

**Gmsh**



# Gmsh Reference Manual

---

The documentation for Gmsh 1.51  
A finite element mesh generator with built-in pre- and post-processing facilities

Edition 1.18 (1 April 2004)

Christophe Geuzaine  
Jean-François Remacle

---

Copyright © 1997-2004 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 General tools . . . . .               | 9   |
| 3 Geometry module . . . . .             | 35  |
| 4 Mesh module . . . . .                 | 45  |
| 5 Solver module . . . . .               | 57  |
| 6 Post-processing module . . . . .      | 77  |
| 7 Tutorial . . . . .                    | 87  |
| 8 Running Gmsh . . . . .                | 111 |
| 9 File formats . . . . .                | 119 |
| 10 Programming notes . . . . .          | 131 |
| 11 Bugs, versions and credits . . . . . | 133 |
| A Tips and tricks . . . . .             | 143 |
| B License . . . . .                     | 145 |
| Concept index . . . . .                 | 151 |
| Syntax index . . . . .                  | 153 |



# Table of Contents

|   |           |
|---|-----------|
| <b>Copying conditions</b> .....                                       | <b>1</b>  |
| <b>1 Overview</b> .....   | <b>3</b>  |
| 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 .....                         | 6         |
| 1.7 Syntactic rules used in this document .....                       | 6         |
| 1.8 Comments .....  | 6         |
| <b>2 General tools</b> .....  | <b>9</b>  |
| 2.1 Expressions .....   | 9         |
| 2.1.1 Floating point expressions .....                                | 9         |
| 2.1.2 Character expressions .....                                     | 10        |
| 2.1.3 Color expressions .....   | 11        |
| 2.2 Operators .....   | 11        |
| 2.3 Built-in functions .....  | 12        |
| 2.4 User-defined functions .....                                      | 14        |
| 2.5 Loops and conditionals .....                                      | 14        |
| 2.6 General commands .....  | 15        |
| 2.7 General options .....   | 17        |
| <b>3 Geometry module</b> .....  | <b>35</b> |
| 3.1 Geometry commands .....   | 35        |
| 3.1.1 Points .....  | 35        |
| 3.1.2 Lines .....   | 36        |
| 3.1.3 Surfaces .....  | 37        |
| 3.1.4 Volumes .....   | 37        |
| 3.1.5 Extrusions .....  | 38        |
| 3.1.6 Transformations .....   | 38        |
| 3.1.7 Miscellaneous .....   | 39        |
| 3.2 Geometry options .....  | 40        |
| <b>4 Mesh module</b> .....  | <b>45</b> |
| 4.1 Elementary vs. physical entities .....                            | 45        |
| 4.2 Mesh commands .....   | 45        |
| 4.2.1 Characteristic lengths .....                                    | 45        |
| 4.2.2 Structured grids .....  | 46        |
| 4.2.3 Miscellaneous .....   | 48        |
| 4.3 Mesh options .....  | 48        |

|           |   |            |
|-----------|---|------------|
| <b>5</b>  | <b>Solver module .....</b>                    | <b>57</b>  |
| 5.1       | Solver options .....                          | 57         |
| 5.2       | Solver example .....                          | 69         |
| <b>6</b>  | <b>Post-processing module .....</b>           | <b>77</b>  |
| 6.1       | Post-processing commands .....                | 77         |
| 6.2       | Post-processing options .....                 | 78         |
| <b>7</b>  | <b>Tutorial .....</b>                         | <b>87</b>  |
| 7.1       | 't1.geo' .....                                | 87         |
| 7.2       | 't2.geo' .....                                | 89         |
| 7.3       | 't3.geo' .....                                | 91         |
| 7.4       | 't4.geo' .....                                | 92         |
| 7.5       | 't5.geo' .....                                | 95         |
| 7.6       | 't6.geo' .....                                | 99         |
| 7.7       | 't7.geo' .....                                | 104        |
| 7.8       | 't8.geo' .....                                | 105        |
| 7.9       | 't9.geo' .....                                | 108        |
| <b>8</b>  | <b>Running Gmsh .....</b>                     | <b>111</b> |
| 8.1       | Interactive vs. non-interactive mode .....    | 111        |
| 8.2       | Command-line options .....                    | 112        |
| 8.3       | Mouse actions .....                           | 114        |
| 8.4       | Keyboard shortcuts .....                      | 115        |
| <b>9</b>  | <b>File formats .....</b>                     | <b>119</b> |
| 9.1       | Gmsh mesh file format .....                   | 119        |
| 9.1.1     | Version 1.0 .....                             | 119        |
| 9.1.2     | Version 2.0 .....                             | 120        |
| 9.2       | Gmsh ASCII post-processing file format .....  | 121        |
| 9.3       | Gmsh binary post-processing file format ..... | 124        |
| 9.4       | Gmsh parsed post-processing file format ..... | 125        |
| 9.5       | Gmsh node ordering .....                      | 126        |
| <b>10</b> | <b>Programming notes .....</b>                | <b>131</b> |
| <b>11</b> | <b>Bugs, versions and credits .....</b>       | <b>133</b> |
| 11.1      | Bugs .....                                    | 133        |
| 11.2      | Versions .....                                | 133        |
| 11.3      | Credits .....                                 | 139        |

|               |                       |     |
|---------------|-----------------------|-----|
| Appendix A    | Tips and tricks ..... | 143 |
| Appendix B    | License .....         | 145 |
| Concept index | .....                 | 151 |
| Syntax index  | .....                 | 153 |



## 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 B \[License\]](#), page 145). 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 [Section 11.3 \[Credits\]](#), page 140.

The source code and various pre-compiled versions of Gmsh (for Unix, Windows and Mac OS) can be downloaded from the webpage <http://www.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://www.geuz.org/gmsh/>. Please send all Gmsh-related questions to the public Gmsh mailing list at [gmsh@geuz.org](mailto: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, primarily Delaunay, with built-in pre- and post-processing facilities. Its design goal is to provide a simple meshing tool for academic test cases with parametric input and up to date visualization capabilities. One of its strengths is the ability to respect a characteristic length field for the generation of adapted meshes on lines, surfaces and volumes, and to mix these meshes with simple structured (transfinite, extruded, etc.) grids.

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 ASCII data 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

Geometries are created in a bottom-up flow by successively defining points, oriented lines (line segments, circles, ellipses, splines, . . .), oriented surfaces (plane surfaces, ruled surfaces, . . .) and volumes. Compound groups of geometrical entities can be defined, based on these elementary geometric entities. Gmsh's scripting language allows all geometrical entities to be fully parameterized.

## 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<sup>1</sup>. This automatically assures the

---

<sup>1</sup> 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...

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. Every meshing step is constrained by the characteristic length field, which can be uniform, specified by characteristic lengths associated with elementary geometrical entities, or associated with another mesh (the background mesh).

For each meshing step, all structured mesh directives are executed first, and serve as additional constraints for the unstructured parts. The implemented Delaunay algorithm is subdivided in the following five steps for surface/volume discretization:

1. trivial meshing of a box including the convex polygon/polyhedron defined by the boundary nodes resulting from the discretization of the lines/surfaces;
2. creation of the initial mesh by insertion of all the nodes on the lines/surfaces thanks to the Bowyer algorithm;
3. boundary restoration to force all the edges/faces of the lines/surfaces to be present in the initial mesh;
4. suppression of all the unwanted triangles/tetrahedra (in particular those containing the nodes of the initial box);
5. insertion of new nodes by the Bowyer algorithm until the characteristic size of each simplex is lower or equal to the characteristic length field evaluated at the center of its circumscribed circle/sphere.

### 1.3 Solver: external solver interface

External solvers can be interfaced with Gmsh through Unix sockets, which permits to easily launch external computations and to collect and exploit the simulation results within Gmsh’s post-processing module. The default solver interfaced with Gmsh is GetDP (<http://www.geuz.org/getdp/>).

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

Multiple post-processing scalar, vector or tensor maps can be loaded and manipulated (globally or individually) along with the geometry and the mesh. Scalar fields are represented by iso-value lines/surfaces or color maps, while vector and tensor fields are represented by three-dimensional arrows or displacement maps. Post-processing functions include section computation of scalar views, offset, elevation, boundary extraction, color map and range modification, animation, vector graphic output, etc. All post-processing options can be accessed either interactively or through the input ASCII text files. Scripting permits to automate all post-processing operations, e.g. for the creation of 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 2.4 \[User-defined functions\]](#), page 14, [Section 2.5 \[Loops and conditionals\]](#), page 14, and [Section 2.6 \[General commands\]](#), page 15);
- parameterize these geometries. Gmsh’s scripting language enables all commands and command arguments to depend on previous calculations (see [Section 2.1 \[Expressions\]](#), page 9, and [Section 3.1 \[Geometry commands\]](#), page 35);
- generate 1D, 2D and 3D simplicial (i.e. using line segments, triangles and tetrahedra) finite element meshes. The performance of the 1D and 2D algorithms is pretty good; the 3D algorithm is still experimental and slow (see [Chapter 4 \[Mesh module\]](#), page 45, and [Chapter 7 \[Tutorial\]](#), page 87);
- specify target element sizes accurately. Gmsh provides several mechanisms to control the size of the elements in the final mesh: through interpolation from geometrical point characteristic lengths or geometrical attractors, or from user-defined background meshes (see [Section 4.2 \[Mesh commands\]](#), page 45);
- create simple extruded geometries and meshes (see [Section 3.1 \[Geometry commands\]](#), page 35, and [Section 4.2 \[Mesh commands\]](#), page 45);
- interact with external solvers. Gmsh provides C/C++ and Perl interfaces, and others can be easily added (see [Chapter 5 \[Solver module\]](#), page 57);
- visualize computational results in a great variety of ways. Gmsh can display scalar, vector and tensor data sets, and can perform various operations on the resulting post-processing views (see [Chapter 6 \[Post-processing module\]](#), page 77);
- export plots in many different formats: vector PostScript or encapsulated PostScript, LaTeX, PNG, JPEG, . . . (see [Section 2.7 \[General options\]](#), page 17);
- generate complex animations (see [Chapter 2 \[General tools\]](#), page 9, and [Section 7.8 \[t8.geo\]](#), page 105);
- run on low end machines and/or machines with no graphic system. Gmsh can be compiled with or without the graphical user interface, and all versions can be used either interactively or not, directly from the command line (see [Chapter 8 \[Running Gmsh\]](#), page 111);
- 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 [Section 2.7 \[General options\]](#), page 17, [Section 3.2 \[Geometry options\]](#), page 40, [Section 4.3 \[Mesh options\]](#), page 48, [Section 6.2 \[Post-processing options\]](#), page 78, and [Chapter 8 \[Running Gmsh\]](#), page 111);
- and do all the above on various platforms (Windows, Mac and Unix), for free (see [\[Copying conditions\]](#), page 1), using clear-text ASCII files and/or a small but powerful graphical user interface.

## 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 bottom-up approach for describing geometries can become inconvenient for complex models;
- there is no support for NURBS and only very limited support for trimmed surfaces;
- Gmsh is not primarily a structured mesh generator: no automatic quadrilateral or hexahedral meshing algorithm is provided. If you want quadrangles, you have to use transfinite or extruded meshes or recombine unstructured triangular meshes. For hexahedra, your only choice is transfinite or extruded meshes;
- Gmsh is not a multi-bloc generator: all meshes produced by Gmsh are conforming in the sense of finite element meshes;
- the user has no control over the quality of the mesh elements generated by the 3D unstructured algorithm;
- the 2D anisotropic and the 3D unstructured algorithms are still experimental and not very robust. If these algorithms fail, try to change some characteristic lengths to generate meshes that better suit the geometrical details of the structures;
- 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 [Chapter 10 \[Programming notes\]](#), [page 131](#)) to remedy the aforementioned (and all other) shortcomings...

## 1.7 Syntactic rules used in this document

Here are the rules we tried to follow when writing this user's guide. Note that metasyntactic 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.

## 1.8 Comments

All Gmsh ASCII text input 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.



## 2 General tools

This chapter describes the general commands and options that can be used in Gmsh’s ASCII text input 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 3 \[Geometry module\]](#), page 35, [Chapter 4 \[Mesh module\]](#), page 45, [Chapter 5 \[Solver module\]](#), page 57, and [Chapter 6 \[Post-processing module\]](#), page 77, respectively.

Note that, if you are just beginning to use Gmsh, or just want to see what Gmsh is all about, you really don’t need to read this chapter and the four next ones. Just have a quick look at [Chapter 8 \[Running Gmsh\]](#), page 111, and go play with the graphical user interface, running the tutorials and demonstration files bundled in the distribution! Most of the commands and options described in the following chapters are available interactively in the GUI, so you don’t need to worry about Gmsh’s internals for creating your first geometries, meshes and post-processing plots. Once you master the tutorial (read the source files: they are heavily commented—see [Chapter 7 \[Tutorial\]](#), page 87), you might want to come back here to learn more about the specific syntax of Gmsh’s commands and esoteric options.

### 2.1 Expressions

The two constant types used in Gmsh 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.

#### 2.1.1 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 1.7 \[Syntactic rules\]](#), page 6), and are evaluated during the parsing of the data 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 expression |
  built-in-function |
  real-option
```

Such *expressions* are used in most of Gmsh’s commands. The operators *operator-unary-left*, *operator-unary-right*, *operator-binary*, *operator-ternary-left* and *operator-ternary-right* are defined in [Section 2.2 \[Operators\]](#), page 11. For the definition of *built-in-functions*, see [Section 2.3 \[Built-in functions\]](#), page 13. The various *real-options* are listed in [Section 2.7 \[General options\]](#), page 17, [Section 3.2 \[Geometry options\]](#), page 40, [Section 4.3 \[Mesh](#)

options], page 48, [Section 5.1 \[Solver options\]](#), page 57, and [Section 6.2 \[Post-processing options\]](#), page 78.

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 3.1.1 \[Points\]](#), page 35). The last two cases permit to retrieve the indices of entities created through geometrical transformations and extrusions (see [Section 3.1.6 \[Transformations\]](#), page 39, and [Section 3.1.5 \[Extrusions\]](#), page 38).

To see the practical use of such expressions, have a look at the first couple of examples in [Chapter 7 \[Tutorial\]](#), page 87. 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.

## 2.1.2 Character expressions

Character expressions are defined as:

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

The second case in this definition permits to take the prefix of a string (e.g. for removing the extension from a file name). The third case permits to concatenate two character expressions, and the fourth is an equivalent of 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 [Section 2.7 \[General options\]](#), page 17, [Section 3.2 \[Geometry options\]](#), page 40,

[Section 4.3 \[Mesh options\]](#), page 48, [Section 5.1 \[Solver options\]](#), page 57, and [Section 6.2 \[Post-processing options\]](#), page 78.

Character expressions are mostly used to specify non-numeric options and input/output file names. See [Section 7.8 \[t8.geo\]](#), page 105, for an interesting usage of *char-expressions* in an animation script.

### 2.1.3 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 Gmsh’s source tree 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 [Section 2.7 \[General options\]](#), page 17, [Section 3.2 \[Geometry options\]](#), page 40, [Section 4.3 \[Mesh options\]](#), page 48, [Section 5.1 \[Solver options\]](#), page 57, and [Section 6.2 \[Post-processing options\]](#), page 78.

See [Section 7.3 \[t3.geo\]](#), page 91, for an example of the use of color expressions.

## 2.2 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.
*      Multiplication.
/      Division.
%      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 below<sup>1</sup> (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. =, +=, -=, \*=, /=

---

<sup>1</sup> The affectation operators are introduced in [Section 2.6 \[General commands\]](#), page 15.

## 2.3 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)<sup>2</sup>. Here is the list of the built-in functions currently implemented:

*built-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* (*expression* > 0).

**Log10** ( *expression* )

Base 10 logarithm of *expression* (*expression* > 0).

**Modulo** ( *expression*, *expression* )

see **Fmod**( *expression*, *expression* ).

<sup>2</sup> 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*.

## 2.4 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 7.5 \[t5.geo\], page 95](#), for an example of a user-defined function.

## 2.5 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 7.5 \[t5.geo\], page 95](#), for an example of **For** and **If** commands. Gmsh does not provide any **Else** (or similar) command at the time of this writing.

## 2.6 General commands

The following commands can be used anywhere in a Gmsh ASCII text input file:

*string* = *expression*;

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

**Pi** Returns 3.1415926535897932.

**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 we will see in [Chapter 3 \[Geometry module\], page 35](#), a unique number is associated with every geometrical point: **newp** permits to know the highest number already attributed. This is mostly useful when writing user-defined functions (see [Section 2.4 \[User-defined functions\], page 14](#)) or general geometric primitives, when one does not know *a priori* which numbers are already attributed, and which ones are still available.

**newl** Returns the next available line number.

**news** Returns the next available surface number.

**newv** Returns the next available volume number.

**newreg** Returns the next available region number. That is, **newreg** returns the maximum of **newp**, **newl**, **news**, **newv** and all physical entity numbers<sup>3</sup>.

*string* [ ] = { *expression-list* };  
Defines a new expression list identifier *string*[], or affects *expression-list* to an existing expression list identifier.

*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. Remember the remark made when defining *expression-lists*: the braces enclosing an *expression-list* are optional if the list only contains a single item.

*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.

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

*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.

<sup>3</sup> For compatibility purposes, the behavior of **newl**, **news**, **newv** and **newreg** can be modified with the **Geometry.OldNewReg** option (see [Section 3.2 \[Geometry options\]](#), page 40).

- 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 2.1 \[Expressions\]](#), page 9), so that only valid floating point formatting characters make sense in *char-expression*. See [Section 7.5 \[t5.geo\]](#), page 95, for an example of the use of **Printf**.
- Merge** *char-expression*;
- Merges a file named *char-expression*. This command is equivalent to the ‘File->Merge’ menu in the graphical user interface.
- MergeWithBoundingBox** *char-expression*;
- Merges a file and forces the recalculation of the scene’s bounding box.
- Draw;**        Redraws the scene.
- Delete All;**
- Deletes all geometrical entities and all currently loaded meshes.
- Print** *char-expression*;
- Prints the graphic window in a file named *char-expression*, using the current **Print.Format** (see [Section 2.7 \[General options\]](#), page 17).
- Sleep** *expression*;
- Suspends the execution of Gmsh during *expression* seconds.
- System** *char-expression*;
- Executes a system call.
- 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 including file.

## 2.7 General options

Here is the list of the general *char-options*, *real-options* and *color-options* (in that order—check the default values to see the actual types). Most of these options are accessible in the graphical user interface, but not all of them. When running Gmsh interactively, changing an option in the ASCII text input 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.

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 'Tools->Options->Save' menu.

`General.DefaultFileName`

Default project file name  
Default value: "untitled.geo"  
Saved in: `General.SessionFileName`

`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.SessionFileName`

`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.Scheme`

FLTK graphical user interface scheme (try e.g. plastic)  
Default value: ""  
Saved in: `General.SessionFileName`

`General.TextEditor`

System command to launch a text editor  
Default value: "open -e %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.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**

Display the axes linked to the model

Default value: 1

Saved in: **General.OptionsFileName**

**General.Clip0**

Enable clip plane 0

Default value: 0

Saved in: -

**General.Clip0A**

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

Default value: 0

Saved in: -

**General.Clip0B**

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

Default value: 0

Saved in: -

**General.Clip0C**

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

Default value: 0

Saved in: -

**General.Clip0D**

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

Default value: 0

Saved in: -

**General.Clip1**

Enable clip plane 1  
Default value: 0  
Saved in: -

**General.Clip1A**

First coefficient in equation for clip plane 1  
Default value: 0  
Saved in: -

**General.Clip1B**

Second coefficient in equation for clip plane 1  
Default value: 0  
Saved in: -

**General.Clip1C**

Third coefficient in equation for clip plane 1  
Default value: 0  
Saved in: -

**General.Clip1D**

Fourth coefficient in equation for clip plane 1  
Default value: 0  
Saved in: -

**General.Clip2**

Enable clip plane 2  
Default value: 0  
Saved in: -

**General.Clip2A**

First coefficient in equation for clip plane 2  
Default value: 0  
Saved in: -

**General.Clip2B**

Second coefficient in equation for clip plane 2  
Default value: 0  
Saved in: -

**General.Clip2C**

Third coefficient in equation for clip plane 2  
Default value: 0  
Saved in: -

**General.Clip2D**

Fourth coefficient in equation for clip plane 2  
Default value: 0  
Saved in: -

**General.Clip3**

Enable clip plane 3

Default value: 0

Saved in: -

**General.Clip3A**

First coefficient in equation for clip plane 3

Default value: 0

Saved in: -

**General.Clip3B**

Second coefficient in equation for clip plane 3

Default value: 0

Saved in: -

**General.Clip3C**

Third coefficient in equation for clip plane 3

Default value: 0

Saved in: -

**General.Clip3D**

Fourth coefficient in equation for clip plane 3

Default value: 0

Saved in: -

**General.Clip4**

Enable clip plane 4

Default value: 0

Saved in: -

**General.Clip4A**

First coefficient in equation for clip plane 4

Default value: 0

Saved in: -

**General.Clip4B**

Second coefficient in equation for clip plane 4

Default value: 0

Saved in: -

**General.Clip4C**

Third coefficient in equation for clip plane 4

Default value: 0

Saved in: -

**General.Clip4D**

Fourth coefficient in equation for clip plane 4

Default value: 0

Saved in: -

**General.Clip5**  
Enable clip plane 5  
Default value: 0  
Saved in: -

**General.Clip5A**  
First coefficient in equation for clip plane 5  
Default value: 0  
Saved in: -

**General.Clip5B**  
Second coefficient in equation for clip plane 5  
Default value: 0  
Saved in: -

**General.Clip5C**  
Third coefficient in equation for clip plane 5  
Default value: 0  
Saved in: -

**General.Clip5D**  
Fourth coefficient in equation for clip plane 5  
Default value: 0  
Saved in: -

**General.ColorScheme**  
Default color scheme (0, 1 or 2)  
Default value: 0  
Saved in: **General.OptionsFileName**

**General.ConfirmOverwrite**  
Ask confirmation before overwriting files?  
Default value: 1  
Saved in: **General.SessionFileName**

**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.DefaultPlugins**  
Load default plugins on startup  
Default value: 1  
Saved in: **General.OptionsFileName**

**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.FastRedraw`

Fast redraw (no mesh or view display) when interacting with the model  
Default value: 1  
Saved in: `General.OptionsFileName`

`General.FontSize`

Size of the font in the graphical user interface  
Default value: 12  
Saved in: `General.SessionFileName`

`General.GraphicsFontSize`

Size of the font in the graphic window  
Default value: 11  
Saved in: `General.SessionFileName`

`General.GraphicsHeight`

Height (in pixels) of the graphic window  
Default value: 500  
Saved in: `General.SessionFileName`

`General.GraphicsPositionX`

Horizontal position (in pixels) of the upper left corner of the graphic window  
Default value: 20  
Saved in: `General.SessionFileName`

`General.GraphicsPositionY`

Vertical position (in pixels) of the upper left corner of the graphic window  
Default value: 30  
Saved in: `General.SessionFileName`

`General.GraphicsWidth`

Width (in pixels) of the graphic window  
Default value: 700  
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: 0.5  
Saved in: `General.OptionsFileName`

`General.Light0Y`  
Y position of light source 0  
Default value: 0.3  
Saved in: `General.OptionsFileName`

`General.Light0Z`  
Z position of light source 0  
Default value: 1  
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.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.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.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.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.LineWidth**  
Display width of lines (in pixels)  
Default value: 1  
Saved in: **General.OptionsFileName**

**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.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: 150  
Saved in: **General.SessionFileName**

**General.MessageHeight**  
Height (in pixels) of the message window  
Default value: 350  
Saved in: **General.SessionFileName**

**General.MessageWidth**  
Width (in pixels) of the message window  
Default value: 450  
Saved in: **General.SessionFileName**

**General.MovingLight**  
Use a moving (i.e. which follows the model) light source  
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.PointSize**

Display size of points (in pixels)

Default value: 3

Saved in: **General.OptionsFileName**

**General.QuadricSubdivisions**

Number of subdivisions used to draw points or lines as spheres or cylinders

Default value: 8

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 center of gravity 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 (must be > 0)

Default value: 0.4

Saved in: General.OptionsFileName

**General.SmallAxes**

Display the small axes

Default value: 1

Saved in: General.OptionsFileName

**General.SmallAxesPositionX**

X position of small axes (use negative values for right alignment)

Default value: -45

Saved in: General.OptionsFileName

**General.SmallAxesPositionY**

Y position of small axes (use negative values for bottom alignment)

Default value: -35

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 graphical 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: 2

Saved in: **General.OptionsFileName**

**General.VisibilityMode**

Default mode for the visibility browser (0=Geometry+Mesh, 1=Geometry, 2=Mesh)

Default value: 0

Saved in: **General.SessionFileName**

**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**

'Speed' of the middle mouse button zoom

Default value: 1.1

Saved in: **General.OptionsFileName**

**General.Color.Background**

Background color

Default value: {0,0,0}

Saved in: **General.OptionsFileName**

**General.Color.Foreground**

Foreground color

Default value: {255,255,255}

Saved in: **General.OptionsFileName**

**General.Color.Text**

Text color

Default value: {255,255,255}

Saved in: **General.OptionsFileName**

**General.Color.Axes**

Axes color

Default value: {255,255,0}

Saved in: **General.OptionsFileName**

**General.Color.SmallAxes**

Small axes color

Default value: {255,255,255}

Saved in: **General.OptionsFileName**

**Print.EpsFont**

Font used in PostScript/PDF output

Default value: "Courier"

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.EpsFontSize**  
Font size used in PostScript/PDF output  
Default value: 12  
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.EpsQuality**  
PostScript/PDF quality (1=simple sort, 2=BSP tree sort)  
Default value: 1  
Saved in: **General.OptionsFileName**

**Print.Format**  
File format (10=automatic)  
Default value: 10  
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**



## 3 Geometry module

Gmsh’s geometry module provides a simple CAD engine, using a bottom-up 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.

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. Each physical entity is assigned a unique identification number when it is created. That is, no two physical entities (even of different types, like a physical line and a physical surface) can share identical identification numbers. See [Chapter 4 \[Mesh module\]](#), page 45, for more information about how physical entities affect the way meshes are saved.

### 3.1 Geometry commands

The next subsections describe all the available geometry commands. These commands can be used anywhere in a Gmsh ASCII text input 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.”

#### 3.1.1 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 last *expression* sets the characteristic mesh length at that point. See [Section 4.2.1 \[Characteristic lengths\]](#), page 46, for more information about how this characteristic length information is used in the meshing process.

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

Creates a physical point. The *expression* inside the parentheses is the physical point’s identification number; 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.

### 3.1.2 Lines

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

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

**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. (A deprecated synonym for **Ellipse** is **Ellipsis**.)

**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 3.1.3 \[Surfaces\]](#), page 37.)

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

Creates a physical line. The *expression* inside the parentheses is the physical line's identification number; 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.

### 3.1.3 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.

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

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 *expression-list* on the right hand side should the identification number of a single line loop, composed of either three or four elementary lines.

**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 3.1.4 \[Volumes\]](#), page 38.)

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

Creates a physical surface. The *expression* inside the parentheses is the physical surface's identification number; 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.

### 3.1.4 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 deprecated synonym for **Volume** is **Complex Volume**.)

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

Creates a physical volume. The *expression* inside the parentheses is the physical volume's identification number; 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.

### 3.1.5 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 4.2.2 \[Structured grids\], page 47](#), to see how these commands can be extended in order to also extrude the mesh):

*extrude*:

**Extrude Point | Line | Surface** { *expression*, { *expression-list* } } ;

Extrudes the *expression*-th point, line or surface using a translation. The *expression-list* should contain three *expressions* giving the X, Y and Z components of the translation vector.

**Extrude Point | Line | Surface** { *expression*, { *expression-list* }, { *expression-list* }, *expression* } ;

Extrudes the *expression*-th point, line or surface 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 Point | Line | Surface** { *expression*, { *expression-list* }, { *expression-list* }, { *expression-list* }, *expression* } ;

Extrudes the *expression*-th point, line or surface 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).

### 3.1.6 Transformations

Geometrical transformations can be applied to elementary entities, or to copies of geometrical 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 (points, lines or surfaces) 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 (points, lines or surfaces) 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 (points, lines or surfaces) 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 (points, lines or surfaces) in *transform-list*. The *expression-list* should contain three *expressions* giving the X, Y and Z components of the translation vector.

with

*transform-list*:

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

### 3.1.7 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 3.2 \[Geometry options\]](#), page 40).

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

Deletes all elementary entities (points, lines or surfaces) whose identification numbers are given in *expression-list*.

**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 "\*").

## 3.2 Geometry options

Geometry options control the behavior of geometry commands, as well as the way geometrical entities are handled in the graphical user interface. For the signification of the ‘Saved in:’ field in the following list, see [Section 2.7 \[General options\], page 17](#).

**Geometry.AutoCoherence**  
 Should all duplicate entities be automatically removed?  
 Default value: 1  
 Saved in: `General.OptionsFileName`

**Geometry.CirclePoints**  
 Number of points used to draw a circle/ellipse  
 Default value: 20  
 Saved in: `General.OptionsFileName`

**Geometry.ColorScheme**  
 Default geometry color scheme (0, 1 or 2)  
 Default value: 0  
 Saved in: `General.OptionsFileName`

**Geometry.CircleWarning**  
 Warn if circle arc is greater than Pi  
 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.Highlight**  
 Not used  
 Default value: 1  
 Saved in: `General.OptionsFileName`

**Geometry.Light**

Enable lighting for the geometry  
Default value: 0  
Saved in: `General.OptionsFileName`

**Geometry.Lines**

Display geometry curves?  
Default value: 1  
Saved in: `General.OptionsFileName`

**Geometry.LinesNumbers**

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) or 3D cylinders (1)  
Default value: 0  
Saved in: `General.OptionsFileName`

**Geometry.LineWidth**

Display width of lines (in pixels)  
Default value: 1  
Saved in: `General.OptionsFileName`

**GeometryNormals**

Size of the vectors normal to the surfaces  
Default value: 0  
Saved in: `General.OptionsFileName`

**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.PointsNumbers**

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: 3

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.StlCreateElementary**

Treat each STL input face as a new geometrical surface

Default value: 1

Saved in: **General.OptionsFileName**

**Geometry.StlCreatePhysical**

Automatically create physical entities when importing STL faces as geometrical surfaces

Default value: 1

Saved in: **General.OptionsFileName**

**Geometry.Surfaces**

Display geometry surfaces?

Default value: 0

Saved in: **General.OptionsFileName**

**Geometry.SurfacesNumbers**

Display surface numbers?

Default value: 0

Saved in: **General.OptionsFileName**

**Geometry.Tangents**

Size of the vectors tangent to the curves

Default value: 0

Saved in: **General.OptionsFileName**

**Geometry.Volumes**

Display geometry volumes? (not implemented yet)

Default value: 0

Saved in: **General.OptionsFileName****Geometry.VolumesNumbers**

Display volume numbers? (not implemented yet)

Default value: 0

Saved in: **General.OptionsFileName****Geometry.Color.Points**

Normal geometry point color

Default value: {178,182,129}

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: {128,128,128}

Saved in: **General.OptionsFileName****Geometry.Color.PointsSelect**

Selected geometry point color

Default value: {255,0,0}

Saved in: **General.OptionsFileName****Geometry.Color.LinesSelect**

Selected geometry curve color

Default value: {255,0,0}

Saved in: **General.OptionsFileName****Geometry.Color.SurfacesSelect**

Selected geometry surface color

Default value: {255,0,0}

Saved in: **General.OptionsFileName****Geometry.Color.VolumesSelect**

Selected geometry volume color

Default value: {255,0,0}

Saved in: **General.OptionsFileName**

`Geometry.Color.PointsHighlight`  
Highlighted geometry point color  
Default value: {0,255,0}  
Saved in: `General.OptionsFileName`

`Geometry.Color.LinesHighlight`  
Highlighted geometry curve color  
Default value: {0,0,255}  
Saved in: `General.OptionsFileName`

`Geometry.Color.SurfacesHighlight`  
Highlighted geometry surface color  
Default value: {128,128,128}  
Saved in: `General.OptionsFileName`

`Geometry.Color.VolumesHighlight`  
Highlighted geometry volume color  
Default value: {128,128,128}  
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`

## 4 Mesh module

Gmsh’s mesh module regroups several 1D, 2D and 3D mesh 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 4.2.3 \[Miscellaneous mesh commands\]](#), page 48). The 3D unstructured algorithm only generates tetrahedra.

The 2D structured algorithms (transfinite and extrusion) generate triangles by default, but quadrangles can be obtained by using the **Recombine** commands (see [Section 4.2.2 \[Structured grids\]](#), page 47, and [Section 4.2.3 \[Miscellaneous mesh commands\]](#), page 48). The 3D structured algorithms generate tetrahedra, hexahedra, prisms and pyramids, depending on the type of the surface meshes they are based on.

### 4.1 Elementary vs. physical entities

If only elementary geometrical entities are defined (or if the **Mesh.SaveAll** option is set; see [Section 4.3 \[Mesh options\]](#), page 48), the grid produced by the mesh module will be saved “as is”. That is, all the elements in the grid will be saved to disk using the identification number of the elementary entities they discretize as their region number (see [Section 9.1 \[Gmsh mesh file format\]](#), page 119). 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 introduces the notion of “physical” entities (see [Chapter 3 \[Geometry module\]](#), page 35). 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. If physical entities are defined, the output mesh only contains those elements that belong to physical entities. The introduction of such physical entities in large models usually greatly facilitates the manipulation of the model (e.g. using ‘Tools->Visibility’ in the GUI) and the interfacing with external solvers.

### 4.2 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 input ASCII text input files. They have to be given either in the GUI or on the command line (see [Chapter 8 \[Running Gmsh\]](#), page 111, and [Section 8.2 \[Command-line options\]](#), page 112).

### 4.2.1 Characteristic lengths

The ‘size’ of a mesh element is defined as the length of the segment for a line segment, the radius of the circumscribed circle for a triangle and the radius of the circumscribed sphere for a tetrahedron. There are three main ways to specify the size of the mesh elements for a given geometry:

1. You can specify characteristic lengths at the points of the geometrical model (with the `Point` command: see [Section 3.1.1 \[Points\]](#), page 35). The actual size of the mesh elements will 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 4.2.2 \[Structured grids\]](#), page 47).

2. You can use geometrical “attractors”, an elaborate version of the method described in the preceding item: see the definition of the `Attractor` command below.

Attractors currently only work with the 2D anisotropic algorithm (see the `Mesh.Algorithm` option in [Section 4.3 \[Mesh options\]](#), page 48).

3. You can give Gmsh an explicit background mesh in the form of a scalar post-processing view (see [Section 6.1 \[Post-processing commands\]](#), page 77, and [Chapter 9 \[File formats\]](#), page 119) 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 the target element sizes can be constrained by the characteristic lengths defined in the geometrical model if the `Mesh.ConstrainedBackgroundMesh` option is set.

This method only works with the isotropic 1D, 2D and 3D algorithm, and is not currently available with the Triangle algorithm. To load a background mesh, use the `-bgm` command-line option (see [Section 8.2 \[Command-line options\]](#), page 112) or select ‘Apply as background mesh’ in the post-processing view option menu.

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

**Attractor** `Point | Line { expression-list } = { expression, expression, expression };`

Specifies a characteristic length attractor. The *expression-list* should contain the identification numbers of the elementary points or lines to serve as attractors; the two first *expressions* prescribe refinement factors in a coordinate system local to the entities, and the last *expression* a decay factor. This feature is still experimental, and only works with the 2D anisotropic algorithm (see `Mesh.Algorithm` in [Section 4.3 \[Mesh options\]](#), page 48). An example of the use of attractors is given in [Section 7.7 \[t7.geo\]](#), page 104.

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

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

### 4.2.2 Structured grids

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

Extrudes both the geometry and the mesh using a translation (see [Section 3.1.5 \[Extrusions\]](#), page 38). The *layers* option determines how the mesh is extruded and has the following syntax:

*layers*:

Layer { { *expression-list* }, { *expression-list* }, { *expression-list* } }; |  
Recombine;

The first *expression-list* defines how many elements should be created in each extruded layer. The second *expression-list* assigns a region number to each layer. The last *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 7.3 \[t3.geo\]](#), page 91, 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.

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

Extrudes both the geometry and the mesh using a rotation (see [Section 3.1.5 \[Extrusions\]](#), page 38). The *layers* option is defined as above.

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

Extrudes both the geometry and the mesh using a combined translation and rotation (see [Section 3.1.5 \[Extrusions\]](#), page 38). The *layers* option is defined as above.

**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 4.2.1 \[Characteristic lengths\]](#), page 46). 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. (A deprecated synonym for **Progression** is **Power**.)

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

Selects the surface *expression* to be meshed with the 2D transfinite algorithm (the surface can only have three or four sides). The *expression-list* should contain the identification numbers of the points on the boundary of the surface. The ordering of these point numbers defines the ordering and orientation of the mesh elements, and should thus follow the node ordering for triangles or quadrangles given in [Section 9.5 \[Gmsh node ordering\]](#), page 126.

**Transfinite Volume** { *expression* } = { *expression-list* };

Selects the volume *expression* to be meshed with the 3D transfinite algorithm (the volume can only have six or eight faces). The *expression-list* should contain the identification numbers of the points on the boundary of the volume. The ordering of these point numbers defines the ordering and orientation of the mesh elements, and should thus follow the node ordering for prisms or hexahedra given in [Section 9.5 \[Gmsh node ordering\]](#), page 126.

### 4.2.3 Miscellaneous

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

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

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

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

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

**Hide** *char-expression*;

Hide 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 recombination angle allowed (a large *expression* leading to more triangle recombinations).

**Save** *char-expression*;

Saves the mesh in a file named *char-expression*, using the current `Mesh.Format` (see [Section 4.3 \[Mesh options\]](#), page 48).

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

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

**Show** *char-expression*;

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

## 4.3 Mesh options

Mesh options control the behavior of mesh commands, as well as the way meshes are displayed in the graphical user interface. For the signification of the ‘Saved in:’ field in the following list, see [Section 2.7 \[General options\]](#), page 17.

**Mesh.TriangleOptions**

Options for Jonathan Shewchuk’s Triangle isotropic algorithm

Default value: "praqzBPY"

Saved in: `General.OptionsFileName`

**Mesh.Algorithm**

2D mesh algorithm (1=isotropic, 2=anisotropic, 3=triangle)

Default value: 1

Saved in: **General.OptionsFileName**

**Mesh.AllowDegeneratedExtrude**

Allow the generation of degenerated hexahedra or prisms during extrusion

Default value: 0

Saved in: -

**Mesh.CharacteristicLengthFactor**

Factor applied to all characteristic lengths (and background meshes)

Default value: 1

Saved in: **General.OptionsFileName**

**Mesh.ColorCarousel**

Color mesh by region? (0=no, 1=by elementary entity, 2=by physical entity, 3=by partition)

Default value: 1

Saved in: **General.OptionsFileName**

**Mesh.ColorScheme**

Default mesh color scheme (0, 1 or 2)

Default value: 0

Saved in: **General.OptionsFileName**

**Mesh.ConstrainedBackgroundMesh**

Should the background mesh be constrained by the characteristic lengths associated with the geometry?

Default value: 0

Saved in: **General.OptionsFileName**

**Mesh.CpuTime**

CPU time for the generation of the current mesh (in seconds)

Default value: 0

Saved in: -

**Mesh.CutPlane**

Enable mesh cut plane

Default value: 0

Saved in: -

**Mesh.CutPlaneA**

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

Default value: 1

Saved in: -

**Mesh.CutPlaneB**

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

Default value: 0

Saved in: -

**Mesh.CutPlaneC**

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

Default value: 0

Saved in: -

**Mesh.CutPlaneD**

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

Default value: 0

Saved in: -

**Mesh.DisplayLists**

Use OpenGL display lists for drawing 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, 2=quadratic elements)

Default value: 1

Saved in: **General.OptionsFileName**

**Mesh.Explode**

Display mesh with non adjacent elements (factor between 0 and 1)

Default value: 1

Saved in: **General.OptionsFileName**

**Mesh.Format**

Mesh output format (1=MSH, 2=UNV, 3=GREF, 19=VRML)

Default value: 1

Saved in: **General.OptionsFileName**

**Mesh.GammaInf**

Only display elements whose Gamma factor is greater than GammaInf

Default value: 0

Saved in: **General.OptionsFileName**

**Mesh.GammaSup**

Only display elements whose Gamma factor is smaller than GammaSup

Default value: 0

Saved in: **General.OptionsFileName**

**Mesh.Interactive**

Show the construction of the 2D mesh in real time (only with the 2D anisotropic algorithm)

Default value: 0

Saved in: **General.OptionsFileName**

**Mesh.Light**

Enable lighting for the mesh  
Default value: 0  
Saved in: `General.OptionsFileName`

**Mesh.Lines**

Display mesh vertices on curves?  
Default value: 1  
Saved in: `General.OptionsFileName`

**Mesh.LinesNumbers**

Display mesh line numbers?  
Default value: 0  
Saved in: `General.OptionsFileName`

**Mesh.LineType**

Display lines as solid color segments (0) or 3D cylinders (1)  
Default value: 0  
Saved in: `General.OptionsFileName`

**Mesh.LineWidth**

Display width of lines (in pixels)  
Default value: 1  
Saved in: `General.OptionsFileName`

**Mesh.MinimumCirclePoints**

Minimum number of points used to mesh a circle  
Default value: 7  
Saved in: `General.OptionsFileName`

**Mesh.MshFileVersion**

MSH mesh file version to generate  
Default value: 1  
Saved in: `General.OptionsFileName`

**Mesh.NbHexahedra**

Number of hexahedra in the current mesh  
Default value: 0  
Saved in: -

**Mesh.NbNodes**

Number of nodes in the current mesh  
Default value: 0  
Saved in: -

**Mesh.NbPrisms**

Number of prisms in the current mesh  
Default value: 0  
Saved in: -

**Mesh.NbPyramids**

Number of pyramids in the current mesh  
Default value: 0  
Saved in: -

**Mesh.NbQuadrangles**

Number of quadrangles in the current mesh  
Default value: 0  
Saved in: -

**Mesh.NbTetrahedra**

Number of tetrahedra in the current mesh  
Default value: 0  
Saved in: -

**Mesh.NbTriangles**

Number of triangles in the current mesh  
Default value: 0  
Saved in: -

**Mesh.Normals**

Size of the normal vectors  
Default value: 0  
Saved in: **General.OptionsFileName**

**Mesh.Points**

Display mesh vertices?  
Default value: 1  
Saved in: **General.OptionsFileName**

**Mesh.PointInsertion**

Point insertion method for isotropic 2D algorithm (1=center of circumscribed circle, 2=voronoi, 3=cog)  
Default value: 1  
Saved in: **General.OptionsFileName**

**Mesh.PointsNumbers**

Display mesh vertex numbers?  
Default value: 0  
Saved in: **General.OptionsFileName**

**Mesh.PointSize**

Display size of points (in pixels)  
Default value: 2  
Saved in: **General.OptionsFileName**

**Mesh.PointType**

Display points as solid color dots (0) or 3D spheres (1)  
Default value: 0  
Saved in: **General.OptionsFileName**

**Mesh.Quality**

Target quality for tetrahedral elements (not fully functional)

Default value: 0

Saved in: **General.OptionsFileName**

**Mesh.RadiusInf**

Only display elements whose Radius is greater than RadiusInf

Default value: 0

Saved in: **General.OptionsFileName**

**Mesh.RadiusSup**

Only display elements whose Radius is smaller than RadiusSup

Default value: 0

Saved in: **General.OptionsFileName**

**Mesh.RandomFactor**

Random factor used in 2D and 3D meshing algorithm (test other values when the algorithm fails)

Default value: 0.0001

Saved in: **General.OptionsFileName**

**Mesh.SaveAll**

Ignore Physical definitions and save all elements

Default value: 0

Saved in: -

**Mesh.ScalingFactor**

Global scaling factor applied to the saved mesh

Default value: 1

Saved in: **General.OptionsFileName**

**Mesh.Smoothing**

Number of smoothing steps applied to the final mesh

Default value: 0

Saved in: **General.OptionsFileName**

**Mesh.Solid**

Draw mesh as solid (1) or wireframe (0)?

Default value: 0

Saved in: **General.OptionsFileName**

**Mesh.SpeedMax**

Disable dubious point insertion tests

Default value: 0

Saved in: **General.OptionsFileName**

**Mesh.Surfaces**

Display surface mesh?

Default value: 1

Saved in: **General.OptionsFileName**

**Mesh.SurfacesNumbers**

Display mesh surface numbers?

Default value: 0

Saved in: **General.OptionsFileName****Mesh.Tangents**

Size of the tangent vectors

Default value: 0

Saved in: **General.OptionsFileName****Mesh.Volumes**

Display volume mesh?

Default value: 1

Saved in: **General.OptionsFileName****Mesh.VolumesNumbers**

Display mesh elements numbers?

Default value: 0

Saved in: **General.OptionsFileName****Mesh.Color.Points**

Mesh vertex color

Default value: {0,123,59}

Saved in: **General.OptionsFileName****Mesh.Color.Lines**

Mesh line color

Default value: {0,255,0}

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: {128,128,128}

Saved in: General.OptionsFileName

**Mesh.ColorNormals**

Normal mesh vector color

Default value: {128,128,128}

Saved in: General.OptionsFileName

**Mesh.Color.One**

First color in color carousel

Default value: {232,210,23}

Saved in: General.OptionsFileName

**Mesh.Color.Two**

Second color in color carousel

Default value: {226,167,29}

Saved in: General.OptionsFileName

**Mesh.Color.Three**

Third color in color carousel

Default value: {217,113,38}

Saved in: General.OptionsFileName

**Mesh.Color.Four**

Fourth color in color carousel

Default value: {201,54,54}

Saved in: General.OptionsFileName

**Mesh.Color.Five**

Fifth color in color carousel

Default value: {169,12,86}

Saved in: General.OptionsFileName

**Mesh.Color.Six**

Sixth color in color carousel

Default value: {114,2,141}

Saved in: General.OptionsFileName

**Mesh.Color.Seven**  
Seventh color in color carousel  
Default value: {67,30,188}  
Saved in: **General.OptionsFileName**

**Mesh.Color.Eight**  
Eighth color in color carousel  
Default value: {44,86,211}  
Saved in: **General.OptionsFileName**

**Mesh.Color.Nine**  
Ninth color in color carousel  
Default value: {32,145,223}  
Saved in: **General.OptionsFileName**

**Mesh.Color.Ten**  
Tenth color in color carousel  
Default value: {25,193,230}  
Saved in: **General.OptionsFileName**

## 5 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 5.1 \[Solver options\]](#), page 57), 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 link your solver with the ‘`GmshClient.c`’ file 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 5.2 \[Solver example\]](#), page 69, for an example of how to interface a C solver. Bindings for solvers written in other languages (e.g. Perl) are available on <http://www.geuz.org/gmsh/>.

### 5.1 Solver options

#### `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) 1997-2004 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.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.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: "-bin -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.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.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.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.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.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.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.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.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.ClientServer0**

Connect solver 0 to the Gmsh server  
Default value: 1  
Saved in: **General.OptionsFileName**

**Solver.MergeViews0**

Automatically merge any post-processing view created by solver 0  
Default value: 1  
Saved in: **General.OptionsFileName**

**Solver.PopupMessages0**

Automatically display messages produced by solver 0  
Default value: 1  
Saved in: **General.OptionsFileName**

**Solver.ClientServer1**

Connect solver 1 to the Gmsh server  
Default value: 0  
Saved in: **General.OptionsFileName**

**Solver.MergeViews1**

Automatically merge any post-processing view created by solver 1  
Default value: 1  
Saved in: **General.OptionsFileName**

**Solver.PopupMessages1**

Automatically display messages produced by solver 1  
Default value: 1  
Saved in: **General.OptionsFileName**

**Solver.ClientServer2**  
Connect solver 2 to the Gmsh server  
Default value: 0  
Saved in: **General.OptionsFileName**

**Solver.MergeViews2**  
Automatically merge any post-processing view created by solver 2  
Default value: 1  
Saved in: **General.OptionsFileName**

**Solver.PopupMessages2**  
Automatically display messages produced by solver 2  
Default value: 1  
Saved in: **General.OptionsFileName**

**Solver.ClientServer3**  
Connect solver 3 to the Gmsh server  
Default value: 0  
Saved in: **General.OptionsFileName**

**Solver.MergeViews3**  
Automatically merge any post-processing view created by solver 3  
Default value: 1  
Saved in: **General.OptionsFileName**

**Solver.PopupMessages3**  
Automatically display messages produced by solver 3  
Default value: 1  
Saved in: **General.OptionsFileName**

**Solver.ClientServer4**  
Connect solver 4 to the Gmsh server  
Default value: 0  
Saved in: **General.OptionsFileName**

**Solver.MergeViews4**  
Automatically merge any post-processing view created by solver 4  
Default value: 1  
Saved in: **General.OptionsFileName**

**Solver.PopupMessages4**  
Automatically display messages produced by solver 4  
Default value: 1  
Saved in: **General.OptionsFileName**

## 5.2 Solver example

Here is a small example of how to interface a C solver with Gmsh. The following listing reproduces the ‘utils/solvers/mysolver.c’ file from the Gmsh source distribution.

```
/* $Id: mysolver.c,v 1.3 2004/02/07 01:40:35 geuzaine Exp $ */
```

```

/*
 * Copyright (C) 1997-2004 C. Geuzaine, J.-F. Remacle
 *
 * Permission is hereby granted, free of charge, to any person
 * obtaining a copy of this software and associated documentation
 * files (the "Software"), to deal in the Software without
 * restriction, including without limitation the rights to use, copy,
 * modify, merge, publish, distribute, and/or sell copies of the
 * Software, and to permit persons to whom the Software is furnished
 * to do so, provided that the above copyright notice(s) and this
 * permission notice appear in all copies of the Software and that
 * both the above copyright notice(s) and this permission notice
 * appear in supporting documentation.
 *
 * THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND,
 * EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF
 * MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND
 * NONINFRINGEMENT OF THIRD PARTY RIGHTS. IN NO EVENT SHALL THE
 * COPYRIGHT HOLDER OR HOLDERS INCLUDED IN THIS NOTICE BE LIABLE FOR
 * ANY CLAIM, OR ANY SPECIAL INDIRECT OR CONSEQUENTIAL DAMAGES, OR ANY
 * DAMAGES WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS,
 * WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS
 * ACTION, ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE
 * OF THIS SOFTWARE.
 *
 * Please report all bugs and problems to <gmsh@geuz.org>.
 */

/* This file contains a dummy 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:

   gcc -o mysolver.exe mysolver.c GmshClient.c

   To test this solver, copy the mysolver.opt file into your default
   Gmsh option file, or launch Gmsh with the command:

   gmsh -option mysolver.opt */

/* We start by including some standard headers. Under Windows, you
   will need to install the cygwin tools (http://www.cygwin.com) to
   compile this example (as well as your own solver), since the Gmsh
   solver interface uses Unix sockets. */

```

```

#include <stdlib.h>

```

```

#include <stdio.h>
#include <string.h>
#include <sys/types.h>
#include <sys/time.h>
#include <unistd.h>

/* Now we include the Gmsh client interface definitions. At the time
   of this writing, the client interface contains only three
   functions: Gmsh_Connect, Gmsh_SendString and Gmsh_Disconnect. This
   example shows how to use these functions in order to program some
   simple interactions between a solver and Gmsh. */

#include "GmshClient.h"

/* The following typedef defines the two actions of our dummy solver:
   either output some valid option strings, or run a dummy computation
   and output a post-processing map. */

typedef enum { options, run } action;

/* Let's now define some fake CPU intensive functions: */

long worktime()
{
    struct timeval tp;
    gettimeofday(&tp, (struct timezone *)0);
    return (long)tp.tv_sec * 1000000 + (long)tp.tv_usec;
}

void work()
{
    long t1 = worktime();
    while(1) {
        if(worktime() - t1 > 1.e5)
            break;
    }
}

/* And here we go with the main routine of the solver: */

int main(int argc, char *argv[])
{
    action what = run;
    int i = 0, s;
    char *name = NULL, *option = NULL, *socket = NULL, tmp[256];
    FILE *file;

```

```

/* 1. Loop through the command line arguments, remember the action
the solver has to perform (what) and store the socket name, the
option name and the problem name. */

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 = options;
        }
        else if(!strcmp(argv[i] + 1, "run")) {
            i++;
            what = run;
            if(argv[i])
                option = argv[i++];
        }
    }
    else
        name = argv[i++];
}

/* 2. If the '-socket' option was not given, we cannot connect to Gmsh... */

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

/* 3. Try to connect to the socket given by the '-socket' command
line option: */

s = Gmsh_Connect(socket);
switch (s) {

    /* 3.1. If the socket is <0, issue an error... */

case -1:
    printf("Couldn't create socket %s\n", socket);
    break;
case -2:
    printf("Couldn't connect to socket %s\n", socket);
    break;

```

default:

```

/* 3.2. ...otherwise, send the GMSH_CLIENT_START command (together
   with the process ID of the solver), check if a problem name was
   specified, and decide what to do according to the 'what'
   variable: */

sprintf(tmp, "%d", getpid());
Gmsh_SendString(s, GMSH_CLIENT_START, tmp);
if(!name) {
    Gmsh_SendString(s, GMSH_CLIENT_ERROR, "Missing file name");
    Gmsh_Disconnect(s);
    exit(1);
}
switch (what) {

    /* 3.2.1. If what==options, the solver sends the valid options
       (here for the first option): */

    case options:
        Gmsh_SendString(s, GMSH_CLIENT_OPTION_1, "Val1");
        Gmsh_SendString(s, GMSH_CLIENT_OPTION_1, "Val2");
        Gmsh_SendString(s, GMSH_CLIENT_OPTION_1, "Val3");
        break;

    /* 3.2.2. If what==run, the solver runs the chosen option,
       updates the progress message, issues some information data,
       produces a post-processing map and asks Gmsh to merge it: */

    case run:
        sprintf(tmp, "Running %s with option %s...", name, option);
        Gmsh_SendString(s, GMSH_CLIENT_INFO, tmp);
        for(i = 0; i < 10; i++) {
            sprintf(tmp, "%d %% complete", 10*i);
            Gmsh_SendString(s, GMSH_CLIENT_PROGRESS, tmp);
            work();
        }
        sprintf(tmp, "Done with %s!", name);
        Gmsh_SendString(s, GMSH_CLIENT_INFO, tmp);
        file = fopen("mysolver.pos", "wb");
        if(!file) {
            Gmsh_SendString(s, GMSH_CLIENT_ERROR, "Unable to open output file");
        }
        else {
            fprintf(file, "View \"%s\"{\n", option);
            fprintf(file, "ST(0,0,0,1,0,0,0,1,0){0,1,2};\n");
            fprintf(file, "};\n");
        }
    }
}

```

```

        fclose(file);
        Gmsh_SendString(s, GMSH_CLIENT_VIEW, "mysolver.pos");
    }
    break;
}

/* 3.3. We can now disconnect the solver from Gmsh: */

Gmsh_SendString(s, GMSH_CLIENT_STOP, "Goodbye!");
Gmsh_Disconnect(s);
break;
}

/* 4. That's it! */

}

```

To define the above solver as the second external solver in Gmsh, you should define the following solver options (either merge them in your Gmsh option file, or use the `-option` command-line option—see [Section 8.2 \[Command-line options\]](#), page 112):

```

// These options define 'mysolver.exe' as the second solver in Gmsh's
// solver module, under the name 'My C Solver'.
Solver.Name1 = "My C solver";
Solver.Help1 = "A simple example of the client/server
solver implementation in Gmsh...";
Solver.Executable1 = "./mysolver.exe";
Solver.Extension1 = "";
Solver.MeshName1 = "";
Solver.MeshCommand1 = "";
Solver.OptionCommand1 = "-options";
Solver.FirstOption1 = "Option";
Solver.SecondOption1 = "";
Solver.ThirdOption1 = "";
Solver.FourthOption1 = "";
Solver.FifthOption1 = "";
Solver.FirstButton1 = "Run";
Solver.FirstButtonCommand1 = "-run %s";
Solver.SecondButton1 = "";
Solver.SecondButtonCommand1 = "";
Solver.ThirdButton1 = "";
Solver.ThirdButtonCommand1 = "";
Solver.FourthButton1 = "";
Solver.FourthButtonCommand1 = "";
Solver.FifthButton1 = "";
Solver.FifthButtonCommand1 = "";

```

```
Solver.ClientServer1 = 1;  
Solver.MergeViews1 = 1;  
Solver.PopupMessages1 = 1;
```



## 6 Post-processing module

Gmsh’s post-processing module can handle multiple scalar, vector or tensor data sets along with the geometry and the mesh. The data sets should be given in one of Gmsh’s post-processing file formats described in [Chapter 9 \[File formats\]](#), [page 119](#). Once loaded into Gmsh, scalar fields can be displayed as iso-value lines and surfaces or color maps, whereas vector and tensor fields can be represented either by three-dimensional arrows or by displacement maps. In Gmsh’s jargon, each data set is called a “view”, and can arbitrarily mix all types of elements and fields. 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 the scripting language) or globally (see the `PostProcessing.LinkView` option in [Section 6.2 \[Post-processing options\]](#), [page 78](#)).

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 table’, 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 table’, 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 7.8 \[t8.geo\]](#), [page 105](#), and [Section 7.9 \[t9.geo\]](#), [page 109](#)).

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 (graph style, 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 (see [Section 9.4 \[Gmsh parsed post-processing file format\]](#), [page 125](#)) are available in the ‘`tutorial`’ directory of Gmsh’s distribution (‘`.pos`’ files).

### 6.1 Post-processing commands

**Combine TimeSteps;**

Combines the data from all the post-processing views having the same name into new multi time step views.

**Combine Views;**

Combines all post-processing views in a single new view.

**Delete View***[expression]*;  
 Deletes (removes) the *expression*-th post-processing view. Note that post-processing view numbers start at 0.

**Duplicata View***[expression]*;  
 Duplicates the *expression*-th post-processing view.

**Plugin** (*string*) . *string*;  
 Executes a plugin function. The plugin name is given between the parentheses. Several plugins are loaded by default: see e.g. [Section 7.9 \[t9.geo\], page 109](#).

**Plugin** (*string*) . *string* = *expression* | *char-expression*;  
 Sets a floating point (*expression*) or a character (*char-expression*) option for a given plugin. See [Section 7.9 \[t9.geo\], page 109](#), for an example.

**Save View***[expression]* *char-expression*;  
 Saves the the *expression*-th post-processing view in a file named *char-expression*.

**View** "*string*" { *string* ( *expression-list* ) { *expression-list* }; ... }  
 Creates a new post-processing view, named "*string*". This is the easiest way to create a post-processing view, but also the least efficient (the view is read through Gmsh's script parser, which can become quite slow if the view is large—e.g. with more than 100,000 elements). Though, this “parsed” post-processing format (explained in detail in [Section 9.4 \[Gmsh parsed post-processing file format\], page 125](#)) is very powerful for testing proposes, since all the values are *expressions*. Two other formats, better adapted for large data sets, are described in [Section 9.2 \[Gmsh ASCII post-processing file format\], page 122](#) and [Section 9.3 \[Gmsh binary post-processing file format\], page 124](#).

## 6.2 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, ...), *after the n-th view is loaded*.

See [Section 7.8 \[t8.geo\], page 105](#), and [Section 7.9 \[t9.geo\], page 109](#), for some examples.

**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.DisplayLists**

Use OpenGL display lists for drawing post-processing views

Default value: 0

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

Default value: 0

Saved in: -

**PostProcessing.Scales**

Show value scales

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.AbscissaName**

Abscissa name for 2D graphs

Default value: ""

Saved in: **General.OptionsFileName**

**View.AbscissaFormat**

Abscissa number format for 2D graphs (in standard C form)

Default value: "%.3e"

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: "%.3e"

Saved in: **General.OptionsFileName**

**View.Name**

Default post-processing view name

Default value: ""

Saved in: -

**View.AlphaChannel**

Global alpha channel value (used only if != 1)

Default value: 1

Saved in: **General.OptionsFileName**

**View.AngleSmoothNormals**

Threshold angle below which normals are not smoothed

Default value: 15

Saved in: **General.OptionsFileName**

**View.ArrowHeadRadius**

Relative radius of arrow head

Default value: 0.12

Saved in: **General.OptionsFileName**

**View.ArrowLocation**

Arrow location (1=cog, 2=vertex)

Default value: 1

Saved in: **General.OptionsFileName**

**View.ArrowSize**

Size of vectors arrows (in pixels)

Default value: 50

Saved in: **General.OptionsFileName**

**View.ArrowStemLength**

Relative length of arrow stem

Default value: 0.56

Saved in: **General.OptionsFileName**

**View.ArrowStemRadius**

Relative radius of arrow stem

Default value: 0.02

Saved in: **General.OptionsFileName**

**View.AutoPosition**

Position the scale or the 2D graph automatically to avoid overlaps

Default value: 1

Saved in: **General.OptionsFileName**

**View.Boundary**

Draw the 'N minus b'-dimensional boundary of the simplex (N=simplex dimension, b=option value)

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.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**

Explode elements (0: reduced to point; 1: not transformed)  
Default value: 1  
Saved in: `General.OptionsFileName`

**View.Grid**

Grid mode for 2D graphs (0=none, 1=simple, 2=frame, 3=grid)  
Default value: 2  
Saved in: `General.OptionsFileName`

**View.Height**

Height (in pixels) of the scale or 2D graph  
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: 0  
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.Max** Maximum value in the view (do not change this!)  
Default value: **-1e+200**  
Saved in: -

**View.Min** Minimum value in the view (do not change this!)  
Default value: **1e+200**  
Saved in: -

**View.NbAbscissa**  
Number of abscissa intervals for 2D graphs  
Default value: 5  
Saved in: **General.OptionsFileName**

**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.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: 2  
Saved in: **General.OptionsFileName**

**View.PointType**  
Display points as solid color dots (0) or 3D spheres (1)  
Default value: 0  
Saved in: **General.OptionsFileName**

**View.PositionX**

Horizontal position (in pixels) of the upper left corner of the scale or 2D graph

Default value: 80

Saved in: **General.OptionsFileName**

**View.PositionY**

Vertical position (in pixels) of the upper left corner of the scale or 2D graph

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**

Show time value in the scale? (1=only if NbTimeStep>1, 2=always)

Default value: 1

Saved in: `General.OptionsFileName`

**View.SmoothNormals**

Smooth the normals?

Default value: 0

Saved in: `General.OptionsFileName`

**View.TensorType**

Tensor Visualization Type

Default value: 0

Saved in: `General.OptionsFileName`

**View.TimeStep**

Current time step displayed

Default value: 0

Saved in: -

**View.TransparentScale**

Display a 'transparent' value scale?

Default value: 1

Saved in: `General.OptionsFileName`

**View.Type**

Type of graph (1=3D, 2=2D-space, 3=2D-time)

Default value: 1

Saved in: `General.OptionsFileName`

**View.VectorType**

Vector display type (1=segment, 2=arrow, 3=pyramid, 4=3D arrow, 5=displacement)

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 graph

Default value: 300

Saved in: `General.OptionsFileName`

**View.ColorTable**

Color table used to draw the view

Saved in: `General.OptionsFileName`)



## 7 Tutorial

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

This tutorial does not explain the mesh and post-processing file formats: see [Chapter 9 \[File formats\]](#), page 119, for this.

To learn how to run Gmsh on your computer, see [Chapter 8 \[Running Gmsh\]](#), page 111.

### 7.1 ‘t1.geo’

```

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

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

lc = 0.007;

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

Point(1) = {0, 0, 0, 9.e-1 * lc};

// The actual distribution of the mesh element sizes is then obtained
// by interpolation of these characteristic lengths throughout the
// geometry. There are also other possibilities to specify
// characteristic lengths: attractors (see 't7.geo') and background
// meshes (see 'bgmesh.pos').

// As can be seen in the previous definition, more complex expressions
// can be constructed from variables and floating point
// constants. Here, the product of the variable 'lc' by the constant
// 9.e-1 is given as the fourth argument of the list defining the
// point.

// 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
// files, both with the region number 1. The mechanism is identical
// for line or surface elements:

Physical Line(10) = {1,2,4} ;

```

```

MySurface = 101;
Physical Surface(MySurface) = {6} ;

// All the line elements created during the meshing of lines 1, 2 and
// 4 will be saved in the output file with the region number 10; and
// all the triangular elements resulting from the discretization of
// surface 6 will be given the region number 100.

// Note that, if no physical entities are defined, all the elements in
// the mesh will be directly saved with their default orientation and
// with a region number equal to the number of the elementary entity
// they discretize.

```

## 7.2 '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, 1c};
Line(5) = {4, 5};

// But Gmsh also provides tools to transform (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:

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

```

```

// In this case, we assign the result of the Translate command to a
// list, so that we can retrieve the number of the newly created point
// later.

// Of course, these transformation commands not only apply to points,
// but also to lines and surfaces. The following command extrudes the
// surface 6 defined in 't1.geo', as well as a new surface 11, along
// the z axis:

h = 0.12;
Extrude Surface { 6, {0, 0, h} };

Line(7) = {3,newpt[0]};
Line(8) = {newpt[0],5};

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

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

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

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

// 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.

// 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 volumes don't have holes and thus consist of single
// surface loops:

Surface Loop(145) = {121,11,131,135,139,144};
Volume(146) = {145};

Surface Loop(146) = {121,6,109,113,117,122};
Volume(147) = {146};

```

```
// To save all the tetrahedra discretizing the volumes 146 and 147
// with a common region number, we finally define a physical
// volume:
```

```
Physical Volume (1) = {146,147};
```

### 7.3 ‘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 the number of layers (4 in this case, with 8, 4,
// 2 and 1 subdivisions, respectively), with volume numbers 9000 to
// 9003 and respective heights equal to h/4:

h = 0.1;

Extrude Surface { 6, {0,0,h} } {
  Layers { {8,4,2,1}, {9000:9003}, {0.25,0.5,0.75,1} };
};

// The extrusion can also be performed with a rotation instead of a
// translation, and the resulting mesh can be recombined into prisms
// (wedges). 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 Surface { 122, {0,1,0} , {-0.1,0,0.1} , -Pi/2 } {
  Recombine; Layers { 7, 9004, 1 };
};

// 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:

```

```

Extrude Surface {news-1, {-2*h,0,0}, {1,0,0} , {0,0.15,0.25} , Pi/2}{
  Layers {10,9004,1}; Recombine;
};

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

Physical Volume(101) = {9000:9004};

// 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, redefine some background
// colors, disable the display of the axes, and select an initial
// viewpoint in XYZ mode (disabling the interactive trackball-like
// rotation mode) directly in the input file:

Mesh.CharacteristicLengthFactor = 4;
General.Color.Background = {120,120,120};
General.Color.Foreground = {255,255,255};
General.Color.Text = White;
Geometry.Color.Points = Orange;
General.Axes = 0;
General.Trackball = 0;
General.RotationCenterGravity = 0;
General.RotationCenterX = 0;
General.RotationCenterY = 0;
General.RotationCenterZ = 0;
General.RotationX = 10;
General.RotationY = 70;
General.TranslationX = -0.2;

// Note that all colors can be defined literally or numerically, i.e.
// 'General.Color.Background = Red' is equivalent to
// 'General.Color.Background = {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'
// button.

```

## 7.4 ‘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};

// Since not all curves are straight lines, Gmsh provides many other
// curve primitives: 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 stricly 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 it 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){"File created on Fri Oct 18 23:50:20 2002"};

  // 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 Grey70{ Physical Surface{ 22 }; }
Color Purple{ Surface{ 24 }; }
Color Red{ Line{ 1:14 }; }
Color Yellow{ Line{ 15:20 }; }

```

## 7.5 ‘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 -clscale 1
//
// this input file produces a mesh of approximately 2,500 nodes and
// 13,000 tetrahedra (in 4 seconds on a 1.2GHz PC). With
//
// > gmsh t5 -clscale 0.2
//
// (i.e. with all characteristic lengths divided by 5), the mesh
// counts approximately 260,000 nodes and 1.6 million tetrahedra (and
// the computation takes 16 minutes on the same machine).

// Let us 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, let us 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 cheese
// 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};

// Please note that all surface meshes are generated by projecting a
// 2D planar mesh onto the surface, and that this method gives nice
// results only if the surface's curvature is small enough. If not,
// you will have to cut the surface in pieces.

// We then use an array of variables to store the surface loops

```

```

// identification numbers for later reference (we will need these to
// define the final volume):

theloops[t] = newreg ;

Surface Loop(theloops[t]) = {18+1, 15+1, 11+1, 12+1, -(13+1), -(17+1),
                             16+1, 14+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 cheese 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 ;
```

## 7.6 't6.geo'

```
/*
 *
 * Gmsh tutorial 6
 *
 * Transfinite meshes
 *
 */
*****/

// We start by defining a more complex geometry, using the same
// commands as in the previous examples:

r_int  = 0.05 ;
r_ext  = 0.051 ;
r_far  = 0.125 ;
r_inf  = 0.4 ;
phi1   = 30. * (Pi/180.) ;
angl   = 45. * (Pi/180.) ;

nbpt_phi   = 5 ; nbpt_int   = 20 ;
nbpt_arc1  = 10 ; nbpt_arc2 = 10 ;
nbpt_shell = 10 ; nbpt_far   = 25 ; nbpt_inf = 15 ;

lc0 = 0.1 ; lc1 = 0.1 ; lc2 = 0.3 ;

Point(1) = {0, 0, 0, lc0} ;
Point(2) = {r_int, 0, 0, lc0} ;
Point(3) = {r_ext, 0, 0, lc1} ;
Point(4) = {r_far, 0, 0, lc2} ;
Point(5) = {r_inf, 0, 0, lc2} ;
Point(6) = {0, 0, r_int, lc0} ;
Point(7) = {0, 0, r_ext, lc1} ;
Point(8) = {0, 0, r_far, lc2} ;
Point(9) = {0, 0, r_inf, lc2} ;
```

```

Point(10) = {r_int*cos(phi1), r_int*sin(phi1), 0, lc0} ;
Point(11) = {r_ext*cos(phi1), r_ext*sin(phi1), 0, lc1} ;
Point(12) = {r_far*cos(phi1), r_far*sin(phi1), 0, lc2} ;
Point(13) = {r_inf*cos(phi1), r_inf*sin(phi1), 0, lc2} ;

Point(14) = {r_int/2, 0, 0, lc2} ;
Point(15) = {r_int/2*cos(phi1), r_int/2*sin(phi1), 0, lc2} ;
Point(16) = {r_int/2, 0, r_int/2, lc2} ;
Point(17) = {r_int/2*cos(phi1), r_int/2*sin(phi1), r_int/2, lc2} ;
Point(18) = {0, 0, r_int/2, lc2} ;
Point(19) = {r_int*cos(angl), 0, r_int*sin(angl), lc2} ;
Point(20) = {r_int*cos(angl)*cos(phi1), r_int*cos(angl)*sin(phi1),
             r_int*sin(angl), lc2} ;
Point(21) = {r_ext*cos(angl), 0, r_ext*sin(angl), lc2} ;
Point(22) = {r_ext*cos(angl)*cos(phi1), r_ext*cos(angl)*sin(phi1),
             r_ext*sin(angl), lc2} ;
Point(23) = {r_far*cos(angl), 0, r_far*sin(angl), lc2} ;
Point(24) = {r_far*cos(angl)*cos(phi1), r_far*cos(angl)*sin(phi1),
             r_far*sin(angl), lc2} ;
Point(25) = {r_inf, 0, r_inf, lc2} ;
Point(26) = {r_inf*cos(phi1), r_inf*sin(phi1), r_inf, lc2} ;

Circle(1) = {2,1,19}; Circle(2) = {19,1,6}; Circle(3) = {3,1,21};
Circle(4) = {21,1,7}; Circle(5) = {4,1,23}; Circle(6) = {23,1,8};
Line(7) = {5,25}; Line(8) = {25,9};
Circle(9) = {10,1,20}; Circle(10) = {20,1,6}; Circle(11) = {11,1,22};
Circle(12) = {22,1,7}; Circle(13) = {12,1,24}; Circle(14) = {24,1,8};
Line(15) = {13,26}; Line(16) = {26,9};
Circle(17) = {19,1,20}; Circle(18) = {21,1,22}; Circle(19) = {23,1,24};
Circle(20) = {25,1,26}; Circle(21) = {2,1,10}; Circle(22) = {3,1,11};
Circle(23) = {4,1,12}; Circle(24) = {5,1,13};

Line(25) = {1,14}; Line(26) = {14,2}; Line(27) = {2,3};
Line(28) = {3,4}; Line(29) = {4,5}; Line(30) = {1,15};
Line(31) = {15,10}; Line(32) = {10,11}; Line(33) = {11,12};
Line(34) = {12,13}; Line(35) = {14,15}; Line(36) = {14,16};
Line(37) = {15,17}; Line(38) = {16,17}; Line(39) = {18,16};
Line(40) = {18,17}; Line(41) = {1,18}; Line(42) = {18,6};
Line(43) = {6,7}; Line(44) = {16,19}; Line(45) = {19,21};
Line(46) = {21,23}; Line(47) = {23,25}; Line(48) = {17,20};
Line(49) = {20,22}; Line(50) = {22,24}; Line(51) = {24,26};
Line(52) = {7,8}; Line(53) = {8,9};

Line Loop(54) = {39,-36,-25,41}; Ruled Surface(55) = {54};
Line Loop(56) = {44,-1,-26,36}; Ruled Surface(57) = {56};
Line Loop(58) = {3,-45,-1,27}; Ruled Surface(59) = {58};

```

```

Line Loop(60) = {5,-46,-3,28};      Ruled Surface(61) = {60};
Line Loop(62) = {7,-47,-5,29};      Ruled Surface(63) = {62};
Line Loop(64) = {-2,-44,-39,42};     Ruled Surface(65) = {64};
Line Loop(66) = {-4,-45,2,43};       Ruled Surface(67) = {66};
Line Loop(68) = {-6,-46,4,52};       Ruled Surface(69) = {68};
Line Loop(70) = {-8,-47,6,53};       Ruled Surface(71) = {70};
Line Loop(72) = {-40,-41,30,37};     Ruled Surface(73) = {72};
Line Loop(74) = {48,-9,-31,37};      Ruled Surface(75) = {74};
Line Loop(76) = {49,-11,-32,9};      Ruled Surface(77) = {76};
Line Loop(78) = {-50,-11,33,13};     Ruled Surface(79) = {78};
Line Loop(80) = {-51,-13,34,15};     Ruled Surface(81) = {80};
Line Loop(82) = {10,-42,40,48};       Ruled Surface(83) = {82};
Line Loop(84) = {12,-43,-10,49};     Ruled Surface(85) = {84};
Line Loop(86) = {14,-52,-12,50};     Ruled Surface(87) = {86};
Line Loop(88) = {16,-53,-14,51};     Ruled Surface(89) = {88};
Line Loop(90) = {-30,25,35};         Ruled Surface(91) = {90};
Line Loop(92) = {-40,39,38};         Ruled Surface(93) = {92};
Line Loop(94) = {37,-38,-36,35};     Ruled Surface(95) = {94};
Line Loop(96) = {-48,-38,44,17};     Ruled Surface(97) = {96};
Line Loop(98) = {18,-49,-17,45};     Ruled Surface(99) = {98};
Line Loop(100) = {19,-50,-18,46};    Ruled Surface(101) = {100};
Line Loop(102) = {20,-51,-19,47};    Ruled Surface(103) = {102};
Line Loop(104) = {-2,17,10};         Ruled Surface(105) = {104};
Line Loop(106) = {-9,-21,1,17};      Ruled Surface(107) = {106};
Line Loop(108) = {-4,18,12};         Ruled Surface(109) = {108};
Line Loop(110) = {-11,-22,3,18};     Ruled Surface(111) = {110};
Line Loop(112) = {-13,-23,5,19};     Ruled Surface(113) = {112};
Line Loop(114) = {-6,19,14};         Ruled Surface(115) = {114};
Line Loop(116) = {-15,-24,7,20};     Ruled Surface(117) = {116};
Line Loop(118) = {-8,20,16};         Ruled Surface(119) = {118};
Line Loop(120) = {-31,-35,26,21};    Ruled Surface(121) = {120};
Line Loop(122) = {32,-22,-27,21};    Ruled Surface(123) = {122};
Line Loop(124) = {33,-23,-28,22};    Ruled Surface(125) = {124};
Line Loop(126) = {34,-24,-29,23};    Ruled Surface(127) = {126};

Surface Loop(128) = {93,-73,-55,95,-91};
Volume(129) = {128}; // int
Surface Loop(130) = {107,-75,-97,95,57,121};
Volume(131) = {130}; // int b
Surface Loop(132) = {105,-65,-97,-83,-93};
Volume(133) = {132}; // int h
Surface Loop(134) = {99,-111,77,123,59,107};
Volume(135) = {134}; // shell b
Surface Loop(136) = {99,-109,67,105,85};
Volume(137) = {136}; // shell h
Surface Loop(138) = {113,79,-101,-111,-125,-61};
Volume(139) = {138}; // ext b

```

```

Surface Loop(140) = {115,-69,-101,-87,-109};
Volume(141) = {140}; // ext h
Surface Loop(142) = {103,-117,-81,113,127,63};
Volume(143) = {142}; // inf b
Surface Loop(144) = {89,-119,71,103,115};
Volume(145) = {144}; // inf h

// Once the geometry is defined, we then add transfinite mesh commands
// in order to explicitly define a structured mesh.

// 1. Transfinite line commands specify the number of points on the
// curves and their distribution ('Progression 2' means that each line
// element in the series will be twice as long as the preceding one):

Transfinite Line{35,21,22,23,24,38,17,18,19,20} = nbpt_phi ;
Transfinite Line{31,26,48,44,42} = nbpt_int Using Progression 0.88;
Transfinite Line{41,37,36,9,11,1,3,13,5,15,7} = nbpt_arc1 ;
Transfinite Line{30,25,40,39,10,2,12,4,14,6,16,8} = nbpt_arc2 ;
Transfinite Line{32,27,49,45,43} = nbpt_shell ;
Transfinite Line{33,28,46,50,52} = nbpt_far Using Progression 1.2 ;
Transfinite Line{34,29,51,47,53} = nbpt_inf Using Progression 1.05;

// 2. Transfinite surfaces are defined by an ordered list of the
// points on their boundary (the ordering of these points defines the
// ordering of the mesh elements). Note that a transfinite surface can
// only have 3 or 4 sides:

Transfinite Surface{55} = {1,14,16,18};
Transfinite Surface{57} = {14,2,19,16};
Transfinite Surface{59} = {2,3,21,19};
Transfinite Surface{61} = {3,4,23,21};
Transfinite Surface{63} = {4,5,25,23};
Transfinite Surface{73} = {1,15,17,18};
Transfinite Surface{75} = {15,10,20,17};
Transfinite Surface{77} = {10,11,22,20};
Transfinite Surface{79} = {11,12,24,22};
Transfinite Surface{81} = {12,13,26,24};
Transfinite Surface{65} = {18,16,19,6};
Transfinite Surface{67} = {6,19,21,7};
Transfinite Surface{69} = {7,21,23,8};
Transfinite Surface{71} = {8,23,25,9};
Transfinite Surface{83} = {17,18,6,20};
Transfinite Surface{85} = {20,6,7,22};
Transfinite Surface{87} = {22,7,8,24};
Transfinite Surface{89} = {24,8,9,26};
Transfinite Surface{91} = {1,14,15};
Transfinite Surface{95} = {15,14,16,17};

```

```

Transfinite Surface{93} = {18,16,17};
Transfinite Surface{121} = {15,14,2,10};
Transfinite Surface{97} = {17,16,19,20};
Transfinite Surface{123} = {10,2,3,11};
Transfinite Surface{99} = {20,19,21,22};
Transfinite Surface{107} = {10,2,19,20};
Transfinite Surface{105} = {6,20,19};
Transfinite Surface{109} = {7,22,21};
Transfinite Surface{111} = {11,3,21,22};
Transfinite Surface{101} = {22,21,23,24};
Transfinite Surface{125} = {11,3,4,12};
Transfinite Surface{115} = {8,24,23};
Transfinite Surface{113} = {24,12,4,23};
Transfinite Surface{127} = {12,13,5,4};
Transfinite Surface{103} = {24,23,25,26};
Transfinite Surface{119} = {9,26,25};
Transfinite Surface{117} = {13,5,25,26};

// 3. Transfinite volumes are also defined by an ordered list of the
// points on their boundary (the ordering defines the ordering of the
// mesh elements). A transfinite volume can only have 6 or 8 faces:

Transfinite Volume{129} = {1,14,15,18,16,17};
Transfinite Volume{131} = {17,16,14,15,20,19,2,10};
Transfinite Volume{133} = {18,17,16,6,20,19};
Transfinite Volume{135} = {10,2,19,20,11,3,21,22};
Transfinite Volume{137} = {6,20,19,7,22,21};
Transfinite Volume{139} = {11,3,4,12,22,21,23,24};
Transfinite Volume{141} = {7,22,21,8,24,23};
Transfinite Volume{143} = {12,4,5,13,24,23,25,26};
Transfinite Volume{145} = {8,24,23,9,26,25};

// As with Extruded meshes, the 'Recombine' command tells Gmsh to
// recombine the simplices into quadrangles, prisms or hexahedra when
// possible:

Recombine Surface {55:127};

// We finish by defining some physical entities:

VolInt          = 1000 ;
SurfIntPhi0     = 1001 ; SurfIntPhi1      = 1002 ;
SurfIntZ0       = 1003 ;

VolShell        = 2000 ;
SurfShellInt    = 2001 ; SurfShellExt      = 2002 ;
SurfShellPhi0   = 2003 ; SurfShellPhi1     = 2004 ;

```

```

SurfShellZ0      = 2005 ;
LineShellIntPhi0 = 2006 ;
LineShellIntPhi1 = 2007 ;   LineShellIntZ0    = 2008 ;
PointShellInt    = 2009 ;

VolExt           = 3000 ;
VolInf           = 3001 ;
SurfInf          = 3002 ;
SurfExtInfPhi0   = 3003 ;   SurfExtInfPhi1    = 3004 ;
SurfExtInfZ0     = 3005 ;
SurfInfRight     = 3006 ;
SurfInfTop       = 3007 ;

Physical Volume  (VolInt)           = {129,131,133} ;
Physical Surface (SurfIntPhi0)      = {55,57,65} ;
Physical Surface (SurfIntPhi1)      = {73,75,83} ;
Physical Surface (SurfIntZ0)        = {91,121} ;

Physical Volume  (VolShell)         = {135,137} ;
Physical Surface (SurfShellInt)      = {105,107} ;
Physical Surface (SurfShellExt)      = {109,111} ;
Physical Surface (SurfShellPhi0)     = {59,67} ;
Physical Surface (SurfShellPhi1)     = {77,85} ;
Physical Surface (SurfShellZ0)       = {123} ;
Physical Line    (LineShellIntPhi0)  = {1,2} ;
Physical Line    (LineShellIntPhi1)  = {9,10} ;
Physical Line    (LineShellIntZ0)    = 21 ;
Physical Point   (PointShellInt)     = 6 ;

Physical Volume  (VolExt)           = {139,141} ;
Physical Volume  (VolInf)           = {143,145} ;
Physical Surface (SurfExtInfPhi0)    = {61,63,69,71} ;
Physical Surface (SurfExtInfPhi1)    = {79,87,81,89} ;
Physical Surface (SurfExtInfZ0)      = {125,127} ;
Physical Surface (SurfInfRight)      = {117} ;
Physical Surface (SurfInfTop)        = {119} ;

```

## 7.7 't7.geo'

```

/*****
*
*   Gmsh tutorial 7
*
*   Anisotropic meshes, attractors
*
*****/

```

```

// The anisotropic 2D mesh generator can be selected with:

Mesh.Algorithm = 2 ;

// One can force a 4 step Laplacian smoothing of the mesh with:

Mesh.Smoothing = 4 ;

lc = .1;

Point(1) = {0.0,0.0,0,lc};
Point(2) = {1.2,-0.2,0,lc};
Point(3) = {1,1,0,lc};
Point(4) = {0,1,0,lc};

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

Line Loop(5) = {1,2,3,4};
Plane Surface(6) = {5};

Point(5) = {0.1,0.2,0,lc};
Point(11) = {0.4,0.7,-1,lc};
Point(12) = {0.5,0.5,0,lc};
Point(22) = {0.9,0.9,1,lc};

Line(5) = {11,22};

Spline(7) = {4,5,12,2};

// Isotropic and anisotropic attractors can be defined on points and
// lines:

Attractor Point{1} = {0.01, 0.01, 2};

Attractor Line{5} = {0.3, 0.01, 2};

Attractor Line{7} = {0.1, 0.02, 8};

```

## 7.8 '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].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].Type = 3;
View[v3].RangeType = 2;
View[v3].IntervalsType = 4 ;
View[v3].ShowScale = 0;
View[v3].Grid = 0;
View[v3].CustomMin = View[v2].CustomMin;
View[v3].CustomMax = View[v2].CustomMax;
View[v3].AutoPosition = 0;
View[v3].PositionX = View[v2].PositionX;
View[v3].PositionY = View[v2].PositionY;
View[v3].Width = View[v2].Width;
View[v3].Height = View[v2].Height;

// 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 {1:255}

    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*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) && (num2 < 10))
    // The 'Print' command saves the graphical window; the 'Sprintf'
    // function permits to create the file names on the fly:
    Print Sprintf("t8-0%g.gif", num2);
    Print Sprintf("t8-0%g.jpg", num2);
  EndIf

  If ((num == 3) && (num2 >= 10))
    Print Sprintf("t8-%g.gif", num2);
    Print Sprintf("t8-%g.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"
  // System "mencoder 'mf://*.jpg' -mf fps=5 -o t8.mpg -ovc lavc -lavcopts vcodec=mpeg4:video"

  // 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

```

## 7.9 ‘t9.geo’

```

/*****
 *
 *   Gmsh tutorial 9
 *
 *   Post-processing, plugins
 *
 *****/

// 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 ;

// We finish by setting some view options and redrawing the scene:

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

View[1].IntervalsType = 2;

```

```
View[2].IntervalsType = 2;  
Draw;
```

## 8 Running Gmsh

### 8.1 Interactive vs. non-interactive mode

There are several ways to actually run Gmsh on your computer<sup>1</sup>. The first working mode of Gmsh is the interactive graphical mode. To launch Gmsh in interactive mode, just click or double-click on the Gmsh icon (Windows and Mac), or type

```
> gmsh
```

at your shell prompt on the command line (Unix). 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 [Chapter 7 \[Tutorial\]](#), [page 87](#)), select the ‘File->Open’ menu, and choose ‘t1.geo’ in the input field. To perform the mesh generation, go to the mesh module (by selecting ‘Mesh’ in the module menu) and choose the required 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, choose ‘Save’ in the context-dependent buttons, or select the appropriate format with the ‘File->Save as’ menu. The default mesh file name is based on the name of the first input file on the command line (or ‘untitled’ if there wasn’t any input file given), with an appended extension depending on the mesh format.

Note that nearly all the interactive commands have shortcuts: see [Section 8.4 \[Keyboard shortcuts\]](#), [page 115](#), or select ‘Help->Shortcuts’ in the menu bar to learn about these.

Instead of opening the tutorial with the ‘File->Open’ menu, it is often more convenient to put the file name on the command line, for example with:

```
> gmsh t1.geo
```

Note that, even if it is often handy to define the variables and the points directly in the ASCII input files (you can use any text editor for this purpose, e.g. Wordpad on Windows, or Emacs on Unix), it is almost always simpler to define the lines, the surfaces and the volumes interactively. To do so, just follow the context dependent buttons in the Geometry module. For example, to create a spline, select ‘Geometry’ in the module menu, and then select ‘Elementary, Add, New, Spline’. You will then be asked (in the status bar of the graphic window) 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 string is automatically added at the end of the currently opened project file.

Gmsh’s second operating mode is the non-interactive mode. In this mode, there is no graphical user interface, and all operations are performed without any user interaction<sup>2</sup>. To mesh the first tutorial in non-interactive mode, just type:

<sup>1</sup> Note that these operation modes can slightly vary depending on your operating system and/or command shell.

<sup>2</sup> If you compile Gmsh without the graphical user interface, i.e. with `./configure --disable-gui`, this is the only mode you have access to.

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

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

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

You should read the notes in the file ‘bgmesh.pos’ if you intend to use background meshes. Several files can be loaded simultaneously in Gmsh. The first one defines the project, while the others are appended (‘merged’) to this project. You can merge such files with the ‘File->Merge’ menu, or by directly specifying the names of the files on the command line. This is most useful for post-processing purposes. For example, to merge the post-processing views contained in the files ‘view1.pos’ and ‘view2.pos’ together with the first tutorial ‘t1.geo’, you can type the following command:

```
> gmsh t1.geo view1.pos view2.pos
```

In the Post-Processing module (select ‘Post-Processing’ in the module menu), two view buttons will appear, respectively labeled ‘a scalar map’ and ‘a vector map’. A mouse click on the 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. If you want the modifications made to one view to affect also all the other views, select the ‘Apply next changes to all views’ or ‘Force same options for all views’ option in the ‘Tools->Options->Post-processing’ menu.

Note that all the options specified interactively can also be directly specified in the ASCII input files. All available options, with their current values, can be saved into a file by selecting ‘File->Save as->Gmsh options’, or simply viewed by pressing the ‘?’ button in the status bar. To save the current options as your default preferences for all future Gmsh sessions, use the ‘Tools->Options->Save’ button.

## 8.2 Command-line options

Geometry options:

```
-0          parse input files, output unrolled geometry, and exit
```

Mesh options:

```
-1, -2, -3      perform batch 1D, 2D and 3D mesh generation
-saveall        save all elements (discard physical group definitions)
-o file         specify mesh output file name
-format msh|unv|gref
                 set output mesh format (default: msh)
-algo iso|tri|aniso
                 select 2D mesh algorithm (default: iso)
-smooth int     set mesh smoothing (default: 0)
```

**-order int**  
set the order of the generated elements (default: 1)

**-scale float**  
set global scaling factor (default: 1.0)

**-meshscale float**  
set mesh scaling factor (default: 1.0)

**-clscale float**  
set characteristic length scaling factor (default: 1.0)

**-rand float**  
set random perturbation factor (default: 1.e-4)

**-bgm file** load background mesh from file

**-constrain**  
constrain background mesh with characteristic lengths

**-histogram**  
print mesh quality histogram

**-extrude** use old extrusion mesh generator

**-recombine**  
recombine meshes from old extrusion mesh generator

**-interactive**  
display 2D mesh construction interactively

Post-processing options:

**-dl** enable display lists

**-noview** hide all views on startup

**-link int** select link mode between views (default: 0)

**-smoothview**  
smooth views

**-combine** combine input views into multi time step ones

**-convert file file**  
convert all views in a file into binary views

Display options:

**-nodb** disable double buffering

**-fontsize int**  
specify the font size for the GUI (default: 12)

**-scheme string**  
specify FLTK scheme

-alpha      enable alpha blending  
 -notrack    don't use trackball mode for rotations  
 -display string  
              specify display  
 -perspective  
              set projection mode to perspective

Other options:

-a, -g, -m, -s, -p  
              start in automatic, geometry, mesh, solver or post-processing mode (default:  
              automatic)  
 -v int      set verbosity level (default: 2)  
 -string "string"  
              parse string before project file  
 -option file  
              parse option file before GUI creation  
 -version    show version number  
 -info       show detailed version information  
 -help       show this message

## 8.3 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 elementary geometrical entity currently under the mouse pointer and display its properties in the status bar
- size a rubber zoom started with *Ctrl+Left button*

*Left button:*

- rotate
- accept a rubber zoom started with *Ctrl+Left button*

*Ctrl+Left button:* start (anisotropic) rubber zoom

*Middle button:*

- zoom (isotropic)
- cancel a rubber zoom

*Ctrl+Middle button:* orthogonalize display

*Right button:*

- pan

- cancel a rubber zoom
- pop up menu on post-processing view button

*Ctrl+Right button*: reset to default viewpoint

## 8.4 Keyboard shortcuts

Menu bar shortcuts:

|                     |   |
|---------------------|---|
| <                   | go back to previous context               |
| >                   | go forward to next context                |
| <i>Shift+a</i>      | raise (show) all open windows             |
| <i>g</i>            | go to geometry module                     |
| <i>Shift+g</i>      | show geometry options                     |
| <i>Shift+i</i>      | show statistics window                    |
| <i>m</i>            | go to mesh module                         |
| <i>Shift+m</i>      | show mesh options                         |
| <i>Ctrl+m</i>       | merge file                                |
| <i>Shift+n</i>      | show general options                      |
| <i>Ctrl+n</i>       | new file                                  |
| <i>Shift+o</i>      | show option window                        |
| <i>Ctrl+o</i>       | open file                                 |
| <i>p</i>            | go to post-processor module               |
| <i>Shift+p</i>      | show general post-processing options      |
| <i>Ctrl+q</i>       | quit                                      |
| <i>Ctrl+s</i>       | save mesh in default format               |
| <i>Ctrl+Shift+s</i> | save file as                              |
| <i>Shift+w</i>      | show current post-processing view options |

Other shortcuts:

|            |                            |
|------------|----------------------------|
| <i>0</i>   |                            |
| <i>Esc</i> | reload geometry input file |
| <i>1</i>   |                            |
| <i>F1</i>  | mesh curves                |
| <i>2</i>   |                            |

|                     |   |
|---------------------|---|
| <i>F2</i>           | mesh surfaces   |
| <i>3</i>            |   |
| <i>F3</i>           | mesh volumes  |
| <i>Alt+a</i>        | hide/show small axes                                      |
| <i>Alt+Shift+a</i>  | hide/show big moving axes                                 |
| <i>Alt+b</i>        | hide/show all post-processing scales                      |
| <i>Alt+c</i>        | loop through predefined color schemes                     |
| <i>Alt+d</i>        | change mesh display mode (solid/wireframe)                |
| <i>Shift+d</i>      | decrease animation delay                                  |
| <i>Ctrl+Shift+d</i> | increase animation delay                                  |
| <i>Alt+f</i>        | change redraw mode (fast/full)                            |
| <i>Alt+h</i>        | hide/show all post-processing views                       |
| <i>Alt+l</i>        | hide/show geometry lines                                  |
| <i>Alt+Shift+l</i>  | hide/show mesh lines                                      |
| <i>Alt+m</i>        | change visibility of all mesh entities                    |
| <i>Alt+o</i>        | change projection mode (ortho/perspective)                |
| <i>Alt+p</i>        | hide/show geometry points                                 |
| <i>Alt+Shift+p</i>  | hide/show mesh points                                     |
| <i>Alt+s</i>        | hide/show geometry surfaces                               |
| <i>Alt+Shift+s</i>  | hide/show mesh surfaces                                   |
| <i>Alt+t</i>        | loop through interval modes for all post-processing views |
| <i>Alt+v</i>        | hide/show geometry volumes                                |
| <i>Alt+Shift+v</i>  | hide/show mesh 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>Left arrow</i>   | go to previous time step                                  |

*Right arrow*

go to next time step

*Up arrow*    make previous view visible

*Down arrow*

make next view visible



## 9 File formats

This chapter describes the file formats that cannot be modified by the user. These formats have a version number (currently 1.2), independent of the Gmsh version number (currently 1.51).

All non-parsed file formats have sections enclosed between \$KEY and \$ENDKEY tags.

### 9.1 Gmsh mesh file format

#### 9.1.1 Version 1.0

The ‘.msh’ file format, version 1.0, is Gmsh’s old native mesh file format, now superseded by the format described in [Section 9.1.2 \[Version 2.0\], page 120](#).

In the ‘.msh’ file format, version 1.0, the file is divided in two sections, defining the nodes (\$NOD-\$ENDNOD) and the elements (\$ELM-\$ENDELM) in the mesh:

```
$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. Note that the *node-numbers* do not have to be given in a consecutive (or even an ordered) way.

*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. Note that the *elm-numbers* do not have to be given in a consecutive (or even an ordered) way.

*elm-type*

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

1            Line (2 nodes, 1 edge).

|    |  |
|----|--|
| 2  | Triangle (3 nodes, 3 edges).             |
| 3  | Quadrangle (4 nodes, 4 edges).           |
| 4  | Tetrahedron (4 nodes, 6 edges, 4 faces). |
| 5  | Hexahedron (8 nodes, 12 edges, 6 faces). |
| 6  | Prism (6 nodes, 9 edges, 5 faces).       |
| 7  | Pyramid (5 nodes, 8 edges, 5 faces).     |
| 15 | Point (1 node).                          |

*reg-phys* is the number of the physical entity to which the element belongs.

*reg-elem* is the number of the elementary entity to which the element belongs.

*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 (separated by white space, without commas).

### 9.1.2 Version 2.0

Version 2.0 of the ‘.msh’ file format is Gmsh’s new native mesh file format. It is very similar to the old one (see [Section 9.1.1 \[Version 1.0\], page 119](#)), but is more general: it contains information about itself and allows to associate an arbitrary number of integer tags with each element.

The ‘.msh’ file format, version 2.0, is divided in three sections, defining the file format (\$MeshFormat-\$EndMeshFormat), the nodes (\$Nodes-\$EndNodes) and the elements (\$Elements-\$EndElements) in the mesh:

```

$MeshFormat
2.0 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

```

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)).

*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. Note that the *node-numbers* do not have to be given in a consecutive (or even an ordered) way.

*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. Note that the *elm-numbers* do not have to be given in a consecutive (or even an ordered) way.

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

- |    |  |
|----|--|
| 1  | Line (2 nodes, 1 edge).                  |
| 2  | Triangle (3 nodes, 3 edges).             |
| 3  | Quadrangle (4 nodes, 4 edges).           |
| 4  | Tetrahedron (4 nodes, 6 edges, 4 faces). |
| 5  | Hexahedron (8 nodes, 12 edges, 6 faces). |
| 6  | Prism (6 nodes, 9 edges, 5 faces).       |
| 7  | Pyramid (5 nodes, 8 edges, 5 faces).     |
| 15 | Point (1 node).                          |

*number-of-tags*  
gives the number of tags for the *n*-th element. By default, Gmsh generates meshes with two tags and reads files with an arbitrary number of tags: see below.

*tag*  
is an integer tag associated with 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.

*node-number-list*  
is the list of the node numbers of the *n*-th element (separated by white space, without commas).

## 9.2 Gmsh ASCII post-processing file format

The ASCII post-processing file is divided in several sections: one format section, enclosed between `$PostFormat-$EndPostFormat` tags, and one or more post-processing views, enclosed between `$View-$EndView` tags:

```

$PostFormat
1.2 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-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 > ...
< 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
...
```

*text2d* is a list of 4 double precision numbers:

```
coord1 coord2 style index
```

where *coord1* and *coord2* give the coordinates of the leftmost element of the 2D string in screen coordinates, *index* gives the starting index of the string in *text2d-chars* and *style* is currently unused.

*text2d-chars*

is a list of *nb-text2d-chars* characters. Substrings are separated with the '^' character (which is a forbidden character in regular strings).

*text3d*

is a list of 5 double precision numbers

*coord1 coord2 coord3 style index*

where *coord1*, *coord2* and *coord3* give the coordinates of the leftmost element of the 3D string in model (real world) coordinates, *index* gives the starting index of the string in *text3d-chars* and *style* is currently unused.

*text3d-chars*

is a list of *nb-text3d-chars* chars. Substrings are separated with the '^' character.

### 9.3 Gmsh binary post-processing file format

The binary post-processing file format is the same as the ASCII file format described in [Section 9.2 \[Gmsh ASCII post-processing file format\]](#), [page 122](#), 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 the beginning of a post-processing file in binary format:

```
int one = 1;

fprintf(file, "$PostFormat\n");
fprintf(file, "%g %d %d\n", 1.2, 1, sizeof(double));
fprintf(file, "$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\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-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.

## 9.4 Gmsh parsed post-processing file format

For relatively small data sets Gmsh provides an additional post-processing format, which is read by Gmsh's script parser. You can thus, for example, embed small post-processing views directly into your geometrical descriptions (see e.g. [Section 7.4 \[t4.geo\], page 93](#)). This format is also useful for testing purposes: its syntax is very permissive, and you can easily generate it by hand or on the fly. The format of the parsed post-processing file is the following:

```

View "string" {
    type ( list-of-coords ) { list-of-values };
    ...
};

```

The 26 objects that can be displayed are the same as in the ASCII or binary post-processing file formats:

|                    | <i>type</i> | <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> |
| text 2d            | T2          | 4                      | arbitrary                 |
| text 3d            | T3          | 5                      | arbitrary                 |

For historical reasons, contrary to the ASCII and binary post-processing file formats, the coordinates are given ‘by node’, i.e.:

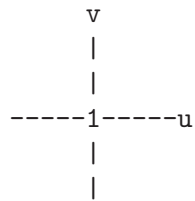
- (coord1, coord2, coord3) for a point,
- (coord1-node1, coord2-node1, coord3-node1,  
coord1-node2, coord2-node2, coord3-node2) for a line,
- (coord1-node1, coord2-node1, coord3-node1,  
coord1-node2, coord2-node2, coord3-node2,  
coord1-node3, coord2-node3, coord3-node3) for a triangle,
- etc.

The values are given in the same order as for the ASCII and binary post-processing file formats.

## 9.5 Gmsh node ordering

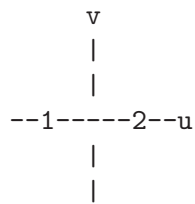
For all mesh and post-processing file formats, the reference elements are defined as follows.

Point:



Line:

edge 1: nodes 1 -> 2



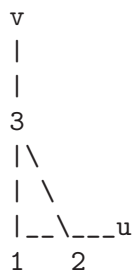
Triangle:

edge 1: nodes 1 -> 2

2: 1 -> 3

3: 2 -> 3

face 1: edges 1 -2 3 nodes 1 2 3



Quadrangle:

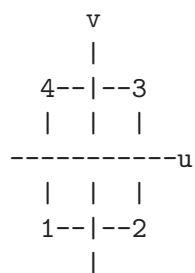
edge 1: nodes 1 -> 2

2: 1 -> 4

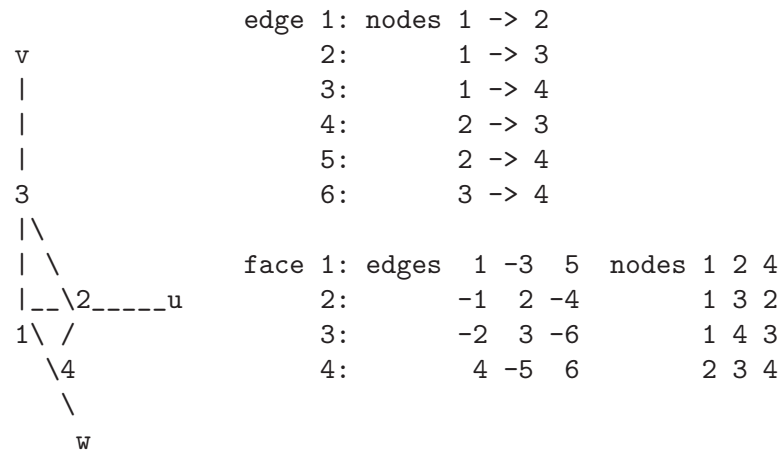
3: 2 -> 3

4: 3 -> 4

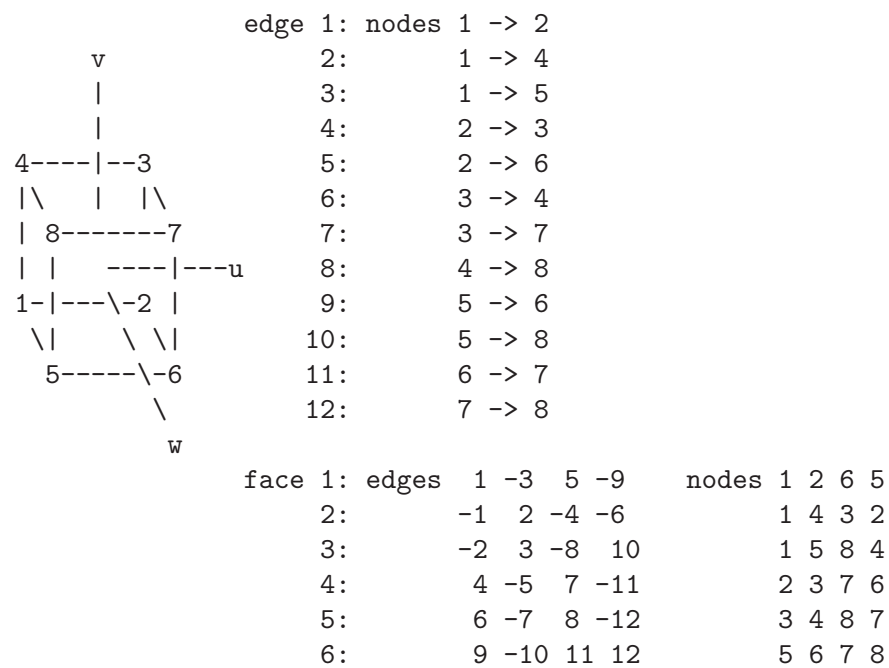
face 1: edges 1 -2 3 4 nodes 1 2 3 4



Tetrahedron:



Hexahedron:



Prism:

```

      v
    3 |
    | \
    | |
    1_|2
      \| 6
      |_- \_--u
      \|  \
      4  _5
      \
      \
      w

edge 1: nodes 1 -> 2
      2:      1 -> 3
      3:      1 -> 4
      4:      2 -> 3
      5:      2 -> 5
      6:      3 -> 6
      7:      4 -> 5
      8:      4 -> 6
      9:      5 -> 6

face 1: edges 1 -3 5 -7      nodes 1 2 5 4
      2:      -1 2 -4      1 3 2
      3:      -2 3 -6 8      1 4 6 3
      4:      4 -5 6 -9      2 3 6 5
      5:      7 -8 9      4 5 6

```

Pyramid:

```

      v
      |
      |
    4---|---3
    | \ | / |
    | \ - / -|---u
    | / 5 \ |
    1/-----\2
      \
      \
      w

edge 1: nodes 1 -> 2
      2:      1 -> 4
      3:      1 -> 5
      4:      2 -> 3
      5:      2 -> 5
      6:      3 -> 4
      7:      3 -> 5
      8:      4 -> 5

face 1: edges 1 5 -3      nodes 1 2 5
      2:      2 -6 -4 -1      1 4 3 2
      3:      3 -8 -2      1 5 4
      4:      4 7 -5      2 3 5
      5:      6 8 -7      3 4 5

```



## 10 Programming notes

Gmsh was originally written in C, and later enhanced with various C++ additions. The resulting code is a hybrid C/C++ beast, hopefully not too badly structured... The scripting language is parsed using Lex and Yacc (actually, Flex and Bison), while the GUI relies on OpenGL for the 3D graphics and FLTK for the widget set. See <http://www.opengl.org>, <http://www.mesa3d.org> and <http://www.fltk.org> for more information.

Gmsh's build system is based on autoconf, and should work on most modern platforms providing standard compliant C and C++ compilers. Practical notes on how to compile Gmsh's source code are included in the distribution. Note that compiling the Windows version requires the Cygwin tools (freely available from <http://www.cygwin.com>). See the 'FAQ' for more information.

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()` function to print information, errors, ...;
3. indent your files using 'utils/misc/indent.sh';
4. if working on Windows, don't leave tabs in your files (e.g. untabify them with 'utils/misc/untabify.sh').

(More to come...)



# 11 Bugs, versions and credits

## 11.1 Bugs

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:gmsh@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 8.2 \[Command-line options\]](#), page 112 to see how to get this information).

See the 'FAQ' and 'TODO' files in the distribution to check the problems we already know about.

## 11.2 Versions

\$Id: VERSIONS,v 1.190 2004/03/07 23:51:30 geuzaine Exp \$

New since 1.51: new raster ("bitmap") PostScript/EPS/PDF output formats; new Plugin(Extract) to extract a given component from a post-processing view; various bug fixes;

New in 1.51: 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.);

New in 1.50: 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;

New in 1.49: 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;

New in 1.48: 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.);

New in 1.47: 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;

New in 1.46: 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;

New in 1.45: 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;

New in 1.44: new reference manual; added support for PNG output; fixed small configure script bugs;

New in 1.43: 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));

New in 1.42: 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;

New in 1.41: Gmsh is now licensed under the GNU General Public License; general code cleanup (indent);

New in 1.40: various small bug fixes (mainly GSL-related);

New in 1.39: removed all non-free routines; more build system work; implemented Von-Mises tensor display for all element types; fixed small GUI bugs;

New in 1.38: 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;

New in 1.37: generalized smoothing and cuts of post-processing views; better Windows integration (solvers, external editors, etc.); small bug fixes;

New in 1.36: 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.);

New in 1.35: 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, ...);

New in 1.34: 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;

New in 1.33: new parameterizable solver interface (allowing up to 5 user-defined solvers); enhanced 2D aniso algorithm; 3D initial mesh speedup;

New in 1.32: 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, ...);

New in 1.31: 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;

New in 1.30: interface polish; fix crash when extruding quadrangles;

New in 1.29: translations and rotations can now be combined in extrusions; fixed coherence bug in Extrude Line; various small

bug fixes and additions;

New in 1.28: 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;

New in 1.27: 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;

New in 1.26: 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);

New in 1.25: 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;

New in 1.24: 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;

New in 1.23: 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);

New in 1.22: 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;

New in 1.21: 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;

New in 1.20: 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;

New in 1.19: 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;

New in 1.18: fixed many small bugs and incoherences in post-processing; fixed broken background mesh in 1D mesh generation.

New in 1.17: 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;

New in 1.16: 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;

New in 1.15: added automatic visibility setting during entity selection; corrected geometrical extrusion bug;

New in 1.14: 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;

New in 1.13: added support for JPEG output on Windows;

New in 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;

New in 1.11: corrected included file loading problem.

New in 1.10: switched from Motif to FLTK for the GUI. Many small tweaks.

New in 1.00: 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.

New in 0.999: 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;

New in 0.998: corrected bug introduced in 0.997 in the generation of the initial 3D mesh;

New in 0.997: 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;

New in 0.996: arrays of variables; enhanced Printf and Sprintf; Simplified options (suppression of option arrays).

New in 0.995: 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 cleanings...

New in 0.992: corrected recombined extrusion; corrected ellipses; added simple automatic animation of post-processing maps; fixed various bugs.

New in 0.991: fixed a serious allocation bug in 2D algorithm, which caused random crashes. All users should upgrade to 0.991.

New in 0.990: bug fix in non-recombined 3D transfinite meshes.

New in 0.989: added ability to reload previously saved meshes; some new command line options; reorganization of the scale menu; GIF output.

New in 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.

New in 0.986: fixed overlay problems; SGI version should now also run on 32 bits machines; fixed small 3d mesh bug.

New in 0.985: corrected colormap bug on HP, SUN, SGI and IBM versions; corrected small initialization bug in postscript output.

New in 0.984: corrected bug in display lists; added some options in Opt->General.

New in 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).

New in 0.982: lighting for mesh and post-processing; corrected 2nd order mesh on non plane surfaces; added example 13.

## 11.3 Credits

\$Id: CREDITS,v 1.11 2004/02/28 00:48:57 geuzaine Exp \$

Gmsh is copyright (C) 1997-2004

Christophe Geuzaine  
<geuzaine at acm.caltech.edu>

and

Jean-Francois Remacle  
<remacle at gce.ucl.ac.be>

The AVL tree code (DataStr/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 (Common/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 also contain code (in the Triangle subdirectory) copyright (C) 1993, 1995, 1997, 1998, 2002, Jonathan Richard Shewchuk: check the configuration options.

Special thanks to David Colignon <David.Colignon at univ.u-3mrs.fr> for new colormaps; Patrick Dular <patrick.dular at ulg.ac.be> for transfinite mesh bug fixes; Laurent Stainier <l.stainier at ulg.ac.be> for the Mac OS port and the tensor display code; Nicolas Tardieu <nicolas.tardieu at edf.fr> for help with the GSL integration and the new STL to elementary geometry interface; Pierre Badel <badel at freesurf.fr> for help with the GSL integration; and Marc Ume <Marc.Ume at digitalgraphics.be> for the original list code.

Special thanks also to Bill Spitzak <spitzak at users.sourceforge.net>, Michael Sweet <easysw at users.sourceforge.net>, Matthias Melcher <mm at matthiasm.com> 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.

Finally, 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 <juanabanto at yahoo.com>, Olivier Adam <o.adam at ulg.ac.be>, Guillaume Alleon <guillaume.alleon at airbus.aeromatra.com>, Eric Bechet <eric.bechet at epost.de>, Laurent Champaney <laurent.champaney at meca.uvvsq.fr>, Pascal Dupuis <Pascal.Dupuis at esat.kuleuven.ac.be>, Philippe Geuzaine <geuzaine at gnat.colorado.edu>, Johan Gyselinck <johan.gyselinck at ulg.ac.be>, Francois Henrotte <fhenrott at esat.kuleuven.ac.be>, Benoit Meys <bmeys at techspace-aero.be>, Nicolas Moes <moes at tam9.mech.nwu.edu>, Osamu Nakamura <naka at hasaki.sumitomometals.co.jp> and Chad Schmutzer <schmutze at acm.caltech.edu>.



## Appendix A Tips and tricks

- Install the ‘info’ version of this user’s guide! 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 3.1.3 \[Surfaces\]](#), [page 37](#).

- 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 ‘Tools->Options->Save’. To reset 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 graphical user interface:
  - 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 the ‘FAQ’...



## Appendix B License

### 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

|                                 |               |
|---------------------------------|---------------|
| .                               |               |
| ‘.msh’ file .....               | 119           |
| ‘.pos’ file .....               | 122, 124, 125 |
| <b>2</b>                        |               |
| 2D plots .....                  | 77            |
| <b>3</b>                        |               |
| 3D plots .....                  | 77            |
| <b>A</b>                        |               |
| Acknowledgments .....           | 140           |
| Authors, e-mail .....           | 133           |
| <b>B</b>                        |               |
| Background mesh .....           | 46            |
| Binary operators .....          | 11            |
| Bindings, keyboard .....        | 115           |
| Bindings, mouse .....           | 114           |
| Bugs, reporting .....           | 133           |
| <b>C</b>                        |               |
| Changelog .....                 | 133           |
| Characteristic lengths .....    | 46            |
| Colors .....                    | 11            |
| Command-line options .....      | 112           |
| Commands, general .....         | 15            |
| Commands, geometry .....        | 35            |
| Commands, mesh .....            | 45            |
| Commands, post-processing ..... | 77            |
| Comments .....                  | 6             |
| Concepts, index .....           | 151           |
| Conditionals .....              | 14            |
| Constants .....                 | 9             |
| Contact information .....       | 133           |
| Contributors, list .....        | 140           |
| Copyright .....                 | 1             |
| Credits .....                   | 140           |
| <b>D</b>                        |               |
| Document syntax .....           | 6             |
| Download .....                  | 1             |

## E

|                                   |     |
|-----------------------------------|-----|
| E-mail, authors .....             | 133 |
| Edges, ordering .....             | 126 |
| Efficiency, tips .....            | 143 |
| Elementary lines .....            | 36  |
| Elementary points .....           | 35  |
| Elementary surfaces .....         | 37  |
| Elementary volumes .....          | 38  |
| Evaluation order .....            | 12  |
| Example, solver .....             | 69  |
| Examples .....                    | 87  |
| Expressions, affectation .....    | 15  |
| Expressions, character .....      | 10  |
| Expressions, color .....          | 11  |
| Expressions, definition .....     | 9   |
| Expressions, floating point ..... | 9   |
| Expressions, identifiers .....    | 15  |
| Expressions, lists .....          | 10  |
| Extrusion, geometry .....         | 38  |
| Extrusion, mesh .....             | 47  |

## F

|  |     |
|--|-----|
| Faces, ordering .....                      | 126 |
| File format, mesh .....                    | 119 |
| File format, post-processing, ASCII .....  | 122 |
| File format, post-processing, binary ..... | 124 |
| File format, post-processing, parsed ..... | 125 |
| File formats .....                         | 119 |
| File, comments .....                       | 6   |
| Floating point numbers .....               | 9   |
| Functions, built-in .....                  | 13  |
| Functions, user-defined .....              | 14  |

## G

|                                  |     |
|----------------------------------|-----|
| General commands .....           | 15  |
| Geometry commands .....          | 35  |
| Geometry, extrusion .....        | 38  |
| Geometry, module .....           | 35  |
| Geometry, options .....          | 40  |
| Geometry, transformations .....  | 39  |
| GNU General Public License ..... | 145 |
| Graphs .....                     | 77  |

## H

|                         |     |
|-------------------------|-----|
| History, versions ..... | 133 |
|-------------------------|-----|

**I**

|                        |     |
|------------------------|-----|
| Index, concepts .....  | 151 |
| Index, syntax .....    | 153 |
| Interactive mode ..... | 111 |
| Internet address ..... | 1   |
| Introduction .....     | 3   |

**K**

|                           |     |
|---------------------------|-----|
| Keyboard, shortcuts ..... | 115 |
| Keywords, index .....     | 153 |

**L**

|                         |        |
|-------------------------|--------|
| License .....           | 1, 145 |
| Lines, elementary ..... | 36     |
| Lines, physical .....   | 36     |
| Loops .....             | 14     |

**M**

|                               |        |
|-------------------------------|--------|
| Mailing list .....            | 1, 133 |
| Mesh commands .....           | 45     |
| Mesh, background .....        | 46     |
| Mesh, element size .....      | 46     |
| Mesh, extrusion .....         | 47     |
| Mesh, file format .....       | 119    |
| Mesh, module .....            | 45     |
| Mesh, options .....           | 48     |
| Mesh, transfinite .....       | 47     |
| Module, geometry .....        | 35     |
| Module, Mesh .....            | 45     |
| Module, Post-processing ..... | 77     |
| Module, Solver .....          | 57     |
| Mouse, actions .....          | 114    |

**N**

|                            |     |
|----------------------------|-----|
| Nodes, ordering .....      | 126 |
| Non-interactive mode ..... | 111 |
| Numbers, real .....        | 9   |

**O**

|                                |        |
|--------------------------------|--------|
| Operating system .....         | 111    |
| Operator precedence .....      | 12     |
| Operators, definition .....    | 11     |
| Options, command-line .....    | 112    |
| Options, geometry .....        | 40, 57 |
| Options, mesh .....            | 48     |
| Options, post-processing ..... | 78     |
| Order, evaluation .....        | 12     |
| Overview .....                 | 3      |

**W**

|                |   |
|----------------|---|
| Web site ..... | 1 |
|----------------|---|

**P**

|   |     |
|---|-----|
| Physical lines .....                      | 36  |
| Physical points .....                     | 35  |
| Physical surfaces .....                   | 37  |
| Physical volumes .....                    | 38  |
| Plots .....                               | 77  |
| Points, elementary .....                  | 35  |
| Points, physical .....                    | 35  |
| Post-processing commands .....            | 77  |
| Post-processing, ASCII file format .....  | 122 |
| Post-processing, binary file format ..... | 124 |
| Post-processing, module .....             | 77  |
| Post-processing, options .....            | 78  |
| Post-processing, parsed file format ..... | 125 |
| Precedence, operators .....               | 12  |
| Programming, notes .....                  | 131 |

**R**

|                        |     |
|------------------------|-----|
| Real numbers .....     | 9   |
| Reporting bugs .....   | 133 |
| Rotation .....         | 39  |
| Rules, syntactic ..... | 6   |
| Running Gmsh .....     | 111 |

**S**

|                            |     |
|----------------------------|-----|
| Scale .....                | 39  |
| Shortcuts, keyboard .....  | 115 |
| Size, elements .....       | 46  |
| Solver commands .....      | 57  |
| Solver example .....       | 69  |
| Solver, module .....       | 57  |
| Strings .....              | 10  |
| Surfaces, elementary ..... | 37  |
| Surfaces, physical .....   | 37  |
| Symmetry .....             | 39  |
| Syntax, index .....        | 153 |
| Syntax, rules .....        | 6   |

**T**

|                                 |     |
|---------------------------------|-----|
| Ternary operators .....         | 11  |
| Tips .....                      | 143 |
| Transfinite, mesh .....         | 47  |
| Transformations, geometry ..... | 39  |
| Translation .....               | 39  |
| Tricks .....                    | 143 |
| Tutorial .....                  | 87  |

**U**

|                       |    |
|-----------------------|----|
| Unary operators ..... | 11 |
|-----------------------|----|

**V**

|                           |     |
|---------------------------|-----|
| Versions .....            | 133 |
| Views .....               | 77  |
| Volumes, elementary ..... | 38  |
| Volumes, physical .....   | 38  |

## Syntax index

|                      |        |                        |     |
|----------------------|--------|------------------------|-----|
| !                    |        | -notrack .....         | 114 |
| !                    | 11     | -noview .....          | 113 |
| !=                   | 12     | -o file .....          | 112 |
|                      |        | -option file .....     | 114 |
| %                    |        | -order int .....       | 113 |
| %                    | 11     | -perspective .....     | 114 |
|                      |        | -rand float .....      | 113 |
|                      |        | -recombine .....       | 113 |
| &                    |        | -saveall .....         | 112 |
| &&                   | 12     | -scale float .....     | 113 |
|                      |        | -scheme string .....   | 113 |
| (                    |        | -smooth int .....      | 112 |
| ()                   | 12     | -smoothview .....      | 113 |
|                      |        | -string "string" ..... | 114 |
|                      |        | -v int .....           | 114 |
|                      |        | -version .....         | 114 |
| *                    |        | /                      |     |
| *                    | 11     | / .....                | 11  |
| *=                   | 15     | /*, */ .....           | 6   |
|                      |        | // .....               | 6   |
| +                    |        | /= .....               | 15  |
| +                    | 12     | :                      |     |
| ++                   | 11     | :                      | 12  |
| +=                   | 15     |                        |     |
| -                    |        | <                      |     |
| -                    | 11, 12 | < .....                | 12  |
| --                   | 11     | <= .....               | 12  |
| -=                   | 15     |                        |     |
| -0                   | 112    | =                      |     |
| -1, -2, -3           | 112    | = .....                | 15  |
| -a, -g, -m, -s, -p   | 114    | == .....               | 12  |
| -algo iso tri aniso  | 112    |                        |     |
| -alpha               | 114    | >                      |     |
| -bgm file            | 113    | > .....                | 12  |
| -clscale float       | 113    | >= .....               | 12  |
| -combine             | 113    |                        |     |
| -constrain           | 113    | ?                      |     |
| -convert file file   | 113    | ? .....                | 12  |
| -display string      | 114    | ^                      |     |
| -dl                  | 113    | ^ .....                | 11  |
| -extrude             | 113    |                        |     |
| -fontsize int        | 113    | .....                  | 12  |
| -format msh unv gref | 112    |                        |     |
| -help                | 114    |                        |     |
| -histogram           | 113    |                        |     |
| -info                | 114    |                        |     |
| -interactive         | 113    |                        |     |
| -link int            | 113    |                        |     |
| -meshscale float     | 113    |                        |     |
| -nodb                | 113    |                        |     |

## A

|  |    |
|--|----|
| <code>Acos ( expression )</code> .....   | 13 |
| <code>Asin ( expression )</code> .....   | 13 |
| <code>Atan ( expression )</code> .....   | 13 |
| <code>Atan2 ( expression, expression )</code> .....  | 13 |
| <code>Attractor Point   Line { expression-list } = {<br/>    expression, expression, expression };</code><br>..... | 46 |

## B

|  |    |
|--|----|
| <code>Bezier ( expression ) = { expression-list }; ....</code> | 36 |
| <code>BSpline ( expression ) = { expression-list }; ...</code> | 36 |
| <code>build-in-function</code> .....                           | 13 |

## C

|  |    |
|--|----|
| <code>Call string; .....</code>  | 14 |
| <code>CatmullRom ( expression ) = { expression-list };<br/>    .....</code>                                  | 36 |
| <code>Ceil ( expression )</code> .....   | 13 |
| <code>char-option = char-expression; .....</code>  | 16 |
| <code>Characteristic Length { expression-list } =<br/>    expression; .....</code>                           | 46 |
| <code>Circle ( expression ) = { expression, expression,<br/>    expression }; .....</code>                   | 36 |
| <code>Coherence; .....</code>  | 39 |
| <code>Color color-expression { Point   Line   Surface  <br/>    Volume { expression-list }; ... } ...</code> | 48 |
| <code>color-option = color-expression; .....</code>  | 16 |
| <code>Combine TimeSteps; .....</code>  | 77 |
| <code>Combine Views; .....</code>  | 77 |
| <code>Cos ( expression )</code> .....  | 13 |
| <code>Cosh ( expression )</code> .....   | 13 |

## D

|  |    |
|--|----|
| <code>Delete { Point   Line   Surface { expression-list<br/>    }; ... } .....</code>    | 39 |
| <code>Delete All; .....</code>   | 17 |
| <code>Delete View[expression]; .....</code>  | 78 |
| <code>Dilate { { expression-list }, expression } {<br/>    transform-list } .....</code> | 39 |
| <code>Draw; .....</code>   | 17 |
| <code>Duplicata View[expression]; .....</code>   | 78 |

## E

|   |    |
|---|----|
| <code>Ellipse ( expression ) = { expression, expression,<br/>    expression, expression }; .....</code> | 36 |
| <code>EndFor .....</code>   | 15 |
| <code>EndIf .....</code>  | 15 |
| <code>Exit; .....</code>  | 17 |
| <code>Exp ( expression )</code> .....   | 13 |
| <code>extrude .....</code>  | 38 |
| <code>Extrude Point   Line   Surface { expression, {<br/>    expression-list } } ; .....</code>         | 38 |

|   |    |
|---|----|
| <code>Extrude Point   Line   Surface { expression, {<br/>    expression-list } } { layers; ... } ;<br/>    .....</code>   | 47 |
| <code>Extrude Point   Line   Surface { expression, {<br/>    expression-list }, { expression-list }, {<br/>    expression-list }, expression } { layers;<br/>    ... } ; .....</code> | 47 |
| <code>Extrude Point   Line   Surface { expression, {<br/>    expression-list }, { expression-list }, {<br/>    expression-list }, expression } ; .....</code>                         | 38 |
| <code>Extrude Point   Line   Surface { expression, {<br/>    expression-list }, { expression-list },<br/>    expression } { layers; ... } ; .....</code>                              | 47 |
| <code>Extrude Point   Line   Surface { expression, {<br/>    expression-list }, { expression-list },<br/>    expression } ; .....</code>  | 38 |

## F

|   |    |
|---|----|
| <code>Fabs ( expression )</code> .....  | 13 |
| <code>Floor ( expression )</code> .....   | 13 |
| <code>Fmod ( expression, expression )</code> .....                                | 13 |
| <code>For ( expression : expression ) .....</code>                                | 14 |
| <code>For ( expression : expression : expression ) ....</code>                    | 14 |
| <code>For string In { expression : expression : expression<br/>    } .....</code> | 15 |
| <code>For string In { expression : expression } .....</code>                      | 15 |
| <code>Function string .....</code>  | 14 |

## G

|  |    |
|--|----|
| <code>General.AlphaBlending .....</code>   | 19 |
| <code>General.ArrowHeadRadius .....</code> | 19 |
| <code>General.ArrowStemLength .....</code> | 19 |
| <code>General.ArrowStemRadius .....</code> | 19 |
| <code>General.Axes .....</code>            | 19 |
| <code>General.Clip0 .....</code>           | 19 |
| <code>General.Clip0A .....</code>          | 19 |
| <code>General.Clip0B .....</code>          | 19 |
| <code>General.Clip0C .....</code>          | 19 |
| <code>General.Clip0D .....</code>          | 19 |
| <code>General.Clip1 .....</code>           | 19 |
| <code>General.Clip1A .....</code>          | 20 |
| <code>General.Clip1B .....</code>          | 20 |
| <code>General.Clip1C .....</code>          | 20 |
| <code>General.Clip1D .....</code>          | 20 |
| <code>General.Clip2 .....</code>           | 20 |
| <code>General.Clip2A .....</code>          | 20 |
| <code>General.Clip2B .....</code>          | 20 |
| <code>General.Clip2C .....</code>          | 20 |
| <code>General.Clip2D .....</code>          | 20 |
| <code>General.Clip3 .....</code>           | 20 |
| <code>General.Clip3A .....</code>          | 21 |
| <code>General.Clip3B .....</code>          | 21 |
| <code>General.Clip3C .....</code>          | 21 |
| <code>General.Clip3D .....</code>          | 21 |
| <code>General.Clip4 .....</code>           | 21 |
| <code>General.Clip4A .....</code>          | 21 |

|                                 |    |                                     |    |
|---------------------------------|----|-------------------------------------|----|
| General.Clip4B .....            | 21 | General.MessagePositionX .....      | 26 |
| General.Clip4C .....            | 21 | General.MessagePositionY .....      | 26 |
| General.Clip4D .....            | 21 | General.MessageWidth .....          | 26 |
| General.Clip5 .....             | 21 | General.MovingLight .....           | 26 |
| General.Clip5A .....            | 22 | General.OptionsFileName .....       | 18 |
| General.Clip5B .....            | 22 | General.OptionsPositionX .....      | 26 |
| General.Clip5C .....            | 22 | General.OptionsPositionY .....      | 27 |
| General.Clip5D .....            | 22 | General.Orthographic .....          | 27 |
| General.Color.Axes .....        | 31 | General.PointSize .....             | 27 |
| General.Color.Background .....  | 31 | General.QuadricSubdivisions .....   | 27 |
| General.Color.Foreground .....  | 31 | General.RotationCenterGravity ..... | 27 |
| General.Color.SmallAxes .....   | 31 | General.RotationCenterX .....       | 27 |
| General.Color.Text .....        | 31 | General.RotationCenterY .....       | 27 |
| General.ColorScheme .....       | 22 | General.RotationCenterZ .....       | 28 |
| General.ConfirmOverwrite .....  | 22 | General.RotationX .....             | 27 |
| General.ContextPositionX .....  | 22 | General.RotationY .....             | 27 |
| General.ContextPositionY .....  | 22 | General.RotationZ .....             | 27 |
| General.DefaultFileName .....   | 18 | General.SaveOptions .....           | 28 |
| General.DefaultPlugins .....    | 22 | General.SaveSession .....           | 28 |
| General.Display .....           | 18 | General.ScaleX .....                | 28 |
| General.DoubleBuffer .....      | 22 | General.ScaleY .....                | 28 |
| General.ErrorFileName .....     | 18 | General.ScaleZ .....                | 28 |
| General.FastRedraw .....        | 23 | General.Scheme .....                | 18 |
| General.FontSize .....          | 23 | General.SessionFileName .....       | 18 |
| General.GraphicsFontSize .....  | 23 | General.Shininess .....             | 28 |
| General.GraphicsHeight .....    | 23 | General.SmallAxes .....             | 28 |
| General.GraphicsPositionX ..... | 23 | General.SmallAxesPositionX .....    | 28 |
| General.GraphicsPositionY ..... | 23 | General.SmallAxesPositionY .....    | 29 |
| General.GraphicsWidth .....     | 23 | General.SolverPositionX .....       | 29 |
| General.InitialModule .....     | 23 | General.SolverPositionY .....       | 29 |
| General.Light0 .....            | 23 | General.StatisticsPositionX .....   | 29 |
| General.Light0X .....           | 23 | General.StatisticsPositionY .....   | 29 |
| General.Light0Y .....           | 24 | General.SystemMenuBar .....         | 29 |
| General.Light0Z .....           | 24 | General.Terminal .....              | 29 |
| General.Light1 .....            | 24 | General.TextEditor .....            | 18 |
| General.Light1X .....           | 24 | General.TmpFileName .....           | 18 |
| General.Light1Y .....           | 24 | General.Tooltips .....              | 29 |
| General.Light1Z .....           | 24 | General.Trackball .....             | 29 |
| General.Light2 .....            | 24 | General.TrackballQuaternion0 .....  | 29 |
| General.Light2X .....           | 24 | General.TrackballQuaternion1 .....  | 29 |
| General.Light2Y .....           | 24 | General.TrackballQuaternion2 .....  | 30 |
| General.Light2Z .....           | 24 | General.TrackballQuaternion3 .....  | 30 |
| General.Light3 .....            | 24 | General.TranslationX .....          | 30 |
| General.Light3X .....           | 25 | General.TranslationY .....          | 30 |
| General.Light3Y .....           | 25 | General.TranslationZ .....          | 30 |
| General.Light3Z .....           | 25 | General.VectorType .....            | 30 |
| General.Light4 .....            | 25 | General.Verbosity .....             | 30 |
| General.Light4X .....           | 25 | General.VisibilityMode .....        | 30 |
| General.Light4Y .....           | 25 | General.VisibilityPositionX .....   | 30 |
| General.Light4Z .....           | 25 | General.VisibilityPositionY .....   | 30 |
| General.Light5 .....            | 25 | General.WebBrowser .....            | 18 |
| General.Light5X .....           | 25 | General.ZoomFactor .....            | 31 |
| General.Light5Y .....           | 25 | Geometry.AutoCoherence .....        | 40 |
| General.Light5Z .....           | 26 | Geometry.CirclePoints .....         | 40 |
| General.LineWidth .....         | 26 | Geometry.CircleWarning .....        | 40 |
| General.MenuPositionX .....     | 26 | Geometry.Color.Lines .....          | 43 |
| General.MenuPositionY .....     | 26 | Geometry.Color.LinesHighlight ..... | 44 |
| General.MessageHeight .....     | 26 | Geometry.Color.LinesSelect .....    | 43 |

|  |    |
|--|----|
| Geometry.ColorNormals .....            | 44 |
| Geometry.Color.Points .....            | 43 |
| Geometry.Color.PointsHighlight .....   | 43 |
| Geometry.Color.PointsSelect .....      | 43 |
| Geometry.Color.Surfaces .....          | 43 |
| Geometry.Color.SurfacesHighlight ..... | 44 |
| Geometry.Color.SurfacesSelect .....    | 43 |
| Geometry.Color.Tangents .....          | 44 |
| Geometry.Color.Volumes .....           | 43 |
| Geometry.Color.VolumesHighlight .....  | 44 |
| Geometry.Color.VolumesSelect .....     | 43 |
| Geometry.ColorScheme .....             | 40 |
| Geometry.ExtrudeSplinePoints .....     | 40 |
| Geometry.Highlight .....               | 40 |
| Geometry.Light .....                   | 41 |
| Geometry.Lines .....                   | 41 |
| Geometry.LineSelectWidth .....         | 41 |
| Geometry.LinesNumbers .....            | 41 |
| Geometry.LineType .....                | 41 |
| Geometry.LineWidth .....               | 41 |
| GeometryNormals .....                  | 41 |
| Geometry.OldCircle .....               | 41 |
| Geometry.OldNewReg .....               | 41 |
| Geometry.Points .....                  | 41 |
| Geometry.PointSelectSize .....         | 42 |
| Geometry.PointSize .....               | 42 |
| Geometry.PointsNumbers .....           | 41 |
| Geometry.PointType .....               | 42 |
| Geometry.ScalingFactor .....           | 42 |
| Geometry.StlCreateElementary .....     | 42 |
| Geometry.StlCreatePhysical .....       | 42 |
| Geometry.Surfaces .....                | 42 |
| Geometry.SurfacesNumbers .....         | 42 |
| Geometry.Tangents .....                | 42 |
| Geometry.Volumes .....                 | 42 |
| Geometry.VolumesNumbers .....          | 43 |

## H

|  |        |
|--|--------|
| Hide { Point   Line   Surface   Volume {<br><i>expression-list</i> } ; ... } ..... | 40, 48 |
| Hide <i>char-expression</i> ; .....  | 40, 48 |
| Hypot ( <i>expression</i> , <i>expression</i> ) .....                              | 13     |

## I

|  |    |
|--|----|
| If ( <i>expression</i> ) .....         | 15 |
| Include <i>char-expression</i> ; ..... | 17 |

## L

|   |    |
|---|----|
| Line ( <i>expression</i> ) = { <i>expression</i> , <i>expression</i> } ;<br>..... | 36 |
| Line Loop ( <i>expression</i> ) = { <i>expression-list</i> } ; ..                 | 36 |
| Log ( <i>expression</i> ) .....   | 13 |
| Log10 ( <i>expression</i> ) .....   | 13 |

## M

|   |    |
|---|----|
| Merge <i>char-expression</i> ; .....                | 17 |
| MergeWithBoundingBox <i>char-expression</i> ; ..... | 17 |
| Mesh.Algorithm .....                                | 49 |
| Mesh.AllowDegeneratedExtrude .....                  | 49 |
| Mesh.CharacteristicLengthFactor .....               | 49 |
| Mesh.Color.Eight .....                              | 56 |
| Mesh.Color.Five .....                               | 55 |
| Mesh.Color.Four .....                               | 55 |
| Mesh.Color.Hexahedra .....                          | 54 |
| Mesh.Color.Lines .....                              | 54 |
| Mesh.Color.Nine .....                               | 56 |
| Mesh.ColorNormals .....                             | 55 |
| Mesh.Color.One .....                                | 55 |
| Mesh.Color.Points .....                             | 54 |
| Mesh.Color.Prisms .....                             | 54 |
| Mesh.Color.Pyramids .....                           | 55 |
| Mesh.Color.Quadrangles .....                        | 54 |
| Mesh.Color.Seven .....                              | 55 |
| Mesh.Color.Six .....                                | 55 |
| Mesh.Color.Tangents .....                           | 55 |
| Mesh.Color.Ten .....                                | 56 |
| Mesh.Color.Tetrahedra .....                         | 54 |
| Mesh.Color.Three .....                              | 55 |
| Mesh.Color.Triangles .....                          | 54 |
| Mesh.Color.Two .....                                | 55 |
| Mesh.ColorCarousel .....                            | 49 |
| Mesh.ColorScheme .....                              | 49 |
| Mesh.ConstrainedBackgroundMesh .....                | 49 |
| Mesh.CpuTime .....                                  | 49 |
| Mesh.CutPlane .....                                 | 49 |
| Mesh.CutPlaneA .....                                | 49 |
| Mesh.CutPlaneB .....                                | 49 |
| Mesh.CutPlaneC .....                                | 50 |
| Mesh.CutPlaneD .....                                | 50 |
| Mesh.DisplayLists .....                             | 50 |
| Mesh.Dual .....                                     | 50 |
| Mesh.ElementOrder .....                             | 50 |
| Mesh.Explode .....                                  | 50 |
| Mesh.Format .....                                   | 50 |
| Mesh.GammaInf .....                                 | 50 |
| Mesh.GammaSup .....                                 | 50 |
| Mesh.Interactive .....                              | 50 |
| Mesh.Light .....                                    | 50 |
| Mesh.Lines .....                                    | 51 |
| Mesh.LinesNumbers .....                             | 51 |
| Mesh.LineType .....                                 | 51 |
| Mesh.LineWidth .....                                | 51 |
| Mesh.MinimumCirclePoints .....                      | 51 |
| Mesh.MshFileVersion .....                           | 51 |
| Mesh.NbHexahedra .....                              | 51 |
| Mesh.NbNodes .....                                  | 51 |
| Mesh.NbPrisms .....                                 | 51 |
| Mesh.NbPyramids .....                               | 51 |
| Mesh.NbQuadrangles .....                            | 52 |
| Mesh.NbTetrahedra .....                             | 52 |
| Mesh.NbTriangles .....                              | 52 |
| MeshNormals .....                                   | 52 |

|   |    |
|---|----|
| Mesh.PointInsertion.....                              | 52 |
| Mesh.Points.....                                      | 52 |
| Mesh.PointSize.....                                   | 52 |
| Mesh.PointsNumbers.....                               | 52 |
| Mesh.PointType.....                                   | 52 |
| Mesh.Quality.....                                     | 52 |
| Mesh.RadiusInf.....                                   | 53 |
| Mesh.RadiusSup.....                                   | 53 |
| Mesh.RandomFactor.....                                | 53 |
| Mesh.SaveAll.....                                     | 53 |
| Mesh.ScalingFactor.....                               | 53 |
| Mesh.Smoothing.....                                   | 53 |
| Mesh.Solid.....                                       | 53 |
| Mesh.SpeedMax.....                                    | 53 |
| Mesh.Surfaces.....                                    | 53 |
| Mesh.SurfacesNumbers.....                             | 53 |
| Mesh.Tangents.....                                    | 54 |
| Mesh.TriangleOptions.....                             | 48 |
| Mesh.Volumes.....                                     | 54 |
| Mesh.VolumesNumbers.....                              | 54 |
| Modulo ( <i>expression</i> , <i>expression</i> )..... | 13 |
| MPI_Rank.....   | 15 |
| MPI_Size.....   | 15 |

## N

|             |    |
|-------------|----|
| newl.....   | 15 |
| newp.....   | 15 |
| newreg..... | 16 |
| news.....   | 15 |
| newv.....   | 16 |

## O

|                                     |    |
|-------------------------------------|----|
| <i>operator-binary</i> .....        | 11 |
| <i>operator-ternary-left</i> .....  | 11 |
| <i>operator-ternary-right</i> ..... | 11 |
| <i>operator-unary-left</i> .....    | 11 |
| <i>operator-unary-right</i> .....   | 11 |

## P

|  |    |
|--|----|
| Physical Line ( <i>expression</i> ) = { <i>expression-list</i> };<br>.....   | 37 |
| Physical Point ( <i>expression</i> ) = { <i>expression-list</i><br>};.....   | 35 |
| Physical Surface ( <i>expression</i> ) = { <i>expression-list</i><br>};.....   | 37 |
| Physical Volume ( <i>expression</i> ) = { <i>expression-list</i><br>};.....  | 38 |
| Pi.....  | 15 |
| Plane Surface ( <i>expression</i> ) = { <i>expression-list</i> };<br>.....   | 37 |
| Plugin ( <i>string</i> ) . <i>string</i> = <i>expression</i>  <br><i>char-expression</i> ;.....                          | 78 |
| Plugin ( <i>string</i> ) . <i>string</i> ;.....  | 78 |
| Point ( <i>expression</i> ) = { <i>expression</i> , <i>expression</i> ,<br><i>expression</i> , <i>expression</i> };..... | 35 |

|  |    |
|--|----|
| PostProcessing.AnimationCycle.....                             | 78 |
| PostProcessing.AnimationDelay.....                             | 78 |
| PostProcessing.DisplayLists.....                               | 79 |
| PostProcessing.Link.....                                       | 79 |
| PostProcessing.NbViews.....                                    | 79 |
| PostProcessing.Scales.....                                     | 79 |
| PostProcessing.Smoothing.....                                  | 79 |
| Print <i>char-expression</i> ;.....                            | 17 |
| Print.EpsBackground.....                                       | 31 |
| Print.EpsBestRoot.....   | 31 |
| Print.EpsCompress.....   | 31 |
| Print.EpsFont.....   | 31 |
| Print.EpsFontSize.....   | 32 |
| Print.EpsLineWidthFactor.....                                  | 32 |
| Print.EpsOcclusionCulling.....                                 | 32 |
| Print.EpsPointSizeFactor.....                                  | 32 |
| Print.EpsQuality.....  | 32 |
| Print.Format.....  | 32 |
| Print.GifDither.....   | 32 |
| Print.GifInterlace.....  | 32 |
| Print.GifSort.....   | 32 |
| Print.GifTransparent.....                                      | 32 |
| Print.JpegQuality.....   | 33 |
| Printf ( <i>char-expression</i> , <i>expression-list</i> );... | 17 |

## R

|  |    |
|--|----|
| Rand ( <i>expression</i> ).....  | 14 |
| <i>real-option</i> = <i>expression</i> ;.....  | 16 |
| Recombine Surface { <i>expression-list</i> } < =<br><i>expression</i> >;.....  | 48 |
| Return.....  | 14 |
| Rotate { { <i>expression-list</i> }, { <i>expression-list</i> },<br><i>expression</i> } { <i>transform-list</i> }..... | 39 |
| Ruled Surface ( <i>expression</i> ) = { <i>expression-list</i> };<br>.....   | 37 |

## S

|   |        |
|---|--------|
| Save <i>char-expression</i> ;.....  | 48     |
| Save View[ <i>expression</i> ] <i>char-expression</i> ;.....                      | 78     |
| Show { Point   Line   Surface   Volume {<br><i>expression-list</i> } ; ... }..... | 40, 48 |
| Show <i>char-expression</i> ;.....  | 40, 48 |
| Sin ( <i>expression</i> ).....  | 14     |
| Sinh ( <i>expression</i> ).....   | 14     |
| Sleep <i>expression</i> ;.....  | 17     |
| Solver.ClientServer0.....   | 68     |
| Solver.ClientServer1.....   | 68     |
| Solver.ClientServer2.....   | 68     |
| Solver.ClientServer3.....   | 69     |
| Solver.ClientServer4.....   | 69     |
| Solver.Executable0.....   | 57     |
| Solver.Executable1.....   | 59     |
| Solver.Executable2.....   | 61     |
| Solver.Executable3.....   | 64     |
| Solver.Executable4.....   | 66     |
| Solver.Extension0.....  | 57     |

|                                  |    |   |    |
|----------------------------------|----|---|----|
| Solver.Extension1.....           | 59 | Solver.MergeViews4.....   | 69 |
| Solver.Extension2.....           | 62 | Solver.MeshCommand0.....  | 57 |
| Solver.Extension3.....           | 64 | Solver.MeshCommand1.....  | 60 |
| Solver.Extension4.....           | 66 | Solver.MeshCommand2.....  | 62 |
| Solver.FifthButton0.....         | 59 | Solver.MeshCommand3.....  | 64 |
| Solver.FifthButton1.....         | 61 | Solver.MeshCommand4.....  | 66 |
| Solver.FifthButton2.....         | 63 | Solver.MeshName0.....   | 57 |
| Solver.FifthButton3.....         | 65 | Solver.MeshName1.....   | 59 |
| Solver.FifthButton4.....         | 68 | Solver.MeshName2.....   | 62 |
| Solver.FifthButtonCommand0.....  | 59 | Solver.MeshName3.....   | 64 |
| Solver.FifthButtonCommand1.....  | 61 | Solver.MeshName4.....   | 66 |
| Solver.FifthButtonCommand2.....  | 63 | Solver.Name0.....   | 57 |
| Solver.FifthButtonCommand3.....  | 66 | Solver.Name1.....   | 59 |
| Solver.FifthButtonCommand4.....  | 68 | Solver.Name2.....   | 61 |
| Solver.FifthOption0.....         | 58 | Solver.Name3.....   | 63 |
| Solver.FifthOption1.....         | 60 | Solver.Name4.....   | 66 |
| Solver.FifthOption2.....         | 62 | Solver.OptionCommand0.....                                      | 58 |
| Solver.FifthOption3.....         | 65 | Solver.OptionCommand1.....                                      | 60 |
| Solver.FifthOption4.....         | 67 | Solver.OptionCommand2.....                                      | 62 |
| Solver.FirstButton0.....         | 58 | Solver.OptionCommand3.....                                      | 64 |
| Solver.FirstButton1.....         | 60 | Solver.OptionCommand4.....                                      | 66 |
| Solver.FirstButton2.....         | 62 | Solver.PopupMessages0.....                                      | 68 |
| Solver.FirstButton3.....         | 65 | Solver.PopupMessages1.....                                      | 68 |
| Solver.FirstButton4.....         | 67 | Solver.PopupMessages2.....                                      | 69 |
| Solver.FirstButtonCommand0.....  | 58 | Solver.PopupMessages3.....                                      | 69 |
| Solver.FirstButtonCommand1.....  | 60 | Solver.PopupMessages4.....                                      | 69 |
| Solver.FirstButtonCommand2.....  | 63 | Solver.SecondButton0.....                                       | 58 |
| Solver.FirstButtonCommand3.....  | 65 | Solver.SecondButton1.....                                       | 60 |
| Solver.FirstButtonCommand4.....  | 67 | Solver.SecondButton2.....                                       | 63 |
| Solver.FirstOption0.....         | 58 | Solver.SecondButton3.....                                       | 65 |
| Solver.FirstOption1.....         | 60 | Solver.SecondButton4.....                                       | 67 |
| Solver.FirstOption2.....         | 62 | Solver.SecondButtonCommand0.....                                | 58 |
| Solver.FirstOption3.....         | 64 | Solver.SecondButtonCommand1.....                                | 61 |
| Solver.FirstOption4.....         | 66 | Solver.SecondButtonCommand2.....                                | 63 |
| Solver.FourthButton0.....        | 59 | Solver.SecondButtonCommand3.....                                | 65 |
| Solver.FourthButton1.....        | 61 | Solver.SecondButtonCommand4.....                                | 67 |
| Solver.FourthButton2.....        | 63 | Solver.SecondOption0.....                                       | 58 |
| Solver.FourthButton3.....        | 65 | Solver.SecondOption1.....                                       | 60 |
| Solver.FourthButton4.....        | 67 | Solver.SecondOption2.....                                       | 62 |
| Solver.FourthButtonCommand0..... | 59 | Solver.SecondOption3.....                                       | 64 |
| Solver.FourthButtonCommand1..... | 61 | Solver.SecondOption4.....                                       | 66 |
| Solver.FourthButtonCommand2..... | 63 | Solver.ThirdButton0.....  | 58 |
| Solver.FourthButtonCommand3..... | 65 | Solver.ThirdButton1.....  | 61 |
| Solver.FourthButtonCommand4..... | 68 | Solver.ThirdButton2.....  | 63 |
| Solver.FourthOption0.....        | 58 | Solver.ThirdButton3.....  | 65 |
| Solver.FourthOption1.....        | 60 | Solver.ThirdButton4.....  | 67 |
| Solver.FourthOption2.....        | 62 | Solver.ThirdButtonCommand0.....                                 | 59 |
| Solver.FourthOption3.....        | 64 | Solver.ThirdButtonCommand1.....                                 | 61 |
| Solver.FourthOption4.....        | 67 | Solver.ThirdButtonCommand2.....                                 | 63 |
| Solver.Help0.....                | 57 | Solver.ThirdButtonCommand3.....                                 | 65 |
| Solver.Help1.....                | 59 | Solver.ThirdButtonCommand4.....                                 | 67 |
| Solver.Help2.....                | 61 | Solver.ThirdOption0.....  | 58 |
| Solver.Help3.....                | 64 | Solver.ThirdOption1.....  | 60 |
| Solver.Help4.....                | 66 | Solver.ThirdOption2.....  | 62 |
| Solver.MergeViews0.....          | 68 | Solver.ThirdOption3.....  | 64 |
| Solver.MergeViews1.....          | 68 | Solver.ThirdOption4.....  | 67 |
| Solver.MergeViews2.....          | 69 | Spline ( <i>expression</i> ) = { <i>expression-list</i> };..... | 36 |
| Solver.MergeViews3.....          | 69 | Sqrt ( <i>expression</i> ).....                                 | 14 |

|   |    |
|---|----|
| <i>string</i> = <i>expression</i> ; .....   | 15 |
| <i>string</i> [ ] = { <i>expression-list</i> }; .....                             | 16 |
| <i>string</i> [ { <i>expression-list</i> } ] *= { <i>expression-list</i> }; ..... | 16 |
| <i>string</i> [ { <i>expression-list</i> } ] += { <i>expression-list</i> }; ..... | 16 |
| <i>string</i> [ { <i>expression-list</i> } ] -= { <i>expression-list</i> }; ..... | 16 |
| <i>string</i> [ { <i>expression-list</i> } ] /= { <i>expression-list</i> }; ..... | 17 |
| <i>string</i> [ { <i>expression-list</i> } ] = { <i>expression-list</i> }; .....  | 16 |
| <i>string</i>   <i>real-option</i> *= <i>expression</i> ; .....                   | 16 |
| <i>string</i>   <i>real-option</i> += <i>expression</i> ; .....                   | 16 |
| <i>string</i>   <i>real-option</i> -= <i>expression</i> ; .....                   | 16 |
| <i>string</i>   <i>real-option</i> /= <i>expression</i> ; .....                   | 16 |
| Surface Loop ( <i>expression</i> ) = { <i>expression-list</i> }; .....            | 37 |
| Symmetry { <i>expression-list</i> } { <i>transform-list</i> } ..                  | 39 |
| System <i>char-expression</i> ; .....   | 17 |

## T

|  |    |
|--|----|
| Tan ( <i>expression</i> ) .....  | 14 |
| Tanh ( <i>expression</i> ) .....   | 14 |
| Transfinite Line { <i>expression-list</i> } = <i>expression</i> <<br>Using Progression   Bump <i>expression</i> ><br>..... | 47 |
| Transfinite Surface { <i>expression</i> } = {<br><i>expression-list</i> }; .....   | 47 |
| Transfinite Volume { <i>expression</i> } = {<br><i>expression-list</i> }; .....  | 48 |
| <i>transform</i> .....   | 39 |
| Translate { <i>expression-list</i> } { <i>transform-list</i> }<br>.....  | 39 |

## V

|   |    |
|---|----|
| View "string" { <i>string</i> ( <i>expression-list</i> ) {<br><i>expression-list</i> }; ... } ..... | 78 |
| View.AbcissaFormat .....  | 79 |
| View.AbcissaName .....  | 79 |
| View.AlphaChannel .....   | 79 |
| View.AngleSmoothNormals .....   | 80 |
| View.ArrowHeadRadius .....  | 80 |
| View.ArrowLocation .....  | 80 |
| View.ArrowSize .....  | 80 |
| View.ArrowStemLength .....  | 80 |
| View.ArrowStemRadius .....  | 80 |
| View.AutoPosition .....   | 80 |
| View.Boundary .....   | 80 |
| View.ColorTable .....   | 85 |
| View.CustomMax .....  | 80 |

|  |    |
|--|----|
| View.CustomMin .....   | 80 |
| View.DisplacementFactor .....                                    | 81 |
| View.DrawHexahedra .....   | 81 |
| View.DrawLines .....   | 81 |
| View.DrawPoints .....  | 81 |
| View.DrawPrisms .....  | 81 |
| View.DrawPyramids .....  | 81 |
| View.DrawQuadrangles .....                                       | 81 |
| View.DrawScalars .....   | 81 |
| View.DrawStrings .....   | 81 |
| View.DrawTensors .....   | 81 |
| View.DrawTetrahedra .....  | 82 |
| View.DrawTriangles .....   | 82 |
| View.DrawVectors .....   | 82 |
| View.Explode .....   | 82 |
| View.FileName .....  | 79 |
| View.Format .....  | 79 |
| View.Grid .....  | 82 |
| View.Height .....  | 82 |
| View.IntervalsType .....   | 82 |
| View.Light .....   | 82 |
| View.LineType .....  | 82 |
| View.LineWidth .....   | 82 |
| View.Max .....   | 83 |
| View.Min .....   | 83 |
| View.Name .....  | 79 |
| View.NbAbcissa .....   | 83 |
| View.NbIso .....   | 83 |
| View.NbTimeStep .....  | 83 |
| View.OffsetX .....   | 83 |
| View.OffsetY .....   | 83 |
| View.OffsetZ .....   | 83 |
| View.PointSize .....   | 83 |
| View.PointType .....   | 83 |
| View.PositionX .....   | 84 |
| View.PositionY .....   | 84 |
| View.RaiseX .....  | 84 |
| View.RaiseY .....  | 84 |
| View.RaiseZ .....  | 84 |
| View.RangeType .....   | 84 |
| View.SaturateValues .....  | 84 |
| View.ScaleType .....   | 84 |
| View.ShowElement .....   | 84 |
| View.ShowScale .....   | 84 |
| View.ShowTime .....  | 84 |
| View.SmoothNormals .....   | 85 |
| View.TensorType .....  | 85 |
| View.TimeStep .....  | 85 |
| View.TransparentScale .....                                      | 85 |
| View.Type .....  | 85 |
| View.VectorType .....  | 85 |
| View.Visible .....   | 85 |
| View.Width .....   | 85 |
| Volume ( <i>expression</i> ) = { <i>expression-list</i> }; ..... | 38 |

