

Gmsh

Gmsh Reference Manual

The documentation for Gmsh 2.4
A finite element mesh generator with built-in pre- and post-processing facilities

18 November 2009

Christophe Geuzaine
Jean-François Remacle

Copyright © 1997-2009 Christophe Geuzaine, Jean-François Remacle

Permission is granted to make and distribute verbatim copies of this manual provided the copyright notice and this permission notice are preserved on all copies.

Short Contents

Copying conditions	1
1 Overview	3
2 How to read this reference manual?	7
3 Running Gmsh on your system	9
4 General tools	17
5 Geometry module	29
6 Mesh module	35
7 Solver module	51
8 Post-processing module	55
9 File formats	75
A Tutorial	91
B Options	109
C Information for developers	181
D Random tips and tricks	183
E Frequently asked questions	185
F Version history	195
G Copyright and credits	209
H License	213
Concept index	221
Syntax index	223

Table of Contents

Copying conditions	1
1 Overview	3
1.1 Geometry: geometrical entity definition.....	3
1.2 Mesh: finite element mesh generation.....	3
1.3 Solver: external solver interface.....	4
1.4 Post-processing: scalar, vector and tensor field visualization.....	4
1.5 What Gmsh is pretty good at	4
1.6 ... and what Gmsh is not so good at	5
1.7 Bug reports	6
2 How to read this reference manual?	7
2.1 Syntactic rules used in the manual.....	7
3 Running Gmsh on your system	9
3.1 Interactive mode	9
3.2 Non-interactive mode	10
3.3 Command-line options	10
3.4 Mouse actions.....	12
3.5 Keyboard shortcuts	13
4 General tools	17
4.1 Comments	17
4.2 Expressions	17
4.2.1 Floating point expressions	17
4.2.2 Character expressions	18
4.2.3 Color expressions.....	19
4.3 Operators	19
4.4 Built-in functions	21
4.5 User-defined functions.....	22
4.6 Loops and conditionals	22
4.7 General commands.....	23
4.8 General options	26
5 Geometry module	29
5.1 Geometry commands.....	29
5.1.1 Points.....	29
5.1.2 Lines.....	30
5.1.3 Surfaces.....	31
5.1.4 Volumes	32
5.1.5 Extrusions	32

5.1.6	Transformations	33
5.1.7	Miscellaneous	34
5.2	Geometry options	34
6	Mesh module	35
6.1	Choosing the right unstructured algorithm	35
6.2	Elementary vs. physical entities	36
6.3	Mesh commands	37
6.3.1	Characteristic lengths	37
6.3.2	Structured grids	47
6.3.3	Miscellaneous	48
6.4	Mesh options	49
7	Solver module	51
7.1	Solver options	51
7.2	Solver example	51
8	Post-processing module	55
8.1	Post-processing commands	55
8.2	Post-processing plugins	59
8.3	Post-processing options	73
9	File formats	75
9.1	MSH ASCII file format	75
9.2	MSH binary file format	80
9.3	Node ordering	81
9.4	Legacy formats	84
9.4.1	MSH file format version 1.0 (Legacy)	84
9.4.2	POS ASCII file format (Legacy)	86
9.4.3	POS binary file format (Legacy)	88
Appendix A	Tutorial	91
A.1	't1.geo'	91
A.2	't2.geo'	93
A.3	't3.geo'	95
A.4	't4.geo'	96
A.5	't5.geo'	99
A.6	't6.geo'	102
A.7	't7.geo'	104
A.8	't8.geo'	104
A.9	't9.geo'	107

Appendix B	Options	109
B.1	General options list	109
B.2	Geometry options list	131
B.3	Mesh options list	137
B.4	Solver options list	151
B.5	Post-processing options list	165
Appendix C	Information for developers	181
C.1	Getting the source	181
C.2	Source code structure	181
C.3	Coding style	181
C.4	Adding a new option	182
Appendix D	Random tips and tricks	183
Appendix E	Frequently asked questions	185
Appendix F	Version history	195
Appendix G	Copyright and credits	209
Appendix H	License	213
Concept index		221
Syntax index		223

Copying conditions

Gmsh is “free software”; this means that everyone is free to use it and to redistribute it on a free basis. Gmsh is not in the public domain; it is copyrighted and there are restrictions on its distribution, but these restrictions are designed to permit everything that a good cooperating citizen would want to do. What is not allowed is to try to prevent others from further sharing any version of Gmsh that they might get from you.

Specifically, we want to make sure that you have the right to give away copies of Gmsh, that you receive source code or else can get it if you want it, that you can change Gmsh or use pieces of Gmsh in new free programs, and that you know you can do these things.

To make sure that everyone has such rights, we have to forbid you to deprive anyone else of these rights. For example, if you distribute copies of Gmsh, you must give the recipients all the rights that you have. You must make sure that they, too, receive or can get the source code. And you must tell them their rights.

Also, for our own protection, we must make certain that everyone finds out that there is no warranty for Gmsh. If Gmsh is modified by someone else and passed on, we want their recipients to know that what they have is not what we distributed, so that any problems introduced by others will not reflect on our reputation.

The precise conditions of the license for Gmsh are found in the General Public License that accompanies the source code (see [Appendix H \[License\]](#), page 213). Further information about this license is available from the GNU Project webpage <http://www.gnu.org/copyleft/gpl-faq.html>. Detailed copyright information can be found in [Appendix G \[Copyright and credits\]](#), page 209.

The source code and various pre-compiled versions of Gmsh (for Unix, Windows and Mac OS) can be downloaded from the webpage <http://geuz.org/gmsh/>.

If you use Gmsh, we would appreciate that you mention it in your work. References, as well as the latest news about Gmsh development, are always available on <http://geuz.org/gmsh/>. Please send all Gmsh-related questions to the public Gmsh mailing list at gmsh@geuz.org.

If you want to integrate Gmsh into a closed-source software, or want to sell a modified closed-source version of Gmsh, please contact one of the authors. You can purchase a version of Gmsh under a different license, with “no strings attached” (for example allowing you to take parts of Gmsh and integrate them into your own proprietary code).

1 Overview

Gmsh is an automatic three-dimensional finite element mesh generator with built-in pre- and post-processing facilities. Its design goal is to provide a simple meshing tool for academic problems with parametric input and advanced visualization capabilities.

Gmsh is built around four modules: geometry, mesh, solver and post-processing. All geometrical, mesh, solver and post-processing instructions are prescribed either interactively using the graphical user interface (GUI) or in text files using Gmsh’s own scripting language. Interactive actions generate language bits in the input files, and vice versa. This makes it possible to automate all treatments, using loops, conditionals and external system calls. A brief description of the four modules is given hereafter.

1.1 Geometry: geometrical entity definition

Gmsh uses a boundary representation (“BRep”) to describe geometries. Models are created in a bottom-up flow by successively defining points, oriented lines (line segments, circles, ellipses, splines, . . .), oriented surfaces (plane surfaces, ruled surfaces, triangulated surfaces, . . .) and volumes. Compound groups of geometrical entities (called “physical groups”) can also be defined, based on these elementary geometric entities. Gmsh’s scripting language allows all geometrical entities to be fully parametrized.

1.2 Mesh: finite element mesh generation

A finite element mesh is a tessellation of a given subset of the three-dimensional space by elementary geometrical elements of various shapes (in Gmsh’s case: lines, triangles, quadrangles, tetrahedra, prisms, hexahedra and pyramids), arranged in such a way that if two of them intersect, they do so along a face, an edge or a node, and never otherwise. All the finite element meshes produced by Gmsh are considered as “unstructured”, even if they were generated in a “structured” way (e.g., by extrusion). This implies that the elementary geometrical elements are defined only by an ordered list of their nodes but that no predefined order relation is assumed between any two elements.

The mesh generation is performed in the same bottom-up flow as the geometry creation: lines are discretized first; the mesh of the lines is then used to mesh the surfaces; then the mesh of the surfaces is used to mesh the volumes. In this process, the mesh of an entity is only constrained by the mesh of its boundary. For example, in three dimensions, the triangles discretizing a surface will be forced to be faces of tetrahedra in the final 3D mesh only if the surface is part of the boundary of a volume; the line elements discretizing a curve will be forced to be edges of tetrahedra in the final 3D mesh only if the curve is part of the boundary of a surface, itself part of the boundary of a volume; a single node discretizing a point in the middle of a volume will be forced to be a vertex of one of the tetrahedra in the final 3D mesh only if this point is connected to a curve, itself part of the boundary of a surface, itself part of the boundary of a volume. This automatically assures the conformity of the mesh when, for example, two surfaces share a common line. But this also implies that the discretization of an “isolated” $(n-1)$ -th dimensional entity inside an n -th dimensional entity does *not* constrain the n -th dimensional mesh—unless it is explicitly told to do so (see [Section 6.3.3 \[Miscellaneous mesh commands\], page 48](#)). Every meshing step is constrained by the characteristic length field, which can be uniform, specified by characteristic lengths

associated with points in the geometry, or defined by general “fields” (a scalar field defined on another mesh using post-processing view, threshold fields associated with point or line “attractors”, etc.).

For each meshing step, all structured mesh directives are executed first, and serve as additional constraints for the unstructured parts¹.

1.3 Solver: external solver interface

External solvers can be interfaced with Gmsh through Unix or TCP/IP sockets, which permits to launch external computations and to collect and process the results directly from within Gmsh’s post-processing module. The default solver interfaced with Gmsh is GetDP (<http://www.geuz.org/getdp/>). Examples on how to interface solvers written in C, C++, Perl and Python are available in the source distribution (in the ‘utils/solvers/’ directory).

1.4 Post-processing: scalar, vector and tensor field visualization

Gmsh can load and manipulate multiple post-processing scalar, vector or tensor maps along with the geometry and the mesh. Scalar fields are represented by iso-value lines/surfaces or color maps, while vector fields are represented by three-dimensional arrows or displacement maps. Post-processing functions include section computation, offset, elevation, boundary and component extraction, color map and range modification, animation, vector graphic output, etc. All the post-processing options can be accessed either interactively or through the input script files. Scripting permits to automate all post-processing operations, as for example to create animations. User-defined operations can also be performed on post-processing views through dynamically loadable plugins.

1.5 What Gmsh is pretty good at . . .

Gmsh is a (relatively) small program, and was principally developed “in academia, to solve academic problems” . . . Nevertheless, over the years, many people outside universities have found Gmsh useful in their day-to-day jobs. Here is a tentative list of what Gmsh does best:

- quickly describe simple and/or “repetitive” geometries, thanks to user-defined functions, loops, conditionals and includes (see [Section 4.5 \[User-defined functions\]](#), [page 22](#), [Section 4.6 \[Loops and conditionals\]](#), [page 22](#), and [Section 4.7 \[General commands\]](#), [page 23](#));
- parametrize these geometries. Gmsh’s scripting language enables all commands and command arguments to depend on previous calculations (see [Section 4.2 \[Expressions\]](#), [page 17](#), and [Section 5.1 \[Geometry commands\]](#), [page 29](#));
- import complex models in industry-standard formats like STEP or IGES (when Gmsh is built with OpenCascade support);

¹ Note that mixing structured volume grids with unstructured volume grids generated with the default 3D Delaunay algorithm can result, in certain cases, to non-conform surface meshes on their shared boundary. If this happens, you may consider using the frontal algorithm for the unstructured part.

- generate 1D, 2D and 3D simplicial (i.e., using line segments, triangles and tetrahedra) finite element meshes (see [Chapter 6 \[Mesh module\]](#), [page 35](#), and [Appendix A \[Tutorial\]](#), [page 91](#));
- specify target element sizes accurately. Gmsh provides several mechanisms to control the size of the elements in the final mesh: through interpolation from sizes specified at geometry points or using flexible mesh size fields (see [Section 6.3 \[Mesh commands\]](#), [page 37](#));
- create simple extruded geometries and meshes (see [Section 5.1 \[Geometry commands\]](#), [page 29](#), and [Section 6.3 \[Mesh commands\]](#), [page 37](#));
- interact with external solvers. Gmsh provides C, C++, Perl and Python interfaces, and others can be easily added (see [Chapter 7 \[Solver module\]](#), [page 51](#));
- visualize computational results in a great variety of ways. Gmsh can display scalar, vector and tensor datasets, and can perform various operations on the resulting post-processing views (see [Chapter 8 \[Post-processing module\]](#), [page 55](#));
- export plots in many different formats: vector PostScript or encapsulated PostScript, LaTeX, PNG, JPEG, . . . (see [Section B.1 \[General options list\]](#), [page 109](#));
- generate complex animations (see [Chapter 4 \[General tools\]](#), [page 17](#), and [Section A.8 \[t8.geo\]](#), [page 104](#));
- run on low end machines and/or machines with no graphical interface. Gmsh can be compiled with or without the GUI, and all versions can be used either interactively or directly from the command line (see [Chapter 3 \[Running Gmsh on your system\]](#), [page 9](#));
- configure your preferred options. Gmsh has a large number of configuration options that can be set interactively using the GUI, scattered inside command files, changed on the fly in scripts, set in per-user configuration files, or specified on the command-line (see [Chapter 3 \[Running Gmsh on your system\]](#), [page 9](#) and [Appendix B \[Options\]](#), [page 109](#));
- and do all the above on various platforms (Windows, Mac and Unix), for free (see [\[Copying conditions\]](#), [page 1](#)), using simple script files and/or a small but powerful GUI.

1.6 . . . and what Gmsh is not so good at

Due to its historical background and limited developer manpower, Gmsh has also some (a lot of?) weaknesses:

- the BRep approach for describing geometries can become inconvenient for complex models;
- there is no support for Nurbs and only very limited support for trimmed surfaces in Gmsh’s scripting language (however you can import STEP or IGES models with such features when Gmsh is built with OpenCascade support);
- Gmsh is not a multi-bloc generator: all meshes produced by Gmsh are conforming in the sense of finite element meshes;
- Gmsh was designed to solve academic “test cases”, not industrial-size problems. You may find that Gmsh is too slow for large problems (with thousands of geometric primitives, or millions of mesh/post-processing elements).

If you have the skills and some free time, feel free to join the project! We gladly accept any code contributions (see [Appendix C \[Information for developers\]](#), page 181) to remedy the aforementioned (and all other) shortcomings...

1.7 Bug reports

If you think you have found a bug in Gmsh, you can report it by electronic mail to the Gmsh mailing list at [gmsh@geuz.org](mailto:gmesh@geuz.org). Please send as precise a description of the problem as you can, including sample input files that produce the bug. Don't forget to mention both the version of Gmsh and the version of your operation system (see [Section 3.3 \[Command-line options\]](#), page 10 to see how to get this information).

See [Appendix E \[Frequently asked questions\]](#), page 185, and the 'TODO.txt' file in the distribution to see which problems we already know about.

2 How to read this reference manual?

Gmsh can be used at three levels:

1. as a stand-alone graphical program, driven by an interactive graphical user interface (GUI);
2. as a stand-alone script-driven program;
3. as a library.

You can skip most of this reference manual if you only want to use Gmsh at the first level (i.e., interactively with the GUI). Just read the next chapter (see [Chapter 3 \[Running Gmsh on your system\]](#), page 9) to learn how to launch Gmsh on your system, then go experiment with the GUI and the tutorial files (see [Appendix A \[Tutorial\]](#), page 91) provided in the distribution. Screencasts that show how to use the GUI are available here: <http://www.geuz.org/gmsh/screencasts/>.

The aim of the reference manual is to explain everything you need to use Gmsh at the second level, i.e., using the built-in scripting language. A Gmsh script file is an ASCII text file that contains instructions in Gmsh's built-in scripting language. Such a file is interpreted by Gmsh's parser, and can be given any extension (or no extension at all). By convention, Gmsh uses the `.geo` extension for geometry scripts, and the `.pos` extension for parsed post-processing datasets. Once you master the tutorial (read the source files: they are heavily commented!), start reading chapter [Chapter 4 \[General tools\]](#), page 17, then proceed with the next four chapters, which detail the syntax of the geometry, mesh, solver and post-processing scripting commands. You will see that most of the interactive actions in the GUI have a direct equivalent in the scripting language. If you want to use Gmsh as a pre- or post-processor for your own software, you will also want to learn about the non-scripting input/output files that Gmsh can read/write. In addition to Gmsh's native "MSH" file format (see [Chapter 9 \[File formats\]](#), page 75), Gmsh can read/write many standard mesh files, depending on how it was built: check the 'File->Save As' menu for a list of available formats.

Finally, to use Gmsh at the third level (i.e., to link the Gmsh library with your own code), you will need to learn the internal Gmsh Application Programming Interface (API). No complete documentation of this API is available yet; a good starting point is [Section C.2 \[Source code structure\]](#), page 181, which gives a short introduction to Gmsh's internal source code structure. Then have a look e.g. at the examples in the `'utils/api_demos/'` directory in the source code.

2.1 Syntactic rules used in the manual

Here are the rules we tried to follow when writing this reference manual. Note that meta-syntactic variable definitions stay valid throughout the manual (and not only in the sections where the definitions appear).

1. Keywords and literal symbols are printed like `this`.
2. Metasyntactic variables (i.e., text bits that are not part of the syntax, but stand for other text bits) are printed like *this*.
3. A colon (:) after a metasyntactic variable separates the variable from its definition.
4. Optional rules are enclosed in `< >` pairs.

5. Multiple choices are separated by |.
6. Three dots (. . .) indicate a possible (multiple) repetition of the preceding rule.

3 Running Gmsh on your system

3.1 Interactive mode

To launch Gmsh in interactive mode, just double-click on the Gmsh icon, or type

```
> gmsh
```

at your shell prompt in a terminal. This will open two windows: the graphic window (with a status bar at the bottom) and the menu window (with a menu bar and some context-dependent buttons).

To open the first tutorial file (see [Appendix A \[Tutorial\], page 91](#)), select the ‘File->Open’ menu, and choose ‘t1.geo’ in the input field. When using a terminal, you can specify the file name directly on the command line, i.e.:

```
> gmsh t1.geo
```

To perform the mesh generation, go to the mesh module (by selecting ‘Mesh’ in the module menu) and choose the dimension in the context-dependent buttons (‘1D’ will mesh all the lines; ‘2D’ will mesh all the surfaces—as well as all the lines if ‘1D’ was not called before; ‘3D’ will mesh all the volumes—and all the surfaces if ‘2D’ was not called before). To save the resulting mesh in the current mesh format click on the ‘Save’ button, or select the appropriate format and file name with the ‘File->Save As’ menu. The default mesh file name is based on the name of the current active model, with an appended extension depending on the mesh format¹.

To create a new geometry or to modify an existing geometry, select ‘Geometry’ in the module menu, and follow the context-dependent buttons. For example, to create a spline, select ‘Elementary’, ‘Add’, ‘New’ and ‘Spline’. You will then be asked to select a list of points, and to type *e* to finish the selection (or *q* to abort it). Once the interactive command is completed, a text string is automatically added at the end of the current script file. You can edit the script file by hand at any time by pressing the ‘Edit’ button in the ‘Geometry’ menu and then reloading the model by pressing ‘Reload’. For example, it is often faster to define variables and points directly in the script file, and then use the GUI to define the lines, the surfaces and the volumes interactively.

Several files can be loaded simultaneously in Gmsh. The first one defines the active model and the others are ‘merged’ into this model. You can merge such files with the ‘File->Merge’ menu, or by directly specifying the names of the files on the command line. For example, to merge the post-processing views contained in the files ‘view1.pos’ and ‘view5.msh’ together with the geometry of the first tutorial ‘t1.geo’, you can type the following command:

```
> gmsh t1.geo view1.pos view5.msh
```

In the Post-Processing module (select ‘Post-Processing’ in the module menu), three buttons will appear, respectively labeled ‘A scalar map’, ‘Nodal scalar map’ and ‘Element 1 vector’. In this example the views contain several time steps: you can loop through them with the small “remote-control” icons at the bottom of the graphic window. A mouse click on the view name will toggle the visibility of the selected view, while a click on the arrow button on the right will provide access to the view’s options.

¹ Nearly all the interactive commands have shortcuts: see [Section 3.5 \[Keyboard shortcuts\], page 13](#), or select ‘Help->Keyboard Shortcuts’ in the menu. For example, to quickly save a mesh, you can press *Ctrl+Shift+s*.

Note that all the options specified interactively can also be directly specified in the script files. You can save the current options of the current active model with the ‘File->Save Options’ menu. This will create a new option file with the same filename as the active model, but with an extra ‘.opt’ extension added. The next time you open this model, the associated options will be automatically loaded, too. To save the current options as your default preferences for all future Gmsh sessions, use the ‘File->Save Default Options’ menu instead. Finally, you can also save the current options in an arbitrary file by choosing the ‘Gmsh options’ format in ‘File->Save As’.

3.2 Non-interactive mode

Gmsh can be run non-interactively in ‘batch’ mode, without GUI². For example, to mesh the first tutorial in batch mode, just type:

```
> gmsh t1.geo -2
```

To mesh the same example, but with the background mesh available in the file ‘bgmesh.pos’, type:

```
> gmsh t1.geo -2 -bgm bgmesh.pos
```

For the list of all command-line options, see [Section 3.3 \[Command-line options\]](#), page 10.

3.3 Command-line options

Geometry options:

-0 Parse all input files, output unrolled geometry, and exit.

-tol float Set geometrical tolerance

Mesh options:

-1, -2, -3 Perform 1D, 2D or 3D mesh generation, then exit

-part int Partition the mesh after batch mesh generation.

-saveall Save all elements (discard physical group definitions)

-o file Specify mesh output file name

-format string Set output mesh format (msh, msh1, msh2, unv, vrml, stl, mesh, bdf, p3d, cgns, med)

-bin Use binary format when available

-algo string Select mesh algorithm (meshadapt, del2d, front2d, del3d, front3d)

-smooth int Set number of mesh smoothing steps

² If you compile Gmsh without the GUI, this is the only mode you have access to.

`-optimize[_netgen]`
Optimize quality of tetrahedral elements

`-order int`
Set the order of the generated elements (1, 2)

`-clscale float`
Set characteristic length scaling factor

`-clmin float`
Set minimum characteristic length

`-clmax float`
Set maximum characteristic length

`-clcurv` Compute characteristic lengths from curvatures

`-rand float`
Set random perturbation factor

`-bgm file` Load background mesh from file

Post-processing options:

`-noview` Hide all views on startup

`-link int` Select link mode between views (0, 1, 2, 3, 4)

`-combine` Combine views having identical names into multi-time-step views

Display options:

`-nodb` Disable double buffering

`-fontsize int`
Specify the font size for the GUI

`-theme string`
Specify FLTK GUI theme

`-display string`
Specify display

Other options:

`-` Parse input files, then exit

`-a, -g, -m, -s, -p`
Start in automatic, geometry, mesh, solver or post-processing mode

`-pid` Print pid on stdout

`-listen` Always listen to incoming connection requests.

`-v int` Set verbosity level

`-nopopup` Don't popup dialog windows in scripts

```

-string "string"
    Parse option string at startup

-option file
    Parse option file at startup

-convert files
    Convert files into latest binary formats, then exit

-version    Show version number

-info       Show detailed version information

-help       Show this message

```

3.4 Mouse actions

In the following, for a 2 button mouse, *Middle button* = *Shift+Left button*. For a 1 button mouse, *Middle button* = *Shift+Left button* and *Right button* = *Alt+Left button*.

Move the mouse:

- Highlight the entity under the mouse pointer and display its properties in the status bar
- Resize a lasso zoom or a lasso selection/unselection started with *Ctrl+Left button*

Left button:

- Rotate
- Select an entity
- Accept a lasso zoom or a lasso selection started with *Ctrl+Left button*

Ctrl+Left button: Start a lasso zoom or a lasso selection/unselection

Middle button:

- Zoom
- Unselect an entity
- Accept a lasso zoom or a lasso unselection

Ctrl+Middle button: Orthogonalize display

Right button:

- Pan
- Cancel a lasso zoom or a lasso selection/unselection
- Pop-up menu on post-processing view button

Ctrl+Right button: Reset to default viewpoint

3.5 Keyboard shortcuts

(On Mac Ctrl is replaced by Cmd (the ‘Apple key’) in the shortcuts below.)

Left arrow

Go to previous time step

Right arrow

Go to next time step

Up arrow Make previous view visible

Down arrow

Make next view visible

< Go back to previous context

> Go forward to next context

0 Reload project file

1 or F1 Mesh lines

2 or F2 Mesh surfaces

3 or F3 Mesh volumes

Escape Cancel lasso zoom/selection, toggle mouse selection ON/OFF

g Go to geometry module

m Go to mesh module

p Go to post-processing module

s Go to solver module

Shift+a Bring all windows to front

Shift+g Show geometry options

Shift+m Show mesh options

Shift+o Show general options

Shift+p Show post-processing options

Shift+s Show solver options

Shift+u Show post-processing view plugins

Shift+w Show post-processing view options

Ctrl+i Show statistics window

Ctrl+l Show message console

Ctrl+n Create new project file

<i>Ctrl+o</i>	Open project file
<i>Ctrl+q</i>	Quit
<i>Ctrl+r</i>	Rename project file
<i>Ctrl+s</i>	Save file
<i>Shift+Ctrl+c</i>	Show clipping plane window
<i>Shift+Ctrl+m</i>	Show manipulator window
<i>Shift+Ctrl+n</i>	Show option window
<i>Shift+Ctrl+o</i>	Merge file(s)
<i>Shift+Ctrl+s</i>	Save mesh in default format
<i>Shift+Ctrl+u</i>	Show plugin window
<i>Shift+Ctrl+v</i>	Show visibility window
<i>Alt+a</i>	Loop through axes modes
<i>Alt+b</i>	Hide/show bounding boxes
<i>Alt+c</i>	Loop through predefined color schemes
<i>Alt+e</i>	Hide/Show element outlines for visible post-processing views
<i>Alt+f</i>	Change redraw mode (fast/full)
<i>Alt+h</i>	Hide/show all post-processing views
<i>Alt+i</i>	Hide/show all post-processing view scales
<i>Alt+l</i>	Hide/show geometry lines
<i>Alt+m</i>	Toggle visibility of all mesh entities
<i>Alt+n</i>	Hide/show all post-processing view annotations
<i>Alt+o</i>	Change projection mode (orthographic/perspective)
<i>Alt+p</i>	Hide/show geometry points
<i>Alt+r</i>	Loop through range modes for visible post-processing views
<i>Alt+s</i>	Hide/show geometry surfaces
<i>Alt+t</i>	Loop through interval modes for visible post-processing views
<i>Alt+v</i>	Hide/show geometry volumes

<i>Alt+w</i>	Enable/disable all lighting
<i>Alt+x</i>	Set X view
<i>Alt+y</i>	Set Y view
<i>Alt+z</i>	Set Z view
<i>Alt+Shift+a</i>	Hide/show small axes
<i>Alt+Shift+b</i>	Hide/show mesh volume faces
<i>Alt+Shift+d</i>	Hide/show mesh surface faces
<i>Alt+Shift+l</i>	Hide/show mesh lines
<i>Alt+Shift+o</i>	Adjust projection parameters
<i>Alt+Shift+p</i>	Hide/show mesh points
<i>Alt+Shift+s</i>	Hide/show mesh surface edges
<i>Alt+Shift+v</i>	Hide/show mesh volume edges
<i>Alt+Shift+w</i>	Reverse all mesh normals
<i>Alt+Shift+x</i>	Set -X view
<i>Alt+Shift+y</i>	Set -Y view
<i>Alt+Shift+z</i>	Set -Z view

4 General tools

This chapter describes the general commands and options that can be used in Gmsh’s script files. By “general”, we mean “not specifically related to one of the geometry, mesh, solver or post-processing modules”. Commands peculiar to these modules will be introduced in [Chapter 5 \[Geometry module\], page 29](#), [Chapter 6 \[Mesh module\], page 35](#), [Chapter 7 \[Solver module\], page 51](#), and [Chapter 8 \[Post-processing module\], page 55](#), respectively.

4.1 Comments

Gmsh script files support both C and C++ style comments:

1. any text comprised between `/*` and `*/` pairs is ignored;
2. the rest of a line after a double slash `//` is ignored.

These commands won’t have the described effects inside double quotes or inside keywords. Also note that ‘white space’ (spaces, tabs, new line characters) is ignored inside all expressions.

4.2 Expressions

The two constant types used in Gmsh scripts are *real* and *string* (there is no integer type). These types have the same meaning and syntax as in the C or C++ programming languages.

4.2.1 Floating point expressions

Floating point expressions (or, more simply, “expressions”) are denoted by the metasyn-tactic variable *expression* (remember the definition of the syntactic rules in [Section 2.1 \[Syntactic rules\], page 7](#)), and are evaluated during the parsing of the script file:

```
expression :
    real |
    string |
    string [ expression ] |
    # string [ ] |
    ( expression ) |
    operator-unary-left expression |
    expression operator-unary-right |
    expression operator-binary expression |
    expression operator-ternary-left expression operator-ternary-right ex-
pression |
    built-in-function |
    real-option |
    GetValue("string", expression)
```

Such *expressions* are used in most of Gmsh’s scripting commands. The third and fourth cases in this definition permit to extract one item from a list (see below) and get the size of a list, respectively. The operators *operator-unary-left*, *operator-unary-right*, *operator-binary*, *operator-ternary-left* and *operator-ternary-right* are defined in [Section 4.3 \[Operators\], page 19](#). For the definition of *built-in-functions*, see [Section 4.4 \[Built-in functions\], page 21](#). The various *real-options* are listed in [Appendix B \[Options\], page 109](#).

The last case in the definition allows to ask the user for a value interactively. For example, inserting `GetValue("Value of parameter alpha?", 5.76)` in an input file will query the user for the value of a certain parameter alpha, assuming the default value is 5.76. If the option `General.NoPopup` is set (see [Section B.1 \[General options list\], page 109](#)), no question is asked and the default value is automatically used.

List of expressions are also widely used, and are defined as:

```
expression-list:
    expression-list-item <, expression-list-item> ...

with

expression-list-item:
    expression |
    expression : expression |
    expression : expression : expression |
    string [ ] |
    string [ { expression-list } ] |
    Point { expression } |
    transform |
    extrude
```

The second case in this last definition permits to create a list containing the range of numbers comprised between two *expressions*, with a unit incrementation step. The third case also permits to create a list containing the range of numbers comprised between two *expressions*, but with a positive or negative incrementation step equal to the third *expression*. The fourth case permits to reference an expression list. The fifth case permits to reference an expression sublist (whose elements are those corresponding to the indices provided by the *expression-list*). The sixth case permits to retrieve the coordinates of a given geometry point (see [Section 5.1.1 \[Points\], page 29](#)). The last two cases permit to retrieve the indices of entities created through geometrical transformations and extrusions (see [Section 5.1.6 \[Transformations\], page 33](#), and [Section 5.1.5 \[Extrusions\], page 32](#)).

To see the practical use of such expressions, have a look at the first couple of examples in [Appendix A \[Tutorial\], page 91](#). Note that, in order to lighten the syntax, you can always omit the braces `{}` enclosing an *expression-list* if this *expression-list* only contains a single item. Also note that a braced *expression-list* can be preceded by a minus sign in order to change the sign of all the *expression-list-items*.

4.2.2 Character expressions

Character expressions are defined as:

```
char-expression:
    "string" |
    Today |
    StrPrefix ( char-expression ) |
    StrRelative ( char-expression ) |
    StrCat ( char-expression , char-expression ) |
    Sprintf ( char-expression , expression-list ) |
    Sprintf ( char-expression )
    Sprintf ( char-option )
```

The third and fourth cases in this definition permit to take the prefix (e.g. to remove the extension) or the relative path of a string. The fifth case permits to concatenate two character expressions, and the sixth and seventh are equivalent to the `sprintf` C function (where *char-expression* is a format string that can contain floating point formatting characters: `%e`, `%g`, etc.). The last case permits to use the value of a *char-option* as a *char-expression*. The various *char-options* are listed in [Appendix B \[Options\]](#), page 109.

Character expressions are mostly used to specify non-numeric options and input/output file names. See [Section A.8 \[t8.geo\]](#), page 104, for an interesting usage of *char-expressions* in an animation script.

4.2.3 Color expressions

Colors expressions are hybrids between fixed-length braced *expression-lists* and *strings*:

```
color-expression:
  string |
  { expression, expression, expression } |
  { expression, expression, expression, expression } |
  color-option
```

The first case permits to use the X Windows names to refer to colors, e.g., `Red`, `SpringGreen`, `LavenderBlush3`, ... (see ‘`Common/Colors.h`’ in the source code for a complete list). The second case permits to define colors by using three expressions to specify their red, green and blue components (with values comprised between 0 and 255). The third case permits to define colors by using their red, green and blue color components as well as their alpha channel. The last case permits to use the value of a *color-option* as a *color-expression*. The various *color-options* are listed in [Appendix B \[Options\]](#), page 109.

See [Section A.3 \[t3.geo\]](#), page 95, for an example of the use of color expressions.

4.3 Operators

Gmsh’s operators are similar to the corresponding operators in C and C++. Here is the list of the unary, binary and ternary operators currently implemented.

operator-unary-left:

- Unary minus.
- ! Logical not.

operator-unary-right:

- ++ Post-incrementation.
- Post-decrementation.

operator-binary:

- ^ Exponentiation.
- *
- /
- % Modulo.

+	Addition.
-	Subtraction.
==	Equality.
!=	Inequality.
>	Greater.
>=	Greater or equality.
<	Less.
<=	Less or equality.
&&	Logical 'and'.
	Logical 'or'. (Warning: the logical 'or' always implies the evaluation of both arguments. That is, unlike in C or C++, the second operand of is evaluated even if the first one is true).

operator-ternary-left:

?

operator-ternary-right:

:

The only ternary operator, formed by *operator-ternary-left* and *operator-ternary-right*, returns the value of its second argument if the first argument is non-zero; otherwise it returns the value of its third argument.

The evaluation priorities are summarized below¹ (from stronger to weaker, i.e., * has a highest evaluation priority than +). Parentheses () may be used anywhere to change the order of evaluation:

1. (), [], ., #
2. ^
3. !, ++, --, - (unary)
4. *, /, %
5. +, -
6. <, >, <=, >=
7. ==, !=
8. &&
9. ||
10. ?:
11. =, +=, -=, *=, /=

¹ The affectation operators are introduced in [Section 4.7 \[General commands\]](#), page 23.

4.4 Built-in functions

A built-in function is composed of an identifier followed by a pair of parentheses containing an *expression-list* (the list of its arguments)². Here is the list of the built-in functions currently implemented:

build-in-function:

- Acos** (*expression*)
Arc cosine (inverse cosine) of an *expression* in $[-1,1]$. Returns a value in $[0,\text{Pi}]$.
- Asin** (*expression*)
Arc sine (inverse sine) of an *expression* in $[-1,1]$. Returns a value in $[-\text{Pi}/2,\text{Pi}/2]$.
- Atan** (*expression*)
Arc tangent (inverse tangent) of *expression*. Returns a value in $[-\text{Pi}/2,\text{Pi}/2]$.
- Atan2** (*expression*, *expression*)
Arc tangent (inverse tangent) of the first *expression* divided by the second.
Returns a value in $[-\text{Pi},\text{Pi}]$.
- Ceil** (*expression*)
Rounds *expression* up to the nearest integer.
- Cos** (*expression*)
Cosine of *expression*.
- Cosh** (*expression*)
Hyperbolic cosine of *expression*.
- Exp** (*expression*)
Returns the value of e (the base of natural logarithms) raised to the power of *expression*.
- Fabs** (*expression*)
Absolute value of *expression*.
- Fmod** (*expression*, *expression*)
Remainder of the division of the first *expression* by the second, with the sign of the first.
- Floor** (*expression*)
Rounds *expression* down to the nearest integer.
- Hypot** (*expression*, *expression*)
Returns the square root of the sum of the square of its two arguments.
- Log** (*expression*)
Natural logarithm of *expression* ($\text{expression} > 0$).
- Log10** (*expression*)
Base 10 logarithm of *expression* ($\text{expression} > 0$).
- Modulo** (*expression*, *expression*)
see **Fmod**(*expression*, *expression*).

² For compatibility with GetDP (<http://www.geuz.org/getdp/>), parentheses can be replaced by brackets `[]`.

Rand (*expression*)
Random number between zero and *expression*.

Sqrt (*expression*)
Square root of *expression* (*expression* \geq 0).

Sin (*expression*)
Sine of *expression*.

Sinh (*expression*)
Hyperbolic sine of *expression*.

Tan (*expression*)
Tangent of *expression*.

Tanh (*expression*)
Hyperbolic tangent of *expression*.

4.5 User-defined functions

User-defined functions take no arguments, and are evaluated as if a file containing the function body was included at the location of the **Call** statement.

Function *string*
Begins the declaration of a user-defined function named *string*. The body of the function starts on the line after ‘**Function** *string*’, and can contain any Gmsh command.

Return
Ends the body of the current user-defined function. Function declarations cannot be imbricated.

Call *string*;
Executes the body of a (previously defined) function named *string*.

See [Section A.5 \[t5.geo\], page 99](#), for an example of a user-defined function. A shortcoming of Gmsh’s scripting language is that all variables are “public”. Variables defined inside the body of a function will thus be available outside, too!

4.6 Loops and conditionals

Loops and conditionals are defined as follows, and can be imbricated:

For (*expression* : *expression*)
Iterates from the value of the first *expression* to the value of the second *expression*, with a unit incrementation step. At each iteration, the commands comprised between ‘**For** (*expression* : *expression*)’ and the matching **EndFor** are executed.

For (*expression* : *expression* : *expression*)
Iterates from the value of the first *expression* to the value of the second *expression*, with a positive or negative incrementation step equal to the third *expression*. At each iteration, the commands comprised between ‘**For** (*expression* : *expression* : *expression*)’ and the matching **EndFor** are executed.

For *string* In { *expression* : *expression* }

Iterates from the value of the first *expression* to the value of the second *expression*, with a unit incrementation step. At each iteration, the value of the iterate is affected to an expression named *string*, and the commands comprised between ‘**For** *string* In { *expression* : *expression* }’ and the matching **EndFor** are executed.

For *string* In { *expression* : *expression* : *expression* }

Iterates from the value of the first *expression* to the value of the second *expression*, with a positive or negative incrementation step equal to the third *expression*. At each iteration, the value of the iterate is affected to an expression named *string*, and the commands comprised between ‘**For** *string* In { *expression* : *expression* : *expression* }’ and the matching **EndFor** are executed.

EndFor Ends a matching **For** command.

If (*expression*)

The body enclosed between ‘**If** (*expression*)’ and the matching **Endif** is evaluated if *expression* is non-zero.

EndIf Ends a matching **If** command.

See [Section A.5 \[t5.geo\], page 99](#), for an example of **For** and **If** commands. Gmsh does not provide any **Else** (or similar) command at the time of this writing.

4.7 General commands

The following commands can be used anywhere in a Gmsh script:

string = *expression* ;

Creates a new expression identifier *string*, or affects *expression* to an existing expression identifier. Thirteen expression identifiers are predefined (hardcoded in Gmsh’s parser):

Pi Returns 3.1415926535897932.

GMSH_MAJOR_VERSION
Returns Gmsh’s major version number.

GMSH_MINOR_VERSION
Returns Gmsh’s minor version number.

GMSH_PATCH_VERSION
Returns Gmsh’s patch version number.

MPI_Size Returns the number of processors on which Gmsh is running (always 1, except if you compiled Gmsh’s parallel extensions).

MPI_Rank Returns the rank of the current processor.

newp Returns the next available point number. As explained in [Chapter 5 \[Geometry module\], page 29](#), a unique number must be associated with every geometrical point: **newp** permits to know the highest number already attributed (plus one). This is mostly useful when

writing user-defined functions (see [Section 4.5 \[User-defined functions\]](#), [page 22](#)) or general geometric primitives, when one does not know *a priori* which numbers are already attributed, and which ones are still available.

<code>newl</code>	Returns the next available line number.
<code>news</code>	Returns the next available surface number.
<code>newv</code>	Returns the next available volume number.
<code>newll</code>	Returns the next available line loop number.
<code>news1</code>	Returns the next available surface loop number.
<code>newreg</code>	Returns the next available region number. That is, <code>newreg</code> returns the maximum of <code>newp</code> , <code>newl</code> , <code>news</code> , <code>newv</code> , <code>newll</code> , <code>news1</code> and all physical entity numbers ³ .

`string [] = { };`

Creates a new expression list identifier `string[]` with an empty list.

`string [] = { expression-list };`

Creates a new expression list identifier `string[]` with the list `expression-list`, or affects `expression-list` to an existing expression list identifier. (Remember the remark we made when we defined `expression-lists`: the braces enclosing an `expression-list` are optional if the list only contains a single item.)

`string [{ expression-list }] = { expression-list };`

Affects each item in the right hand side `expression-list` to the elements (indexed by the left hand side `expression-list`) of an existing expression list identifier. The two `expression-lists` must contain the same number of items.

`real-option = expression;`

Affects `expression` to a real option.

`char-option = char-expression;`

Affects `char-expression` to a character option.

`color-option = color-expression;`

Affects `color-expression` to a color option.

`string | real-option += expression;`

Adds and affects `expression` to an existing expression identifier or to a real option.

`string | real-option -= expression;`

Subtracts and affects `expression` to an existing expression identifier or to a real option.

`string | real-option *= expression;`

Multiplies and affects `expression` to an existing expression identifier or to a real option.

³ For compatibility purposes, the behavior of `newl`, `news`, `newv` and `newreg` can be modified with the `Geometry.OldNewReg` option (see [Section B.2 \[Geometry options list\]](#), [page 131](#)).

`string | real-option /= expression;`
 Divides and affects *expression* to an existing expression identifier or to a real option.

`string [] += { expression-list };`
 Appends *expression-list* to an existing expression list or creates a new expression list with *expression-list*).

`string [{ expression-list }] += { expression-list };`
 Adds and affects, item per item, the right hand side *expression-list* to an existing expression list identifier.

`string [{ expression-list }] -= { expression-list };`
 Subtracts and affects, item per item, the right hand side *expression-list* to an existing expression list identifier.

`string [{ expression-list }] *= { expression-list };`
 Multiplies and affects, item per item, the right hand side *expression-list* to an existing expression list identifier.

`string [{ expression-list }] /= { expression-list };`
 Divides and affects, item per item, the right hand side *expression-list* to an existing expression list identifier.

`Exit;` Aborts the current script.

`Printf (char-expression , expression-list);`
 Prints a character expression in the information window and/or on the terminal. `Printf` is equivalent to the `printf` C function: *char-expression* is a format string that can contain formatting characters (%f, %e, etc.). Note that all expressions are evaluated as floating point values in Gmsh (see [Section 4.2 \[Expressions\]](#), page 17), so that only valid floating point formatting characters make sense in *char-expression*. See [Section A.5 \[t5.geo\]](#), page 99, for an example of the use of `Printf`.

`Printf (char-expression , expression-list) > char-expression;`
 Same as `Printf` above, but output the expression in a file.

`Printf (char-expression , expression-list) >> char-expression;`
 Same as `Printf` above, but appends the expression at the end of the file.

`Merge char-expression;`
 Merges a file named *char-expression*. This command is equivalent to the ‘File->Merge’ menu in the GUI. If the path in *char-expression* is not absolute, *char-expression* is appended to the path of the current file.

`Draw;` Redraws the scene.

`BoundingBox;`
 Recomputes the bounding box of the scene (which is normally computed only after new geometrical entities are added or after files are included or merged). The bounding box is computed as follows:

1. If there is a mesh (i.e., at least one mesh vertex), the bounding box is taken as the box enclosing all the mesh vertices;

2. If there is no mesh but there is a geometry (i.e., at least one geometrical point), the bounding box is taken as the box enclosing all the geometrical points;
3. If there is no mesh and no geometry, but there are some post-processing views, the bounding box is taken as the box enclosing all the primitives in the views.

BoundingBox { *expression*, *expression*, *expression*, *expression*, *expression*, *expression* };
 Forces the bounding box of the scene to the given *expressions* (X min, X max, Y min, Y max, Z min, Z max).

Delete Model;
 Deletes the current model (all geometrical entities and their associated meshes).

Delete Physicals;
 Deletes all physical groups.

Delete Variables;
 Deletes all the expressions.

Delete *string*;
 Deletes the expression *string*.

Mesh *expression*;
 Generate *expression*-D mesh.

Print *char-expression*;
 Prints the graphic window in a file named *char-expression*, using the current **Print.Format** (see [Section B.1 \[General options list\]](#), page 109). If the path in *char-expression* is not absolute, *char-expression* is appended to the path of the current file.

Sleep *expression*;
 Suspends the execution of Gmsh during *expression* seconds.

System *char-expression*;
 Executes a system call.

SyncModel;
 Forces an immediate transfer from the old geometrical database into the new one (this transfer normally occurs right after a file is read).

Include *char-expression*;
 Includes the file named *char-expression* at the current position in the input file. The include command should be given on a line of its own. If the path in *char-expression* is not absolute, *char-expression* is appended to the path of the current file.

4.8 General options

The list of all the general *char-options*, *real-options* and *color-options* (in that order—check the default values to see the actual types) is given in [Section B.1 \[General options list\]](#),

page 109. Most of these options are accessible in the GUI, but not all of them. When running Gmsh interactively, changing an option in the script file will modify the option in the GUI in real time. This permits for example to resize the graphical window in a script, or to interact with animations in the script and in the GUI at the same time.

5 Geometry module

Gmsh’s geometry module provides a simple CAD engine, using a boundary representation (“BRep”) approach: you need to first define points (using the `Point` command: see below), then lines (using `Line`, `Circle`, `Spline`, ..., commands or by extruding points), then surfaces (using for example the `Plane Surface` or `Ruled Surface` commands, or by extruding lines), and finally volumes (using the `Volume` command or by extruding surfaces).

These geometrical entities are called “elementary” in Gmsh’s jargon, and are assigned identification numbers when they are created:

1. each elementary point must possess a unique identification number;
2. each elementary line must possess a unique identification number;
3. each elementary surface must possess a unique identification number;
4. each elementary volume must possess a unique identification number.

Elementary geometrical entities can then be manipulated in various ways, for example using the `Translate`, `Rotate`, `Scale` or `Symmetry` commands. They can be deleted with the `Delete` command, provided that no higher-dimension entity references them.

Compound groups of elementary geometrical entities can also be defined and are called “physical” entities. These physical entities cannot be modified by geometry commands: their only purpose is to assemble elementary entities into larger groups, possibly modifying their orientation, so that they can be referred to by the mesh module as single entities. As is the case with elementary entities, each physical point, physical line, physical surface or physical volume must be assigned a unique identification number. See [Chapter 6 \[Mesh module\]](#), [page 35](#), for more information about how physical entities affect the way meshes are saved.

5.1 Geometry commands

The next subsections describe all the available geometry commands. These commands can be used anywhere in a Gmsh script file. Note that the following general syntax rule is followed for the definition of geometrical entities: “If an *expression* defines a new entity, it is enclosed between parentheses. If an *expression* refers to a previously defined entity, it is enclosed between braces.”

5.1.1 Points

`Point (expression) = { expression, expression, expression <, expression > };`

Creates an elementary point. The *expression* inside the parentheses is the point’s identification number; the three first *expressions* inside the braces on the right hand side give the three X, Y and Z coordinates of the point in the three-dimensional Euclidean space; the optional last *expression* sets the characteristic mesh length at that point. See [Section 6.3.1 \[Characteristic lengths\]](#), [page 37](#), for more information about how this characteristic length information is used in the meshing process.

`Physical Point (expression | char-expression) = { expression-list };`

Creates a physical point. The *expression* inside the parentheses is the physical point’s identification number (if a *char-expression* is given instead, a unique

identification number is automatically created); the *expression-list* on the right hand side should contain the identification numbers of all the elementary points that need to be grouped inside the physical point.

5.1.2 Lines

BSpline (*expression*) = { *expression-list* };

Creates a B-spline curve. The *expression* inside the parentheses is the B-spline curve's identification number; the *expression-list* on the right hand side should contain the identification numbers of all the B-spline's control points. Repeating control points has the expected effect.

Circle (*expression*) = { *expression*, *expression*, *expression* };

Creates a circle arc (strictly) smaller than Pi. The *expression* inside the parentheses is the circle arc's identification number; the first *expression* inside the braces on the right hand side gives the identification number of the start point of the arc; the second *expression* gives the identification number of the center of the circle; the last *expression* gives the identification number of the end point of the arc.

CatmullRom (*expression*) = { *expression-list* };

CatmullRom is a synonym for Spline.

Ellipse (*expression*) = { *expression*, *expression*, *expression*, *expression* };

Creates an ellipse arc. The *expression* inside the parentheses is the ellipse arc's identification number; the first *expression* inside the braces on the right hand side gives the identification number of the start point of the arc; the second *expression* gives the identification number of the center of the ellipse; the third *expression* gives the identification number of any point located on the major axis of the ellipse; the last *expression* gives the identification number of the end point of the arc.

Line (*expression*) = { *expression*, *expression* };

Creates a straight line segment. The *expression* inside the parentheses is the line segment's identification number; the two *expressions* inside the braces on the right hand side give identification numbers of the start and end points of the segment.

Spline (*expression*) = { *expression-list* };

Creates a spline curve. The *expression* inside the parentheses is the spline's identification number; the *expression-list* on the right hand side should contain the identification numbers of all the spline's control points.

Line Loop (*expression*) = { *expression-list* };

Creates an oriented line loop. The *expression* inside the parentheses is the line loop's identification number; the *expression-list* on the right hand side should contain the identification numbers of all the elementary lines that constitute the line loop. A line loop must be a closed loop, and the elementary lines should be ordered and oriented (using negative identification numbers to specify reverse orientation). If the orientation is correct, but the ordering is wrong, Gmsh will actually reorder the list internally to create a consistent loop. Although Gmsh

supports it, it is not recommended to specify multiple line loops (or subloops) in a single **Line Loop** command. (Line loops are used to create surfaces: see [Section 5.1.3 \[Surfaces\]](#), page 31.)

Physical Line (*expression* | *char-expression*) = { *expression-list* };

Creates a physical line. The *expression* inside the parentheses is the physical line's identification number (if a *char-expression* is given instead, a unique identification number is automatically created); the *expression-list* on the right hand side should contain the identification numbers of all the elementary lines that need to be grouped inside the physical line. Specifying negative identification numbers in the *expression-list* will reverse the orientation of the mesh elements belonging to the corresponding elementary lines in the saved mesh.

5.1.3 Surfaces

Plane Surface (*expression*) = { *expression-list* };

Creates a plane surface. The *expression* inside the parentheses is the plane surface's identification number; the *expression-list* on the right hand side should contain the identification numbers of all the line loops defining the surface. The first line loop defines the exterior boundary of the surface; all other line loops define holes in the surface. A line loop defining a hole should not have any lines in common with the exterior line loop (in which case it is not a hole, and the two surfaces should be defined separately). Likewise, a line loop defining a hole should not have any lines in common with another line loop defining a hole in the same surface (in which case the two line loops should be combined).

Ruled Surface (*expression*) = { *expression-list* } < In Sphere { *expression* } >;

Creates a ruled surface, i.e., a surface that can be interpolated using transfinite interpolation. The *expression* inside the parentheses is the ruled surface's identification number; the first *expression-list* on the right hand side should be the identification number of a line loop composed of either three or four elementary lines. The optional **In Sphere** argument forces the surface to be a spherical patch (the extra parameter gives the identification number of the center of the sphere).

Surface Loop (*expression*) = { *expression-list* };

Creates a surface loop (a shell). The *expression* inside the parentheses is the surface loop's identification number; the *expression-list* on the right hand side should contain the identification numbers of all the elementary surfaces that constitute the surface loop. A surface loop must always represent a closed shell, and the elementary surfaces should be oriented consistently (using negative identification numbers to specify reverse orientation). (Surface loops are used to create volumes: see [Section 5.1.4 \[Volumes\]](#), page 32.)

Physical Surface (*expression* | *char-expression*) = { *expression-list* };

Creates a physical surface. The *expression* inside the parentheses is the physical surface's identification number (if a *char-expression* is given instead, a unique identification number is automatically created); the *expression-list* on the right hand side should contain the identification numbers of all the elementary surfaces that need to be grouped inside the physical surface. Specifying negative

identification numbers in the *expression-list* will reverse the orientation of the mesh elements belonging to the corresponding elementary surfaces in the saved mesh.

5.1.4 Volumes

Volume (*expression*) = { *expression-list* };

Creates a volume. The *expression* inside the parentheses is the volume's identification number; the *expression-list* on the right hand side should contain the identification numbers of all the surface loops defining the volume. The first surface loop defines the exterior boundary of the volume; all other surface loops define holes in the volume. A surface loop defining a hole should not have any surfaces in common with the exterior surface loop (in which case it is not a hole, and the two volumes should be defined separately). Likewise, a surface loop defining a hole should not have any surfaces in common with another surface loop defining a hole in the same volume (in which case the two surface loops should be combined).

Physical Volume (*expression* | *char-expression*) = { *expression-list* };

Creates a physical volume. The *expression* inside the parentheses is the physical volume's identification number (if a *char-expression* is given instead, a unique identification number is automatically created); the *expression-list* on the right hand side should contain the identification numbers of all the elementary volumes that need to be grouped inside the physical volume.

5.1.5 Extrusions

Lines, surfaces and volumes can also be created through extrusion of points, lines and surfaces, respectively. Here is the syntax of the geometrical extrusion commands (go to [Section 6.3.2 \[Structured grids\]](#), page 47, to see how these commands can be extended in order to also extrude the mesh):

extrude:

Extrude { *expression-list* } { *extrude-list* }

Extrudes all elementary entities (points, lines or surfaces) in *extrude-list* using a translation. The *expression-list* should contain three *expressions* giving the X, Y and Z components of the translation vector.

Extrude { { *expression-list* }, { *expression-list* }, *expression* } { *extrude-list* }

Extrudes all elementary entities (points, lines or surfaces) in *extrude-list* using a rotation. The first *expression-list* should contain three *expressions* giving the X, Y and Z direction of the rotation axis; the second *expression-list* should contain three *expressions* giving the X, Y and Z components of any point on this axis; the last *expression* should contain the rotation angle (in radians).

Extrude { { *expression-list* }, { *expression-list* }, { *expression-list* }, *expression* } { *extrude-list* }

Extrudes all elementary entities (points, lines or surfaces) in *extrude-list* using a translation combined with a rotation. The first *expression-list* should contain

three *expressions* giving the X, Y and Z components of the translation vector; the second *expression-list* should contain three *expressions* giving the X, Y and Z direction of the rotation axis; the third *expression-list* should contain three *expressions* giving the X, Y and Z components of any point on this axis; the last *expression* should contain the rotation angle (in radians).

with

extrude-list:

Point | Line | Surface { *expression-list* }; ...

As explained in [Section 4.2.1 \[Floating point expressions\]](#), page 17, *extrude* can be used in an expression, in which case it returns a list of identification numbers. By default, the list contains the “top” of the extruded entity at index 0 and the extruded entity at index 1, followed by the “sides” of the extruded entity at indices 2, 3, etc. For example:

```
Point(1) = {0,0,0};
Point(2) = {1,0,0};
Line(1) = {1, 2};
out[] = Extrude{0,1,0}{ Line{1}; };
Printf("top line = %g", out[0]);
Printf("surface = %g", out[1]);
Printf("side lines = %g and %g", out[2], out[3]);
```

This behaviour can be changed with the `Geometry.ExtrudeReturnLateralEntities` option (see [Section B.2 \[Geometry options list\]](#), page 131).

5.1.6 Transformations

Geometrical transformations can be applied to elementary entities, or to copies of elementary entities (using the `Duplicata` command: see below). The syntax of the transformation commands is:

transform:

Dilate { { *expression-list* }, *expression* } { *transform-list* }

Scales all elementary entities in *transform-list* by a factor *expression*. The *expression-list* should contain three *expressions* giving the X, Y and Z direction of the homothetic transformation.

Rotate { { *expression-list* }, { *expression-list* }, *expression* } { *transform-list* }

Rotates all elementary entities in *transform-list* by an angle of *expression* radians. The first *expression-list* should contain three *expressions* giving the X, Y and Z direction of the rotation axis; the second *expression-list* should contain three *expressions* giving the X, Y and Z components of any point on this axis.

Symmetry { *expression-list* } { *transform-list* }

Transforms all elementary entities symmetrically to a plane. The *expression-list* should contain four *expressions* giving the coefficients of the plane’s equation.

Translate { *expression-list* } { *transform-list* }

Translates all elementary entities in *transform-list*. The *expression-list* should contain three *expressions* giving the X, Y and Z components of the translation vector.

Boundary { *transform-list* }
 (Not a transformation per-se.) Returns the boundary of the elementary entities in *transform-list*.

with

```
transform-list:
  Point | Line | Surface | Volume { expression-list }; ... |
  Duplicata { Point | Line | Surface | Volume { expression-list }; ... } |
  transform
```

5.1.7 Miscellaneous

Here is a list of all other geometry commands currently available:

Coherence;

Removes all duplicate elementary geometrical entities (e.g., points having identical coordinates). Note that Gmsh executes the **Coherence** command automatically after each geometrical transformation, unless **Geometry.AutoCoherence** is set to zero (see [Section B.2 \[Geometry options list\], page 131](#)).

Delete { Point | Line | Surface | Volume { *expression-list* }; ... }

Deletes all elementary entities whose identification numbers are given in *expression-list*. If an entity is linked to another entity (for example, if a point is used as a control point of a curve), **Delete** has no effect (the line will have to be deleted before the point can).

Hide { Point | Line | Surface | Volume { *expression-list* }; ... }

Hide the entities listed in *expression-list*, if **General.VisibilityMode** is set to 0 or 1.

Hide char-expression;

Hide the entity *char-expression*, if **General.VisibilityMode** is set to 0 or 1 (*char-expression* can for example be "*").

Show { Point | Line | Surface | Volume { *expression-list* }; ... }

Show the entities listed in *expression-list*, if **General.VisibilityMode** is set to 0 or 1.

Show char-expression;

Show the entity *char-expression*, if **General.VisibilityMode** is set to 0 or 1 (*char-expression* can for example be "*").

5.2 Geometry options

The list of all the options that control the behavior of geometry commands, as well as the way geometrical entities are handled in the GUI, is give in [Section B.2 \[Geometry options list\], page 131](#).

6 Mesh module

Gmsh’s mesh module regroups several 1D, 2D and 3D meshing algorithms, all producing grids conforming in the sense of finite elements (see [Section 1.2 \[Mesh\]](#), page 3):

- The 2D *unstructured* algorithms generate triangles or both triangles and quadrangles (when **Recombine Surface** is used: see [Section 6.3.3 \[Miscellaneous mesh commands\]](#), page 48). The 3D *unstructured* algorithms generate tetrahedra.
- The 2D *structured* algorithms (transfinite and extrusion) generate triangles by default, but quadrangles can be obtained by using the **Recombine** commands (see [Section 6.3.2 \[Structured grids\]](#), page 47, and [Section 6.3.3 \[Miscellaneous mesh commands\]](#), page 48). The 3D *structured* algorithms generate tetrahedra, hexahedra, prisms and pyramids, depending on the type of the surface meshes they are based on.

All meshes can be subdivided to generate fully quadrangular or fully hexahedral meshes with the `Mesh.SubdivisionAlgorithm` option (see [Section B.3 \[Mesh options list\]](#), page 137). However, beware that the quality of subdivided elements initially generated with an *unstructured* algorithm can be quite poor.

6.1 Choosing the right unstructured algorithm

Gmsh currently provides a choice between three 2D unstructured algorithms and between two 3D unstructured algorithms. Each algorithm has its own advantages and disadvantages. For all 2D unstructured algorithms a Delaunay mesh that contains all the points of the 1D mesh is initially constructed using a divide-and-conquer algorithm¹. Missing edges are recovered using edge swaps². After this initial step three different algorithms can be applied to generate the final mesh:

1. The “MeshAdapt” algorithm³ is based on local mesh modifications. This technique makes use of edge swaps, splits, and collapses: long edges are split, short edges are collapsed, and edges are swapped if a better geometrical configuration is obtained.
2. The “Delaunay” algorithm is inspired by the work of the GAMMA team at INRIA⁴. New points are inserted sequentially at the circumcenter of the element that has the largest adimensional circumradius. The mesh is then reconnected using an anisotropic Delaunay criterion.
3. The “Frontal” algorithm is inspired by the work of S. Rebay⁵.

These algorithms can be ranked as follows:

¹ R. A. Dwyer, *A simple divide-and-conquer algorithm for computing Delaunay triangulations in $O(n \log n)$ expected time*, In Proceedings of the second annual symposium on computational geometry, Yorktown Heights, 2–4 June 1986.

² N. P. Weatherill, *The integrity of geometrical boundaries in the two-dimensional Delaunay triangulation*, Commun. Appl. Numer. Methods 6(2), pp. 101–109, 1990.

³ C. Geuzaine and J.-F. Remacle, *Gmsh: a three-dimensional finite element mesh generator with built-in pre- and post-processing facilities*, International Journal for Numerical Methods in Engineering, Accepted for publication, 2009.

⁴ P.-L. George and P. Frey, *Mesh generation*, Hermes, Lyon, 2000.

⁵ S. Rebay, *Efficient unstructured mesh generation by means of Delaunay triangulation and Bowyer-Watson algorithm*, J. Comput. Phys. 106, pp. 25–138, 1993.

	Robustness	Performance	Element quality
MeshAdapt	1	3	2
Delaunay	2	1	2
Frontal	3	2	1

For very complex curved surfaces the “MeshAdapt” algorithm is the best choice. When high element quality is important, the “Frontal” algorithm should be tried. For very large meshes of plane surfaces the “Delaunay” algorithm is the fastest.

In 3D two unstructured algorithms are available:

1. The “Delaunay” algorithm is split into two separate steps. First, an initial mesh of the union of all the volumes in the model is performed using H. Si’s Tetgen algorithm⁶. Then a three-dimensional version of the 2D Delaunay algorithm described above is applied.
2. The “Frontal” algorithm uses J. Schoeberl’s Netgen algorithm⁷.

The “Delaunay” algorithm is the most robust and the fastest, and is the only one that supports the `Field` mechanism to specify element sizes (see [Section 6.3.1 \[Characteristic lengths\], page 37](#)). However, this algorithm will sometimes modify the surface mesh, and is thus not suitable for producing hybrid structured/unstructured grids. In that case the “Frontal” algorithm should be preferred. The quality of the elements produced by both algorithms is comparable. If element quality is important the mesh optimizer(s) should be applied.

6.2 Elementary vs. physical entities

If only elementary geometrical entities are defined (or if the `Mesh.SaveAll` option is set; see [Section B.3 \[Mesh options list\], page 137](#)), the grid produced by the mesh module will be saved “as is”. That is, all the elements in the grid will be saved using the identification number of the elementary entities they discretize as their elementary region number (and 0 as their physical region number⁸; [Chapter 9 \[File formats\], page 75](#)). This can sometimes be inconvenient:

- mesh elements cannot be duplicated;
- the orientation of the mesh elements (the ordering of their nodes) is determined entirely by the orientation of their “parent” elementary entities, and cannot be modified;
- elements belonging to different elementary entities cannot be linked as being part of a larger group having a physical or mathematical meaning (like ‘Left wing’, ‘Metallic part’, ‘Dirichlet boundary condition’, ...).

To remedy these problems, the geometry module (see [Chapter 5 \[Geometry module\], page 29](#)) introduces the notion of “physical” entities (also called “physical groups”). The purpose of physical entities is to assemble elementary entities into larger, possibly overlapping groups, and to control the orientation of the elements in these groups. The introduction of physical entities in large models usually greatly facilitates the manipulation

⁶ H. Si, *Tetgen: a quality tetrahedral mesh generator and three-dimensional Delaunay triangulator*, 2004.

⁷ J. Schoeberl, *Netgen, an advancing front 2d/3d-mesh generator based on abstract rules*, Comput. Visual. Sci., 1, pp. 41–52, 1997.

⁸ This behaviour was introduced in Gmsh 2.0. In older versions, both the elementary and the physical region numbers would be set to the identification number of the elementary region.

of the model (e.g., using ‘Tools->Visibility’ in the GUI) and the interfacing with external solvers.

In the MSH file format (see [Chapter 9 \[File formats\]](#), page 75), if physical entities are defined, the output mesh only contains those elements that belong to physical entities. Other file formats each treat physical entities in slightly different ways, depending on their capability to define groups.

In all cases, Gmsh reindexes the mesh vertices and elements so that they are numbered in a continuous sequence in the output files. Note that the numbers displayed on screen after mesh generation thus usually differ from the ones saved in the mesh files. To check the actual numbers saved in the output file just load the file back using ‘File->Open’.

6.3 Mesh commands

The mesh module commands mostly permit to modify the characteristic lengths and specify structured grid parameters. The actual mesh “actions” (i.e., “mesh the lines”, “mesh the surfaces” and “mesh the volumes”) cannot be specified in the script files. They have to be given either in the GUI or on the command line (see [Chapter 3 \[Running Gmsh on your system\]](#), page 9, and [Section 3.3 \[Command-line options\]](#), page 10).

6.3.1 Characteristic lengths

There are three ways to specify the size of the mesh elements for a given geometry:

1. First, if `Mesh.CharacteristicLengthFromPoints` is set (it is by default), you can simply specify characteristic lengths at the geometrical points of the model (with the `Point` command: see [Section 5.1.1 \[Points\]](#), page 29). The size of the mesh elements will then be computed by linearly interpolating these characteristic lengths on the initial mesh (see [Section 1.2 \[Mesh\]](#), page 3). This might sometimes lead to over-refinement in some areas, so that you may have to add “dummy” geometrical entities in the model in order to get the desired element sizes.

This method works with all the algorithms implemented in the mesh module. The final element sizes are of course constrained by the structured algorithms for which the element sizes are explicitly specified (e.g., transfinite and extruded grids: see [Section 6.3.2 \[Structured grids\]](#), page 47).

2. Second, if `Mesh.CharacteristicLengthFromCurvature` is set (it is not by default), the mesh will be adapted with respect to the curvature of the geometrical entities.
3. Finally, you can specify general characteristic lengths using mesh size “fields”. Various fields exist:
 - A `PostView` field specifies an explicit background mesh in the form of a scalar post-processing view (see [Section 8.1 \[Post-processing commands\]](#), page 55, and [Chapter 9 \[File formats\]](#), page 75) in which the nodal values are the target element sizes. This method is very general but it requires a first (usually rough) mesh and a way to compute the target sizes on this mesh (usually through an error estimation procedure, in an iterative process of mesh adaptation).

(Note that you can also load a background mesh directly from the command line using the `-bgm` option (see [Section 3.3 \[Command-line options\]](#), page 10), or in the GUI by selecting ‘Apply as background mesh’ in the post-processing view option menu.)

- A **Box** field specifies the size of the elements inside and outside of a parallelepipedic region.
- A **Threshold** field specifies the size of the mesh according to the distance to some geometrical entities. These entities can for example be geometry points and lines specified by an **Attractor** field.
- A **MathEval** field specifies the size of the mesh using an explicit mathematical function.
- A **Min** field specifies the size as the minimum of the sizes computed using other fields
- ...

Fields are supported by all the algorithms except those based on Netgen. The list of available fields with their options is given below.

The three aforementioned methods can be used simultaneously, in which case the smallest element size is selected at any given point.

All element sizes are further constrained by the `Mesh.CharacteristicLengthMin`, `Mesh.CharacteristicLengthMax` and `Mesh.CharacteristicLengthFactor` options (see [Section B.3 \[Mesh options list\], page 137](#))

Here are the mesh commands that are related to the specification of characteristic lengths:

Characteristic Length { *expression-list* } = *expression*;

Modify the characteristic length of the points whose identification numbers are listed in *expression-list*. The new value is given by *expression*.

Field[*expression*] = *string*;

Create a new field (with id number *expression*), of type *string*.

Field[*expression*].*string* = *char-expression* | *expression* | *expression-list*;

Set the option *string* of the *expression*-th field.

Background Field = *expression*;

Select the *expression*-th field as the one used to compute element sizes. Only one background field can be given; if you want to combine several field, use the **Min** or **Max** field (see below).

Here is the list of all available fields with their associated options:

Attractor

Compute the distance from the nearest node in a list. It can also be used to compute the distance from curves, in which case each curve is replaced by `NNodesByEdge` equidistant nodes and the distance from those nodes is computed.

Options:

EdgesList

Indices of curves in the geometric model

type: list

default value: {}

FacesList
 Indices of surfaces in the geometric model (Warning: might give strange results for complex surfaces)
 type: list
 default value: {}

NNodesByEdge
 Number of nodes used to discretized each curve
 type: integer
 default value: 20

NodesList
 Indices of nodes in the geometric model
 type: list
 default value: {}

BoundaryLayer

$F = L_{CMin}$ if $Field[IField] \leq DistMin$,
 $F = L_{CMax}$ if $Field[IField] \geq DistMax$,
 $F =$ interpolation between L_{CMin} and L_{CMax} if $DistMin < Field[IField] < DistMax$
 Options:

DistMax Distance from entity after which element size will be L_{CMax}
 type: float
 default value: 10

DistMin Distance from entity up to which element size will be L_{CMin}
 type: float
 default value: 1

IField Index of the field to evaluate
 type: integer
 default value: 0

LcMax Element size outside $DistMax$
 type: float
 default value: 1

LcMin Element size inside $DistMin$
 type: float
 default value: 0.1

Sigmoid True to interpolate between L_{CMin} and L_{CMax} using a sigmoid, false to interpolate linearly
 type: boolean
 default value: 0

StopAtDistMax
 True to not impose element size outside $DistMax$ (i.e., $F =$ a very big value if $Field[IField] > DistMax$)

	type: boolean default value: 0
Box	The value of this field is VIn inside the box, VOut outside the box. The box is given by $X_{min} \leq x \leq X_{Max} \ \&\&$ $Y_{min} \leq y \leq Y_{Max} \ \&\&$ $Z_{min} \leq z \leq Z_{Max}$ Options:
VIn	Value inside the box type: float default value: 0
VOut	Value outside the box type: float default value: 0
XMax	Maximum X coordinate of the box type: float default value: 0
XMin	Minimum X coordinate of the box type: float default value: 0
YMax	Maximum Y coordinate of the box type: float default value: 0
YMin	Minimum Y coordinate of the box type: float default value: 0
ZMax	Maximum Z coordinate of the box type: float default value: 0
ZMin	Minimum Z coordinate of the box type: float default value: 0
Curvature	Compute the curvature of Field[IField]: $F = \text{div}(\text{norm}(\text{grad}(\text{Field}[\text{IField}])))$ Options:
Delta	Step of the finite differences type: float default value: 0

	IField Field index type: integer default value: 1
Cylinder	The value of this field is VIn inside a frustrated cylinder, VOut outside. The cylinder is given by $ dX ^2 < R^2 \ \&\&$ $(X-X0).A < A ^2$ $dX = (X - X0) - ((X - X0).A)/(A ^2) \cdot A$ Options:
	Radius Radius type: float default value: 0
	VIn Value inside the cylinder type: float default value: 0
	VOut Value outside the cylinder type: float default value: 0
	XAxis X component of the cylinder axis type: float default value: 0
	XCenter X coordinate of the cylinder center type: float default value: 0
	YAxis Y component of the cylinder axis type: float default value: 0
	YCenter Y coordinate of the cylinder center type: float default value: 0
	ZAxis Z component of the cylinder axis type: float default value: 1
	ZCenter Z coordinate of the cylinder center type: float default value: 0
Gradient	Compute the finite difference gradient of Field[IField]: $F = (Field[IField](X + Delta/2) -$ $Field[IField](X - Delta/2)) / Delta$

Options:

Delta	Finite difference step type: float default value: 0
IField	Field index type: integer default value: 1
Kind	Component of the gradient to evaluate: 0 for X, 1 for Y, 2 for Z, 3 for the norm type: integer default value: 0

Laplacian

Compute finite difference the Laplacian of Field[IField]:

$$F = G(x+d,y,z) + G(x-d,y,z) + G(x,y+d,z) + G(x,y-d,z) + G(x,y,z+d) + G(x,y,z-d) - 6 * G(x,y,z),$$

where $G = \text{Field}[\text{IField}]$ and $d = \text{Delta}$

Options:

Delta	Finite difference step type: float default value: 0.1
IField	Field index type: integer default value: 1

LonLat Evaluate Field[IField] in geographic coordinates (longitude, latitude):

$$F = \text{Field}[\text{IField}](\text{atan}(y/x), \text{asin}(z/\sqrt{x^2+y^2+z^2}))$$

Options:

IField	Index of the field to evaluate. type: integer default value: 1
---------------	--

MathEval Evaluate a mathematical expression. The expression can contain x, y, z for spatial coordinates, F0, F1, ... for field values, and and mathematical functions.

Options:

	<p>F Mathematical function to evaluate. type: string default value: "F2 + Sin(z)"</p>
Max	<p>Take the maximum value of a list of fields. Options:</p> <p>FieldsList Field indices type: list default value: {}</p>
MaxEigenHessian	<p>Compute the maximum eigenvalue of the Hessian matrix of Field[IField], with the gradients evaluated by finite differences:</p> $F = \max(\text{eig}(\text{grad}(\text{grad}(\text{Field}[\text{IField}]))))$ <p>Options:</p> <p>Delta Step used for the finite differences type: float default value: 0</p> <p>IField Field index type: integer default value: 1</p>
Mean	<p>Simple smoother:</p> $F = (G(x+\text{delta},y,z) + G(x-\text{delta},y,z) + G(x,y+\text{delta},z) + G(x,y-\text{delta},z) + G(x,y,z+\text{delta}) + G(x,y,z-\text{delta}) + G(x,y,z)) / 7,$ <p>where $G=\text{Field}[\text{IField}]$ Options:</p> <p>Delta Distance used to compute the mean value type: float default value: 0.0001</p> <p>IField Field index type: integer default value: 0</p>
Min	<p>Take the minimum value of a list of fields. Options:</p>

	FieldsList Field indices type: list default value: {}
Param	Evaluate Field IField in parametric coordinates: $F = \text{Field}[\text{IField}](FX, FY, FZ)$ See the MathEval Field help to get a description of valid FX, FY and FZ expressions. Options:
	FX X component of parametric function type: string default value: ""
	FY Y component of parametric function type: string default value: ""
	FZ Z component of parametric function type: string default value: ""
	IField Field index type: integer default value: 1
PostView	Evaluate the post processing view IView. Options:
	CropNegativeValues return LC_MAX instead of a negative value (this option is needed for backward compatibility with the BackgroundMesh option) type: boolean default value: 1
	IView Post-processing view index type: integer default value: 0
Restrict	Restrict the application of a field to a given list of geometrical curves, surfaces or volumes. Options:
	EdgesList Curve indices type: list default value: {}

FacesList Surface indices
 type: list
 default value: {}

IField Field index
 type: integer
 default value: 1

RegionsList
 Volume indices
 type: list
 default value: {}

Structured

Linearly interpolate between data provided on a 3D rectangular structured grid.

The format of the input file is:

```
Ox Oy Oz
Dx Dy Dz
nx ny nz
v(0,0,0) v(0,0,1) v(0,0,2) ...
v(0,1,0) v(0,1,1) v(0,1,2) ...
v(0,2,0) v(0,2,1) v(0,2,2) ...
... ..
v(1,0,0) ... ..
```

where O are the coordinates of the first node, D are the distances between nodes in each direction, n are the numbers of nodes in each direction, and v are the values on each node.

Options:

FileName Name of the input file
 type: path
 default value: ""

TextFormat
 True for ASCII input files, false for binary files (4 bite signed integers for n, double precision floating points for v, D and O)
 type: boolean
 default value: 0

Threshold

F = LCMIn if Field[IField] <= DistMin,
 F = LCMax if Field[IField] >= DistMax,
 F = interpolation between LcMin and LcMax if DistMin < Field[IField] < DistMax

Options:

DistMax	Distance from entity after which element size will be LcMax type: float default value: 10
DistMin	Distance from entity up to which element size will be LcMin type: float default value: 1
IField	Index of the field to evaluate type: integer default value: 0
LcMax	Element size outside DistMax type: float default value: 1
LcMin	Element size inside DistMin type: float default value: 0.1
Sigmoid	True to interpolate between LcMin and LcMax using a sigmoid, false to interpolate linearly type: boolean default value: 0
StopAtDistMax	True to not impose element size outside DistMax (i.e., $F = a$ very big value if $\text{Field}[\text{IField}] > \text{DistMax}$) type: boolean default value: 0

UTM Evaluate Field[IField] in Universal Transverse Mercator coordinates.
The formulas for the coordinates transformation are taken from:

<http://www.uwgb.edu/dutchs/UsefulData/UTMFormulas.HTM>
Options:

IField	Index of the field to evaluate type: integer default value: 1
Zone	Zone of the UTM projection type: integer default value: 0

6.3.2 Structured grids

Extrude { *expression-list* } { *extrude-list layers* }

Extrudes both the geometry and the mesh using a translation (see [Section 5.1.5 \[Extrusions\]](#), page 32). The *layers* option determines how the mesh is extruded and has the following syntax:

```
layers :
  Layers { expression } |
  Layers { { expression-list }, { expression-list } } |
  Recombine; ...
```

In the first **Layers** form, *expression* gives the number of elements to be created in the (single) layer. In the second form, the first *expression-list* defines how many elements should be created in each extruded layer, and the second *expression-list* gives the normalized height of each layer (the list should contain a sequence of n numbers $0 < h1 < h2 < \dots < hn \leq 1$). See [Section A.3 \[t3.geo\]](#), page 95, for an example.

For line extrusions, the **Recombine** option will recombine triangles into quadrangles when possible. For surface extrusions, the **Recombine** option will recombine tetrahedra into prisms, hexahedra or pyramids.

Please note that, starting with Gmsh 2.0, region numbers cannot be specified explicitly anymore in **Layers** commands. Instead, as with all other geometry commands, you must use the automatically created entity identifier created by the extrusion command. For example, the following extrusion command will return the id of the new “top” surface in `num[0]` and the id of the new volume in `num[1]`:

```
num[] = Extrude {0,0,1} { Surface{1}; Layers{10}; };
```

Extrude { { *expression-list* }, { *expression-list* }, *expression* } { *extrude-list layers* }

Extrudes both the geometry and the mesh using a rotation (see [Section 5.1.5 \[Extrusions\]](#), page 32). The *layers* option is defined as above.

Extrude { { *expression-list* }, { *expression-list* }, { *expression-list* }, *expression* } { *extrude-list layers* }

Extrudes both the geometry and the mesh using a combined translation and rotation (see [Section 5.1.5 \[Extrusions\]](#), page 32). The *layers* option is defined as above.

Extrude { Surface { *expression-list* }; *layers* }

Extrudes a boundary layer along the normals of the specified surfaces.

Transfinite Line { *expression-list* } | "*" = *expression* < Using Progression | Bump *expression* >;

Selects the lines in *expression-list* to be meshed with the 1D transfinite algorithm. The *expression* on the right hand side gives the number of nodes that will be created on the line (this overrides any characteristic length prescription—see [Section 6.3.1 \[Characteristic lengths\]](#), page 37). The optional argument ‘Using Progression *expression*’ instructs the transfinite algorithm to distribute the

nodes following a geometric progression (**Progression 2** meaning for example that each line element in the series will be twice as long as the preceding one). The optional argument '**Using Bump expression**' instructs the transfinite algorithm to distribute the nodes with a refinement at both ends of the line.

Transfinite Surface { expression-list } | "*" <= { expression-list } > < Left | Right | Alternate > ;

Selects surfaces to be meshed with the 2D transfinite algorithm. The *expression-list* on the right-hand-side should contain the identification numbers of three or four points on the boundary of the surface that define the corners of the transfinite interpolation. If no identification numbers are given, the transfinite algorithm will try to find the corners automatically. The optional argument specifies the way the triangles are oriented when the mesh is not recombined.

Transfinite Volume { expression-list } | "*" <= { expression-list } > ;

Selects five- or six-face volumes to be meshed with the 3D transfinite algorithm. The *expression-list* on the right-hand-side should contain the identification numbers of the six or eight points on the boundary of the volume that define the corners of the transfinite interpolation. If no identification numbers are given, the transfinite algorithm will try to find the corners automatically.

6.3.3 Miscellaneous

Here is a list of all other mesh commands currently available:

Point | Line { expression-list } In Surface { expression } ;

Embed the point(s) or line(s) in the given surface. The surface mesh will conform to the mesh of the point(s) or lines(s). Note that embedded lines only work with the MeshAdapt 2-D algorithm.

Coherence Mesh;

Removes all duplicate mesh vertices.

Color color-expression { Point | Line | Surface | Volume { expression-list } ; ... }

Sets the mesh color of the entities in *expression-list* to *color-expression*.

Hide { Point | Line | Surface | Volume { expression-list } ; ... }

Hides the mesh of the entities in *expression-list*, if **General.VisibilityMode** is set to 0 or 2.

Hide char-expression;

Hides the mesh of the entity *char-expression*, if **General.VisibilityMode** is set to 0 or 2 (*char-expression* can for example be "*").

Recombine Surface { expression-list } | "*" <= expression > ;

Recombines the triangular meshes of the surfaces listed in *expression-list* into mixed triangular/quadrangular meshes. The optional *expression* on the right hand side specifies the maximum difference (in degrees) allowed between the largest angle of a quadrangle and a right angle (a value of 0 would only accept quadrangles with right angles; a value of 90 would allow degenerate quadrangles; default value is 45).

Save *char-expression*;

Saves the mesh in a file named *char-expression*, using the current `Mesh.Format` (see [Section B.3 \[Mesh options list\], page 137](#)). If the path in *char-expression* is not absolute, *char-expression* is appended to the path of the current file.

Show { Point | Line | Surface | Volume { *expression-list* }; ... }

Shows the mesh of the entities in *expression-list*, if `General.VisibilityMode` is set to 0 or 2.

Show *char-expression*;

Shows the mesh of the entity *char-expression*, if `General.VisibilityMode` is set to 0 or 2 (*char-expression* can for example be "*").

Smoother Surface { *expression-list* } = *expression*;

Sets number of elliptic smoothing steps for the surfaces listed in *expression-list* (smoothing only applies to transfinite meshes at the moment).

6.4 Mesh options

The list of all the options that control the behavior of mesh commands, as well as the way meshes are displayed in the GUI, is given in [Section B.3 \[Mesh options list\], page 137](#).

7 Solver module

Five external solvers can be interfaced simultaneously with Gmsh.

If you just want to start a solver from the solver module, with no further interactions between the solver and Gmsh, just edit the options relative to one of the five available solvers (e.g., `Solver.Name0`, `Solver.Executable0`, ...; see [Section B.4 \[Solver options list\]](#), page 151), and set the corresponding “client-server” option to zero (e.g., `Solver.ClientServer0 = 0`). This doesn’t require any modification to be made to the solver.

If you want the solver to interact with Gmsh (for error messages, option definitions, post-processing, etc.), you need to include ‘`GmshSocket.h`’ in your code and add the appropriate function calls inside your program. You can then proceed as in the previous case, but this time you should set the client-server option to 1 (e.g., `Solver.ClientServer0 = 1`), so that Gmsh and the solver can communicate through a Unix socket. See [Section 7.2 \[Solver example\]](#), page 51, for an example of how to interface a C++ solver. Bindings for solvers written in other languages (C, Perl and Python) are available in the source distribution.

7.1 Solver options

The list of all the solver options is given in [Section B.4 \[Solver options list\]](#), page 151.

7.2 Solver example

Here is a small example of how to interface a C++ solver with Gmsh. The following listing reproduces the ‘`utils/solvers/c++/solver.cpp`’ file from the Gmsh source distribution (C, Perl and Python examples are also available).

```
// This is a dummy C++ client solver for Gmsh: it does not solve
// anything, but shows how to program your own solver to interact with
// the Gmsh solver module.
//
// To compile this solver, type something like:
//
// g++ solver.cpp -o solver.exe
//
// To run it, merge the contents of the file solver.opt into your
// default Gmsh option file, or launch Gmsh with the command:
//
// gmsh -option solver.opt
//
// You will then see a new button labeled "My C++ solver" in Gmsh's
// solver menu.

#include <math.h>
#include "GmshSocket.h"

typedef enum { send_options, run_code } action;
```

```

int main(int argc, char *argv[])
{
    action what_to_do = run_code;
    char *name = 0, *option = 0, *socket = 0;

    // parse command line
    int i = 0;
    while(i < argc) {
        if(argv[i][0] == '-') {
            if(!strcmp(argv[i] + 1, "socket")) {
                i++;
                if(argv[i]) socket = argv[i++];
            }
            else if(!strcmp(argv[i] + 1, "options")) {
                i++;
                what_to_do = send_options;
            }
            else if(!strcmp(argv[i] + 1, "run")) {
                i++;
                what_to_do = run_code;
                if(argv[i]) option = argv[i++];
            }
        }
        else
            name = argv[i++];
    }

    if(!socket) {
        printf("No socket specified: running non-interactively...\n");
        exit(1);
    }

    // connect to Gmsh
    GmshClient client;
    if(client.Connect(socket) < 0){
        printf("Unable to connect to Gmsh\n");
        exit(1);
    }
    client.Start();

    if(what_to_do == send_options) {
        // send the available options for this computation
        client.Option(1, "FormulationH");
        client.Option(1, "ConvTest");
        client.Option(1, "Blablabli");
    }
    else if(what_to_do == run_code){

```

```

    // do the computation and merge some views
    for(int i = 0; i < 10; i++){
        client.Info("Computing curve...");
        // fake computation for 500ms:
#ifdef WIN32 || defined(__CYGWIN__)
        usleep(500 * 1000);
#else
        Sleep(500);
#endif
        client.Info("Done computing curve");
        FILE *file = fopen("solver.pos", "w");
        if(!file)
            client.Error("Unable to open output file");
        else {
            fprintf(file, "View.Type = 2;\n");
            fprintf(file, "View.Axes = 3;\n");
            fprintf(file, "Delete View[0];\n");
            fprintf(file, "View \"%s\"{\n", option);
            for(int j = 0; j < 100; j++)
                fprintf(file, "SP(%d,0,0){%g};\n", j, sin(j*i*M_PI/10.));
            fprintf(file, "};\n");
            fclose(file);
            client.MergeFile("solver.pos");
        }
    }
    client.Info("Done!");
}

client.Stop();
client.Disconnect();
}

```

To define the above solver as the second external solver in Gmsh, you then need to define the following options (either merge them in your Gmsh option file, or use the `-option` command-line option—see [Section 3.3 \[Command-line options\]](#), page 10):

```

Solver.Name1 = "My C++ Solver";
Solver.Executable1 = "./solver.exe";
Solver.InputName1 = "dummy";
Solver.OptionCommand1 = "-options";
Solver.FirstOption1 = "My options";
Solver.FirstButton1 = "Run !";
Solver.FirstButtonCommand1 = "-run %s";
Solver.ClientServer1 = 1;
Solver.MergeViews1 = 1;
Solver.PopupMessages1 = 1;

```


8 Post-processing module

Gmsh’s post-processing module can handle multiple scalar, vector or tensor datasets along with the geometry and the mesh. The datasets can be given in several formats: in human-readable “parsed” format (these are just part of a standard input script, but are usually put in separate files with a ‘.pos’ extension), in native MSH files (ASCII or binary files with ‘.msh’ extensions: see [Chapter 9 \[File formats\]](#), page 75), or in standard third-party formats (like MED: <http://www.code-aster.org/outils/med/>).

Once loaded into Gmsh, scalar fields can be displayed as iso-value lines and surfaces or color maps, whereas vector fields can be represented either by three-dimensional arrows or by displacement maps. (Tensor fields are currently displayed as Von-Mises effective stresses. To display other (combinations of) components, use `Plugin(Extract)`: see [Section 8.2 \[Post-processing plugins\]](#), page 59.)

In Gmsh’s jargon, each dataset is called a “view”. Each view is given a name, and can be manipulated either individually (each view has its own button in the GUI and can be referred to by its index in a script) or globally (see the `PostProcessing.Link` option in [Section B.5 \[Post-processing options list\]](#), page 165).

By default, Gmsh treats all post-processing views as three-dimensional plots, i.e., draws the scalar, vector and tensor primitives (points, lines, triangles, tetrahedra, etc.) in 3D space. But Gmsh can also represent each post-processing view containing *scalar points* as two-dimensional (“X-Y”) plots, either space- or time-oriented:

- in a ‘2D space’ plot, the scalar points are taken in the same order as they are defined in the post-processing view: the abscissa of the 2D graph is the curvilinear abscissa of the curve defined by the point series, and only one curve is drawn using the values associated with the points. If several time steps are available, each time step generates a new curve;
- in a ‘2D time’ plot, one curve is drawn for each scalar point in the view and the abscissa is the time step.

Although visualization is usually mostly an interactive task, Gmsh exposes all the post-processing commands and options to the user in its scripting language to permit a complete automation of the post-processing process (see e.g., [Section A.8 \[t8.geo\]](#), page 104, and [Section A.9 \[t9.geo\]](#), page 107).

The two following sections summarize all available post-processing commands and options. Most options apply to both 2D and 3D plots (colormaps, point/line sizes, interval types, time step selection, etc.), but some are peculiar to 3D (lightning, element selection, etc.) or 2D plots (abscissa labels, etc.). Note that 2D plots can be positioned explicitly inside the graphical window, or be automatically positioned in order to avoid overlaps.

Sample post-processing files in human-readable “parsed” format and in the native MSH file format are available in the ‘tutorial’ directory of Gmsh’s distribution (‘.pos’ and ‘.msh’ files). The “parsed” format is defined in the next section (cf. the `View` command); the MSH format is defined in [Chapter 9 \[File formats\]](#), page 75.

8.1 Post-processing commands

```
Alias View[expression];
```

Creates an alias of the *expression*-th post-processing view.

Note that `Alias` creates a logical duplicate of the view without actually duplicating the data in memory. This is very useful when you want multiple simultaneous renderings of the same large dataset (usually with different display options), but you cannot afford to store all copies in memory. If what you really want is multiple physical copies of the data, just merge the file containing the post-processing view multiple times.

`AliasWithOptions View[expression];`

Creates an alias of the *expression*-th post-processing view and copies all the options of the *expression*-th view to the new aliased view.

`Combine ElementsByViewName;`

Combines all the post-processing views having the same name into new views. The combination is done “spatially”, i.e., simply by appending the elements at the end of the new views.

`Combine ElementsFromAllViews | Combine Views;`

Combines all the post-processing views into a single new view. The combination is done “spatially”, i.e., simply by appending the elements at the end of the new view.

`Combine ElementsFromVisibleViews;`

Combines all the visible post-processing views into a single new view. The combination is done “spatially”, i.e., simply by appending the elements at the end of the new view.

`Combine TimeStepsByViewName | Combine TimeSteps;`

Combines the data from all the post-processing views having the same name into new multi-time-step views. The combination is done “temporally”, i.e., as if the data in each view corresponds to a different time instant. The combination will fail if the meshes in all the views are not identical.

`Combine TimeStepsFromAllViews;`

Combines the data from all the post-processing views into a new multi-time-step view. The combination is done “temporally”, i.e., as if the data in each view corresponds to a different time instant. The combination will fail if the meshes in all the views are not identical.

`Combine TimeStepsFromVisibleViews;`

Combines the data from all the visible post-processing views into a new multi-time-step view. The combination is done “temporally”, i.e., as if the data in each view corresponds to a different time instant. The combination will fail if the meshes in all the views are not identical.

`Delete View[expression];`

Deletes (removes) the *expression*-th post-processing view. Note that post-processing view numbers start at 0.

`Delete Empty Views;`

Deletes (removes) all the empty post-processing views.

Background Mesh View[*expression*];

Applies the *expression*-th post-processing view as the current background mesh.
Note that post-processing view numbers start at 0.

Plugin (*string*) . Run;

Executes the plugin *string*. The list of default plugins is given in [Section 8.2 \[Post-processing plugins\]](#), page 59.

Plugin (*string*) . *string* = *expression* | *char-expression*;

Sets an option for a given plugin. See [Section 8.2 \[Post-processing plugins\]](#), page 59, for a list of default plugins and [Section A.9 \[t9.geo\]](#), page 107, for some examples.

Save View[*expression*] *char-expression*;

Saves the the *expression*-th post-processing view in a file named *char-expression*.
If the path in *char-expression* is not absolute, *char-expression* is appended to the path of the current file.

View "*string*" { *string* < (*expression-list*) > { *expression-list* }; ... };

Creates a new post-processing view, named "*string*". This is an easy and quite powerful way to import post-processing data: all the values are *expressions*, you can embed datasets directly into your geometrical descriptions (see, e.g., [Section A.4 \[t4.geo\]](#), page 96), the data can be easily generated “on-the-fly” (there is no header containing *a priori* information on the size of the dataset). The syntax is also very permissive, which makes it ideal for testing purposes.

However this “parsed format” is read by Gmsh’s script parser, which makes it inefficient if there are many elements in the dataset. Also, there is no connectivity information in parsed views and all the elements are independent (all fields can be discontinuous), so a lot of information can be duplicated. For large datasets, you should thus use the mesh-based post-processing file format described in [Chapter 9 \[File formats\]](#), page 75, or use one of the standard formats like MED.

More explicitly, the syntax for a parsed View is the following

```
View "string" {
  type ( list-of-coords ) { list-of-values }; ...
  < TIME { expression-list }; >
  < INTERPOLATION_SCHEME { val-coef-matrix } { val-exp-matrix }
    < { geo-coef-matrix } { geo-exp-matrix } > ; >
};
```

where the 47 object types that can be displayed are:

	type	# <i>list-of-coords</i>	# <i>list-of-values</i>
Scalar point	SP	3	1 * <i>nb-time-steps</i>
Vector point	VP	3	3 * <i>nb-time-steps</i>
Tensor point	TP	3	9 * <i>nb-time-steps</i>
Scalar line	SL	6	2 * <i>nb-time-steps</i>
Vector line	VL	6	6 * <i>nb-time-steps</i>
Tensor line	TL	6	18 * <i>nb-time-steps</i>
Scalar triangle	ST	9	3 * <i>nb-time-steps</i>
Vector triangle	VT	9	9 * <i>nb-time-steps</i>

Tensor triangle	TT	9	27 * <i>nb-time-steps</i>
Scalar quadrangle	SQ	12	4 * <i>nb-time-steps</i>
Vector quadrangle	VQ	12	12 * <i>nb-time-steps</i>
Tensor quadrangle	TQ	12	36 * <i>nb-time-steps</i>
Scalar tetrahedron	SS	12	4 * <i>nb-time-steps</i>
Vector tetrahedron	VS	12	12 * <i>nb-time-steps</i>
Tensor tetrahedron	TS	12	36 * <i>nb-time-steps</i>
Scalar hexahedron	SH	24	8 * <i>nb-time-steps</i>
Vector hexahedron	VH	24	24 * <i>nb-time-steps</i>
Tensor hexahedron	TH	24	72 * <i>nb-time-steps</i>
Scalar prism	SI	18	6 * <i>nb-time-steps</i>
Vector prism	VI	18	18 * <i>nb-time-steps</i>
Tensor prism	TI	18	54 * <i>nb-time-steps</i>
Scalar pyramid	SY	15	5 * <i>nb-time-steps</i>
Vector pyramid	VY	15	15 * <i>nb-time-steps</i>
Tensor pyramid	TY	15	45 * <i>nb-time-steps</i>
2D text	T2	3	arbitrary
3D text	T3	4	arbitrary

The coordinates are given ‘by node’, i.e.,

- (*coord1*, *coord2*, *coord3*) for a point,
- (*coord1-node1*, *coord2-node1*, *coord3-node1*,
coord1-node2, *coord2-node2*, *coord3-node2*) for a line,
- (*coord1-node1*, *coord2-node1*, *coord3-node1*,
coord1-node2, *coord2-node2*, *coord3-node2*,
coord1-node3, *coord2-node3*, *coord3-node3*) for a triangle,
- etc.

The ordering of the nodes is given in [Section 9.3 \[Node ordering\]](#), page 81.

The values are given by time step, by node and by component, i.e.:

```
comp1-node1-time1, comp2-node1-time1, comp3-node1-time1,
comp1-node2-time1, comp2-node2-time1, comp3-node2-time1,
comp1-node3-time1, comp2-node3-time1, comp3-node3-time1,
comp1-node1-time2, comp2-node1-time2, comp3-node1-time2,
comp1-node2-time2, comp2-node2-time2, comp3-node2-time2,
comp1-node3-time2, comp2-node3-time2, comp3-node3-time2,
...
```

For the 2D text objects, the two first *expressions* in *list-of-coords* give the X-Y position of the string in screen coordinates, measured from the top-left corner of the window. If the first (respectively second) *expression* is negative, the position is measured from the right (respectively bottom) edge of the window. If the value of the first (respectively second) *expression* is larger than 99999, the string is centered horizontally (respectively vertically). If the third *expression* is equal to zero, the text is aligned bottom-left and displayed using the default font and size. Otherwise, the third *expression* is converted into an integer whose eight lower bits give the font size, whose eight next bits select the font (the index corresponds to the position in the font menu in the GUI), and whose eight next bits define the text alignment (0=bottom-left, 1=bottom-center, 2=bottom-right, 3=top-left, 4=top-center, 5=top-right, 6=center-left, 7=center-center, 8=center-right).

For the 3D text objects, the three first *expressions* in *list-of-coords* give the XYZ position of the string in model (real world) coordinates. The fourth *expression* has the same meaning as the third *expression* in 2D text objects.

For both 2D and 3D text objects, the *list-of-values* can contain an arbitrary number of *char-expressions*.

The optional TIME list can contain a list of expressions giving the value of the time (or any other variable) for which an evolution was saved.

The optional INTERPOLATION_SCHEME lists can contain the interpolation matrices used for high-order adaptive visualization.

Let us assume that the approximation of the view's value over an element is written as a linear combination of d basis functions $f[i]$, $i=0, \dots, d-1$ (the coefficients being stored in *list-of-values*). Defining $f[i] = \text{Sum}(j=0, \dots, d-1) F[i][j] p[j]$, with $p[j] = u^{\wedge}P[j][0] v^{\wedge}P[j][1] w^{\wedge}P[j][2]$ (u , v and w being the coordinates in the element's parameter space), then *val-coef-matrix* denotes the $d \times d$ matrix F and *val-exp-matrix* denotes the $d \times 3$ matrix P .

In the same way, let us also assume that the coordinates x , y and z of the element are obtained through a geometrical mapping from parameter space as a linear combination of m basis functions $g[i]$, $i=0, \dots, m-1$ (the coefficients being stored in *list-of-coords*). Defining $g[i] = \text{Sum}(j=0, \dots, m-1) G[i][j] q[j]$, with $q[j] = u^{\wedge}Q[j][0] v^{\wedge}Q[j][1] w^{\wedge}Q[j][2]$, then *val-coef-matrix* denotes the $m \times m$ matrix G and *val-exp-matrix* denotes the $m \times 3$ matrix Q .

Here are for example the interpolation matrices for a first order quadrangle:

```
INTERPOLATION_SCHEME
{
  {1/4,-1/4, 1/4,-1/4},
  {1/4, 1/4,-1/4,-1/4},
  {1/4, 1/4, 1/4, 1/4},
  {1/4,-1/4,-1/4, 1/4}
}
{
  {0, 0, 0},
  {1, 0, 0},
  {0, 1, 0},
  {1, 1, 0}
};
```

8.2 Post-processing plugins

Post-processing plugins permit to extend the functionality of Gmsh's post-processing module. The difference between regular post-processing options (see [Section B.5 \[Post-processing options list\]](#), page 165) and post-processing plugins is that regular post-processing options only change the way the data is displayed, while post-processing plugins either create new post-processing views, or modify the data stored in a view (in a destructive, non-reversible way).

Plugins are available in the GUI by right-clicking on a view button (or by clicking on the black arrow next to the view button) and then selecting the 'Plugin' submenu.

Here is the list of the plugins that are shipped by default with Gmsh:

Plugin(Annotate)

Plugin(Annotate) adds the text string ‘Text’, in font ‘Font’ and size ‘FontSize’, in the view ‘iView’. If ‘ThreeD’ is equal to 1, the plugin inserts the string in model coordinates at the position (‘X’,‘Y’,‘Z’). If ‘ThreeD’ is equal to 0, the plugin inserts the string in screen coordinates at the position (‘X’,‘Y’). The string is aligned according to ‘Align’. If ‘iView’ < 0, the plugin is run on the current view.

Plugin(Annotate) is executed in-place for list-based datasets or creates a new view for other datasets.

String options:

Text	Default value: "My Text"
Font	Default value: "Helvetica"
Align	Default value: "Left"

Numeric options:

X	Default value: 50
Y	Default value: 30
Z	Default value: 0
ThereD	Default value: 0
FontSize	Default value: 14
iView	Default value: -1

Plugin(Curl)

Plugin(Curl) computes the curl of the field in the view ‘iView’. If ‘iView’ < 0, the plugin is run on the current view.

Plugin(Curl) creates one new view.

Numeric options:

iView	Default value: -1
--------------	-------------------

Plugin(CutGrid)

Plugin(CutGrid) cuts the view ‘iView’ with a rectangular grid defined by the 3 points (‘X0’,‘Y0’,‘Z0’) (origin), (‘X1’,‘Y1’,‘Z1’) (axis of U) and (‘X2’,‘Y2’,‘Z2’) (axis of V). The number of points along U and V is set with the options ‘nPointsU’ and ‘nPointsV’. If ‘ConnectPoints’ is zero, the plugin creates points; otherwise, the plugin generates quadrangles, lines or points depending on the values of ‘nPointsU’ and ‘nPointsV’. If ‘iView’ < 0, the plugin is run on the current view.

Plugin(CutGrid) creates one new view.

Numeric options:

X0	Default value: 0
Y0	Default value: 0
Z0	Default value: 0

X1	Default value: 1
Y1	Default value: 0
Z1	Default value: 0
X2	Default value: 0
Y2	Default value: 1
Z2	Default value: 0
nPointsU	Default value: 20
nPointsV	Default value: 20
ConnectPoints	
	Default value: 1
iView	Default value: -1

Plugin(CutMap)

Plugin(CutMap) extracts the isosurface of value 'A' from the view 'iView' and draws the 'dTimeStep'-th value of the view 'dView' on the isosurface. If 'iView' < 0, the plugin is run on the current view. If 'dTimeStep' < 0, the plugin uses, for each time step in 'iView', the corresponding time step in 'dView'. If 'dView' < 0, the plugin uses 'iView' as the value source. If 'ExtractVolume' is nonzero, the plugin extracts the isovolume with values greater (if 'ExtractVolume' > 0) or smaller (if 'ExtractVolume' < 0) than the isosurface 'A'.

Plugin(CutMap) creates as many views as there are time steps in 'iView'.

Numeric options:

A	Default value: 0
dTimeStep	
	Default value: -1
dView	Default value: -1
ExtractVolume	
	Default value: 0
RecurLevel	
	Default value: 4
TargetError	
	Default value: 0
iView	Default value: -1

Plugin(CutParametric)

Plugin(CutParametric) cuts the view 'iView' with the parametric function ('X'(u), 'Y'(u), 'Z'(u)), using 'nPointsU' values of the parameter u in ['MinU', 'MaxU']. If 'ConnectPoints' is set, the plugin creates line elements; otherwise, the plugin generates points. If 'iView' < 0, the plugin is run on the current view.

Plugin(CutParametric) creates one new view.

String options:

X Default value: "0 + 1 * Cos(u)"
 Y Default value: "0 + 1 * Sin(u)"
 Z Default value: "0"

Numeric options:

MinU Default value: 0
 MaxU Default value: 6.2832
 nPointsU Default value: 360
 ConnectPoints
 Default value: 0
 iView Default value: -1

Plugin(CutPlane)

Plugin(CutPlane) cuts the view 'iView' with the plane ' $A * X + B * Y + C * Z + D = 0$ '. If 'ExtractVolume' is nonzero, the plugin extracts the elements on one side of the plane (depending on the sign of 'ExtractVolume'). If 'iView' < 0, the plugin is run on the current view.

Plugin(CutPlane) creates one new view.

Numeric options:

A Default value: 1
 B Default value: 0
 C Default value: 0
 D Default value: -0.01

ExtractVolume
 Default value: 0

RecurLevel
 Default value: 4

TargetError
 Default value: 0

iView Default value: -1

Plugin(CutSphere)

Plugin(CutSphere) cuts the view 'iView' with the sphere $(X - X_c)^2 + (Y - Y_c)^2 + (Z - Z_c)^2 = R^2$. If 'ExtractVolume' is nonzero, the plugin extracts the elements inside (if 'ExtractVolume' < 0) or outside (if 'ExtractVolume' > 0) the sphere. If 'iView' < 0, the plugin is run on the current view.

Plugin(CutSphere) creates one new view.

Numeric options:

Xc Default value: 0
 Yc Default value: 0

Zc Default value: 0
R Default value: 0.25
ExtractVolume
 Default value: 0
RecurLevel
 Default value: 4
iView Default value: -1

Plugin(Divergence)

Plugin(Divergence) computes the divergence of the field in the view 'iView'. If 'iView' < 0, the plugin is run on the current view.

Plugin(Divergence) creates one new view.

Numeric options:

iView Default value: -1

Plugin(Eigenvalues)

Plugin(Eigenvalues) computes the three real eigenvalues of each tensor in the view 'iView'. If 'iView' < 0, the plugin is run on the current view.

Plugin(Eigenvalues) creates three new scalar views.

Numeric options:

iView Default value: -1

Plugin(Eigenvectors)

Plugin(Eigenvectors) computes the three (right) eigenvectors of each tensor in the view 'iView' and sorts them according to the value of the associated eigenvalues. If 'ScaleByEigenvalues' is set, each eigenvector is scaled by its associated eigenvalue. The plugin gives an error if the eigenvectors are complex. If 'iView' < 0, the plugin is run on the current view.

Plugin(Eigenvectors) creates three new vector views.

Numeric options:

ScaleByEigenvalues
 Default value: 1

iView Default value: -1

Plugin(Evaluate)

Plugin(Evaluate) sets the 'Component'-th component of the 'TimeStep'-th time step in the view 'iView' to the expression 'Expression'. 'Expression' can contain:

- the usual mathematical functions (Log, Sqrt, Sin, Cos, Fabs, ...) and operators (+, -, *, /, ^);
- the symbols x, y and z, to retrieve the coordinates of the current node;
- the symbols Time and TimeStep, to retrieve the current time and time step values;
- the symbol v, to retrieve the 'Component'-th component of the field in 'iView' at the 'TimeStep'-th time step;

- the symbols `v0`, `v1`, `v2`, ..., `v8`, to retrieve each component of the field in 'iView' at the 'TimeStep'-th time step;
- the symbol `w`, to retrieve the 'Component'-th component of the field in 'ExternalView' at the 'ExternalTimeStep'-th time step. If 'ExternalView' and 'iView' are based on different spatial grids, or if their data types are different, 'ExternalView' is interpolated onto 'iView';
- the symbols `w0`, `w1`, `w2`, ..., `w8`, to retrieve each component of the field in 'ExternalView' at the 'ExternalTimeStep'-th time step.

If 'TimeStep' < 0, the plugin automatically loops over all the time steps in 'iView' and evaluates 'Expression' for each one. If 'ExternalTimeStep' < 0, the plugin uses 'TimeStep' instead. If 'Component' < 0, the plugin automatically loops over all the components in the view and evaluates 'Expression' for each one. If 'iView' < 0, the plugin is run on the current view. If 'ExternalView' < 0, the plugin uses 'iView' instead.

Plugin(Evaluate) is executed in-place.

String options:

Expression

Default value: "`v0*Sin(x)`"

Numeric options:

Component

Default value: -1

TimeStep Default value: -1

ExternalView

Default value: -1

ExternalTimeStep

Default value: -1

iView Default value: -1

Plugin(Extract)

Plugin(Extract) extracts a combination of components from the 'TimeStep'-th time step in the view 'iView'. If only 'Expression0' is given (and 'Expression1', ..., 'Expression8' are all empty), the plugin creates a scalar view. If 'Expression0', 'Expression1' and/or 'Expression2' are given (and 'Expression3', ..., 'Expression8' are all empty) the plugin creates a vector view. Otherwise the plugin creates a tensor view. In addition to the usual mathematical functions (Exp, Log, Sqrt, Sin, Cos, Fabs, etc.) and operators (+, -, *, /, ^), all expressions can contain the symbols `v0`, `v1`, `v2`, ..., `vn`, which represent the `n` components of the field, and the symbols `x`, `y` and `z`, which represent the three spatial coordinates. If 'TimeStep' < 0, the plugin extracts data from all the time steps in the view. If 'iView' < 0, the plugin is run on the current view.

Plugin(Extract) creates one new view.

String options:

Expression0
Default value: " $\text{Sqrt}(v_0^2+v_1^2+v_2^2)$ "

Expression1
Default value: ""

Expression2
Default value: ""

Expression3
Default value: ""

Expression4
Default value: ""

Expression5
Default value: ""

Expression6
Default value: ""

Expression7
Default value: ""

Expression8
Default value: ""

Numeric options:

TimeStep Default value: -1

iView Default value: -1

Plugin(ExtractElements)

Plugin(ExtractElements) extracts the elements from the view 'iView' whose 'TimeStep'-th values (averaged by element) are comprised between 'MinVal' and 'MaxVal'. If 'iView' < 0, the plugin is run on the current view.

Plugin(ExtractElements) creates one new view.

Numeric options:

MinVal Default value: 0

MaxVal Default value: 1

TimeStep Default value: 0

iView Default value: -1

Plugin(FieldView)

Plugin(FieldView) evaluates a field on the choosen view.

Numeric options:

Component

Default value: -1

iView Default value: -1

iField Default value: -1

Plugin(FiniteElement)

Plugin(FiniteElement) solves simple PDEs using the finite element method. This is only intended as a demonstration tool: it is NOT intended for general use. Plugin(FiniteElement) creates a new view.

String options:

Equation Default value: "Projection"

Parameter
 Default value: "Sin(x*y)"

Gamma1BC Default value: ""

Gamma2BC Default value: ""

Numeric options:

Omega Default value: 1

Gamma1 Default value: 0

Gamma1Value
 Default value: 0

Gamma2 Default value: 0

Gamma2Value
 Default value: 0

Plugin(GSHHS)

Plugin(GSHHS) read different kind of contour lines data and write a .geo file on the surface of a sphere (the Earth). The principal application is to load GSHHS data (see <http://www.soest.hawaii.edu/wessel/gshhs/gshhs.html>). Valid values for "Format" are): -"gshhs" : open GSHHS file -"loops2" : import 2D contour lines in simple text format : NB_POINTS_IN_FIRST_LOOP FIRST_LOOP_IS_CLOSED COORD1 COORD2 COORD1 COORD2 ... NB_POINTS_IN_SECOND_LOOP SECOND_LOOP_IS_CLOSED ... (LOOP_IS_CLOSED specify if this coast line describe a closed curve (0=no, 1=yes). In the case of "loops2" format, you can specify the the coordinate system used in the input file with the "Coordinate" option, valid values are -"lonlat" for longitude-latitude radian, -"lonlat_degrees" for longitude-latitude degrees, -"UTM" for universal transverse mercator ("UTMZone" option should be specified) -"cartesian" for full 3D coordinates -"radius" specify the earth radius. If the "iField" option is set, consecutive points closer than the value of the field iField (in meters) will not be added. If "MinStraitsFactor" >0 and if a field iField is provided, coastlines closer than MinStraitsFactor*field(iField) are merged and inner corners which form an angle < pi/3 are removed. The output is always in stereographic coordinates, if the "WritePolarSphere" option is not 0, a sphere is added to the geo file. WARNING : this plugin is still experimental and need polishing and error-handling. In particular, it will probably crash if an inexistant field id is given or if the input/output cannot be open.

String options:

```

InFileName
    Default value: "gshhs_c.b"

OutFileName
    Default value: "earth.geo"

Format    Default value: "gshhs"

Coordinate
    Default value: "cartesian"

Numeric options:

iField    Default value: -1

UTMZone   Default value: 0

UTMEquatorialRadius
    Default value: 6.37814e+06

UTMPolarRadius
    Default value: 6.35675e+06

radius    Default value: 6.37101e+06

WritePolarSphere
    Default value: 1

MinStraitsFactor
    Default value: 1

```

Plugin(Gradient)

Plugin(Gradient) computes the gradient of the field in the view 'iView'. If 'iView' < 0, the plugin is run on the current view.

Plugin(Gradient) creates one new view.

Numeric options:

```
iView    Default value: -1
```

Plugin(HarmonicToTime)

Plugin(HarmonicToTime) takes the values in the time steps 'RealPart' and 'ImaginaryPart' of the view 'iView', and creates a new view containing $(\text{'iView'}[\text{'RealPart'}] * \cos(p) - \text{'iView'}[\text{'ImaginaryPart'}] * \sin(p))$, with $p = 2 * \pi * k / \text{'nSteps'}$, $k = 0, \dots, \text{'nSteps'} - 1$. If 'iView' < 0, the plugin is run on the current view.

Plugin(HarmonicToTime) creates one new view.

Numeric options:

```
RealPart  Default value: 0
```

```
ImaginaryPart
    Default value: 1
```

```
nSteps    Default value: 20
```

```
iView     Default value: -1
```

Plugin(HomologyComputation)

Plugin(HomologyComputation) computes generators for (relative) homology groups and their thick cuts.

Plugin(HomologyComputation) creates new views.

String options:

Filename Default value: "homology.msh"

Numeric options:

PhysicalGroupForDomain1
Default value: 0

PhysicalGroupForDomain2
Default value: 0

PhysicalGroupForSubdomain1
Default value: 0

PhysicalGroupForSubdomain2
Default value: 0

ComputeGenerators
Default value: 1

ComputeDualGenerators
Default value: 0

ComputeBettiNumbers
Default value: 0

Plugin(Integrate)

Plugin(Integrate) integrates scalar fields over all the elements in the view 'iView', as well as the circulation/flux of vector fields over line/surface elements. If 'iView' < 0, the plugin is run on the current view.

Plugin(Integrate) creates one new view.

Numeric options:

iView Default value: -1

Plugin(Lambda2)

Plugin(Lambda2) computes the eigenvalues $\Lambda(1,2,3)$ of the tensor $(S_{ik}S_{kj} + \Omega_{ik}\Omega_{kj})$, where $S_{ij} = 0.5(u_{i,j} + u_{j,i})$ and $\Omega_{ij} = 0.5(u_{i,j} - u_{j,i})$ are respectively the symmetric and antisymmetric parts of the velocity gradient tensor. Vortices are well represented by regions where $\Lambda(2)$ is negative. If 'iView' contains tensor elements, the plugin directly uses the tensors as the values of the velocity gradient tensor; if 'iView' contains vector elements, the plugin uses them as the velocities from which to derive the velocity gradient tensor. If 'iView' < 0, the plugin is run on the current view.

Plugin(Lambda2) creates one new view.

Numeric options:

Eigenvalue
Default value: 2

`iView` Default value: -1

`Plugin(LongitudeLatitude)`

`Plugin(LongitudeLatitude)` Project the view 'iView' in Longitude-Latitude. If 'iView' < 0, the plugin is run on the current view.

`Plugin(LongitudeLatitude)` is executed in place.

Numeric options:

`iView` Default value: -1

`Plugin(MakeSimplex)`

`Plugin(MakeSimplex)` decomposes all non- simplectic elements (quadrangles, prisms, hexahedra, pyramids) in the view 'iView' into simplices (triangles, tetrahedra). If 'iView' < 0, the plugin is run on the current view.

`Plugin(MakeSimplex)` is executed in-place.

Numeric options:

`iView` Default value: -1

`Plugin(ModulusPhase)`

`Plugin(ModulusPhase)` interprets the time steps 'realPart' and 'imaginaryPart' in the view 'iView' as the real and imaginary parts of a complex field and replaces them with their corresponding modulus and phase. If 'iView' < 0, the plugin is run on the current view.

`Plugin(ModulusPhase)` is executed in-place.

Numeric options:

`RealPart` Default value: 0

`ImaginaryPart`
Default value: 1

`iView` Default value: -1

`Plugin(Probe)`

`Plugin(Probe)` gets the value of the view 'iView' at the point ('X','Y','Z'). If 'iView' < 0, the plugin is run on the current view.

`Plugin(Probe)` creates one new view.

Numeric options:

`X` Default value: 0

`Y` Default value: 0

`Z` Default value: 0

`iView` Default value: -1

`Plugin(Remove)`

`Plugin(Remove)` removes the marked items from the view 'iView'. If 'iView' < 0, the plugin is run on the current view.

`Plugin(Remove)` is executed in-place.

Numeric options:

```

Text2D      Default value: 1
Text3D      Default value: 1
Points      Default value: 0
Lines       Default value: 0
Triangles   Default value: 0
Quadrangles Default value: 0
Tetrahedra  Default value: 0
Hexahedra   Default value: 0
Prisms      Default value: 0
Pyramids    Default value: 0
Scalar      Default value: 1
Vector      Default value: 1
Tensor      Default value: 1
iView       Default value: -1

```

Plugin(Skin)

Plugin(Skin) extracts the skin (the boundary) of the view 'iView'. If 'iView' < 0, the plugin is run on the current view.

Plugin(Skin) creates one new view.

Numeric options:

```
iView      Default value: -1
```

Plugin(Smooth)

Plugin(Smooth) averages the values at the nodes of the scalar view 'iView'. If 'iView' < 0, the plugin is run on the current view.

Plugin(Smooth) is executed in-place.

Numeric options:

```
iView      Default value: -1
```

Plugin(SphericalRaise)

Plugin(SphericalRaise) transforms the coordinates of the elements in the view 'iView' using the values associated with the 'TimeStep'-th time step. Instead of elevating the nodes along the X, Y and Z axes as in View['iView'].RaiseX, View['iView'].RaiseY and View['iView'].RaiseZ, the raise is applied along the radius of a sphere centered at ('Xc', 'Yc', 'Zc'). To produce a standard radiation pattern, set 'Offset' to minus the radius of the sphere the original data lives on. If 'iView' < 0, the plugin is run on the current view.

Plugin(SphericalRaise) is executed in-place.

Numeric options:

Xc	Default value: 0
Yc	Default value: 0
Zc	Default value: 0
Raise	Default value: 1
Offset	Default value: 0
TimeStep	Default value: 0
iView	Default value: -1

Plugin(StreamLines)

Plugin(StreamLines) computes stream lines from the 'TimeStep'-th time step of a vector view 'iView' and optionally interpolates the scalar view 'dView' on the resulting stream lines. The plugin takes as input a grid defined by the 3 points ('X0','Y0','Z0') (origin), ('X1','Y1','Z1') (axis of U) and ('X2','Y2','Z2') (axis of V). The number of points that are to be transported along U and V is set with the options 'nPointsU' and 'nPointsV'. The equation $DX(t)/dt=V(x,y,z)$ is then solved with the initial condition $X(t=0)$ chosen as the grid and with $V(x,y,z)$ interpolated on the vector view. The time stepping scheme is a RK44 with step size 'DT' and 'MaxIter' maximum number of iterations. If 'iView' < 0, the plugin is run on the current view. If 'TimeStep' < 0, the plugin tries to compute streamlines of the unsteady flow.

Plugin(StreamLines) creates one new view. This view contains multi-step vector points if 'dView' < 0, or single-step scalar lines if 'dView' >= 0.

Numeric options:

X0	Default value: 0
Y0	Default value: 0
Z0	Default value: 0
X1	Default value: 1
Y1	Default value: 0
Z1	Default value: 0
X2	Default value: 0
Y2	Default value: 1
Z2	Default value: 0
nPointsU	Default value: 10
nPointsV	Default value: 1
MaxIter	Default value: 100
DT	Default value: 0.1

TimeStep Default value: 0
dView Default value: -1
iView Default value: -1

Plugin(Transform)

Plugin(Transform) transforms the homogeneous node coordinates (x,y,z,1) of the elements in the view 'iView' by the matrix ['A11' 'A12' 'A13' 'Tx'] ['A21' 'A22' 'A23' 'Ty'] ['A31' 'A32' 'A33' 'Tz']. If 'SwapOrientation' is set, the orientation of the elements is reversed. If 'iView' < 0, the plugin is run on the current view.

Plugin(Transform) is executed in-place.

Numeric options:

A11 Default value: 1
A12 Default value: 0
A13 Default value: 0
A21 Default value: 0
A22 Default value: 1
A23 Default value: 0
A31 Default value: 0
A32 Default value: 0
A33 Default value: 1
Tx Default value: 0
Ty Default value: 0
Tz Default value: 0
SwapOrientation
 Default value: 0
iView Default value: -1

Plugin(Triangulate)

Plugin(Triangulate) triangulates the points in the view 'iView', assuming that all the points belong to a surface that can be projected one-to-one onto a plane. If 'iView' < 0, the plugin is run on the current view.

Plugin(Triangulate) creates one new view.

Numeric options:

iView Default value: -1

Plugin(Warp)

Plugin(Warp) transforms the elements in the view 'iView' by adding to their node coordinates the vector field stored in the 'TimeStep'-th time step of the view 'dView', scaled by 'Factor'. If 'dView' < 0, the vector field is taken as

the field of surface normals multiplied by the ‘TimeStep’ value in ‘iView’. (The smoothing of the surface normals is controlled by the ‘SmoothingAngle’ parameter.) If ‘iView’ < 0, the plugin is run on the current view.

Plugin(Warp) is executed in-place.

Numeric options:

Factor Default value: 1

TimeStep Default value: 0

SmoothingAngle
 Default value: 180

dView Default value: -1

iView Default value: -1

8.3 Post-processing options

General post-processing option names have the form ‘PostProcessing.string’. Options peculiar to post-processing views take two forms.

1. options that should apply to all views can be set through ‘View.string’, *before any view is loaded*;
2. options that should apply only to the n -th view take the form ‘View[n].string’ ($n = 0, 1, 2, \dots$), *after the n -th view is loaded*.

The list of all post-processing and view options is given in [Section B.5 \[Post-processing options list\]](#), page 165. See [Section A.8 \[t8.geo\]](#), page 104, and [Section A.9 \[t9.geo\]](#), page 107, for some examples.

9 File formats

This chapter describes Gmsh’s native “MSH” file format, used to store meshes and associated post-processing datasets. The MSH format exists in two flavors: ASCII and binary. The format has a version number (currently: 2.1) that is independent of Gmsh’s main version number.

(Remember that for small post-processing datasets you can also use human-readable “parsed” post-processing views, as described in [Section 8.1 \[Post-processing commands\]](#), [page 55](#). Such “parsed” views do not require an underlying mesh, and can therefore be easier to use in some cases.)

9.1 MSH ASCII file format

The MSH ASCII file format contains one mandatory section giving information about the file (`$MeshFormat`), followed by several optional sections defining the nodes (`$Nodes`), elements (`$Elements`), region names (`$PhysicalName`) and post-processing datasets (`$NodeData`, `$ElementData`, `$ElementNodeData`).

Any section with an unrecognized header is simply ignored: you can thus add comments in a ‘.msh’ file by putting them e.g. inside a `$Comments/$EndComments` section.

Sections can be repeated in the same file, and post-processing sections can be put into separate files (e.g. one file per time step).

The format is defined as follows:

```

$MeshFormat
version-number file-type data-size
$EndMeshFormat
$Nodes
number-of-nodes
node-number x-coord y-coord z-coord
...
$EndNodes
$Elements
number-of-elements
elm-number elm-type number-of-tags < tag > ... node-number-list
...
$EndElements
$PhysicalNames
number-of-names
physical-dimension physical-number "physical-name"
...
$EndPhysicalNames
$NodeData
number-of-string-tags
< "string-tag" >
...
number-of-real-tags
< real-tag >

```

```

...
number-of-integer-tags
< integer-tag >
...
node-number value ...
...
$EndNodeData
$ElementData
number-of-string-tags
< "string-tag" >
...
number-of-real-tags
< real-tag >
...
number-of-integer-tags
< integer-tag >
...
elm-number value ...
...
$EndElementData
$ElementNodeData
number-of-string-tags
< "string-tag" >
...
number-of-real-tags
< real-tag >
...
number-of-integer-tags
< integer-tag >
...
elm-number number-of-nodes-per-element value ...
...
$ElementEndNodeData

```

where

version-number

is a real number equal to 2.1

file-type

is an integer equal to 0 in the ASCII file format.

data-size

is an integer equal to the size of the floating point numbers used in the file (currently only *data-size* = sizeof(double) is supported).

number-of-nodes

is the number of nodes in the mesh.

node-number

is the number (index) of the n -th node in the mesh; *node-number* must be a positive (non-zero) integer. Note that the *node-numbers* do not necessarily have to form a dense nor an ordered sequence.

x-coord y-coord z-coord

are the floating point values giving the X, Y and Z coordinates of the n -th node.

number-of-elements

is the number of elements in the mesh.

elm-number

is the number (index) of the n -th element in the mesh; *elm-number* must be a positive (non-zero) integer. Note that the *elm-numbers* do not necessarily have to form a dense nor an ordered sequence.

elm-type defines the geometrical type of the n -th element:

- | | |
|----|--|
| 1 | 2-node line. |
| 2 | 3-node triangle. |
| 3 | 4-node quadrangle. |
| 4 | 4-node tetrahedron. |
| 5 | 8-node hexahedron. |
| 6 | 6-node prism. |
| 7 | 5-node pyramid. |
| 8 | 3-node second order line (2 nodes associated with the vertices and 1 with the edge). |
| 9 | 6-node second order triangle (3 nodes associated with the vertices and 3 with the edges). |
| 10 | 9-node second order quadrangle (4 nodes associated with the vertices, 4 with the edges and 1 with the face). |
| 11 | 10-node second order tetrahedron (4 nodes associated with the vertices and 6 with the edges). |
| 12 | 27-node second order hexahedron (8 nodes associated with the vertices, 12 with the edges, 6 with the faces and 1 with the volume). |
| 13 | 18-node second order prism (6 nodes associated with the vertices, 9 with the edges and 3 with the quadrangular faces). |
| 14 | 14-node second order pyramid (5 nodes associated with the vertices, 8 with the edges and 1 with the quadrangular face). |
| 15 | 1-node point. |
| 16 | 8-node second order quadrangle (4 nodes associated with the vertices and 4 with the edges). |

17	20-node second order hexahedron (8 nodes associated with the vertices and 12 with the edges).
18	15-node second order prism (6 nodes associated with the vertices and 9 with the edges).
19	13-node second order pyramid (5 nodes associated with the vertices and 8 with the edges).
20	9-node third order incomplete triangle (3 nodes associated with the vertices, 6 with the edges)
21	10-node third order triangle (3 nodes associated with the vertices, 6 with the edges, 1 with the face)
22	12-node fourth order incomplete triangle (3 nodes associated with the vertices, 9 with the edges)
23	15-node fourth order triangle (3 nodes associated with the vertices, 9 with the edges, 3 with the face)
24	15-node fifth order incomplete triangle (3 nodes associated with the vertices, 12 with the edges)
25	21-node fifth order complete triangle (3 nodes associated with the vertices, 12 with the edges, 6 with the face)
26	4-node third order edge (2 nodes associated with the vertices, 2 internal to the edge)
27	5-node fourth order edge (2 nodes associated with the vertices, 3 internal to the edge)
28	6-node fifth order edge (2 nodes associated with the vertices, 4 internal to the edge)
29	20-node third order tetrahedron (4 nodes associated with the vertices, 12 with the edges, 4 with the faces)
30	35-node fourth order tetrahedron (4 nodes associated with the vertices, 18 with the edges, 12 with the faces, 1 in the volume)
31	56-node fifth order tetrahedron (4 nodes associated with the vertices, 24 with the edges, 24 with the faces, 4 in the volume)

See below for the ordering of the nodes.

number-of-tags

gives the number of integer tags that follow for the n -th element. By default, the first *tag* is the number of the physical entity to which the element belongs; the second is the number of the elementary geometrical entity to which the element belongs; the third is the number of a mesh partition to which the element belongs. All tags must be positive integers, or zero. A zero tag is equivalent to no tag.

node-number-list

is the list of the node numbers of the n -th element. The ordering of the nodes is given in [Section 9.3 \[Node ordering\]](#), page 81.

number-of-string-tags

gives the number of string tags that follow. By default the first *string-tag* is interpreted as the name of the post-processing view.

number-of-real-tags

gives the number of real number tags that follow. By default the first *real-tag* is interpreted as a time value associated with the dataset.

number-of-integer-tags

gives the number of integer tags that follow. By default the first *integer-tag* is interpreted as a time step index (starting at 0), the second as the number of field components of the data in the view (1, 3 or 9), the third as the number of entities (nodes or elements) in the view, and the fourth as the partition index for the view data (0 for no partition).

number-of-nodes-per-elements

gives the number of node values for an element in an element-based view.

value is a real number giving the value associated with a node or an element. For *NodeData* (respectively *ElementData*) views, there are *ncomp* values per node (resp. per element), where *ncomp* is the number of field components. For *ElementNodeData* views, there are *ncomp* times *number-of-nodes-per-elements* values per element.

Below is a small example (a mesh consisting of two quadrangles with an associated nodal scalar dataset; the comments are not part of the actual file!):

```

$MeshFormat
2.1 0 8
$EndMeshFormat
$Nodes
6
1 0.0 0.0 0.0
2 1.0 0.0 0.0
3 1.0 1.0 0.0
4 0.0 1.0 0.0
5 2.0 0.0 0.0
6 2.0 1.0 0.0
$EndNodes
$Elements
2
1 3 2 99 2 1 2 3 4
2 3 2 99 2 2 5 6 3
$EndElements
$NodeData
1
"A scalar view"
1
0.0
3
0
1
6
1 0.0
2 0.1
3 0.2
4 0.0

```

six mesh nodes:
node #1: coordinates (0.0, 0.0, 0.0)
node #2: coordinates (1.0, 0.0, 0.0)
etc.

two elements:
quad #1: type 3, physical 99, elementary 2, nodes 1 2 3 4
quad #2: type 3, physical 99, elementary 2, nodes 2 5 6 3

one string tag:
the name of the view ("A scalar view")

one real tag:
the time value (0.0)

three integer tags:
the time step (0; time steps always start at 0)
1-component (scalar) field
six associated nodal values
value associated with node #1 (0.0)
value associated with node #2 (0.1)
etc.

```

5 0.2
6 0.4
$EndNodeData

```

9.2 MSH binary file format

The binary file format is similar to the ASCII format described above:

```

$MeshFormat
version-number file-type data-size
one-binary
$EndMeshFormat
$Nodes
number-of-nodes
nodes-binary
$EndNodes
$Elements
number-of-elements
element-header-binary
elements-binary
element-header-binary
elements-binary
...
$EndElements

```

[all other sections are identical to ASCII, except that *node-number*, *elm-number*, *number-of-nodes-per-element* and *values* are written in binary format]

where

version-number

is a real number equal to 2.1.

file-type

is an integer equal to 1.

data-size

has the same meaning as in the ASCII file format. Currently only *data-size* = sizeof(double) is supported.

one-binary

is an integer of value 1 written in binary form. This integer is used for detecting if the computer on which the binary file was written and the computer on which the file is read are of the same type (little or big endian).

Here is a pseudo C code to write *one-binary*:

```

int one = 1;
fwrite(&one, sizeof(int), 1, file);

```

number-of-nodes

has the same meaning as in the ASCII file format.

nodes-binary

is the list of nodes in binary form, i.e., a array of *number-of-nodes* * (4 + 3 * *data-size*) bytes. For each node, the first 4 bytes contain the node number and the next (3 * *data-size*) bytes contain the three floating point coordinates.

Here is a pseudo C code to write *nodes-binary*:

```
for(i = 0; i < number_of_nodes; i++){
    fwrite(&num_i, sizeof(int), 1, file);
    double xyz[3] = {node_i_x, node_i_y, node_i_z};
    fwrite(&xyz, sizeof(double), 3, file);
}
```

number-of-elements

has the same meaning as in the ASCII file format.

element-header-binary

is a list of 3 integers in binary form, i.e., an array of (3 * 4) bytes: the first four bytes contain the type of the elements that follow (same as *elm-type* in the ASCII format), the next four contain the number of elements that follow, and the last four contain the number of tags per element (same as *number-of-tags* in the ASCII format).

Here is a pseudo C code to write *element-header-binary*:

```
int header[3] = {elm_type, num_elm_follow, num_tags};
fwrite(&header, sizeof(int), 3, file);
```

elements-binary

is a list of elements in binary form, i.e., an array of “number of elements that follow” * (4 + *number-of-tags* * 4 + *#node-number-list* * 4) bytes. For each element, the first four bytes contain the element number, the next (*number-of-tags* * 4) contain the tags, and the last (*#node-number-list* * 4) contain the node indices.

Here is a pseudo C code to write *elements-binary* for triangles with the 3 standard tags (the physical and elementary regions, and the mesh partition):

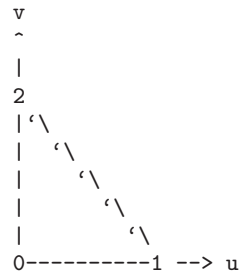
```
for(i = 0; i < number_of_triangles; i++){
    int data[7] = {num_i, physical, elementary, partition,
                  node_i_1, node_i_2, node_i_3};
    fwrite(data, sizeof(int), 7, file);
}
```

9.3 Node ordering

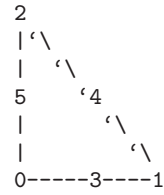
For all mesh and post-processing file formats, the reference elements are defined as follows.

Line:	Line3:	Line4:
0-----1 --> u	0-----2-----1	0----2-----3----1

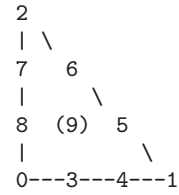
Triangle:



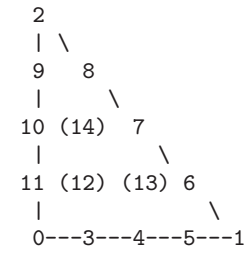
Triangle6:



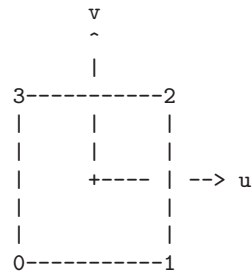
Triangle9/10:



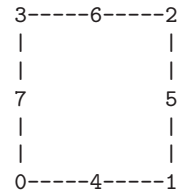
Triangle12/15:



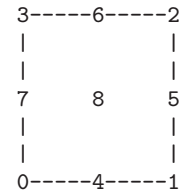
Quadrangle:



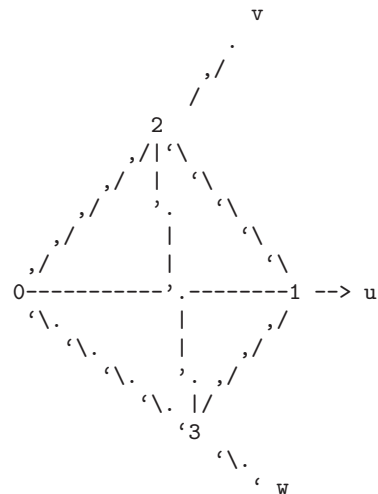
Quadrangle8:



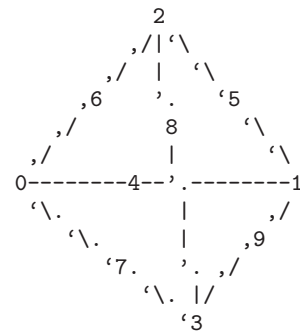
Quadrangle9:



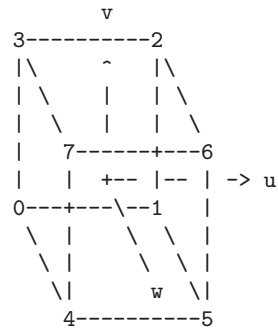
Tetrahedron:



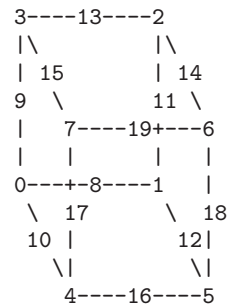
Tetrahedron10:



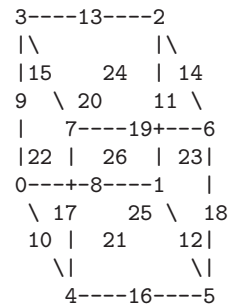
Hexahedron:



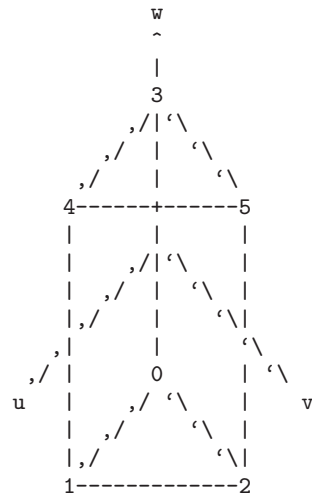
Hexahedron20:



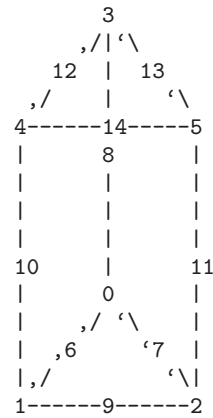
Hexahedron27:



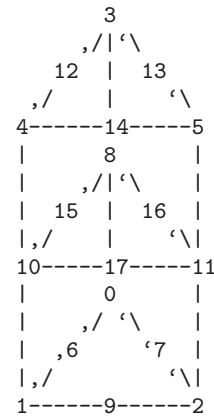
Prism:



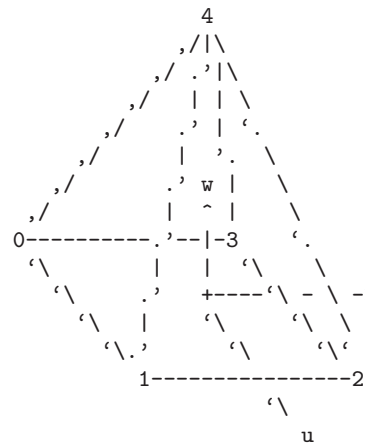
Prism15:



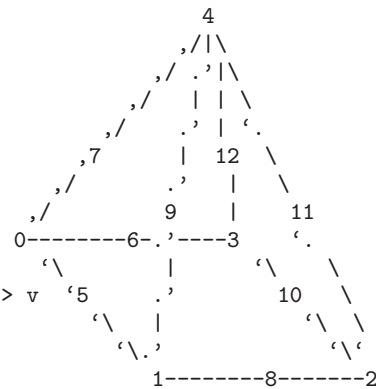
Prism18:



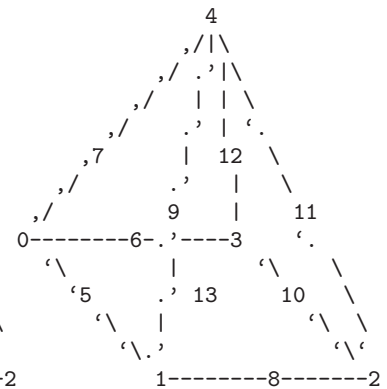
Pyramid:



Pyramid13:



Pyramid14:



The nodes of a curved element are numbered in the following order:

- the element principal vertices;
- the internal nodes for each edge;

- the internal nodes for each face;
- the volume internal nodes.

The numbering for face and volume internal nodes is recursive, i.e., the numbering follows that of the nodes of an embedded face/volume. The higher order nodes are assumed to be equispaced on the element.

9.4 Legacy formats

This section describes Gmsh's older native file formats. Future versions of Gmsh will continue to support these formats, but we recommend that you do not use them in new applications.

9.4.1 MSH file format version 1.0 (Legacy)

The MSH file format version 1.0 is Gmsh's old native mesh file format, now superseded by the format described in [Section 9.1 \[MSH ASCII file format\]](#), [page 75](#). It is defined as follows:

```
$NOD
  number-of-nodes
  node-number x-coord y-coord z-coord
  ...
$ENDNOD
$ELM
  number-of-elements
  elm-number elm-type reg-phys reg-elem number-of-nodes node-number-list
  ...
$ENDELM
```

where

number-of-nodes
is the number of nodes in the mesh.

node-number
is the number (index) of the *n*-th node in the mesh; *node-number* must be a positive (non-zero) integer. Note that the *node-numbers* do not necessarily have to form a dense nor an ordered sequence.

x-coord y-coord z-coord
are the floating point values giving the X, Y and Z coordinates of the *n*-th node.

number-of-elements
is the number of elements in the mesh.

elm-number
is the number (index) of the *n*-th element in the mesh; *elm-number* must be a positive (non-zero) integer. Note that the *elm-numbers* do not necessarily have to form a dense nor an ordered sequence.

elm-type defines the geometrical type of the *n*-th element:

1 2-node line.

2	3-node triangle.
3	4-node quadrangle.
4	4-node tetrahedron.
5	8-node hexahedron.
6	6-node prism.
7	5-node pyramid.
8	3-node second order line (2 nodes associated with the vertices and 1 with the edge).
9	6-node second order triangle (3 nodes associated with the vertices and 3 with the edges).
10	9-node second order quadrangle (4 nodes associated with the vertices, 4 with the edges and 1 with the face).
11	10-node second order tetrahedron (4 nodes associated with the vertices and 6 with the edges).
12	27-node second order hexahedron (8 nodes associated with the vertices, 12 with the edges, 6 with the faces and 1 with the volume).
13	18-node second order prism (6 nodes associated with the vertices, 9 with the edges and 3 with the quadrangular faces).
14	14-node second order pyramid (5 nodes associated with the vertices, 8 with the edges and 1 with the quadrangular face).
15	1-node point.
16	8-node second order quadrangle (4 nodes associated with the vertices and 4 with the edges).
17	20-node second order hexahedron (8 nodes associated with the vertices and 12 with the edges).
18	15-node second order prism (6 nodes associated with the vertices and 9 with the edges).
19	13-node second order pyramid (5 nodes associated with the vertices and 8 with the edges).

See below for the ordering of the nodes.

reg-phys is the number of the physical entity to which the element belongs; *reg-phys* must be a positive integer, or zero. If *reg-phys* is equal to zero, the element is considered not to belong to any physical entity.

reg-elem is the number of the elementary entity to which the element belongs; *reg-elem* must be a positive (non-zero) integer.

number-of-nodes

is the number of nodes for the *n*-th element. This is redundant, but kept for backward compatibility.

node-number-list

is the list of the *number-of-nodes* node numbers of the *n*-th element. The ordering of the nodes is given in [Section 9.3 \[Node ordering\]](#), page 81.

9.4.2 POS ASCII file format (Legacy)

The POS ASCII file is Gmsh's old native post-processing format, now superseded by the format described in [Section 9.1 \[MSH ASCII file format\]](#), page 75. It is defined as follows:

```
$PostFormat
1.4 file-type data-size
$EndPostFormat
$View
view-name nb-time-steps
nb-scalar-points nb-vector-points nb-tensor-points
nb-scalar-lines nb-vector-lines nb-tensor-lines
nb-scalar-triangles nb-vector-triangles nb-tensor-triangles
nb-scalar-quadrangles nb-vector-quadrangles nb-tensor-quadrangles
nb-scalar-tetrahedra nb-vector-tetrahedra nb-tensor-tetrahedra
nb-scalar-hexahedra nb-vector-hexahedra nb-tensor-hexahedra
nb-scalar-prisms nb-vector-prisms nb-tensor-prisms
nb-scalar-pyramids nb-vector-pyramids nb-tensor-pyramids
nb-scalar-lines2 nb-vector-lines2 nb-tensor-lines2
nb-scalar-triangles2 nb-vector-triangles2 nb-tensor-triangles2
nb-scalar-quadrangles2 nb-vector-quadrangles2 nb-tensor-quadrangles2
nb-scalar-tetrahedra2 nb-vector-tetrahedra2 nb-tensor-tetrahedra2
nb-scalar-hexahedra2 nb-vector-hexahedra2 nb-tensor-hexahedra2
nb-scalar-prisms2 nb-vector-prisms2 nb-tensor-prisms2
nb-scalar-pyramids2 nb-vector-pyramids2 nb-tensor-pyramids2
nb-text2d nb-text2d-chars nb-text3d nb-text3d-chars
time-step-values
< scalar-point-value > ... < vector-point-value > ...
    < tensor-point-value > ...
< scalar-line-value > ... < vector-line-value > ...
    < tensor-line-value > ...
< scalar-triangle-value > ... < vector-triangle-value > ...
    < tensor-triangle-value > ...
< scalar-quadrangle-value > ... < vector-quadrangle-value > ...
    < tensor-quadrangle-value > ...
< scalar-tetrahedron-value > ... < vector-tetrahedron-value > ...
    < tensor-tetrahedron-value > ...
< scalar-hexahedron-value > ... < vector-hexahedron-value > ...
    < tensor-hexahedron-value > ...
< scalar-prism-value > ... < vector-prism-value > ...
    < tensor-prism-value > ...
< scalar-pyramid-value > ... < vector-pyramid-value > ...
    < tensor-pyramid-value > ...
< scalar-line2-value > ... < vector-line2-value > ...
```



```

    < tensor-line2-value > ...
  < scalar-triangle2-value > ... < vector-triangle2-value > ...
    < tensor-triangle2-value > ...
  < scalar-quadrangle2-value > ... < vector-quadrangle2-value > ...
    < tensor-quadrangle2-value > ...
  < scalar-tetrahedron2-value > ... < vector-tetrahedron2-value > ...
    < tensor-tetrahedron2-value > ...
  < scalar-hexahedron2-value > ... < vector-hexahedron2-value > ...
    < tensor-hexahedron2-value > ...
  < scalar-prism2-value > ... < vector-prism2-value > ...
    < tensor-prism2-value > ...
  < scalar-pyramid2-value > ... < vector-pyramid2-value > ...
    < tensor-pyramid2-value > ...
  < text2d > ... < text2d-chars > ...
  < text3d > ... < text3d-chars > ...
$EndView

```

where

file-type

is an integer equal to 0 in the ASCII file format.

data-size

is an integer equal to the size of the floating point numbers used in the file (usually, *data-size* = sizeof(double)).

view-name

is a string containing the name of the view (max. 256 characters).

nb-time-steps

is an integer giving the number of time steps in the view.

nb-scalar-points

nb-vector-points

... are integers giving the number of scalar points, vector points, ..., in the view.

nb-text2d

nb-text3d

are integers giving the number of 2D and 3D text strings in the view.

nb-text2d-chars

nb-text3d-chars

are integers giving the total number of characters in the 2D and 3D strings.

time-step-values

is a list of *nb-time-steps* double precision numbers giving the value of the time (or any other variable) for which an evolution was saved.

scalar-point-value

vector-point-value

... are lists of double precision numbers giving the node coordinates and the values associated with the nodes of the *nb-scalar-points* scalar points, *nb-vector-points* vector points, ..., for each of the *time-step-values*.

For example, *vector-triangle-value* is defined as:

```
coord1-node1 coord1-node2 coord1-node3
coord2-node1 coord2-node2 coord2-node3
coord3-node1 coord3-node2 coord3-node3
comp1-node1-time1 comp2-node1-time1 comp3-node1-time1
comp1-node2-time1 comp2-node2-time1 comp3-node2-time1
comp1-node3-time1 comp2-node3-time1 comp3-node3-time1
comp1-node1-time2 comp2-node1-time2 comp3-node1-time2
comp1-node2-time2 comp2-node2-time2 comp3-node2-time2
comp1-node3-time2 comp2-node3-time2 comp3-node3-time2
...
```

The ordering of the nodes is given in [Section 9.3 \[Node ordering\]](#), page 81.

text2d is a list of 4 double precision numbers:

```
coord1 coord2 style index
```

where *coord1* and *coord2* give the X-Y position of the 2D string in screen coordinates (measured from the top-left corner of the window) and where *index* gives the starting index of the string in *text2d-chars*. If *coord1* (respectively *coord2*) is negative, the position is measured from the right (respectively bottom) edge of the window. If *coord1* (respectively *coord2*) is larger than 99999, the string is centered horizontally (respectively vertically). If *style* is equal to zero, the text is aligned bottom-left and displayed using the default font and size. Otherwise, *style* is converted into an integer whose eight lower bits give the font size, whose eight next bits select the font (the index corresponds to the position in the font menu in the GUI), and whose eight next bits define the text alignment (0=bottom-left, 1=bottom-center, 2=bottom-right, 3=top-left, 4=top-center, 5=top-right, 6=center-left, 7=center-center, 8=center-right).

text2d-chars

is a list of *nb-text2d-chars* characters. Substrings are separated with the null ‘\0’ character.

text3d is a list of 5 double precision numbers

```
coord1 coord2 coord3 style index
```

where *coord1*, *coord2* and *coord3* give the XYZ coordinates of the string in model (real world) coordinates, *index* gives the starting index of the string in *text3d-chars*, and *style* has the same meaning as in *text2d*.

text3d-chars

is a list of *nb-text3d-chars* chars. Substrings are separated with the null ‘\0’ character.

9.4.3 POS binary file format (Legacy)

The POS binary file format is the same as the POS ASCII file format described in [Section 9.4.2 \[POS ASCII file format\]](#), page 86, except that:

1. *file-type* equals 1.
2. all lists of floating point numbers and characters are written in binary format

3. there is an additional integer, of value 1, written before *time-step-values*. This integer is used for detecting if the computer on which the binary file was written and the computer on which the file is read are of the same type (little or big endian).

Here is a pseudo C code to write a post-processing file in binary format:

```
int one = 1;

fprintf(file, "$PostFormat\n");
fprintf(file, "%g %d %d\n", 1.4, 1, sizeof(double));
fprintf(file, "$EndPostFormat\n");
fprintf(file, "$View\n");
fprintf(file, "%s %d "
    "%d %d %d %d %d %d %d %d %d "
    "%d %d %d %d %d %d %d %d %d "
    "%d %d %d %d %d %d %d %d %d "
    "%d %d %d %d %d %d %d %d %d "
    "%d %d %d %d %d %d %d %d %d "
    "%d %d %d %d\n",
    view-name, nb-time-steps,
    nb-scalar-points, nb-vector-points, nb-tensor-points,
    nb-scalar-lines, nb-vector-lines, nb-tensor-lines,
    nb-scalar-triangles, nb-vector-triangles, nb-tensor-triangles,
    nb-scalar-quadrangles, nb-vector-quadrangles, nb-tensor-quadrangles,
    nb-scalar-tetrahedra, nb-vector-tetrahedra, nb-tensor-tetrahedra,
    nb-scalar-hexahedra, nb-vector-hexahedra, nb-tensor-hexahedra,
    nb-scalar-prisms, nb-vector-prisms, nb-tensor-prisms,
    nb-scalar-pyramids, nb-vector-pyramids, nb-tensor-pyramids,
    nb-scalar-lines2, nb-vector-lines2, nb-tensor-lines2,
    nb-scalar-triangles2, nb-vector-triangles2, nb-tensor-triangles2,
    nb-scalar-quadrangles2, nb-vector-quadrangles2, nb-tensor-quadrangles2,
    nb-scalar-tetrahedra2, nb-vector-tetrahedra2, nb-tensor-tetrahedra2,
    nb-scalar-hexahedra2, nb-vector-hexahedra2, nb-tensor-hexahedra2,
    nb-scalar-prisms2, nb-vector-prisms2, nb-tensor-prisms2,
    nb-scalar-pyramids2, nb-vector-pyramids2, nb-tensor-pyramids2,
    nb-text2d, nb-text2d-chars, nb-text3d, nb-text3d-chars);
fwrite(&one, sizeof(int), 1, file);
fwrite(time-step-values, sizeof(double), nb-time-steps, file);
fwrite(all-scalar-point-values, sizeof(double), ..., file);
...
fprintf(file, "\n$EndView\n");
```

In this pseudo-code, *all-scalar-point-values* is the array of double precision numbers containing all the *scalar-point-value* lists, put one after each other in order to form a long array of doubles. The principle is the same for all other kinds of values.

Appendix A Tutorial

The nine following examples introduce new features gradually, starting with ‘t1.geo’. The files corresponding to these examples are available in the ‘tutorial’ directory of the Gmsh distribution.

To learn how to run Gmsh on your computer, see [Chapter 3 \[Running Gmsh on your system\]](#), page 9. Screencasts that show how to use the GUI are available on <http://www.geuz.org/gmsh/screencasts/>.

A.1 ‘t1.geo’

```

/*****
*
*   Gmsh tutorial 1
*
*   Variables, elementary entities (points, lines, surfaces), physical
*   entities (points, lines, surfaces)
*
*****/

// The simplest construction in Gmsh's scripting language is the
// 'affectation'. The following command defines a new variable 'lc':

lc = 0.009;

// This variable can then be used in the definition of Gmsh's simplest
// 'elementary entity', a 'Point'. A Point is defined by a list of
// four numbers: three coordinates (X, Y and Z), and a characteristic
// length (lc) that sets the target element size at the point:

Point(1) = {0, 0, 0, lc};

// The distribution of the mesh element sizes is then obtained by
// interpolation of these characteristic lengths throughout the
// geometry. Another method to specify characteristic lengths is to
// use a background mesh (see 't7.geo' and 'bgmesh.pos').

// We can then define some additional points as well as our first
// curve. Curves are Gmsh's second type of elementary entities, and,
// amongst curves, straight lines are the simplest. A straight line is
// defined by a list of point numbers. In the commands below, for
// example, the line 1 starts at point 1 and ends at point 2:

Point(2) = {.1, 0, 0, lc} ;
Point(3) = {.1, .3, 0, lc} ;
Point(4) = {0, .3, 0, lc} ;

```

```
Line(1) = {1,2} ;
Line(2) = {3,2} ;
Line(3) = {3,4} ;
Line(4) = {4,1} ;

// The third elementary entity is the surface. In order to define a
// simple rectangular surface from the four lines defined above, a
// line loop has first to be defined. A line loop is a list of
// connected lines, a sign being associated with each line (depending
// on the orientation of the line):

Line Loop(5) = {4,1,-2,3} ;

// We can then define the surface as a list of line loops (only one
// here, since there are no holes--see 't4.geo'):

Plane Surface(6) = {5} ;

// At this level, Gmsh knows everything to display the rectangular
// surface 6 and to mesh it. An optional step is needed if we want to
// associate specific region numbers to the various elements in the
// mesh (e.g. to the line segments discretizing lines 1 to 4 or to the
// triangles discretizing surface 6). This is achieved by the
// definition of 'physical entities'. Physical entities will group
// elements belonging to several elementary entities by giving them a
// common number (a region number), and specifying their orientation.

// We can for example group the points 1 and 2 into the physical
// entity 1:

Physical Point(1) = {1,2} ;

// Consequently, two punctual elements will be saved in the output
// mesh file, both with the region number 1. The mechanism is
// identical for line or surface elements:

MyLine = 99;
Physical Line(MyLine) = {1,2,4} ;

Physical Surface("My fancy surface label") = {6} ;

// All the line elements created during the meshing of lines 1, 2 and
// 4 will be saved in the output mesh file with the region number 99;
// and all the triangular elements resulting from the discretization
// of surface 6 will be given an automatic region number (100,
// associated with the label "My fancy surface label").
```

```
// Note that if no physical entities are defined, then all the
// elements in the mesh will be saved "as is", with their default
// orientation.
```

A.2 ‘t2.geo’

```

/*****
 *
 * Gmsh tutorial 2
 *
 * Includes, geometrical transformations, extruded geometries,
 * elementary entities (volumes), physical entities (volumes)
 *
 *****/

// We first include the previous tutorial file, in order to use it as
// a basis for this one:

Include "t1.geo";

// We can then add new points and lines in the same way as we did in
// ‘t1.geo’:

Point(5) = {0, .4, 0, lc};
Line(5) = {4, 5};

// But Gmsh also provides tools to tranform (translate, rotate, etc.)
// elementary entities or copies of elementary entities. For example,
// the point 3 can be moved by 0.05 units to the left with:

Translate {-0.05, 0, 0} { Point{3}; }

// The resulting point can also be duplicated and translated by 0.1
// along the y axis:

tmp[] = Translate {0, 0.1, 0} { Duplicata{ Point{3}; } } ;

// In this case, we assigned the result of the Translate command to a
// list, so that we can retrieve the number of the newly created point
// and use it to create new lines and a new surface:

Line(7) = {3,tmp[0]};
Line(8) = {tmp[0],5};
Line Loop(10) = {5,-8,-7,3};
Plane Surface(11) = {10};

// Of course, these transformation commands not only apply to points,
```

```

// but also to lines and surfaces. We can for example translate a copy
// of surface 6 by 0.12 units along the z axis and define some
// additional lines and surfaces with:

h = 0.12;
Translate {0, 0, h} { Duplicata{ Surface{6}; } }

Line(106) = {1,8};
Line(107) = {2,12};
Line(108) = {3,16};
Line(109) = {4,7};

Line Loop(110) = {1,107,-103,-106}; Plane Surface(111) = {110};
Line Loop(112) = {2,107,104,-108}; Plane Surface(113) = {112};
Line Loop(114) = {3,109,-105,-108}; Plane Surface(115) = {114};
Line Loop(116) = {4,106,-102,-109}; Plane Surface(117) = {116};

// Volumes are the fourth type of elementary entities in Gmsh. In the
// same way one defines line loops to build surfaces, one has to
// define surface loops (i.e. 'shells') to build volumes. The
// following volume does not have holes and thus consists of a single
// surface loop:

Surface Loop(118) = {117,-6,111,-113,101,115};
Volume(119) = {118};

// Another way to define a volume is by extruding a surface. The
// following command extrudes the surface 11 along the z axis and
// automatically creates a new volume:

Extrude {0, 0, h} { Surface{11}; }

// All these geometrical transformations automatically generate new
// elementary entities. The following command permits to manually
// assign a characteristic length to some of the new points:

Characteristic Length {tmp[0], 2, 12, 3, 16, 6, 22} = lc * 4;

// Note that, if the transformation tools are handy to create complex
// geometries, it is also sometimes useful to generate the 'flat'
// geometry, with an explicit list of all elementary entities. This
// can be achieved by selecting the 'File->Save as->Gmsh unrolled
// geometry' menu or by typing
//
// > gmsh t2.geo -0
//
// on the command line.

```



```
// To save all the tetrahedra discretizing the volumes 119 and 120
// with a common region number, we finally define a physical
// volume:
```

```
Physical Volume (1) = {119,120};
```

A.3 ‘t3.geo’

```

/*****
 *
 * Gmsh tutorial 3
 *
 * Extruded meshes, options
 *
 *****/

// Again, we start by including the first tutorial:

Include "t1.geo";

// As in ‘t2.geo’, we plan to perform an extrusion along the z axis.
// But here, instead of only extruding the geometry, we also want to
// extrude the 2D mesh. This is done with the same ‘Extrude’ command,
// but by specifying element ‘Layers’ (2 layers in this case, the
// first one with 8 subdivisions and the second one with 2
// subdivisions, both with a height of h/2):

h = 0.1;

Extrude {0,0,h} {
  Surface{6}; Layers{ {8,2}, {0.5,1} };
}

// The extrusion can also be performed with a rotation instead of a
// translation, and the resulting mesh can be recombined into prisms
// (we use only one layer here, with 7 subdivisions). All rotations
// are specified by an axis direction ({0,1,0}), an axis point
// ({-0.1,0,0.1}) and a rotation angle (-Pi/2):

Extrude { {0,1,0} , {-0.1,0,0.1} , -Pi/2 } {
  Surface{122}; Layers{7}; Recombine;
}

// Note that a translation ({-2*h,0,0}) and a rotation ({1,0,0},
// {0,0.15,0.25}, Pi/2) can also be combined:

```

```

out[] = Extrude { {-2*h,0,0}, {1,0,0} , {0,0.15,0.25} , Pi/2 } {
  Surface{news-1}; Layers{10}; Recombine;
};

// In this last extrusion command we retrieved the volume number
// programatically by saving the output of the command into a
// list. This list will contain the "top" of the extruded surface (in
// out[0]) as well as the newly created volume (in out[1]).

// We can then define a new physical volume to save all the tetrahedra
// with a common region number (101):

Physical Volume(101) = {1, 2, out[1]};

// Let us now change some options... Since all interactive options are
// accessible in Gmsh's scripting language, we can for example define
// a global characteristic length factor or redefine some colors
// directly in the input file:

Mesh.CharacteristicLengthFactor = 4;
General.Color.Text = White;
Geometry.Color.Points = Orange;
Mesh.Color.Points = {255,0,0};

// Note that all colors can be defined literally or numerically, i.e.
// 'Mesh.Color.Points = Red' is equivalent to 'Mesh.Color.Points =
// {255,0,0}'; and also note that, as with user-defined variables, the
// options can be used either as right or left hand sides, so that the
// following command will set the surface color to the same color as
// the points:

Geometry.Color.Surfaces = Geometry.Color.Points;

// You can click on the '?' button in the status bar of the graphic
// window to see the current values of all options. To save all the
// options in a file, you can use the 'File->Save as->Gmsh options'
// menu. To save the current options as the default options for all
// future Gmsh sessions, you should use the 'Tools->Options->Save as
// defaults' button.

```

A.4 't4.geo'

```

/*****
*
*   Gmsh tutorial 4
*
*   Built-in functions, holes, strings, mesh color

```

```

*
*****/

// As usual, we start by defining some variables, some points and some
// lines:

cm = 1e-02;

e1 = 4.5*cm; e2 = 6*cm / 2; e3 = 5*cm / 2;

h1 = 5*cm; h2 = 10*cm; h3 = 5*cm; h4 = 2*cm; h5 = 4.5*cm;

R1 = 1*cm; R2 = 1.5*cm; r = 1*cm;

ccos = ( -h5*R1 + e2 * Hypot(h5,Hypot(e2,R1)) ) / (h5^2 + e2^2);
ssin = Sqrt(1-ccos^2);

Lc1 = 0.01;
Lc2 = 0.003;

Point(1) = { -e1-e2, 0.0 , 0.0 , Lc1};
Point(2) = { -e1-e2, h1 , 0.0 , Lc1};
Point(3) = { -e3-r , h1 , 0.0 , Lc2};
Point(4) = { -e3-r , h1+r , 0.0 , Lc2};
Point(5) = { -e3 , h1+r , 0.0 , Lc2};
Point(6) = { -e3 , h1+h2, 0.0 , Lc1};
Point(7) = { e3 , h1+h2, 0.0 , Lc1};
Point(8) = { e3 , h1+r , 0.0 , Lc2};
Point(9) = { e3+r , h1+r , 0.0 , Lc2};
Point(10)= { e3+r , h1 , 0.0 , Lc2};
Point(11)= { e1+e2, h1 , 0.0 , Lc1};
Point(12)= { e1+e2, 0.0 , 0.0 , Lc1};
Point(13)= { e2 , 0.0 , 0.0 , Lc1};

Point(14)= { R1 / ssin , h5+R1*ccos, 0.0 , Lc2};
Point(15)= { 0.0 , h5 , 0.0 , Lc2};
Point(16)= { -R1 / ssin , h5+R1*ccos, 0.0 , Lc2};
Point(17)= { -e2 , 0.0 , 0.0 , Lc1};

Point(18)= { -R2 , h1+h3 , 0.0 , Lc2};
Point(19)= { -R2 , h1+h3+h4, 0.0 , Lc2};
Point(20)= { 0.0 , h1+h3+h4, 0.0 , Lc2};
Point(21)= { R2 , h1+h3+h4, 0.0 , Lc2};
Point(22)= { R2 , h1+h3 , 0.0 , Lc2};
Point(23)= { 0.0 , h1+h3 , 0.0 , Lc2};

Point(24)= { 0 , h1+h3+h4+R2, 0.0 , Lc2};

```

```

Point(25)= { 0 , h1+h3-R2, 0.0 , Lc2};

Line(1) = {1 ,17};
Line(2) = {17,16};

// Gmsh provides other curve primitives than stright lines: splines,
// B-splines, circle arcs, ellipse arcs, etc. Here we define a new
// circle arc, starting at point 14 and ending at point 16, with the
// circle's center being the point 15:

Circle(3) = {14,15,16};

// Note that, in Gmsh, circle arcs should always be smaller than
// Pi. We can then define additional lines and circles, as well as a
// new surface:

Line(4) = {14,13};
Line(5) = {13,12};
Line(6) = {12,11};
Line(7) = {11,10};
Circle(8) = {8,9,10};
Line(9) = {8,7};
Line(10) = {7,6};
Line(11) = {6,5};
Circle(12) = {3,4,5};
Line(13) = {3,2};
Line(14) = {2,1};
Line(15) = {18,19};
Circle(16) = {21,20,24};
Circle(17) = {24,20,19};
Circle(18) = {18,23,25};
Circle(19) = {25,23,22};
Line(20) = {21,22};

Line Loop(21) = {17,-15,18,19,-20,16};
Plane Surface(22) = {21};

// But we still need to define the exterior surface. Since this
// surface has a hole, its definition now requires two lines loops:

Line Loop(23) = {11,-12,13,14,1,2,-3,4,5,6,7,-8,9,10};
Plane Surface(24) = {23,21};

// Finally, we can add some comments by embedding a post-processing
// view containing some strings, and change the color of some mesh
// entities:

```

```

View "comments" {
  // 10 pixels from the left and 15 pixels from the top of the graphic
  // window:
  T2(10,15,0){StrCat("File created on ", Today)};

  // 10 pixels from the left and 10 pixels from the bottom of the
  // graphic window:
  T2(10,-10,0){"Copyright (C) My Company"};

  // in the model, at (X,Y,Z) = (0.0,0.11,0.0):
  T3(0,0.11,0,0){"Hole"};
};

Color Grey50{ Surface{ 22 }; }
Color Purple{ Surface{ 24 }; }
Color Red{ Line{ 1:14 }; }
Color Yellow{ Line{ 15:20 }; }

```

A.5 ‘t5.geo’

```

/*****
*
* Gmsh tutorial 5
*
* Characteristic lengths, arrays of variables, functions, loops
*
*****/

// Again, we start by defining some characteristic lengths:

lcar1 = .1;
lcar2 = .0005;
lcar3 = .055;

// If we wanted to change these lengths globally (without changing the
// above definitions), we could give a global scaling factor for all
// characteristic lengths on the command line with the ‘-clscale’
// option (or with ‘Mesh.CharacteristicLengthFactor’ in an option
// file). For example, with:
//
// > gmsh t5.geo -clscale 1
//
// this input file produces a mesh of approximately 3,000 nodes and
// 15,000 tetrahedra. With
//
// > gmsh t5.geo -clscale 0.2
//

```

```

// the mesh counts approximately 600,000 nodes and 3.6 million
// tetrahedra.

// We proceed by defining some elementary entities describing a
// truncated cube:

Point(1) = {0.5,0.5,0.5,lcar2}; Point(2) = {0.5,0.5,0,lcar1};
Point(3) = {0,0.5,0.5,lcar1};   Point(4) = {0,0,0.5,lcar1};
Point(5) = {0.5,0,0.5,lcar1};   Point(6) = {0.5,0,0,lcar1};
Point(7) = {0,0.5,0,lcar1};     Point(8) = {0,1,0,lcar1};
Point(9) = {1,1,0,lcar1};       Point(10) = {0,0,1,lcar1};
Point(11) = {0,1,1,lcar1};      Point(12) = {1,1,1,lcar1};
Point(13) = {1,0,1,lcar1};      Point(14) = {1,0,0,lcar1};

Line(1) = {8,9};   Line(2) = {9,12};   Line(3) = {12,11};
Line(4) = {11,8};   Line(5) = {9,14};   Line(6) = {14,13};
Line(7) = {13,12};   Line(8) = {11,10}; Line(9) = {10,13};
Line(10) = {10,4};   Line(11) = {4,5};   Line(12) = {5,6};
Line(13) = {6,2};    Line(14) = {2,1};   Line(15) = {1,3};
Line(16) = {3,7};    Line(17) = {7,2};   Line(18) = {3,4};
Line(19) = {5,1};    Line(20) = {7,8};   Line(21) = {6,14};

Line Loop(22) = {-11,-19,-15,-18};   Plane Surface(23) = {22};
Line Loop(24) = {16,17,14,15};       Plane Surface(25) = {24};
Line Loop(26) = {-17,20,1,5,-21,13}; Plane Surface(27) = {26};
Line Loop(28) = {-4,-1,-2,-3};       Plane Surface(29) = {28};
Line Loop(30) = {-7,2,-5,-6};        Plane Surface(31) = {30};
Line Loop(32) = {6,-9,10,11,12,21};   Plane Surface(33) = {32};
Line Loop(34) = {7,3,8,9};           Plane Surface(35) = {34};
Line Loop(36) = {-10,18,-16,-20,4,-8}; Plane Surface(37) = {36};
Line Loop(38) = {-14,-13,-12,19};     Plane Surface(39) = {38};

// Instead of using included files, we now use a user-defined function
// in order to carve some holes in the cube:

Function CheeseHole

// In the following commands we use the reserved variable name
// 'newp', which automatically selects a new point number. This
// number is chosen as the highest current point number, plus
// one. (Note that, analogously to 'newp', the variables 'newc',
// 'news', 'newv' and 'newreg' select the highest number amongst
// currently defined curves, surfaces, volumes and 'any entities
// other than points', respectively.)

p1 = newp; Point(p1) = {x, y, z, lcar3} ;
p2 = newp; Point(p2) = {x+r,y, z, lcar3} ;

```

```

p3 = newp; Point(p3) = {x, y+r,z, lcar3} ;
p4 = newp; Point(p4) = {x, y, z+r,lcar3} ;
p5 = newp; Point(p5) = {x-r,y, z, lcar3} ;
p6 = newp; Point(p6) = {x, y-r,z, lcar3} ;
p7 = newp; Point(p7) = {x, y, z-r,lcar3} ;

c1 = newreg; Circle(c1) = {p2,p1,p7};
c2 = newreg; Circle(c2) = {p7,p1,p5};
c3 = newreg; Circle(c3) = {p5,p1,p4};
c4 = newreg; Circle(c4) = {p4,p1,p2};
c5 = newreg; Circle(c5) = {p2,p1,p3};
c6 = newreg; Circle(c6) = {p3,p1,p5};
c7 = newreg; Circle(c7) = {p5,p1,p6};
c8 = newreg; Circle(c8) = {p6,p1,p2};
c9 = newreg; Circle(c9) = {p7,p1,p3};
c10 = newreg; Circle(c10) = {p3,p1,p4};
c11 = newreg; Circle(c11) = {p4,p1,p6};
c12 = newreg; Circle(c12) = {p6,p1,p7};

// We need non-plane surfaces to define the spherical holes. Here we
// use ruled surfaces, which can have 3 or 4 sides:

l1 = newreg; Line Loop(l1) = {c5,c10,c4}; Ruled Surface(newreg) = {l1};
l2 = newreg; Line Loop(l2) = {c9,-c5,c1}; Ruled Surface(newreg) = {l2};
l3 = newreg; Line Loop(l3) = {c12,-c8,-c1}; Ruled Surface(newreg) = {l3};
l4 = newreg; Line Loop(l4) = {c8,-c4,c11}; Ruled Surface(newreg) = {l4};
l5 = newreg; Line Loop(l5) = {-c10,c6,c3}; Ruled Surface(newreg) = {l5};
l6 = newreg; Line Loop(l6) = {-c11,-c3,c7}; Ruled Surface(newreg) = {l6};
l7 = newreg; Line Loop(l7) = {-c2,-c7,-c12}; Ruled Surface(newreg) = {l7};
l8 = newreg; Line Loop(l8) = {-c6,-c9,c2}; Ruled Surface(newreg) = {l8};

// We then store the surface loops identification numbers in a list
// for later reference (we will need these to define the final
// volume):

theloops[t] = newreg ;

Surface Loop(theloops[t]) = {l8+1,l5+1,l1+1,l2+1,l3+1,l7+1,l6+1,l4+1};

thehole = newreg ;
Volume(thehole) = theloops[t] ;

Return

// We can use a 'For' loop to generate five holes in the cube:

x = 0 ; y = 0.75 ; z = 0 ; r = 0.09 ;

```

```

For t In {1:5}

    x += 0.166 ;
    z += 0.166 ;

    Call CheeseHole ;

    // We define a physical volume for each hole:

    Physical Volume (t) = thehole ;

    // We also print some variables on the terminal (note that, since
    // all variables are treated internally as floating point numbers,
    // the format string should only contain valid floating point format
    // specifiers):

    Printf("Hole %g (center = {%g,%g,%g}, radius = %g) has number %g!",
           t, x, y, z, r, thehole) ;

EndFor

// We can then define the surface loop for the exterior surface of the
// cube:

theloops[0] = newreg ;

Surface Loop(theloops[0]) = {35,31,29,37,33,23,39,25,27} ;

// The volume of the cube, without the 5 holes, is now defined by 6
// surface loops (the exterior surface and the five interior loops).
// To reference an array of variables, its identifier is followed by
// '[]':

Volume(186) = {theloops[]} ;

// We finally define a physical volume for the elements discretizing
// the cube, without the holes (whose elements were already tagged
// with numbers 1 to 5 in the 'For' loop):

Physical Volume (10) = 186 ;

```

A.6 't6.geo'

```

/*****
*
*   Gmsh tutorial 6

```



```

*
*   Transfinite meshes
*
*****/

// Let's use the geometry from the first tutorial as a basis for this
// one
Include "t1.geo";

// Delete the left line and create replace it with 3 new ones
Delete{ Surface{6}; Line{4}; }

p1 = newp; Point(p1) = {-0.05, 0.05, 0, 1c};
p2 = newp; Point(p2) = {-0.05, 0.1, 0, 1c};

l1 = newl; Line(l1) = {1, p1};
l2 = newl; Line(l2) = {p1, p2};
l3 = newl; Line(l3) = {p2, 4};

// Create surface
Line Loop(1) = {2, -1, l1, l2, l3, -3};
Plane Surface(1) = {1};

// Put 20 points with a refinement toward the extremities on curve 2
Transfinite Line{2} = 20 Using Bump 0.05;

// Put 20 points total on combination of curves l1, l2 and l3
Transfinite Line{l1} = 6;
Transfinite Line{l2} = 6;
Transfinite Line{l3} = 10;

// Put 30 points following a geometric progression on curve 1
// (reversed) and on curve 3
Transfinite Line{-1,3} = 30 Using Progression 1.2;

// Define the Surface as transfinite, by specifying the four corners
// of the transfinite interpolation
Transfinite Surface{1} = {1,2,3,4};

// (Note that the list on the right hand side refers to points, not
// curves. When the surface has only 3 or 4 points on its boundary the
// list can be omitted. The way triangles are generated can be
// controlled by appending "Left", "Right" or "Alternate" after the
// list.)

// Recombine the triangles into quads
Recombine Surface{1};

```

```
// Apply an elliptic smoother to the grid
Mesh.Smoother = 100;
```

A.7 ‘t7.geo’

```

/*****
 *
 *   Gmsh tutorial 7
 *
 *   Background mesh
 *
 *****/

// Characteristic lengths can be specified very accurately by
// providing a background mesh, i.e., a post-processing view that
// contains the target mesh sizes.

// Merge the first tutorial
Merge "t1.geo";

// Merge a post-processing view containing the target mesh sizes
Merge "bgmesh.pos";

// Apply the view as the current background mesh
Background Mesh View[0];

```

A.8 ‘t8.geo’

```

/*****
 *
 *   Gmsh tutorial 8
 *
 *   Post-processing, scripting, animations, options
 *
 *****/

// We first include ‘t1.geo’ as well as some post-processing views:

Include "t1.geo" ;
Include "view1.pos" ;
Include "view1.pos" ;
Include "view4.pos" ;

// We then set some general options:

General.Trackball = 0 ;
General.RotationX = 0 ;

```

```
General.RotationY = 0 ;
General.RotationZ = 0 ;
General.Color.Background = White ;
General.Color.Foreground = Black ;
General.Color.Text = Black ;
General.Orthographic = 0 ;
General.Axes = 0 ;
General.SmallAxes = 0 ;

// We also set some options for each post-processing view:

v0 = PostProcessing.NbViews-4;
v1 = v0+1;
v2 = v0+2;
v3 = v0+3;

View[v0].IntervalsType = 2 ;
View[v0].OffsetZ = 0.05 ;
View[v0].RaiseZ = 0 ;
View[v0].Light = 1 ;
View[v0].ShowScale = 0;
View[v0].SmoothNormals = 1;

View[v1].IntervalsType = 1 ;
View[v1].ColorTable = { Green, Blue } ;
View[v1].NbIso = 10 ;
View[v1].ShowScale = 0;

View[v2].Name = "Test..." ;
View[v2].Axes = 1;
View[v2].Color.Axes = Black;
View[v2].IntervalsType = 2 ;
View[v2].Type = 2;
View[v2].IntervalsType = 2 ;
View[v2].AutoPosition = 0;
View[v2].PositionX = 85;
View[v2].PositionY = 50;
View[v2].Width = 200;
View[v2].Height = 130;

View[v3].Visible = 0;

// We then loop from 1 to 255 with a step of 1. (To use a different
// step, just add a third argument in the list. For example, 'For num
// In {0.5:1.5:0.1}' would increment num from 0.5 to 1.5 with a step
// of 0.1.)
```

```

t = 0 ;

//For num In {1:1}
For num In {1:255}

    View[v0].TimeStep = t ;
    View[v1].TimeStep = t ;
    View[v2].TimeStep = t ;
    View[v3].TimeStep = t ;

    t = (View[v0].TimeStep < View[v0].NbTimeStep-1) ? t+1 : 0 ;

    View[v0].RaiseZ += 0.01/View[v0].Max * t ;

    If (num == 3)
        // We want to create 320x240 frames when num == 3:
        General.GraphicsWidth = 320 ;
        General.GraphicsHeight = 240 ;
    EndIf

    // It is possible to nest loops:
    For num2 In {1:50}

        General.RotationX += 10 ;
        General.RotationY = General.RotationX / 3 ;
        General.RotationZ += 0.1 ;

        Sleep 0.01; // sleep for 0.01 second
        Draw; // draw the scene

        If (num == 3)
            // The 'Print' command saves the graphical window; the 'Sprintf'
            // function permits to create the file names on the fly:
            Print Sprintf("t8-%02g.gif", num2);
            Print Sprintf("t8-%02g.jpg", num2);
        EndIf

    EndFor

    If(num == 3)
        // Here we could make a system call to generate a movie. For example,

        // with whirlgif:
        //
        // System "whirlgif -minimize -loop -o t8.gif t8-*.gif";

        // with mpeg_encode:

```

```

//
// System "mpeg_encode t8.par";

// with mencoder:
//
// System "mencoder 'mf://*.jpg' -mf fps=5 -o t8.mpg -ovc lavc
//          -lavcopts vcodec=mpeg1video:vhq";
// System "mencoder 'mf://*.jpg' -mf fps=5 -o t8.mpg -ovc lavc
//          -lavcopts vcodec=mpeg4:vhq";

// with ffmpeg:
//
// System "ffmpeg -hq -r 5 -b 800 -vcodec mpeg1video
//          -i t8-%02d.jpg t8.mpg"
// System "ffmpeg -hq -r 5 -b 800 -i t8-%02d.jpg t8.asf"
EndIf

EndFor

```

A.9 ‘t9.geo’

```

/*****
*
*   Gmsh tutorial 9
*
*   Post-processing plugins (levelsets, sections, annotations)
*
*****/

// Plugins can be added to Gmsh in order to extend its
// capabilities. For example, post-processing plugins can modify a
// view, or create a new view based on previously loaded
// views. Several default plugins are statically linked with Gmsh,
// e.g. CutMap, CutPlane, CutSphere, Skin, Transform or Smooth.
// Plugins can be controlled in the same way as other options: either
// from the graphical interface (right click on the view button, then
// ‘Plugins’), or from the command file.

// Let us for example include a three-dimensional scalar view:

Include "view3.pos" ;

// We then set some options for the ‘CutMap’ plugin (which extracts an
// isovalue surface from a 3D scalar view), and run it:

Plugin(CutMap).A = 0.67 ; // iso-value level
Plugin(CutMap).iView = 0 ; // source view is View[0]

```

```
Plugin(CutMap).Run ;

// We also set some options for the 'CutPlane' plugin (which computes
// a section of a 3D view), and then run it:

Plugin(CutPlane).A = 0 ;
Plugin(CutPlane).B = 0.2 ;
Plugin(CutPlane).C = 1 ;
Plugin(CutPlane).D = 0 ;
Plugin(CutPlane).Run ;

// Add a title

Plugin(Annotate).Text = "A nice title" ;
// By convention, a value greater than 99999 represents the center (we
// could also use 'General.GraphicsWidth/2', but that would only center
// the string for the current window size):
Plugin(Annotate).X = 1.e5;
Plugin(Annotate).Y = 50 ;
Plugin(Annotate).Font = "Times-BoldItalic" ;
Plugin(Annotate).FontSize = 28 ;
Plugin(Annotate).Align = "Center" ;
Plugin(Annotate).Run ;

Plugin(Annotate).Text = "(and a small subtitle)" ;
Plugin(Annotate).Y = 70 ;
Plugin(Annotate).Font = "Times-Roman" ;
Plugin(Annotate).FontSize = 12 ;
Plugin(Annotate).Run ;

// We finish by setting some options:

View[0].Light = 1;
View[0].IntervalsType = 1;
View[0].NbIso = 6;
View[0].SmoothNormals = 1;
View[1].IntervalsType = 2;
View[2].IntervalsType = 2;
```

Appendix B Options

This appendix lists all the available options. Gmsh's default behavior is to save some of these options in a per-user "session resource" file (`General.SessionFileName`) every time Gmsh is shut down. This permits for example to automatically remember the size and location of the windows or which fonts to use. Other options can be saved in a per-user "option" file (`General.OptionsFileName`), automatically loaded by Gmsh every time it starts up, by using the 'File->Save Default Options' menu.

B.1 General options list

`General.AxesFormatX`

Number format for X-axis (in standard C form)

Default value: "%.3g"

Saved in: `General.OptionsFileName`

`General.AxesFormatY`

Number format for Y-axis (in standard C form)

Default value: "%.3g"

Saved in: `General.OptionsFileName`

`General.AxesFormatZ`

Number format for Z-axis (in standard C form)

Default value: "%.3g"

Saved in: `General.OptionsFileName`

`General.AxesLabelX`

X-axis label

Default value: ""

Saved in: `General.OptionsFileName`

`General.AxesLabelY`

Y-axis label

Default value: ""

Saved in: `General.OptionsFileName`

`General.AxesLabelZ`

Z-axis label

Default value: ""

Saved in: `General.OptionsFileName`

`General.BackgroundImageFileName`

Background image file in JPEG or PNG format

Default value: ""

Saved in: `General.OptionsFileName`

`General.DefaultFileName`

Default project file name

Default value: "untitled.geo"

Saved in: `General.OptionsFileName`

General.Display

X server to use (only for Unix versions)

Default value: ""

Saved in: -

General.ErrorFileName

File into which the log is saved if a fatal error occurs

Default value: ".gmsh-errors"

Saved in: **General.OptionsFileName**

General.FileName

Current project file name (read-only)

Default value: ""

Saved in: -

General.FltkTheme

FLTK user interface theme (try e.g. plastic or gtk+)

Default value: ""

Saved in: **General.OptionsFileName**

General.GraphicsFont

Font used in the graphic window

Default value: "Helvetica"

Saved in: **General.OptionsFileName**

General.OptionsFileName

Option file created with 'Tools->Options->Save'; automatically read on startup

Default value: ".gmsh-options"

Saved in: **General.SessionFileName**

General.SessionFileName

Option file into which session specific information is saved; automatically read on startup

Default value: ".gmshrc"

Saved in: -

General.TextEditor

System command to launch a text editor

Default value: "open -t %s"

Saved in: **General.OptionsFileName**

General.TmpFileName

Temporary file used by the geometry module

Default value: ".gmsh-tmp"

Saved in: **General.SessionFileName**

General.WebBrowser

System command to launch a web browser

Default value: "open %s"

Saved in: **General.OptionsFileName**

General.AlphaBlending

Enable alpha blending (transparency) in post-processing views

Default value: 1

Saved in: **General.OptionsFileName**

General.Antialiasing

Use multisample antialiasing (will slow down rendering)

Default value: 0

Saved in: **General.OptionsFileName**

General.ArrowHeadRadius

Relative radius of arrow head

Default value: 0.12

Saved in: **General.OptionsFileName**

General.ArrowStemLength

Relative length of arrow stem

Default value: 0.56

Saved in: **General.OptionsFileName**

General.ArrowStemRadius

Relative radius of arrow stem

Default value: 0.02

Saved in: **General.OptionsFileName**

General.Axes

Axes (0=none, 1=simple axes, 2=box, 3=full grid, 4=open grid, 5=ruler)

Default value: 0

Saved in: **General.OptionsFileName**

General.AxesMikado

Mikado axes style

Default value: 0

Saved in: **General.OptionsFileName**

General.AxesAutoPosition

Position the axes automatically

Default value: 1

Saved in: **General.OptionsFileName**

General.AxesMaxX

Maximum X-axis coordinate

Default value: 1

Saved in: **General.OptionsFileName**

General.AxesMaxY

Maximum Y-axis coordinate

Default value: 1

Saved in: **General.OptionsFileName**

General.AxesMaxZ
Maximum Z-axis coordinate
Default value: 1
Saved in: **General.OptionsFileName**

General.AxesMinX
Minimum X-axis coordinate
Default value: 0
Saved in: **General.OptionsFileName**

General.AxesMinY
Minimum Y-axis coordinate
Default value: 0
Saved in: **General.OptionsFileName**

General.AxesMinZ
Minimum Z-axis coordinate
Default value: 0
Saved in: **General.OptionsFileName**

General.AxesTicsX
Number of tics on the X-axis
Default value: 5
Saved in: **General.OptionsFileName**

General.AxesTicsY
Number of tics on the Y-axis
Default value: 5
Saved in: **General.OptionsFileName**

General.AxesTicsZ
Number of tics on the Z-axis
Default value: 5
Saved in: **General.OptionsFileName**

General.BackgroundGradient
Draw background gradient (0=none, 1=vertical, 2=horizontal, 3=radial)
Default value: 1
Saved in: **General.OptionsFileName**

General.BackgroundImagePositionX
X position (in pixels) of background image (< 0: measure from right edge; >= 1e5: centered)
Default value: 100000
Saved in: **General.OptionsFileName**

General.BackgroundImagePositionY
Y position (in pixels) of background image (< 0: measure from bottom edge; >= 1e5: centered)
Default value: 100000
Saved in: **General.OptionsFileName**

General.Clip0A

First coefficient in equation for clipping plane 0 ('A' in 'AX+BY+CZ+D=0')

Default value: 1

Saved in: -

General.Clip0B

Second coefficient in equation for clipping plane 0 ('B' in 'AX+BY+CZ+D=0')

Default value: 0

Saved in: -

General.Clip0C

Third coefficient in equation for clipping plane 0 ('C' in 'AX+BY+CZ+D=0')

Default value: 0

Saved in: -

General.Clip0D

Fourth coefficient in equation for clipping plane 0 ('D' in 'AX+BY+CZ+D=0')

Default value: 0

Saved in: -

General.Clip1A

First coefficient in equation for clipping plane 1

Default value: 0

Saved in: -

General.Clip1B

Second coefficient in equation for clipping plane 1

Default value: 1

Saved in: -

General.Clip1C

Third coefficient in equation for clipping plane 1

Default value: 0

Saved in: -

General.Clip1D

Fourth coefficient in equation for clipping plane 1

Default value: 0

Saved in: -

General.Clip2A

First coefficient in equation for clipping plane 2

Default value: 0

Saved in: -

General.Clip2B

Second coefficient in equation for clipping plane 2

Default value: 0

Saved in: -

General.Clip2C

Third coefficient in equation for clipping plane 2

Default value: 1

Saved in: -

General.Clip2D

Fourth coefficient in equation for clipping plane 2

Default value: 0

Saved in: -

General.Clip3A

First coefficient in equation for clipping plane 3

Default value: -1

Saved in: -

General.Clip3B

Second coefficient in equation for clipping plane 3

Default value: 0

Saved in: -

General.Clip3C

Third coefficient in equation for clipping plane 3

Default value: 0

Saved in: -

General.Clip3D

Fourth coefficient in equation for clipping plane 3

Default value: 0

Saved in: -

General.Clip4A

First coefficient in equation for clipping plane 4

Default value: 0

Saved in: -

General.Clip4B

Second coefficient in equation for clipping plane 4

Default value: -1

Saved in: -

General.Clip4C

Third coefficient in equation for clipping plane 4

Default value: 0

Saved in: -

General.Clip4D

Fourth coefficient in equation for clipping plane 4

Default value: 0

Saved in: -

General.Clip5A

First coefficient in equation for clipping plane 5

Default value: 0

Saved in: -

General.Clip5B

Second coefficient in equation for clipping plane 5

Default value: 0

Saved in: -

General.Clip5C

Third coefficient in equation for clipping plane 5

Default value: -1

Saved in: -

General.Clip5D

Fourth coefficient in equation for clipping plane 5

Default value: 0

Saved in: -

General.ClipFactor

Near and far clipping plane distance factor (decrease value for better z-buffer resolution)

Default value: 5

Saved in: -

General.ClipOnlyDrawIntersectingVolume

Only draw layer of elements that intersect the clipping plane

Default value: 0

Saved in: **General.OptionsFileName**

General.ClipOnlyVolume

Only clip volume elements

Default value: 0

Saved in: **General.OptionsFileName**

General.ClipPositionX

Horizontal position (in pixels) of the upper left corner of the clipping planes window

Default value: 650

Saved in: **General.SessionFileName**

General.ClipPositionY

Vertical position (in pixels) of the upper left corner of the clipping planes window

Default value: 150

Saved in: **General.SessionFileName**

General.ClipWholeElements

Clip whole elements

Default value: 0

Saved in: **General.OptionsFileName**

General.ColorScheme

Default color scheme (0=dark, 1=light or 2=grayscale)

Default value: 1

Saved in: **General.OptionsFileName**

General.ConfirmOverwrite

Ask confirmation before overwriting files?

Default value: 1

Saved in: **General.OptionsFileName**

General.ContextPositionX

Horizontal position (in pixels) of the upper left corner of the contextual windows

Default value: 650

Saved in: **General.SessionFileName**

General.ContextPositionY

Vertical position (in pixels) of the upper left corner of the contextual windows

Default value: 150

Saved in: **General.SessionFileName**

General.DoubleBuffer

Use a double buffered graphic window (on Unix, should be set to 0 when working on a remote host without GLX)

Default value: 1

Saved in: **General.OptionsFileName**

General.DrawBoundingBoxes

Draw bounding boxes

Default value: 0

Saved in: **General.OptionsFileName**

General.ExpertMode

Enable expert mode (to disable all the messages meant for inexperienced users)

Default value: 0

Saved in: **General.OptionsFileName**

General.FastRedraw

Draw simplified model while rotating, panning and zooming

Default value: 0

Saved in: **General.OptionsFileName**

General.FieldPositionX

Horizontal position (in pixels) of the upper left corner of the field window

Default value: 650

Saved in: **General.SessionFileName**

General.FieldPositionY

Vertical position (in pixels) of the upper left corner of the field window

Default value: 550

Saved in: **General.SessionFileName**

General.FieldHeight

Height (in pixels) of the field window

Default value: 300

Saved in: **General.SessionFileName**

General.FieldWidth

Width (in pixels) of the field window

Default value: 300

Saved in: **General.SessionFileName**

General.FileChooserPositionX

Horizontal position (in pixels) of the upper left corner of the file chooser windows

Default value: 200

Saved in: **General.SessionFileName**

General.FileChooserPositionY

Vertical position (in pixels) of the upper left corner of the file chooser windows

Default value: 200

Saved in: **General.SessionFileName**

General.FontSize

Size of the font in the user interface (-1=automatic)

Default value: -1

Saved in: **General.OptionsFileName**

General.GraphicsFontSize

Size of the font in the graphic window

Default value: 17

Saved in: **General.OptionsFileName**

General.GraphicsHeight

Height (in pixels) of the graphic window

Default value: 600

Saved in: **General.SessionFileName**

General.GraphicsPositionX

Horizontal position (in pixels) of the upper left corner of the graphic window

Default value: 50

Saved in: **General.SessionFileName**

General.GraphicsPositionY

Vertical position (in pixels) of the upper left corner of the graphic window

Default value: 50

Saved in: **General.SessionFileName**

General.GraphicsWidth

Width (in pixels) of the graphic window

Default value: 600

Saved in: **General.SessionFileName**

General.InitialModule

Module launched on startup (0=automatic, 1=geometry, 2=mesh, 3=solver, 4=post-processing)

Default value: 0
Saved in: `General.OptionsFileName`

`General.Light0`
Enable light source 0
Default value: 1
Saved in: `General.OptionsFileName`

`General.Light0X`
X position of light source 0
Default value: 0.65
Saved in: `General.OptionsFileName`

`General.Light0Y`
Y position of light source 0
Default value: 0.65
Saved in: `General.OptionsFileName`

`General.Light0Z`
Z position of light source 0
Default value: 1
Saved in: `General.OptionsFileName`

`General.Light0W`
Divisor of the X, Y and Z coordinates of light source 0 (W=0 means infinitely far source)
Default value: 0
Saved in: `General.OptionsFileName`

`General.Light1`
Enable light source 1
Default value: 0
Saved in: `General.OptionsFileName`

`General.Light1X`
X position of light source 1
Default value: 0.5
Saved in: `General.OptionsFileName`

`General.Light1Y`
Y position of light source 1
Default value: 0.3
Saved in: `General.OptionsFileName`

`General.Light1Z`
Z position of light source 1
Default value: 1
Saved in: `General.OptionsFileName`

`General.Light1W`
Divisor of the X, Y and Z coordinates of light source 1 (W=0 means infinitely far source)

Default value: 0
Saved in: `General.OptionsFileName`

`General.Light2`
Enable light source 2
Default value: 0
Saved in: `General.OptionsFileName`

`General.Light2X`
X position of light source 2
Default value: 0.5
Saved in: `General.OptionsFileName`

`General.Light2Y`
Y position of light source 2
Default value: 0.3
Saved in: `General.OptionsFileName`

`General.Light2Z`
Z position of light source 2
Default value: 1
Saved in: `General.OptionsFileName`

`General.Light2W`
Divisor of the X, Y and Z coordinates of light source 2 (W=0 means infinitely far source)
Default value: 0
Saved in: `General.OptionsFileName`

`General.Light3`
Enable light source 3
Default value: 0
Saved in: `General.OptionsFileName`

`General.Light3X`
X position of light source 3
Default value: 0.5
Saved in: `General.OptionsFileName`

`General.Light3Y`
Y position of light source 3
Default value: 0.3
Saved in: `General.OptionsFileName`

`General.Light3Z`
Z position of light source 3
Default value: 1
Saved in: `General.OptionsFileName`

`General.Light3W`
Divisor of the X, Y and Z coordinates of light source 3 (W=0 means infinitely far source)

Default value: 0
Saved in: `General.OptionsFileName`

`General.Light4`
Enable light source 4
Default value: 0
Saved in: `General.OptionsFileName`

`General.Light4X`
X position of light source 4
Default value: 0.5
Saved in: `General.OptionsFileName`

`General.Light4Y`
Y position of light source 4
Default value: 0.3
Saved in: `General.OptionsFileName`

`General.Light4Z`
Z position of light source 4
Default value: 1
Saved in: `General.OptionsFileName`

`General.Light4W`
Divisor of the X, Y and Z coordinates of light source 4 (W=0 means infinitely far source)
Default value: 0
Saved in: `General.OptionsFileName`

`General.Light5`
Enable light source 5
Default value: 0
Saved in: `General.OptionsFileName`

`General.Light5X`
X position of light source 5
Default value: 0.5
Saved in: `General.OptionsFileName`

`General.Light5Y`
Y position of light source 5
Default value: 0.3
Saved in: `General.OptionsFileName`

`General.Light5Z`
Z position of light source 5
Default value: 1
Saved in: `General.OptionsFileName`

`General.Light5W`
Divisor of the X, Y and Z coordinates of light source 5 (W=0 means infinitely far source)

Default value: 0
Saved in: `General.OptionsFileName`

`General.LineWidth`
Display width of lines (in pixels)
Default value: 1
Saved in: `General.OptionsFileName`

`General.ManipulatorPositionX`
Horizontal position (in pixels) of the upper left corner of the manipulator window
Default value: 650
Saved in: `General.SessionFileName`

`General.ManipulatorPositionY`
Vertical position (in pixels) of the upper left corner of the manipulator window
Default value: 150
Saved in: `General.SessionFileName`

`General.MaxX`
Maximum model coordinate along the X-axis (read-only)
Default value: 0
Saved in: -

`General.MaxY`
Maximum model coordinate along the Y-axis (read-only)
Default value: 0
Saved in: -

`General.MaxZ`
Maximum model coordinate along the Z-axis (read-only)
Default value: 0
Saved in: -

`General.MenuPositionX`
Horizontal position (in pixels) of the upper left corner of the menu window
Default value: 800
Saved in: `General.SessionFileName`

`General.MenuPositionY`
Vertical position (in pixels) of the upper left corner of the menu window
Default value: 50
Saved in: `General.SessionFileName`

`General.MessageAutoScroll`
Automatically scroll message window
Default value: 1
Saved in: `General.OptionsFileName`

`General.MessagePositionX`
Horizontal position (in pixels) of the upper left corner of the message window
Default value: 650
Saved in: `General.SessionFileName`

General.MessagePositionY

Vertical position (in pixels) of the upper left corner of the message window

Default value: 490

Saved in: **General.SessionFileName**

General.MessageHeight

Height (in pixels) of the message window

Default value: 300

Saved in: **General.SessionFileName**

General.MessageWidth

Width (in pixels) of the message window

Default value: 400

Saved in: **General.SessionFileName**

General.MinX

Minimum model coordinate along the X-axis (read-only)

Default value: 0

Saved in: -

General.MinY

Minimum model coordinate along the Y-axis (read-only)

Default value: 0

Saved in: -

General.MinZ

Minimum model coordinate along the Z-axis (read-only)

Default value: 0

Saved in: -

General.MouseHoverMeshes

Enable mouse hover on meshes

Default value: 0

Saved in: **General.OptionsFileName**

General.MouseSelection

Enable mouse selection

Default value: 1

Saved in: **General.OptionsFileName**

General.NonModalWindows

Force all control windows to be on top of the graphic window ("non-modal")

Default value: 1

Saved in: **General.SessionFileName**

General.NoPopup

Disable interactive dialog windows in scripts (and use default values instead)

Default value: 0

Saved in: **General.OptionsFileName**

General.OptionsPositionX

Horizontal position (in pixels) of the upper left corner of the option window

Default value: 650

Saved in: **General.SessionFileName**

General.OptionsPositionY

Vertical position (in pixels) of the upper left corner of the option window

Default value: 150

Saved in: **General.SessionFileName**

General.Orthographic

Orthographic projection mode (0=perspective projection)

Default value: 1

Saved in: **General.OptionsFileName**

General.PluginPositionX

Horizontal position (in pixels) of the upper left corner of the plugin window

Default value: 650

Saved in: **General.SessionFileName**

General.PluginPositionY

Vertical position (in pixels) of the upper left corner of the plugin window

Default value: 550

Saved in: **General.SessionFileName**

General.PluginHeight

Height (in pixels) of the plugin window

Default value: 300

Saved in: **General.SessionFileName**

General.PluginWidth

Width (in pixels) of the plugin window

Default value: 300

Saved in: **General.SessionFileName**

General.PointSize

Display size of points (in pixels)

Default value: 3

Saved in: **General.OptionsFileName**

General.PolygonOffsetAlwaysOn

Always apply polygon offset, instead of trying to detect when it is required

Default value: 0

Saved in: **General.OptionsFileName**

General.PolygonOffsetFactor

Polygon offset factor (offset = factor * DZ + r * units)

Default value: 0.5

Saved in: **General.OptionsFileName**

General.PolygonOffsetUnits

Polygon offset units (offset = factor * $DZ + r$ * units)

Default value: 1

Saved in: **General.OptionsFileName**

General.QuadricSubdivisions

Number of subdivisions used to draw points or lines as spheres or cylinders

Default value: 6

Saved in: **General.OptionsFileName**

General.RotationX

First Euler angle (used if Trackball=0)

Default value: 0

Saved in: -

General.RotationY

Second Euler angle (used if Trackball=0)

Default value: 0

Saved in: -

General.RotationZ

Third Euler angle (used if Trackball=0)

Default value: 0

Saved in: -

General.RotationCenterGravity

Rotate around the (pseudo) center of mass instead of (RotationCenterX, RotationCenterY, RotationCenterZ)

Default value: 1

Saved in: **General.OptionsFileName**

General.RotationCenterX

X coordinate of the center of rotation

Default value: 0

Saved in: -

General.RotationCenterY

Y coordinate of the center of rotation

Default value: 0

Saved in: -

General.RotationCenterZ

Z coordinate of the center of rotation

Default value: 0

Saved in: -

General.SaveOptions

Automatically save current options in General.OptionsFileName each time you quit Gmsh?

Default value: 0

Saved in: **General.SessionFileName**

General.SaveSession

Automatically save session specific information in General.SessionFileName each time you quit Gmsh?

Default value: 1

Saved in: General.SessionFileName

General.ScaleX

X-axis scale factor

Default value: 1

Saved in: -

General.ScaleY

Y-axis scale factor

Default value: 1

Saved in: -

General.ScaleZ

Z-axis scale factor

Default value: 1

Saved in: -

General.Shininess

Material shininess

Default value: 0.4

Saved in: General.OptionsFileName

General.ShininessExponent

Material shininess exponent (between 0 and 128)

Default value: 40

Saved in: General.OptionsFileName

General.SmallAxes

Display the small axes

Default value: 1

Saved in: General.OptionsFileName

General.SmallAxesPositionX

X position (in pixels) of small axes (< 0: measure from right edge; >= 1e5: centered)

Default value: -60

Saved in: General.OptionsFileName

General.SmallAxesPositionY

Y position (in pixels) of small axes (< 0: measure from bottom edge; >= 1e5: centered)

Default value: -40

Saved in: General.OptionsFileName

General.SmallAxesSize

Size (in pixels) of small axes

Default value: 30

Saved in: General.OptionsFileName

General.SolverPositionX

Horizontal position (in pixels) of the upper left corner of the solver windows

Default value: 650

Saved in: **General.SessionFileName**

General.SolverPositionY

Vertical position (in pixels) of the upper left corner of the solver windows

Default value: 150

Saved in: **General.SessionFileName**

General.StatisticsPositionX

Horizontal position (in pixels) of the upper left corner of the statistic window

Default value: 650

Saved in: **General.SessionFileName**

General.StatisticsPositionY

Vertical position (in pixels) of the upper left corner of the statistic window

Default value: 150

Saved in: **General.SessionFileName**

General.SystemMenuBar

Use the system menu bar on Mac OS X?

Default value: 1

Saved in: **General.SessionFileName**

General.Terminal

Should information be printed on the terminal (if available)?

Default value: 0

Saved in: **General.OptionsFileName**

General.Tooltips

Show tooltips in the user interface

Default value: 1

Saved in: **General.OptionsFileName**

General.Trackball

Use trackball rotation mode

Default value: 1

Saved in: **General.OptionsFileName**

General.TrackballQuaternion0

First trackball quaternion component (used if **General.Trackball=1**)

Default value: 0

Saved in: -

General.TrackballQuaternion1

Second trackball quaternion component (used if **General.Trackball=1**)

Default value: 0

Saved in: -

General.TrackballQuaternion2

Third trackball quaternion component (used if General.Trackball=1)

Default value: 0

Saved in: -

General.TrackballQuaternion3

Fourth trackball quaternion component (used if General.Trackball=1)

Default value: 1

Saved in: -

General.TranslationX

X-axis translation (in model units)

Default value: 0

Saved in: -

General.TranslationY

Y-axis translation (in model units)

Default value: 0

Saved in: -

General.TranslationZ

Z-axis translation (in model units)

Default value: 0

Saved in: -

General.VectorType

Default vector display type (for normals, etc.)

Default value: 4

Saved in: **General.OptionsFileName**

General.Verbosity

Level of information printed during processing (0=no information)

Default value: 4

Saved in: **General.OptionsFileName**

General.VisibilityPositionX

Horizontal position (in pixels) of the upper left corner of the visibility window

Default value: 650

Saved in: **General.SessionFileName**

General.VisibilityPositionY

Vertical position (in pixels) of the upper left corner of the visibility window

Default value: 150

Saved in: **General.SessionFileName**

General.ZoomFactor

Middle mouse button zoom acceleration factor

Default value: 4

Saved in: **General.OptionsFileName**

`General.Color.Background`
Background color
Default value: {255,255,255}
Saved in: `General.OptionsFileName`

`General.Color.BackgroundGradient`
Background gradient color
Default value: {128,147,255}
Saved in: `General.OptionsFileName`

`General.Color.Foreground`
Foreground color
Default value: {85,85,85}
Saved in: `General.OptionsFileName`

`General.Color.Text`
Text color
Default value: {0,0,0}
Saved in: `General.OptionsFileName`

`General.Color.Axes`
Axes color
Default value: {0,0,0}
Saved in: `General.OptionsFileName`

`General.Color.SmallAxes`
Small axes color
Default value: {0,0,0}
Saved in: `General.OptionsFileName`

`General.Color.AmbientLight`
Ambient light color
Default value: {25,25,25}
Saved in: `General.OptionsFileName`

`General.Color.DiffuseLight`
Diffuse light color
Default value: {255,255,255}
Saved in: `General.OptionsFileName`

`General.Color.SpecularLight`
Specular light color
Default value: {255,255,255}
Saved in: `General.OptionsFileName`

`Print.CompositeWindows`
Composite all window tiles in the same output image (for bitmap output only)
Default value: 0
Saved in: `General.OptionsFileName`

Print.EpsBackground

Save image background in PostScript/PDF output

Default value: 1

Saved in: `General.OptionsFileName`

Print.EpsBestRoot

Try to minimize primitive splitting in BSP tree sorted PostScript/PDF output

Default value: 1

Saved in: `General.OptionsFileName`

Print.EpsCompress

Compress PostScript/PDF output using zlib

Default value: 0

Saved in: `General.OptionsFileName`

Print.EpsLineWidthFactor

Width factor for lines in PostScript/PDF output

Default value: 0.5

Saved in: `General.OptionsFileName`

Print.EpsOcclusionCulling

Cull occluded primitives (to reduce PostScript/PDF file size)

Default value: 1

Saved in: `General.OptionsFileName`

Print.EpsPointSizeFactor

Size factor for points in PostScript/PDF output

Default value: 1

Saved in: `General.OptionsFileName`

Print.EpsPS3Shading

Enable PostScript Level 3 shading

Default value: 0

Saved in: `General.OptionsFileName`

Print.EpsQuality

PostScript/PDF quality (0=bitmap, 1=vector (simple sort), 2=vector (accurate sort), 3=vector (unsorted))

Default value: 1

Saved in: `General.OptionsFileName`

Print.Format

File format (10=automatic)

Default value: 10

Saved in: `General.OptionsFileName`

Print.GeoLabels

Save labels in unrolled Gmsh geometries

Default value: 1

Saved in: `General.OptionsFileName`

Print.GifDither
Apply dithering to GIF output
Default value: 0
Saved in: **General.OptionsFileName**

Print.GifInterlace
Interlace GIF output
Default value: 0
Saved in: **General.OptionsFileName**

Print.GifSort
Sort the colormap in GIF output
Default value: 1
Saved in: **General.OptionsFileName**

Print.GifTransparent
Output transparent GIF image
Default value: 0
Saved in: **General.OptionsFileName**

Print.JpegQuality
JPEG quality (between 1 and 100)
Default value: 100
Saved in: **General.OptionsFileName**

Print.JpegSmoothing
JPEG smoothing (between 0 and 100)
Default value: 0
Saved in: **General.OptionsFileName**

Print.PostElementary
Save elementary region tags in mesh statistics exported as post-processing views
Default value: 1
Saved in: **General.OptionsFileName**

Print.PostElement
Save element numbers in mesh statistics exported as post-processing views
Default value: 0
Saved in: **General.OptionsFileName**

Print.PostGamma
Save Gamma quality measure in mesh statistics exported as post-processing views
Default value: 0
Saved in: **General.OptionsFileName**

Print.PostEta
Save Eta quality measure in mesh statistics exported as post-processing views
Default value: 0
Saved in: **General.OptionsFileName**

Print.PostRho

Save Rho quality measure in mesh statistics exported as post-processing views

Default value: 0

Saved in: `General.OptionsFileName`

Print.PostDisto

Save Disto quality measure in mesh statistics exported as post-processing views

Default value: 0

Saved in: `General.OptionsFileName`

Print.TexAsEquation

Print all TeX strings as equations

Default value: 0

Saved in: `General.OptionsFileName`

Print.Text

Print text strings?

Default value: 1

Saved in: `General.OptionsFileName`

B.2 Geometry options list

Geometry.AutoCoherence

Should all duplicate entities be automatically removed?

Default value: 1

Saved in: `General.OptionsFileName`

Geometry.Clip

Enable clipping planes? (Plane[i]=2ⁱ, i=0,...,5)

Default value: 0

Saved in: -

Geometry.CopyMeshingMethod

Copy meshing method when duplicating geometrical entities?

Default value: 0

Saved in: `General.OptionsFileName`

Geometry.ExactExtrusion

Use exact extrusion formula in interpolations (set to 0 to allow geometrical transformations of extruded entities)

Default value: 1

Saved in: `General.OptionsFileName`

Geometry.ExtrudeReturnLateralEntities

Add lateral entities in lists returned by extrusion commands?

Default value: 1

Saved in: `General.OptionsFileName`

Geometry.ExtrudeSplinePoints

Number of control points for splines created during extrusion

Default value: 5

Saved in: `General.OptionsFileName`

Geometry.HighlightOrphans

Highlight orphan entities (lines connected to a single surface, etc.)?

Default value: 0

Saved in: **General.OptionsFileName**

Geometry.Light

Enable lighting for the geometry

Default value: 1

Saved in: **General.OptionsFileName**

Geometry.LightTwoSide

Light both sides of surfaces (leads to slower rendering)

Default value: 1

Saved in: **General.OptionsFileName**

Geometry.Lines

Display geometry curves?

Default value: 1

Saved in: **General.OptionsFileName**

Geometry.LineNumbers

Display curve numbers?

Default value: 0

Saved in: **General.OptionsFileName**

Geometry.LineSelectWidth

Display width of selected lines (in pixels)

Default value: 2

Saved in: **General.OptionsFileName**

Geometry.LineType

Display lines as solid color segments (0), 3D cylinders (1) or tapered cylinders (2)

Default value: 0

Saved in: **General.OptionsFileName**

Geometry.LineWidth

Display width of lines (in pixels)

Default value: 2

Saved in: **General.OptionsFileName**

Geometry.MatchGeomAndMesh

Matches geometries and meshes.

Default value: 0

Saved in: **General.OptionsFileName**

GeometryNormals

Display size of normal vectors (in pixels)

Default value: 0

Saved in: **General.OptionsFileName**

- Geometry.NumSubEdges**
Number of edge subdivisions between control points when displaying curves
Default value: 20
Saved in: **General.OptionsFileName**
- Geometry.OCCFixSmallEdges**
Fix small edges in STEP, IGES and BRep models
Default value: 1
Saved in: **General.OptionsFileName**
- Geometry.OCCFixSmallFaces**
Fix small faces in STEP, IGES and BRep models
Default value: 1
Saved in: **General.OptionsFileName**
- Geometry.OCCSewFaces**
Sew faces in STEP, IGES and BRep models
Default value: 0
Saved in: **General.OptionsFileName**
- Geometry.OCCCConnectFaces**
Cut and connect faces in STEP, IGES and BRep models
Default value: 0
Saved in: **General.OptionsFileName**
- Geometry.OffsetX**
Model display offset along X-axis (in model coordinates)
Default value: 0
Saved in: -
- Geometry.OffsetY**
Model display offset along Y-axis (in model coordinates)
Default value: 0
Saved in: -
- Geometry.OffsetZ**
Model display offset along Z-axis (in model coordinates)
Default value: 0
Saved in: -
- Geometry.OldCircle**
Use old circle description (compatibility option for old Gmsh geometries)
Default value: 0
Saved in: **General.OptionsFileName**
- Geometry.OldNewReg**
Use old newreg definition for geometrical transformations (compatibility option for old Gmsh geometries)
Default value: 1
Saved in: **General.OptionsFileName**

Geometry.Points

Display geometry points?

Default value: 1

Saved in: **General.OptionsFileName****Geometry.PointNumbers**

Display points numbers?

Default value: 0

Saved in: **General.OptionsFileName****Geometry.PointSelectSize**

Display size of selected points (in pixels)

Default value: 5

Saved in: **General.OptionsFileName****Geometry.PointSize**

Display size of points (in pixels)

Default value: 4

Saved in: **General.OptionsFileName****Geometry.PointType**

Display points as solid color dots (0) or 3D spheres (1)

Default value: 0

Saved in: **General.OptionsFileName****Geometry.ScalingFactor**

Global geometry scaling factor

Default value: 1

Saved in: **General.OptionsFileName****Geometry.SnapX**

Snapping grid spacing along the X-axis

Default value: 0.1

Saved in: **General.OptionsFileName****Geometry.SnapY**

Snapping grid spacing along the Y-axis

Default value: 0.1

Saved in: **General.OptionsFileName****Geometry.SnapZ**

Snapping grid spacing along the Z-axis

Default value: 0.1

Saved in: **General.OptionsFileName****Geometry.Surfaces**

Display geometry surfaces?

Default value: 0

Saved in: **General.OptionsFileName**

Geometry.SurfaceNumbers

Display surface numbers?

Default value: 0

Saved in: **General.OptionsFileName****Geometry.SurfaceType**

Surface display type (0=cross, 1=wireframe, 2=solid)

Default value: 2

Saved in: **General.OptionsFileName****Geometry.Tangents**

Display size of tangent vectors (in pixels)

Default value: 0

Saved in: **General.OptionsFileName****Geometry.Tolerance**

Geometrical tolerance

Default value: 1e-06

Saved in: **General.OptionsFileName****Geometry.Transform**

Transform model display coordinates (0=no, 1=scale)

Default value: 0

Saved in: -

Geometry.TransformXX

Element (1,1) of the 3x3 model display transformation matrix

Default value: 1

Saved in: -

Geometry.TransformXY

Element (1,2) of the 3x3 model display transformation matrix

Default value: 0

Saved in: -

Geometry.TransformXZ

Element (1,3) of the 3x3 model display transformation matrix

Default value: 0

Saved in: -

Geometry.TransformYX

Element (2,1) of the 3x3 model display transformation matrix

Default value: 0

Saved in: -

Geometry.TransformYY

Element (2,2) of the 3x3 model display transformation matrix

Default value: 1

Saved in: -

Geometry.TransformYZ

Element (2,3) of the 3x3 model display transformation matrix
Default value: 0
Saved in: -

Geometry.TransformZX

Element (3,1) of the 3x3 model display transformation matrix
Default value: 0
Saved in: -

Geometry.TransformZY

Element (3,2) of the 3x3 model display transformation matrix
Default value: 0
Saved in: -

Geometry.TransformZZ

Element (3,3) of the 3x3 model display transformation matrix
Default value: 1
Saved in: -

Geometry.Volumes

Display geometry volumes? (not implemented yet)
Default value: 0
Saved in: **General.OptionsFileName**

Geometry.VolumeNumbers

Display volume numbers? (not implemented yet)
Default value: 0
Saved in: **General.OptionsFileName**

Geometry.Color.Points

Normal geometry point color
Default value: {90,90,90}
Saved in: **General.OptionsFileName**

Geometry.Color.Lines

Normal geometry curve color
Default value: {0,0,255}
Saved in: **General.OptionsFileName**

Geometry.Color.Surfaces

Normal geometry surface color
Default value: {128,128,128}
Saved in: **General.OptionsFileName**

Geometry.Color.Volumes

Normal geometry volume color
Default value: {255,255,0}
Saved in: **General.OptionsFileName**

Geometry.Color.Selection
Selected geometry color
Default value: {255,0,0}
Saved in: **General.OptionsFileName**

Geometry.Color.HighlightZero
Highlight 0 color
Default value: {255,0,0}
Saved in: **General.OptionsFileName**

Geometry.Color.HighlightOne
Highlight 1 color
Default value: {255,150,0}
Saved in: **General.OptionsFileName**

Geometry.Color.HighlightTwo
Highlight 2 color
Default value: {255,255,0}
Saved in: **General.OptionsFileName**

Geometry.Color.Tangents
Tangent geometry vectors color
Default value: {255,255,0}
Saved in: **General.OptionsFileName**

Geometry.ColorNormals
Normal geometry vectors color
Default value: {255,0,0}
Saved in: **General.OptionsFileName**

Geometry.Color.Projection
Projection surface color
Default value: {0,255,0}
Saved in: **General.OptionsFileName**

B.3 Mesh options list

Mesh.Algorithm
2D mesh algorithm (1=MeshAdapt, 5=Delaunay, 6=Frontal)
Default value: 1
Saved in: **General.OptionsFileName**

Mesh.Algorithm3D
3D mesh algorithm (1=Delaunay, 4=Frontal)
Default value: 1
Saved in: **General.OptionsFileName**

Mesh.AngleSmoothNormals
Threshold angle below which normals are not smoothed
Default value: 30
Saved in: **General.OptionsFileName**

Mesh.AllowSwapAngle

Threshold angle (in degrees) between faces normals under which we allow an edge swap

Default value: 10

Saved in: **General.OptionsFileName**

Mesh.BdfFieldFormat

Field format for Nastran BDF files (0=free, 1=small, 2=large)

Default value: 1

Saved in: **General.OptionsFileName**

Mesh.Binary

Write mesh files in binary format (if possible)

Default value: 0

Saved in: **General.OptionsFileName**

Mesh.ChacoArchitecture

(Adv. Chaco): Parallel architecture topology (0=hypercube, 1-3=mesh dimensions)

Default value: 1

Saved in: **General.OptionsFileName**

Mesh.ChacoEigensolver

(Adv. Chaco): Type of eigensolver for a spectral algorithm (0=Lanczos, 1=Multilevel RQI/Symmlq)

Default value: 1

Saved in: **General.OptionsFileName**

Mesh.ChacoEigTol

(Adv. Chaco): Tolerance of the eigensolver for spectral or multilevel-KL algorithms

Default value: 0.001

Saved in: **General.OptionsFileName**

Mesh.ChacoGlobalMethod

Chaco partitioning algorithm (1=Multilevel-KL, 2=Spectral, 4=Linear, 5=Random, 6=Scattered)

Default value: 1

Saved in: **General.OptionsFileName**

Mesh.ChacoHypercubeDim

(Adv. Chaco): Dimensional partitioning for a hypercube topology

Default value: 2

Saved in: **General.OptionsFileName**

Mesh.ChacoLocalMethod

(Adv. Chaco): Local partitioning algorithm

Default value: 1

Saved in: **General.OptionsFileName**

Mesh.ChacoMeshDim1

(Adv. Chaco): Number of partitions in the first dimension of a mesh topology

Default value: 4

Saved in: **General.OptionsFileName**

Mesh.ChacoMeshDim2

(Adv. Chaco): Number of partitions in the second dimension of a mesh topology

Default value: 1

Saved in: **General.OptionsFileName**

Mesh.ChacoMeshDim3

(Adv. Chaco): Number of partitions in the third dimension of a mesh topology

Default value: 1

Saved in: **General.OptionsFileName**

Mesh.ChacoPartitionSection

(Adv. Chaco): Partition by (1=bisection, 2=quadrisection, 3=octasection)

Default value: 1

Saved in: **General.OptionsFileName**

Mesh.ChacoSeed

(Adv. Chaco): Seed for random number generator

Default value: **7.65432e+06**

Saved in: **General.OptionsFileName**

Mesh.ChacoVMax

(Adv. Chaco): Maximum vertices in a coarse graph (for multilevel-KL algorithm and Multilevel RQI/Symmlq eigensolver)

Default value: 250

Saved in: **General.OptionsFileName**

Mesh.ChacoParamINTERNAL_VERTICES

(Adv. Chaco): Parameter INTERNAL_VERTICES

Default value: 0

Saved in: **General.OptionsFileName**

Mesh.ChacoParamREFINE_MAP

(Adv. Chaco): Parameter REFINE_MAP

Default value: 1

Saved in: **General.OptionsFileName**

Mesh.ChacoParamREFINE_PARTITION

(Adv. Chaco): Parameter REFINE_PARTITION

Default value: 0

Saved in: **General.OptionsFileName**

Mesh.ChacoParamTERMINAL_PROPOGATION

(Adv. Chaco): Parameter TERMINAL_PROPOGATION

Default value: 0

Saved in: **General.OptionsFileName**

Mesh.CharacteristicLengthExtendFromBoundary
Extend characteristic lengths from the boundaries inside the surface/volume
Default value: 1
Saved in: **General.OptionsFileName**

Mesh.CharacteristicLengthFactor
Factor applied to all characteristic lengths
Default value: 1
Saved in: **General.OptionsFileName**

Mesh.CharacteristicLengthMin
Minimum characteristic length
Default value: 0
Saved in: **General.OptionsFileName**

Mesh.CharacteristicLengthMax
Maximum characteristic length
Default value: $1e+22$
Saved in: **General.OptionsFileName**

Mesh.CharacteristicLengthFromCurvature
Compute characteristic lengths from curvature
Default value: 0
Saved in: **General.OptionsFileName**

Mesh.CharacteristicLengthFromPoints
Compute characteristic lengths from values given at geometry points
Default value: 1
Saved in: **General.OptionsFileName**

Mesh.Clip
Enable clipping planes? (Plane[i]= 2^i , i=0,...,5)
Default value: 0
Saved in: -

Mesh.ColorCarousel
Mesh coloring (0=by element type, 1=by elementary entity, 2=by physical entity, 3=by partition)
Default value: 1
Saved in: **General.OptionsFileName**

Mesh.CpuTime
CPU time (in seconds) for the generation of the current mesh (read-only)
Default value: 0
Saved in: -

Mesh.DrawSkinOnly
Draw only the skin of 3D meshes?
Default value: 0
Saved in: **General.OptionsFileName**

Mesh.Dual

Display the dual mesh obtained by barycentric subdivision

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.ElementOrder

Element order (1=linear elements, N (<6) = elements of higher order)

Default value: 1

Saved in: `General.OptionsFileName`

Mesh.Explode

Element shrinking factor (between 0 and 1)

Default value: 1

Saved in: `General.OptionsFileName`

Mesh.Format

Mesh output format (1=msh, 2=unv, 19=vrml, 27=stl, 30=mesh, 31=bdf, 32=cgns, 33=med)

Default value: 1

Saved in: `General.OptionsFileName`

Mesh.Hexahedra

Display mesh hexahedra?

Default value: 1

Saved in: `General.OptionsFileName`

Mesh.LabelsFrequency

Labels display frequency?

Default value: 100

Saved in: `General.OptionsFileName`

Mesh.LabelType

Type of element label (0=element number, 1=elementary entity number, 2=physical entity number, 3=partition number, 4=coordinates)

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.LcIntegrationPrecision

Accuracy of evaluation of the LC field for 1D mesh generation

Default value: 1e-09

Saved in: `General.OptionsFileName`

Mesh.Light

Enable lighting for the mesh

Default value: 1

Saved in: `General.OptionsFileName`

Mesh.LightLines

Enable lighting for mesh lines (element edges)

Default value: 1

Saved in: `General.OptionsFileName`

Mesh.LightTwoSide

Light both sides of surfaces (leads to slower rendering)

Default value: 1

Saved in: `General.OptionsFileName`

Mesh.Lines

Display mesh lines (1D elements)?

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.LineNumbers

Display mesh line numbers?

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.LineWidth

Display width of mesh lines (in pixels)

Default value: 1

Saved in: `General.OptionsFileName`

Mesh.MeshOnlyVisible

Mesh only visible entities (experimental: use with caution!)

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.MetisAlgorithm

METIS partitioning algorithm (1=Recursive, 2=K-way)

Default value: 1

Saved in: `General.OptionsFileName`

Mesh.MetisEdgeMatching

(Adv. METIS): Determines the matching type (1=Random, 2=Heavy-Edge, 3=Sorted Heavy-Edge)

Default value: 3

Saved in: `General.OptionsFileName`

Mesh.MetisRefinementAlgorithm

(Adv. METIS): Algorithm for k-way refinement (1=Random, 2=Greedy, 3=Random with minimized connectivity)

Default value: 3

Saved in: `General.OptionsFileName`

Mesh.MinimumCirclePoints

Minimum number of points used to mesh a circle

Default value: 7

Saved in: `General.OptionsFileName`

Mesh.MinimumCurvePoints

Minimum number of points used to mesh a (non-straight) curve

Default value: 3

Saved in: `General.OptionsFileName`

Mesh.MshFileVersion

Version of the MSH file format to use

Default value: 2.1

Saved in: **General.OptionsFileName**

Mesh.NbHexahedra

Number of hexahedra in the current mesh (read-only)

Default value: 0

Saved in: -

Mesh.NbNodes

Number of nodes in the current mesh (read-only)

Default value: 0

Saved in: -

Mesh.NbPartitions

Number of partitions

Default value: 4

Saved in: **General.OptionsFileName**

Mesh.NbPrisms

Number of prisms in the current mesh (read-only)

Default value: 0

Saved in: -

Mesh.NbPyramids

Number of pyramids in the current mesh (read-only)

Default value: 0

Saved in: -

Mesh.NbQuadrangles

Number of quadrangles in the current mesh (read-only)

Default value: 0

Saved in: -

Mesh.NbTetrahedra

Number of tetrahedra in the current mesh (read-only)

Default value: 0

Saved in: -

Mesh.NbTriangles

Number of triangles in the current mesh (read-only)

Default value: 0

Saved in: -

Mesh.Normals

Display size of normal vectors (in pixels)

Default value: 0

Saved in: **General.OptionsFileName**

Mesh.NumSubEdges

Number of edge subdivisions when displaying high order elements

Default value: 2

Saved in: `General.OptionsFileName`

Mesh.Optimize

Optimize the mesh to improve the quality of tetrahedral elements

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.OptimizeNetgen

Optimize the mesh using Netgen to improve the quality of tetrahedral elements

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.Partitioner

Partitioner software (1=Chacho, 2=METIS)

Default value: 2

Saved in: `General.OptionsFileName`

Mesh.Points

Display mesh vertices (nodes)?

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.PointNumbers

Display mesh node numbers?

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.PointSize

Display size of mesh vertices (in pixels)

Default value: 4

Saved in: `General.OptionsFileName`

Mesh.PointType

Display mesh vertices as solid color dots (0) or 3D spheres (1)

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.Prisms

Display mesh prisms?

Default value: 1

Saved in: `General.OptionsFileName`

Mesh.Pyramids

Display mesh pyramids?

Default value: 1

Saved in: `General.OptionsFileName`

Mesh.Quadrangles

Display mesh quadrangles?

Default value: 1

Saved in: **General.OptionsFileName****Mesh.QualityInf**

Only display elements whose quality measure is greater than QualityInf

Default value: 0

Saved in: **General.OptionsFileName****Mesh.QualitySup**

Only display elements whose quality measure is smaller than QualitySup

Default value: 0

Saved in: **General.OptionsFileName****Mesh.QualityType**Type of quality measure (0= $\gamma \sim \text{vol}/\text{sum_face}/\text{max_edge}$,
1= $\eta \sim \text{vol}^{(2/3)}/\text{sum_edge}^2$, 2= $\rho \sim \text{min_edge}/\text{max_edge}$)

Default value: 2

Saved in: **General.OptionsFileName****Mesh.RadiusInf**

Only display elements whose longest edge is greater than RadiusInf

Default value: 0

Saved in: **General.OptionsFileName****Mesh.RadiusSup**

Only display elements whose longest edge is smaller than RadiusSup

Default value: 0

Saved in: **General.OptionsFileName****Mesh.RandomFactor**

Random factor used in the 2D meshing algorithm (should be increased if RandomFactor * size(triangle)/size(model) approaches machine accuracy)

Default value: 1e-09

Saved in: **General.OptionsFileName****Mesh.RefineSteps**

Number of refinement steps in the MeshAdapt-based 2D algorithms

Default value: 10

Saved in: **General.OptionsFileName****Mesh.ReverseAllNormals**

Reverse all the mesh normals (for display)

Default value: 0

Saved in: **General.OptionsFileName****Mesh.SaveAll**

Ignore Physical definitions and save all elements

Default value: 0

Saved in: -

Mesh.SaveElementTagType

Type of the element tag saved in mesh formats that don't support saving physical or partition ids (1=elementary, 2=physical, 3=partition)

Default value: 1

Saved in: **General.OptionsFileName**

Mesh.SaveParametric

Save parametric coordinates of nodes

Default value: 0

Saved in: **General.OptionsFileName**

Mesh.SaveGroupsOfNodes

Save groups of nodes for each physical line and surface (UNV mesh format only)

Default value: 0

Saved in: **General.OptionsFileName**

Mesh.ScalingFactor

Global scaling factor applied to the saved mesh

Default value: 1

Saved in: **General.OptionsFileName**

Mesh.SecondOrderExperimental

Use experimental code to generate second order mesh

Default value: 0

Saved in: **General.OptionsFileName**

Mesh.SecondOrderIncomplete

Create incomplete second order elements? (8-node quads, 20-node hexas, etc.)

Default value: 1

Saved in: **General.OptionsFileName**

Mesh.SecondOrderLinear

Should second order vertices simply be created by linear interpolation?

Default value: 0

Saved in: **General.OptionsFileName**

Mesh.Smoothing

Number of smoothing steps applied to the final mesh

Default value: 1

Saved in: **General.OptionsFileName**

Mesh.SmoothInternalEdges

Number of smoothing steps of internal edges for high order meshes

Default value: 0

Saved in: **General.OptionsFileName**

Mesh.SmoothNormals

Smooth the mesh normals?

Default value: 0

Saved in: **General.OptionsFileName**

Mesh.SubdivisionAlgorithm

Mesh subdivision algorithm (0=none, 1=all quadrangles, 2=all hexahedra)

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.SurfaceEdges

Display edges of surface mesh?

Default value: 1

Saved in: `General.OptionsFileName`

Mesh.SurfaceFaces

Display faces of surface mesh?

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.SurfaceNumbers

Display surface mesh element numbers?

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.Tangents

Display size of tangent vectors (in pixels)

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.Tetrahedra

Display mesh tetrahedra?

Default value: 1

Saved in: `General.OptionsFileName`

Mesh.ToleranceEdgeLength

Skip a model edge in mesh generation if its length is less than user's defined tolerance

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.Triangles

Display mesh triangles?

Default value: 1

Saved in: `General.OptionsFileName`

Mesh.VolumeEdges

Display edges of volume mesh?

Default value: 1

Saved in: `General.OptionsFileName`

Mesh.VolumeFaces

Display faces of volume mesh?

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.VolumeNumbers

Display volume mesh element numbers?

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.Voronoi

Display the voronoi diagram

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.ZoneDefinition

Method for defining a zone (0=single zone, 1=by partition, 2=by physical)

Default value: 0

Saved in: `General.OptionsFileName`

Mesh.Color.Points

Mesh node color

Default value: {0,0,255}

Saved in: `General.OptionsFileName`

Mesh.Color.PointsSup

Second order mesh node color

Default value: {255,0,255}

Saved in: `General.OptionsFileName`

Mesh.Color.Lines

Mesh line color

Default value: {0,0,0}

Saved in: `General.OptionsFileName`

Mesh.Color.Triangles

Mesh triangle color (if `Mesh.ColorCarousel=0`)

Default value: {160,150,255}

Saved in: `General.OptionsFileName`

Mesh.Color.Quadrangles

Mesh quadrangle color (if `Mesh.ColorCarousel=0`)

Default value: {130,120,225}

Saved in: `General.OptionsFileName`

Mesh.Color.Tetrahedra

Mesh tetrahedron color (if `Mesh.ColorCarousel=0`)

Default value: {160,150,255}

Saved in: `General.OptionsFileName`

Mesh.Color.Hexahedra

Mesh hexahedron color (if `Mesh.ColorCarousel=0`)

Default value: {130,120,225}

Saved in: `General.OptionsFileName`

Mesh.Color.Prisms

Mesh prism color (if Mesh.ColorCarousel=0)

Default value: {232,210,23}

Saved in: General.OptionsFileName

Mesh.Color.Pyramids

Mesh pyramid color (if Mesh.ColorCarousel=0)

Default value: {217,113,38}

Saved in: General.OptionsFileName

Mesh.Color.Tangents

Tangent mesh vector color

Default value: {255,255,0}

Saved in: General.OptionsFileName

Mesh.ColorNormals

Normal mesh vector color

Default value: {255,0,0}

Saved in: General.OptionsFileName

Mesh.Color.Zero

Color 0 in color carousel

Default value: {255,120,0}

Saved in: General.OptionsFileName

Mesh.Color.One

Color 1 in color carousel

Default value: {255,160,0}

Saved in: General.OptionsFileName

Mesh.Color.Two

Color 2 in color carousel

Default value: {255,200,0}

Saved in: General.OptionsFileName

Mesh.Color.Three

Color 3 in color carousel

Default value: {255,240,0}

Saved in: General.OptionsFileName

Mesh.Color.Four

Color 4 in color carousel

Default value: {228,255,0}

Saved in: General.OptionsFileName

Mesh.Color.Five

Color 5 in color carousel

Default value: {188,255,0}

Saved in: General.OptionsFileName

`Mesh.Color.Six`
Color 6 in color carousel
Default value: {148,255,0}
Saved in: `General.OptionsFileName`

`Mesh.Color.Seven`
Color 7 in color carousel
Default value: {108,255,0}
Saved in: `General.OptionsFileName`

`Mesh.Color.Eight`
Color 8 in color carousel
Default value: {68,255,0}
Saved in: `General.OptionsFileName`

`Mesh.Color.Nine`
Color 9 in color carousel
Default value: {0,255,52}
Saved in: `General.OptionsFileName`

`Mesh.Color.Ten`
Color 10 in color carousel
Default value: {0,255,132}
Saved in: `General.OptionsFileName`

`Mesh.Color.Eleven`
Color 11 in color carousel
Default value: {0,255,192}
Saved in: `General.OptionsFileName`

`Mesh.Color.Twelve`
Color 12 in color carousel
Default value: {0,216,255}
Saved in: `General.OptionsFileName`

`Mesh.Color.Thirteen`
Color 13 in color carousel
Default value: {0,176,255}
Saved in: `General.OptionsFileName`

`Mesh.Color.Fourteen`
Color 14 in color carousel
Default value: {0,116,255}
Saved in: `General.OptionsFileName`

`Mesh.Color.Fifteen`
Color 15 in color carousel
Default value: {0,76,255}
Saved in: `General.OptionsFileName`

Mesh.Color.Sixteen
Color 16 in color carousel
Default value: {24,0,255}
Saved in: `General.OptionsFileName`

Mesh.Color.Seventeen
Color 17 in color carousel
Default value: {84,0,255}
Saved in: `General.OptionsFileName`

Mesh.Color.Eighteen
Color 18 in color carousel
Default value: {104,0,255}
Saved in: `General.OptionsFileName`

Mesh.Color.Nineteen
Color 19 in color carousel
Default value: {184,0,255}
Saved in: `General.OptionsFileName`

B.4 Solver options list

Solver.SocketName
Name of socket (TCP/IP if it contains the ‘:’ character, UNIX otherwise)
Default value: `".gmshsock"`
Saved in: `General.OptionsFileName`

Solver.Name0
Name of solver 0
Default value: `"GetDP"`
Saved in: `General.OptionsFileName`

Solver.Help0
Help string for solver 0
Default value: `"A General environment for the treatment of Discrete Problems. Copyright (C) 1997–2009 Patrick Dular and Christophe Geuzaine. Visit http://www.geuz.org/getdp/ for more info"`
Saved in: `General.OptionsFileName`

Solver.Executable0
System command to launch solver 0 (should not contain the ‘&’ character)
Default value: `"getdp"`
Saved in: `General.OptionsFileName`

Solver.InputName0
Default input file name for solver 0
Default value: `""`
Saved in: `General.OptionsFileName`

Solver.Extension0
Default file name extension for solver 0
Default value: `".pro"`
Saved in: `General.OptionsFileName`

`Solver.MeshName0`
Default mesh file name for solver 0
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.MeshCommand0`
Command used to specify the mesh file for solver 0
Default value: `"-msh %s"`
Saved in: `General.OptionsFileName`

`Solver.SocketCommand0`
Command to specify the socket to solver 0
Default value: `"-socket %s"`
Saved in: `General.OptionsFileName`

`Solver.NameCommand0`
Command to specify the problem name to solver 0
Default value: `"%s"`
Saved in: `General.OptionsFileName`

`Solver.OptionCommand0`
Command to get options from solver 0
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FirstOption0`
Label of first option for solver 0
Default value: `"Resolution"`
Saved in: `General.OptionsFileName`

`Solver.SecondOption0`
Label of second option for solver 0
Default value: `"PostOperation"`
Saved in: `General.OptionsFileName`

`Solver.ThirdOption0`
Label of third option for solver 0
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FourthOption0`
Label of fourth option for solver 0
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FifthOption0`
Label of fifth option for solver 0
Default value: ""
Saved in: `General.OptionsFileName`

Solver.FirstButton0

Label of first button for solver 0
Default value: "Pre"
Saved in: **General.OptionsFileName**

Solver.FirstButtonCommand0

Command associated with the first button for solver 0
Default value: "-pre %s"
Saved in: **General.OptionsFileName**

Solver.SecondButton0

Label of second button for solver 0
Default value: "Cal"
Saved in: **General.OptionsFileName**

Solver.SecondButtonCommand0

Command associated with the second button for solver 0
Default value: "-cal"
Saved in: **General.OptionsFileName**

Solver.ThirdButton0

Label of third button for solver 0
Default value: "Pos"
Saved in: **General.OptionsFileName**

Solver.ThirdButtonCommand0

Command associated with the third button for solver 0
Default value: "-pos %s"
Saved in: **General.OptionsFileName**

Solver.FourthButton0

Label of fourth button for solver 0
Default value: ""
Saved in: **General.OptionsFileName**

Solver.FourthButtonCommand0

Command associated with the fourth button for solver 0
Default value: ""
Saved in: **General.OptionsFileName**

Solver.FifthButton0

Label of fifth button for solver 0
Default value: ""
Saved in: **General.OptionsFileName**

Solver.FifthButtonCommand0

Command associated with the fifth button for solver 0
Default value: ""
Saved in: **General.OptionsFileName**

`Solver.Name1`
Name of solver 1
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.Help1`
Help string for solver 1
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.Executable1`
System command to launch solver 1 (should not contain the ‘&’ character)
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.InputName1`
Default input file name for solver 1
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.Extension1`
Default file name extension for solver 1
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.MeshName1`
Default mesh file name for solver 1
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.MeshCommand1`
Command used to specify the mesh file for solver 1
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.SocketCommand1`
Command to specify the socket to solver 1
Default value: `"-socket %s"`
Saved in: `General.OptionsFileName`

`Solver.NameCommand1`
Command to specify the problem name to solver 1
Default value: `"%s"`
Saved in: `General.OptionsFileName`

`Solver.OptionCommand1`
Command to get options from solver 1
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FirstOption1`
Label of first option for solver 1
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.SecondOption1`
Label of second option for solver 1
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.ThirdOption1`
Label of third option for solver 1
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FourthOption1`
Label of fourth option for solver 1
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FifthOption1`
Label of fifth option for solver 1
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FirstButton1`
Label of first button for solver 1
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FirstButtonCommand1`
Command associated with the first button for solver 1
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.SecondButton1`
Label of second button for solver 1
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.SecondButtonCommand1`
Command associated with the second button for solver 1
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.ThirdButton1`
Label of third button for solver 1
Default value: ""
Saved in: `General.OptionsFileName`

Solver.ThirdButtonCommand1

Command associated with the third button for solver 1

Default value: ""

Saved in: **General.OptionsFileName**

Solver.FourthButton1

Label of fourth button for solver 1

Default value: ""

Saved in: **General.OptionsFileName**

Solver.FourthButtonCommand1

Command associated with the fourth button for solver 1

Default value: ""

Saved in: **General.OptionsFileName**

Solver.FifthButton1

Label of fifth button for solver 1

Default value: ""

Saved in: **General.OptionsFileName**

Solver.FifthButtonCommand1

Command associated with the fifth button for solver 1

Default value: ""

Saved in: **General.OptionsFileName**

Solver.Name2

Name of solver 2

Default value: ""

Saved in: **General.OptionsFileName**

Solver.Help2

Help string for solver 2

Default value: ""

Saved in: **General.OptionsFileName**

Solver.Executable2

System command to launch solver 2 (should not contain the ‘&’ character)

Default value: ""

Saved in: **General.OptionsFileName**

Solver.InputName2

Default input file name for solver 2

Default value: ""

Saved in: **General.OptionsFileName**

Solver.Extension2

Default file name extension for solver 2

Default value: ""

Saved in: **General.OptionsFileName**

`Solver.MeshName2`
Default mesh file name for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.MeshCommand2`
Command used to specify the mesh file for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.SocketCommand2`
Command to specify the socket to solver 2
Default value: `"-socket %s"`
Saved in: `General.OptionsFileName`

`Solver.NameCommand2`
Command to specify the problem name to solver 2
Default value: `"%s"`
Saved in: `General.OptionsFileName`

`Solver.OptionCommand2`
Command to get options from solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FirstOption2`
Label of first option for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.SecondOption2`
Label of second option for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.ThirdOption2`
Label of third option for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FourthOption2`
Label of fourth option for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FifthOption2`
Label of fifth option for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FirstButton2`
Label of first button for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FirstButtonCommand2`
Command associated with the first button for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.SecondButton2`
Label of second button for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.SecondButtonCommand2`
Command associated with the second button for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.ThirdButton2`
Label of third button for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.ThirdButtonCommand2`
Command associated with the third button for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FourthButton2`
Label of fourth button for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FourthButtonCommand2`
Command associated with the fourth button for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FifthButton2`
Label of fifth button for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FifthButtonCommand2`
Command associated with the fifth button for solver 2
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.Name3`
Name of solver 3
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.Help3`
Help string for solver 3
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.Executable3`
System command to launch solver 3 (should not contain the ‘&’ character)
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.InputName3`
Default input file name for solver 3
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.Extension3`
Default file name extension for solver 3
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.MeshName3`
Default mesh file name for solver 3
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.MeshCommand3`
Command used to specify the mesh file for solver 3
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.SocketCommand3`
Command to specify the socket to solver 3
Default value: `"-socket %s"`
Saved in: `General.OptionsFileName`

`Solver.NameCommand3`
Command to specify the problem name to solver 3
Default value: `"%s"`
Saved in: `General.OptionsFileName`

`Solver.OptionCommand3`
Command to get options from solver 3
Default value: ""
Saved in: `General.OptionsFileName`

```
Solver.FirstOption3
    Label of first option for solver 3
    Default value: ""
    Saved in: General.OptionsFileName

Solver.SecondOption3
    Label of second option for solver 3
    Default value: ""
    Saved in: General.OptionsFileName

Solver.ThirdOption3
    Label of third option for solver 3
    Default value: ""
    Saved in: General.OptionsFileName

Solver.FourthOption3
    Label of fourth option for solver 3
    Default value: ""
    Saved in: General.OptionsFileName

Solver.FifthOption3
    Label of fifth option for solver 3
    Default value: ""
    Saved in: General.OptionsFileName

Solver.FirstButton3
    Label of first button for solver 3
    Default value: ""
    Saved in: General.OptionsFileName

Solver.FirstButtonCommand3
    Command associated with the first button for solver 3
    Default value: ""
    Saved in: General.OptionsFileName

Solver.SecondButton3
    Label of second button for solver 3
    Default value: ""
    Saved in: General.OptionsFileName

Solver.SecondButtonCommand3
    Command associated with the second button for solver 3
    Default value: ""
    Saved in: General.OptionsFileName

Solver.ThirdButton3
    Label of third button for solver 3
    Default value: ""
    Saved in: General.OptionsFileName
```

Solver.ThirdButtonCommand3

Command associated with the third button for solver 3

Default value: ""

Saved in: **General.OptionsFileName**

Solver.FourthButton3

Label of fourth button for solver 3

Default value: ""

Saved in: **General.OptionsFileName**

Solver.FourthButtonCommand3

Command associated with the fourth button for solver 3

Default value: ""

Saved in: **General.OptionsFileName**

Solver.FifthButton3

Label of fifth button for solver 3

Default value: ""

Saved in: **General.OptionsFileName**

Solver.FifthButtonCommand3

Command associated with the fifth button for solver 3

Default value: ""

Saved in: **General.OptionsFileName**

Solver.Name4

Name of solver 4

Default value: ""

Saved in: **General.OptionsFileName**

Solver.Help4

Help string for solver 4

Default value: ""

Saved in: **General.OptionsFileName**

Solver.Executable4

System command to launch solver 4 (should not contain the ‘&’ character)

Default value: ""

Saved in: **General.OptionsFileName**

Solver.InputName4

Default input file name for solver 4

Default value: ""

Saved in: **General.OptionsFileName**

Solver.Extension4

Default file name extension for solver 4

Default value: ""

Saved in: **General.OptionsFileName**

`Solver.MeshName4`
Default mesh file name for solver 4
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.MeshCommand4`
Command used to specify the mesh file for solver 4
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.SocketCommand4`
Command to specify the socket to solver 4
Default value: `"-socket %s"`
Saved in: `General.OptionsFileName`

`Solver.NameCommand4`
Command to specify the problem name to solver 4
Default value: `"%s"`
Saved in: `General.OptionsFileName`

`Solver.OptionCommand4`
Command to get options from solver 4
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FirstOption4`
Label of first option for solver 4
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.SecondOption4`
Label of second option for solver 4
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.ThirdOption4`
Label of third option for solver 4
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FourthOption4`
Label of fourth option for solver 4
Default value: ""
Saved in: `General.OptionsFileName`

`Solver.FifthOption4`
Label of fifth option for solver 4
Default value: ""
Saved in: `General.OptionsFileName`

Solver.FirstButton4

Label of first button for solver 4

Default value: ""

Saved in: **General.OptionsFileName****Solver.FirstButtonCommand4**

Command associated with the first button for solver 4

Default value: ""

Saved in: **General.OptionsFileName****Solver.SecondButton4**

Label of second button for solver 4

Default value: ""

Saved in: **General.OptionsFileName****Solver.SecondButtonCommand4**

Command associated with the second button for solver 4

Default value: ""

Saved in: **General.OptionsFileName****Solver.ThirdButton4**

Label of third button for solver 4

Default value: ""

Saved in: **General.OptionsFileName****Solver.ThirdButtonCommand4**

Command associated with the third button for solver 4

Default value: ""

Saved in: **General.OptionsFileName****Solver.FourthButton4**

Label of fourth button for solver 4

Default value: ""

Saved in: **General.OptionsFileName****Solver.FourthButtonCommand4**

Command associated with the fourth button for solver 4

Default value: ""

Saved in: **General.OptionsFileName****Solver.FifthButton4**

Label of fifth button for solver 4

Default value: ""

Saved in: **General.OptionsFileName****Solver.FifthButtonCommand4**

Command associated with the fifth button for solver 4

Default value: ""

Saved in: **General.OptionsFileName**

Solver.AlwaysListen
Always listen to incoming connection requests?
Default value: 0
Saved in: **General.OptionsFileName**

Solver.ClientServer0
Connect solver 0 to the Gmsh server
Default value: 1
Saved in: **General.OptionsFileName**

Solver.ClientServer1
Connect solver 1 to the Gmsh server
Default value: 0
Saved in: **General.OptionsFileName**

Solver.ClientServer2
Connect solver 2 to the Gmsh server
Default value: 0
Saved in: **General.OptionsFileName**

Solver.ClientServer3
Connect solver 3 to the Gmsh server
Default value: 0
Saved in: **General.OptionsFileName**

Solver.ClientServer4
Connect solver 4 to the Gmsh server
Default value: 0
Saved in: **General.OptionsFileName**

Solver.MergeViews0
Automatically merge any post-processing view created by solver 0
Default value: 1
Saved in: **General.OptionsFileName**

Solver.MergeViews1
Automatically merge any post-processing view created by solver 1
Default value: 1
Saved in: **General.OptionsFileName**

Solver.MergeViews2
Automatically merge any post-processing view created by solver 2
Default value: 1
Saved in: **General.OptionsFileName**

Solver.MergeViews3
Automatically merge any post-processing view created by solver 3
Default value: 1
Saved in: **General.OptionsFileName**

Solver.MergeViews4
Automatically merge any post-processing view created by solver 4
Default value: 1
Saved in: `General.OptionsFileName`

Solver.Plugins
Enable default solver plugins?
Default value: 0
Saved in: `General.OptionsFileName`

Solver.PopupMessages0
Automatically display messages produced by solver 0
Default value: 1
Saved in: `General.OptionsFileName`

Solver.PopupMessages1
Automatically display messages produced by solver 1
Default value: 1
Saved in: `General.OptionsFileName`

Solver.PopupMessages2
Automatically display messages produced by solver 2
Default value: 1
Saved in: `General.OptionsFileName`

Solver.PopupMessages3
Automatically display messages produced by solver 3
Default value: 1
Saved in: `General.OptionsFileName`

Solver.PopupMessages4
Automatically display messages produced by solver 4
Default value: 1
Saved in: `General.OptionsFileName`

B.5 Post-processing options list

PostProcessing.AnimationDelay
Delay (in seconds) between frames in automatic animation mode
Default value: 0.25
Saved in: `General.OptionsFileName`

PostProcessing.AnimationCycle
Cycle through views instead of time steps in automatic animation mode
Default value: 0
Saved in: `General.OptionsFileName`

PostProcessing.CombineRemoveOriginal
Remove original views after a Combine operation
Default value: 1
Saved in: `General.OptionsFileName`

PostProcessing.Format

Default file format for post-processing views (0=ASCII view, 1=binary view, 2=parsed view, 3=STL triangulation, 4=text, 5=mesh)

Default value: 0

Saved in: **General.OptionsFileName**

PostProcessing.HorizontalScales

Display value scales horizontally

Default value: 1

Saved in: **General.OptionsFileName**

PostProcessing.Link

Link post-processing views (0=none, 1/2=changes in visible/all, 3/4=everything in visible/all)

Default value: 0

Saved in: **General.OptionsFileName**

PostProcessing.NbViews

Current number of views merged (read-only)

Default value: 0

Saved in: -

PostProcessing.Plugins

Enable default post-processing plugins?

Default value: 1

Saved in: **General.OptionsFileName**

PostProcessing.Smoothing

Apply (non-reversible) smoothing to post-processing view when merged

Default value: 0

Saved in: **General.OptionsFileName**

View.AxesFormatX

Number format for X-axis (in standard C form)

Default value: "%.3g"

Saved in: **General.OptionsFileName**

View.AxesFormatY

Number format for Y-axis (in standard C form)

Default value: "%.3g"

Saved in: **General.OptionsFileName**

View.AxesFormatZ

Number format for Z-axis (in standard C form)

Default value: "%.3g"

Saved in: **General.OptionsFileName**

View.AxesLabelX

X-axis label

Default value: ""

Saved in: **General.OptionsFileName**

View.AxesLabelY

Y-axis label

Default value: ""

Saved in: **General.OptionsFileName****View.AxesLabelZ**

Z-axis label

Default value: ""

Saved in: **General.OptionsFileName****View.FileName**

Default post-processing view file name

Default value: ""

Saved in: -

View.Format

Number format (in standard C form)

Default value: "%.3g"

Saved in: **General.OptionsFileName****View.GeneralizedRaiseX**

Generalized elevation of the view along X-axis (in model coordinates)

Default value: "v0"

Saved in: **General.OptionsFileName****View.GeneralizedRaiseY**

Generalized elevation of the view along Y-axis (in model coordinates)

Default value: "v1"

Saved in: **General.OptionsFileName****View.GeneralizedRaiseZ**

Generalized elevation of the view along Z-axis (in model coordinates)

Default value: "v2"

Saved in: **General.OptionsFileName****View.Name**

Default post-processing view name

Default value: ""

Saved in: -

View.Stipple0

First stippling pattern

Default value: "1*0x1F1F"

Saved in: **General.OptionsFileName****View.Stipple1**

Second stippling pattern

Default value: "1*0x3333"

Saved in: **General.OptionsFileName**

`View.Stipple2`
Third stippling pattern
Default value: "1*0x087F"
Saved in: `General.OptionsFileName`

`View.Stipple3`
Fourth stippling pattern
Default value: "1*0xCCCC"
Saved in: `General.OptionsFileName`

`View.Stipple4`
Fifth stippling pattern
Default value: "2*0x1111"
Saved in: `General.OptionsFileName`

`View.Stipple5`
Sixth stippling pattern
Default value: "2*0x0F0F"
Saved in: `General.OptionsFileName`

`View.Stipple6`
Seventh stippling pattern
Default value: "1*0xCFFF"
Saved in: `General.OptionsFileName`

`View.Stipple7`
Eighth stippling pattern
Default value: "2*0x0202"
Saved in: `General.OptionsFileName`

`View.Stipple8`
Ninth stippling pattern
Default value: "2*0x087F"
Saved in: `General.OptionsFileName`

`View.Stipple9`
Tenth stippling pattern
Default value: "1*0xFFFF"
Saved in: `General.OptionsFileName`

`View.AdaptVisualizationGrid`
Use adaptive visualization grid (for high-order elements)?
Default value: 0
Saved in: `General.OptionsFileName`

`View.AngleSmoothNormals`
Threshold angle below which normals are not smoothed
Default value: 30
Saved in: `General.OptionsFileName`

View.ArrowSizeMax

Maximum display size of arrows (in pixels)

Default value: 60

Saved in: `General.OptionsFileName`**View.ArrowSizeMin**

Minimum display size of arrows (in pixels)

Default value: 0

Saved in: `General.OptionsFileName`**View.AutoPosition**

Position the scale or 2D plot automatically

Default value: 1

Saved in: `General.OptionsFileName`**View.Axes**

Axes (0=none, 1=simple axes, 2=box, 3=full grid, 4=open grid, 5=ruler)

Default value: 0

Saved in: `General.OptionsFileName`**View.AxesMikado**

Mikado axes style

Default value: 0

Saved in: `General.OptionsFileName`**View.AxesAutoPosition**

Position the axes automatically

Default value: 1

Saved in: `General.OptionsFileName`**View.AxesMaxX**

Maximum X-axis coordinate

Default value: 1

Saved in: `General.OptionsFileName`**View.AxesMaxY**

Maximum Y-axis coordinate

Default value: 1

Saved in: `General.OptionsFileName`**View.AxesMaxZ**

Maximum Z-axis coordinate

Default value: 1

Saved in: `General.OptionsFileName`**View.AxesMinX**

Minimum X-axis coordinate

Default value: 0

Saved in: `General.OptionsFileName`

View.AxesMinY

Minimum Y-axis coordinate

Default value: 0

Saved in: `General.OptionsFileName`

View.AxesMinZ

Minimum Z-axis coordinate

Default value: 0

Saved in: `General.OptionsFileName`

View.AxesTicksX

Number of ticks on the X-axis

Default value: 5

Saved in: `General.OptionsFileName`

View.AxesTicksY

Number of ticks on the Y-axis

Default value: 5

Saved in: `General.OptionsFileName`

View.AxesTicksZ

Number of ticks on the Z-axis

Default value: 5

Saved in: `General.OptionsFileName`

View.Boundary

Draw the 'N minus b'-dimensional boundary of the element (N=element dimension, b=option value)

Default value: 0

Saved in: `General.OptionsFileName`

View.CenterGlyphs

Center glyphs (arrows, numbers, etc.)

Default value: 0

Saved in: `General.OptionsFileName`

View.Clip

Enable clipping planes? (Plane[i]=2ⁱ, i=0,...,5)

Default value: 0

Saved in: -

View.ColormapAlpha

Colormap alpha channel value (used only if != 1)

Default value: 1

Saved in: `General.OptionsFileName`

View.ColormapAlphaPower

Colormap alpha channel power

Default value: 0

Saved in: `General.OptionsFileName`

View.ColormapBetaColormap beta parameter ($\gamma = 1 - \beta$)

Default value: 0

Saved in: `General.OptionsFileName`**View.ColormapBias**

Colormap bias

Default value: 0

Saved in: `General.OptionsFileName`**View.ColormapCurvature**

Colormap curvature or slope coefficient

Default value: 0

Saved in: `General.OptionsFileName`**View.ColormapInvert**Invert the color values, i.e., replace x with $(255-x)$ in the colormap?

Default value: 0

Saved in: `General.OptionsFileName`**View.ColormapNumber**

Default colormap number

Default value: 2

Saved in: `General.OptionsFileName`**View.ColormapRotation**

Incremental colormap rotation

Default value: 0

Saved in: `General.OptionsFileName`**View.ColormapSwap**

Swap the min/max values in the colormap?

Default value: 0

Saved in: `General.OptionsFileName`**View.CustomMax**

User-defined maximum value to be displayed

Default value: 0

Saved in: -

View.CustomMin

User-defined minimum value to be displayed

Default value: 0

Saved in: -

View.DisplacementFactor

Displacement amplification

Default value: 1

Saved in: `General.OptionsFileName`

View.DrawHexahedra

Display post-processing hexahedra?
Default value: 1
Saved in: `General.OptionsFileName`

View.DrawLines

Display post-processing lines?
Default value: 1
Saved in: `General.OptionsFileName`

View.DrawPoints

Display post-processing points?
Default value: 1
Saved in: `General.OptionsFileName`

View.DrawPrisms

Display post-processing prisms?
Default value: 1
Saved in: `General.OptionsFileName`

View.DrawPyramids

Display post-processing pyramids?
Default value: 1
Saved in: `General.OptionsFileName`

View.DrawQuadrangles

Display post-processing quadrangles?
Default value: 1
Saved in: `General.OptionsFileName`

View.DrawScalars

Display scalar values?
Default value: 1
Saved in: `General.OptionsFileName`

View.DrawSkinOnly

Draw only the skin of 3D scalar views?
Default value: 0
Saved in: `General.OptionsFileName`

View.DrawStrings

Display post-processing annotation strings?
Default value: 1
Saved in: `General.OptionsFileName`

View.DrawTensors

Display tensor values?
Default value: 1
Saved in: `General.OptionsFileName`

View.DrawTetrahedra

Display post-processing tetrahedra?
Default value: 1
Saved in: `General.OptionsFileName`

View.DrawTriangles

Display post-processing triangles?
Default value: 1
Saved in: `General.OptionsFileName`

View.DrawVectors

Display vector values?
Default value: 1
Saved in: `General.OptionsFileName`

View.Explode

Element shrinking factor (between 0 and 1)
Default value: 1
Saved in: `General.OptionsFileName`

View.ExternalView

Index of the view used to color vector fields (-1=self)
Default value: -1
Saved in: `General.OptionsFileName`

View.FakeTransparency

Use fake transparency (cheaper than the real thing, but incorrect)
Default value: 0
Saved in: `General.OptionsFileName`

View.GeneralizedRaiseFactor

Generalized raise amplification factor
Default value: 1
Saved in: `General.OptionsFileName`

View.GeneralizedRaiseView

Index of the view used for generalized raise (-1=self)
Default value: -1
Saved in: `General.OptionsFileName`

View.GlyphLocation

Glyph (arrow, number, etc.) location (1=center of gravity, 2=node)
Default value: 1
Saved in: `General.OptionsFileName`

View.Height

Height (in pixels) of the scale or 2D plot
Default value: 200
Saved in: `General.OptionsFileName`

View.IntervalsType

Type of interval display (1=iso, 2=continuous, 3=discrete, 4=numeric)

Default value: 2

Saved in: **General.OptionsFileName**

View.Light

Enable lighting for the view

Default value: 1

Saved in: **General.OptionsFileName**

View.LightLines

Light element edges

Default value: 1

Saved in: **General.OptionsFileName**

View.LightTwoSide

Light both sides of surfaces (leads to slower rendering)

Default value: 1

Saved in: **General.OptionsFileName**

View.LineType

Display lines as solid color segments (0) or 3D cylinders (1)

Default value: 0

Saved in: **General.OptionsFileName**

View.LineWidth

Display width of lines (in pixels)

Default value: 1

Saved in: **General.OptionsFileName**

View.MaxRecursionLevel

Maximum recursion level for adaptive views

Default value: 0

Saved in: **General.OptionsFileName**

View.Max Maximum value in the view (read-only)

Default value: 0

Saved in: -

View.MaxX

Maximum view coordinate along the X-axis (read-only)

Default value: 0

Saved in: -

View.MaxY

Maximum view coordinate along the Y-axis (read-only)

Default value: 0

Saved in: -

View.MaxZ

Maximum view coordinate along the Z-axis (read-only)

Default value: 0

Saved in: -

View.Min Minimum value in the view (read-only)
Default value: 0
Saved in: -

View.MinX
Minimum view coordinate along the X-axis (read-only)
Default value: 0
Saved in: -

View.MinY
Minimum view coordinate along the Y-axis (read-only)
Default value: 0
Saved in: -

View.MinZ
Minimum view coordinate along the Z-axis (read-only)
Default value: 0
Saved in: -

View.NbIso
Number of intervals
Default value: 15
Saved in: `General.OptionsFileName`

View.NbTimeStep
Number of time steps in the view (do not change this!)
Default value: 1
Saved in: -

View.NormalRaise
Elevation of the view along the normal (in model coordinates)
Default value: 0
Saved in: -

ViewNormals
Display size of normal vectors (in pixels)
Default value: 0
Saved in: `General.OptionsFileName`

View.OffsetX
Translation of the view along X-axis (in model coordinates)
Default value: 0
Saved in: -

View.OffsetY
Translation of the view along Y-axis (in model coordinates)
Default value: 0
Saved in: -

View.OffsetZ
Translation of the view along Z-axis (in model coordinates)
Default value: 0
Saved in: -

View.PointSize

Display size of points (in pixels)
Default value: 3
Saved in: **General.OptionsFileName**

View.PointType

Display points as solid color dots (0), 3D spheres (1), scaled dots (2) or scaled spheres (3)
Default value: 0
Saved in: **General.OptionsFileName**

View.PositionX

X position (in pixels) of the scale or 2D plot (< 0: measure from right edge; >= 1e5: centered)
Default value: 100
Saved in: **General.OptionsFileName**

View.PositionY

Y position (in pixels) of the scale or 2D plot (< 0: measure from bottom edge; >= 1e5: centered)
Default value: 50
Saved in: **General.OptionsFileName**

View.RaiseX

Elevation of the view along X-axis (in model coordinates)
Default value: 0
Saved in: -

View.RaiseY

Elevation of the view along Y-axis (in model coordinates)
Default value: 0
Saved in: -

View.RaiseZ

Elevation of the view along Z-axis (in model coordinates)
Default value: 0
Saved in: -

View.RangeType

Value scale range type (1=default, 2=custom, 3=per time step)
Default value: 1
Saved in: **General.OptionsFileName**

View.SaturateValues

Saturate the view values to custom min and max (1=true, 0=false)
Default value: 0
Saved in: **General.OptionsFileName**

View.ScaleType

Value scale type (1=linear, 2=logarithmic, 3=double logarithmic)
Default value: 1
Saved in: **General.OptionsFileName**

View.ShowElement

Show element boundaries?

Default value: 0

Saved in: `General.OptionsFileName`**View.ShowScale**

Show value scale?

Default value: 1

Saved in: `General.OptionsFileName`**View.ShowTime**

Time display mode (0=hidden, 1=value if multi-step, 2=value always, 3=step if multi-step, 4=step always)

Default value: 1

Saved in: `General.OptionsFileName`**View.SmoothNormals**

Smooth the normals?

Default value: 0

Saved in: `General.OptionsFileName`**View.Stipple**

Stipple curves in 2D plots?

Default value: 0

Saved in: `General.OptionsFileName`**View.Tangents**

Display size of tangent vectors (in pixels)

Default value: 0

Saved in: `General.OptionsFileName`**View.TargetError**

Target representation error for adaptive views

Default value: 0.01

Saved in: `General.OptionsFileName`**View.TensorType**

Tensor Visualization Type

Default value: 1

Saved in: `General.OptionsFileName`**View.TimeStep**

Current time step displayed

Default value: 0

Saved in: -

View.TransformXX

Element (1,1) of the 3x3 coordinate transformation matrix

Default value: 1

Saved in: -

View.TransformXY

Element (1,2) of the 3x3 coordinate transformation matrix
Default value: 0
Saved in: -

View.TransformXZ

Element (1,3) of the 3x3 coordinate transformation matrix
Default value: 0
Saved in: -

View.TransformYX

Element (2,1) of the 3x3 coordinate transformation matrix
Default value: 0
Saved in: -

View.TransformYY

Element (2,2) of the 3x3 coordinate transformation matrix
Default value: 1
Saved in: -

View.TransformYZ

Element (2,3) of the 3x3 coordinate transformation matrix
Default value: 0
Saved in: -

View.TransformZX

Element (3,1) of the 3x3 coordinate transformation matrix
Default value: 0
Saved in: -

View.TransformZY

Element (3,2) of the 3x3 coordinate transformation matrix
Default value: 0
Saved in: -

View.TransformZZ

Element (3,3) of the 3x3 coordinate transformation matrix
Default value: 1
Saved in: -

View.Type

Type of plot (1=3D, 2=2D space, 3=2D time)
Default value: 1
Saved in: -

View.UseGeneralizedRaise

Use generalized raise?
Default value: 0
Saved in: **General.OptionsFileName**

View.VectorType

Vector display type (1=segment, 2=arrow, 3=pyramid, 4=3D arrow, 5=displacement, 6=comet)

Default value: 4
Saved in: `General.OptionsFileName`

`View.Visible`

Is the view visible?
Default value: 1
Saved in: -

`View.Width`

Width (in pixels) of the scale or 2D plot
Default value: 300
Saved in: `General.OptionsFileName`

`View.Color.Points`

Point color
Default value: {0,0,0}
Saved in: `General.OptionsFileName`

`View.Color.Lines`

Line color
Default value: {0,0,0}
Saved in: `General.OptionsFileName`

`View.Color.Triangles`

Triangle color
Default value: {0,0,0}
Saved in: `General.OptionsFileName`

`View.Color.Quadrangles`

Quadrangle color
Default value: {0,0,0}
Saved in: `General.OptionsFileName`

`View.Color.Tetrahedra`

Tetrahedron color
Default value: {0,0,0}
Saved in: `General.OptionsFileName`

`View.Color.Hexahedra`

Hexahedron color
Default value: {0,0,0}
Saved in: `General.OptionsFileName`

`View.Color.Prisms`

Prism color
Default value: {0,0,0}
Saved in: `General.OptionsFileName`

`View.Color.Pyramids`

Pyramid color
Default value: {0,0,0}
Saved in: `General.OptionsFileName`

View.Color.Tangents
Tangent vector color
Default value: {255,255,0}
Saved in: **General.OptionsFileName**

View.Color.Normals
Normal vector color
Default value: {255,0,0}
Saved in: **General.OptionsFileName**

View.Color.Text2D
2D text color
Default value: {0,0,0}
Saved in: **General.OptionsFileName**

View.Color.Text3D
3D text color
Default value: {0,0,0}
Saved in: **General.OptionsFileName**

View.Color.Axes
Axes color
Default value: {0,0,0}
Saved in: **General.OptionsFileName**

View.ColorTable
Color table used to draw the view
Saved in: **General.OptionsFileName**

Appendix C Information for developers

Gmsh is written in C++, the scripting language is parsed using Lex and Yacc (actually, Flex and Bison), and the GUI relies on OpenGL for the 3D graphics and FLTK (<http://www.fltk.org>) for the widget set. Gmsh's build system is based on CMake (<http://www.cmake.org>). Practical notes on how to compile Gmsh's source code are included in the distribution. See [Appendix E \[Frequently asked questions\]](#), page 185, for more information.

C.1 Getting the source

Stable releases and nightly source snapshots are available from <http://www.geuz.org/gmsh/src/>.

If you have an account on cvs.geuz.org you can also access the CVS repository directly:

1. Set the variable CVS_RSH to ssh ('export CVS_RSH=ssh' with bash, or 'setenv CVS_RSH ssh' with tcsh)

2. The first time you want to download the latest full source by CVS, type:

```
cvs -d username@cvs.geuz.org:/cvsroot checkout gmsh
```

where username is your login on cvs.geuz.org

3. To update your local version to the latest and greatest, go in the gmsh directory and type:

```
cvs update -dPA
```

4. To commit your changes to the central repository, go in the gmsh directory and type:

```
cvs commit
```

C.2 Source code structure

Gmsh's code is structured in several libraries, roughly separated between the three main core modules ('Geo', 'Mesh', 'Post') and associated utility libraries ('Common', 'Numeric') on one hand, and graphics ('Graphics') and interface ('Fltk', 'Parser') libraries on the other.

The geometry and mesh modules are based on an object-oriented model class ('Geo/GModel.h'), built upon abstract geometrical entity classes ('Geo/GVertex.h', 'Geo/GEdge.h', 'Geo/GFace.h' and 'Geo/GRegion.h'). Concrete implementations of the geometrical entity classes are provided for each supported CAD kernel (e.g. 'Geo/gmshVertex.h' for geometry points in Gmsh's native CAD format, or 'Geo/OCCVertex.h' for geometry points from OpenCascade). The post-processing module is based on the concept of views ('Post/PView.h') and abstract data containers (derived from 'Post/PViewData.h').

C.3 Coding style

If you plan to contribute code to the Gmsh project, here are some easy rules to make the code easy to read/debug/maintain:

1. please enable full warnings for your compiler (e.g., add `-Wall` to `FLAGS` in the 'variables' file);
2. always use the `Msg::` class to print information, errors, ...;

3. indent your files (2 spaces)
4. convert all tabs to spaces.

C.4 Adding a new option

To add a new option in Gmsh:

1. create the option in the `CTX` class (`Common/Context.h`) if it's a classical option, or in the `PViewOptions` class (`Post/PViewOptions.h`) if it's a post-processing view-dependent option;
2. in `Common/DefaultOptions.h`, give a name (for the parser to be able to access it), a reference to a handling routine (i.e. `opt_XXX`) and a default value for this option;
3. create the handling routine `opt_XXX` in `Common/Options.cpp` (and add the prototype in `Common/Options.h`);
4. optional: create the associated widget in `Fltk/optionWindow.cpp`;

Appendix D Random tips and tricks

- Install the ‘info’ version of this reference manual! On your (Unix) system, this can be achieved by
 1. copying all ‘gmsh.info*’ files to the place where your info files live (usually ‘/usr/info’), and
 2. issuing the command `install-info /usr/info/gmsh.info /usr/info/dir`.

You will then be able to access the documentation with the command `info gmsh`. Note that particular sections (‘nodes’) can be accessed directly. For example, `info gmsh surfaces` or `info gmsh surf` will take you directly to [Section 5.1.3 \[Surfaces\]](#), [page 31](#).

- Use emacs to edit your files, and load the C++ mode. This permits automatic syntax highlighting and easy indentation. Automatic loading of the C++ mode for ‘.geo’ files can be achieved by adding the following command in your .emacs file: `(setq auto-mode-alist (append '(("\\.geo$" . c++-mode)) auto-mode-alist))`.
- Define common geometrical objects and options in separate files, reusable in all your problem definition structures.
- Save your preferred options with ‘File->Save Default Options’. To reset the default options, erase the `General.OptionsFileName` (usually ‘.gmsh-options’ in your home directory) or use the ‘Restore default options’ button in ‘Tools->Options->General->Output’.
- In the GUI:
 - dragging the mouse in a numeric input field slides the value. The left button moves one step per pixel, the middle by 10 * step, and the right button by 100 * step;
 - selecting the content of an input field, or lines in the message console (‘Tools->Message Console’), copies the selected text to the clipboard;
- Read [Appendix E \[Frequently asked questions\]](#), [page 185...](#)

Appendix E Frequently asked questions

\$Id: FAQ.txt,v 1.6 2009-08-14 08:25:37 geuzaine Exp \$

This is the Gmsh FAQ

Section 1: The basics

* 1.1 What is Gmsh?

Gmsh is an automatic three-dimensional finite element mesh generator with built-in pre- and post-processing facilities. Its design goal is to provide a simple meshing tool for academic problems with parametric input and advanced visualization capabilities.

* 1.2 What are the terms and conditions of use?

Gmsh is distributed under the terms of the GNU General Public License. See the file 'doc/LICENSE' for more information, or go to the GNU foundation's web site at <http://www.gnu.org>.

* 1.3 What does 'Gmsh' mean?

Nothing... The name was derived from a previous version called "msh" (a shortcut for "mesh"), with the "g" prefix added to differentiate it. The default mesh file format used by Gmsh still uses the ".msh" extension.

In English people tend to pronounce 'Gmsh' as "gee-mesh".

* 1.4 Where can I find more information?

<http://www.geuz.org/gmsh/> is the primary location to obtain information about Gmsh. You will for example find a complete reference manual as well as a searchable archive of the Gmsh mailing list (gmsh@geuz.org) on this webpage.

Section 2: Installation

* 2.1 Which OSes does Gmsh run on?

Gmsh is known to run on Windows 2000/XP/Vista, Mac OS X, Linux and most Unix variants.

* 2.2 Are there additional requirements to run Gmsh?

You should have the OpenGL libraries installed on your system, and in the path of the library loader. A free replacement for OpenGL can be found at <http://www.mesa3d.org>.

* 2.3 How do I compile Gmsh from the source code?

You need cmake (<http://www.cmake.org>) and a C++ compiler. See the README.txt file in the top-level source directory for more information.

* 2.4 Where does Gmsh save its configuration files?

Gmsh will attempt to save temporary files and persistent configuration options first in the \$GMSH_HOME directory, then in the \$HOME, \$TMP or \$TEMP directories (in that order) if the \$GMSH_HOME environment variable is not defined. If none of these variables are defined, Gmsh will try to save/load its configuration files from the current working directory.

Section 3: General problems

* 3.1 Gmsh (from a binary distribution) complains about missing libraries.

On Windows, if your system complains about missing OPENG32.DLL or GLU32.DLL libraries, then OpenGL is not properly installed on your machine. You can download OpenGL from Microsoft's web site, or directly from <http://www.opengl.org>.

On Unix try 'ldd gmsh' (or 'otool -L gmsh' on Mac OS X) to check if all the required shared libraries are installed on your system. If not, install them. If it still doesn't work, recompile Gmsh from the sources.

* 3.2 Gmsh keeps re-displaying its graphics when other windows partially hide the graphical window.

Disable opaque move in your window manager.

* 3.3 The graphics display very slowly.

Are you are executing Gmsh from a remote host (via the network)

without GLX? You should turn double buffering off (with the `'-nodb'` command line option).

* 3.4 There is an ugly "ghost triangulation" in the vector PostScript/PDF files generated by Gmsh!

No, there isn't. This "ghost triangulation" is due to the fact that most PostScript previewers nowadays antialias the graphic primitives when they display the page on screen. (For example, in gv, you can disable antialiasing with the `'State->Antialias'` menu.) You should not see this ghost triangulation in the printed output (on paper).

* 3.5 How can I save GIF, JPEG, ..., images?

Just choose the appropriate format in `'File->Save As'`. By default Gmsh guesses the format from the file extension, so you can just choose `"myfile.jpg"` in the dialog.

* 3.6 How can I save MPEG, AVI, ..., animations?

See question 7.9.

Section 4: Geometry module

* 4.1 Does Gmsh support NURBS curves/surfaces?

Yes, but only via STEP, IGES or BREP model import (not in `.geo` files). Gmsh has to be compiled with OpenCascade support for this to work.

* 4.2 Gmsh is very slow when I use many transformations (Translate, Rotate, Symmetry, Extrude, etc.). What's wrong?

The default behavior of Gmsh is to check and suppress all duplicate entities (points, lines and surfaces) each time a transformation command is issued. This can slow down things a lot if many transformations are performed. There are two solutions to this problem:

- you may save the unrolled geometry in another file (e.g. with `gmsh file.geo -O`), and use this new file for subsequent computations;
- or you may set the `'Geometry.AutoCoherence'` option to 0. This will prevent any automatic duplicate check/replacement. If you still need to remove the duplicates entities, simply add `'Coherence;'` at strategic locations in your geo files (e.g. before the creation of line loops, etc.).

* 4.3 How can I display only selected parts of my model?

Use 'Tools->Visibility'. This allows you to select elementary entities and physical groups, as well as mesh elements, in a variety of ways (in a list or tree browser, by identification number, interactively, or per window).

* 4.4 Can I edit STEP/IGES/BRep models?

Not yet. At the moment you can only change characteristic lengths, define volumes and physical groups, or delete entities. The easiest way to do this is to merge the model in a .geo file using 'Merge "file.step";' and add the relevant scripting command after that. We plan to add more advanced editing features in the future (to delete entities, to create "mixed" surfaces and volumes, to export in .geo format, etc.).

Section 5: Mesh module

* 5.1 What should I do when the 2D unstructured algorithm fails?

Verify that the curves in the model do not self-intersect. If `Mesh.RandomFactor * size(triangle)/size(model)` approaches machine accuracy, increase `Mesh.RandomFactor`.

If everything fails send us a bug report with the version of your operating system and the full geometry.

* 5.2 What should I do when the 3D unstructured algorithm fails?

Verify that the surfaces in your model do not self-intersect or partially overlap. If they don't, try the other 3D algorithms (Tool->Options->Mesh->General->3D algorithm) or try to adapt the characteristic lengths in your input file so that the surface mesh better matches the geometrical details of the model.

If nothing works, send us a bug report (including your geometry).

* 5.3 The quality of the elements generated by the 3D algorithm is very bad.

Use 'Optimize quality' in the mesh menu.

* 5.4 Non-recombined 3D extruded meshes sometimes fail.

The swapping algorithm is not very clever at the moment. Try to change the surface mesh a bit, or recombine your mesh to generate prisms or hexahedra instead of tetrahedra.

* 5.5 Does Gmsh automatically couple unstructured tetrahedral meshes and structured hexahedral meshed using pyramids?

No. We need your help to implement this.

* 5.6 Can I explicitly assign region numbers to extruded layers?

No, this feature has been removed in Gmsh 2.0. You must use the standard entity number instead.

* 5.7 Did you remove the elliptic mesh generator in Gmsh 2.0?

Yes. You can achieve the same result by using the transfinite algorithm with smoothing (e.g., with "Mesh.Smoothering = 10").

* 5.8 Does Gmsh support curved elements?

Yes, Gmsh can generate both 1st order and 2nd order elements. To generate second order elements, click on 'Second order' in the mesh menu after the mesh is completed. To always generate 2nd order elements, select 'Generate second order elements' in the mesh option panel. From the command line, you can also use '-order 2'.

* 5.9 Can I import an existing surface mesh in Gmsh and use it to build a 3D mesh?

Yes, you can import a surface mesh in any one of the supported mesh file formats, define a volume, and mesh it. For an example see 'demos/sphere-discrete.geo'.

* 5.10 How do I define boundary conditions or material properties in Gmsh?

By design, Gmsh does not try to incorporate every possible definition of boundary conditions or material properties--this is a job best left to the solver. Instead, Gmsh provides a simple mechanism to tag groups of elements, and it is up to the solver to interpret these tags as boundary conditions, materials, etc. Associating tags with elements in Gmsh is done by defining Physical entities (Physical Points, Physical Lines, Physical Surfaces and Physical Volumes). See the reference manual as well as the tutorials (in particular 'tutorial/t1.geo') for a detailed description and some examples.

- * 5.11 How can I display only the mesh associated with selected geometrical entities?

See question 4.3.

- * 5.12 How can I "explore" a mesh (for example, to see inside a complex structure)?

You can use 'Tools->Clipping Planes' to clip the region of interest. You can define up to 6 clipping planes in Gmsh (i.e., enough to define a "cube" inside your model) and each plane can clip either the geometry, the mesh, the post-processing views, or any combination of the above. The clipping planes are defined using the four coefficients A,B,C,D of the equation $A*x+B*y+C*z+D=0$, which can be adjusted interactively by dragging the mouse in the input fields.

- * 5.13 What is the signification of Rho, Eta and Gamma in Tools->Statistics?

They measure the quality of the tetrahedra in a mesh:

$\text{Gamma} \sim \text{inscribed_radius} / \text{circumscribed_radius}$
 $\text{Eta} \sim \text{volume}^{(2/3)} / \text{sum_edge_length}^2$
 $\text{Rho} \sim \text{min_edge_length} / \text{max_edge_length}$

For the exact definitions, see Geo/MElement.cpp. The graphs plot the the number of elements vs. the quality measure.

- * 5.14 Why don't the vertex and/or element numbers on the screen match the numbers in the mesh file?

Gmsh reindexes the mesh vertices and elements so that they are numbered in a continuous sequence in the output files. The numbers displayed on screen after mesh generation thus usually differ from the ones saved in the mesh files. To check the actual numbers saved in the output file just load the mesh file back using File->Open.

Section 6: Solver module

- * 6.1 How do I integrate my own solver with Gmsh?

If you want to simply launch a program from within Gmsh, just edit the options to define your solver commands (e.g. Solver.Name0,

Solver.Executable0, etc.), and set the ClientServer option to zero (e.g. Solver.ClientServer0 = 0).

If you want your solver to interact with Gmsh (for error messages, option definitions, post-processing, etc.), you will need to link your solver with the GmshClient routines and add the appropriate function calls inside your program. You will of course also need to define your solver commands in an option file, but this time you should set the ClientServer variable to 1 (e.g. Solver.ClientServer = 1). C, C++, Perl and Python solver examples are available in the source distribution in the 'utils/solvers' directory.

* 6.2 On Windows, Gmsh does not seem to find the solver executable. What's wrong?

The solver executable (for example, 'getdp.exe') has to be in your path. If it is not specify its location in the 'Command' field.

* 6.3 Can I launch Gmsh from my solver (instead of launching my solver from Gmsh) in order to monitor a solution?

Sure. The simplest (but rather crude) approach is to re-launch Gmsh everytime you want to visualize something (a simple C program showing how to do this is given in 'utils/misc/callgmsh.c'). A better approach is to modify your program so that it can communicate with Gmsh over a socket (see question 6.1 above; you can skip the option file creation). Then select 'Always listen to incoming connection requests' in the solver option panel (or run gmsh with the '-listen' command line option) and Gmsh will always listen for your program on the Solver.SocketName socket.

Section 7: Post-processing module

* 7.1 How do I compute a section of a plot?

Use 'Tools->Plugins->Cut Plane'.

* 7.2 Can I save an isosurface to a file?

Yes: first run 'Tools->Plugins->Cut Map' to extract the isosurface, then use 'View->Save As' to save the new view.

* 7.3 Can Gmsh generate isovolumes?

Yes, with the CutMap plugin (set the ExtractVolume option to -1 or 1

to extract the negative or positive levelset).

* 7.4 How do I animate my plots?

If the views contain multiple time steps, you can press the 'play' button at the bottom of the graphic window, or change the time step by hand in the view option panel. You can also use the left and right arrow keys on your keyboard to change the time step in all visible views in real time.

If you want to loop through different views instead of time steps, you can use the 'Loop through views instead of time steps' option in the view option panel, or use the up and down arrow keys on your keyboard.

* 7.5 How do I visualize a deformed mesh?

Load a vector view containing the displacement field, and set 'Vector display' to 'Displacement' in View->Options->Aspect. If the displacement is too small (or too large), you can scale it with the 'Displacement factor' option. (Remember that you can drag the mouse in all numeric input fields to slide the value!)

Another option is to use the 'General transformation expressions' (in View->Options->Offset) on a scalar view, with the displacement map selected as the data source.

* 7.6 Can I visualize a field on a deformed mesh?

Yes, there are several ways to do that.

The easiest is to load two views: the first one containing a displacement field (a vector view that will be used to deform the mesh), and the second one containing the field you want to display (this view has to contain the same number of elements as the displacement view). You should then set 'Vector display' to 'Displacement' in the first view, as well as set 'Data source' to point to the second view. (You might want to make the second view invisible, too. If you want to amplify or decrease the amount of deformation, just modify the 'Displacement factor' option.)

Another solution is to use the 'General transformation expressions' (in 'View->Options->Offset') on the field you want to display, with the displacement map selected as the data source.

And yet another solution is to use the Warp plugin.

* 7.7 Can I color the arrows representing a vector field with data

from a scalar field?

Yes: load both the vector and the scalar fields (the two views must have the same number of elements) and, in the vector field options, select the scalar view in 'Data source'.

* 7.8 Can I color isovalue surfaces with data from another scalar view?

Yes, using either the CutMap plugin (with the 'dView' option) or the Evaluate plugin.

* 7.9 Is there a way to save animations?

Yes, using scripts. Have a look at 'tutorial/t8.geo' or 'demos/anim.script' for some examples.

* 7.10 Is there a way to visualize only certain components of vector/tensor fields?

Yes, using 'Tools->Plugins->Extract'.

* 7.11 Can I do arithmetic operations on a view? Can I perform operations involving different views?

Yes, with the Evaluate plugin.

* 7.12 Some plugins seem to create empty views. What's wrong?

There can be several reasons:

- the plugin might be written for specific element types only (for example, only for scalar triangles or tetrahedra). In that case, you should transform your view before running the plugin (you can use `Plugin(DecomposeinSimplex)` to transform all quads, hexas, prisms and pyramids into triangles and tetrahedra).
- the plugin might expect a mesh while all you provide is a point cloud. In 2D, you can use `Plugin(Triangulate)` to transform a point cloud into a triangulated surface. A 3D version of this plugin is not available yet but it is on our TODO list.
- the input parameters are out of range.

In any case, you can automatically remove all empty views with 'View->Remove->Empty Views' in the GUI, or with "Delete Empty Views;" in a script.

* 7.13 How can I see "inside" a complicated post-processing view?

See question 5.12.

When viewing 3D scalar fields, you can also modify the colormap ('Tools->Options->View->Map') to make the iso-surfaces "transparent": either by holding 'Ctrl' while dragging the mouse to draw the alpha channel by hand, or by using the 'a', 'Ctrl+a', 'p' and 'Ctrl+p' keyboard shortcuts.

Yet another (destructive) option is to use the ExtractVolume option in the CutSphere or CutPlane plugins.

* 7.14 I am loading a valid 3D scalar view but Gmsh does not display anything!

If your dataset is constant per element make sure you don't use the 'Iso-values' interval type in 'Tools->Options->View->Range'.

Appendix F Version history

\$Id: VERSIONS.txt,v 1.61 2009-09-21 17:38:55 geuzaine Exp \$

2.4.2 (Sep 21, 2009): solver code refactoring.

2.4.1 (Sep 1, 2009): fixed surface mesh orientation bug introduced in 2.4.0; mesh and graphics code refactoring, small usability enhancements and bug fixes.

2.4.0 (Aug 22, 2009): switched build system to CMake; optionally copy transfinite mesh constraints during geometry transformations; bumped mesh version format to 2.1 (small change in the \$PhysicalNames section, where the group dimension is now required); ported most plugins to the new post-processing API; switched from MathEval to MathEx and Flu_Tree_Browser to Fl_Tree; small bug fixes and improvements all over the place.

2.3.1 (Mar 18, 2009): removed GSL dependency (Gmsh now simply uses Blas and Lapack); new per-window visibility; added support for composite window printing and background images; fixed string option affectation in parser; fixed surface mesh orientation for Open Cascade models; fixed random triangle orientations in Delaunay and Frontal algorithms.

2.3.0 (Jan 23, 2009): major graphics and GUI code refactoring; new full-quad/hexa subdivision algorithm (removed Mesh.RecombineAlgo); improved automatic transfinite corner selection (now also for volumes); improved visibility browser; new automatic adaptive visualization for high-order simplices; modified arrow size, clipping planes and transform options; many improvements and bug fixes all over the place.

2.2.6 (Nov 21, 2008): better transfinite smoothing and automatic corner selection; fixed high order meshing crashes on Windows and Linux; new uniform mesh refinement (thanks Brian!); fixed various other small bugs.

2.2.5 (Oct 25, 2008): Gmsh now requires FLTK 1.1.7 or above; various small improvements (STL and VTK mesh IO, Netgen upgrade, Visual C++ support, Fields, Mesh.{Msh,Stl,...}Binary changed to Mesh.Bindary) and bug fixes (pyramid interpolation, Chaco crashes).

2.2.4 (Aug 14, 2008): integrated Metis and Chaco mesh partitioners; variables can now be deleted in geo files; added support for point datasets in model-based postprocessing views; small bug fixes.

2.2.3 (Jul 14, 2008): enhanced clipping interface; API cleanup; fixed various bugs (Plugin(Integrate), high order meshes, surface info crash).

2.2.2 (Jun 20, 2008): added geometrical transformations on volumes; fixed bug in high order mesh generation.

2.2.1 (Jun 15, 2008): various small improvements (adaptive views, GUI, code cleanup) and bug fixes (high order meshes, Netgen interface).

2.2.0 (Apr 19, 2008): new model-based post-processing backend; added MED I/O for mesh and post-processing; fixed BDF vertex ordering for 2nd order elements; replaced Mesh.ConstrainedBackgroundMesh with Mesh.CharacteristicLength{FromPoints,ExtendFromBoundary}; new Fields interface; control windows are now non-modal by default; new experimental 2D frontal algorithm; fixed various bugs.

2.1.1 (Mar 1, 2008): small bug fixes (second order meshes, combine views, divide and conquer crash, ...).

2.1.0 (Feb 23, 2008): new post-processing database; complete rewrite of post-processing drawing code; improved surface mesh algorithms; improved STEP/IGES/BREP support; new 3D mesh optimization algorithm; new default native file choosers; fixed 'could not find extruded vertex' in extrusions; many improvements and bug fixes all over the place.

2.0.8 (Jul 13, 2007): unused vertices are not saved in mesh files anymore; new plugin GUI; automatic GUI font size selection; renamed Plugin(DecomposeInSimplex) into Plugin(MakeSimplex); reintroduced enhanced Plugin(SphericalRaise); clarified meshing algo names; new option to save groups of nodes in UNV meshes; new background mesh infrastructure; many small improvements and small bug fixes.

2.0.7 (Apr 3, 2007): volumes can now be defined from external CAD surfaces; Delaunay/Tetgen algorithm is now used by default when available; re-added support for Plot3D structured mesh format; added ability to export external CAD models as GEO files (this only works for the limited set of geometrical primitives available in the GEO language, of course--so trying to convert e.g. a trimmed NURBS from a STEP file into a GEO file will fail); "lateral" entities are now added at the end of the list returned by extrusion commands; fixed various bugs.

2.0 (Feb 5, 2007): new geometry and mesh databases, with support for STEP and IGES import via OpenCascade; complete rewrite of geometry and mesh drawing code; complete rewrite of mesh I/O layer (with new native

binary MSH format and support for import/export of I-deas UNV, Nastran BDF, STL, Medit MESH and VRML 1.0 files); added support for incomplete second order elements; new 2D and 3D meshing algorithms; improved integration of Netgen and TetGen algorithms; removed anisotropic meshing algorithm (as well as attractors); removed explicit region number specification in extrusions; option changes in the graphical interface are now applied instantaneously; added support for offscreen rendering using OSMesa; added support for SVG output; added string labels for Physical entities; lots of other improvements all over the place.

1.65 (May 15, 2006): new Plugin(ExtractEdges); fixed compilation errors with gcc4.1; replaced Plugin(DisplacementRaise) and Plugin(SphericalRaise) with the more flexible Plugin(Warp); better handling of discrete curves; new Status command in parser; added option to renumber nodes in .msh files (to avoid holes in the numbering sequence); fixed 2 special cases in quad->prism extrusion; fixed saving of 2nd order hexas with negative volume; small bug fixes and cleanups.

1.64 (Mar 18, 2006): Windows versions do no depend on Cygwin anymore; various bug fixes and cleanups.

1.63 (Feb 01, 2006): post-processing views can now be exported as meshes; improved background mesh handling (a lot faster, and more accurate); improved support for input images; new Plugin(ExtractElements); small bug fixes and enhancements.

1.62 (Jan 15, 2006): new option to draw color gradients in the background; enhanced perspective projection mode; new "lasso" selection mode (same as "lasso" zoom, but in selection mode); new "invert selection" button in the visibility browser; new snapping grid when adding points in the GUI; nicer normal smoothing; new extrude syntax (old syntax still available, but deprecated); various small bug fixes and enhancements.

1.61 (Nov 29, 2005): added support for second order (curved) elements in post-processor; new version (1.4) of post-processing file formats; new stippling options for 2D plots; removed limit on allowed number of files on command line; all "Combine" operations are now available in the parser; changed View.ArrowLocation into View.GlyphLocation; optimized memory usage when loading many (>1000) views; optimized loading and drawing of line meshes and 2D iso views; optimized handling of meshes with large number of physical entities; optimized vertex array creation for large post-processing views on Windows/Cygwin; removed Discrete Line and Discrete Surface commands (the same functionality can now be obtained by simply loading a mesh

in .msh format); fixed coloring by mesh partition; added option to light wireframe meshes and views; new "mesh statistics" export format; new full-quad recombine option; new Plugin(ModulusPhase); hexas and prisms are now always saved with positive volume; improved interactive entity selection; new experimental Tetgen integration; new experimental STL remeshing algorithm; various small bug fixes and improvements.

1.60 (Mar 15, 2005): added support for discrete curves; new Window menu on Mac OS X; generalized all octree-based plugins (CutGrid, StreamLines, Probe, etc.) to handle all element types (and not only scalar and vector triangles+tetrahedra); generalized Plugin(Evaluate), Plugin(Extract) and Plugin(Annotate); enhanced clipping plane interface; new grid/axes/rulers for 3D post-processing views (renamed the AbscissaName, NbAbscissa and AbscissaFormat options to more general names in the process); better automatic positioning of 2D graphs; new manipulator dialog to specify rotations, translations and scalings "by hand"; various small enhancements and bug fixes.

1.59 (Feb 06, 2005): added support for discrete (triangulated) surfaces, either in STL format or with the new "Discrete Surface" command; added STL and Text output format for post-processing views and STL output format for surface meshes; all levelset-based plugins can now also compute isovolumes; generalized Plugin(Evaluate) to handle external view data (based on the same or on a different mesh); generalized Plugin(CutGrid); new plugins (Eigenvalues, Gradient, Curl, Divergence); changed default colormap to match Matlab's "Jet" colormap; new transformation matrix option for views (for non-destructive rotations, symmetries, etc.); improved solver interface to keep the GUI responsive during solver calls; new C++ and Python solver examples; simplified Tools->Visibility GUI; transfinite lines with "Progression" now allow negative line numbers to reverse the progression; added ability to retrieve Gmsh's version number in the parser (to help write backward compatible scripts); fixed white space in unv mesh output; fixed various small bugs.

1.58 (Jan 01, 2005): fixed UNIX socket interface on Windows (broken by the TCP solver patch in 1.57); bumped version number of default post-processing file formats to 1.3 (the only small modification is the handling of the end-of-string character for text2d and text3d objects in the ASCII format); new File->Rename menu; new colormaps+improved colormap handling; new color+min/max options in views; new GetValue() function to ask for values interactively in scripts; generalized For/EndFor loops in parser; new plugins (Annotate, Remove, Probe); new text attributes in views; renamed some shortcuts; fixed TeX output for large scenes; new option dialogs for various output formats; fixed many small memory leaks in parser; many

small enhancements to polish the graphics and the user interface.

1.57 (Dec 23, 2004): generalized displacement maps to display arbitrary view types; the arrows representing a vector field can now also be colored by the values from other scalar, vector or tensor fields; new adaptive high order visualization mode; new options (Solver.SocketCommand, Solver.NameCommand, View.ArrowSizeProportional, ViewNormals, View.Tangents and General.ClipFactor); fixed display of undesired solver plugin popups; enhanced interactive plugin behavior; new plugins (HarmonicToTime, Integrate, Eigenvectors); tetrahedral mesh file reading speedup (50% faster on large meshes); large memory footprint reduction (up to 50%) for the visualization of triangular/tetrahedral meshes; the solver interface now supports TCP/IP connections; new generalized raise mode (allows to use complex expressions to offset post-processing maps); upgraded Netgen kernel to version 4.4; new optional TIME list in parsed views to specify the values of the time steps; several bug fixes in the Elliptic mesh algorithm; various other small bug fixes and enhancements.

1.56 (Oct 17, 2004): new post-processing option to draw a scalar view raised by a displacement view without using Plugin(DisplacementRaise) (makes drawing arbitrary scalar fields on deformed meshes much easier); better post-processing menu (arbitrary number of views+scrollable+show view number); improved view->combine; new horizontal post-processing scales; new option to draw the mesh nodes per element; views can now also be saved in "parsed" format; fixed various path problems on Windows; small bug fixes.

1.55 (Aug 21, 2004): added background mesh support for Triangle; meshes can now be displayed using "smoothed" normals (like post-processing views); added GUI for clipping planes; new interactive clipping/cutting plane definition; reorganized the Options GUI; enhanced 3D iso computation; enhanced lighting; many small bug fixes.

1.54 (Jul 03, 2004): integrated Netgen (3D mesh quality optimization + alternative 3D algorithm); Extrude Surface now always automatically creates a new volume (in the same way Extrude Point or Extrude Line create new lines and surfaces, respectively); fixed UNV output; made the "Layers" region numbering consistent between lines, surfaces and volumes; fixed home directory problem on Win98; new Plugin(CutParametric); the default project file is now created in the home directory if no current directory is defined (e.g., when double-clicking on the icon on Windows/Mac); fixed the discrepancy between the orientation of geometrical surfaces and the associated surface meshes; added automatic orientation of surfaces in surface loops; generalized Plugin(Triangulate) to handle vector and tensor views; much nicer display of discrete iso-surfaces and custom ranges

using smooth normals; small bug fixes and cleanups.

1.53 (Jun 04, 2004): completed support for second order elements in the mesh module (line, triangles, quadrangles, tetrahedra, hexahedra, prisms and pyramids); various background mesh fixes and enhancements; major performance improvements in mesh and post-processing drawing routines (OpenGL vertex arrays for tri/quads); new Plugin(Evaluate) to evaluate arbitrary expressions on post-processing views; generalized Plugin(Extract) to handle any combination of components; generalized "Coherence" to handle transfinite surface/volume attributes; plugin options can now be set in the option file (like all other options); added "undo" capability during geometry creation; rewrote the contour guessing routines so that entities can be selected in an arbitrary order; Mac users can now double click on geo/msh/pos files in the Finder to launch Gmsh; removed support for FLTK 1.0; rewrote most of the code related to quadrangles; fixed 2d elliptic algorithm; removed all OpenGL display list code and options; fixed light positioning; new BoundingBox command to set the bounding box explicitly; added support for inexpensive "fake" transparency mode; many code cleanups.

1.52 (May 06, 2004): new raster ("bitmap") PostScript/EPS/PDF output formats; new Plugin(Extract) to extract a given component from a post-processing view; new Plugin(CutGrid) and Plugin(StreamLines); improved mesh projection on non-planar surfaces; added support for second order tetrahedral elements; added interactive control of element order; refined mesh entity drawing selection (and renamed most of the corresponding options); enhanced log scale in post-processing; better font selection; simplified View.Raise{X,Y,Z} by removing the scaling; various bug fixes (default postscript printing mode, drawing of 3D arrows/cylinders on Linux, default home directory on Windows, default initial file browser directory, extrusion of points with non-normalized axes of rotation, computation of the scene bounding box in scripts, + the usual documentation updates).

1.51 (Feb 29, 2004): initial support for visualizing mesh partitions; integrated version 2.0 of the MSH mesh file format; new option to compute post-processing ranges (min/max) per time step; Multiple views can now be combined into multi time step ones (e.g. for programs that generate data one time step at a time); new syntax: #var[] returns the size of the list var[]; enhanced "gmsh -convert"; temporary and error files are now created in the home directory to avoid file permission issues; new 3D arrows; better lighting support; STL facets can now be converted into individual geometrical surfaces; many other small improvements and bug fixes (multi timestep tensors, color by physical entity, parser cleanup, etc.).

1.50 (Dec 06, 2003): small changes to the visibility browser + made

visibility scriptable (new Show/Hide commands); fixed (rare) crash when deleting views; split File->Open into File->Open and File->New to behave like most other programs; Mac versions now use the system menu bar by default (if possible); fixed bug leading to degenerate and/or duplicate tetrahedra in extruded meshes; fixed crash when reloading sms meshes.

1.49 (Nov 30, 2003): made Merge, Save and Print behave like Include (i.e., open files in the same directory as the main project file if the path is relative); new Plugin(DecomposeInSimplex); new option View.AlphaChannel to set the transparency factor globally for a post-processing view; new "Combine Views" command; various bug fixes and cleanups.

1.48 (Nov 23, 2003): new DisplacementRaise plugin to plot arbitrary fields on deformed meshes; generalized CutMap, CutPlane, CutSphere and Skin plugins to handle all kinds of elements and fields; new "Save View[n]" command to save views from a script; many small bug fixes (configure tests for libpng, handling of erroneous options, multi time step scalar prism drawings, copy of surface mesh attributes, etc.).

1.47 (Nov 12, 2003): fixed extrusion of surfaces defined by only two curves; new syntax to retrieve point coordinates and indices of entities created through geometrical transformations; new PDF and compressed PostScript output formats; fixed numbering of elements created with "Extrude Point/Line"; use \$GMSH_HOME as home directory if defined.

1.46 (Aug 23, 2003): fixed crash for very long command lines; new options for setting the displacement factor and Triangle's parameters + renamed a couple of options to more sensible names (View.VectorType, View.ArrowSize); various small bug fixes; documentation update.

1.45 (Jun 14, 2003): small bug fixes (min/max computation for tensor views, missing physical points in read mesh, "jumping" geometry during interactive manipulation of large models, etc.); variable definition speedup; restored support for second order elements in one- and two-dimensional meshes; documentation updates.

1.44 (Apr 21, 2003): new reference manual; added support for PNG output; fixed small configure script bugs.

1.43 (Mar 28, 2003): fixed solver interface problem on Mac OS X; new option to specify the interactive rotation center (default is now the pseudo "center of gravity" of the object, instead of (0,0,0)).

1.42 (Mar 19, 2003): suppressed the automatic addition of a ".geo" extension

if the file given on the command line is not recognized; added missing Layer option for Extrude Point; fixed various small bugs.

1.41 (Mar 04, 2003): Gmsh is now licensed under the GNU General Public License; general code cleanup (indent).

1.40 (Feb 26, 2003): various small bug fixes (mainly GSL-related).

1.39 (Feb 23, 2003): removed all non-free routines; more build system work; implemented Von-Mises tensor display for all element types; fixed small GUI bugs.

1.38 (Feb 17, 2003): fixed custom range selection for 3D iso graphs; new build system based on autoconf; new image reading code to import bitmaps as post-processing views.

1.37 (Jan 25, 2003): generalized smoothing and cuts of post-processing views; better Windows integration (solvers, external editors, etc.); small bug fixes.

1.36 (Nov 20, 2002): enhanced view duplication (one can now use "Duplicata View[num]" in the input file); merged all option dialogs in a new general option window; enhanced discoverability of the view option menus; new 3D point and line display; many small bug fixes and enhancements ("Print" format in parser, post-processing statistics, smooth normals, save window positions, restore default options, etc.).

1.35 (Sep 11, 2002): graphical user interface upgraded to FLTK 1.1 (tooltips, new file chooser with multiple selection, full keyboard navigation, cut/paste of messages, etc.); colors can be now be directly assigned to mesh entities; initial tensor visualization; new keyboard animation (right/left arrow for time steps; up/down arrow for view cycling); new VRML output format for surface meshes; new plugin for spherical elevation plots; new post-processing file format (version 1.2) supporting quadrangles, hexahedra, prisms and pyramids; transparency is now enabled by default for post-processing plots; many small bug fixes (read mesh, ...).

1.34 (Feb 18, 2002): improved surface mesh of non-plane surfaces; fixed orientation of elements in 2D anisotropic algorithm; minor user interface polish and additions (mostly in post-processing options); various small bug fixes.

1.33 (Jan 24, 2002): new parameterizable solver interface (allowing up to 5 user-defined solvers); enhanced 2D aniso algorithm; 3D initial mesh speedup.

1.32 (Oct 04, 2001): new visibility browser; better floating point exception checks; fixed infinite looping when merging meshes in project files; various small clean ups (degenerate 2D extrusion, view->reload, ...).

1.31 (Nov 30, 2001): corrected ellipses; PostScript output update (better shading, new combined PS/LaTeX output format); more interface polish; fixed extra memory allocation in 2D meshes; Physical Volume handling in unv format; various small fixes.

1.30 (Nov 16, 2001): interface polish; fix crash when extruding quadrangles.

1.29 (Nov 12, 2001): translations and rotations can now be combined in extrusions; fixed coherence bug in Extrude Line; various small bug fixes and additions.

1.28 (Oct 30, 2001): corrected the 'Using Progression' attribute for tranfinite meshes to actually match a real geometric progression; new Triangulate plugin; new 2D graphs (space+time charts); better performance of geometrical transformations (warning: the numbering of some automatically created entities has changed); new text primitives in post-processing views (file format updated to version 1.1); more robust mean plane computation and error checks; various other small additions and clean-ups.

1.27 (Oct 05, 2001): added ability to extrude curves with Layers/Recombine attributes; new PointSize/LineWidth options; fixed For/EndFor loops in included files; fixed error messages (line numbers+file names) in loops and functions; made the automatic removal of duplicate geometrical entities optional (Geometry.AutoCoherence=0); various other small bug fixes and clean-ups.

1.26 (Sep 06, 2001): enhanced 2D anisotropic mesh generator (metric intersections); fixed small bug in 3D initial mesh; added alternative syntax for built-in functions (for GetDP compatibility); added line element display; Gmsh now saves all the elements in the mesh if no physical groups are defined (or if Mesh.SaveAll=1).

1.25 (Sep 01, 2001): fixed bug with mixed recombined/non-recombined extruded meshes; Linux versions are now build with no optimization, due to bugs in gcc 2.95.X.

1.24 (Aug 30, 2001): fixed characteristic length interpolation for Splines; fixed edge swapping bug in 3D initial mesh; fixed degenerated case in geometrical extrusion (ruled surface with 3 borders); fixed generation of degenerated hexahedra and prisms for recombined+extruded

meshes; added BSplines creation in the GUI; integrated Jonathan Shewchuk's Triangle as an alternative isotropic 2D mesh generator; added AngleSmoothNormals to control sharp edge display with smoothed normals; fixed random crash for lighted 3D iso surfaces.

1.23 (Aug, 2001): fixed duplicate elements generation + non-matching tetrahedra faces in 3D extruded meshes; better display of displacement maps; fixed interactive ellipsis construction; generalized boundary operator; added new explode option for post-processing views; enhanced link view behavior (to update only the changed items); added new default plugins: Skin, Transform, Smooth; fixed various other small bugs (mostly in the post-processing module and for extruded meshes).

1.22 (Aug 03, 2001): fixed (yet another) bug for 2D mesh in the mean plane; fixed surface coherence bug in extruded meshes; new double logarithmic scale, saturate value and smoothed normals option for post-processing views; plugins are now enabled by default; three new experimental statically linked plugins: CutMap (extracts a given iso surface from a 3D scalar map), CutPlane (cuts a 3D scalar map with a plane section), CutSphere (cuts a 3D scalar map with a sphere); various other bug fixes, additions and clean-ups.

1.21 (Jul 25, 2001): fixed more memory leaks; added -opt command line option to parse definitions directly from the command line; fixed missing screen refreshes during contour/surface/volume selection; enhanced string manipulation functions (Sprintf, StrCat, StrPrefix); many other small fixes and clean-ups.

1.20 (Jun 14, 2001): fixed various bugs (memory leaks, functions in included files, solver command selection, ColorTable option, duplicate nodes in extruded meshes (not finished yet), infinite loop on empty views, orientation of recombined quadrangles, ...); reorganized the interface menus; added constrained background mesh and mesh visibility options; added mesh quality histograms; changed default mesh colors; reintegrated the old command-line extrusion mesh generator.

1.19 (May 07, 2001): fixed seg. fault for scalar simplex post-processing; new Solver menu; interface for GetDP solver through sockets; fixed multiple scale alignment; added some options + full option descriptions.

1.18 (Apr 26, 2001): fixed many small bugs and incoherences in post-processing; fixed broken background mesh in 1D mesh generation.

1.17 (Apr 17, 2001): corrected physical points saving; fixed parsing of DOS files (carriage return problems); easier geometrical selections (cursor change); plugin manager; enhanced variable arrays (sublist

selection and affectation); line loop check; New arrow display; reduced number of 'fatal' errors + better handling in interactive mode; fixed bug when opening meshes; enhanced File->Open behavior for meshes and post-processing views.

1.16 (Feb 26, 2001): added single/double buffer selection (only useful for Unix versions of Gmsh run from remote hosts without GLX); fixed a bug for recent versions of the opengl32.dll on Windows, which caused OpenGL fonts not to show up.

1.15 (Feb 23, 2001): added automatic visibility setting during entity selection; corrected geometrical extrusion bug.

1.14 (Feb 17, 2001): corrected a few bugs in the GUI (most of them were introduced in 1.13); added interactive color selection; made the option database bidirectional (i.e. scripts now correctly update the GUI); default options can now be saved and automatically reloaded at startup; made some changes to the scripting syntax (PostProcessing.View[n] becomes View[n]; Offset0 becomes OffsetX, etc.); corrected the handling of simple triangular surfaces with large characteristic lengths in the 2D isotropic algorithm; added an ASCII to binary post-processing view converter.

1.13 (Feb 09, 2001): added support for JPEG output on Windows.

1.12: corrected vector lines in the post-processing parsed format; corrected animation on Windows; corrected file creation in scripts on Windows; direct affectation of variable arrays.

1.11 (Feb 07, 2001): corrected included file loading problem.

1.10 (Feb 04, 2001): switched from Motif to FLTK for the GUI. Many small tweaks.

1.00 (Jan 15, 2001): added PPM and YUV output; corrected nested If/Endif; Corrected several bugs for pixel output and enhanced GIF output (dithering, transparency); slightly changed the post-processing file format to allow both single and double precision numbers.

0.999 (Dec 20, 2000): added JPEG output and easy MPEG generation (see t8.geo in the tutorial); clean up of export functions; small fixes; Linux versions are now compiled with gcc 2.95.2, which should fix the problems encountered with Mandrake 7.2.

0.998 (Dec 19, 2000): corrected bug introduced in 0.997 in the generation of the initial 3D mesh.

0.997 (Dec 14, 2000): corrected bug in interactive surface/volume selection; Added interactive symmetry; corrected geometrical extrusion with rotation in degenerated or partially degenerated cases; corrected bug in 2D mesh when meshing in the mean plane.

0.996: arrays of variables; enhanced Printf and Sprintf; Simplified options (suppression of option arrays).

0.995 (Dec 11, 2000): totally rewritten geometrical database (performance has been drastically improved for all geometrical transformations, and most notably for extrusion). As a consequence, the internal numbering of geometrical entities has changed: this will cause incompatibilities with old .geo files, and will require a partial rewrite of your old .geo files if these files made use of geometrical transformations. The syntax of the .geo file has also been clarified. Many additions for scripting purposes. New extrusion mesh generator. Preliminary version of the coupling between extruded and Delaunay meshes. New option and procedural database. All interactive operations can be scripted in the input files. See the last example in the tutorial for an example. Many stability enhancements in the 2D and 3D mesh algorithms. Performance boost of the 3D algorithm. Gmsh is still slow, but the performance becomes acceptable. An average 1000 tetrahedra/second is obtained on a 600Mhz computer for a mesh of one million tetrahedra. New anisotropic 2D mesh algorithm. New (ASCII and binary) post-processing file format and clarified mesh file format. New handling for interactive rotations (trackball mode). New didactic interactive mesh construction (watch the Delaunay algorithm in real time on complex geometries: that's exciting ;-). And many, many bug fixes and cleanups.

0.992 (Nov 13, 2000): corrected recombined extrusion; corrected ellipses; added simple automatic animation of post-processing maps; fixed various bugs.

0.991 (Oct 24, 2000): fixed a serious allocation bug in 2D algorithm, which caused random crashes. All users should upgrade to 0.991.

0.990: bug fix in non-recombined 3D transfinite meshes.

0.989 (Sep 01, 2000): added ability to reload previously saved meshes; some new command line options; reorganization of the scale menu; GIF output.

0.987: fixed bug with smoothing (leading to the possible generation of erroneous 3d meshes); corrected bug for mixed 3D meshes; moved the 'toggle view link' option to Opt->Postprocessing_Options.

0.986: fixed overlay problems; SGI version should now also run on 32 bits machines; fixed small 3d mesh bug.

0.985: corrected colormap bug on HP, SUN, SGI and IBM versions; corrected small initialization bug in postscript output.

0.984: corrected bug in display lists; added some options in Opt->General.

0.983: corrected some seg. faults in interactive mode; corrected bug in rotations; changed default window sizes for better match with 1024x768 screens (default X resources can be changed: see ex03.geo).

0.982: lighting for mesh and post-processing; corrected 2nd order mesh on non plane surfaces; added example 13.

Appendix G Copyright and credits

Gmsh is copyright (C) 1997-2009

Christophe Geuzaine
<cgeuzaine at ulg.ac.be>

and

Jean-Francois Remacle
<jean-francois.remacle at uclouvain.be>

Code contributions to Gmsh have been provided by David Colignon (colormaps), Emilie Marchandise (compound geometrical entities), Gaetan Bricteux (Gauss integration and levelsets), Jacques Lechelle (DIFFPACK mesh format), Jonathan Lambrechts (fields), Jozef Vesely (Tetgen), Koen Hillewaert (high order elements), Laurent Stainier (eigenvalue solvers, tensor display and MacOS bits), Marc Ume (original list code), Mark van Doesburg (OpenCascade face connection), Matt Gundry (Plot3d mesh format), Matti Pellikka (Homology), Nicolas Tardieu (Netgen), Pascale Noyret (MED mesh format), Pierre Badel (root finding and minimization), Ruth Sabariego (pyramids), Stephen Guzik (CGNS and partitioners). See comments in the sources for more information. If we forgot to list your contributions please send us an email!

The AVL tree code (Common/avl.*) and the YUV image code (Graphics/gl2yuv.*) are copyright (C) 1988-1993, 1995 The Regents of the University of California. Permission to use, copy, modify, and distribute this software and its documentation for any purpose and without fee is hereby granted, provided that the above copyright notice appear in all copies and that both that copyright notice and this permission notice appear in supporting documentation, and that the name of the University of California not be used in advertising or publicity pertaining to distribution of the software without specific, written prior permission. The University of California makes no representations about the suitability of this software for any purpose. It is provided "as is" without express or implied warranty.

The trackball code (Graphics/Trackball.*) is copyright (C) 1993, 1994, Silicon Graphics, Inc. ALL RIGHTS RESERVED. Permission to use, copy, modify, and distribute this software for any purpose and without fee is hereby granted, provided that the above copyright notice appear in all copies and that both the copyright notice and this permission notice appear in supporting documentation, and that the name of Silicon Graphics, Inc. not be used in advertising or publicity pertaining to distribution of the software without specific, written

prior permission.

The GIF and PPM routines (Graphics/gl2gif.cpp) are based on code copyright (C) 1989, 1991, Jef Poskanzer. Permission to use, copy, modify, and distribute this software and its documentation for any purpose and without fee is hereby granted, provided that the above copyright notice appear in all copies and that both that copyright notice and this permission notice appear in supporting documentation. This software is provided "as is" without express or implied warranty.

The colorbar widget (Fltk/Colorbar_Window.cpp) was inspired by code from the Vis5d program for visualizing five dimensional gridded data sets, copyright (C) 1990-1995, Bill Hibbard, Brian Paul, Dave Santek, and Andre Battaola.

This version of Gmsh may contain code (in the contrib/ANN subdirectory) copyright (C) 1997-2005 University of Maryland and Sunil Arya and David Mount: check the configuration options.

This version of Gmsh may contain code (in the contrib/Chaco subdirectory) written by Bruce Hendrickson and Robert Leland at Sandia National Laboratories under US Department of Energy contract DE-AC04-76DP00789 and is copyrighted by Sandia Corporation: check the configuration options.

This version of Gmsh may contain code (in the contrib/Fl_Tree subdirectory), copyright (C) 2009 Greg Ercolano: check the configuration options.

This version of Gmsh may contain code (in the contrib/gmm subdirectory) copyright (C) 2002-2008 Yves Renard: check the configuration options.

This version of Gmsh may contain code (in the contrib/MathEx subdirectory) based in part on the work of the SSCILIB Library, copyright (C) 2000-2003 Sadao Massago: check the configuration options.

This version of Gmsh may contain code (in the contrib/Metis subdirectory) written by George Karypis (karypis at cs.umn.edu), copyright (C) 1998 Regents of the University of Minnesota: check the configuration options.

This version of Gmsh may contain code (in the contrib/NativeFileChooser subdirectory), copyright (C) 2004 Greg Ercolano: check the configuration options.

This version of Gmsh may contain code (in the contrib/Netgen subdirectory) copyright (C) 1994-2004 Joachim Sch"oberl: check the configuration options.

This version of Gmsh may contain code (in the contrib/Tetgen subdirectory) copyright (C) 2002-2007 Hang Si: check the configuration options.

Special thanks to Bill Spitzak, Michael Sweet, Matthias Melcher, Greg Ercolano and others for the Fast Light Tool Kit on which Gmsh's GUI is based. See <http://www.fltk.org> for more info on this excellent object-oriented, cross-platform toolkit.

Special thanks also to EDF for funding the OpenCascade and MED integration.

Thanks to the following folks who have contributed by providing fresh ideas on theoretical or programming topics, who have sent patches, requests for changes or improvements, or who gave us access to exotic machines for testing Gmsh: Juan Abanto, Olivier Adam, Guillaume Alleon, Eric Bechet, Laurent Champaney, Pascal Dupuis, Patrick Dular, Philippe Geuzaine, Johan Gyselinck, Francois Henrotte, Benoit Meys, Nicolas Moes, Osamu Nakamura, Chad Schmutzer, Jean-Luc Fl'ejou, Xavier Dardenne, Christophe Prud'homme, Sebastien Clerc, Jose Miguel Pasini, Philippe Lussou, Jacques Kools, Bayram Yenikaya, Peter Hornby, Krishna Mohan Gundu, Christopher Stott, Timmy Schumacher, Carl Osterwisch, Bruno Frackowiak, Philip Kelleners, Romuald Conty, Renaud Sizaire, Michel Benhamou, Tom De Vuyst, Kris Van den Abeele, Simon Vun, Simon Corbin, Thomas De-Soza, Marcus Drosson, Antoine Dechaume, Jose Paulo Moitinho de Almeida, Thomas Pinchard, Corrado Chisari, Axel Hackbarth, Peter Wainwright, Jiri Hnidek, Thierry Thomas, Konstantinos Poullos, Laurent Van Miegroet.

Appendix H License

Gmsh is provided under the terms of the GNU General Public License (GPL) with the following exception:

The copyright holders of Gmsh give you permission to combine Gmsh with code included in the standard release of TetGen (from Hang Si), Netgen (from Joachim Sch"oberl), Chaco (from Bruce Hendrickson and Robert Leland at Sandia National Laboratories) and METIS (from George Karypis at the University of Minnesota) under their respective licenses. You may copy and distribute such a system following the terms of the GNU GPL for Gmsh and the licenses of the other code concerned, provided that you include the source code of that other code when and as the GNU GPL requires distribution of source code.

Note that people who make modified versions of Gmsh are not obligated to grant this special exception for their modified versions; it is their choice whether to do so. The GNU General Public License gives permission to release a modified version without this exception; this exception also makes it possible to release a modified version which carries forward this exception.

End of exception.

GNU General Public License

Version 2, June 1991

Copyright © 1989, 1991 Free Software Foundation, Inc.
59 Temple Place - Suite 330, Boston, MA 02111-1307, USA

Everyone is permitted to copy and distribute verbatim copies
of this license document, but changing it is not allowed.

Preamble

The licenses for most software are designed to take away your freedom to share and change it. By contrast, the GNU General Public License is intended to guarantee your freedom to share and change free software—to make sure the software is free for all its users. This General Public License applies to most of the Free Software Foundation's software and to any other program whose authors commit to using it. (Some other Free Software Foundation software is covered by the GNU Library General Public License instead.) You can apply it to your programs, too.

When we speak of free software, we are referring to freedom, not price. Our General Public Licenses are designed to make sure that you have the freedom to distribute copies of free software (and charge for this service if you wish), that you receive source code or can get it if you want it, that you can change the software or use pieces of it in new free programs; and that you know you can do these things.

To protect your rights, we need to make restrictions that forbid anyone to deny you these rights or to ask you to surrender the rights. These restrictions translate to certain responsibilities for you if you distribute copies of the software, or if you modify it.

For example, if you distribute copies of such a program, whether gratis or for a fee, you must give the recipients all the rights that you have. You must make sure that they, too, receive or can get the source code. And you must show them these terms so they know their rights.

We protect your rights with two steps: (1) copyright the software, and (2) offer you this license which gives you legal permission to copy, distribute and/or modify the software.

Also, for each author's protection and ours, we want to make certain that everyone understands that there is no warranty for this free software. If the software is modified by someone else and passed on, we want its recipients to know that what they have is not the original, so that any problems introduced by others will not reflect on the original authors' reputations.

Finally, any free program is threatened constantly by software patents. We wish to avoid the danger that redistributors of a free program will individually obtain patent licenses, in effect making the program proprietary. To prevent this, we have made it clear that any patent must be licensed for everyone's free use or not licensed at all.

The precise terms and conditions for copying, distribution and modification follow.

TERMS AND CONDITIONS FOR COPYING, DISTRIBUTION AND MODIFICATION

0. This License applies to any program or other work which contains a notice placed by the copyright holder saying it may be distributed under the terms of this General Public License. The "Program", below, refers to any such program or work, and a "work based on the Program" means either the Program or any derivative work under copyright law: that is to say, a work containing the Program or a portion of it, either verbatim or with modifications and/or translated into another language. (Hereinafter, translation is included without limitation in the term "modification".) Each licensee is addressed as "you".

Activities other than copying, distribution and modification are not covered by this License; they are outside its scope. The act of running the Program is not restricted, and the output from the Program is covered only if its contents constitute a work based on the Program (independent of having been made by running the Program). Whether that is true depends on what the Program does.

1. You may copy and distribute verbatim copies of the Program's source code as you receive it, in any medium, provided that you conspicuously and appropriately publish on each copy an appropriate copyright notice and disclaimer of warranty; keep intact all the notices that refer to this License and to the absence of any warranty; and give any other recipients of the Program a copy of this License along with the Program.

You may charge a fee for the physical act of transferring a copy, and you may at your option offer warranty protection in exchange for a fee.

2. You may modify your copy or copies of the Program or any portion of it, thus forming a work based on the Program, and copy and distribute such modifications or work under the terms of Section 1 above, provided that you also meet all of these conditions:
 - a. You must cause the modified files to carry prominent notices stating that you changed the files and the date of any change.

- b. You must cause any work that you distribute or publish, that in whole or in part contains or is derived from the Program or any part thereof, to be licensed as a whole at no charge to all third parties under the terms of this License.
- c. If the modified program normally reads commands interactively when run, you must cause it, when started running for such interactive use in the most ordinary way, to print or display an announcement including an appropriate copyright notice and a notice that there is no warranty (or else, saying that you provide a warranty) and that users may redistribute the program under these conditions, and telling the user how to view a copy of this License. (Exception: if the Program itself is interactive but does not normally print such an announcement, your work based on the Program is not required to print an announcement.)

These requirements apply to the modified work as a whole. If identifiable sections of that work are not derived from the Program, and can be reasonably considered independent and separate works in themselves, then this License, and its terms, do not apply to those sections when you distribute them as separate works. But when you distribute the same sections as part of a whole which is a work based on the Program, the distribution of the whole must be on the terms of this License, whose permissions for other licensees extend to the entire whole, and thus to each and every part regardless of who wrote it.

Thus, it is not the intent of this section to claim rights or contest your rights to work written entirely by you; rather, the intent is to exercise the right to control the distribution of derivative or collective works based on the Program.

In addition, mere aggregation of another work not based on the Program with the Program (or with a work based on the Program) on a volume of a storage or distribution medium does not bring the other work under the scope of this License.

- 3. You may copy and distribute the Program (or a work based on it, under Section 2) in object code or executable form under the terms of Sections 1 and 2 above provided that you also do one of the following:
 - a. Accompany it with the complete corresponding machine-readable source code, which must be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange; or,
 - b. Accompany it with a written offer, valid for at least three years, to give any third party, for a charge no more than your cost of physically performing source distribution, a complete machine-readable copy of the corresponding source code, to be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange; or,
 - c. Accompany it with the information you received as to the offer to distribute corresponding source code. (This alternative is allowed only for noncommercial distribution and only if you received the program in object code or executable form with such an offer, in accord with Subsection b above.)

The source code for a work means the preferred form of the work for making modifications to it. For an executable work, complete source code means all the source code for all modules it contains, plus any associated interface definition files, plus the scripts used to control compilation and installation of the executable. However, as a special exception, the source code distributed need not include anything that is normally

distributed (in either source or binary form) with the major components (compiler, kernel, and so on) of the operating system on which the executable runs, unless that component itself accompanies the executable.

If distribution of executable or object code is made by offering access to copy from a designated place, then offering equivalent access to copy the source code from the same place counts as distribution of the source code, even though third parties are not compelled to copy the source along with the object code.

4. You may not copy, modify, sublicense, or distribute the Program except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense or distribute the Program is void, and will automatically terminate your rights under this License. However, parties who have received copies, or rights, from you under this License will not have their licenses terminated so long as such parties remain in full compliance.
5. You are not required to accept this License, since you have not signed it. However, nothing else grants you permission to modify or distribute the Program or its derivative works. These actions are prohibited by law if you do not accept this License. Therefore, by modifying or distributing the Program (or any work based on the Program), you indicate your acceptance of this License to do so, and all its terms and conditions for copying, distributing or modifying the Program or works based on it.
6. Each time you redistribute the Program (or any work based on the Program), the recipient automatically receives a license from the original licensor to copy, distribute or modify the Program subject to these terms and conditions. You may not impose any further restrictions on the recipients' exercise of the rights granted herein. You are not responsible for enforcing compliance by third parties to this License.
7. If, as a consequence of a court judgment or allegation of patent infringement or for any other reason (not limited to patent issues), conditions are imposed on you (whether by court order, agreement or otherwise) that contradict the conditions of this License, they do not excuse you from the conditions of this License. If you cannot distribute so as to satisfy simultaneously your obligations under this License and any other pertinent obligations, then as a consequence you may not distribute the Program at all. For example, if a patent license would not permit royalty-free redistribution of the Program by all those who receive copies directly or indirectly through you, then the only way you could satisfy both it and this License would be to refrain entirely from distribution of the Program.

If any portion of this section is held invalid or unenforceable under any particular circumstance, the balance of the section is intended to apply and the section as a whole is intended to apply in other circumstances.

It is not the purpose of this section to induce you to infringe any patents or other property right claims or to contest validity of any such claims; this section has the sole purpose of protecting the integrity of the free software distribution system, which is implemented by public license practices. Many people have made generous contributions to the wide range of software distributed through that system in reliance on consistent application of that system; it is up to the author/donor to decide if he or she is willing to distribute software through any other system and a licensee cannot impose that choice.

This section is intended to make thoroughly clear what is believed to be a consequence of the rest of this License.

8. If the distribution and/or use of the Program is restricted in certain countries either by patents or by copyrighted interfaces, the original copyright holder who places the Program under this License may add an explicit geographical distribution limitation excluding those countries, so that distribution is permitted only in or among countries not thus excluded. In such case, this License incorporates the limitation as if written in the body of this License.
9. The Free Software Foundation may publish revised and/or new versions of the General Public License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns.

Each version is given a distinguishing version number. If the Program specifies a version number of this License which applies to it and “any later version”, you have the option of following the terms and conditions either of that version or of any later version published by the Free Software Foundation. If the Program does not specify a version number of this License, you may choose any version ever published by the Free Software Foundation.

10. If you wish to incorporate parts of the Program into other free programs whose distribution conditions are different, write to the author to ask for permission. For software which is copyrighted by the Free Software Foundation, write to the Free Software Foundation; we sometimes make exceptions for this. Our decision will be guided by the two goals of preserving the free status of all derivatives of our free software and of promoting the sharing and reuse of software generally.

NO WARRANTY

11. BECAUSE THE PROGRAM IS LICENSED FREE OF CHARGE, THERE IS NO WARRANTY FOR THE PROGRAM, TO THE EXTENT PERMITTED BY APPLICABLE LAW. EXCEPT WHEN OTHERWISE STATED IN WRITING THE COPYRIGHT HOLDERS AND/OR OTHER PARTIES PROVIDE THE PROGRAM “AS IS” WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE ENTIRE RISK AS TO THE QUALITY AND PERFORMANCE OF THE PROGRAM IS WITH YOU. SHOULD THE PROGRAM PROVE DEFECTIVE, YOU ASSUME THE COST OF ALL NECESSARY SERVICING, REPAIR OR CORRECTION.
12. IN NO EVENT UNLESS REQUIRED BY APPLICABLE LAW OR AGREED TO IN WRITING WILL ANY COPYRIGHT HOLDER, OR ANY OTHER PARTY WHO MAY MODIFY AND/OR REDISTRIBUTE THE PROGRAM AS PERMITTED ABOVE, BE LIABLE TO YOU FOR DAMAGES, INCLUDING ANY GENERAL, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE PROGRAM (INCLUDING BUT NOT LIMITED TO LOSS OF DATA OR DATA BEING RENDERED INACCURATE OR LOSSES SUSTAINED BY YOU OR THIRD PARTIES OR A FAILURE OF THE PROGRAM TO OPERATE WITH ANY OTHER PROGRAMS), EVEN IF SUCH

HOLDER OR OTHER PARTY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

END OF TERMS AND CONDITIONS

How to Apply These Terms to Your New Programs

If you develop a new program, and you want it to be of the greatest possible use to the public, the best way to achieve this is to make it free software which everyone can redistribute and change under these terms.

To do so, attach the following notices to the program. It is safest to attach them to the start of each source file to most effectively convey the exclusion of warranty; and each file should have at least the “copyright” line and a pointer to where the full notice is found.

```
one line to give the program's name and a brief idea of what it does.
Copyright (C) yyyy  name of author
```

```
This program is free software; you can redistribute it and/or modify
it under the terms of the GNU General Public License as published by
the Free Software Foundation; either version 2 of the License, or
(at your option) any later version.
```

```
This program is distributed in the hope that it will be useful,
but WITHOUT ANY WARRANTY; without even the implied warranty of
MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
GNU General Public License for more details.
```

```
You should have received a copy of the GNU General Public License
along with this program; if not, write to the Free Software
Foundation, Inc., 59 Temple Place - Suite 330, Boston,
MA 02111-1307, USA.
```

Also add information on how to contact you by electronic and paper mail.

If the program is interactive, make it output a short notice like this when it starts in an interactive mode:

```
Gnomovision version 69, Copyright (C) 19yy  name of author
Gnomovision comes with ABSOLUTELY NO WARRANTY; for details type
'show w'.
This is free software, and you are welcome to redistribute it
under certain conditions; type 'show c' for details.
```

The hypothetical commands ‘show w’ and ‘show c’ should show the appropriate parts of the General Public License. Of course, the commands you use may be called something other than ‘show w’ and ‘show c’; they could even be mouse-clicks or menu items—whatever suits your program.

You should also get your employer (if you work as a programmer) or your school, if any, to sign a “copyright disclaimer” for the program, if necessary. Here is a sample; alter the names:

```
Yoyodyne, Inc., hereby disclaims all copyright interest in the program
'Gnomovision' (which makes passes at compilers) written by James Hacker.
```

```
signature of Ty Coon, 1 April 1989
```

Ty Coon, President of Vice

This General Public License does not permit incorporating your program into proprietary programs. If your program is a subroutine library, you may consider it more useful to permit linking proprietary applications with the library. If this is what you want to do, use the GNU Library General Public License instead of this License.

Concept index

2

2D plots 55

3

3D plots 55

A

Acknowledgments 209

Authors, e-mail 6

B

Background mesh 37

Binary operators 19

Bindings, keyboard 13

Bindings, mouse 12

Bugs, reporting 6

C

Changelog 195

Characteristic lengths 37

Colors 19

Command-line options 10

Commands, general 23

Commands, geometry 29

Commands, mesh 37

Commands, post-processing 55

Comments 17

Concepts, index 221

Conditionals 22

Constants 17

Contact information 6

Contributors, list 209

Copyright 1, 209

Credits 209

D

Developer, information 181

Document syntax 7

Download 1

E

E-mail, authors 6

Efficiency, tips 183

Elementary lines 30

Elementary points 29

Elementary surfaces 31

Elementary volumes 32

Evaluation order 20

Example, solver 51

Examples 91

Expressions, affectation 23

Expressions, character 18

Expressions, color 19

Expressions, definition 17

Expressions, floating point 17

Expressions, identifiers 23

Expressions, lists 18

Extrusion, geometry 32

Extrusion, mesh 47

F

FAQ 185

File format, mesh 75

File formats 75

File, comments 17

Floating point numbers 17

Frequently asked questions 185

Functions, built-in 21

Functions, user-defined 22

G

General commands 23

Geometry commands 29

Geometry, extrusion 32

Geometry, module 29

Geometry, options 34

Geometry, transformations 33

GNU General Public License 213

Graphs 55

H

History, versions 195

I

Index, concepts 221

Index, syntax 223

Interactive mode 9

Internet address 1

Introduction 3

K

Keyboard, shortcuts 13

Keywords, index 223

L

License	1, 213
Lines, elementary	30
Lines, physical	30
Loops	22

M

Mailing list	1, 6
Mesh commands	37
Mesh, background	37
Mesh, element size	37
Mesh, extrusion	47
Mesh, file format	75
Mesh, module	35
Mesh, options	49
Mesh, transfinite	47
Module, geometry	29
Module, Mesh	35
Module, Post-processing	55
Module, Solver	51
Mouse, actions	12
MSH file	75

N

Nodes, ordering	81
Non-interactive mode	10
Numbers, real	17

O

Operating system	9
Operator precedence	20
Operators, definition	19
Options, command-line	10
Options, geometry	34, 51
Options, mesh	49
Options, post-processing	73
Order, evaluation	20
Overview	3

P

Physical lines	30
Physical points	29
Physical surfaces	31
Physical volumes	32
Plots	55
Plugins, post-processing	59
Points, elementary	29
Points, physical	29
Post-processing commands	55
Post-processing plugins	59
Post-processing, module	55

Post-processing, options	73
Precedence, operators	20
Programming, notes	181

Q

Questions, frequently asked	185
-----------------------------------	-----

R

Real numbers	17
Reporting bugs	6
Rotation	33
Rules, syntactic	7
Running Gmsh	9

S

Scale	33
Shortcuts, keyboard	13
Size, elements	37
Solver commands	51
Solver example	51
Solver, module	51
Strings	18
Surfaces, elementary	31
Surfaces, physical	31
Symmetry	33
Syntax, index	223
Syntax, rules	7

T

Ternary operators	19
Tips	183
Transfinite, mesh	47
Transformations, geometry	33
Translation	33
Tricks	183
Tutorial	91

U

Unary operators	19
-----------------------	----

V

Versions	195
Views	55
Volumes, elementary	32
Volumes, physical	32

W

Web site	1
----------------	---

Syntax index

!		-o file	10
!	19	-optimize[_netgen]	11
!=	20	-option file	12
%		-order int	11
%	19	-part int	10
&		-pid	11
&&	20	-rand float	11
(-saveall	10
()	20	-smooth int	10
*		-string "string"	12
*	19	-theme string	11
*=	23	-tol float	10
+		-v int	11
+	20	-version	12
++	19	/	
+=	23	/	19
-		/*, */	17
-	11, 19, 20	//	17
--	19	/=	23
--=	23	:	
-0	10	:	20
-1, -2, -3	10	<	
-a, -g, -m, -s, -p	11	<	20
-algo string	10	<=	20
-bgm file	11	=	
-bin	10	=	23
-clcurv	11	=	20
-clmax float	11	>	
-clmin float	11	>	20
-clscale float	11	>=	20
-combine	11	?	
-convert files	12	?	20
-display string	11	^	
-fontsize int	11	^	19
-format string	10		
-help	12	20
-info	12		
-link int	11		
-listen	11		
-nodb	11		
-nopopup	11		
-noview	11		

A

Acos (expression)	21
Alias View[expression];	55
AliasWithOptions View[expression];	56
Asin (expression)	21
Atan (expression)	21
Atan2 (expression, expression)	21
Attractor	38

B

Background Field = expression;	38
Background Mesh View[expression];	57
Boundary { transform-list }	34
BoundaryLayer	39
BoundingBox { expression, expression, expression, expression, expression, expression };	26
BoundingBox;	25
Box	40
BSpline (expression) = { expression-list };	30
build-in-function	21

C

Call string;	22
CatmullRom (expression) = { expression-list };	30
Ceil (expression)	21
char-option = char-expression;	24
Characteristic Length { expression-list } = expression;	38
Circle (expression) = { expression, expression, expression };	30
Coherence Mesh;	48
Coherence;	34
Color color-expression { Point Line Surface Volume { expression-list }; ... }	48
color-option = color-expression;	24
Combine ElementsByViewName;	56
Combine ElementsFromAllViews Combine Views;	56
Combine ElementsFromVisibleViews;	56
Combine TimeStepsByViewName Combine TimeSteps;	56
Combine TimeStepsFromAllViews;	56
Combine TimeStepsFromVisibleViews;	56
Cos (expression)	21
Cosh (expression)	21
Curvature	40
Cylinder	41

D

Delete { Point Line Surface Volume { expression-list }; ... }	34
--	----

Delete Empty Views;	56
Delete Model;	26
Delete Physicals;	26
Delete string;	26
Delete Variables;	26
Delete View[expression];	56
Dilate { { expression-list }, expression } { transform-list }	33
Draw;	25

E

Ellipse (expression) = { expression, expression, expression, expression };	30
EndFor	23
EndIf	23
Exit;	25
Exp (expression)	21
extrude	32
Extrude { { expression-list }, { expression-list }, { expression-list }, expression } { extrude-list }	32
Extrude { { expression-list }, { expression-list }, { expression-list }, expression } { extrude-list layers } ..	47
Extrude { { expression-list }, { expression-list }, expression } { extrude-list }	32
Extrude { { expression-list }, { expression-list }, expression } { extrude-list layers }	47
Extrude { expression-list } { extrude-list }	32
Extrude { expression-list } { extrude-list layers }	47
Extrude { Surface { expression-list }; layers }	47

F

Fabs (expression)	21
Field[expression] = string;	38
Field[expression].string = char-expression expression expression-list;	38
Floor (expression)	21
Fmod (expression, expression)	21
For (expression : expression)	22
For (expression : expression : expression)	22
For string In { expression : expression : expression }	23
For string In { expression : expression } ..	23
Function string	22

G

General.AlphaBlending	111
-----------------------------	-----

General.Antialiasing	111	General.Color.Background	128
General.ArrowHeadRadius	111	General.Color.BackgroundGradient	128
General.ArrowStemLength	111	General.Color.DiffuseLight	128
General.ArrowStemRadius	111	General.Color.Foreground	128
General.Axes	111	General.Color.SmallAxes	128
General.AxesAutoPosition	111	General.Color.SpecularLight	128
General.AxesFormatX	109	General.Color.Text	128
General.AxesFormatY	109	General.ColorScheme	116
General.AxesFormatZ	109	General.ConfirmOverwrite	116
General.AxesLabelX	109	General.ContextPositionX	116
General.AxesLabelY	109	General.ContextPositionY	116
General.AxesLabelZ	109	General.DefaultFileName	109
General.AxesMaxX	111	General.Display	110
General.AxesMaxY	111	General.DoubleBuffer	116
General.AxesMaxZ	112	General.DrawBoundingBoxes	116
General.AxesMikado	111	General.ErrorFileName	110
General.AxesMinX	112	General.ExpertMode	116
General.AxesMinY	112	General.FastRedraw	116
General.AxesMinZ	112	General.FieldHeight	117
General.AxesTicsX	112	General.FieldPositionX	116
General.AxesTicsY	112	General.FieldPositionY	116
General.AxesTicsZ	112	General.FieldWidth	117
General.BackgroundGradient	112	General.FileChooserPositionX	117
General.BackgroundImageFileName	109	General.FileChooserPositionY	117
General.BackgroundImagePositionX	112	General.FileName	110
General.BackgroundImagePositionY	112	General.FltkTheme	110
General.Clip0A	113	General.FontSize	117
General.Clip0B	113	General.GraphicsFont	110
General.Clip0C	113	General.GraphicsFontSize	117
General.Clip0D	113	General.GraphicsHeight	117
General.Clip1A	113	General.GraphicsPositionX	117
General.Clip1B	113	General.GraphicsPositionY	117
General.Clip1C	113	General.GraphicsWidth	117
General.Clip1D	113	General.InitialModule	117
General.Clip2A	113	General.Light0	118
General.Clip2B	113	General.Light0W	118
General.Clip2C	114	General.Light0X	118
General.Clip2D	114	General.Light0Y	118
General.Clip3A	114	General.Light0Z	118
General.Clip3B	114	General.Light1	118
General.Clip3C	114	General.Light1W	118
General.Clip3D	114	General.Light1X	118
General.Clip4A	114	General.Light1Y	118
General.Clip4B	114	General.Light1Z	118
General.Clip4C	114	General.Light2	119
General.Clip4D	114	General.Light2W	119
General.Clip5A	115	General.Light2X	119
General.Clip5B	115	General.Light2Y	119
General.Clip5C	115	General.Light2Z	119
General.Clip5D	115	General.Light3	119
General.ClipFactor	115	General.Light3W	119
General.ClipOnlyDrawIntersectingVolume ..	115	General.Light3X	119
General.ClipOnlyVolume	115	General.Light3Y	119
General.ClipPositionX	115	General.Light3Z	119
General.ClipPositionY	115	General.Light4	120
General.ClipWholeElements	115	General.Light4W	120
General.Color.AmbientLight	128	General.Light4X	120
General.Color.Axes	128	General.Light4Y	120

General.Light4Z.....	120	General.SolverPositionX.....	126
General.Light5.....	120	General.SolverPositionY.....	126
General.Light5W.....	120	General.StatisticsPositionX.....	126
General.Light5X.....	120	General.StatisticsPositionY.....	126
General.Light5Y.....	120	General.SystemMenuBar.....	126
General.Light5Z.....	120	General.Terminal.....	126
General.LineWidth.....	121	General.TextEditor.....	110
General.ManipulatorPositionX.....	121	General.TmpFileName.....	110
General.ManipulatorPositionY.....	121	General.Tooltips.....	126
General.MaxX.....	121	General.Trackball.....	126
General.MaxY.....	121	General.TrackballQuaternion0.....	126
General.MaxZ.....	121	General.TrackballQuaternion1.....	126
General.MenuPositionX.....	121	General.TrackballQuaternion2.....	127
General.MenuPositionY.....	121	General.TrackballQuaternion3.....	127
General.MessageAutoScroll.....	121	General.TranslationX.....	127
General.MessageHeight.....	122	General.TranslationY.....	127
General.MessagePositionX.....	121	General.TranslationZ.....	127
General.MessagePositionY.....	122	General.VectorType.....	127
General.MessageWidth.....	122	General.Verbosity.....	127
General.MinX.....	122	General.VisibilityPositionX.....	127
General.MinY.....	122	General.VisibilityPositionY.....	127
General.MinZ.....	122	General.WebBrowser.....	110
General.MouseHoverMeshes.....	122	General.ZoomFactor.....	127
General.MouseSelection.....	122	Geometry.AutoCoherence.....	131
General.NonModalWindows.....	122	Geometry.Clip.....	131
General.NoPopup.....	122	Geometry.Color.HighlightOne.....	137
General.OptionsFileName.....	110	Geometry.Color.HighlightTwo.....	137
General.OptionsPositionX.....	123	Geometry.Color.HighlightZero.....	137
General.OptionsPositionY.....	123	Geometry.Color.Lines.....	136
General.Orthographic.....	123	Geometry.ColorNormals.....	137
General.PluginHeight.....	123	Geometry.Color.Points.....	136
General.PluginPositionX.....	123	Geometry.Color.Projection.....	137
General.PluginPositionY.....	123	Geometry.Color.Selection.....	137
General.PluginWidth.....	123	Geometry.Color.Surfaces.....	136
General.PointSize.....	123	Geometry.Color.Tangents.....	137
General.PolygonOffsetAlwaysOn.....	123	Geometry.Color.Volumes.....	136
General.PolygonOffsetFactor.....	123	Geometry.CopyMeshingMethod.....	131
General.PolygonOffsetUnits.....	124	Geometry.ExactExtrusion.....	131
General.QuadricSubdivisions.....	124	Geometry.ExtrudeReturnLateralEntities.....	131
General.RotationCenterGravity.....	124	Geometry.ExtrudeSplinePoints.....	131
General.RotationCenterX.....	124	Geometry.HighlightOrphans.....	132
General.RotationCenterY.....	124	Geometry.Light.....	132
General.RotationCenterZ.....	124	Geometry.LightTwoSide.....	132
General.RotationX.....	124	Geometry.LineNumbers.....	132
General.RotationY.....	124	Geometry.Lines.....	132
General.RotationZ.....	124	Geometry.LineSelectWidth.....	132
General.SaveOptions.....	124	Geometry.LineType.....	132
General.SaveSession.....	125	Geometry.LineWidth.....	132
General.ScaleX.....	125	Geometry.MatchGeomAndMesh.....	132
General.ScaleY.....	125	GeometryNormals.....	132
General.ScaleZ.....	125	Geometry.NumSubEdges.....	133
General.SessionFileName.....	110	Geometry.OCCConnectFaces.....	133
General.Shininess.....	125	Geometry.OCCFixSmallEdges.....	133
General.ShininessExponent.....	125	Geometry.OCCFixSmallFaces.....	133
General.SmallAxes.....	125	Geometry.OCCSewFaces.....	133
General.SmallAxesPositionX.....	125	Geometry.OffsetX.....	133
General.SmallAxesPositionY.....	125	Geometry.OffsetY.....	133
General.SmallAxesSize.....	125	Geometry.OffsetZ.....	133

Geometry.OldCircle	133
Geometry.OldNewReg	133
Geometry.PointNumbers	134
Geometry.Points	134
Geometry.PointSelectSize	134
Geometry.PointSize	134
Geometry.PointType	134
Geometry.ScalingFactor	134
Geometry.SnapX	134
Geometry.SnapY	134
Geometry.SnapZ	134
Geometry.SurfaceNumbers	135
Geometry.Surfaces	134
Geometry.SurfaceType	135
Geometry.Tangents	135
Geometry.Tolerance	135
Geometry.Transform	135
Geometry.TransformXX	135
Geometry.TransformXY	135
Geometry.TransformXZ	135
Geometry.TransformYX	135
Geometry.TransformYY	135
Geometry.TransformYZ	136
Geometry.TransformZX	136
Geometry.TransformZY	136
Geometry.TransformZZ	136
Geometry.VolumeNumbers	136
Geometry.Volumes	136
GMSH_MAJOR_VERSION	23
GMSH_MINOR_VERSION	23
GMSH_PATCH_VERSION	23
Gradient	41

H

Hide { Point Line Surface Volume { <i>expression-list</i> }; ... }	34, 48
Hide <i>char-expression</i> ;	34, 48
Hypot (<i>expression</i> , <i>expression</i>)	21

I

If (<i>expression</i>)	23
Include <i>char-expression</i> ;	26

L

Laplacian	42
Line (<i>expression</i>) = { <i>expression</i> , <i>expression</i> };	30
Line Loop (<i>expression</i>) = { <i>expression-list</i> };	30
Log (<i>expression</i>)	21
Log10 (<i>expression</i>)	21
LonLat	42

M

MathEval	42
Max	43
MaxEigenHessian	43
Mean	43
Merge <i>char-expression</i> ;	25
Mesh <i>expression</i> ;	26
Mesh.Algorithm	137
Mesh.Algorithm3D	137
Mesh.AllowSwapAngle	138
Mesh.AngleSmoothNormals	137
Mesh.BdfFieldFormat	138
Mesh.Binary	138
Mesh.ChacoArchitecture	138
Mesh.ChacoEigensolver	138
Mesh.ChacoEigTol	138
Mesh.ChacoGlobalMethod	138
Mesh.ChacoHypercubeDim	138
Mesh.ChacoLocalMethod	138
Mesh.ChacoMeshDim1	139
Mesh.ChacoMeshDim2	139
Mesh.ChacoMeshDim3	139
Mesh.ChacoParamINTERNAL_VERTICES	139
Mesh.ChacoParamREFINE_MAP	139
Mesh.ChacoParamREFINE_PARTITION	139
Mesh.ChacoParamTERMINAL_PROPOGATION	139
Mesh.ChacoPartitionSection	139
Mesh.ChacoSeed	139
Mesh.ChacoVMax	139
Mesh.CharacteristicLengthExtendFromBoundary	140
Mesh.CharacteristicLengthFactor	140
Mesh.CharacteristicLengthFromCurvature ..	140
Mesh.CharacteristicLengthFromPoints	140
Mesh.CharacteristicLengthMax	140
Mesh.CharacteristicLengthMin	140
Mesh.Clip	140
Mesh.Color.Eight	150
Mesh.Color.Eighteen	151
Mesh.Color.Eleven	150
Mesh.Color.Fifteen	150
Mesh.Color.Five	149
Mesh.Color.Four	149
Mesh.Color.Fourteen	150
Mesh.Color.Hexahedra	148
Mesh.Color.Lines	148
Mesh.Color.Nine	150
Mesh.Color.Nineteen	151
Mesh.ColorNormals	149
Mesh.Color.One	149
Mesh.Color.Points	148
Mesh.Color.PointsSup	148
Mesh.Color.Prisms	149
Mesh.Color.Pyramids	149
Mesh.Color.Quadrangles	148
Mesh.Color.Seven	150
Mesh.Color.Seventeen	151
Mesh.Color.Six	150

Mesh.Color.Sixteen	151	Mesh.RadiusSup	145
Mesh.Color.Tangents	149	Mesh.RandomFactor	145
Mesh.Color.Ten	150	Mesh.RefineSteps	145
Mesh.Color.Tetrahedra	148	Mesh.ReverseAllNormals	145
Mesh.Color.Thirteen	150	Mesh.SaveAll	145
Mesh.Color.Three	149	Mesh.SaveElementTagType	146
Mesh.Color.Triangles	148	Mesh.SaveGroupsOfNodes	146
Mesh.Color.Twelve	150	Mesh.SaveParametric	146
Mesh.Color.Two	149	Mesh.ScalingFactor	146
Mesh.Color.Zero	149	Mesh.SecondOrderExperimental	146
Mesh.ColorCarousel	140	Mesh.SecondOrderIncomplete	146
Mesh.CpuTime	140	Mesh.SecondOrderLinear	146
Mesh.DrawSkinOnly	140	Mesh.Smoothing	146
Mesh.Dual	141	Mesh.SmoothInternalEdges	146
Mesh.ElementOrder	141	Mesh.SmoothNormals	146
Mesh.Explode	141	Mesh.SubdivisionAlgorithm	147
Mesh.Format	141	Mesh.SurfaceEdges	147
Mesh.Hexahedra	141	Mesh.SurfaceFaces	147
Mesh.LabelsFrequency	141	Mesh.SurfaceNumbers	147
Mesh.LabelType	141	Mesh.Tangents	147
Mesh.LcIntegrationPrecision	141	Mesh.Tetrahedra	147
Mesh.Light	141	Mesh.ToleranceEdgeLength	147
Mesh.LightLines	141	Mesh.Triangles	147
Mesh.LightTwoSide	142	Mesh.VolumeEdges	147
Mesh.LineNumbers	142	Mesh.VolumeFaces	147
Mesh.Lines	142	Mesh.VolumeNumbers	148
Mesh.LineWidth	142	Mesh.Voronoi	148
Mesh.MeshOnlyVisible	142	Mesh.ZoneDefinition	148
Mesh.MetisAlgorithm	142	Min	43
Mesh.MetisEdgeMatching	142	Modulo (expression, expression)	21
Mesh.MetisRefinementAlgorithm	142	MPI_Rank	23
Mesh.MinimumCirclePoints	142	MPI_Size	23
Mesh.MinimumCurvePoints	142		
Mesh.MshFileVersion	143	N	
Mesh.NbHexahedra	143	newl	24
Mesh.NbNodes	143	newll	24
Mesh.NbPartitions	143	newp	23
Mesh.NbPrisms	143	newreg	24
Mesh.NbPyramids	143	news	24
Mesh.NbQuadrangles	143	news1	24
Mesh.NbTetrahedra	143	newv	24
Mesh.NbTriangles	143		
MeshNormals	143	O	
Mesh.NumSubEdges	144	operator-binary	19
Mesh.Optimize	144	operator-ternary-left	19
Mesh.OptimizeNetgen	144	operator-ternary-right	19
Mesh.Partitioner	144	operator-unary-left	19
Mesh.PointNumbers	144	operator-unary-right	19
Mesh.Points	144		
Mesh.PointSize	144	P	
Mesh.PointType	144	Param	44
Mesh.Prisms	144	Physical Line (expression char-expression) = { expression-list };	31
Mesh.Pyramids	144	Physical Point (expression char-expression) = { expression-list };	29
Mesh.Quadrangles	145		
Mesh.QualityInf	145		
Mesh.QualitySup	145		
Mesh.QualityType	145		
Mesh.RadiusInf	145		

Physical Surface (expression char-expression) = { expression-list };	31
Physical Volume (expression char-expression) = { expression-list };	32
Pi.....	23
Plane Surface (expression) = { expression-list };.....	31
Plugin (string) . Run;.....	57
Plugin (string) . string = expression char-expression;.....	57
Plugin(Annotate).....	60
Plugin(Curl).....	60
Plugin(CutGrid).....	60
Plugin(CutMap).....	61
Plugin(CutParametric).....	61
Plugin(CutPlane).....	62
Plugin(CutSphere).....	62
Plugin(Divergence).....	63
Plugin(Eigenvalues).....	63
Plugin(Eigenvectors).....	63
Plugin(Evaluate).....	63
Plugin(Extract).....	64
Plugin(ExtractElements).....	65
Plugin(FieldView).....	65
Plugin(FiniteElement).....	66
Plugin(Gradient).....	67
Plugin(GSHHS).....	66
Plugin(HarmonicToTime).....	67
Plugin(HomologyComputation).....	68
Plugin(Integrate).....	68
Plugin(Lambda2).....	68
Plugin(LongitudeLatitude).....	69
Plugin(MakeSimplex).....	69
Plugin(ModulusPhase).....	69
Plugin(Probe).....	69
Plugin(Remove).....	69
Plugin(Skin).....	70
Plugin(Smooth).....	70
Plugin(SphericalRaise).....	70
Plugin(StreamLines).....	71
Plugin(Transform).....	72
Plugin(Triangulate).....	72
Plugin(Warp).....	72
Point (expression) = { expression, expression, expression <, expression > };	29
Point Line { expression-list } In Surface { expression };.....	48
PostProcessing.AnimationCycle.....	165
PostProcessing.AnimationDelay.....	165
PostProcessing.CombineRemoveOriginal.....	165
PostProcessing.Format.....	166
PostProcessing.HorizontalScales.....	166
PostProcessing.Link.....	166
PostProcessing.NbViews.....	166
PostProcessing.Plugins.....	166
PostProcessing.Smoothing.....	166
PostView.....	44
Print char-expression;.....	26
Print.CompositeWindows.....	128
Print.EpsBackground.....	129
Print.EpsBestRoot.....	129
Print.EpsCompress.....	129
Print.EpsLineWidthFactor.....	129
Print.EpsOcclusionCulling.....	129
Print.EpsPointSizeFactor.....	129
Print.EpsPS3Shading.....	129
Print.EpsQuality.....	129
Print.Format.....	129
Print.GeoLabels.....	129
Print.GifDither.....	130
Print.GifInterlace.....	130
Print.GifSort.....	130
Print.GifTransparent.....	130
Print.JpegQuality.....	130
Print.JpegSmoothing.....	130
Print.PostDisto.....	131
Print.PostElement.....	130
Print.PostElementary.....	130
Print.PostEta.....	130
Print.PostGamma.....	130
Print.PostRho.....	131
Print.TexAsEquation.....	131
Print.Text.....	131
Printf (char-expression , expression-list) > char-expression;.....	25
Printf (char-expression , expression-list) >> char-expression;.....	25
Printf (char-expression , expression-list);	25
R	
Rand (expression).....	22
real-option = expression;.....	24
Recombine Surface { expression-list } "*" < = expression >;.....	48
Restrict.....	44
Return.....	22
Rotate { { expression-list }, { expression-list }, expression } { transform-list }.....	33
Ruled Surface (expression) = { expression-list } < In Sphere { expression } >;.....	31
S	
Save char-expression;.....	49
Save View[expression] char-expression;....	57
Show { Point Line Surface Volume { expression-list }; ... }.....	34, 49
Show char-expression;.....	34, 49
Sin (expression).....	22

Sinh (expression)	22	Solver.FourthButtonCommand3	161
Sleep expression;	26	Solver.FourthButtonCommand4	163
Smoother Surface { expression-list } = expression;	49	Solver.FourthOption0	152
Solver.AlwaysListen	164	Solver.FourthOption1	155
Solver.ClientServer0	164	Solver.FourthOption2	157
Solver.ClientServer1	164	Solver.FourthOption3	160
Solver.ClientServer2	164	Solver.FourthOption4	162
Solver.ClientServer3	164	Solver.Help0	151
Solver.ClientServer4	164	Solver.Help1	154
Solver.Executable0	151	Solver.Help2	156
Solver.Executable1	154	Solver.Help3	159
Solver.Executable2	156	Solver.Help4	161
Solver.Executable3	159	Solver.InputName0	151
Solver.Executable4	161	Solver.InputName1	154
Solver.Extension0	151	Solver.InputName2	156
Solver.Extension1	154	Solver.InputName3	159
Solver.Extension2	156	Solver.InputName4	161
Solver.Extension3	159	Solver.MergeViews0	164
Solver.Extension4	161	Solver.MergeViews1	164
Solver.FifthButton0	153	Solver.MergeViews2	164
Solver.FifthButton1	156	Solver.MergeViews3	164
Solver.FifthButton2	158	Solver.MergeViews4	165
Solver.FifthButton3	161	Solver.MeshCommand0	152
Solver.FifthButton4	163	Solver.MeshCommand1	154
Solver.FifthButtonCommand0	153	Solver.MeshCommand2	157
Solver.FifthButtonCommand1	156	Solver.MeshCommand3	159
Solver.FifthButtonCommand2	158	Solver.MeshCommand4	162
Solver.FifthButtonCommand3	161	Solver.MeshName0	152
Solver.FifthButtonCommand4	163	Solver.MeshName1	154
Solver.FifthOption0	152	Solver.MeshName2	157
Solver.FifthOption1	155	Solver.MeshName3	159
Solver.FifthOption2	157	Solver.MeshName4	162
Solver.FifthOption3	160	Solver.Name0	151
Solver.FifthOption4	162	Solver.Name1	154
Solver.FirstButton0	153	Solver.Name2	156
Solver.FirstButton1	155	Solver.Name3	159
Solver.FirstButton2	158	Solver.Name4	161
Solver.FirstButton3	160	Solver.NameCommand0	152
Solver.FirstButton4	163	Solver.NameCommand1	154
Solver.FirstButtonCommand0	153	Solver.NameCommand2	157
Solver.FirstButtonCommand1	155	Solver.NameCommand3	159
Solver.FirstButtonCommand2	158	Solver.NameCommand4	162
Solver.FirstButtonCommand3	160	Solver.OptionCommand0	152
Solver.FirstButtonCommand4	163	Solver.OptionCommand1	154
Solver.FirstOption0	152	Solver.OptionCommand2	157
Solver.FirstOption1	155	Solver.OptionCommand3	159
Solver.FirstOption2	157	Solver.OptionCommand4	162
Solver.FirstOption3	160	Solver.Plugins	165
Solver.FirstOption4	162	Solver.PopupMessages0	165
Solver.FourthButton0	153	Solver.PopupMessages1	165
Solver.FourthButton1	156	Solver.PopupMessages2	165
Solver.FourthButton2	158	Solver.PopupMessages3	165
Solver.FourthButton3	161	Solver.PopupMessages4	165
Solver.FourthButton4	163	Solver.SecondButton0	153
Solver.FourthButtonCommand0	153	Solver.SecondButton1	155
Solver.FourthButtonCommand1	156	Solver.SecondButton2	158
Solver.FourthButtonCommand2	158	Solver.SecondButton3	160
		Solver.SecondButton4	163

Solver.SecondButtonCommand0.....	153	System char-expression;.....	26
Solver.SecondButtonCommand1.....	155		
Solver.SecondButtonCommand2.....	158	T	
Solver.SecondButtonCommand3.....	160	Tan (<i>expression</i>)	22
Solver.SecondButtonCommand4.....	163	Tanh (<i>expression</i>)	22
Solver.SecondOption0	152	Threshold.....	45
Solver.SecondOption1	155	Transfinite Line { <i>expression-list</i> } "*" =	
Solver.SecondOption2	157	<i>expression</i> < Using Progression Bump	
Solver.SecondOption3	160	<i>expression</i> >;.....	47
Solver.SecondOption4	162	Transfinite Surface { <i>expression-list</i> } "*" <	
Solver.SocketCommand0.....	152	< = { <i>expression-list</i> } > < Left Right	
Solver.SocketCommand1.....	154	Alternate > ;	48
Solver.SocketCommand2.....	157	Transfinite Volume { <i>expression-list</i> } "*" <	
Solver.SocketCommand3.....	159	= { <i>expression-list</i> } > ;	48
Solver.SocketCommand4.....	162	<i>transform</i>	33
Solver.SocketName	151	Translate { <i>expression-list</i> } {	
Solver.ThirdButton0	153	<i>transform-list</i> }	33
Solver.ThirdButton1	155		
Solver.ThirdButton2	158	U	
Solver.ThirdButton3	160	UTM.....	46
Solver.ThirdButton4	163		
Solver.ThirdButtonCommand0.....	153	V	
Solver.ThirdButtonCommand1.....	156	View "string" { <i>string</i> < (<i>expression-list</i>) >	
Solver.ThirdButtonCommand2.....	158	{ <i>expression-list</i> }; ... };	57
Solver.ThirdButtonCommand3.....	161	View.AdaptVisualizationGrid.....	168
Solver.ThirdButtonCommand4.....	163	View.AngleSmoothNormals	168
Solver.ThirdOption0	152	View.ArrowSizeMax	169
Solver.ThirdOption1	155	View.ArrowSizeMin	169
Solver.ThirdOption2	157	View.AutoPosition	169
Solver.ThirdOption3	160	View.Axes.....	169
Solver.ThirdOption4	162	View.AxesAutoPosition.....	169
Spline (<i>expression</i>) = { <i>expression-list</i> };		View.AxesFormatX.....	166
.....	30	View.AxesFormatY.....	166
Sqrt (<i>expression</i>)	22	View.AxesFormatZ.....	166
<i>string</i> = <i>expression</i> ;	23	View.AxesLabelX.....	166
<i>string</i> [] += { <i>expression-list</i> };	25	View.AxesLabelY.....	167
<i>string</i> [] = { };	24	View.AxesLabelZ.....	167
<i>string</i> [] = { <i>expression-list</i> };	24	View.AxesMaxX.....	169
<i>string</i> [{ <i>expression-list</i> }] *= {		View.AxesMaxY.....	169
<i>expression-list</i> };	25	View.AxesMaxZ.....	169
<i>string</i> [{ <i>expression-list</i> }] += {		View.AxesMikado.....	169
<i>expression-list</i> };	25	View.AxesMinX.....	169
<i>string</i> [{ <i>expression-list</i> }] -= {		View.AxesMinY.....	170
<i>expression-list</i> };	25	View.AxesMinZ.....	170
<i>string</i> [{ <i>expression-list</i> }] /= {		View.AxesTicksX.....	170
<i>expression-list</i> };	25	View.AxesTicksY.....	170
<i>string</i> [{ <i>expression-list</i> }] = {		View.AxesTicksZ.....	170
<i>expression-list</i> };	24	View.Boundary	170
<i>string</i> real-option *= <i>expression</i> ;	24	View.CenterGlyphs	170
<i>string</i> real-option += <i>expression</i> ;	24	View.Clip.....	170
<i>string</i> real-option -= <i>expression</i> ;	24	View.Color.Axes.....	180
<i>string</i> real-option /= <i>expression</i> ;	25	View.Color.Hexahedra.....	179
Structured.....	45	View.Color.Lines.....	179
Surface Loop (<i>expression</i>) = {		View.ColorNormals	180
<i>expression-list</i> };	31	View.Color.Points	179
Symmetry { <i>expression-list</i> } { <i>transform-list</i>			
}	33		
SyncModel;	26		

View.Color.Prisms	179	View.Min.....	175
View.Color.Pyramids	179	View.MinX.....	175
View.Color.Quadrangles.....	179	View.MinY.....	175
View.Color.Tangents.....	180	View.MinZ.....	175
View.Color.Tetrahedra.....	179	View.Name.....	167
View.Color.Text2D.....	180	View.NbIso.....	175
View.Color.Text3D.....	180	View.NbTimeStep.....	175
View.Color.Triangles.....	179	View.NormalRaise.....	175
View.ColormapAlpha.....	170	ViewNormals.....	175
View.ColormapAlphaPower.....	170	View.OffsetX.....	175
View.ColormapBeta.....	171	View.OffsetY.....	175
View.ColormapBias.....	171	View.OffsetZ.....	175
View.ColormapCurvature.....	171	View.PointSize.....	176
View.ColormapInvert.....	171	View.PointType.....	176
View.ColormapNumber.....	171	View.PositionX.....	176
View.ColormapRotation.....	171	View.PositionY.....	176
View.ColormapSwap.....	171	View.RaiseX.....	176
View.ColorTable.....	180	View.RaiseY.....	176
View.CustomMax.....	171	View.RaiseZ.....	176
View.CustomMin.....	171	View.RangeType.....	176
View.DisplacementFactor.....	171	View.SaturateValues.....	176
View.DrawHexahedra.....	172	View.ScaleType.....	176
View.DrawLines.....	172	View.ShowElement.....	177
View.DrawPoints.....	172	View.ShowScale.....	177
View.DrawPrisms.....	172	View.ShowTime.....	177
View.DrawPyramids.....	172	View.SmoothNormals.....	177
View.DrawQuadrangles.....	172	View.Stipple.....	177
View.DrawScalars.....	172	View.Stipple0.....	167
View.DrawSkinOnly.....	172	View.Stipple1.....	167
View.DrawStrings.....	172	View.Stipple2.....	168
View.DrawTensors.....	172	View.Stipple3.....	168
View.DrawTetrahedra.....	173	View.Stipple4.....	168
View.DrawTriangles.....	173	View.Stipple5.....	168
View.DrawVectors.....	173	View.Stipple6.....	168
View.Explode.....	173	View.Stipple7.....	168
View.ExternalView.....	173	View.Stipple8.....	168
View.FakeTransparency.....	173	View.Stipple9.....	168
View.FileName.....	167	View.Tangents.....	177
View.Format.....	167	View.TargetError.....	177
View.GeneralizedRaiseFactor.....	173	View.TensorType.....	177
View.GeneralizedRaiseView.....	173	View.TimeStep.....	177
View.GeneralizedRaiseX.....	167	View.TransformXX.....	177
View.GeneralizedRaiseY.....	167	View.TransformXY.....	178
View.GeneralizedRaiseZ.....	167	View.TransformXZ.....	178
View.GlyphLocation.....	173	View.TransformYX.....	178
View.Height.....	173	View.TransformYY.....	178
View.IntervalsType.....	174	View.TransformYZ.....	178
View.Light.....	174	View.TransformZX.....	178
View.LightLines.....	174	View.TransformZY.....	178
View.LightTwoSide.....	174	View.TransformZZ.....	178
View.LineType.....	174	View.Type.....	178
View.LineWidth.....	174	View.UseGeneralizedRaise.....	178
View.Max.....	174	View.VectorType.....	178
View.MaxRecursionLevel.....	174	View.Visible.....	179
View.MaxX.....	174	View.Width.....	179
View.MaxY.....	174	Volume (expression) = { expression-list };	
View.MaxZ.....	174	32