()</code> or <code>appendResult()</code> . Applicable only for parametric sweep models. The level values (<code>level1</code> , <code>level2</code> , and so on) are the levels in the parametric sweep.
unit	string	Model-dependent	The unit to use for the expression in <code>expr</code> . If the old unit is not valid when the expression changes, the unit property is reset to default.

See Also [EvalGlobalMatrix](#), [Eval](#), [EvalPoint](#)

Synopsis

Evaluate quantities

Syntax

```

model.result().numerical().create(<ftag>, "EvalGlobalMatrix");
model.result().numerical(<ftag>).set(property, <value>);
model.result().numerical(<ftag>).getReal();
model.result().numerical(<ftag>).getReal(<columnwise>);
model.result().numerical(<ftag>).getReal(<outersolnum>);
model.result().numerical(<ftag>).getReal(<columnwise>,
    <outersolnum>);
model.result().numerical(<ftag>).getImag();
model.result().numerical(<ftag>).getImag(<allocate>,
    <columnwise>);
model.result().numerical(<ftag>).getImag(<outersolnum>);
model.result().numerical(<ftag>).getImag(<allocate>, <columnwise>,
    <outersolnum>);
model.result().numerical(<ftag>).isComplex();
model.result().numerical(<ftag>).isComplex(<outersolnum>);
model.result().numerical(<ftag>).setResult();
model.result().numerical(<ftag>).appendResult();

```

Description

`model.result().numerical().create(<ftag>, "EvalGlobalMatrix")`
creates an evaluation feature with the name `<ftag>`.

`model.result().numerical(<ftag>).getReal()` returns the real result, recomputing the feature if necessary. Data is ordered such that one row contains data for all solution numbers. This is identical to `(<columnwise>)` when `columnwise` is `false`. If `columnwise` is `true`, the ordering is the opposite: each *column* contains the values for all solution numbers.

`model.result().numerical(<ftag>).getImag(<allocate>, <columnwise>)` returns the imaginary part of complex result, recomputing the feature if necessary. If `allocate` is `true`, a zero-valued matrix is allocated even when the result is real. `getImag()` uses `<allocate> true` and `<columnwise> false`.

`model.result().numerical(<ftag>).isComplex()` returns `true` if the result is complex.

`<outersolnum>` is applicable only for parametric sweep solutions and is the index of each outer parametric solution.

`model.result().numerical(<ftag>).setResult()` and
`model.result().numerical(<ftag>).appendResult()` evaluates the feature and set or append the result in the table indicated by the `table` property.

The following properties are available:

TABLE 6-22: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
data	none data set name	First compatible data set	The data set this feature refers to.
dataserie	average none sum	none	The operation that is applied to the data series formed by the evaluation over inner solutions.
descr	string	Model-dependent	The description of the expression in expr. Is used in the automatic title.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent	The matrix variable to plot.
ignorenan	on off	on	When on, NaN is ignored when taking the average in the inner or outer data series. If all entries are NaN for a given component, however, you get NaN as output.
innerinput	all first last manual manualindices interp	all	How to input the solution to use. manual indicates that solnum is used. manualindices indicates that solnumindices is used. interp indicates that t is used.
interp	double row matrix	Empty on all levels.	The times to use, for transient levels. Available when data is not parent and the underlying data is transient.
looplevel	integer row matrix	All solutions on all levels	The solutions to use, per level.
looplevelindices	integer row matrix	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when looplevelinput is manualindices on a level.

TABLE 6-22: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
looplevelinput	String array with all first last manual manualindices interp on each level	all on all levels	How to input the solution to use, per level. manual on a level indicates that looplevel is used on that level. manualindices on a level indicates that looplevelindices is used on that level. interp on a level indicates that interp is used on that level.
outerdataseries	average none sum	none	The operation that is applied to the data series formed by the evaluation over outer solutions.
outerinput	all first last manual manualindices	all	How to input the outer solutions to use. Applicable only for parametric sweep models. manual indicates that outersolnum is used. manualindices indicates that outersolnumindices is used.
outersolnum	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models. Since the various outer solutions can have different number of solnum, the solnum property is not used.
outersolnumindices	string or integer array	Empty	An alternate way to specify the outer solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when outerinput is manualindices.
solnum	non-negative integer array	All solutions	The solutions to use.
solnumindices	string or integer array	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when innerinput is manualindices.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
t	double array	Empty	The times to use. Available when the underlying solution is transient.
table	new table name	new	The table to use when calling setResult() or appendResult(). new indicates that a new table is created.
tablerows	inner outer	inner	Whether to use inner or outer solutions as rows in the table when calling setResult() or appendResult(). Applicable only for parametric sweep models.

TABLE 6-22: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
trans	none inverse sy sz ys yz zs zy	none	The transformation to apply to the matrix.
unit	string	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.
y0	double array	Taken from the physics interfaces.	If trans is sy or ys: The characteristic admittance.
z0	double array	Taken from the physics interfaces.	If trans is sz or zs: The characteristic impedance.

See Also [EvalGlobal](#), [Eval](#), [EvalPoint](#)

Synopsis

Evaluate quantities in points.

Syntax

```
model.result().numerical().create(<ftag>, "EvalPoint");
model.result().numerical(<ftag>).selection(...);
model.result().numerical(<ftag>).set(property, <value>);
model.result().numerical(<ftag>).getReal();
model.result().numerical(<ftag>).getReal(<columnwise>);
model.result().numerical(<ftag>).getReal(<outersolnum>);
model.result().numerical(<ftag>).getReal(<columnwise>,
    <outersolnum>);
model.result().numerical(<ftag>).getImag();
model.result().numerical(<ftag>).getImag(<allocate>,
    <columnwise>);
model.result().numerical(<ftag>).getImag(<outersolnum>);
model.result().numerical(<ftag>).getImag(<allocate>, <columnwise>,
    <outersolnum>);
model.result().numerical(<ftag>).isComplex();
model.result().numerical(<ftag>).isComplex(<outersolnum>);
model.result().numerical(<ftag>).setResult();
model.result().numerical(<ftag>).appendResult();
```

Description

`model.result().numerical().create(<ftag>, "EvalPoint")` creates a point evaluation feature with the name `<ftag>`. Point evaluations can be performed both on points in a geometry or on cut points.

`model.result().numerical(<ftag>).getReal()` returns the real result, recomputing the feature if necessary. Data is ordered such that there is one row per point, with one row containing data for all solution numbers. This is identical to `<columnwise>` when `<columnwise>` is `false`. If `<columnwise>` is `true`, the ordering is the opposite: each `column` contains the values for all solution numbers.

`model.result().numerical(<ftag>).getImag(<allocate>, <columnwise>)` returns the imaginary part of complex result, recomputing the feature if necessary. If `<allocate>` is `true`, a zero-valued matrix is allocated even when the result is real. `getImag()` uses `<allocate>` `true` and `<columnwise>` `false`.

`model.result().numerical(<ftag>).isComplex()` returns `true` if the result is complex.

`<outersolnum>` is applicable only for parametric sweep solutions and is the index of each outer parametric solution.

`model.result().numerical(<ftag>).setResult()` and `model.result().numerical(<ftag>).appendResult()` evaluates the feature and set or append the result in the table indicated by the `table` property.

The following properties are available:

TABLE 6-23: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
data	none data set name	First compatible data set	The data set this feature refers to.
dataseries	average integral maximum minimum none rms stddev variance	none	The operation that is applied to the data series formed by the evaluation.
descr	string	Model-dependent	The description of the expression in expr. Is used in the automatic title.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent	The expression to plot.
innerinput	all first last manual manualindices interp	all	How to input the solution to use. manual indicates that solnum is used. manualindices indicates that solnumindices is used. interp indicates that t is used.
interp	double row matrix	Empty on all levels.	The times to use, for transient levels. Available when data is not parent and the underlying data is transient.
looplevel	integer row matrix	All solutions on all levels	The solutions to use, per level.
looplevelindices	integer row matrix	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1,1, 20). Applicable when looplevelinput is manualindices on a level.

TABLE 6-23: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
looplevelinput	String array with all first last manual manualindices interp on each level	all on all levels	How to input the solution to use, per level. manual on a level indicates that looplevel is used on that level. manualindices on a level indicates that looplevelindices is used on that level. interp on a level indicates that interp is used on that level.
maximumobj	abs real	real	The value being maximized if dataseries is maximum.
minimumobj	abs real	real	The value being minimized if dataseries is minimum.
outerinput	all first last manual manualindices	all	How to input the outer solutions to use. Applicable only for parametric sweep models. manual indicates that outersolnum is used. manualindices indicates that outersolnumindices is used.
outersolnum	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models. Since the various outer solutions can have different number of solnum, the solnum property is not used.
outersolnumindices	string or integer array	Empty	An alternate way to specify the outer solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when outerinput is manualindices.
solnum	non-negative integer array	All solutions	The solutions to use.
solnumindices	string or integer array	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when innerinput is manualindices.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
t	double array	Empty	The times to use. Available when the underlying solution is transient.
table	new table name	new	The table to use when calling setResult() or appendResult(). new indicates that a new table is created.

TABLE 6-23: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
tablecols	inner outer data level1	data	Whether to use inner or outer solutions as columns in the table when calling setResult() or appendResult(). Applicable only for parametric sweep models. The level values (level1, level2, and so on) are the levels in the parametric sweep.
unit	string	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.

See Also [EvalGlobal](#)

Synopsis	Far-field plot.
Syntax	<pre>model.result(<pgtag>).feature().create(<ftag>,"FarField"); model.result(<pgtag>).feature(<ftag>).set(property, <value>); model.result(<pgtag>).feature(<ftag>).run();</pre>
Description	<p><code>model.result(<pgtag>).feature().create(<ftag>,"FarField")</code> creates a plot feature named <code><ftag></code> belonging to the plot group <code><pgtag></code>.</p> <p>Far-field plots are used to visualize radiation patterns in the far field for antennas, for example. They can be added to all types of plot groups.</p> <p>The following properties are available:</p>

TABLE 6-24: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
anglerestr	manual none	none	Whether there is a restriction on the angle range that is evaluated.
autodescr	on off	Model dependent	Whether the automatic legends should include the expression descriptions. Available in ID.
autoexpr	on off	Model dependent	Whether the automatic legends should include the expressions. Available in ID.
autolegends	on off	on	Whether to use the automatically computed legends or the legends defined in the legends property. The automatic legends display the description and expression for each line. Available in ID.
center	double array of length 3	{0, 0, 0}	If circle is manual: The center of the circle to evaluate on. Available in 2D and 3D.
center2	double array of length 2	{0, 0}	If circle is manual and the data set is 2D: The center of the circle to evaluate on. Available in ID.
center3	double array of length 3	{0, 0, 0}	If circle is manual and the data set is 3D: The center of the circle to evaluate on. Available in ID.
circle	manual unit	unit	The circle to evaluate. Available in ID.
colorexpr	string	Model-dependent.	The color of the far-field surface. Available in 3D.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.

TABLE 6-24: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
customgridcolor	RGB-triplet	{0,0,1}	f grid is fine, normal, or coarse and gridcolor is custom: The grid's color. Available in 3D.
customlinecolor	RGB-triplet	{0,0,1} or last used edgcolor.	The color to use for the lines. Active when linecolor is set to custom. Available in 1D.
data	none parent data set name	parent	The data set this feature refers to.
descr	string array	Model-dependent.	The description of the expressions in expr. Is used in the automatic legends.
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
directivity	on off	off	Whether to compute the maximum directivity and the direction where it is attained. Available in 2D and 3D.
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string array	Model-dependent.	The expressions to plot.
expressionintitle	on off	off	Whether the title contribution should contain the expression when titletype is custom.
grid	fine normal coarse none	none	The type of grid to display on the far-field surface. Available in 3D.
gridcolor	custom black blue cyan green magenta red white yellow	black	If grid is fine, normal, or coarse: The grid's color. Available in 3D.

TABLE 6-24: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
inheritcolor	boolean	true	If inheritplot is not none: Determines if the color is inherited. Available in 2D and 3D.
innerinput	all first last manual manualindices interp	all	How to input the solution to use. manual indicates that solnum is used. manualindices indicates that solnumindices is used. interp indicates that t is used.
interp	double row matrix	Empty on all levels.	The times to use, for transient levels. Available when data is not parent and the underlying data is transient.
legend	on off	off	Whether to show legends. Available in ID.
legendmethod	automatic manual	automatic	Whether to use the automatic legends or the legends supplied in the legends property. Available in ID.
legends	string array	The last computed automatic legends.	Manual legends active when legendmethod is set to manual. Available in ID.
linecolor	custom cycle black blue cyan green magenta red white yellow	cycle	How to color the lines in the graph. Cycle indicates that the colors is different for each line. Available in ID.
linewidth	double	0.5	The line width. Available in ID.
linemarker	none cycle asterisk circle diamond plus point square star triangle	none	The line markers, if any. Cycle indicates that the marker is different for each line. Available in ID.
linestyle	none cycle solid dotted dashed dashdot	solid	The line style, if any. Cycle indicates that the line style is different for each line. Available in ID.

TABLE 6-24: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
looplevel	integer row matrix	All solutions on all levels	The solutions to use, per level.
looplevelindices	integer row matrix	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when looplevelinput is manualindices on a level.
looplevelinput	String array with all first last manual manualindices interp on each level	all on all levels	How to input the solution to use, per level. manual on a level indicates that looplevel is used on that level. manualindices on a level indicates that looplevelindices is used on that level. interp on a level indicates that interp is used on that level.
markerpos	interp datapoints	interp	Controls whether the positions of the markers are in the data points of the plot, or interpolated depending on the number (set in markers). Markers are visible when linemarker is set. Available in ID.
markers	integer	8	The number of markers to show. Markers are visible when linemarker is set. Available in ID.
normal	double array of length 3	{0, 0, 1}	If circle is manual and the data set is 3D: The normal of the circle to evaluate on. Available in ID.
outerinput	all first last manual manualindices	all	How to input the outer solutions to use. Applicable only for parametric sweep models. manual indicates that outersolnum is used. manualindices indicates that outersolnumindices is used.
outersolnum	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models. Since the various outer solutions can have different number of solnum, the solnum property is not used.
outersolnumindices	string or integer array	Empty	An alternate way to specify the outer solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when outerinput is manualindices.
phidisc	integer >= 2	50	The angular discretization in the phi direction. Available in ID.

TABLE 6-24: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
phimin	double	0	If <code>anglerestr</code> is manual: The minimum phi angle in degrees.
phirange	double	360	If <code>anglerestr</code> is manual: The phi angle's range in degrees.
prefixintitle	string	Empty	Added prefix to contribution to title.
radius	double	1	If <code>circle</code> is manual: The radius of the circle to evaluate on.
solnum	non-negative integer array	All solutions	The solutions to plot. Available when data is not parent and the underlying data has multiple solutions.
solnumindices	string or integer array	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, <code>range(1, 1, 20)</code> . Applicable when <code>innerinput</code> is <code>manualindices</code> .
solrepresentation	<code>solnum</code> <code>solutioninfo</code>	<code>solutioninfo</code>	Indicates which method of selecting solutions is active.
sphere	manual unit	unit	The sphere to evaluate on. Available in 2D and 3D.
suffixintitle	string	Empty	Added suffix to contribution to title.
t	double array	Empty	The times to plot. Available when data is not parent and the underlying solution is transient.
thetadisc	integer >= 2	10	The angular discretization in the theta direction. Available in 2D and 3D.
thetamin	double	0	If <code>anglerestr</code> is manual: The minimum theta angle in degrees. Available in 2D and 3D.
thetarange	double	360	If <code>anglerestr</code> is manual: The phi angle's range in degrees. Available in 2D and 3D.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the <code>title</code> property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when <code>titletype</code> is custom.

TABLE 6-24: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
unit	string	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.
unitintitle	on off	on	Whether the title contribution should contain the unit when titletype is custom.

Attributes None

Synopsis	Element filter attribute.
Syntax	<pre>model.result(<pgtag>).feature(<ftag>).feature().create(<atag>, "Filter"); model.result(<pgtag>).feature(<ftag>).feature(<atag>).set(property, <value>);</pre>
Description	<pre>model.result(<pgtag>).feature(<ftag>).feature().create(<atag>, "Filter")</pre> <p>creates an element filter attribute named <atag> belonging to the plot feature <ftag>.</p>

Use filters to limit plots to elements satisfying a condition.

Filters can be added to arrow plots, contour plots, isosurface plots, line plots, mesh plots, slice plots, surface plots, and volume plots.

The following properties are available:

TABLE 6-25: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
expr	string		The logical expression that must be satisfied for an element to be included in the plot.
nodespec	all any xor	all	The set of nodes in an element that have to satisfy the logical expression for it to be included in the plot.

Synopsis	Data set that can evaluate functions.
Syntax	<pre>model.result().dataset().create(<dtag>, "Function1D"); model.result().dataset().create(<dtag>, "Function2D"); model.result().dataset().create(<dtag>, "Function3D"); model.result().dataset(<dtag>).set(property, <value>);</pre>
Description	<p><code>model.result().dataset().create(<dtag>, "Function1D")</code> creates a 1D function data set feature named <code><dtag></code>.</p> <p>This data set provides support for evaluation of functions on a domain. All functions in the same function list as the selected function can also be evaluated. The domain is an interval for Function1D, a rectangle for Function2D, and a block for Function3D. The domain need not have the same dimension as the number of arguments to the function.</p>

The following properties are available:

TABLE 6-26: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
function	none function name	none	The function this feature refers to.
parmin1	double	0	Lower bound for the first dimension of the domain.
parmax1	double	1	Upper bound for the first dimension of the domain.
parmin2	double	0	Lower bound for the second dimension of the domain. (For Function2D and Function3D.)
parmax2	double	1	Upper bound for the second dimension of the domain. (For Function2D and Function3D.)
parmin3	double	0	Lower bound for the third dimension of the domain. (For Function3D.)
parmax3	double	1	Upper bound for the third dimension of the domain. (For Function3D.)
resolution	integer ≥ 2	1000 for 1D, 100 for 2D, and 30 for 3D	The number of points into which each dimension is discretized.

Synopsis	Evaluate quantities.
Syntax	<pre> model.result().numerical().create(<ftag>, "Global"); model.result().numerical(<ftag>).set(property, <value>); model.result().numerical(<ftag>).getData(); model.result().numerical(<ftag>).getData(<expressionIndex>); model.result().numerical(<ftag>).getImagData(); model.result().numerical(<ftag>).getImagData(<expressionIndex>); model.result().numerical(<ftag>).isComplex(); model.result().numerical(<ftag>).isComplex(<outersolnum>); model.result().numerical(<ftag>).getNData(); model.result().numerical(<ftag>).run(); </pre>
Description	<p><code>model.result().numerical().create(<ftag>, "Global)</code> creates an evaluation feature with the name <code><ftag></code>.</p> <p>Global is a feature made specifically for users of the COMSOL Java API and does not appear in the COMSOL Multiphysics GUI. Global features support multiple expressions as well as some additional advanced properties not available in EvalGlobal.</p> <p><code>result = model.result().numerical(<ftag>).getData()</code> returns the real part of the result, recomputing the feature if necessary. <code>result</code> is a three-dimensional double matrix ordered <code>result[expression][solnum][value]</code>.</p> <p><code>model.result().numerical(<ftag>).getData(<expressionIndex>)</code> returns the real part of the result for one expression, equivalent to <code>result[expressionIndex]</code>.</p> <p><code>result = model.result().numerical(<ftag>).getImagData()</code> returns the imaginary part of the result, recomputing the feature if necessary. <code>result</code> is a three-dimensional double matrix ordered <code>result[expression][solnum][value]</code>.</p> <p><code>model.result().numerical(<ftag>).getImagData(<expressionIndex>)</code> returns the imaginary part of the result for one expression, equivalent to <code>result[expressionIndex]</code>.</p> <p><code>model.result().numerical(<ftag>).isComplex()</code> returns true if the result is complex.</p> <p><code><outersolnum></code> is applicable only for parametric sweep solutions and is the index of each outer parametric solution.</p> <p><code>model.result().numerical(<ftag>).getNData()</code> returns the number of data vectors in the result.</p>

The following properties are available:

TABLE 6-27: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
data	none data set name	First compatible data set	The data set this feature refers to.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string array	Model-dependent	The expression to evaluate.
complexfun	on off	on	Use complex-valued functions with real input
matherr	on off	off	Error for undefined operation or variable
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
phase	double	0	Evaluate solution at this angle, given in degrees.
solnum	non-negative integer array	All solutions	The solutions to use.
t	double array	Empty	The times to use. Available when the underlying solution is transient.
unit	String	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.

See Also

[Eval](#), [Interp](#), [EvalPoint](#), [EvalGlobal](#)

Synopsis Global plot for 1D plot groups.

Syntax

```
model.result(<pgtag>).feature().create(<ftag>, "Global");
model.result(<pgtag>).feature(<ftag>).set(property, <value>);
model.result(<pgtag>).feature(<ftag>).run();
```

Description `model.result(<pgtag>).feature().create(<ftag>, "Global")` creates a plot feature named `<ftag>` belonging to the plot group `<pgtag>`.

Global plot is used to visualize defined variables, such as solutions to ODEs or coupling operators with a destination. Global plots can be added to 1D plot groups.

The following properties are available:

TABLE 6-28: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
autodescr	on off	Model dependent	Whether the automatic legends should include the expression descriptions.
autoexpr	on off	Model dependent	Whether the automatic legends should include the expressions.
autolegends	on off	on	Whether to use the automatically computed legends or the legends defined in the legends property. The automatic legends display the description and expression for each line.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
customlinecolor	RGB-triplet	{0,0,1} or last used edgcolor.	The color to use for the lines. Active when linecolor is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
descr	string array	Model-dependent.	The description of the expressions in expr. Is used in the automatic legends.
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic

TABLE 6-28: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string array	Model-dependent.	The expressions to plot.
expressionintitle	on off	off	Whether the title contribution should contain the expression when titletype is custom.
freqmax	integer		If xaxisdata is spectrum and freqrangeactive is true: The upper frequency bound.
freqmin	integer		If xaxisdata is spectrum and freqrangeactive is true: The lower frequency bound.
freqrangeactive	on off	false	If xaxisdata is spectrum: Controls whether a manual frequency range is used.
innerinput	all first last manual manualindices interp	all	How to input the solution to use. manual indicates that solnum is used. manualindices indicates that solnumindices is used. interp indicates that t is used.
interp	double row matrix	Empty on all levels.	The times to use, for transient levels. Available when data is not parent and the underlying data is transient.
legend	on off	off	Whether to show legends.
legendmethod	automatic manual	automatic	Whether to use the automatic legends or the legends supplied in the legends property.
legends	string array	The last computed automatic legends.	Manual legends active when legendmethod is set to manual.
linecolor	custom cycle black blue cyan green magenta red white yellow	cycle	How to color the lines in the graph. Cycle indicates that the colors is different for each line.
linewidth	double	0.5	The line width.

TABLE 6-28: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
linemarker	none cycle asterisk circle diamond plus point square star triangle	none	The line markers, if any. Cycle indicates that the marker is different for each line.
linestyle	none cycle solid dotted dashed dashdot	solid	The line style, if any. Cycle indicates that the line style is different for each line.
looplevel	integer row matrix	All solutions on all levels	The solutions to use, per level.
looplevelindices	integer row matrix	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when looplevelinput is manualindices on a level.
looplevelinput	String array with all first last manual manualindices interp on each level	all on all levels	How to input the solution to use, per level. manual on a level indicates that looplevel is used on that level. manualindices on a level indicates that looplevelindices is used on that level. interp on a level indicates that interp is used on that level.
markerpos	interp datapoints	interp	Controls whether the positions of the markers are in the data points of the plot, or interpolated depending on the number (set in markers). Markers are visible when linemarker is set.
markers	integer	8	The number of markers to show. Markers are visible when linemarker is set.
nfreqs	integer	1	If xaxisdata is spectrum and nfreqsactive is true: The number of frequencies to plot.
nfreqsactive	boolean	false	If xaxisdata is spectrum: Controls whether the number of frequencies is set manually.
outerinput	all first last manual manualindices	all	How to input the outer solutions to use. Applicable only for parametric sweep models. manual indicates that outersolnum is used. manualindices indicates that outersolnumindices is used.

TABLE 6-28: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
outersolnum	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models. Since the various outer solutions can have different number of solnum, the solnum property is not used.
outersolnumindices	string or integer array	Empty	An alternate way to specify the outer solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when outerinput is manualindices.
prefixintitle	string	Empty	Added prefix to contribution to title.
scale	boolean	false	If xaxisdata is spectrum: The frequency spectrum is transformed so that it has the same scale as the original data.
solnum	non-negative integer array	All solutions	The solutions to plot. Available when data is not parent and the underlying data has multiple solutions.
solnumindices	string or integer array	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when innerinput is manualindices.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
suffixintitle	string	Empty	Added suffix to contribution to title.
t	double array	Empty	The times to plot. Available when data is not parent and the underlying solution is transient.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when titletype is custom.
unit	string	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.

TABLE 6-28: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
unitintitle	on off	on	Whether the title contribution should contain the unit when <code>titletype</code> is <code>custom</code> .
xdata	expr solution spectrum phase	solution	x-axis data. <code>expr</code> uses the expression in <code>xdataexpr</code> . <code>solution</code> uses the available solutions in the underlying data set, such as time steps. <code>phase</code> uses a phase range, and rearranged phase plots.
xdataexpr	string	Model-dependent	Expression for x-axis data.
xdatadescr	string	Model-dependent	Description of expression in <code>xdataexpr</code> .
xdataphaserange	double array	range(0, 0.5, 2 π)	The phases for which the expressions should be evaluated when <code>xdata</code> is <code>phase</code> .
xdataphaseunit	string	rad	The unit in which <code>xdataphaserange</code> is described.
xdatasolnumtype	all inner outer valid level	outer	Whether the expression should be evaluated for every inner or every outer solution, or for a specific level (<code>level1</code> , <code>level2</code> , and so on). Applicable only for models containing multiple levels.
xdataunit	string	Model-dependent	The unit to use for the expression in <code>xdataexpr</code> . If the old unit is not valid when the expression changes, the unit property is reset to default.

Attributes None

See Also [LineGraph](#)

- Synopsis** Height attribute for 2D line and surface plots.
- Syntax**
- ```
model.result(<pgtag>).feature(<ftag>).feature().create(<atag>,
 "Height");
model.result(<pgtag>).feature(<ftag>).feature(<atag>).set(property, <value>);
```
- Description**
- ```
model.result(<pgtag>).feature(<ftag>).feature().create(<atag>,
    "Height") creates a Height attribute feature with the name <atag>, belonging to
the feature <ftag>.
```

Height attributes are available for 2D line and surface plots. Adding a height attribute changes the rendered view to 3D. The plot group, however, still remains a 2D plot group. Any other plots in the group that do not have heights attribute is rendered at z=0.

The following properties are available:

TABLE 6-29: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
descr	string	Model-dependent	The description of the expression in expr. Is used in the automatic title.
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent	The expression to plot.
expressionintitle	on off	off	Whether the title contribution should contain the expression when titletype is custom.
heightdata	parent expr	parent	parent uses the expression and description in the plot the height feature has been added to. expr uses the expr and descr properties.
offset	double	0	The offset along the z-axis where to place the height plot.

TABLE 6-29: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
prefixintitle	string	Empty	Added prefix to contribution to title.
scale	positive double	1	If <code>scaleactive</code> is true: The scale factor for the height.
scaleactive	boolean	false	Whether to use manual scaling.
suffixintitle	string	Empty	Added suffix to contribution to title.
title	string	The auto-title.	The title to use when <code>titletype</code> is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the <code>title</code> property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when <code>titletype</code> is custom.
unit	string	Model-dependent	The unit to use for the expression in <code>expr</code> . If the old unit is not valid when the expression changes, the unit property is reset to default.
unitintitle	on off	on	Whether the title contribution should contain the unit when <code>titletype</code> is custom.

See Also

[Color](#), [Deform](#)

- Synopsis** Histogram plot for 1D and 2D plot groups.
- Syntax**

```
model.result(<pgtag>).feature().create(<ftag>,"Histogram");
model.result(<pgtag>).feature(<ftag>).set(property, <value>);
model.result(<pgtag>).feature(<ftag>).run();
```
- Description**

```
model.result(<pgtag>).feature().create(<ftag>,"Histogram")
```

 creates a histogram plot feature named <ftag> belonging to the plot group <pgtag>.

 Histogram are used to visualize the distribution of the range of an expression. The result is a plot with the expression's range on the x-axis and element length, area, or volume on the y-axis. Histogram plots can be added to 1D plot groups.

 The following properties are available:

TABLE 6-30: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
cumulative	boolean	false	Whether a cumulative histogram is plot.
customlinecolor	RGB-triplet	{0,0,1} or last used edgecolor.	The color to use for the lines. Active when linecolor is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
descr	string	Model-dependent.	The description of the expression in expr. Is used in the automatic title.
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent.	The expression to plot.
expressionintitle	on off	off	Whether the title contribution should contain the expression when titletype is custom.

TABLE 6-30: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
innerinput	all first last manual manualindices interp	all	How to input the solution to use. manual indicates that solnum is used. manualindices indicates that solnumindices is used. interp indicates that t is used.
interp	double row matrix	Empty on all levels.	The times to use, for transient levels. Available when data is not parent and the underlying data is transient.
level	fromdataset volume surface line point	fromdataset	The geometry level to evaluate on.
limits	double array	0 1	The bin limits if method is limits.
linecolor	custom cycle black blue cyan green magenta red white yellow	cycle	How to color the lines in the graph. Cycle indicates that the colors is different for each line.
linewidth	double	0.5	The line width.
linemarker	none cycle asterisk circle diamond plus point square star triangle	none	The line markers, if any. Cycle indicates that the marker is different for each line.
linestyle	none cycle solid dotted dashed dashdot	solid	The line style, if any. Cycle indicates that the line style is different for each line.
looplevel	integer row matrix	All solutions on all levels	The solutions to use, per level.

TABLE 6-30: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
looplevelindices	integer row matrix	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when looplevelinput is manualindices on a level.
looplevelinput	String array with all first last manual manualindices interp on each level	all on all levels	How to input the solution to use, per level. manual on a level indicates that looplevel is used on that level. manualindices on a level indicates that looplevelindices is used on that level. interp on a level indicates that interp is used on that level.
markerpos	interp datapoints	interp	Controls whether the positions of the markers are in the data points of the plot, or interpolated depending on the number (set in markers). Markers are visible when linemarker is set.
markers	integer	8	The number of markers to show. Markers are visible when linemarker is set.
method	limit number	number	The method used to specify the bins in which the expression's range is split
normalization	integral none peak	none	The normalization of the values plot on the y-axis.
number	non-negative integer	10	The number of bins if method is number.
outerinput	all first last manual manualindices	all	How to input the outer solutions to use. Applicable only for parametric sweep models. manual indicates that outersolnum is used. manualindices indicates that outersolnumindices is used.
outersolnum	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models. Since the various outer solutions can have different number of solnum, the solnum property is not used.
outersolnumindices	string or integer array	Empty	An alternate way to specify the outer solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when outerinput is manualindices.
prefixintitle	string	Empty	Added prefix to contribution to title.

TABLE 6-30: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
refine	non-negative integer	1	The element refinement to use, if resolution is set to manual. Bear in mind that this is the refinement used for the base data set, so the number of elements in the model can increase radically if the plot uses, for example, a revolve data set.
resolution	norefine coarse normal fine finer extrafine custom	normal	Controls the plot's resolution. A finer setting results in a higher resolution by modifying the internally computed default refinement. Use custom to enter your own refinement in the refine property.
sdim	fromdataset 0 1 2 3	fromdataset	The space dimension to evaluate the underlying data set in.
solnum	integer array	All solutions	The solutions to plot. Available when data is not parent and the underlying data has multiple solutions.
solnumindices	string or integer array	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when innerinput is manualindices.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
suffixintitle	string	Empty	Added suffix to contribution to title.
t	double array	Empty	The times to plot. Available when data is not parent and the underlying solution is transient.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when titletype is custom.

TABLE 6-30: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
unit	string	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.
unitintitle	on off	on	Whether the title contribution should contain the unit when titletype is custom.

Synopsis	Height attribute for 2D histogram plots.
Syntax	<pre>model.result(<pgtag>).feature(<ftag>).feature().create(<atag>, "HistogramHeight"); model.result(<pgtag>).feature(<ftag>).feature(<atag>).set(property, <value>);</pre>
Description	<p>model.result(<pgtag>).feature(<ftag>).feature().create(<atag>, "HistogramHeight") creates a HistogramHeight attribute feature with the name <atag>, belonging to the feature <ftag>.</p> <p>Adding a height attribute to a 2D histogram plot changes the rendered view to 3D. The plot group, however, still remains a 2D plot group. Any other plots in the group that do not have heights attribute is rendered at z=0.</p> <p>The following properties are available:</p>

TABLE 6-31: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
description intitle	on off	on	Whether the title contribution should contain the description when titletype is custom.
offset	double	0	The offset along the z-axis where to place the height plot.
prefixintitle	string	Empty	Added prefix to contribution to title.
scale	positive double	1	If scaleactive is true: The scale factor for the height.
scaleactive	boolean	false	Whether to use manual scaling.
suffixintitle	string	Empty	Added suffix to contribution to title.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when titletype is custom.

See Also [Height](#), [Histogram](#)

Synopsis	Export an image
Syntax	<pre> model.result().export().create(<ftag>, "Image1D"); model.result().export().create(<ftag>, "Image2D"); model.result().export().create(<ftag>, "Image3D"); model.result().export().create(<ftag>, <pgtag>, "Image1D"); model.result().export().create(<ftag>, <pgtag>, "Image2D"); model.result().export().create(<ftag>, <pgtag>, "Image3D"); model.result().export(<ftag>).set(property, <value>); model.result().export(<ftag>).run(); </pre>
Description	<p><code>model.result().export().create(<ftag>, "Image1D")</code> creates a 1D image feature with the name <code><ftag></code>.</p> <p><code>model.result().export().create(<ftag>, <pgtag>, "Image1D")</code> creates a 1D image feature with the name <code><ftag></code> for the plot group <code><pgtag></code>.</p> <p><code>result().export(<ftag>).set("plotgroup", <pgtag>)</code> changes the source of the image to the plot group named <code><pgtag></code>.</p> <p>Image features can be used both to export images and to have ready-made views of plot groups.</p> <p>The following properties are available: The default values listed before any image has been exported successfully. After that, the settings from the last successful image export are used as default values the next time an image export feature is created.</p>

TABLE 6-32: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
antialias	on off	on	Enable/disable antialiasing.
axes	on off	on	If options is on; enable/disable display of the coordinate axes. Used for 1D and 2D plots.
axisorientation	on off	on	If options is on; enable/disable display of the axis orientation indicator. Used for 3D plots.
background	current color	color	The background color.
bmpfilename	string		The name of the output file if imagetype is bmp.
customcolor	double array	{1, 1, 1}	If background is color; the red, green, and blue components of the background color.
epsfilename	string		The name of the output file if imagetype is eps.
fontsize	integer	9	The font size.
grid	on off	on	If options is on; enable/disable display of the coordinate grid. Used for 3D plots.

TABLE 6-32: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
height	double	600	The height of the image.
imagetype	png eps jpeg bmp	png	The type of image to export; eps can only be used for 1D plots.
jpegfilename	string		The name of the output file if imagetype is jpeg.
legend	on off	on	If options is on; enable/disable display of the legend.
lockratio	boolean	false	If true, then the aspect ratio of the image is preserved when the width or the height is changed.
logo	on off	on	If options is on; enable/disable display of the logotype.
options	on off	off	Enable/disable optional components of the image.
pngfilename	string		The name of the output file if imagetype is png.
resolution	integer	96	The frame resolution in dots per inch.
plotgroup	string		The plot group to export.
title	on off	on	If options is on; enable/disable display of the title.
unit	px mm in	mm	The unit for the dimensions of the image.
width	double	800	The width of the image.

Changing plot group after creation does not reset plot group-dependent default settings (title, colorlegend)

See Also

[Animation](#)

Synopsis

Evaluate expressions in arbitrary points or data sets.

Syntax

```
model.result().numerical().create(<ftag>,"Interp");
model.result().numerical(<ftag>).set(property, <value>);
model.result().numerical(<ftag>).getCoordinates();
model.result().numerical(<ftag>).getData();
model.result().numerical(<ftag>).getData(<expressionIndex>);
model.result().numerical(<ftag>).getImagData();
model.result().numerical(<ftag>).getImagData(<expressionIndex>);
model.result().numerical(<ftag>).isComplex();
model.result().numerical(<ftag>).isComplex(<outersolnum>);
model.result().numerical(<ftag>).getElements();
model.result().numerical(<ftag>).getNData();
model.result().numerical(<ftag>).run();
model.result().numerical(<ftag>).setInterpolationCoordinates(<value>);
```

Description

`model.result().numerical().create(<ftag>,"Interp")` creates an interpolation feature with the name `<ftag>`.

Interp is a feature made specifically for users of the COMSOL Java API and does not appear in the COMSOL Multiphysics GUI. Interp combines cut points and evaluation features, as well as allowing evaluation of arbitrary data sets. It supports multiple expressions and some additional advanced properties not available when using cut points and [EvalPoint](#) features.

`result = model.result().numerical(<ftag>).getData()` returns the real part of the result, recomputing the feature if necessary. `result` is a three-dimensional double matrix ordered

`result[expression][solnum][coordinates]`.

`model.result().numerical(<ftag>).getData(<expressionIndex>)` returns the real part of the result for one expression, equivalent to `result[expressionIndex]`.

`result = model.result().numerical(<ftag>).getImagData()` returns the imaginary part of the result, recomputing the feature if necessary. `result` is a three-dimensional double matrix ordered

`result[expression][solnum][coordinates]`.

`model.result().numerical(<ftag>).getImagData(<expressionIndex>)` returns the imaginary part of the result for one expression, equivalent to `result[expressionIndex]`.

`model.result().numerical(<ftag>.isComplex()` returns true if the result is complex.

`<outersolnum>` is applicable only for parametric sweep solutions and is the index of each outer parametric solution.

`model.result().numerical(<ftag>.getElements()` returns indices to columns in `p` of a simplex mesh.

`model.result().numerical(<ftag>.getNData()` returns the number of data vectors in the result.

`model.result().numerical(<ftag>.getCoordinates()` returns the coordinates of the interpolation.

`model.result().numerical(<ftag>.setInterpolationCoordinates(<value>)` is identical to `model.result().numerical(<ftag>.set(coord, <value>)`, when `value` is of type `double[][]`.

The columns of the `coord` property are the coordinates for the evaluation points. If the number of rows in `coord` equals the space dimension, then `coord` are global coordinates, and the selection (or the property `edim`) determines the dimension in which the expressions are evaluated. For instance, dimension 2 means that the expressions are evaluated on boundaries in a 3D model. If the dimension to evaluate on is less than the space dimension, then the points in `coord` are projected onto the closest point on a domain of that dimension. It is further possible to select a single geometric entity of a given dimension. If so, then the closest point on that domain in the given dimension is used.

If the number of rows in `coord` is less than the space dimension, then these coordinates are parameter values on a geometry face or edge. In that case, the domain number for that face or edge must be specified in the selection.

For data sets that do not support selections, the `edim` property must always be used, and no selections are possible.

The following properties are available:

TABLE 6-33: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
<code>complexfun</code>	on off	on	Use complex-valued functions with real input
<code>const</code>	String array of property/value pairs	Empty	Parameters to use in the expressions.

TABLE 6-33: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
coord	double matrix	Empty	The coordinates to evaluate in. Data sets that define an interpolation in themselves, such as cut planes, revolve etc., can be evaluated directly in the coordinates that define their shapes, without specifying coord.
coorderr	on off	on	If on, evaluating for a set of points that all fall outside the geometry results in an error being reported.
data	none data set name	First compatible data set	The data set this feature refers to.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
edim	auto 0 1 2 3	auto	Element dimension. This is used for arbitrary data sets. Solution data sets use selections as usual to specify where to perform the evaluation, and ignore the value of the edim property.
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string array	Model-dependent	The expressions to evaluate.
ext	double between 0 and 1	0.1	Extrapolation distance: How much outside the mesh that the interpolation searches. The scale is in terms of the local element size.
matherr	on off	off	Error for undefined operation or variable
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
phase	double	0	Evaluate solution at this angle, given in degrees.
recover	off pprint ppr	off	The derivative recovery method.
solnum	non-negative integer array	All solutions	The solutions to use.

TABLE 6-33: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
t	double array	Empty	The times to use. Available when the underlying solution is transient.
unit	String	Model-dependent	The unit to use for the expression in <code>expr</code> . If the old unit is not valid when the expression changes, the unit property is reset to default.

See Also[Eval](#), [Global \(numerical\)](#), [EvalPoint](#), [EvalGlobal](#)

Synopsis

Integration numerical results.

Syntax

```
model.result().numerical().create(<ftag>,"IntVolume");
model.result().numerical().create(<ftag>,"IntSurface");
model.result().numerical().create(<ftag>,"IntLine");
model.result().numerical(<ftag>).selection(...);
model.result().numerical(<ftag>).set(property, <value>);
model.result().numerical(<ftag>).getReal();
model.result().numerical(<ftag>).getReal(<columnwise>);
model.result().numerical(<ftag>).getReal(<outersolnum>);
model.result().numerical(<ftag>).getReal(<columnwise>,
    <outersolnum>);
model.result().numerical(<ftag>).getImag();
model.result().numerical(<ftag>).getImag(<allocate>,
    <columnwise>);
model.result().numerical(<ftag>).getImag(<outersolnum>);
model.result().numerical(<ftag>).getImag(<allocate>, <columnwise>,
    <outersolnum>);
model.result().numerical(<ftag>).isComplex();
model.result().numerical(<ftag>).isComplex(<outersolnum>);
model.result().numerical(<ftag>).setResult();
model.result().numerical(<ftag>).appendResult();
```

Description

`model.result().numerical().create(<ftag>,"IntVolume")` creates a volume integral feature with the name `<ftag>`.

`model.result().numerical().create(<ftag>,"IntSurface")` creates a surface integral feature with the name `<ftag>`.

`model.result().numerical().create(<ftag>,"IntLine")` creates a line integral feature with the name `<ftag>`.

`model.result().numerical(<ftag>).getReal()` returns the real result, recomputing the feature if necessary. Data is ordered such that one row contains data for all solution numbers. This is identical to `(columnwise)` when `columnwise` is `false`. If `columnwise` is `true`, the ordering is the opposite: each *column* contains the values for all solution numbers.

`model.result().numerical(<ftag>).getImag(allocate, columnwise)` returns the imaginary part of complex result, recomputing the feature if necessary. If `allocate` is `true`, a zero-valued matrix is allocated even when the result is real. `getImag()` uses `allocate true` and `columnwise false`.

`model.result().numerical(<ftag>).isComplex()` returns `true` if the result is complex.

`<outersolnum>` is applicable only for parametric sweep solutions and is the index of each outer parametric solution.

`model.result().numerical(<ftag>).setResult()` and `model.result().numerical(<ftag>).appendResult()` evaluates the feature and set or append the result in the table indicated by the `table` property.

The following properties are available:

TABLE 6-34: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
data	none data set name	First compatible data set	The data set this feature refers to.
dataseries	average integral maximum minimum none rms stddev variance	none	The operation that is applied to the data series formed by the evaluation.
descr	string	Model-dependent	The description of the expression in <code>expr</code> . Is used in the automatic title.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if <code>evalmethod</code> is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent	The expression to plot.
innerinput	all first last manual manualindices interp	all	How to input the solution to use. <code>manual</code> indicates that <code>solnum</code> is used. <code>manualindices</code> indicates that <code>solnumindices</code> is used. <code>interp</code> indicates that <code>t</code> is used.

TABLE 6-34: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
interp	double row matrix	Empty on all levels.	The times to use, for transient levels. Available when data is not parent and the underlying data is transient.
intorder	positive integer	4	The integration order.
intorderactive	on off	off	Whether to use manually specified integration order.
intsurface	on off	off	Compute surface integral. Available for line integration features of axisymmetric models.
intvolume	on off	off	Compute volume integral. Available for surface integration features of axisymmetric models.
looplevel	integer row matrix	All solutions on all levels	The solutions to use, per level.
looplevelindices	integer row matrix	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range (1, 1, 20). Applicable when looplevelinput is manualindices on a level.
looplevelinput	String array with all first last manual manualindices interp on each level	all on all levels	How to input the solution to use, per level. manual on a level indicates that looplevel is used on that level. manualindices on a level indicates that looplevelindices is used on that level. interp on a level indicates that interp is used on that level.
maximumobj	abs real	real	The value being maximized if dataseries is maximum.
method	auto integration summation	auto	The integration method.
minimumobj	abs real	real	The value being minimized if dataseries is minimum.
outerinput	all first last manual manualindices	all	How to input the outer solutions to use. Applicable only for parametric sweep models. manual indicates that outersolnum is used. manualindices indicates that outersolnumindices is used.

TABLE 6-34: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
outersolnum	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models. Since the various outer solutions can have different number of solnum, the solnum property is not used.
outersolnumindices	string or integer array	Empty	An alternate way to specify the outer solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when outerinput is manualindices.
solnum	non-negative integer array	All solutions	The solutions to use.
solnumindices	string or integer array	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when innerinput is manualindices.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
t	double array	Empty	The times to use. Available when the underlying solution is transient.
table	new table name	new	The table to use when calling setResult() or appendResult(). new indicates that a new table is created.
tablecols	inner outer data level1	data	Whether to use inner or outer solutions as columns in the table when calling setResult() or appendResult(). Applicable only for parametric sweep models. The level values (level1, level2, and so on) are the levels in the parametric sweep.
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.
unit	string	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.

See Also [EvalGlobal](#), [EvalPoint](#), [Global \(numerical\)](#)

- Synopsis** Isosurface plot.
- Syntax**

```
model.result(<pgtag>).feature().create(<ftag>,"Isosurface");
model.result(<pgtag>).feature(<ftag>).set(property, <value>);
model.result(<pgtag>).feature(<ftag>).run();
```
- Description**

```
model.result(<pgtag>).feature().create(<ftag>,"Isosurface")
```

 creates an isosurface plot feature named `<ftag>` belonging to the plot group `<pgtag>`.

The following properties are available:

TABLE 6-35: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
color	custom black blue cyan green magenta red white yellow	red	The uniform color to use. Active when coloring is uniform.
coloring	colortable uniform	colortable	How to color this isosurface.
colorlegend	on off	on	Whether to show color legend, when coloring is set to colortable.
colortable	colortable name	Rainbow	The color table to use when colormethod is set to colortable.
colortablereverse	on off	off	Whether to reverse to color table when colormethod is set to colortable.
colortablesymm	on off	off	Whether to symmetrize the color range around 0 when colormethod is set to colortable.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
customcolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use. Active when color is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
descr	string	Model-dependent	The description of the expression in expr. Is used in the automatic title.

TABLE 6-35: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
description n title	on off	on	Whether the title contribution should contain the description when <code>titletype</code> is <code>custom</code> .
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if <code>evalmethod</code> is <code>harmonic</code> .
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model- dependent	The expression to plot.
expression in title	on off	off	Whether the title contribution should contain the expression when <code>titletype</code> is <code>custom</code> .
inheritcolor	boolean	true	If <code>inheritplot</code> is not <code>none</code> : Determines if the color is inherited.
inheritdefor mscale	boolean	true	If <code>inheritplot</code> is not <code>none</code> : Determines if the deformation scale is inherited.
inheritplot	none plot name	none	The plot that color and deformation scale is inherited from.
interactive	on off	off	If true, the isosurfaces can be moved interactively after the plot has been made.
interp	double array	Time corresponding to last selected <code>solnum</code> for transient levels.	The time to use, for transient levels. Available when data is not parent and the underlying data is transient.
levelmethod	number levels	number	How to enter isosurface levels.
levels	double array		The levels to plot. Active when <code>levelmethod</code> equals <code>levels</code> .

TABLE 6-35: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
looplevel	array of non-negative integers and strings	Last solution for transient or parametric solution for each level. Otherwise first solution for each level.	The index of the solution to use, per level, or <code>interp</code> , but only for transient solutions. Available when data is not parent and the underlying data has multiple solutions.
number	positive integer	5	Total number of iso levels. Active when <code>levelmethod</code> equals <code>number</code> .
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
prefixintitle	string	Empty	Added prefix to contribution to title.
recover	off pprint ppr	off	The derivative recovery method.
refine	non-negative integer	1	The element refinement to use, if <code>resolution</code> is set to <code>manual</code> . Bear in mind that this is the refinement used for the base data set, so the number of elements in the model can increase radically if the plot uses, for example, a <code>revolve</code> data set.
resolution	norefine coarse normal fine finer extrafine custom	normal	Controls the plot's resolution. A finer setting results in a higher resolution by modifying the internally computed default refinement. Use <code>custom</code> to enter your own refinement in the <code>refine</code> property.
smooth	none internal everywhere	internal	Smoothing settings.
shift	double	0	If <code>interactive</code> is on: The shift that is applied to the level values.

TABLE 6-35: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
solnum	non-negative integer	Last solution for transient or parametric solution. Otherwise first solution.	The index of the solution to use. Available when data is not parent and the underlying data has multiple solutions.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
suffixintitle	string	Empty	Added suffix to contribution to title.
t	double	Time corresponding to last selected solnum.	The time to use, for transient problems. Available when data is not parent and the underlying data is transient.
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when titletype is custom.
unit	string	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.
unitintitle	on off	on	Whether the title contribution should contain the unit when titletype is custom.
userder	boolean	true	Only for isosurface plots: If true, space derivatives of the iso expression are used to produce smoother plots.

Attributes [Color](#), [Deform](#), [Filter](#)

See Also [Isosurface \(data set\)](#), [Slice](#), [Volume](#)

Isosurface (data set)

Synopsis	Isosurface data set.
Syntax	<pre>model.result().dataset().create(<dtag>, "Isosurface"); model.result().dataset(<dtag>).set(property, <value>);</pre>
Description	<p><code>model.result().dataset().create(<dtag>, "Isosurface")</code> creates an isosurface data set feature named <code><dtag></code>.</p> <p>The following properties are available:</p>

TABLE 6-36: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
data	none data set name	First compatible data set	The data set this feature refers to.
descr	string		Description of expr.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	u	Expression to find constant level for.
level	double array	{0}	Levels that defines the data set if levelmethod is levels.
levelmethod	number levels	number	How to specify levels.
number	positive integer	5	Total number of contour levels. Active when levelmethod is number.
unit	string		Unit of expr. If the old unit is not valid when the expression changes, the unit property is reset to default.

See Also [Isosurface](#)

Synopsis	Join data set.
Syntax	<pre>model.result().dataset().create(<dtag>,"Join"); model.result().dataset(<dtag>).set(property, <value>);</pre>
Description	<p><code>model.result().dataset().create(<dtag>,"Join")</code> creates a join data set feature named <code><dtag></code>.</p> <p>The following properties are available:</p>

TABLE 6-37: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
data	none data set name	None	The first source data set.
data2	none data set name	None	The second source data set.
expr	string	data1 - data2	When method is general: The way the evaluations in the first and second data sets is combined. data1 and data2 can be used as symbols for the values from the two data sets, respectively.
method	difference explicit general product quotient sum	difference	How to combine the results from evaluating in the two source data sets.
solutions	all one	all	Whether to expose one or all solutions from the first data set.
solutions2	all one	all	Whether to expose one or all solutions from the second data set.

Synopsis	Line plot.
Syntax	<pre>model.result(<pgtag>).feature().create(<ftag>,"Line"); model.result(<pgtag>).feature(<ftag>).set(property, <value>); model.result(<pgtag>).feature(<ftag>).run();</pre>
Description	<p>model.result(<pgtag>).feature().create(<ftag>,"Line") creates a line plot feature named <ftag> belonging to the plot group <pgtag>.</p> <p>Line plots display a quantity on lines, curves and edges in 2D or 3D.</p> <p>The following properties are available:</p>

TABLE 6-38: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
color	custom black blue cyan green magenta red white yellow	red	The uniform color to use. Active when coloring is uniform.
coloring	colortable uniform	colortable	How to color this line plot.
colorlegend	on off	on	Whether to show color legend, when coloring is set to colortable.
colortable	colortable name	Rainbow	The color table to use when colormethod is set to colortable.
colortablerev	on off	off	Whether to reverse to color table when colormethod is set to colortable.
colortablesym	on off	off	Whether to symmetrize the color range around 0 when colormethod is set to colortable.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
customcolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use. Active when color is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
descr	string	Model-dependent.	The description of the expression in expr. Is used in the automatic title.

TABLE 6-38: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent.	The expression to plot.
expressionintitle	on off	off	Whether the title contribution should contain the expression when titletype is custom.
inheritcolor	boolean	true	If inheritplot is not none: Determines if the color is inherited.
inheritdeformscale	boolean	true	If inheritplot is not none: Determines if the deformation scale is inherited.
inheritplot	none plot name	none	The plot that color, color range, tube scale, and deformation scale is inherited from.
inheritrange	boolean	true	If inheritplot is not none: Determines if the color and data ranges are inherited.
inherittube scale	boolean	true	If inheritplot is not none and linetype is tube: Determines if the tube scale is inherited.
interp	double array	Time corresponding to last selected solnum for transient levels.	The time to use, for transient levels. Available when data is not parent and the underlying data is transient.
linetype	line tube	line	Plot lines or tubes.

TABLE 6-38: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
looplevel	array of non-negative integers and strings	Last solution for transient or parametric solution for each level. Otherwise first solution for each level.	The index of the solution to use, per level, or interp, but only for transient solutions. Available when data is not parent and the underlying data has multiple solutions.
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
prefixintitle	string	Empty	Added prefix to contribution to title.
radiusexpr	string	1	The tube radius. Active when linetype is tubes.
rangecoloractive	on off	off	Whether to use the manual color range specified in rangecolormin and rangecolormax. The color range specifies the minimum and maximum value in the plotted colors. Default is the minimum and maximum data values.
rangecolormax	double	Plot-dependent	The maximum color range value. Active when rangecoloractive is on.
rangecolormin	double	Plot-dependent	The minimum color range value. Active when rangecoloractive is on.
rangeadataactive	on off	off	Whether to use the manual data range specified in rangedatamin and rangedatamax. Values outside the data range is not plotted.
rangeadatamax	double	Plot-dependent	The maximum data value. Active when rangeadataactive is on.
rangeadatamin	double	Plot-dependent	The minimum data value. Active when rangeadataactive is on.
recover	off pprint ppr	off	The derivative recovery method.
refine	non-negative integer	1	The element refinement to use, if resolution is set to manual. Bear in mind that this is the refinement used for the base data set, so the number of elements in the model can increase radically if the plot uses, for example, a revolve data set.

TABLE 6-38: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
resolution	norefine coarse normal fine finer extrafine custom	normal	Controls the plot's resolution. A finer setting results in a higher resolution by modifying the internally computed default refinement. Use custom to enter your own refinement in the refine property.
smooth	none internal everywhere	internal	Smoothing settings.
solnum	non-negative integer	Last solution for transient or parametric solution. Otherwise first solution.	The index of the solution to use. Available when data is not parent and the underlying data has multiple solutions.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
suffixintitle	string	Empty	Added suffix to contribution to title.
t	double	Time corresponding to last selected solnum.	The time to use, for transient problems. Available when data is not parent and the underlying data is transient.
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.
title	string	The auto-title	The title to use when titletype is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
tuberadiussscale	double	1	The scale factor applied to the tube radii if tuberadiusscaleactive is true.
tuberadiussscaleactive	boolean	false	If true, tuberadiussscale is used, otherwise the scale factor is computed automatically
typeintitle	on off	on	Whether the title contribution should contain the type when titletype is custom.

TABLE 6-38: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
unit	string	Model-dependent	The unit to use for the expression in <code>expr</code> . If the old unit is not valid when the expression changes, the unit property is reset to default.
unitintitle	on off	on	Whether the title contribution should contain the unit when <code>titletype</code> is custom.
wireframe	on off	off	Whether to plot filled elements or only their edges.

Attributes [Deform](#), [Filter](#), [Height](#)

Examples Line plot on 2D solution:

```
model.result().dataset().create("dset1", "Solution");
model.result().dataset("dset1").set("solution", "sol1");

result().create("pg1", 2);
result("pg1").set("data", "dset1");
result("pg1").feature().create("line1", "Line");

result("pg1").feature("lngr1").set("expr", "3*u");
```

Line plot on cut plane in 3D:

```
result().dataset().create("cp1", "CutPlane");
result().dataset("cp1").set("data", "dset2");

result().create("pg2", 3);
result("pg2").feature().create("line2", "Line");
result("pg2").feature("line2").set("data", "cp1");
result("pg2").feature("line2").set("expr", "2*u");
result("pg2").feature("line2").set("colortable", "Thermal");

result("pg2").run();
```

See Also [LineGraph](#)

Synopsis	Line graph plot.
Syntax	<pre>model.result(<pgtag>).feature().create(<ftag>,"LineGraph"); model.result(<pgtag>).feature(<ftag>).selection(...); model.result(<pgtag>).feature(<ftag>).set(property, <value>); model.result(<pgtag>).feature(<ftag>).run();</pre>
Description	<p><code>model.result(<pgtag>).feature().create(<ftag>,"LineGraph")</code> creates a line graph plot feature named <code><ftag></code> belonging to the plot group <code><pgtag></code>.</p> <p>Line graph plot is used to visualize quantities on lines, either cut lines or boundaries (2D) and edges (3D) in a geometry. Line graph plots can be added to 1D plot groups.</p> <p>The following properties are available:</p>

TABLE 6-39: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
autlegends	on off	on	Whether to use the automatically generated legends or the legends defined in the legends property.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
customlinecolor	RGB-triplet	{0,0,1} or last used edgecolor.	The color to use for the lines. Active when linecolor is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
descr	string	Model-dependent	The description of the expression in expr. Is used in the automatic title.
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent	The expression to plot.

TABLE 6-39: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
expressionintitle	on off	off	Whether the title contribution should contain the expression when titletype is custom.
innerinput	all first last manual manualindices interp	all	How to input the solution to use. manual indicates that solnum is used. manualindices indicates that solnumindices is used. interp indicates that t is used.
interp	double row matrix	Empty on all levels.	The times to use, for transient levels. Available when data is not parent and the underlying data is transient.
legend	on off	off	Whether to show legends.
legendmethod	automatic manual	automatic	Whether to use the automatic legends or the legends supplied in the legends property.
legends	string array	The last computed automatic legends	Manual legends active when legendmethod is set to manual.
linecolor	custom cycle black blue cyan green magenta red white yellow	cycle	How to color the lines in the graph. Cycle indicates that the colors is different for each line.
linewidth	double	0.5	The line width.
linemarker	none cycle asterisk circle diamond plus point square star triangle	none	The line markers, if any. Cycle indicates that the marker is different for each line.
looplevel	integer row matrix	All solutions on all levels	The solutions to use, per level.
looplevelindices	integer row matrix	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1,1, 20). Applicable when looplevelinput is manualindices on a level.

TABLE 6-39: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
looplevelinput	String array with all first last manual manualindices interp on each level	all on all levels	How to input the solution to use, per level. manual on a level indicates that looplevel is used on that level. manualindices on a level indicates that looplevelindices is used on that level. interp on a level indicates that interp is used on that level.
markerpos	interp datapoints	interp	Controls whether the positions of the markers are in the data points of the plot, or interpolated depending on the number (set in markers). Markers are visible when linemarker is set.
markers	integer	8	The number of markers to show. Markers are visible when linemarker is set.
linestyle	none cycle solid dotted dashed dashdot	solid	The line style, if any. Cycle indicates that the line style is different for each line.
outerinput	all first last manual manualindices	all	How to input the outer solutions to use. Applicable only for parametric sweep models. manual indicates that outersolnum is used. manualindices indicates that outersolnumindices is used.
outersolnum	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models. Since the various outer solutions can have different number of solnum, the solnum property is not used.
outersolnumindices	string or integer array	Empty	An alternate way to specify the outer solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when outerinput is manualindices.
prefixintitle	string	Empty	Added prefix to contribution to title.
refine	non-negative integer	1	The element refinement to use, if resolution is set to manual. Bear in mind that this is the refinement used for the base data set, so the number of elements in the model can increase radically if the plot uses, for example, a revolve data set.

TABLE 6-39: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
resolution	norefine coarse normal fine finer extrafine custom	normal	Controls the plot's resolution. A finer setting results in a higher resolution by modifying the internally computed default refinement. Use custom to enter your own refinement in the refine property.
solnum	integer array	All solutions	The solutions to plot. Available when data is not parent and the underlying data has multiple solutions.
solnumindices	string or integer array	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when innerinput is manualindices.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
suffixintitle	string	Empty	Added suffix to contribution to title.
t	double array	Empty	The times to plot. Available when data is not parent and the underlying solution is transient.
title	string	The auto-title	The title to use when titletype is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when titletype is custom.
unit	string	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.
unitintitle	on off	on	Whether the title contribution should contain the unit when titletype is custom.
xdata	expr solution	solution	x-axis data. expr uses the expression in xdataexpr. solution uses the available solutions in the underlying data set such as time steps.
xdataexpr	string	Model-dependent	Expression for x-axis data.

TABLE 6-39: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
xdatadescr	string	Model-dependent	Description of expression in xdataexpr.
xdataunit	string	Model-dependent	The unit to use for the expression in xdataexpr. If the old unit is not valid when the expression changes, the unit property is reset to default.

Attributes None

See Also [Line](#)

Synopsis	Max/min marker plots.
Syntax	<pre>model.result(<pgtag>).feature().create(<ftag>,"MaxMinVolume"); model.result(<pgtag>).feature().create(<ftag>,"MaxMinSurface"); model.result(<pgtag>).feature().create(<ftag>,"MaxMinLine"); model.result(<pgtag>).feature(<ftag>).set(property, <value>); model.result(<pgtag>).feature(<ftag>).run();</pre>
Description	<p>model.result(<pgtag>).feature().create(<ftag>,"MaxMinVolume") creates a max/min marker plot feature named <ftag> belonging to the plot group <pgtag>.</p> <p>This plot type displays the maximum and minimum of an expression and the points there they are attained.</p> <p>The following properties are available:</p>

TABLE 6-40: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
color	custom black blue cyan green magenta red white yellow	black	The color with which markers will be plotted.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
customcolor	RGB-triplet	{1,0,0} or last used color	The color to use when color is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.
display	minmax min max	minmax	The selection determines which markers are shown.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic

TABLE 6-40: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string		The expression to compute the maximum and minimum for.
expressionintitle	on off	off	Whether the title contribution should contain the expression when <code>titletype</code> is custom.
inheritcolor	boolean	true	If <code>inheritplot</code> is not none: Determines if the color is inherited.
inheritdeformscale	boolean	true	If <code>inheritplot</code> is not none: Determines if the deformation scale is inherited.
inheritplot	none plot name	none	The plot that deformation scale is inherited from.
precision	integer > 0	6	The number of decimals displayed in the labels in the GUI.
prefixintitle	string	Empty	Added prefix to contribution to title.
refine	integer > 0	2	The number of refinements of each mesh element when computing the maximum and minimum.
recover	off pprint ppr	off	The derivative recovery method.
suffixintitle	string	Empty	Added suffix to contribution to title.
title	string	The auto-title	The title to use when <code>titletype</code> is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when <code>titletype</code> is custom.
unitintitle	on off	on	Whether the title contribution should contain the unit when <code>titletype</code> is custom.

Attributes

[Deform](#)

Synopsis

Finding external values.

Syntax

```
model.result().numerical().create(<ftag>,"MaxVolume");
model.result().numerical().create(<ftag>,"MinVolume");
model.result().numerical().create(<ftag>,"MaxSurface");
model.result().numerical().create(<ftag>,"MinSurface");
model.result().numerical().create(<ftag>,"MaxLine");
model.result().numerical().create(<ftag>,"MinLine");
model.result().numerical(<ftag>).selection(...);
model.result().numerical(<ftag>).set(property, <value>);
model.result().numerical(<ftag>).getReal();
model.result().numerical(<ftag>).getReal(<columnwise>);
model.result().numerical(<ftag>).getReal(<outersolnum>);
model.result().numerical(<ftag>).getReal(<columnwise>,
    <outersolnum>);
model.result().numerical(<ftag>).getImag();
model.result().numerical(<ftag>).getImag(<allocate>,
    <columnwise>);
model.result().numerical(<ftag>).getImag(<outersolnum>);
model.result().numerical(<ftag>).getImag(<allocate>, <columnwise>,
    <outersolnum>);
model.result().numerical(<ftag>).isComplex();
model.result().numerical(<ftag>).isComplex(<outersolnum>);
model.result().numerical(<ftag>).setResult();
model.result().numerical(<ftag>).appendResult();
```

Description

`model.result().numerical().create(<ftag>,"MaxVolume")` creates a volume maximum feature with the name `<ftag>`, and similarly for "MinVolume".

`model.result().numerical().create(<ftag>,"MaxSurface")` creates a surface maximum feature with the name `<ftag>`, and similarly for "MinSurface".

`model.result().numerical().create(<ftag>,"MaxLine")` creates a line maximum feature with the name `<ftag>`, and similarly for "MinLine".

`model.result().numerical(<ftag>).getReal()` returns the real result, recomputing the feature if necessary. Data is ordered such that one row contains data for all solution numbers. This is identical to `(columnwise)` when `columnwise` is false. If `columnwise` is true, the ordering is the opposite: each *column* contains the values for all solution numbers.

`model.result().numerical(<ftag>).getImag(allocate, columnwise)` returns the imaginary part of complex result, recomputing the feature if necessary. If `allocate` is true, a zero-valued matrix is allocated even when the result is real. `getImag()` uses `allocate true` and `columnwise false`.

`model.result().numerical(<ftag>).isComplex()` returns true if the result is complex.

`<outersolnum>` is applicable only for parametric sweep solutions and is the index of each outer parametric solution.

`model.result().numerical(<ftag>).setResult()` and

`model.result().numerical(<ftag>).appendResult()` evaluates the feature and set or append the result in the table indicated by the `table` property.

The following properties are available:

TABLE 6-41: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
<code>const</code>	String array of property/value pairs	Empty	Parameters to use in the expressions.
<code>data</code>	<code>none</code> data set name	First compatible data set	The data set this feature refers to.
<code>dataseries</code>	<code>average</code> <code>integral</code> <code>maximum</code> <code>minimum</code> <code>none</code> <code>rms</code> <code>stddev</code> <code>variance</code>	<code>none</code>	The operation that is applied to the data series formed by the evaluation.
<code>descr</code>	<code>string</code>	Model-dependent	The description of the expression in <code>expr</code> . Is used in the automatic title.
<code>differential</code>	<code>on</code> <code>off</code>	<code>on</code>	Whether the expression should be linearized at the linearization point. Applicable only if <code>evalmethod</code> is <code>harmonic</code>
<code>evalmethod</code>	<code>linpoint</code> <code>harmonic</code> <code>lintotal</code> <code>lintotalavg</code> <code>lintotalrms</code> <code>lintotalpeak</code>	<code>harmonic</code>	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
<code>expr</code>	<code>string</code>	Model-dependent	The expression to plot.
<code>innerinput</code>	<code>all</code> <code>first</code> <code>last</code> <code>manual</code> <code>manualindices</code> <code>interp</code>	<code>all</code>	How to input the solution to use. <code>manual</code> indicates that <code>solnum</code> is used. <code>manualindices</code> indicates that <code>solnumindices</code> is used. <code>interp</code> indicates that <code>t</code> is used.

TABLE 6-41: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
interp	double row matrix	Empty on all levels.	The times to use, for transient levels. Available when data is not parent and the underlying data is transient.
looplevel	integer row matrix	All solutions on all levels	The solutions to use, per level.
looplevelindices	integer row matrix	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when looplevelinput is manualindices on a level.
looplevelinput	String array with all first last manual manualindices interp on each level	all on all levels	How to input the solution to use, per level. manual on a level indicates that looplevel is used on that level. manualindices on a level indicates that looplevelindices is used on that level. interp on a level indicates that interp is used on that level.
obj	abs real	real	The function of each real or complex number that is maximized/minimized.
outerinput	all first last manual manualindices	all	How to input the outer solutions to use. Applicable only for parametric sweep models. manual indicates that outersolnum is used. manualindices indicates that outersolnumindices is used.
outersolnum	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models. Since the various outer solutions can have different number of solnum, the solnum property is not used.
outersolnumindices	string or integer array	Empty	An alternate way to specify the outer solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when outerinput is manualindices.
solnum	non-negative integer array	All solutions	The solutions to use.
solnumindices	string or integer array	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when innerinput is manualindices.

TABLE 6-41: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
t	double array	Empty	The times to use. Available when the underlying solution is transient.
table	new table name	new	The table to use when calling setResult() or appendResult(). new indicates that a new table is created.
tablecols	inner outer data level1	data	Whether to use inner or outer solutions as columns in the table when calling setResult() or appendResult(). Applicable only for parametric sweep models. The level values (level1, level2, and so on) are the levels in the parametric sweep.
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.
unit	string	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.

See Also [IntVolume](#), [IntSurface](#), [IntLine](#)

Synopsis Mesh plot.

Syntax `model.result(<pgtag>).feature().create(<ftag>,"Mesh");`
`model.result(<pgtag>).feature(<ftag>).set(property, <value>);`
`model.result(<pgtag>).feature(<ftag>).run();`

Description `model.result(<pgtag>).feature().create(<ftag>,"Mesh")` creates a mesh plot feature named `<ftag>` belonging to the plot group `<pgtag>`.

This plot type provides visualization of 2D and 3D meshes.

The following properties are available:

TABLE 6-42: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
colortable	colortable name	Rainbow	The element color table to use when elemcolor is set to quality.
data	none parent data set name	parent	The data set this feature refers to.
elemcolor	quality color	quality	How to color the elements.
elemfilter	random quality qualityrev size expression logicalexpr ession	random	If filteractive is on: The expression to use for filtering when only a subset of the elements are shown.
elemscale	double in [0,1]	1	The factor with which the elements are scaled before display.
elemtype2	all tri quad	all	2D mesh element types to plot.
elemtype3	all tet prism hex	all	3D mesh element types to plot.
filteractive	on off	off	Whether to use element filtering.
filterexpr	string	x	The expression to use for filtering when elemfilter is set to expression.
logfilterexpr	String	'1'	The logical expression to use for filtering when elemfilter is set to 'logicalexpression'.

TABLE 6-42: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
meshdomain	all point edge surface volume (if 3D)	all	Mesh domain level(s) to plot.
tetkeep	Double in [0, 1]	1	The fraction of the elements to display.
title	string	The auto-title	The title to use when titletype is manual.
titletype	auto manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. manual if the manual title should be used (the title property). none if no title should be displayed.
wireframecolor	none color	black	How to color the wireframe mesh, 'none' means that it is not displayed at all.

Attributes [Filter](#)

See Also Mesh (data set)

Mesh (data set)

- Synopsis** Mesh data set.
- Syntax**

```
model.result().dataset().create(<dtag>, "Mesh");  
model.result().dataset(<dtag>).set(property, <value>);
```
- Description** `model.result().dataset().create(<dtag>, "Mesh")` creates a mesh data set feature named `<dtag>`.

This data set provides support for evaluation of spatial coordinates and mesh variables on a mesh.

The following properties are available:

TABLE 6-43: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
mesh	string	Empty	The mesh that this data set refers to.

See Also [Mesh](#)

Synopsis Mesh export.

Syntax

```
model.result().export().create(<ftag>,"Mesh");
model.result().export().create(<ftag>,<dtag>,"Mesh");
model.result().export(<ftag>).set(property, <value>);
model.result().export(<ftag>).run();
```

Description `model.result().export().create(<ftag>,"Mesh")` creates a mesh export feature with the name `<ftag>`.

`model.result().export().create(<ftag>,<dtag>,"Mesh")` creates a mesh export feature with the name `<ftag>` for the data set `<dtag>`.

The following properties are available:

TABLE 6-44: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
data	string		The name of the data set to export.
filename	string		The output file.
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
solnum	integer array		Solution number to take values from.
stlformat	binary text	binary	STL file format.
t	string		Time to evaluate in if timeinterp is on.
timeinterp	on off	off	Enable/disable explicit time to evaluate in.

See Also [Data](#)

Synopsis	Mirror data set.
Syntax	<pre>model.result().dataset().create(<dtag>, "Mirror2D"); model.result().dataset().create(<dtag>, "Mirror3D"); model.result().dataset(<dtag>).set(property, <value>);</pre>
Description	<p><code>model.result().dataset().create(<dtag>, "Mirror2D")</code> creates a 2D mirror data set feature named <code><dtag></code>.</p> <p><code>model.result().dataset().create(<dtag>, "Mirror3D")</code> creates a 3D mirror data set feature named <code><dtag></code>.</p> <p>This data set takes data from another data set and adds a mirror copy with respect to an axis or plane of reflection (for 2D and 3D respectively).</p> <p>The following properties are available for Mirror 2D and Mirror 3D:</p>

TABLE 6-45: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
data	none data set name	First compatible data set	The data set this feature refers to.
genpoints	double matrix	{{0, 0, 0}, {1,0,0}}	Active when method equals twopoint, this property contains the coordinates of the two points in the two rows of the matrix.
hasvar	boolean	false	If true, an axis indicator variable is defined.
method	twopoint pointdir	twopoint	Decides if the line should be specified by two points or through one point and a direction.
pddir	double array	{0, 1}	Active when method equals pointdir, this property contains the direction.
pdpoint	double array	{0, 0}	Active when method equals pointdir, this property contains the coordinates of the point.
sidevar	string		If hasvar is true: The name of the positive side variable, which is 1 on the side where the original data resides and 0 on the other side.

The following properties are available for Mirror 3D:

TABLE 6-46: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
data	none data set name	First compatible data set	The data set this feature refers to.
genmethod	threepoint pointnormal	threepoint	Active when planetype equals general, this property indicates whether the plane should be specified by three points or through one point and a normal.
genpoints	double matrix	{{0, 0, 0}, {1,0,0}, {0,1,0}}	Active when method equals threepoint, this property contains the coordinates of the three points in the rows of the matrix.
genpnpoint	double array of length three	Zero vector	Active when genmethod equals pointnormal, this property contains the coordinates of the point.
genpnvec	double array of length three	Zero vector	Active when genmethod equals pointnormal, this property contains the normal vector.
hasvar	boolean	false	If true, an axis indicator variable is defined.
planetype	quick general	yz	Specify plane type.)
quickplane	xy yz zx	yz	Specify quick plane type. Active when planetype is quick.
quickx	double	0	x-coordinate if planetype is yz
quicky	double	0	y-coordinate if planetype is zx
quickz	double	0	z-coordinate if planetype is xy
sidevar	string		If hasvar is true: The name of the positive side variable, which is 1 on the side where the original data resides and 0 on the other side.

Synopsis Slice plot in multiple directions at once.

Syntax `model.result(<pgtag>).feature().create(<ftag>,"Multislice");`
`model.result(<pgtag>).feature(<ftag>).set(property, <value>);`
`model.result(<pgtag>).feature(<ftag>).run();`

Description `model.result(<pgtag>).feature().create(<ftag>,"Multislice")` creates a slice feature in multiple directions named `<ftag>` belonging to the plot group `<pgtag>`.

The following properties are available:

TABLE 6-47: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
color	custom black blue cyan green magenta red white yellow	red	The uniform color to use. Active when coloring is uniform.
coloring	colortable uniform	colortable	How to color the slices.
colorlegend	on off	on	Whether to show color legend, when coloring is set to colortable.
colortable	colortable name	Rainbow	The color table to use when colormethod is set to colortable.
colortablerev	on off	off	Whether to reverse to color table when colormethod is set to colortable.
colortablesym	on off	off	Whether to symmetrize the color range around 0 when colormethod is set to colortable.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
customcolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use. Active when color is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
descr	string	Model-dependent.	The description of the expression in expr. Is used in the automatic title.
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.

TABLE 6-47: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent.	The expression to plot.
expressionintitle	on off	off	Whether the title contribution should contain the expression when titletype is custom.
inheritcolor	boolean	true	If inheritplot is not none: Determines if the color is inherited.
inheritdeformation	boolean	true	If inheritplot is not none: Determines if the deformation scale is inherited.
inheritplot	none plot name	none	The plot that color, color range, and deformation scale is inherited from.
inheritrange	boolean	true	If inheritplot is not none: Determines if the color and data ranges are inherited.
interp	double array	Time corresponding to last selected solnum for transient levels.	The time to use, for transient levels. Available when data is not parent and the underlying data is transient.
looplevel	array of non-negative integers and strings	Last solution for transient or parametric solution for each level. Otherwise first solution for each level.	The index of the solution to use, per level, or interp, but only for transient solutions. Available when data is not parent and the underlying data has multiple solutions.
multiplanexmethod	number coord	number	Indicates whether the x-coordinates of the x-planes should be specified by number of planes to distribute evenly across the data or by coordinates.
multiplaneymethod	number coord	number	Indicates whether the y-coordinates of the y-planes should be specified by number of planes to distribute evenly across the data or by coordinates.

TABLE 6-47: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
multiplanezmethod	number coord	number	Indicates whether the z-coordinates of the z-planes should be specified by number of planes to distribute evenly across the data or by coordinates.
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
prefixintitle	string	Empty	Added prefix to contribution to title.
rangecoloractive	on off	off	Whether to use the manual color range specified in rangecolormin and rangecolormax. The color range specifies the minimum and maximum value in the plotted colors. Default is the minimum and maximum data values.
rangecolormax	double	Plot-dependent	The maximum color range value. Active when rangecoloractive is on.
rangecolormin	double	Plot-dependent	The minimum color range value. Active when rangecoloractive is on.
rangedataactive	on off	off	Whether to use the manual data range specified in rangedatamin and rangedatamax. Values outside the data range is not plotted.
rangedatamax	double	Plot-dependent	The maximum data value. Active when rangedataactive is on.
rangedatamin	double	Plot-dependent	The minimum data value. Active when rangedataactive is on.
recover	off pprint ppr	off	The derivative recovery method.
refine	non-negative integer	1	The element refinement to use, if resolution is set to manual. Bear in mind that this is the refinement used for the base data set, so the number of elements in the model can increase radically if the plot uses, for example, a revolve data set.
resolution	norefine coarse normal fine finer extrafine custom	normal	Controls the plot's resolution. A finer setting results in a higher resolution by modifying the internally computed default refinement. Use custom to enter your own refinement in the refine property.
smooth	none internal everywhere	internal	Smoothing settings.

TABLE 6-47: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
suffixintitle	string	Empty	Added suffix to contribution to title.
solnum	non-negative integer	Last solution for transient or parametric solution. Otherwise first solution.	The index of the solution to use. Available when data is not parent and the underlying data has multiple solutions.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
t	double	Time corresponding to last selected solnum.	The time to use, for transient problems. Available when data is not parent and the underlying data is transient.
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when titletype is custom.
unit	string	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.
unitintitle	on off	on	Whether the title contribution should contain the unit when titletype is custom.
xnumber	non-negative integer	1	Number of planes in the x-direction. Active when multiplanexmethod is set to number.
xcoord	double array	Empty	Absolute coordinates in the x-direction, active when multiplanexmethod is set to coord.
ynumber	integer	1	Number of planes in the y-direction. Active when multiplaneymethod is set to number.
ycoord	double array	Empty	Absolute coordinates in the z-direction, active when multiplaneymethod is set to coord.

Multislice

TABLE 6-47: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
znumber	integer	1	Number of planes in the z-direction. Active when <code>multiplanemethod</code> is set to <code>number</code> .
zcoord	double array	Empty	Absolute coordinates in the z-direction, active when <code>multiplanemethod</code> is set to <code>coord</code> .

Attributes [Deform](#), [Filter](#)

See Also [Slice](#), [Volume](#)

Synopsis	Nyquist plot.
Syntax	<pre>model.result(<pgtag>).feature().create(<ftag>, "Nyquist"); model.result(<pgtag>).feature(<ftag>).set(property, <value>); model.result(<pgtag>).feature(<ftag>).run();</pre>
Description	<p><code>model.result(<pgtag>).feature().create(<ftag>, "Nyquist")</code> creates a Nyquist plot feature named <code><ftag></code> belonging to the plot group <code><pgtag></code>.</p> <p>Nyquist plots are used to visualize complex variables. Nyquist plots can be added to 1D plot groups.</p> <p>The following properties are available:</p>

TABLE 6-48: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
autodescr	on off	Model dependent	Whether the automatic legends should include the expression descriptions.
autoexpr	on off	Model dependent	Whether the automatic legends should include the expressions.
autolegends	on off	on	Whether to use the automatically computed legends or the legends defined in the legends property. The automatic legends display the description and expression for each line.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
customlinecolor	RGB-triplet	{0,0,1} or last used edgcolor.	The color to use for the lines. Active when linecolor is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
descr	string array	Model-dependent.	The description of the expressions in expr. Is used in the automatic legends.
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic

TABLE 6-48: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string array	Model-dependent.	The expressions to plot.
expressionintitle	on off	off	Whether the title contribution should contain the expression when titletype is custom.
legend	on off	off	Whether to show legends.
legendmethod	automatic manual	automatic	Whether to use the automatic legends or the legends supplied in the legends property.
legends	string array	The last computed automatic legends.	Manual legends active when legendmethod is set to manual.
linecolor	custom cycle black blue cyan green magenta red white yellow	cycle	How to color the lines in the graph. Cycle indicates that the colors is different for each line.
linewidth	double	0.5	The line width.
linemarker	none cycle asterisk circle diamond plus point square star triangle	none	The line markers, if any. Cycle indicates that the marker is different for each line.
linestyle	none cycle solid dotted dashed dashdot	solid	The line style, if any. Cycle indicates that the line style is different for each line.

TABLE 6-48: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
markerpos	interp datapoints	interp	Controls whether the positions of the markers are in the data points of the plot, or interpolated depending on the number (set in markers). Markers are visible when linemarker is set.
markers	integer	8	The number of markers to show. Markers are visible when linemarker is set.
outersolnum	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models. Since the various outer solutions can have different number of solnum, the solnum property is not used.
outersolnumindices	string or integer array	Empty	An alternate way to specify the outer solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when outerinput is manualindices.
prefixintitle	string	Empty	Added prefix to contribution to title.
solnum	non-negative integer array	All solutions	The solutions to plot. Available when data is not parent and the underlying data has multiple solutions.
solnumindices	string or integer array	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when innerinput is manualindices.
suffixintitle	string	Empty	Added suffix to contribution to title.
t	double array	Empty	The times to plot. Available when data is not parent and the underlying solution is transient.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when titletype is custom.

TABLE 6-48: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
unit	string array	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.
unitcircle	boolean	false	Whether to plot the unit circle along with the axis.
unitintitle	on off	on	Whether the title contribution should contain the unit when titletype is custom.

Synopsis Extends another data set by using a parameter as dimension.

Syntax `model.result().dataset().create(<dtag>, "Parametric");`
`odel.result().dataset(<dtag>).set(property, <value>);`

Description `model.result().dataset().create(<dtag>, "Parametric")` creates a parametric data set feature named `<dtag>`. This data set extends another data set by using a parameter, such as time, as a dimension.

The following properties are available:

TABLE 6-49: VALID PROPERTY/VALUE PAIRS FOR THE PARAMETRIC DATA SET

NAME	VALUE	DEFAULT	DESCRIPTION
data	none data set name	First compatible data set	The data set this feature refers to.
innerinput	all first last manual manualindices interp	all	How to input the solution to use. manual indicates that solnum is used. manualindices indicates that solnumindices is used. interp indicates that t is used.
levelscale	double	1	The scaling factor applied to the levels if levelscaleactive is true.
levelscaleactive	boolean	false	If true, levelscale is used to scale the levels, otherwise the scale factor is computed automatically.
solnum	Integer array	All solutions	The solutions to use for extrapolation.
t	double array	Empty	The times to use as intermediate layers in the extrusion.

Synopsis	Parameterized curve data set.
Syntax	<pre>model.result().dataset().create(<dtag>, "ParCurve2D"); model.result().dataset().create(<dtag>, "ParCurve3D"); model.result().dataset(<dtag>).set(property, <value>);</pre>
Description	<p><code>model.result().dataset().create(<dtag>, "ParCurve2D")</code> creates a 2D parameterized curve data set feature named <code><dtag></code>.</p> <p><code>model.result().dataset().create(<dtag>, "ParCurve3D")</code> creates a 3D parameterized curve data set feature named <code><dtag></code>.</p> <p>Evaluation is made along an arbitrary parameterized curve in 2D or 3D.</p> <p>The following properties are available:</p>

TABLE 6-50: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
name	string	none	The name of this feature.
data	none data set name	First compatible data set	The data set this feature refers to.
par1	string	t	The curve parameter.
parmin1	double	0	The minimum value for par.
parmax1	double	1	The maximum value for par.
exprx	string	0	The expression for x(par).
expy	string	0	The expression for y(par).
exprz	string	0	The expression for z(par).
res	integer	1000	Resolution (the number of discretization points along the curve).

See Also [ParSurface](#)

Synopsis The parametric surface data set.

Syntax `model.result().dataset().create(<dtag>, "ParSurface");`
`model.result().dataset(<dtag>).set(property, <value>);`

Description `model.result().dataset().create(<dtag>, "ParSurface")` creates a parameterized surface data set feature named `<dtag>`.

Evaluation is made along an arbitrary parameterized surface in 3D.

The following properties are available:

TABLE 6-51: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
data	none data set name	First compatible data set	The data set this feature refers to.
exprx	string	0	The expression for x(par1, par2).
expry	string	0	The expression for y(par1, par2).
exprz	string	0	The expression for z(par1, par2).
par1	string	s	The first surface parameter.
par2	string	t	The second surface parameter.
parmin1	double	0	The minimum value for par1.
parmax1	double	1	The maximum value for par1.
parmin2	double	0	The minimum value for par2.
parmax2	double	1	The maximum value for par2.
res	integer	200	Resolution (the number of discretization points for each parameter).

See Also [ParCurve2D](#), [ParCurve3D](#)

Synopsis Massless particle tracing plot.

Syntax

```
model.result(<pgtag>).feature().create(<ftag>,"Particle");
model.result(<pgtag>).feature(<ftag>).set(property, <value>);
model.result(<pgtag>).feature(<ftag>).run();
```

Description

```
model.result(<pgtag>).feature().create(<ftag>,"Particle")
```

 creates a massless particle tracing plot feature named `<ftag>` belonging to the plot group `<pgtag>`.

With massless particle tracing, you can visualize path lines, that is, trajectories of particles released in a flow field, which can be time-dependent or static. For time-dependent flows you can also use a snapshot in time of the flow field as a static field. The motion of the particles does not affect the flow field. Particle tracing is available in 2D and 3D plot groups.

The following properties are available:

TABLE 6-52: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
atol	manual automatic	automatic	Whether to specify a manual absolute tolerance for the position. <code>automatic</code> indicates that the absolute tolerance for the position is the mean of the lengths of the bounding box of the geometry multiplied by the relative tolerance.
atolpos	positive double	0.001	Absolute tolerance for the position. Active when <code>atol</code> is set to <code>manual</code> .
bndcoord	double array	0	Vector of values from 0 to 1 to describe the start points. Active when <code>bndmethod</code> is set to <code>coord</code> . Available in 2D only.
bndmethod	number coord	number	Active when <code>posmethod</code> is set to <code>bnd</code> . Available in 2D only.
bndnumber	positive integer	10	The number of equidistant start points along the selected boundaries. Available in 2D only.
bndselection	Reference to a named selection on boundaries	First available named selection	The boundaries to start from. Available in 2D only.
comettailexpr	string array		Active when <code>pointtype</code> is set to <code>cometail</code> . Determines the direction in which the comet tail points.

TABLE 6-52: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
customlinecolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use for lines. Active when linecolor is set to custom.
custompointcolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use for points. Active when pointcolor is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
descr	string	Model-dependent	The description of the expressions in expr. Is used in the automatic title.
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.
dropfreq	positive double	1	Particles are released at these intervals when dropmethod is set to freq.
dropmethod	once freq times	once	Method to use when releasing particles.
droptimes	double array	1	The specific times when to release particles. Used when dropmethod is set to times.
edgetol	positive double	0.001	The absolute tolerance controlling how close to the geometry boundary the path lines are cut when they exit the geometry. A lower value cuts the line closer to the geometry boundary.
expr	String array of length 2 in 2D and 3 in 3D	Model-dependent	Expressions for the components to plot.
hmax	double	0.1	The maximum time step. Active when stepsize is set to manual.
hstart	double	0.1	The initial time step. Active when stepsize is set to manual.
inheritdeformscale	boolean	true	If inheritplot is not none: Determines if the deformation scale is inherited.
inheritplot	none plot name	none	The plot that sphere scale, tube scale, and deformation scale is inherited from.

TABLE 6-52: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
inheritpherescale	boolean	true	If inheritplot is not none: Determines if the sphere scale is inherited.
inheritubescale	boolean	true	If inheritplot is not none and linetype is tube: Determines if the tube scale is inherited.
interp	double array	Time corresponding to last selected solnum for transient levels.	The time to use, for transient levels. Available when data is not parent and the underlying data is transient.
linecolor	custom black blue cyan green magenta red white yellow	black (2D), red (3D)	The uniform color to use for lines.
linetype	none line tube	line	Plot particle traces as lines or tubes, or not at all.
looplevel	array of non-negative integers and strings	Last solution for transient or parametric solution for each level. Otherwise first solution for each level.	The index of the solution to use, per level, or interp, but only for transient solutions. Available when data is not parent and the underlying data has multiple solutions.
maxsteps	positive integer	1000	The maximum number of steps to use in the particle simulation. Active when maxstepsactive is set to on.
maxstepsactive	on off	off	Whether to manually specify the maximum number of steps used in particle simulation. off indicates that the limit varies in this way: for static flow fields, the algorithm uses the value 1000; for time-dependent flows, there is no upper limit of the number of steps, and the particle simulation goes on until it reaches the end time.

TABLE 6-52: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
pointcolor	custom black blue cyan green magenta red white yellow	red	The uniform color to use for points.
pointdom	disappear stick	stick	stick plots the points on the boundary at the exit point, and disappear does not render these points at all.
pointlineanim	on off	off	When animating particle tracing plots with points, this property indicates whether the points at the current time should appear on top of the lines.
pointautoscale	on off	on	If enabled, the point radii are scaled so that the maximum radius is 0.01 of the plot scale.
pointradiusexpr	string	1	The point radius expression.
pointtype	none point comettail	none	Selects between plotting the path lines' endpoints as points, comet tails, or not at all.
posmethod	start bnd	start	The type of particle tracing positioning. Choose specific start points or a boundary to start from. Available in 2D only.
prefixintitle	string	Empty	Added prefix to contribution to title.
radiusexpr	string	1	The tube radius.
resolution	coarser coarse normal fine finer extrafine		Affects the number of output points by adding points between each time step taken in the ODE solver, using a 4th-order interpolation, to produce a smoother output.
rtol	positive double	0.001	The relative error tolerance that the ODE solver uses.

TABLE 6-52: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
solnum	non-negative integer	Last solution for transient or parametric solution. Otherwise first solution.	The index of the solution to use. Available when data is not parent and the underlying data has multiple solutions.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
static	on off	off	Only affects time-dependent problems. When set to on, this property freezes the time and considers this a static flow field.
statictend	double	1	The maximum time at which to end the particle-tracing simulation for static flow fields. Active when statictendactive is set to on.
statictendactive	on off	off	Whether to specify the end time for static flow fields automatically. (For time-dependent flows, the automatic end time is the last time that the time-dependent solver returns.) When set to off, there is no upper limit of the time. In this case, the particle simulation goes on until all particles exit the geometry or the simulation reaches the maximum number of steps.
stepsize	automatic manual	automatic	Whether to specify initial (hstart) and maximum (hmax) time step manually.
suffixintitle	string	Empty	Added suffix to contribution to title.
t	double	Time corresponding to last selected solnum.	The time to use, for transient problems. Available when data is not parent and the underlying data is transient.
tailscale	positive double	1	Active when pointtype is set to comettail and tailscaleactive is on. Specifies the manual scale factor with which the comet tail expression is multiplied.

TABLE 6-52: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
tailscaleactive	on off	off	Active when pointtype is set to comettail. Specifies whether manual tail scaling is enabled.
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
tstart	double	0	Manual start time. Active when tstartactive is set to on.
tstartactive	on off	off	on indicates a manual start time (set in the tstart property). Off indicates that the start time becomes either the first time value that the time-dependent solver returns or 0 for stationary flows. Available when dropmethod is set to once or freq.
tubeautoscale	on off	on	If enabled, the tube radii are scaled so that the maximum tube radius is 0.02 of the plot scale.
tvar	string	partt	The name of the variable for time. Normally there is no need to change the default name. You can use this names in expressions as well as for the color when coloring the path lines according to an expression.
typeintitle	on off	on	Whether the title contribution should contain the type when titletype is custom.
xcoord	double array	Empty	Absolute coordinates in the x-direction, active when posmethod is set to start.
ycoord	double array	Empty	Absolute coordinates in the y-direction, active when postmethod is set to start.
zcoord	double array	Empty	Absolute coordinates in the z-direction, active when posmethod is set to coord. Available in 3D only.

Attributes [Color](#) (applies to lines), [Deform](#)

See Also [ParticleMass](#), [Streamline](#)

Synopsis

Evaluate quantities on particle trajectories.

Syntax

```
model.result().numerical().create(<ftag>,"Particle");
odel.result().numerical(<ftag>).set(property, <value>);
model.result().numerical(<ftag>).getReal();
model.result().numerical(<ftag>).getReal(<columnwise>);
model.result().numerical(<ftag>).getReal(<outersolnum>);
model.result().numerical(<ftag>).getReal(<columnwise>,
    <outersolnum>);
model.result().numerical(<ftag>).getImag();
model.result().numerical(<ftag>).getImag(<allocate>,
    <columnwise>);
model.result().numerical(<ftag>).getImag(<outersolnum>);
model.result().numerical(<ftag>).getImag(<allocate>, <columnwise>,
    <outersolnum>);
model.result().numerical(<ftag>).isComplex();
model.result().numerical(<ftag>).isComplex(<outersolnum>);
model.result().numerical(<ftag>).setResult();
model.result().numerical(<ftag>).appendResult();
```

Description

`model.result().numerical().create(<ftag>,"Particle")` creates a particle evaluation feature with the name `<ftag>`. Particle evaluation can be performed on trajectories accessed through a particle data set.

`model.result().numerical(<ftag>).getReal()` returns the real result, recomputing the feature if necessary. Data is ordered such that there is one row per point, with one row containing data for all solution numbers. This is identical to `<columnwise>` when `<columnwise>` is `false`. If `<columnwise>` is `true`, the ordering is the opposite: each `column` contains the values for all solution numbers.

`model.result().numerical(<ftag>).getImag(<allocate>, <columnwise>)` returns the imaginary part of complex result, recomputing the feature if necessary. If `<allocate>` is `true`, a zero-valued matrix is allocated even when the result is real. `getImag()` uses `<allocate>` `true` and `<columnwise>` `false`.

`model.result().numerical(<ftag>).isComplex()` returns `true` if the result is complex.

`<outersolnum>` is applicable only for parametric sweep solutions and is the index of each outer parametric solution.

`model.result().numerical(<ftag>).setResult()` and `model.result().numerical(<ftag>).appendResult()` evaluates the feature and set or append the result in the table indicated by the `table` property.

The following properties are available:

TABLE 6-53: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
data	none data set name	First particle compatible data set	The particle data set this feature refers to.
descr	string	Model-dependent	The description of the expression in expr. Is used in the automatic title.
evaluate	all fraction number	al	What particles to evaluate.
expr	string	Model-dependent	The expression to plot.
fraction	double	1	If evaluate is fraction: The fraction of particles to evaluate.
innerinput	all first last manual manualindices interp	all	How to input the solution to use. manual indicates that solnum is used. manualindices indicates that solnumindices is used. interp indicates that t is used.
interp	double row matrix	Empty on all levels.	The times to use, for transient levels. Available when data is not parent and the underlying data is transient.
looplevel	integer row matrix	All solutions on all levels	The solutions to use, per level.
looplevelindices	integer row matrix	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when looplevelinput is manualindices on a level.
looplevelinput	String array with all first last manual manualindices interp on each level	all on all levels	How to input the solution to use, per level. manual on a level indicates that looplevel is used on that level. manualindices on a level indicates that looplevelindices is used on that level. interp on a level indicates that interp is used on that level.
number	double	100	If evaluate is number: The number of particles to evaluate.
outerinput	all first last manual manualindices	all	How to input the outer solutions to use. Applicable only for parametric sweep models. manual indicates that outersolnum is used. manualindices indicates that outersolnumindices is used.

TABLE 6-53: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
outersolnum	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models. Since the various outer solutions can have different number of solnum, the solnum property is not used.
outersolnumindices	string or integer array	Empty	An alternate way to specify the outer solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when outerinput is manualindices.
solnum	non-negative integer array	All solutions	The solutions to use.
solnumindices	string or integer array	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when innerinput is manualindices.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
t	double array	Empty	The times to use. Available when the underlying solution is transient.
table	new table name	new	The table to use when calling setResult() or appendResult(). new indicates that a new table is created.
tablecols	inner outer data level1	data	Whether to use inner or outer solutions as columns in the table when calling setResult() or appendResult(). Applicable only for parametric sweep models. The level values (level1, level2, and so on) are the levels in the parametric sweep.
unit	string	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.

Synopsis	Particle tracing plot with mass.
Syntax	<pre>model.result(<pgtag>).feature().create(<ftag>, "ParticleMass"); model.result(<pgtag>).feature(<ftag>).set(property, <value>); model.result(<pgtag>).feature(<ftag>).run();</pre>
Description	<pre>model.result(<pgtag>).feature().create(<ftag>, "ParticleMass")</pre> <p>creates a particle tracing plot feature named <code><ftag></code> belonging to the plot group <code><pgtag></code>.</p>

With particle tracing, you can visualize path lines, that is, trajectories of particles released in a flow field, which can be time-dependent or static. For time-dependent flows you can also use a snapshot in time of the flow field as a static field. The motion of the particles does not affect the flow field. Particle tracing is available in 2D and 3D plot groups.

The following properties are available:

TABLE 6-54: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
atol	manual automatic	automatic	Whether to specify a manual absolute tolerance for the position and velocity. automatic indicates that the absolute tolerance for the position is the mean of the lengths of the bounding box of the geometry multiplied by the relative tolerance.
atolpos	positive double	0.001	Absolute tolerance for the position. Active when atol is set to manual.
atolvel	positive double	0.001	Absolute tolerance for the velocity. Active when atol is set to manual.
bndcoord	double array	0	Vector of values from 0 to 1 to describe the start points. Active when bndmethod is set to coord. Available in 2D only.
bndmethod	number coord	number	Active when posmethod is set to bnd. Available in 2D only.
bndnumber	positive integer	10	The number of equidistant start points along the selected boundaries. Available in 2D only.
bndselection	Reference to a named selection on boundaries	First available named selection	The boundaries to start from. Available in 2D only.

TABLE 6-54: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
comettailexpr	string array		Active when pointtype is set to comettail. Determines the direction in which the comet tail points.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
customlinecolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use for lines. Active when linecolor is set to custom.
custompointcolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use for points. Active when pointcolor is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
descr	string	Model-dependent	Description of forces to plot.
dropfreq	positive double	1	Particles are released at these intervals when dropmethod is set to freq.
dropmethod	once freq times	once	Method to use when releasing particles.
droptimes	double array	1	The specific times when to release particles. Used when dropmethod is set to times.
edgetol	positive double	0.001	The absolute tolerance controlling how close to the geometry boundary the path lines are cut when they exit the geometry. A lower value cuts the line closer to the geometry boundary.
fx	string	Mode-dependent	x-component for the force expression.
fy	string	Mode-dependent	y-component for the force expression.
fz	string	Model-dependent	z-component for the force expression. In 2D, this property is only used if the underlying geometry is axisymmetric.
hmax	double	0.1	The maximum time step. Active when stepsize is set to manual.
hstart	double	0.1	The initial time step. Active when stepsize is set to manual.

TABLE 6-54: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
inheritdeformscale	boolean	true	If inheritplot is not none: Determines if the deformation scale is inherited.
inheritplot	none plot name	none	The plot that sphere scale, tube scale, and deformation scale is inherited from.
inheritspherescale	boolean	true	If inheritplot is not none: Determines if the sphere scale is inherited.
inherit tubescale	boolean	true	If inheritplot is not none and linetype is tube: Determines if the tube scale is inherited.
interp	double array	Time corresponding to last selected solnum for transient levels.	The time to use, for transient levels. Available when data is not parent and the underlying data is transient.
linecolor	custom black blue cyan green magenta red white yellow	black (2D), red (3D)	The uniform color to use for lines.
linetype	none line tube	line	Plot particle tracing lines as lines or tubes, or not at all.
looplevel	array of non-negative integers and strings	Last solution for transient or parametric solution for each level. Otherwise first solution for each level.	The index of the solution to use, per level, or interp, but only for transient solutions. Available when data is not parent and the underlying data has multiple solutions.
mass	string	1	The particle mass.
maxsteps	positive integer	1000	The maximum number of steps to use in the particle simulation. Active when maxstepsactive is set to on.

TABLE 6-54: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
maxstepsactive	on off	off	Whether to manually specify the maximum number of steps used in particle simulation. off indicates that the limit varies in this way: for static flow fields, the algorithm uses the value 1000; for time-dependent flows, there is no upper limit of the number of steps, and the particle simulation goes on until it reaches the end time.
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
pointcolor	custom black blue cyan green magenta red white yellow	red	The uniform color to use for points.
pointdom	disappear stick	stick	stick plots the points on the boundary at the exit point, and disappear does not render these points at all.
pointlineanim	on off	off	When animating particle tracing plots with points, this property indicates whether the points at the current time should appear on top of the lines.
pointtype	none point comettail	none	Selects between plotting the path lines' endpoints as points, comet tails, or not at all.
posmethod	start bnd (in 2D)	start	The type of particle tracing positioning. Choose specific start points or a boundary to start from. Available in 2D only.
radiusexpr	string	1	The tube radius.
pointautoscale	on off	on	If enabled, the point radii are scaled so that the maximum radius is 0.01 of the plot scale.
pointradiusexpr	string	1	The point radius expression.
resolution	coarser coarse normal fine finer extrafine		Affects the number of output points by adding points between each time step taken in the ODE solver, using a 4th-order interpolation, to produce a smoother output
rtol	positive double	0.001	The relative error tolerance that the ODE solver uses.

TABLE 6-54: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
solnum	non-negative integer	Last solution for transient or parametric solution. Otherwise first solution.	The index of the solution to use. Available when data is not parent and the underlying data has multiple solutions.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
static	on off	off	Only affects time-dependent problems. When set to on, this property freezes the time and considers this a static flow field.
statictend	double	1	The maximum time at which to end the particle-tracing simulation for static flow fields. Active when statictendactive is set to on.
statictendactive	on off	off	Whether to specify the end time for static flow fields automatically. (For time-dependent flows, the automatic end time is the last time that the time-dependent solver returns.) When set to off, there is no upper limit of the time. In this case, the particle simulation goes on until all particles exit the geometry or the simulation reaches the maximum number of steps.
stepsize	automatic manual	automatic	Whether to specify initial (hstart) and maximum (hmax) time step manually.
t	double	Time corresponding to last selected solnum.	The time to use, for transient problems. Available when data is not parent and the underlying data is transient.
tailscale	positive double	1	Active when pointtype is set to comettail and tailscaleactive is on. Specifies the manual scale factor with which the comet tail expression is multiplied.
tailscaleactive	on off	off	Active when pointtype is set to comettail. Specifies whether manual tail scaling is enabled.

TABLE 6-54: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. manual if the manual title should be used (the title property). none if no title should be displayed.
tstart	double	0	Manual start time. Active when tstartactive is set to on.
tubeautoscale	on off	on	If enabled, the tube radii are scaled so that the maximum tube radius is 0.02 of the plot scale.
tstartactive	on off	off	On indicates a manual start time (set in the tstart property). Off indicates that the start time becomes either the first time value that the time-dependent solver returns or 0 for stationary flows. Available when dropmethod is set to once or freq.
tvar	string	partt	The name of the variable for time. Normally there is no need to change the default name. You can use this names in expressions as well as for the color when coloring the path lines according to an expression.
velvarx	string	partu	The name of the variable for the x-component of the velocity.
velvary	string	partv	The name of the variable for the y-component of the velocity.
velvarz	string	partw	The name of the variable for the z-component of the velocity. In 2D, this property is only used if the underlying geometry is axisymmetric.
velstartx	string	0	x-component for initial velocity.
velstarty	string	0	y-component for initial velocity.
velstartz	string	0	z-component for initial velocity. In 2D, this property is only used if the underlying geometry is axisymmetric.
xcoord	double array	Empty	Absolute coordinates in the x-direction, active when posmethod is set to start.

TABLE 6-54: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
ycoord	double array	Empty	Absolute coordinates in the y-direction, active when postmethod is set to start.
zcoord	double array	Empty	Absolute coordinates in the z-direction, active when posmethod is set to coord. Available in 3D only.

Attributes [Color](#) (applies to lines), [Deform](#)

See Also [Particle](#), [Streamline](#)

Synopsis Animation in a player in the COMSOL Multiphysics main window.

Syntax

```
model.result().export().create(<ftag>, "Player");
model.result().export().create(<ftag>, <pgtag>, <plottag>,
    "Player");
model.result().export(<ftag>).set(property, <value>);
model.result().export(<ftag>).run();
```

Description `model.result().export().create(<ftag>, "Player")` creates a player feature with the name `<ftag>`.

The following properties are available:

TABLE 6-55: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
cycletype	fullharm halfharm linear	fullharm	The transformation of the solution that is performed if sweeptype is dde.
maxframes	integer >= 2	25	The number of frames.
framesel	all number	number	When sweeptype is solutions, framesel controls whether to look through all solutions or a specified number of frames.
frametime	positive double	0.1	The time in seconds that each frame is displayed when playing.
outerinnertype	first last all	last	When solnumtype is outer, outerinnertype controls whether to plot all, the first or the last inner solution. Applicable only for parametric sweep models.
outersolnumarray	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models when solnumtype is outer.
outersolnumsingle	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models when solnumtype is inner.
parameter	string		The model parameter that varies if sweeptype is parameter.
pframes	positive integer	11	The number of frames if sweeptype is parameter.
plotgroup	string		The name of the plot group to animate.

TABLE 6-55: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
pstart	double	0	The start parameter if sweeptype is parameter.
pstop	double	1	The stop parameter if sweeptype is parameter.
repeat	boolean	false	Whether to repeat from the beginning when the end is reached when playing.
showframe	positive integer	1	The shown frame.
solnum	integer array	all	The solutions to animate if sweeptype is solutions
solnumtype	inner outer	inner	Whether to sweep over inner or outer solutions in a parametric sweep model.
staticframes	positive integer	11	The number of frames if sweeptype is dde.
sweeptype	solutions parameter dde	solutions	The parameter that varies during animation.
timeinterp	on off	off	Enable/disable sweep over interpolated times if sweeptype is solutions.
tint	double array		The interpolated times to animate if timeinterp is on.

Synopsis Plot export.

Syntax

```
model.result().export().create(<ftag>, "Plot");
model.result().export().create(<ftag>, <pgtag>, <plottag>, "Plot");
model.result().export(<ftag>).set(property, <value>);
model.result().export(<ftag>).run();
```

Description

`model.result().export().create(<ftag>, "Plot")` creates a plot export feature with the name `<ftag>`.

`model.result().export().create(<ftag>, <pgtag>, <plottag>, "Plot")` creates a plot export feature with the name `<ftag>` for the plot `<plottag>` in the plot group `<pgtag>`.

The following properties are available:

TABLE 6-56: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
plotgroup	string		The name of the plot group containing the plot to export.
plot	string		The name of the plot (in plotgroup) to export.
compact	boolean	false	Only applicable for streamline and particle tracing plots. If true, the exported data contains one line per streamline or particle rather than one line per point on a streamline or particle trajectory.
filename	string		The output file.
fullprec	on off	on	If on, floating-point numbers are written in full precision, otherwise they are written with six significant digits.
header	on off	off	Enable/disable a data header in the output file.
repeat	on off	off	Enable/disable repeated playing of the animation.
sort	on off	off	Enable/disable sorting of the points with respect to the coordinates.
struct	sectionwise spreadsheet		Format of the exported data.

See Also [HistogramHeight](#)

Synopsis Plot group.

Syntax
`model.result().create(<pgtag>, dim);`
`model.result(<pgtag>).set(property, <value>);`
`model.result(<pgtag>).run();`

Description `model.result().create(<pgtag>, dim)` creates a plot group named *<pgtag>* of view dimension *dim*. A plot group is a group of plots that are shown together in a graphics window.

1D plot groups contain graph plots.

The following properties are available for 1D plot groups:

TABLE 6-57: VALID PROPERTY/VALUE PAIRS FOR 1D PLOT GROUPS

NAME	VALUE	DEFAULT	DESCRIPTION
data	none data set name	First compatible data set	The data set this feature refers to. This is the default data set for all plots in the group.
datasetintitle	on off	off	Whether the title should contain the data set when <code>titletype</code> is custom.
descriptionintitle	on off	on	Whether the title contribution of plots in this group should contain the description when <code>titletype</code> is custom.
expressionintitle	on off	off	Whether the title contribution of plots in this group should contain the expression when <code>titletype</code> is custom.
innerinput	all first last manual manualindices interp	all	How to input the solution to use. <code>manual</code> indicates that <code>solnum</code> is used. <code>manualindices</code> indicates that <code>solnumindices</code> is used. <code>interp</code> indicates that <code>t</code> is used.
interp	double row matrix	Empty on all levels.	The times to use, for transient levels. Available when data is not none and the underlying data is transient.
legendpos	upperright lowerright upperleft lowerleft	upperright	The position of the legends for all plots in this group.
looplevel	integer row matrix	All solutions on all levels	The solutions to use, per level.

TABLE 6-57: VALID PROPERTY/VALUE PAIRS FOR 1D PLOT GROUPS

NAME	VALUE	DEFAULT	DESCRIPTION
looplevelindices	integer row matrix	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when looplevelinput is manualindices on a level.
looplevelinput	String array with all first last manual manualindices interp on each level	all on all levels	How to input the solution to use, per level. manual on a level indicates that looplevel is used on that level. manualindices on a level indicates that looplevelindices is used on that level. interp on a level indicates that interp is used on that level.
manualgrid	on off	off	Whether to use the automatic grid spacing or the grid settings specified in xspacing and yspacing.
outerinput	all first last manual manualindices	all	How to input the outer solutions to use. Applicable only for parametric sweep models. manual indicates that outersolnum is used. manualindices indicates that outersolnumindices is used.
outersolnum	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models. Since the various outer solutions can have different number of solnum, the solnum property is not used.
outersolnumindices	string or integer array	Empty	An alternate way to specify the outer solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when outerinput is manualindices.
phaseintitle	on off	off	Whether the title should contain the phase when titletype is custom.
prefixintitle	string	Empty	Added prefix to group contribution to title.
preserveaspect	on off	off	Whether the x- and y-axis should have equal scale.
solnum	Integer array	All solutions	The solutions to plot. Available when the underlying data has multiple solutions.
solnumindices	string or integer array	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when innerinput is manualindices.

TABLE 6-57: VALID PROPERTY/VALUE PAIRS FOR 1D PLOT GROUPS

NAME	VALUE	DEFAULT	DESCRIPTION
solutionintitle	on off	on	Whether the title should contain the solution when <code>titletype</code> is <code>custom</code> .
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
suffixintitle	string	Empty	Added suffix to group contribution to title.
t	double array	Empty	The times to plot. Available when the underlying solution is transient.
title	string	The auto-title.	The title to use when <code>titletype</code> is <code>manual</code> .
titletype	auto custom manual none	auto	<code>auto</code> if the title should be computed automatically. <code>custom</code> if the title should be computed automatically, but customized. <code>manual</code> if the manual title should be used (the <code>title</code> property). <code>none</code> if no title should be displayed.
typeintitle	on off	on	Whether the title contribution of plots in this group should contain the type when <code>titletype</code> is <code>custom</code> .
unitintitle	on off	on	Whether the title contribution of plots in this group should contain the unit when <code>titletype</code> is <code>custom</code> .
xextra	double array	Empty	Extra grid points to include along the x-axis.
xlabel	string	Empty	The label on the x-axis.
xlabelactive	on off	off	on if a manual x-axis label should be used, off if it should be computed automatically.
xlog	on off	off	Whether to use a logarithmic scale along the x-axis.
xmax	double	Computed automatically	The maximum value of the x-axis.
xmin	double	Computed automatically	The minimum value of the x-axis.
xspacing	double	Computed automatically	The grid spacing on the x-axis. Used if <code>manualgrid</code> is set to <code>on</code> .
yextra	double array	Empty	Extra grid points to include along the y-axis.
ylabel	string	Empty	The label on the y-axis.
ylabelactive	on off	off	on if a manual y-axis label should be used, off if it should be computed automatically.

TABLE 6-57: VALID PROPERTY/VALUE PAIRS FOR 1D PLOT GROUPS

NAME	VALUE	DEFAULT	DESCRIPTION
ylog	on off	off	Whether to use a logarithmic scale along the y-axis.
ymin	double	Computed automatically	The minimum value of the y-axis.
ymax	double	Computed automatically	The maximum value of the x-axis.
yspacing	double	Computed automatically	The grid spacing on the y-axis. Used if manualgrid is set to on.
window	graphics new windowX, where X is an integer	graphics	The window where the plot group is displayed. When plotting on a graphics server, graphics is equivalent to new.
windowtitle	string	Computed automatically	The title to use for the window where the plot group is displayed. It is not possible to change the title of the graphics window.
windowtitleactive	on off	off	Set windowtitleactive to on to enter a manual window title in windowtitle.

The following properties are available for 2D and 3D plot groups:

TABLE 6-58: VALID PROPERTY/VALUE PAIRS FOR 2D AND 3D PLOT GROUPS

NAME	VALUE	DEFAULT	DESCRIPTION
customedgecolor	RGB-triplet	{1,1,1} or last used edgecolor.	The color to use when plotting data set edges. Active when edgecolor is set to custom.
data	none data set name	parent	The data set this feature refers to. This is the default data set for all plots in the group.
datasetintitle	on off	off	Whether the title should contain the data set when titletype is custom.
edgecolor	custom black blue cyan green magenta red white yellow	black	The color to use when plotting data set edges.
edges	on off	on	Whether to plot data set edges.

TABLE 6-58: VALID PROPERTY/VALUE PAIRS FOR 2D AND 3D PLOT GROUPS

NAME	VALUE	DEFAULT	DESCRIPTION
expressionintitle	on off	off	Whether the title contribution of plots in this group should contain the expression when titletype is custom.
frametype	mesh material spatial	spatial	The frame used when data set edges are plotted.
interp	double array	Time corresponding to last selected solnum for transient levels.	The time to use, for transient levels. Available when data is not none and the underlying data is transient.
legendpos	alternating bottom left leftdouble right rightdouble	right	The position of the legends for all plots in this group.
looplevel	array of non-negative integers and strings	Last solution for transient or parametric solution for each level. Otherwise first solution for each level.	The index of the solution to use, per level, or interp, but only for transient solutions. Available when data is not none and the underlying data has multiple solutions.
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
phaseintitle	on off	off	Whether the title should contain the phase when titletype is custom.
prefixintitle	string	Empty	Added prefix to group contribution to title.
showhiddenobjects	on off	off	Whether objects hidden in geometry sequence should be visible in plots.
solnum	non-negative integer	Last solution for transient or parametric solution. Otherwise first solution.	The index of the solution to use. Available when the underlying data has multiple solutions.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.

TABLE 6-58: VALID PROPERTY/VALUE PAIRS FOR 2D AND 3D PLOT GROUPS

NAME	VALUE	DEFAULT	DESCRIPTION
solutionintitle	on off	on	Whether the title should contain the solution when <code>titletype</code> is <code>custom</code> .
suffixintitle	string	Empty	Added suffix to group contribution to title.
t	double	Time corresponding to last selected <code>solnum</code> .	The time to use, for transient problems. If it is not available in any <code>solnum</code> , the time is interpolated in the solution.
timeinterp	on off	off	on if <code>t</code> is used to determine time steps, off if <code>solnum</code> is used.
title	string	The auto-title.	The title to use when <code>titletype</code> is <code>manual</code> .
titletype	auto custom manual none	auto	<code>auto</code> if the title should be computed automatically. <code>custom</code> if the title should be computed automatically, but customized. <code>manual</code> if the manual title should be used (the <code>title</code> property). <code>none</code> if no title should be displayed.
typeintitle	on off	on	Whether the title contribution of plots in this group should contain the type when <code>titletype</code> is <code>custom</code> .
unitintitle	on off	on	Whether the title contribution of plots in this group should contain the unit when <code>titletype</code> is <code>custom</code> .
view	auto view name	auto	The view settings to use when displaying this plot group. <code>auto</code> indicates that the view is selected automatically, or be created if there is none. Typically geometry-based data sets such as solution or mesh data sets use the current geometry view. Surface plots with height attributes do not use the view setting.
window	graphics new windowX, where X is an integer	graphics	The window where the plot group is displayed. When plotting on a graphics server, <code>graphics</code> is equivalent to <code>new</code> .
windowtitle	string	Computed automatically	The title to use for the window where the plot group is displayed. It is not possible to change the title of the graphics window.
windowtitleactive	on off	off	Set <code>windowtitleactive</code> to <code>on</code> to enter a manual window title in <code>windowtitle</code> .

TABLE 6-58: VALID PROPERTY/VALUE PAIRS FOR 2D AND 3D PLOT GROUPS

NAME	VALUE	DEFAULT	DESCRIPTION
xlabel	string	Empty	The label on the x-axis. Available for 2D plot groups.
xlabelactive	on off	off	on if a manual x-axis label should be used, off if it should be computed automatically. Available for 2D plot groups.
ylabel	string	Empty	The label on the y-axis. Available for 2D plot groups.
ylabelactive	on off	off	on if a manual y-axis label should be used, off if it should be computed automatically. Available for 2D plot groups.

See Also [PolarGroup](#), [Solution](#)

Synopsis Graph point plot.

Syntax

```
model.result(<pgtag>).feature().create(<ftag>,"PointGraph");
model.result(<pgtag>).feature(<ftag>).selection(...);
model.result(<pgtag>).feature(<ftag>).set(property, <value>);
model.result(<pgtag>).feature(<ftag>).run();
```

Description

model.result(<pgtag>).feature().create(<ftag>,"PointGraph") creates a graph point plot feature named <ftag> belonging to the plot group <pgtag>.

Point plot is used to visualize quantities on points, either cut points or points in a geometry. Point plots can be added to 1D plot groups.

The following properties are available:

TABLE 6-59: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
autolegends	on off	on	Whether to use the automatically computed legends or the legends defined in the legends property. The automatic legends display the point numbers of the plotted points for geometry-based point plots. For cut point plots, the legend displays the point coordinates.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
customlinecolor	RGB-triplet	{0,0,1} or last used edgecolor	The color to use for the lines. Active when linecolor is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
descr	string	Model-dependent.	The description of the expression in expr. Is used in the automatic title.
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic

TABLE 6-59: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent.	The expression to plot.
expressionintitle	on off	off	Whether the title contribution should contain the expression when titletype is custom.
freqmax	integer		If xaxisdata is spectrum and freqrangeactive is true: The upper frequency bound.
freqmin	integer		If xaxisdata is spectrum and freqrangeactive is true: The lower frequency bound.
freqrangeactive	on off	false	If xaxisdata is spectrum: Controls whether a manual frequency range is used.
innerinput	all first last manual manualindices interp	all	How to input the solution to use. manual indicates that solnum is used. manualindices indicates that solnumindices is used. interp indicates that t is used.
interp	double row matrix	Empty on all levels.	The times to use, for transient levels. Available when data is not parent and the underlying data is transient.
legend	on off	off	Whether to show legends.
legendmethod	automatic manual	automatic	Whether to use the automatic legends or the legends supplied in the legends property.
legends	String array	The last computed automatic legends.	Manual legends active when legendmethod is set to manual.
linecolor	custom cycle black blue cyan green magenta red white yellow	cycle	How to color the lines in the graph. Cycle indicates that the colors is different for each line.
linewidth	double	0.5	The line width.

TABLE 6-59: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
linemarker	none cycle asterisk circle diamond plus point square star triangle	none	The line markers, if any. Cycle indicates that the marker is different for each line.
linestyle	none cycle solid dotted dashed dashdot	solid	The line style, if any. Cycle indicates that the line style is different for each line.
looplevel	integer row matrix	All solutions on all levels	The solutions to use, per level.
looplevelindices	integer row matrix	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when looplevelinput is manualindices on a level.
looplevelinput	String array with all first last manual manualindices interp on each level	all on all levels	How to input the solution to use, per level. manual on a level indicates that looplevel is used on that level. manualindices on a level indicates that looplevelindices is used on that level. interp on a level indicates that interp is used on that level.
markerpos	interp datapoints	interp	Controls whether the positions of the markers are in the data points of the plot, or interpolated depending on the number (set in markers). Markers are visible when linemarker is set.
markers	integer	8	The number of markers to show. Markers are visible when linemarker is set.
nfreqs	integer	1	If xaxisdata is spectrum and nfreqsactive is true: The number of frequencies to plot.
nfreqsactive	boolean	false	If xaxisdata is spectrum: Controls whether the number of frequencies is set manually.
outerinput	all first last manual manualindices	all	How to input the outer solutions to use. Applicable only for parametric sweep models. manual indicates that outersolnum is used. manualindices indicates that outersolnumindices is used.

TABLE 6-59: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
outersolnum	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models. Since the various outer solutions can have different number of solnum, the solnum property is not used.
outersolnumindices	string or integer array	Empty	An alternate way to specify the outer solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when outerinput is manualindices.
prefixintitle	string	Empty	Added prefix to contribution to title.
scale	boolean	false	If xdata is spectrum: The frequency spectrum is transformed so that it has the same scale as the original data.
solnum	integer array	All solutions	The solutions to plot. Available when data is not parent and the underlying data has multiple solutions.
solnumindices	string or integer array	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1,1,20). Applicable when innerinput is manualindices.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
suffixintitle	string	Empty	Added suffix to contribution to title.
t	double array	Empty	The times to plot. Available when data is not parent and the underlying solution is transient.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when titletype is custom.

TABLE 6-59: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
unit	string	Model-dependent	The unit to use for the expression in <code>expr</code> . If the old unit is not valid when the expression changes, the unit property is reset to default.
unitintitle	on off	on	Whether the title contribution should contain the unit when <code>titletype</code> is custom.
xdata	expr solution spectrum phase	solution	x-axis data. <code>expr</code> uses the expression in <code>xdataexpr</code> . <code>solution</code> uses the available solutions in the underlying data set, for example, time steps. <code>phase</code> uses a phase range, and rearranged phase plots.
xdataexpr	string	Model-dependent	Expression for x-axis data.
xdatadescr	string	Model-dependent	Description of expression in <code>xdataexpr</code> .
xdataphaserange	double array	range(0, 0.5, 2 π)	The phases for which the expression should be evaluated when <code>xdata</code> is <code>phase</code> .
xdataphaseunit	string	rad	The unit in which <code>xdataphaserange</code> is described.
xdatasolnumtype	all inner outer valid level	outer	Whether the expression should be evaluated for every inner or every outer solution, or for a specific level (<code>level1</code> , <code>level2</code> , and so on). Applicable only for models containing multiple levels.
xdataunit	string	Model-dependent	The unit to use for the expression in <code>xdataexpr</code> . If the old unit is not valid when the expression changes, the unit property is reset to default.

Attributes None

See Also [LineGraph](#)

Synopsis Polar plot group.

Syntax

```
model.result().create(<pgtag>, "PolarGroup");
model.result(<pgtag>).set(property, <value>);
model.result(<pgtag>).run();
```

Description `model.result().create(<pgtag>, "PolarGroup")` creates a polar plot group named `<pgtag>`. A polar plot group displays the containing graph plots in a polar coordinate system.

The following properties are available for polar plot groups:

TABLE 6-60: VALID PROPERTY/VALUE PAIRS FOR ID PLOT GROUPS

NAME	VALUE	DEFAULT	DESCRIPTION
data	none data set name	First compatible data set	The data set this feature refers to. This is the default data set for all plots in the group.
datasetintitle	on off	off	Whether the title should contain the data set when <code>titletype</code> is <code>custom</code> .
expressionintitle	on off	off	Whether the title contribution of plots in this group should contain the expression when <code>titletype</code> is <code>custom</code> .
innerinput	all first last manual manualindices interp	all	How to input the solution to use. <code>manual</code> indicates that <code>solnum</code> is used. <code>manualindices</code> indicates that <code>solnumindices</code> is used. <code>interp</code> indicates that <code>t</code> is used.
interp	double row matrix	Empty on all levels.	The times to use, for transient levels. Available when data is not none and the underlying data is transient.
legendpos	upperright lowerright upperleft lowerleft	upperright	The position of the legends for all plots in this group.
looplevel	integer row matrix	All solutions on all levels	The solutions to use, per level.
looplevelindices	integer row matrix	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, <code>range(1, 1, 20)</code> . Applicable when <code>looplevelinput</code> is <code>manualindices</code> on a level.

TABLE 6-60: VALID PROPERTY/VALUE PAIRS FOR 1D PLOT GROUPS

NAME	VALUE	DEFAULT	DESCRIPTION
looplevelinput	String array with all first last manual manualindices interp on each level	all on all levels	How to input the solution to use, per level. manual on a level indicates that looplevel is used on that level. manualindices on a level indicates that looplevelindices is used on that level. interp on a level indicates that interp is used on that level.
manualgrid	on off	off	Whether to use the automatic grid spacing or the grid settings specified in rspacing and tspacing.
outerinput	all first last manual manualindices	all	How to input the outer solutions to use. Applicable only for parametric sweep models. manual indicates that outersolnum is used. manualindices indicates that outersolnumindices is used.
outersolnum	non-negative integer array	1	The index of the outer solutions to use. Applicable only for parametric sweep models. Since the various outer solutions can have different number of solnum, the solnum property is not used.
outersolnumindices	string or integer array	Empty	An alternate way to specify the outer solutions to use, allowing you to enter, for example, range(1, 1,20). Applicable when outerinput is manualindices.
phaseintitle	on off	off	Whether the title should contain the phase when titletype is custom.
prefixintitle	string	Empty	Added prefix to group contribution to title.
rextra	double array	Empty	Extra grid points to include along the r-axis.
rmax	double	Computed automatically	The maximum value of the r-axis.
rmin	double	Computed automatically	The minimum value of the r-axis.
rspacing	double	Computed automatically	The grid spacing on the r-axis. Used if manualgrid is set to on.
solnum	Integer array	All solutions	The solutions to plot. Available when the underlying data has multiple solutions.
solnumindices	string or integer array	Empty	An alternate way to specify the solutions to use, allowing you to enter, for example, range(1, 1, 20). Applicable when innerinput is manualindices.

TABLE 6-60: VALID PROPERTY/VALUE PAIRS FOR 1D PLOT GROUPS

NAME	VALUE	DEFAULT	DESCRIPTION
solutionintitle	on off	on	Whether the title should contain the solution when <code>titletype</code> is <code>custom</code> .
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
suffixintitle	string	Empty	Added suffix to group contribution to title.
t	double array	Empty	The times to plot. Available when the underlying solution is transient.
textra	double array	Empty	Extra grid points to include along the θ -axis, in degrees.
title	string	The auto-title.	The title to use when <code>titletype</code> is <code>manual</code> .
titletype	auto custom manual none	auto	auto if the title should be computed automatically. custom if the title should be computed automatically, but customized. manual if the manual title should be used (the <code>title</code> property). none if no title should be displayed.
tspacing	double	Computed automatically	The grid spacing on the θ -axis. Used of <code>manualgrid</code> is set to <code>on</code> .
typeintitle	on off	on	Whether the title contribution of plots in this group should contain the type when <code>titletype</code> is <code>custom</code> .
unitintitle	on off	on	Whether the title contribution of plots in this group should contain the unit when <code>titletype</code> is <code>custom</code> .
window	graphics new windowX, where X is an integer	graphics	The window where the plot group is displayed. When plotting on a graphics server, <code>graphics</code> is equivalent to <code>new</code> .
windowtitle	string	Computed automatically	The title to use for the window where the plot group is displayed. It is not possible to change the title of the graphics window.
windowtitleactive	on off	off	Set <code>windowtitleactive</code> to <code>on</code> to enter a manual window title in <code>windowtitle</code> .

See Also [PlotGroup1D](#), [PlotGroup2D](#), [PlotGroup3D](#)

Synopsis	Make principal stress/strain plot.
Syntax	<pre>model.result(<pgtag>).feature().create(<ftag>,"PrincipalVolume"); model.result(<pgtag>).feature().create(<ftag>,"PrincipalSurface"); model.result(<pgtag>).feature(<ftag>).set(property, <value>); model.result(<pgtag>).feature(<ftag>).run();</pre>
Description	<p>model.result(<pgtag>).feature().create(<ftag>,"PrincipalVolume") create a volume principal stress/strain plot named <ftag> belonging to the plot group <pgtag>.</p>

The following properties are available:

TABLE 6-61: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
arrowcount	positive integer	200	The number of arrows. Available for PrincipalSurface in 3D.
arrowlength	normalized proportional logarithmic	proportional	The arrow scaling: Proportional uses the actual arrow length, normalized a unit length, and logarithmic a length proportional to the logarithm of the arrow length.
arrowtype	arrow cone	arrow	The type of arrow to draw.
arrowxmethod	number coord	number	Indicates whether the x-coordinates of the arrows should be specified by number of points to distribute evenly across the data or by coordinates. Available for PrincipalSurface in 2D and PrincipalVolume in 3D.
arrowymethod	number coord	number	Indicates whether the y-coordinates of the arrows should be specified by number of points to distribute evenly across the data or by coordinates. Available for PrincipalSurface in 2D and PrincipalVolume in 3D.
arrowzmethod	number coord	number	Indicates whether the z-coordinates of the arrows should be specified by number of points to distribute evenly across the data or by coordinates. Available for PrincipalVolume in 3D.
color	custom black blue cyan green magenta red white yellow	red	The color to use.

TABLE 6-61: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
customcolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use. Active when color is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
inheritarrow scale	boolean	true	If inheritplot is not none: Determines if arrow scale is inherited.
inherit color	boolean	true	If inheritplot is not none: Determines if the color is inherited.
inheritplot	none plot name	none	The plot that arrow scale, color, and deformation scale is inherited from.
interp	double array	Time corresponding to last selected solnum for transient levels.	The time to use, for transient levels. Available when data is not parent and the underlying data is transient.
logrange	double > 1	100	If arrowlength is logarithmic: The ratio between the maximum arrow length and the arrow length below which no arrow is drawn.
looplevel	array of non-negative integers and strings	Last solution for transient or parametric solution for each level. Otherwise first solution for each level.	The index of the solution to use, per level, or interp, but only for transient solutions. Available when data is not parent and the underlying data has multiple solutions.
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
placement	elements uniform uniformani	uniform	If uniform, then the arrows are distributed uniformly. If uniformanisotropic, then the arrows are distributed uniformly with weights taken from the weight property.If elements, then arrows are drawn in each element. Available for PrincipalSurface in 3D.
princdirstra inexpr	3-by-3 string matrix	Physics-dependent	If type is strain: The expressions for the principal directions.

TABLE 6-61: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
princcdirstre ssexpr	3-by-3 string matrix	Physics- dependent	If type is stress: The expressions for the principal directions.
princvalstra inexpr	1-by-3 string matrix	Physics- dependent	If type is strain: The expressions for the principal values.
princvalstre ssexpr	1-by-3 string matrix	Physics- dependent	If type is stress: The expressions for the principal values.
scale	positive double	1	If scaleactive is true: The length scale factor.
scaleactive	boolean	false	Whether to use manual scaling.
solnum	non-negative integer	Last solution for transient or parametric solution. Otherwise first solution	The index of the solution to use. Available when data is not parent and the underlying data has multiple solutions.
solrepresent ation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
t	double	Time corresponding to last selected solnum	The time to use, for transient problems. Available when data is not parent and the underlying data is transient.
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. manual if the manual title should be used (the title property). none if no title should be displayed.
type	stress strain	stress	Selection between principal stress and principal strain plot.
weight	double array	1	If placement is uniformani: The weights given to the different axis directions.
xnumber	non-negative integer	15 (3D), 7 (2D)	Number of points in the x-direction. Active when arrowxmethod is set to number. Available for PrincipalSurface in 2D and PrincipalVolume in 3D.

TABLE 6-61: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
xcoord	double array	Empty	Absolute coordinates in the x-direction, active when arrowmethod is set to coord. Available for PrincipalSurface in 2D and PrincipalVolume in 3D.
ynumber	integer	15 (3D), 7 (2D)	Number of points in the y-direction. Active when arrowmethod is set to number. Available for PrincipalSurface in 2D and PrincipalVolume in 3D.
ycoord	double array	Empty	Absolute coordinates in the z-direction, active when arrowmethod is set to coord. Available for PrincipalSurface in 2D and PrincipalVolume in 3D.
znumber	integer	15 (3D), 7 (2D)	Number of points in the z-direction. Active when arrowmethod is set to number. Available for PrincipalVolume in 3D.
zcoord	double array	Empty	Absolute coordinates in the z-direction, active when arrowmethod is set to coord. Available for PrincipalVolume in 3D.

Synopsis Revolve data set.

Syntax `model.result().dataset().create(<dtag>, "Revolve1D");`
`model.result().dataset().create(<dtag>, "Revolve2D");`
`model.result().dataset(<dtag>).set(property, <value>);`

Description `model.result().dataset().create(<dtag>, "Revolve1D")` creates a 1D revolved data set feature named `<dtag>`.

`model.result().dataset().create(<dtag>, "Revolve2D")` creates a 2D revolved data set feature named `<dtag>`.

The revolved data set needs to supply variables that cannot be expressed in terms of the coordinates of the underlying data set: The spatial coordinates and the rotation angle. Therefore the `xmesh` interpolation/evaluation has to be extended with support for supplying the values of these variables in a given set of points. The names of the spatial coordinates need not be exposed to the user, but the revolution angle should be available as `revphi`.

The source data sets for the revolutions can be any 1D and 2D data sets although the feature is primarily intended for axisymmetric coordinate systems.

The following properties are available for Revolve1D:

TABLE 6-62: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
<code>anglevar</code>	String	Derived from feature name	The name of the angle variable in the revolved coordinate system.
<code>data</code>	none data set name	First compatible data set	The data set this feature refers to.
<code>hasspacevars</code>	boolean	false	If true, <code>spacevars</code> and <code>anglevars</code> are made available for evaluation.
<code>planemap</code>	xy xz	xz	The 3D plane that the 2D xy plane is mapped to.
<code>point</code>	double	0	The point that is the axis of revolution.
<code>revangle</code>	double	360	The revolution angle (degrees)
<code>revlayers</code>	integer >= 3	50	The number of revolution layers.
<code>spacevars</code>	String array	Derived from feature name	The names of the space variables in the revolved coordinate system.
<code>startangle</code>	double	0	The angle where the revolved sector begins (degrees).

The following properties are available for Revolve2D:

TABLE 6-63: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
data	none data set name	First compatible data set	The data set this feature refers to.
method	twopoint pointdir	twopoint	Decides if the line should be specified by two points or through one point and a direction.
genpoints	double matrix	{{0, 0, 0}, {1,0,0}}	Active when method equals twopoint, this property contains the coordinates of the two points in the two rows of the matrix.
layermethod	coarse custom fine normal	normal	The method used for choosing how many layers to use.
pdpoint	double array	{0, 0}	Active when method equals pointdir, this property contains the coordinates of the point.
pddir	double array	{0, 1}	Active when method equals pointdir, this property contains the direction.
revlayers	integer >= 3	50	The number of revolution layers if layermethod is custom.

See Also

[Solution](#)

Synopsis	Scatter plot.
Syntax	<pre>model.result(<pgtag>).feature().create(<ftag>,"ScatterVolume"); model.result(<pgtag>).feature().create(<ftag>,"ScatterSurface"); model.result(<pgtag>).feature(<ftag>).set(property, <value>); model.result(<pgtag>).feature(<ftag>).run();</pre>
Description	<p>model.result(<pgtag>).feature().create(<ftag>,"Scatter...") creates a scatter plot feature named <ftag> belonging to the plot group <pgtag>.</p> <p>Scatter plots are available in 2D and 3D.</p> <p>The following properties are available:</p>

TABLE 6-64: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
arrowxmethod	number coord	number	Indicates whether the x-coordinates of the spheres should be specified by number of points to distribute evenly across the data or by coordinates.
arrowymethod	number coord	number	Indicates whether the y-coordinates of the spheres should be specified by number of points to distribute evenly across the data or by coordinates.
arrowzmethod	number coord	number	Indicates whether the z-coordinates of the spheres should be specified by number of points to distribute evenly across the data or by coordinates. Available for ScatterVolume.
color	custom black blue cyan green magenta red white yellow	red	The color to use.
colorexpr	string		The expression for the colors of the spheres.
colordescr	string		A description of colorexpr.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
customcolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use. Active when color is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
descr	string	Model-dependent	The description of the expressions in expr. Is used in the automatic title.

TABLE 6-64: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	String array of length 2 in 2D and 3 in 3D	Mode-dependent	The components to plot.
inheritcolor	boolean	true	If inheritplot is not none: Determines if the color is inherited.
inheritplot	none plot name	none	The plot that color and sphere scale is inherited from.
inheritspherescale	boolean	true	If inheritplot is not none: Determines if the sphere scale is inherited.
interp	double array	Time corresponding to last selected solnum for transient levels.	The time to use, for transient levels. Available when data is not parent and the underlying data is transient.
looplevel	array of non-negative integers and strings	Last solution for transient or parametric solution for each level. Otherwise first solution for each level.	The index of the solution to use, per level, or interp, but only for transient solutions. Available when data is not parent and the underlying data has multiple solutions.
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
prefixintitle	string	Empty	Added prefix to contribution to title.
radiusexpr	string		The expression for the radii of the spheres.
radiusdescr	string		A description of radiusexpr.

TABLE 6-64: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
solnum	non-negative integer	Last solution for transient or parametric solution. Otherwise first solution.	The index of the solution to use. Available when data is not parent and the underlying data has multiple solutions.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
sphereradius scale	double	1	The scale factor applied to the sphere radii if sphereradius scaleactive is true.
sphereradius scaleactive	boolean	false	If true, sphereradius scale is used, otherwise the scale factor is computed automatically
suffixintitle	string	Empty	Added suffix to contribution to title.
t	double	Time corresponding to last selected solnum.	The time to use, for transient problems. Available when data is not parent and the underlying data is transient.
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when titletype is custom.
xnumber	non-negative integer	15 (3D), 7 (2D)	Number of points in the x-direction. Active when arrowxmethod is set to number.
xcoord	double array	Empty	Absolute coordinates in the x-direction, active when arrowxmethod is set to coord.
ynumber	integer	15 (3D), 7 (2D)	Number of points in the y-direction. Active when arrowymethod is set to number.
ycoord	double array	Empty	Absolute coordinates in the z-direction, active when arrowymethod is set to coord.

TABLE 6-64: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
znumber	integer	15 (3D), 7 (2D)	Number of points in the z-direction. Active when arrowzmethod is set to number. Available for ScatterVolume.
zcoord	double array	Empty	Absolute coordinates in the z-direction, active when arrowzmethod is set to coord. Available for ScatterVolume.

Attributes None

See Also [Surface](#), [Volume](#)

Synopsis	Sector symmetry data set.
Syntax	<pre>model.result().dataset().create(<dtag>, "Sector2D"); model.result().dataset().create(<dtag>, "Sector3D"); model.result().dataset(<dtag>).set(property, <value>);</pre>
Description	<p><code>model.result().dataset().create(<dtag>, "Sector2D")</code> creates a 2D sector symmetry data set feature named <code><dtag></code>.</p> <p><code>model.result().dataset().create(<dtag>, "Sector3D")</code> creates a 3D sector symmetry feature named <code><dtag></code>.</p> <p>This data set takes data from another data sets and expands it using sector symmetry around an axis.</p> <p>The following properties are available for Sector 2D and Sector 3D:</p>

TABLE 6-65: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
data	none data set name	First compatible data set	The data set this feature refers to.
genpoints	double matrix	{{0, 0, 0}, {1,0,0}}	When method is twopoint: The coordinates of two points on the symmetry axis.Available for Sector3D.
haspacevars	boolean	false	If true, spacevars are made available for evaluation.
hasvar	boolean	false	If true, an axis indicator variable is defined.
method	twopoint pointdir	twopoint	Decides if the line should be specified by two points or through one point and a direction. Available for Sector3D
mode	integer	0	If sectors is odd or trans is rot: The azimuthal mode number use to transform the solution's phase between sectors.
pddir	double array	{0, 1}	When method is pointdir: The direction in which the symmetry axis points. Available for Sector3D.
pdpoint	double array	{0, 0}	When method is pointdir: The coordinates of a point on the symmetry axis. Available for Sector3D.
point	double array of length 2	{0, 0}	The coordinates of the symmetry axis. Available for Sector2D.
reflaxis	double array of length 2 in 2D and length 3 in3D	{1, 0} in 2D, {1, 0, 0} in 3D	If trans is rotrefl: The direction in which the reflection axis/plane (for 2D and 3D respectively) points.
sectors	integer >= 2	2	The number of sectors.

TABLE 6-65: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
spacevars	string array of length 2 in 2D and length 3 in 3D	created from feature's tag	Names of variables that when evaluate to the space coordinates in the coordinate system after sector symmetry expansion.
trans	rot rotrefl	rot	If sectors is even: Controls whether the transformation performed between consecutive sectors is rotation or rotation and reflection.

Synopsis Slice plot.

Syntax

```
model.result(<pgtag>).feature().create(<ftag>,"Slice");
model.result(<pgtag>).feature(<ftag>).set(property, <value>);
model.result(<pgtag>).feature(<ftag>).run();
```

Description `model.result(<pgtag>).feature().create(<ftag>,"Slice")` creates a slice feature named `<ftag>` belonging to the plot group `<pgtag>`.

The following properties are available:

TABLE 6-66: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
color	custom black blue cyan green magenta red white yellow	red	The uniform color to use. Active when coloring is uniform.
coloring	colortable uniform	colortable	How to color the slices.
colorlegend	on off	on	Whether to show color legend, when coloring is set to colortable.
colortable	colortable name	Rainbow	The color table to use when colormethod is set to colortable.
colortablerev	on off	off	Whether to reverse to color table when colormethod is set to colortable.
colortablesym	on off	off	Whether to symmetrize the color range around 0 when colormethod is set to colortable.
customcolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use. Active when color is set to custom.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
data	none parent data set name	parent	The data set this feature refers to.
descr	string	Model-dependent.	The description of the expression in expr. Is used in the automatic title.
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.

TABLE 6-66: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent.	The expression to plot.
expressionintitle	on off	off	Whether the title contribution should contain the expression when titletype is custom.
gendistance	double array	Empty	Vector of distances from base plane, indicating position of additional parallel planes. Active when genparaactive equals on and genpara equals number.
genmethod	threepoint pointnormal	threepoint	Active when planetype equals general, this property indicates whether the plane should be specified by three points or through one point and a normal.
gennumber	positive integer	4	Number of additional parallel planes. Active when genparaactive equals on and genpara equals number.
genpara	gennumber gendistances	number	Active when planetype equals general, and genparaactive equals on, this property indicates whether the additional parallel planes should be specify by a number, or by a vector of relative distances.
genparaactive	on off	off	Active when planetype equals general, this property indicates whether there should be additional parallel planes created.
genpnpoint	double array of length three	{0,0,0}	Active when genmethod equals pointnormal, this property contains the coordinates of the point.
genpnvec	double array of length three	{0,0,0}	Active when genmethod equals pointnormal, this property contains the normal vector.
genpoints	double matrix of size 3x3	{{0,0,0}, {1,0,0}, {0,1,0}}	Active when genmethod equals threepoint, this property contains the coordinates of the three points, with one row per point.

TABLE 6-66: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
inheritcolor	boolean	true	If inheritplot is not none: Determines if the color is inherited.
inheritdeformscale	boolean	true	If inheritplot is not none: Determines if the deformation scale is inherited.
inheritplot	none plot name	none	The plot that color, color range, and deformation scale is inherited from.
inheritrange	boolean	true	If inheritplot is not none: Determines if the color and data ranges are inherited.
interactive	on off	off	If true, the isosurfaces can be moved interactively after the plot has been made.
interp	double array	Time corresponding to last selected solnum for transient levels.	The time to use, for transient levels. Available when data is not parent and the underlying data is transient.
looplevel	array of non-negative integers and strings	Last solution for transient or parametric solution for each level. Otherwise first solution for each level.	The index of the solution to use, per level, or interp, but only for transient solutions. Available when data is not parent and the underlying data has multiple solutions.
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
planetype	quick general	yz	Specify plane type.
prefixintitle	string	Empty	Added prefix to contribution to title.
quickplane	xy yz zx	yz	Specify quick plane type. Active when planetype is quick.
quickx	double array	0	Absolute x-coordinates for planes, active when quickxmethod is set to coord.
quickxmethod	number coord	number	Active when planetype equals quick and quickplane equals yz, this property indicates whether the planes should be specified by one or more absolute coordinates along the x-axis, or a number indicating the number of planes to distribute evenly.

TABLE 6-66: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
quickxnumber	positive integer	5	The number of planes when quickxmethod is set to number.
quicky	double array	0	Absolute y-coordinates for planes, active when quickymethod is set to coord.
quickymethod	number coord	number	Active when planetype equals quick and quickplane equals zx, this property indicates whether the planes should be specified by one or more absolute coordinates along the y-axis, or a number indicating the number of planes to distribute evenly.
quickynumber	positive integer	5	The number of planes when quickymethod is set to number.
quickz	double array	0	Absolute z-coordinates for planes, active when quickzmethod is set to coord.
quickzmethod	number coord	number	Active when planetype equals quick and quickplane equals xy, this property indicates whether the planes should be specified by one or more absolute coordinates along the z-axis, or a number indicating the number of planes to distribute evenly.
quickznumber	positive integer	5	The number of planes when quickzmethod is set to number.
rangecoloractive	on off	off	Whether to use the manual color range specified in rangecolormin and rangecolormax. The color range specifies the minimum and maximum value in the plotted colors. Default is the minimum and maximum data values.
rangecolormax	double	Plot-dependent	The maximum color range value. Active when rangecoloractive is on.
rangecolormin	double	Plot-dependent	The minimum color range value. Active when rangecoloractive is on.
rangedataactive	on off	off	Whether to use the manual data range specified in rangedatamin and rangedatamax. Values outside the data range is not plotted.
rangedatamax	double	Plot-dependent	The maximum data value. Active when rangedataactive is on.
rangedatamin	double	Plot-dependent	The minimum data value. Active when rangedataactive is on.

TABLE 6-66: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
recover	off pprint ppr	off	The derivative recovery method.
refine	non-negative integer	1	The element refinement to use, if resolution is set to manual. Bear in mind that this is the refinement used for the base data set, so the number of elements in the model can increase radically if the plot uses, for example, a revolve data set.
resolution	norefine coarse normal fine finer extrafine custom	normal	Controls the plot's resolution. A finer setting results in a higher resolution by modifying the internally computed default refinement. Use custom to enter your own refinement in the refine property.
shift	double	0	If interactive is on: The shift that is applied to the level values.
smooth	none internal everywhere	internal	Smoothing settings.
solnum	non-negative integer	Last solution for transient or parametric solution. Otherwise first solution.	The index of the solution to use. Available when data is not parent and the underlying data has multiple solutions.
solrepresentat ion	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
suffixintitle	string	Empty	Added suffix to contribution to title.
t	double	Time corresponding to last selected solnum.	The time to use, for transient problems. Available when data is not parent and the underlying data is transient.
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.
title	string	The auto-title.	The title to use when titletype is manual.

TABLE 6-66: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when titletype is custom.
unit	string	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.
unitintitle	on off	on	Whether the title contribution should contain the unit when titletype is custom.

Note Only one direction of slices is possible in one plot. Use different slice plots together to accomplish several slices in different directions.

Attributes [Deform](#), [Filter](#)

See Also [Volume](#)

Purpose Solution data set.

Syntax

```
model.result().dataset().create(<dtag>, "Solution");
model.result().dataset(<dtag>).set(property, <value>);
model.result().dataset(<dtag>).selection(...);
model.result().dataset(<dtag>).createDeformedConfig(<gtag>,
                                                    <mtag>);
```

Description `model.result().dataset().create(<dtag>, "Solution")` creates a solution data set.

Solution data sets refer to a solution in a solver sequence. All result features that perform evaluations on a solution refer to these data sets, rather than directly to the solution itself. The solution data sets specify which geometry and frame to use for evaluation and whether to evaluate only on a specific selection, among other things. It is possible to have multiple data set solutions referring to the same solution.

The following properties are available:

TABLE 6-67: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
frametype	mesh material spatial	material or spatial	The frame type that this data set uses for evaluation of spatial coordinates.
geom	string	First available geometry, if any.	The geometry this data set refers to. Only applicable for solutions that refer to a geometry.
phase	double	0	Evaluate solution at this angle, given in degrees.
scalefactor	double	1	Multiply solution by this scaling factor.
solution	string	First compatible solution	The solution this data set refers to.

`model.result().dataset(<dtag>).createDeformedConfig(<gtag>, <mtag>)` creates a new geometry sequence (deformed configuration) tagged `<gtag>` together with a mesh sequence tagged `<mtag>` to use for remeshing of a deformed mesh. The created geometry sequence only contains a `FromMesh` feature.

Examples Create a solution data set and set it to point to the second geometry in the solver sequence `sol1`:

```
model.result().dataset().create("dset1", "Solution");
model.result().dataset("dset1").set("solution", "sol1");
model.result().dataset("dset1").set("geom", "geom2");
```

See Also [PlotGroup1D](#), [PlotGroup2D](#), [PlotGroup3D](#)

Synopsis	Streamline plot.
Syntax	<pre>model.result(<pgtag>).feature().create(<ftag>,"Streamline"); model.result(<pgtag>).feature(<ftag>).set(property, <value>); model.result(<pgtag>).feature(<ftag>).run();</pre>
Description	<p><code>model.result(<pgtag>).feature().create(<ftag>,"Streamline")</code> creates a streamline plot feature named <code><ftag></code> belonging to the plot group <code><pgtag></code>.</p> <p>Streamlines visualize a vector quantity on domains. A streamline is a curve everywhere tangent to an instantaneous vector field. Streamlines are available in 2D and 3D plot groups.</p> <p>The following properties are available:</p>

TABLE 6-68: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
back	on off	on	Allow backward time integration. Only available for time-dependent data sets.
color	custom black blue cyan green magenta red white yellow	black (2D), red (3D)	The uniform color to use.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
customcolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use. Active when color is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
descr	string	Model-dependent	The description of the expression in expr. Is used in the automatic title.
descriptionin title	on off	on	Whether the title contribution should contain the description when titletype is custom.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic

TABLE 6-68: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string array of length 2 in 2D and 3 in 3D	Model-dependent	The components to plot.
inheritcolor	boolean	true	If inheritplot is not none: Determines if the color is inherited.
inheritdeform scale	boolean	true	If inheritplot is not none: Determines if the deformation scale is inherited.
inheritplot	none plot name	none	The plot that color, tube scale, and deformation scale is inherited from.
inherittube scale	boolean	true	If inheritplot is not none and linetype is tube or ribbon: Determines if the tube or ribbon scale is inherited.
interp	double array	Time corresponding to last selected solnum for transient levels.	The time to use, for transient levels. Available when data is not parent and the underlying data is transient.
inttol	positive double	0.001 (2D), 0.01 (3D)	Integration tolerance.
linetype	line tube ribbon	line	Plot streamlines as lines, tubes, or ribbons.
looplevel	array of non-negative integers and strings	Last solution for transient or parametric solution for each level. Otherwise first solution for each level.	The index of the solution to use, per level, or interp, but only for transient solutions. Available when data is not parent and the underlying data has multiple solutions.
looptol	positive double	0.01	Loop tolerance.
madv	manual automatic	automatic	Whether to specify advanced parameters when positioning method is magnitude.

TABLE 6-68: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
maxsteps	positive integer	5000	The maximum number of integration steps.
maxtime	positive double	Inf	Maximum integration time.
mdensity	non-negative integer	20	The density of the streamlines. Active when posmethod is set to magnitude. Only available in 2D.
mdist	double array of length two containing positive doubles	{0.05, 0.15}	Minimum and maximum distance relative to the size of the geometry. Active when posmethod is set to magnitude. Only available in 3D.
minitref	positive integer	1	Boundary element refinement. Active when madv is set to manual.
msatfactor	non-negative double	1.3	Starting distance factor. Active when madv is set to manual. Only available in 3D.
mseed	double array of length 2 or 3, depending on space dimension.	{0,0} (2D), {0,0,0} (3D)	The first start point. Active when mseedactive is set to on.
mseedactive	on off	off	Whether to manually specify first start point. Active when madv is set to manual.
normal	on off	off	on when vector field should be normalized.
number	integer	20	Approximate number of streamlines. Active when startmethod is set to number.
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
posmethod	magnitude start uniform selection	selection	The type of streamline positioning. Either start point controlled, uniform density, magnitude controlled, or starting from selected lines (2D) or surfaces (3D).
prefixintitle	string	Empty	Added prefix to contribution to title.
radiusexpr	string	1	The tube radius.

TABLE 6-68: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
refine	non-negative integer	1	The element refinement to use, if resolution is set to manual. Bear in mind that this is the refinement used for the base data set, so the number of elements in the model can increase radically if the plot uses, for example, a revolve data set.
resolution	norefine coarse normal fine finer extrafine custom	normal	Controls the plot's resolution. A finer setting results in a higher resolution by modifying the internally computed default refinement. Use custom to enter your own refinement in the refine property.
selnumber	non-negative integer	20	If posmethod is selection: The approximate number of streamlines placed on the selected edges (2D) or surfaces (3D).
solnum	non-negative integer	Last solution for transient or parametric solution. Otherwise first solution.	The index of the solution to use. Available when data is not parent and the underlying data has multiple solutions.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
startdata	none cut line or cut plane name	none	Active when posmethod is start: The line or plane where the start points are distributed evenly.
startmethod	number coord	number	Active when posmethod is start. Indicates whether the start points should be specified by number of points to distribute evenly or by coordinates.
stattol	positive double	0.01	Stationary point stop tolerance.
suffixintitle	string	Empty	Added suffix to contribution to title.
t	double	Time corresponding to last selected solnum.	The time to use, for transient problems. Available when data is not parent and the underlying data is transient.
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.

TABLE 6-68: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
title	string	The auto-title.	The title to use when <code>titletype</code> is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the <code>title</code> property). none if no title contribution should be used.
tuberadiussscale	double	1	The scale factor applied to the tube radii if <code>tuberadiussscaleactive</code> is true.
tuberadiussscaleactive	boolean	false	If true, <code>tuberadiussscale</code> is used, otherwise the scale factor is computed automatically
typeintitle	on off	on	Whether the title contribution should contain the type when <code>titletype</code> is custom.
uadv	manual automatic	automatic	Whether to specify advanced parameters when positioning method is uniform.
udist	positive double	0.15 (3D), 0.05 (2D)	Separating distance relative to the size of the geometry. Active when <code>posmethod</code> is set to uniform.
udistend	non-negative double	0.5	Terminating distance factor. Active when <code>uadv</code> is set to manual.
uignoredist	non-negative double	0.5	Fraction of streamline length to ignore. Active when <code>uadv</code> is set to manual.
uinitref	positive integer	1	Boundary element refinement. Active when <code>uadv</code> is set to manual.
unit	String	Model-dependent	The unit to use for the expression in <code>expr</code> . If the old unit is not valid when the expression changes, the unit property is reset to default.
usatfactor	non-negative double	1.3	Starting distance factor. Active when <code>uadv</code> is set to manual.
useed	double array of length 2 or 3, depending on space dimension.	{0,0} (2D) or {0,0,0} (3D)	The first start point. Active when <code>useedactive</code> is set to on.
useedactive	on off	off	Whether to manually specify first start point. Active when <code>uadv</code> is set to manual.
widthexpr	string	1	The ribbon width.

TABLE 6-68: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
widthscale	double	1	The scale factor applied to the ribbon widths if widthscaleactive is true.
widthscaleactive	boolean	false	If true, widthscale is used, otherwise the scale factor is computed automatically
xcoord	double array	Empty	Absolute coordinates in the x-direction, active when startmethod is set to coord.
ycoord	double array	Empty	Absolute coordinates in the y-direction, active when startmethod is set to coord.
zcoord	double array	Empty	Absolute coordinates in the z-direction, active when startmethod is set to coord. Available in 3D only.

Attributes [Color](#), [Deform](#), [Filter](#)

See Also [Particle](#), [ParticleMass](#)

Purpose Surface plot.

Syntax `model.result(<pgtag>).feature().create(<ftag>, "Surface");`
`model.result(<pgtag>).feature(<ftag>).set(property, <value>);`
`model.result(<pgtag>).feature(<ftag>).run();`

Description `model.result(<pgtag>).feature().create(<ftag>, "Surface")` creates a surface plot feature named `<ftag>` belonging to the plot group `<pgtag>`.

Surface plots display a quantity as a colored 2D or 3D surface.

The following properties are available:

TABLE 6-69: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
color	custom black blue cyan green magenta red white yellow	red	The uniform color to use. Active when coloring is uniform.
coloring	colortable uniform	colortable	How to color this surface.
colorlegend	on off	on	Whether to show color legend, when coloring is set to colortable.
colortable	colortable name	Rainbow	The color table to use when colormethod is set to colortable.
colortablereverse	on off	off	Whether to reverse to color table when colormethod is set to colortable.
colortablesymm	on off	off	Whether to symmetrize the color range around 0 when colormethod is set to colortable.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
customcolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use. Active when color is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
descr	string	Model-dependent.	The description of the expression in expr. Is used in the automatic title.

TABLE 6-69: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent.	The expression to plot.
expressionintitle	on off	off	Whether the title contribution should contain the expression when titletype is custom.
inheritcolor	boolean	true	If inheritplot is not none: Determines if the color is inherited.
inheritdeformscale	boolean	true	If inheritplot is not none: Determines if the deformation scale is inherited.
inheritheightscale	boolean	true	If inheritplot is not none: Determines if height scale is inherited.
inheritplot	none plot name	none	The plot that color, color range, and deformation scale is inherited from.
inheritrange	boolean	true	If inheritplot is not none: Determines if the color and data ranges are inherited.
interp	double array	Time corresponding to last selected solnum for transient levels.	The time to use, for transient levels. Available when data is not parent and the underlying data is transient.
looplevel	array of non-negative integers and strings	Last solution for transient or parametric solution for each level. Otherwise first solution for each level.	The index of the solution to use, per level, or interp, but only for transient solutions. Available when data is not parent and the underlying data has multiple solutions.

TABLE 6-69: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
prefixintitle	string	Empty	Added prefix to contribution to title.
rangecoloractive	on off	off	Whether to use the manual color range specified in rangecolormin and rangecolormax. The color range specifies the minimum and maximum value in the plotted colors. Default is the minimum and maximum data values.
rangecolormax	double	Plot-dependent	The maximum color range value. Active when rangecoloractive is on.
rangecolormin	double	Plot-dependent	The minimum color range value. Active when rangecoloractive is on.
rangedataactive	on off	off	Whether to use the manual data range specified in rangedatamin and rangedatamax. Values outside the data range is not plotted.
rangedatamax	double	Plot-dependent	The maximum data value. Active when rangedataactive is on.
rangedatamin	double	Plot-dependent	The minimum data value. Active when rangedataactive is on.
recover	off pprint ppr	off	The derivative recovery method.
refine	non-negative integer	1	The element refinement to use, if resolution is set to manual. Bear in mind that this is the refinement used for the base data set, so the number of elements in the model can increase radically if the plot uses, for example, a revolve data set.
resolution	norefine coarse normal fine finer extrafine custom	normal	Controls the plot's resolution. A finer setting results in a higher resolution by modifying the internally computed default refinement. Use custom to enter your own refinement in the refine property.
smooth	none internal everywhere	internal	Smoothing settings.

TABLE 6-69: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
solnum	non-negative integer	Last solution for transient or parametric solution. Otherwise first solution.	The index of the solution to use. Available when data is not parent and the underlying data has multiple solutions.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
suffixintitle	string	Empty	Added suffix to contribution to title.
t	double	Time corresponding to last selected solnum.	The time to use, for transient problems. Available when data is not parent and the underlying data is transient.
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when titletype is custom.
unit	string	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.
unitintitle	on off	on	Whether the title contribution should contain the unit when titletype is custom.
wireframe	on off	off	Whether to plot filled elements or only their edges.

Attributes [Deform](#), [Filter](#), [Height](#)

Examples Surface plot on 2D solution:

```
model.result().dataset().create("dset1", "Solution");
```

```
model.result().dataset("dset1").set("Solution", "sol1");  
result().create("pg1",2);  
result("pg1").set("data","dset1");  
result("pg1").feature().create("surf1","Surface");  
result("pg1").feature("surf1").set("expr", "3*u");
```

Surface plot on cut plane in 3D:

```
result().dataset().create("cp1", "CutPlane");  
  
result().create("pg2",3);  
result("pg2").feature().create("surf2","Surface");  
result("pg2").feature("surf2").set("data", "cp1");  
result("pg2").feature("surf1").set("expr", "2*u");  
result("pg2").feature("surf1").set("colortable", "Thermal");  
  
result("pg2").run();
```

See Also

[Volume](#)

Surface (data set)

Synopsis	Surface data set.
Syntax	<pre>model.result().dataset().create(<dtag>, "Surface"); model.result().dataset(<dtag>).set(property, <value>);</pre>
Description	<pre>model.result().dataset().create(<dtag>, "Surface")</pre> creates a surface data set with the name <code><dtag></code> .

The surface data set makes it possible to evaluate surfaces of a 3D model in 2D or 3D. For evaluation in 2D, different parameterizations of the 2D projection are available.

The following properties are available:

TABLE 6-70: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
data	none data set name	First compatible data set	The solution data set this feature refers to.
param	face xy yz zx yx zy xz expr	face	The projection used when evaluating in 2D.
exprx	String		When param is expr: The x-axis expression when evaluating in 2D.
expy	String		When param is expr: The y-axis expression when evaluating in 2D.

Purpose	Feature containing a table of data.
Syntax	<pre> model.result().table().create(<ftag>, "Table"); model.result().table(<ftag>).setColumnHeaders(<headers>); model.result().table(<ftag>).setTableData(<realData>); model.result().table(<ftag>).setTableData(<realData>, <imagData>); model.result().table(<ftag>).addColumnns(<headers>, <realData>); model.result().table(<ftag>).addColumnns(<headers>, <realData>, <imagData>); model.result().table(<ftag>).addRow(<realData>); model.result().table(<ftag>).addRow(<realData>, <imagData>); model.result().table(<ftag>).removeRow(<index>); model.result().table(<ftag>).getColumnHeaders(); model.result().table(<ftag>).getReal(); model.result().table(<ftag>).getImag(); model.result().table(<ftag>).Row(<index>); model.result().table(<ftag>).getImagRow(<index>); model.result().table(<ftag>).getTableData(<fullPrecision>); model.result().table(<ftag>).getTableRow(<index>, <fullPrecision>); model.result().table(<ftag>).getNRows(); model.result().table(<ftag>).isComplex(); model.result().table(<ftag>).clearTableData(); model.result().table(<ftag>).set(property, <value>); model.result().table(<ftag>).save(<filename>); model.result().table(<ftag>).save(<filename>, <fullPrecision>); </pre>

Description `model.result().table().create(<ftag>, "Table")` creates a table feature named `<ftag>`. Tables support two data formats, *all* or *filled*. Filled data is typically produced from parametric sweeps and makes it possible to retrieve data for a pair of parameters on a matrix format. Filled tables can be used to make response surface plots. (See [TableSurface](#).)

`model.result().table(<ftag>).setColumnHeaders(<headers>)` sets the table's column headers from the string array `<headers>`.

`model.result().table(<ftag>).setTableData(<realData>)` sets the table content from a double matrix containing real data. Any previous real or imaginary data is removed.

`model.result().table(<ftag>).setTableData(<realData>, <imagData>)` sets both real and imaginary data from the double matrices `<realData>` and `<imagData>`, which must be of the same size. `<imagData>` can be null to indicate that there is no imaginary data.

`model.result().table(<ftag>).getColumnHeaders()` retrieves the column headers.

`model.result().table(<ftag>).addColumns(<headers>, <realData>)` adds one or more columns and associated real data to the table.

`model.result().table(<ftag>).addColumns(<headers>, <realData>, <imagData>)` adds one or more columns and associated real data and imaginary data to the table.

`model.result().table(<ftag>).addRow(<realData>)` adds one row of real data to the table.

`model.result().table(<ftag>).addRow(<realData>, <imagData>)` adds one row of real and imaginary data to the table.

`model.result().table(<ftag>).removeRow(<index>)` removes the row with a given index from the table. If the row index is out of bounds, nothing happens.

`model.result().table(<ftag>).getColumnHeaders()` returns the column headers in the table.

`model.result().table(<ftag>).getReal()` returns the real part of the table content.

`model.result().table(<ftag>).getImag()` returns the imaginary part of the table content. Note: this method allocates imaginary data if there was none. Check for imaginary content with the `isComplex` method before calling this method if you want to avoid this.

`model.result().table(<ftag>).getRealRow(<index>)` returns the real data in one row.

`model.result().table(<ftag>).getImagRow(<index>)` returns the imaginary data in one row.

`model.result().table(<ftag>).getFilledReal()` returns the real part of the table content on a filled format, when available.

`model.result().table(<ftag>).getFilledImag()` returns the imaginary part of the table content on a filled format, when available.

`model.result().table(<ftag>).getTableData(<fullPrecision>)` returns the table data as a string matrix, with limited or full precision as specified by the boolean `<fullPrecision>`.

`model.result().table(<ftag>).getTableRow(<index>, <fullPrecision>)` returns the table data for one row as a string array, with limited or full precision.

`model.result().table(<ftag>).getNRows()` returns the number of rows in the table.

`model.result().table(<ftag>).isComplex()` returns true if the table contains imaginary data. This method checks whether imaginary data has been allocated, not if it is different from 0.

`model.result().table(<ftag>).clearTableData()` removes all table data and column headers.

`model.result().table(<ftag>).save(<filename>)` saves the table <ftag> content to the text file <filename> in full precision.

The following properties are available:

TABLE 6-71: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
cols	Parameters in table none	none	For tables with filled data, cols controls which parameter is used on the columns. May not be the same parameter as in rows.
datacol	Positive integer	1	For tables with filled data, datacol controls which data column should be used to populate the filled table.
descr	none data manual	data	For tables with filled data, descr controls which description to use for the columns, in addition to the parameter values. none will give no description, manual uses the description in descrmanual and data uses the description in the table data.
descrmanual	String	Empty	Manual column header for tables with filled data, used when descr is set to manual.
filename	String	Empty	The name of the file on which the table is stored, used when storetable is set to inmodelandonfile or onfile.
filterstringdata	on off	off	For tables with filled data, filterstringdata controls whether to filter the input column using showrowstep.
format	all filled	all	Controls whether you retrieve all or filled table data when calling the getTableData method.

Table

TABLE 6-71: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
param	Positive integer	1	For tables with filled data containing more than two parameters, param is the index indicating which values to use for fixing additional parameters. Additional parameters are ordered from left to right in the original table data.
rows	Parameters in table none	none	For tables with filled data, rows controls which parameter is used on the rows.
showrowstep	Positive integer	1	When retrieving filled data using the <code>getTableData</code> method, showrowstep controls whether to leave all but every showrowstep input cells empty, for example, every third cell in the first column. This refers to the input column only. Only applied when <code>filterstringdata</code> is on.
storetable	inmodel inmodelandonfile onfile	inmodel	Controls whether table will be stored in model(inmodel) or on file(onfile), or both(inmodelandonfile).
tablebuffersize	Positive integer	Taken from buffer size preference. The default of which is 10000.	The size of the in memory buffer size table is stored, used when storetable is set to inmodel or inmodelandonfile. In the second case only the last tablebuffersize rows are kept in the model; the rest is read from file when necessary.

See Also

[Table \(plot\)](#), [TableSurface](#)

Purpose	Plot data from a table in a graph plot.
Syntax	<pre>model.result(<phtag>).feature().create(<ftag>, "Table"); model.result(<phtag>).feature(<ftag>).set(property, <value>); model.result(<phtag>).feature(<ftag>).run();</pre>
Description	<p><code>model.result(<phtag>).feature().create(<ftag>, "Table")</code> creates a graph table plot feature named <code><ftag></code>.</p> <p>Table plots can be added to 1D and polar plot groups and displays data from a table.</p> <p>The following properties are available:</p>

TABLE 6-72: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
autolegends	on off	on	Whether to use the automatically generated legends or the legends defined in the legends property.
customlinecolor	RGB-triplet	{0,0,1} or last used edgcolor.	The color to use for the lines. Active when linecolor is set to custom.
freqmax	integer		If transform is spectrum and freqrangeactive is true: The upper frequency bound.
freqmin	integer		If transform is spectrum and freqrangeactive is true: The lower frequency bound.
freqrangeactive	on off	false	If transform is spectrum: Controls whether a manual frequency range is used.
imagplot	on off	off	If transform is none: When on, the imaginary part of the data in the table is plotted.
legend	on off	off	Whether to show legends.
legendmethod	automatic manual	automatic	Whether to use the automatic legends or the legends supplied in the legends property.
legends	string array	The last computed automatic legends.	Manual legends active when legendmethod is set to manual.
linecolor	custom cycle black blue cyan green magenta red white yellow	cycle	How to color the lines in the graph. Cycle indicates that the colors is different for each line.

Table (plot)

TABLE 6-72: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
linewidth	double	0.5	The line width.
linemarker	none cycle asterisk circle diamond plus point square star triangle	none	The line markers, if any. Cycle indicates that the marker is different for each line.
linestyle	none cycle solid dotted dashed dashdot	solid	The line style, if any. Cycle indicates that the line style is different for each line.
markerpos	interp datapoints	interp	Controls whether the positions of the markers are in the data points of the plot, or interpolated depending on the number (set in markers). Markers are visible when linemarker is set.
markers	integer	8	The number of markers to show. Markers are visible when linemarker is set.
nfreqs	integer	1	If transform is spectrum and nfreqsactive is true: The number of frequencies to plot.
nfreqsactive	boolean	false	If transform is spectrum: Controls whether the number of frequencies is set manually.
plotcolumninput	all manual	all	The columns to plot. all indicates all columns excluding those used in xaxisdata, manual indicates the columns specified in plotcolumns.
plotcolumns	positive integer array	Empty	The columns to plot when plotcolumninput is manual.
scale	boolean	false	If transform ffs spectrum: The frequency spectrum is transformed so that it has the same scale as the original data.
table	none table feature name	First available table	The table feature this plot refers to.

TABLE 6-72: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
transform	none spectrum	none	The transformation to apply to the data before plotting.
xaxisdata	auto rowindex positive integer	auto	The column supplying x-axis data. auto determines input based on evaluated result, for example, using an index if the table contains output from a parametric sweep with multiple parameters. rowindex means that all columns are used as data and are plotted against the row number in the table.

See Also[Table](#)

TableHeight

Synopsis	Height attribute for 2D table plots.
Syntax	<pre>model.result(<pgtag>).feature(<ftag>).feature().create(<atag>, "TableHeight"); model.result(<pgtag>).feature(<ftag>).feature(<atag>).set(property, <value>);</pre>
Description	<pre>model.result(<pgtag>).feature(<ftag>).feature().create(<atag>, "TableHeight")</pre> creates a TableHeight attribute feature with the name <atag>, belonging to the feature <ftag>.

Table height attributes are available for 2D table surface plots. Adding a height attribute changes the rendered view to 3D. The plot group, however, still remains a 2D plot group. Any other plots in the group that do not have heights attribute is rendered at $z=0$.

The following properties are available:

TABLE 6-73: VALID PROPERTY/VALUE PAIRS

PROPERTY	VALUE	DEFAULT	DESCRIPTION
datacol	Positive integer	1	For tables with filled data, datacol controls which data column should be used to populate the filled table. Used when heightdata is data.
heightdata	parent data	parent	parent uses the data from the surface plot the height feature has been added to. data uses the data specified by the height attribute's properties.
offset	double	0	The offset along the z-axis where to place the height plot.
scale	positive double	1	If scaleactive is true: The scale factor for the height.
scaleactive	boolean	false	Whether to use manual scaling.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.

See Also [TableSurface](#), [Table](#)

Purpose	Plot data from a table in a surface plot.
Syntax	<pre>model.result(<pgtag>).feature().create(<ftag>, "TableSurface"); model.result(<pgtag>).feature(<ftag>).set(property, <value>); model.result(<pgtag>).feature(<ftag>).run();</pre>
Description	<pre>model.result(<pgtag>).feature().create(<ftag>, "Table")</pre> creates a table surface plot feature named <code><ftag></code> .

Table surface plots can only be used with tables containing filled data, produced from a parametric sweep. They can be added to 2D plot groups.

The following properties are available:

TABLE 6-74: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
color	custom black blue cyan green magenta red white yellow	red	The uniform color to use. Active when coloring is uniform.
coloring	colortable uniform	colortable	How to color this surface.
colorlegend	on off	on	Whether to show color legend, when coloring is set to colortable.
colortable	colortable name	Rainbow	The color table to use when colormethod is set to colortable.
colortablerev	on off	off	Whether to reverse to color table when colormethod is set to colortable.
colortablesym	on off	off	Whether to symmetrize the color range around 0 when colormethod is set to colortable.
customcolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use. Active when color is set to custom.
datacol	Positive integer	1	For tables with filled data, datacol controls which data column should be used to populate the filled table.

TABLE 6-74: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
descr	none data manual	data	For tables with filled data, descr controls which description to use for the columns, in addition to the parameter values. none will give no description, manual uses the description in descrmanual and data uses the description in the table data.
descrmanual	String	Empty	Manual column header for tables with filled data, used when descr is set to manual.
filterstringdata	on off	off	For tables with filled data, filterstringdata controls whether to filter the input column using showrowstep.
format	all filled	all	Controls whether you retrieve all or filled table data when calling the getTableData method.
imagplot	on off	off	If transform is none: When on, the imaginary part of the data in the table is plotted.
inheritcolor	boolean	true	If inheritplot is not none: Determines if the color is inherited.
inheritheightscale	boolean	true	If inheritplot is not none: Determines if height scale is inherited.
inheritplot	none plot name	none	The plot that color, color range, and height scale is inherited from.
inheritrange	boolean	true	If inheritplot is not none: Determines if the color and data ranges are inherited.
param	Positive integer	1	For tables with filled data containing more than two parameters, param is the index indicating which values to use for fixing additional parameters. Additional parameters are ordered from left to right in the original table data.
plotdata	table manual	table	For tables with filled data containing more than two parameters, plotdata controls whether to use manual settings in the plot (table row, column, and so forth), or the filled settings in the table feature. In the latter case, the table's properties are automatically synchronized with the plot's properties.

TABLE 6-74: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
rangecoloractive	on off	off	Whether to use the manual color range specified in rangecolormin and rangecolormax. The color range specifies the minimum and maximum value in the plotted colors. Default is the minimum and maximum data values.
rangecolormax	double	Plot-dependent	The maximum color range value. Active when rangecoloractive is on.
rangecolormin	double	Plot-dependent	The minimum color range value. Active when rangecoloractive is on.
rangedataactive	on off	off	Whether to use the manual data range specified in rangedatamin and rangedatamax. Values outside the data range is not plotted.
rangedatamax	double	Plot-dependent	The maximum data value. Active when rangedataactive is on.
rangedatamin	double	Plot-dependent	The minimum data value. Active when rangedataactive is on.
showrowstep	Positive integer	1	When retrieving filled data using the getTableData method, showrowstep controls whether to leave all but every showrowstep input cells empty, for example, every third cell in the first column. This refers to the input column only. Only applied when filterstringdata is on.
smooth	none internal everywhere	internal	Smoothing settings.
table	none table feature name	First available table	The table feature this plot refers to.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
xaxisdata	Parameters in table none	none	For tables with filled data, xaxisdata controls which parameter is used on the x-axis.

TableSurface

TABLE 6-74: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
yaxisdata	Parameters in table none	none	For tables with filled data, yaxisdata controls which parameter is used on the y-axis. May not be the same parameter as in xaxisdata.
wireframe	on off	off	Whether to plot filled elements or only their edges.

See Also [Table, Table \(plot\)](#)

Purpose	Volume plot.
Syntax	<pre>model.result(<pgtag>).feature().create(<ftag>, "Volume"); model.result(<pgtag>).feature(<ftag>).set(property, <value>); model.result(<pgtag>).feature(<ftag>).run();</pre>
Description	<p><code>model.result(<pgtag>).feature().create(<ftag>, "Volume")</code> creates a volume plot feature named <code><ftag></code> belonging to the plot group <code><pgtag></code>.</p> <p>A volume plot shows an expression evaluated in all elements of a 3D volume.</p> <p>The following properties are available:</p>

TABLE 6-75: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
color	custom black blue cyan green magenta red white yellow	red	The uniform color to use. Active when coloring is uniform.
coloring	colortable uniform	colortable	How to color this surface.
colorlegend	on off	on	Whether to show color legend, when coloring is set to colortable.
colortable	colortable name	Rainbow	The color table to use when colormethod is set to colortable.
colortablerev	on off	off	Whether to reverse to color table when colormethod is set to colortable.
colortablesym	on off	off	Whether to symmetrize the color range around 0 when colormethod is set to colortable.
const	String array of property/value pairs	Empty	Parameters to use in the expressions.
customcolor	RGB-triplet	{1,0,0} or last used color.	The uniform color to use. Active when color is set to custom.
data	none parent data set name	parent	The data set this feature refers to.
descr	string	Model-dependent.	The description of the expression in expr. Is used in the automatic title.
descriptionintitle	on off	on	Whether the title contribution should contain the description when titletype is custom.

TABLE 6-75: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
elemfilter	random expression	random	If filteractive is on: The expression to use for filtering when only a subset of the elements are shown.
elemscale	double in [0,1]	1	The scale factor with which each element is scaled.
differential	on off	on	Whether the expression should be linearized at the linearization point. Applicable only if evalmethod is harmonic
evalmethod	linpoint harmonic lintotal lintotalavg lintotalrms lintotalpeak	harmonic	Applicable only for solutions with a stored linearization point. Controls if the linearization point, the perturbation, or a combination should be used when evaluating the expression.
expr	string	Model-dependent.	The expression to plot.
expressionin title	on off	off	Whether the title contribution should contain the expression when titletype is custom.
filteractive	on off	off	Whether to use element filtering.
filterexpr	string	x	The expression to use for filtering when elemfilter is set to expression.
inheritcolor	boolean	true	If inheritplot is not none: Determines if the color is inherited.
inheritdefor mscale	boolean	true	If inheritplot is not none: Determines if the deformation scale is inherited.
inheritplot	none plot name	none	The plot that color, color range, and deformation scale is inherited from.
inheritrange	boolean	true	If inheritplot is not none: Determines if the color and data ranges are inherited.
interp	double array	Time corresponding to last selected solnum for transient levels.	The time to use, for transient levels. Available when data is not parent and the underlying data is transient.

TABLE 6-75: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
looplevel	array of non-negative integers and strings	Last solution for transient or parametric solution for each level. Otherwise first solution for each level.	The index of the solution to use, per level, or interp, but only for transient solutions. Available when data is not parent and the underlying data has multiple solutions.
outersolnum	non-negative integer	1	The index of the outer solutions to use. Applicable only for parametric sweep models.
prefixintitle	string	Empty	Added prefix to contribution to title.
rangecoloractive	on off	off	Whether to use the manual color range specified in rangecolormin and rangecolormax. The color range specifies the minimum and maximum value in the plotted colors. Default is the minimum and maximum data values.
rangecolormax	double	Plot-dependent	The maximum color range value. Active when rangecoloractive is on.
rangecolormin	double	Plot-dependent	The minimum color range value. Active when rangecoloractive is on.
rangedataactive	on off	off	Whether to use the manual data range specified in rangedatamin and rangedatamax. Values outside the data range is not plotted.
rangedatamax	double	Plot-dependent	The maximum data value. Active when rangedataactive is on.
rangedatamin	double	Plot-dependent	The minimum data value. Active when rangedataactive is on.
recover	off pprint ppr	off	The derivative recovery method.
refine	non-negative integer	1	The element refinement to use, if resolution is set to manual. Bear in mind that this is the refinement used for the base data set, so the number of elements in the model can increase radically if the plot uses, for example, a revolve data set.

TABLE 6-75: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
resolution	norefine coarse normal fine finer extrafine custom	normal	Controls the plot's resolution. A finer setting results in a higher resolution by modifying the internally computed default refinement. Use custom to enter your own refinement in the refine property.
tetkeep	double in [0, 1]	1	The fraction of the elements to display.
smooth	none internal everywhere	internal	Smoothing settings
solnum	non-negative integer	Last solution for transient or parametric solution. Otherwise first solution.	The index of the solution to use. Available when data is not parent and the underlying data has multiple solutions.
solrepresentation	solnum solutioninfo	solutioninfo	Indicates which method of selecting solutions is active.
suffixintitle	string	Empty	Added suffix to contribution to title.
t	double	Time corresponding to last selected solnum.	The time to use, for transient problems. Available when data is not parent and the underlying data is transient.
timeinterp	on off	off	on if t is used to determine time steps, off if solnum is used.
title	string	The auto-title.	The title to use when titletype is manual.
titletype	auto custom manual none	auto	auto if the title contribution should be computed automatically, possibly using the group's customization. custom if the title contribution should be computed automatically, but customized. manual if the manual title contribution should be used (the title property). none if no title contribution should be used.
typeintitle	on off	on	Whether the title contribution should contain the type when titletype is custom.
unit	string	Model-dependent	The unit to use for the expression in expr. If the old unit is not valid when the expression changes, the unit property is reset to default.

TABLE 6-75: VALID PROPERTY/VALUE PAIRS

NAME	VALUE	DEFAULT	DESCRIPTION
unitintitle	on off	on	Whether the title contribution should contain the unit when <code>titletype</code> is <code>custom</code> .
wireframe	on off	off	Whether to plot filled elements or only their lines

Graphical User Interface

In this chapter you find reference information about functionality that is useful if you want to create your own Graphical User Interface (GUI) that calls the COMSOL Java API.

Using the functionality described in this guide, you can create custom GUIs that utilize COMSOL's modeling and analysis capabilities and create 1D, 2D, and 3D plots directly in your applications.

In this chapter:

- [Getting Started](#)
- [Example Graphical User Interface](#)
- [GUI Classes](#)

Getting Started

The COMSOL API is based on Java. You must have access to a Java compiler to create and compile programs that can utilize the functionality provided by the COMSOL API.

You can either use an old-fashioned compiler or you can use an integrated development environment.

You can get a compiler from www.oracle.com. Go to this website and download a Java JDK that suits you. The version for Java SE is suitable for most uses. The Oracle website also has plenty of background information on the Java language. Especially the Java Tutorial can be recommended for users that have little or no prior experience in using the Java language.

It is highly recommended that you use an integrated development environment (IDE) for writing and compiling the Java programs. An IDE helps when writing the source code because it provides the user with code completion, syntax highlighting, and access to help text (JavaDoc). An IDE usually also provides an integrated debugger that makes it possible to run the program line by line in order to easier find any bugs in the programs while running.

One such IDE is Eclipse. Eclipse is free and can be downloaded from www.eclipse.org. Together with Eclipse, also download the *Eclipse IDE for Java Development*.

The following sections assume that you have basic knowledge of the Java language and knows how to, for example, compile a Java program.

Example Graphical User Interface

In this section:

- [Introduction](#)
- [Downloading Extra Material](#)
- [Creating the Java Code for the Model](#)
- [Construction of the Initial GUI with Graphics](#)
- [Handling of Progress Information](#)
- [Setting Up Inputs From the GUI to the Model](#)
- [Displaying Results in the GUI](#)
- [Other Details](#)

Introduction

In the following sections a GUI is built based on a model of a cross section of a beam. Beam models are used within the field of structural mechanics, but the application area is not important to the given example. The example model itself solves a simple Poisson type of equation (heat transfer) to calculate the area and moment of inertia for the beam. These calculated values can then later be used as input parameters in a real beam model. A reference for the used modeling method can be found in *Foundations of Solid Mechanics* by Y.C. Fung.

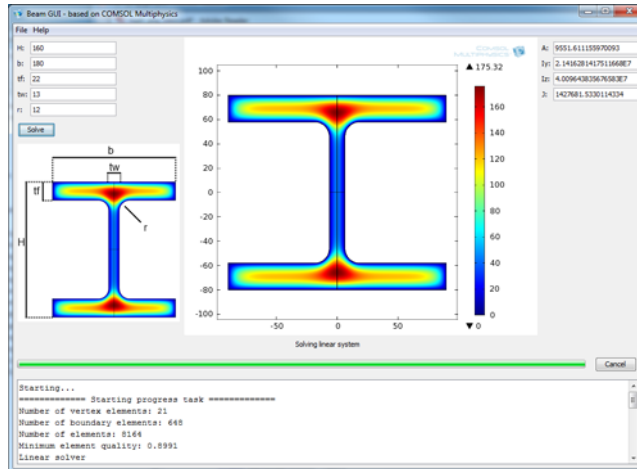
The example includes:

- Save a Model Java-file from an existing COMSOL model
- Integrate the Java file into a GUI built in Java
- How to handle graphics in your own application
- How to handle progress information and, for example, stopping a solver
- How to hook up inputs in the GUI to the simulation
- How to show output from the simulation in the GUI
- Additional details such as adding a menu and icon to the application window

The example is based on the model stored in the `BeamModel.mph` file. The windows includes a lot of detail. The goal of creating a user-defined GUI is to be able to reduce the amount of clutter on the screen by only allowing suitable settings to be viewed and

changed. This allows users who are not experienced in modeling to benefit from models created by others.

The final user interface looks like this



In this window only the absolutely necessary settings are provided on the left side. These settings are used to change the dimensions of the geometry. After the model has been solved the results are shown in the right side and can be copied to another application or report for further use.

Downloading Extra Material

Layout managers are used in Java applications to create appealing GUIs that support automatic resizing. This demo uses the MIG Layout Manager. It is a free Java layout manager that removes a lot of the pain of using layout managers in Java.

The MIG Layout manager is free and can be downloaded from www.miglayout.com.

Creating the Java Code for the Model

In the `demo` folder under the COMSOL installation directory there are some files that can be used for creating the demonstration example. The example models for this demonstration is placed in the `demo\api\beammodel` directory. There is a model file called `BeamModel.mph`. This file contains the model to use for the GUI. Open COMSOL and open the model.

You spend some time familiarizing yourself with the model. Note especially that the model has a set of parameters under **Global Definitions** that are used to update the dimensions of the geometry, and that there is a set of variables defined under **Model>Definitions>Variables** that are used to define the outputs from the simulations.

Although any parameter or setting in the model can be changed using the COMSOL Java API it is recommended that input and output data are well defined as shown in this model. Such definitions make it easier to follow the data flow in the model.

You can export a Model Java-file from the COMSOL Desktop. Before exporting it is worth while to reset the model history. This makes sure that the exported Java-file only contains the absolutely necessary steps that are needed to reproduce the model. Use **File>Reset History** to reset the model. Then export the Model Java-file using **File>Save As Model Java-File** and name the file `BeamModel.java`.

Construction of the Initial GUI with Graphics

Perform the following steps to set up Eclipse for handling your exported Java-file and create a GUI:

- 1 Start Eclipse.
- 2 Create a new Java Project. Enter `BeamModelDemo` as the project name and click **Next**.
- 3 Go to the Libraries tab and click **Add External JARs**. Add all the JAR files placed in the `plugins` directory under the COMSOL installation directory (typically `C:\Program Files\COMSOL\COMSOL43\plugins`). This allows Eclipse to find the definitions of the classes used by the COMSOL Java API and to run the code. In addition add the external Jar file `miglayout-3.7.4-swing.jar` (the numbers may be different for the file you downloaded). Click **Finish**.
- 4 Drag and drop your exported Java file to the `src` folder of your Eclipse project. Choose Copy files when Eclipse asks you and click OK.
- 5 Open the copied Java-file by double-clicking it and navigate to the Main method. Remove the three lines of the Main method. A main method in this file is not required.
- 6 Navigate to the run method. The run method contains all settings necessary to set up the model and solve it. It even contains the definition of the Plot that is displayed in the application.
- 7 Remove this line that says `model.solve("sol1").runAll();` The model does not require solving when setting it up.

- 8 In order to be able to extract numerical results from the model add some Global nodes to the model. The Global nodes are only available in the COMSOL Java API and thus cannot be added using the COMSOL Desktop. Add the following lines to the bottom of the `run()` method; just above the `return` statement.

```
model.result().numerical().create("glA", "Global");
model.result().numerical("glA").set("expr", "A");
model.result().numerical().create("glIy", "Global");
model.result().numerical("glIy").set("expr", "Iy");
model.result().numerical().create("glIz", "Global");
model.result().numerical("glIz").set("expr", "Iz");
model.result().numerical().create("glJ", "Global");
model.result().numerical("glJ").set("expr", "J");
```

The file `BeamModel.java` now contains all the necessary settings to set up a model. This file is not changed again.

Add the `main()` method of the program that opens the graphics window (frame) and shows the model.

- 1 Select **New Java Class**. Name the new class `BeamModelDemo`. Select that this class should have a `public static void main(String[] args)` method. Click **Finish**.

- 2 Add a `Model` field to the `BeamModelDemo` class by adding these lines to the top of the class

```
private JFrame frame;
private Model model;
```

Eclipse might complain that `JFrame` and `Model` are unknown at this time, and you have to add import statements in order to resolve the names. For the `Model` variable it is the `com.comsol.model` package that you should import. Eclipse is helpful and can provide such import statements automatically if you point to the offending new class name and press `Ctrl+I`. Throughout this demonstration example, add new classes for which such import statements have to be added.

- 3 Navigate to the main method and edit it such that it contains these lines

```
public static void main(String[] args) {
    BeamModelDemo demo = new BeamModelDemo();
    demo.init();
    demo.start();
}
```

- 4 Create an `init` method in `BeamModelDemo`. It should only contain a single line and the method should look like this:

```
public void init() {
    ModelUtil.initStandalone(true);
}
```

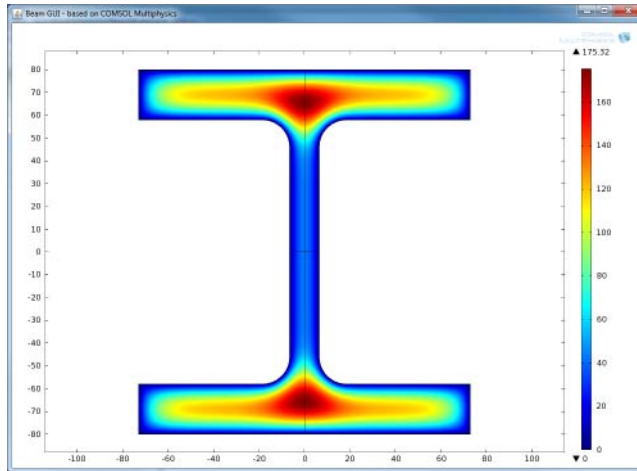

- 5 Create the start method. It is the main method to set up a model and the GUI used to display it. This method is updated frequently when setting up this demonstration model.

```
public void start() {
    frame = new JFrame("Beam GUI - based on COMSOL Multiphysics");
    frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
    frame.setSize(1000, 730);
    JPanel mainPanel = new JPanel();
    frame.getContentPane().add(mainPanel);
    mainPanel.setLayout(new BorderLayout());
    SwingGraphicsPanel graphicsPanel =
        new SwingGraphicsPanel("window1", "Window1");
    mainPanel.add(graphicsPanel, BorderLayout.CENTER);
    frame.setVisible(true);

    model = BeamModel.run();
    model.sol("sol1").runAll();
    model.result("pg1").set("window", "window1");
    model.result("pg1").run();
}
```

- 6 Right click on the BeamModelDemo.java file in the **Package Explorer** and select **Run as>Run configuration**. Select the **Environment** tab. Click the **New** button. Use the **Name** PATH (on Windows), LD_LIBRARY_PATH (on Linux) or DYLD_LIBRARY_PATH (on Mac) and enter the following text in **Value**:
<comsolinstalldir>/lib/<platformname> where <comsolinstalldir> is the directory where COMSOL Multiphysics is installed and <platformname> is one of win32/win64/glnx86/glnxa64/maci32/maci64 depending on your platform. Click **Apply**.

- 7 Click **Run**. The application window opens and a COMSOL graphics panel displays. After several seconds the model is solved and the 2D graphics with the result are presented.



The application window is missing some information and some ways to control the simulation.

Handling of Progress Information

It is possible to create a monitor for the progress of the solver. This monitor can also be used to cancel long running simulations if desired.

The progress information is made available using two different classes. `SwingProgressPanel` is used to display the progress in the GUI, and `SwingDemoProgressContext` is used to handle the communication between COMSOL Multiphysics and the areas the application that needs information about progress.

`SwingDemoProgressContext` extends `SwingProgressContext`, which is described in the reference section at the end of this chapter.

Both classes are added by copying two files instead of writing them from scratch.

- 1 Use the mouse to drag and drop these files to the `src` folder shown in the **Package Explorer** in Eclipse: `SwingDemoProgressContext.java` and `SwingProgressPanel.java`.

2 Open the `BeamModelDemo.java` file and navigate to the start method.

3 Add these lines before the call to `frame.setVisible`

```
SwingProgressPanel progressPanel =  
    new SwingProgressPanel();  
mainPanel.add(progressPanel, BorderLayout.PAGE_END);  
progressPanel.updateProgressLog("Starting\n");  
ProgressWorker.setContext(  
    new SwingDemoProgressContext(progressPanel));
```

4 These lines are added to the progress panel to the bottom of the main window and the context is set up between COMSOL and the user application.

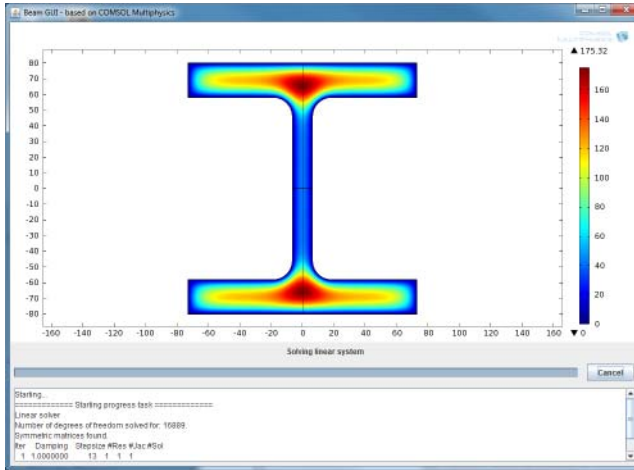
5 In order to show any progress in the GUI the solver must not run in the main thread. This means that a separate thread for the solver is created. Create the following solve method by removing the corresponding lines from the start method:

```
private void solve() {  
    ProgressWorker.run(new Runnable() {  
        public void run() {  
            model.sol("sol1").runAll();  
            model.result("pg1").  
                set("window", "window1");  
            model.result("pg1").run();  
        }  
    });
```

6 Remember to add a call to the solve method at the end of the start method.

7 Run the application by right-clicking `BeamModelDemo.java` in the Package Explorer and select **Run as>Java Application**.

- 8 The application window opens and shows progress information while starting and solving.



Setting Up Inputs From the GUI to the Model

In order to add some more dynamics to the application, add a method of inputting parameters to the model and create a Solve button.

The input data is provided by fields in the right side of the window.

Add these fields to the top of the class definition of the `BeamModelDemo` class:

```
JTextField editH;  
JTextField editb;  
JTextField edittf;  
JTextField editr;  
JTextField edittw;
```

A method `leftPanel` is created that sets up the various components.

```
private JPanel leftPanel() {  
    MigLayout layout = new MigLayout("wrap 2");  
    JPanel panel = new JPanel(layout);  
  
    JLabel label = new JLabel("H:");  
    panel.add(label);  
    editH = new JTextField(16);  
    editH.setText("160");  
    panel.add(editH);  
  
    label = new JLabel("b:");
```

```

panel.add(label);
editb = new JTextField(16);
editb.setText("145");
panel.add(editb);

label = new JLabel("tf:");
panel.add(label);
edittf = new JTextField(16);
edittf.setText("22");
panel.add(edittf);

label = new JLabel("tw:");
panel.add(label);
edittw = new JTextField(16);
edittw.setText("13");
panel.add(edittw);

label = new JLabel("r:");
panel.add(label);
editr = new JTextField(16);
editr.setText("12");
panel.add(editr, "wrap 10px");

JButton solveButton = new JButton("Solve");
panel.add(solveButton, "span, wrap 10px");

solveButton.addActionListener(new ActionListener() {
    public void actionPerformed(ActionEvent e) {
        solve();
    }
});

return panel;

```

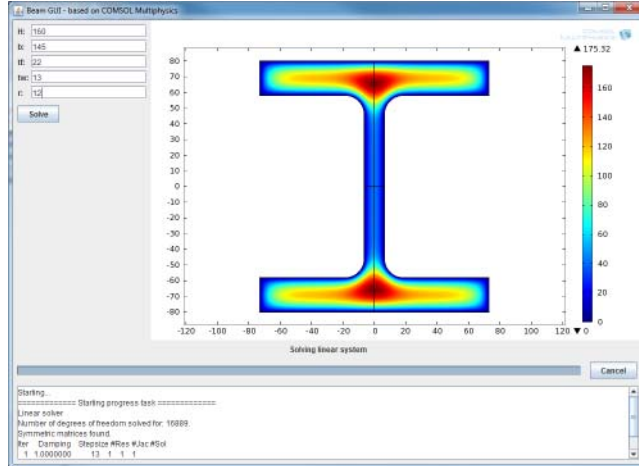
Add a call to `leftPanel` in the start method just before the definition of the `graphicsPanel` variable. Also comment out the call to the solve method at the end of the start method. Solving is handled manually by clicking the **Solve** button.

```

JPanel panel = leftPanel();
mainPanel.add(panel, BorderLayout.LINE_START);

```

Run the application by, for example, pressing Ctrl+F11



It is now possible to re-solve the model by pressing the **Solve** button, but the fields still needs to be hooked into the model.

- 1 Navigate to the solve method in the `BeamModelDemo.java` file. Add the following lines to the top of the method:

```
model.param().set("H",
    editH.getText()+" [mm]");
model.param().set("b",
    editb.getText()+" [mm]");
model.param().set("tw",
    edittw.getText()+" [mm]");
model.param().set("tf", edittf.getText()+" [mm]");
model.param().set("r",
    editr.getText()+" [mm]");
```

- 2 Save the file and start the application again.
- 3 Try to change the H parameter to, for example, 200 and press the **Solve** button.
- 4 The new model geometry and new simulation results display.

Displaying Results in the GUI

The aim of the GUI is to provide the user with calculations of areas and moments of inertia based on the model. These results are added in a panel to the right of the graphics panel.

- 1 Add these fields to the top of the `BeamModelDemo` class file:

```
JTextField editA;  
JTextField editIy;  
JTextField editIz;  
JTextField editJ;
```

- 2 Add a method `rightPanel` at the end of the `BeamModelDeom.java` that contains the output. Choose `JTextFields` to display the result. It is possible to copy text from these fields for use in other applications.

```
private JPanel rightPanel() {  
    MigLayout layout = new MigLayout("wrap 2");  
    JPanel panel = new JPanel(layout);  
  
    JLabel label = new JLabel("A:");  
    panel.add(label);  
    editA = new JTextField(16);  
    panel.add(editA);  
  
    label = new JLabel("Iy:");  
    panel.add(label);  
    editIy = new JTextField(16);  
    panel.add(editIy);  
    label = new JLabel("Iz:");  
    panel.add(label);  
    editIz = new JTextField(16);  
    panel.add(editIz);  
    label = new JLabel("J:");  
    panel.add(label);  
    editJ = new JTextField(16);  
    panel.add(editJ, "wrap 10px");  
  
    return panel;  
}
```

- 3 A small utility method is required in order to extract numerical data from the Global nodes. Add this method after the `rightPanel` method.

```
private String getScalar(NumericalFeature num) {  
    double[][] array = num.getData(0);  
    double A = array[0][0];  
    return Double.toString(A);  
}
```

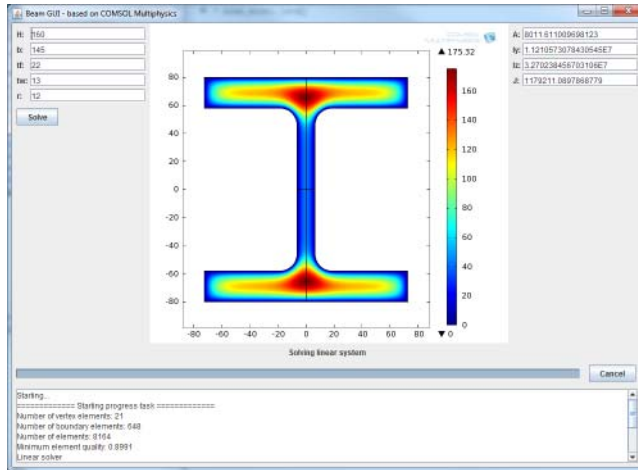
- 4 Add a few lines to extract the numerical results from the model after is being solved and show the numbers in the main window. Add the following lines to the `solve` method just after the call to the `run` method

```
editA.setText(getScalar(model.result().numerical("glA")));  
editIy.setText(getScalar(model.result().numerical("glIy")));  
editIz.setText(getScalar(model.result().numerical("glIz")));  
editJ.setText(getScalar(model.result().numerical("glJ")));
```

- 5 Add code for producing the `rightPanel` to the start method just below the addition of the `graphicsPanel`.

```
panel = rightPanel();
mainPanel.add(panel, BorderLayout.LINE_END);
```

- 6 Run the application again.



Other Details

The application by now is able to accept input from the user, simulate a model, and display results graphically as well as numerical results.

In order to finalize the model, add some additional features to the application. At the end, there is a short description of things that remains to be done.

ADDING A MENU

A menu is usually added.

- 1 Add implements `ActionListener` to the definition of the `BeamModelDemo` class such that the first line of the class definition reads

```
public class BeamModelDemo implements ActionListener {
```

- 2 Add a method that handles the event when the user performs actions with the menus. Here an action is added that can be used to exit the application and an about box is added that utilizes one of the `JOptionPane` dialog boxes.

```
public void actionPerformed(ActionEvent e) {
```



```

String ac = e.getActionCommand();
if (ac.equals("exit")) {
    System.exit(0);
}
else if (ac.equals("about")) {
    JOptionPane.showMessageDialog(frame,
        "Beam GUI Example\n"+
        "Simple DEMO example\n"+
        "Copyright 2011",
        "About",
        JOptionPane.DEFAULT_OPTION);
}

```

- 3 Add a method that defines the menu and menu items. The code adds a **File** and a **Help** menu where the exit and about actions are placed as menu items.

```

private JMenuBar menu() {
    JMenuBar menubar = new JMenuBar();

    JMenu menu = new JMenu("File");
    menubar.add(menu);

    JMenuItem item = new JMenuItem("Exit");
    item.setActionCommand("exit");
    item.addActionListener(this);
    menu.add(item);

    menu = new JMenu("Help");
    menubar.add(menu);

    item = new JMenuItem("About");
    item.setActionCommand("about");
    item.addActionListener(this);
    menu.add(item);

    return menubar;
}

```

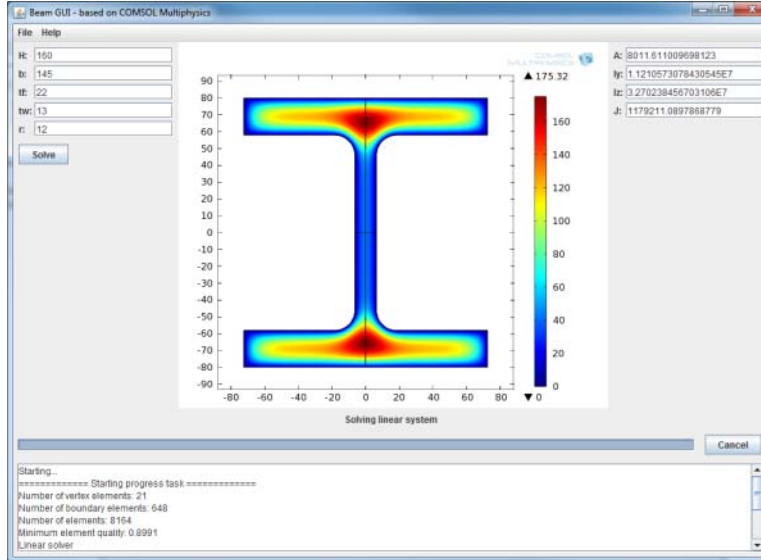
- 4 Add a call to menu in the start method just before the call to `setVisible`

```

JMenuBar menubar = menu();
frame.setJMenuBar(menubar);

```

5 Start the application



ADDING AN ICON AND AN IMAGE

An application that has to be used by other people should have appealing appearance and graphics and a suitable icon. For this application add the COMSOL logo to the window. Choose any icon you want to use for your own application.

1 Add a `setIcon` method to the `BeamModelDemo` class

```
private void setIcon(String filename) {  
    BufferedImage img;  
    img = null;  
    try {  
        img = ImageIO.read(new File(filename));  
    } catch (IOException e) {  
        return;  
    }  
    frame.setIconImage(img);  
}
```

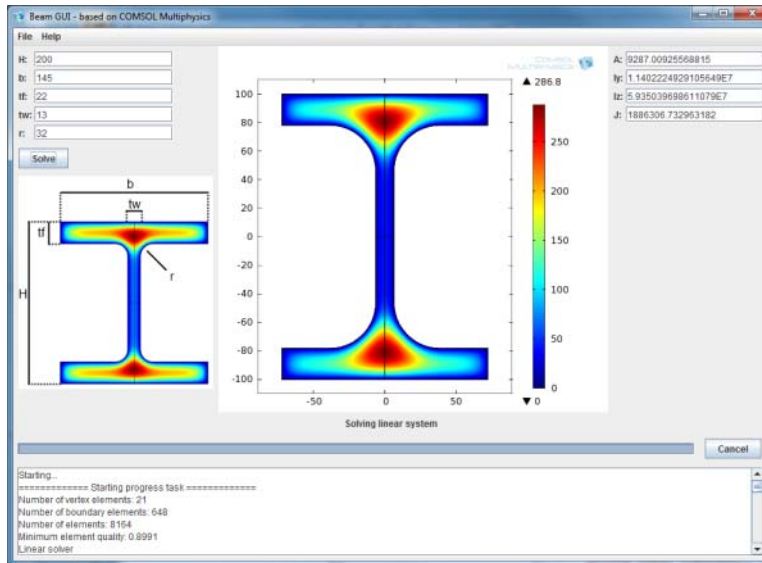
2 Add this line to the top of the start method (right after the call to `setSize`)

```
setIcon("comsolicon.png");
```

3 Place the icon file `comsolicon.png` in your workspace directory for this project. Right-click `BeamModelDemo.java` in the **Package Explorer** and choose **Properties** in order to determine the location of this directory.

- 4 It is convenient to have an image that describes the parameters used in the panel on the left side of the window. Start by adding the `ImageComponent.java` file to the project by dragging it to the `src` folder in the **Package Explorer**.
- 5 Add these lines to the `leftPanel` method just before the call the return panel;


```
ImageComponent img =
    new ImageComponent("beam_dim_small.png");
panel.add(img, "span");
```
- 6 Place the `beam_dim_small.png` file in the workspace directory for this project.
- 7 Start the application



LOOK AND FEEL

The appearance of a Java Swing application by default does not look like other applications that are written specifically for the platform you are running on. You can improve the appearance by setting the Look and Feel for the Java application:

- 1 Add a `lookandfeel` method to the `BeamModelDemo` class

```
private void lookandfeel() {
    try {
        UIManager.setLookAndFeel(
            UIManager.getSystemLookAndFeelClassName());
    }
    catch (Exception e) {
```

```
}  
}
```

2 Add a call to `lookandfeel` at the very top of the start method

```
lookandfeel();
```

3 Run the application. The application demonstration example is now complete.

FINISHING NOTES

The demonstration example is not an application that is ready to be sent to customers. For further development of the application, consider adding the following functionality:

- Error handling such that the application becomes insensitive to user's incorrect input and such that proper error messages are displayed in the event of an error or malfunction.
- For long running jobs, show an hour glass mouse pointer in order to show the user that a time consuming task has started.
- The model object keeps the history that is recorded every time the model object is changed such that a Model Java-file later can be saved that includes all actions on the object. If that is not required the history generation can be switched off, which saves memory.
- It is possible to have more than one model in an application. For example, it is possible to add a 3D beam model that utilizes the values calculated by the demonstration application.
- The graphics window can show 1D, 2D, and 3D graphics, so any results obtained in COMSOL can be shown in your own applications.
- Code can be added that remembers the choices made in the program. For example, to remember the location of the main window and the values entered in the fields.
- On-line help is missing.
- Calculated values could be copied to the clipboard or saved as a text file for easy sharing of the values.

GUI Classes

The following classes are available for working with graphical user interfaces:

- [ProgressContext](#)
- [ProgressWorker](#)
- [SWTGraphicsPanel](#)
- [SwingGraphicsPanel](#)

Purpose	Receive progress and log information from lengthy tasks and cancel them.
Syntax	<pre>progressUpdated(double progress); progressDescriptionUpdated(String description); progressLogUpdated(String message); started(); finished(Throwable t); cancel(); isCanceled();</pre>
Description	<p><code>ProgressContext</code> is the base class that you can extend to create a class that handles progress and log information. There are 5 different methods that you can override to receive calls when various events happen. The calls to these methods display on the background thread that the task is running on. The default implementation in <code>ProgressContext</code> for these methods does nothing.</p> <p>If you are creating a GUI in SWT the class <code>SWTProgressContext</code> is also available to extend from. It receives the method calls for the methods overridden on the SWT event dispatching thread. This is convenient since calls to update SWT widgets must be made from that thread.</p> <p><code>progressUpdated(progress)</code> is the method to override if you want to receive information when the current progress is updated. <code>progress</code> is a value between 0 and 1.</p> <p><code>progressDescriptionUpdated(description)</code> is called when the description for what progress task that is currently running is changed.</p> <p><code>progressLogUpdated(message)</code> is called when a new line is added to the log of messages. This is mostly used for log information from the solvers.</p> <p><code>started()</code> is called when the progress task is about to start.</p> <p><code>finished(t)</code> is called when the progress task is finished. If an exception occurred while the progress task was running it is non-null. You can use the <code>isCanceled</code> method to check if the progress task was canceled.</p> <p><code>cancel()</code> is the method to call if you want to request cancelation of the currently running progress task. You typically call it from a listener for a cancel button in your GUI.</p> <p><code>isCanceled()</code> returns true if the <code>cancel</code> method has been called.</p>

Purpose	Run lengthy tasks on a separate thread and report progress and log information.
Syntax	<pre>ProgressWorker.setContext(ProgressContext context); ProgressWorker.run(Runnable run); ProgressWorker.run(Runnable run, ProgressContext context);</pre>
Description	<p><code>ProgressWorker.setContext(context)</code> sets that the <code>ProgressContext</code> <code>context</code> should receive progress information when the <code>run</code> method in <code>ProgressWorker</code> is called.</p> <p><code>ProgressWorker.run(runnable)</code> calls the <code>run</code> method on <code>runnable</code> on a separate thread and reports progress back to the registered <code>ProgressContext</code>.</p> <p><code>ProgressWorker.run(runnable, context)</code> calls the <code>run</code> method on <code>runnable</code> on a separate thread and reports progress back to the <code>ProgressContext context</code>.</p>

SWTGraphicsPanel

Purpose	Create an SWT Composite (panel) that can be used to plot COMSOL graphics into a custom GUI.
Syntax	<code>SWTGraphicsPanel(Composite parent, String tag, String description);</code>
Description	<code>SWTGraphicsPanel(parent, tag, description)</code> creates an SWT Composite that can be used in a GUI created using the Standard Widget Toolkit (SWT). <code>parent</code> is the SWT composite that is the parent of the panel in the GUI. <code>tag</code> is a unique tag used to identify the panel. The "window" property of a plot group in the model object should be set to this tag to plot into the panel.

Purpose Create an Swing JPanel that can be used to plot COMSOL graphics into a custom GUI.

Syntax `SwingGraphicsPanel(String tag, String description);`

Description `SwingGraphicsPanel(tag, description)` creates an Swing JPanel that can be used in a GUI created using Swing. `tag` is a unique tag used to identify the panel. The "window" property of a plot group in the model object should be set to this tag to plot into the panel.

This panel support 1D, 2D and 3D graphics.

I n d e x

ID

- asymmetric geometry 92
- coupling operators 56
- cut point data set 520
- cut point data sets 520
- function data sets 550
- geometric entity counter methods 187
- geometric primitives 167
- global plots 553, 560
- images, exporting 566
- intervals 257
- line graphs 587
- mesh refinements 410
- nvtx matrix 191
- plot groups 635, 638
- point graphs 642
- points, reflecting 263
- revolved data sets 654
- table plots 685

2D

- asymmetric geometry 92
- Bézier polygons 202
- boundary similarity 62
- chamfers 206
- circles 207
- coupling operators 56
- cut point data set 520
- cut point data sets 520
- DXF files, importing 243
- ECAD files, importing 245–247
- ellipses 227
- fillets 234
- function data sets 550
- geometric entity counter methods 187
- getVertex 191
- height attribute 558

- images, exporting 566
- lines, reflecting 263
- objects, rotating 281
- parameterized curve data sets 614
- parametric curves 267
- plot groups 635
- Polygons 272
- rectangles 276
- rectangular arrays 200
- revolved data sets 654
- squares 289
- tangents 294
- work planes 300

3D

- Bézier polygons 202
- block shaped arrays 200
- blocks 204
- boundary similarity 60
- coupling operators 56
- cut point data set 520
- cut point data sets 520
- cylinders 219
- ECAD files, importing 245–247
- ellipsoids 229
- extruding planar objects 231
- function data sets 550
- geometric entity counter methods 187
- getVertex 191
- helix 237
- images, exporting 566
- objects, rotating 281
- parameterized curve data sets 614
- parametric curves 267
- parametric data sets 615
- parametric surfaces 269
- planar objects, revolving 278

- planes, reflecting 263
 - plot groups 635
 - Polygons 272
 - pyramids 274
 - rectangular arrays 200
 - spheres 285
 - sweeps 291
 - tetrahedrons 297
 - torus 298
 - work planes 300
- A**
- absolute repair tolerance 182
 - access methods 22
 - Adaption (meshes) 409
 - adding
 - geometry 173
 - height attributes to 2D plots 558
 - meshing sequences 310
 - adjacency information, geometry 188
 - Advanced (solvers) 415
 - analytic functions 79
 - angular units 92, 180
 - Animation (plots) 491
 - Array 200
 - arrays, geometry 191
 - ArrowLine (plots) 494
 - ArrowSurface (plots) 494
 - ArrowVolume (plots) 494
 - Assemble (solvers) 417
 - asymptotic waveform evaluation (AWE)
 - 420
 - AtolGlobalMethod (solvers) 459
 - attribute feature, meshes 309
 - automatic rescaling of linear equations
 - 415
 - Average (data sets) 502
 - average coupling operators 56, 65
 - AvVolume, AvSurface, AvLine 498
 - AWE (solvers) 420
- B**
- axisymmetric geometries 92
 - Ball (meshes) 334
 - ball, meshes 334, 340, 349, 352, 370
 - base-vector coordinate system 52
 - Batch (job type) 40
 - batch jobs
 - running Model Class-files 15
 - BezierPolygon 202
 - Block 204
 - block shaped arrays 200
 - block size, assembly 415
 - block versions, meshes 326
 - BndLayer (meshes) 335
 - BndLayerProp (meshes) 338
 - boolean operations 210
 - boundary coordinate systems 52, 54
 - boundary layers, meshes 335
 - boundary probes 127
 - boundary similarity coupling operators
 - 56
 - Box (meshes) 340
 - build status, meshes 107, 312
 - building
 - geometry 94, 176
 - meshes 106, 309, 311
 - Bunch-Kaufmann pivoting 430
- C**
- C linkage 85
 - C matrix 450
 - CAD Import Module
 - 3D kernels 181
 - arrays 191
 - cadps 93
 - defeaturing 96
 - geometry, exporting 196
 - geometry, importing 250
 - hasCadRep 171
 - cadps 93
 - callback 443

- Chamfer 206
- changing units 180
- Circle 207
- class files 10
- Cluster (job type) 42
- coarse grid solver types 428
- coefficient form contributions 48
- Color 504
- compiling Model Java-files 14
- Compose (geometry) 210
- COMSOL Desktop 13
- COMSOL server 32
- Cone 215
- Constraint group 98
- constraint Jacobian 417
- constraint vector 417
- constraints 50
- contact pairs 118
- continuing operations, meshes 328
- Contour 507
- Convert (meshes) 341
- converting objects 218
- coordinate names 77
- coordinate systems 52
- coordinates, mesh vertices 321
- CoordSysLine (plots) 513
- CoordSysSurface (plots) 513
- CoordSysVolume (plots) 513
- Copy (geometry) 265
- CopyDomain 347
- CopyEdge 343
- CopyFace 345
- coupling operators 56
- CreateVertex (meshes) 349
- curves, creating 202, 272
- CutLine2D (data sets) 517
- CutLine3D (data sets) 517
- CutPlane (data sets) 518
- CutPoint (data sets) 520
- Cylinder 219
- cylindrical coordinate systems 52, 55

D

- D matrix 450
- DAE 459
- damped Newton method 425
- damping matrix 417
- damping ratios 436
- Data (plots, exporting) 522
- data job type 44
- data sets, creating 131
- data types 26
- data, mesh 322
- defeaturing, in CAD 96
- Deform (plots) 525
- Delete (geometry) 221
- Delete (meshes) 350
- DeleteEntities (meshes) 352
- deleting
 - geometry 178–179
 - geometry sequences 92
 - mesh sequences 105
 - meshes 312
- dependent variables 99
- destination map 57, 62
- Difference (geometry) 210
- differential algebraic equation 459
- Direct (solvers) 428
- direct properties 429
- Dirichlet boundary conditions 436
- disabling
 - geometry 178
 - mesh features 312
- Distribution (meshes) 353
- documentation, finding 11
- domain mesh, copying 347
- domains, deleting 221
- drop tolerance 429

- DXF, CAD drawing 243
- E**
 - ECAD 245–247
 - eccentric oblique cones, creating 223
 - Eclipse 700
 - setting up for compiling Java files 16
 - ECone 223
 - Edge (data sets) 527
 - Edge (meshes) 355
 - edge elements, meshes 326
 - edge evaluation, geometry 189
 - edge map 61
 - edge meshes, copying 343
 - edgeangle, plane type 300
 - EdgeGroup 356
 - EdgeMap 357
 - edges, deleting 221
 - edited status, meshes 312
 - editing
 - geometry 174
 - meshes 311
 - eigenmodal method 436
 - eigenpairs 436
 - Eigenvalue 422
 - Eigenvalue (solvers) 409
 - elements 67, 71
 - elements, deleting from meshes 350
 - Ellipse 227
 - Ellipsoid 229
 - emailing COMSOL 11
 - error estimation function 411
 - error features 176
 - error status, meshes 312, 329
 - Euler step 460
 - Eval (Java API only) 528
 - EvalGlobal 531
 - EvalPoint 539
 - expand (meshes) 376
 - explicit element distribution 354
 - explicit time stepping 466
 - exploding objects 287
 - exporting
 - geometry 95, 196
 - meshes 107, 331
 - external functions 84
 - extrapolation tolerance 58
 - Extrude 231
 - extruding, work planes 183
 - extrusion coupling operator 57
- F**
 - face evaluation, geometry 190
 - face mesh, copying 345
 - faceparallel, plane type 300
 - faces, deleting 221
 - far-field feature 67
 - feature status 177
 - field attributes 74
 - Fillet 234
 - Filter (plot attribute) 549
 - Finalize (geometry) 235
 - finalized geometry 173
 - flattened corners, creating 206
 - fonts 33
 - force null-space basis 418
 - frames 75
 - FreeQuad (meshes) 359
 - FreeTet (meshes) 361
 - FreeTri (meshes) 364
 - FromMesh 236
 - frustums, creating 223, 274
 - FullyCoupled (solvers) 425
 - Function (data sets) 550
 - functional, as error estimator 411
- G**
 - gaussian pulse functions 82
 - general extrusion coupling operator 56, 59
 - general matrix information 406
 - general projection coupling operator 56,

- 63
- general, plane type 300
- geometric entities 28, 56, 187
- geometrical shape order 76–77
- geometry
 - arrays 191
 - exporting 196
 - manipulating 90
 - name 77
 - object names 177
 - object selection 96
 - objects, moving and copying 265
 - representation 181
 - selection 28
- geometry objects
 - importing 250
- geometry sequences
 - constructing 173
 - deleting 92
 - importing 249
- getType 22
- global
 - attribute features 309
 - equations 112
 - selections 28
 - variable probes 127
- Global (plot) 553, 560
- Global numerical) 551
- gradient/Jacobian evaluation method
 - 438–439
- growth rate
 - mesh 319
- H** Height 558, 565, 688
- Helix 237
- hexahedral elements, numbering 327
- Hexahedron 239
- highly nonlinear 426
- host name 32
- I** identity mapping coupling operator 56
- identity mapping coupling operators 62
- identity pairs 118
- Image (exporting) 566
- Import (geometry) 243
- Import (meshes) 366
- importing
 - ECAD files 245
 - geometry objects 250
 - geometry sequences 249
 - meshes 310
 - mphbin 250
 - STL or VRML files 252–253
- imprints, creating 235
- initial values 99
- installation path 16
- Integral (data sets) 502
- integrated development environment
 - 700
- integration coupling operator 56, 64
- integration rules 48, 100
- intermediate space 57, 62
- Internet resources 10
- Interp (data sets) 568
- interpolation functions 80
- Intersection (geometry) 210
- Interval (geometry) 257
- IntLine (results feature) 498, 572, 594
- IntSurface (results feature) 498, 572, 594
- IntVolume (results feature) 498, 572, 594
- Isosurface (data sets) 580
- Isosurface (plots) 576
- Iterative (solvers) 428
- iterative properties 431
- J** Jacobian update technique 425–426, 447
- Java

- development kit (JDK) 10, 14
- evaluate expressions 528
- memory, meshing limitations 326
- syntax 24
- syntax for data types 24
- Java IDE 700
- JDK 10
- job 39
- job type 39
- JoinEntities (meshes) 370
- K**
 - kernels 181
 - knowledge base, COMSOL 12
 - Krylov space 422
- L**
 - length units 92, 180
 - Line (plots) 582
 - Linear (solvers) 428
 - linear extrusion coupling operator 56
 - linear extrusion map properties 60
 - linear projection coupling operator 56, 64
 - linearization point method 423
 - LineGraph 587
 - Load group 98
 - load vector 417
 - local attribute feature 309
 - lower bound constraint vector 417
- M**
 - Map (meshes) 371
 - mapped coordinate systems 52
 - mass matrix 417
 - material frames 76
 - material models 101
 - materials 101
 - MATLAB
 - file names 34
 - functions, general 86
 - LiveLink for 10
 - objects, assigning 25
 - syntax 24
 - syntax for data types 24
 - matrix assembly 417
 - matrix data 407
 - matrix properties 26
 - Maximum (data sets) 502
 - maximum and minimum coupling operator 56, 65
 - MaxMinLine (plots) 592
 - MaxMinSurface (plots) 592
 - MaxMinVolume (plots) 592
 - Mc, McA, McB matrices 450
 - measuring
 - geometric entities 193
 - geometry 95
 - objects 193
 - mesh
 - growth rate 319
 - Mesh (datasets) 600
 - Mesh (exporting) 601
 - Mesh (plots) 598
 - Mesh control entity 184
 - MeshError 329
 - meshes
 - frames 75
 - importing 366
 - manipulating 105
 - refining 378, 409, 412
 - sequences 105
 - setting data 107
 - MeshWarning 329
 - MIG Layout Manager 702
 - Minimum (data sets) 502
 - Mirror (data sets) 602
 - Mirror (geometry) 263
 - Modal (solvers) 436
 - model
 - .batch 39

- .coeff 48
- .constr 50
- .coordSystem 52
- .cpl 56
- .elem 67, 71
- .field 74
- .frame 75
- .func 79
- .geom 90
- .group 98
- .init 99
- .intRule 100
- .material 101
- .mesh 105
- .modelNode 110
- .ode 112
- .opt 114
- .pair 118
- .param 121
- .physics 122
- .probe 127
- .result 130
- .selection 136
- .shape 142
- .sol 145
- .study 148
- .unitSystem 152
- .variable 154
- .view 156
- .weak 160
- Model Builder 13
- Model Class-files
 - running as batch jobs 15
 - running from Desktop 15
- model entity 35, 37
- Model Java-files
 - compiling 14
 - structure of 14

- Model Library 11
- model object 13
- model parameters 121
- model tree 110
- models, adding geometry 173
- ModelUtil.connect 31
- Move (geometry) 265
- mphbin 250
- MPH-files 11
- mphtxt 250
- Multigrid (solvers) 428
- multigrid levels 148
- multigrid properties 433
- MUMPS SPOOLES 430

N

- naming, geometry objects 178
- NASTRAN bulk data format 369
- needs rebuild status, meshes 312
- Neumann boundary conditions 436
- Newton iterations 425
- nodes 110
- nonlinear solver 425
- null matrix 450
- null-space basis 418
- null-space function 415
- number conventions, meshes 326
- number of elements, meshes 317

O

- objective functions 114
- objects, deleting 179, 221
- one point map 61
- OnePointMap (meshes) 373
- operation features, geometry 173
- operation features, meshes 309
- Optimization 438
- optimization 114
- optimization constraint 417
- orthonormal system 52
- out-of-core solvers 429

- P**
 - pairs, creating 118
 - Parametric (data sets) 613
 - Parametric (job type) 40
 - Parametric (solvers) 441
 - ParametricCurve (geometry) 267
 - Parasolid kernel 187
 - ParCurve (data sets) 614
 - PARDISO 430
 - ParSurface (data sets) 615
 - Particle (plots) 616
 - ParticleMass (plots) 625
 - PDE problems 422
 - physics interfaces, manipulating 122
 - physics-controlled meshing 315
 - piecewise functions 82
 - pivot perturbation threshold 430
 - planar objects 231
 - Player (plots) 632
 - Plot (exporting) 634
 - plot groups, creating 131
 - PlotGroup 635
 - plots, color attribute 504
 - PlotWhileSolving (solvers) 443
 - Point (geometry) 271
 - Point (meshes) 375
 - PointGraph 642
 - polar coordinate systems 647
 - PolarGroup 647
 - Polygon 272
 - port number 32
 - preconditioner feature types 428
 - preordering algorithm 430
 - PreviousSolution (solvers) 444
 - PrincipalSurface (plots) 650
 - PrincipalVolume (plots) 650
 - prism elements, numbering 327
 - probes 127
 - processes 44
 - projection coupling operator 62
 - properties, boundary layers 338
 - Pyramid 274
 - pyramid elements, numbering 327
- Q**
 - quadrilateral elements, numbering 327
 - quadrilateral mesh, creating 359, 371
 - quality of elements, meshes 316, 318
 - quick, plane type 300
- R**
 - ramp functions 83
 - random functions 83
 - reaction forces, computation and storage of 453, 461
 - Rectangle (geometry) 276
 - rectangle functions 83
 - rectangular arrays 200
 - Reference (meshes) 376
 - Refine (meshes) 378
 - reflecting objects 263
 - registry key 16
 - relative repair tolerance 93, 182
 - relative tolerance 423
 - relaxation factor 431
 - results 130
 - Revolve (data sets) 654
 - Revolve (geometry) 278
 - revolving, work planes 183
 - Rotate (geometry) 281
 - rotated coordinate systems 52, 54
 - Runge-Kutta explicit time stepping 466
- S**
 - save point model 135
 - Scale (geometry) 283
 - Scale (meshes) 380
 - scale vector 418
 - scaling values 181
 - ScatterSurface (plots) 656
 - ScatterVolume (plots) 656
 - Segregated (solvers) 445

- SegregatedStep (solvers) 447
- Selection (geometry) 284
- selection name 78
- Selections 27
- selections
 - editing 175
 - frames and 77
 - manipulating 136
 - meshes and 313
- sensitivity 114
- Sensitivity (solvers) 449
- sequences of operations 13
- sequences, meshing 315
- servers, connecting 31
- set (assign parameters) 24
- setIndex(data types) 26
- shape functions 50, 142
- simplex meshes, converting 341
- Size (meshes) 382
- Slice (plots) 662
- solid polygons, creating 202, 272
- Solution (data sets) 668
- solutions
 - creating 405
 - manipulating 145
 - object data 399
- solver sequences 399
- source map 57, 62
- spatial coordinates 77
- spatial frames 76
- spatial shapes 76
- Sphere 285
- Split (geometry) 287
- splitmethod (meshes) 341
- Square 289
- StateSpace 450
- static linearized model 450
- Stationary (solvers) 409, 452
- statistics, meshes 107, 316
- status, meshes 312, 319
- step functions 84
- stiffness matrix 417
- STL 252
- StopCondition (solvers) 454
- stopping operations, meshes 328
- storing, mesh data 322
- Streamline (plots) 669
- study types 148
- StudyStep (solvers) 145, 456
- summary of commands 476
- Surface (data sets) 680
- Surface (plots) 675
- Sweep (geometry) 291
- Sweep (meshes) 386
- symmetric matrices 415

T

- Table (data) 681
- Table (plots) 685, 689
- Tangent (geometry) 294
- task 43
- task type 43
- task type property 44
- technical support, COMSOL 12
- tetrahedral elements, numbering 327
- tetrahedral mesh, creating 361
- Tetrahedron (geometry) 297
- Time (solvers) 457
- time dependencies 461, 464
- TimeDiscrete (solvers) 463
- TimeParametric (solvers) 467
- Torus 298
- transferring, mesh data 323
- transposed form 432
- triangle functions 84
- triangular elements, numbering 327
- triangular meshes, unstructured 364
- two point map 61

- TwoPointMap (meshes) 389
- U** Union (geometry) 210
 - unit systems 33, 152
 - upper bound constraint vector 418
 - user community, COMSOL 12
 - Uzawa iterations 445
- V** Vanka method 432
 - variable name suffix 77
 - variables 154
 - Variables (solvers) 468
 - vertices, deleting 221
 - vertices, plane type 300
 - views 156
 - virtual composite edge, face, domain, and entity 184
 - virtual operations 173, 184
 - void regions, representing 191
 - Volume (plots) 693
 - volume of elements, meshes 318
 - VRML 252
- W** warning status, meshes 312, 328
 - warnings, build operations 177
 - wave functions 87–88
 - weak expressions 112
 - web sites, COMSOL 12
 - work planes 183, 300
 - WorkPlane (geometry) 300
- X** XmeshInfo (solvers) 470
 - xport feature 131