GiD

THE PERSONAL PRE
AND POSTPROCESSOR

The universal, adaptive and user friendly pre and post processing system for computer analysis in science and engineering

User Manual

Version 8

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TABLE OF CONTENTS

Presentation of GiD……………………………………………………………………………… 1
Initiation to GiD…………………………………………………………………………….. 23
Case study 1: implementing a mechanical part……………………………………………….. 42
Case study 2: implementing a cooling pipe………………………………………………….. 73
Assigning element sizes for generation the mesh…………………………………………….. 96
Methods for generating the mesh………………………………………………………….… 111
A postprocess case study: postprocessing a ratchet wheel……………………………….…128
Importing files: a case study…………………………………………………………………...160
Defining a problem type…………………………………………………………………..183

PRESENTATION OF GID

This chapter will introduce the user to the user-interface and graphic environment of **GiD**.

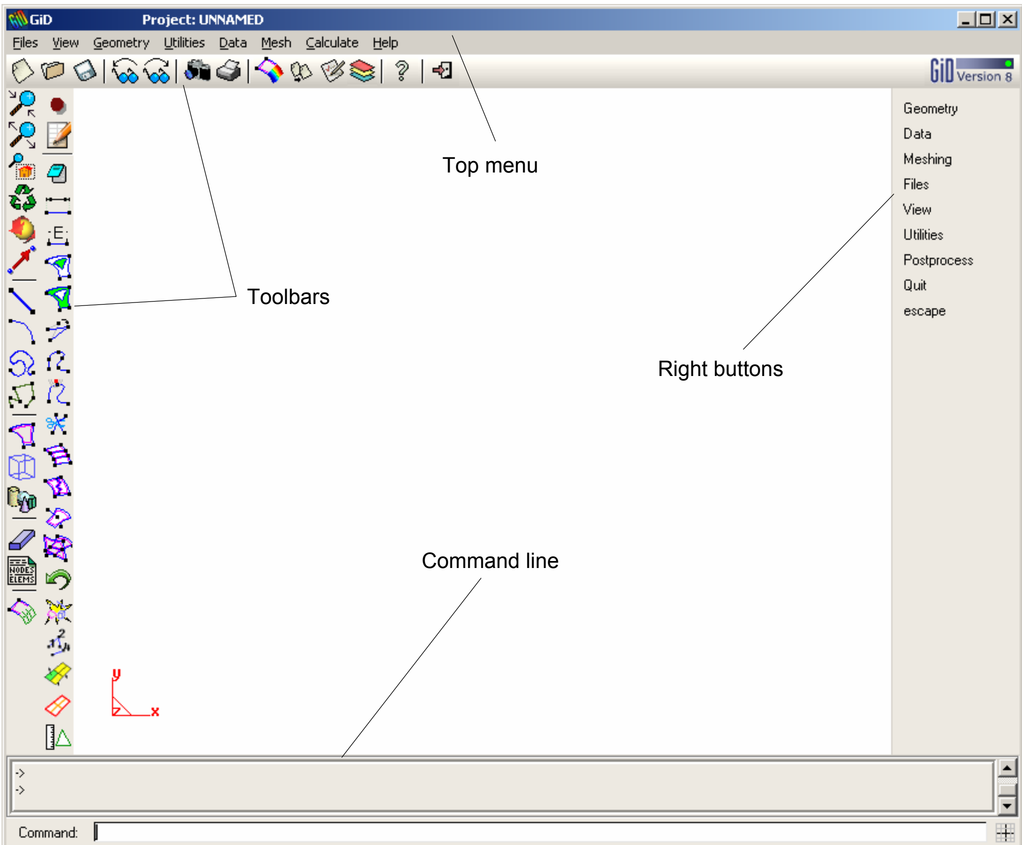
GiD is a general purpose pre-postprocessor for computer analysis.
All the data, geometry and mesh generation can be performed inside. Also, the visualization of all types of results can be performed.

It can be adapted to a specific analysis module by the creation of a 'problem type'.

Typical problems that can be successfully tackled with GiD include most situations in solid and structural mechanics, fluid dynamics, electromagnetics, heat transfer, geomechanics, etc. using finite element, finite volume, boundary element, finite difference or point based (meshless) numerical procedures.

USER INTERFACE

Upon opening **GiD,** the following window appears on the screen:



To change the configuration of toolbars and menus, use the toolbars option, located in **Utilities→Tools→Toolbars.**

1. TOP MENU

The **Top Menu** offers various types of commands.
It is important to note that these options will differ depending on the whether the user is performing a preprocessing or postprocessing analysis, and that the options needed in each case differ as well.

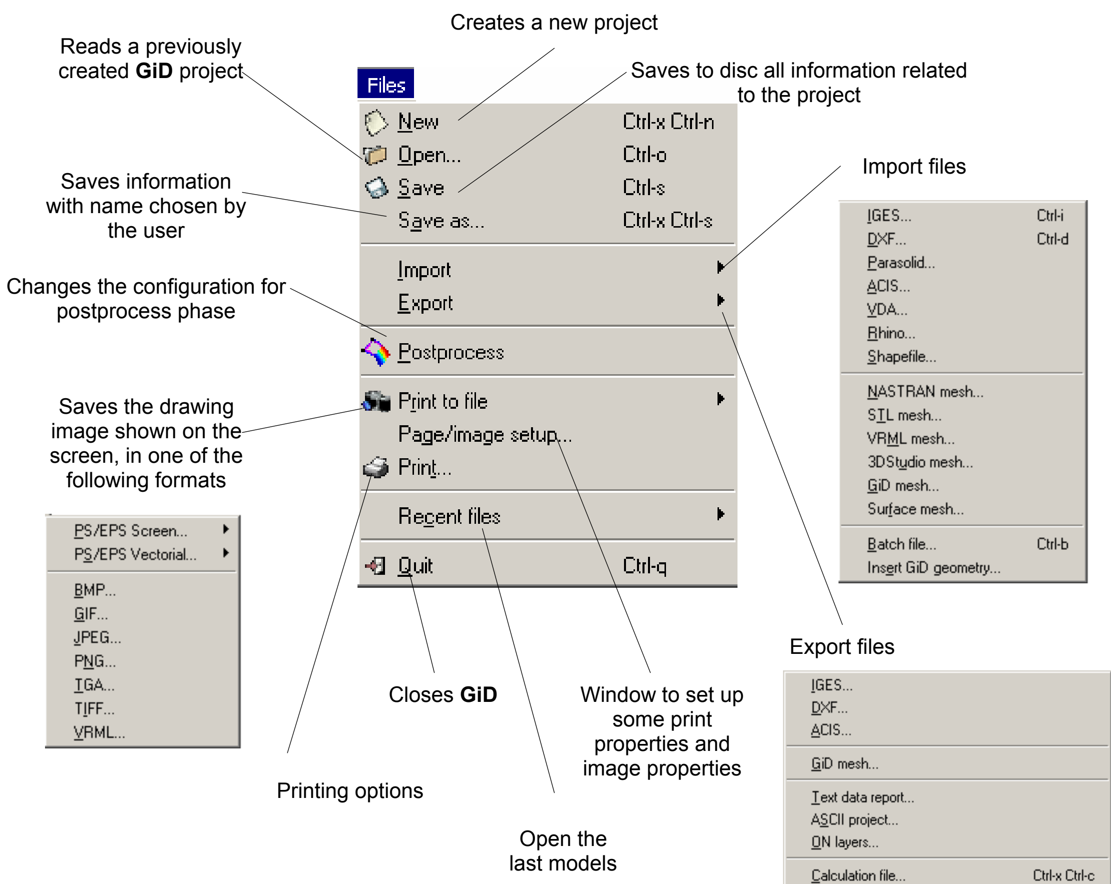
Two possible configurations of the **Top Menu** are presented below:

And in the postprocessing phase:

These two options will be presented in more detail later.
Next, each drop-down menu in the **Top Menu** will be described in detail.

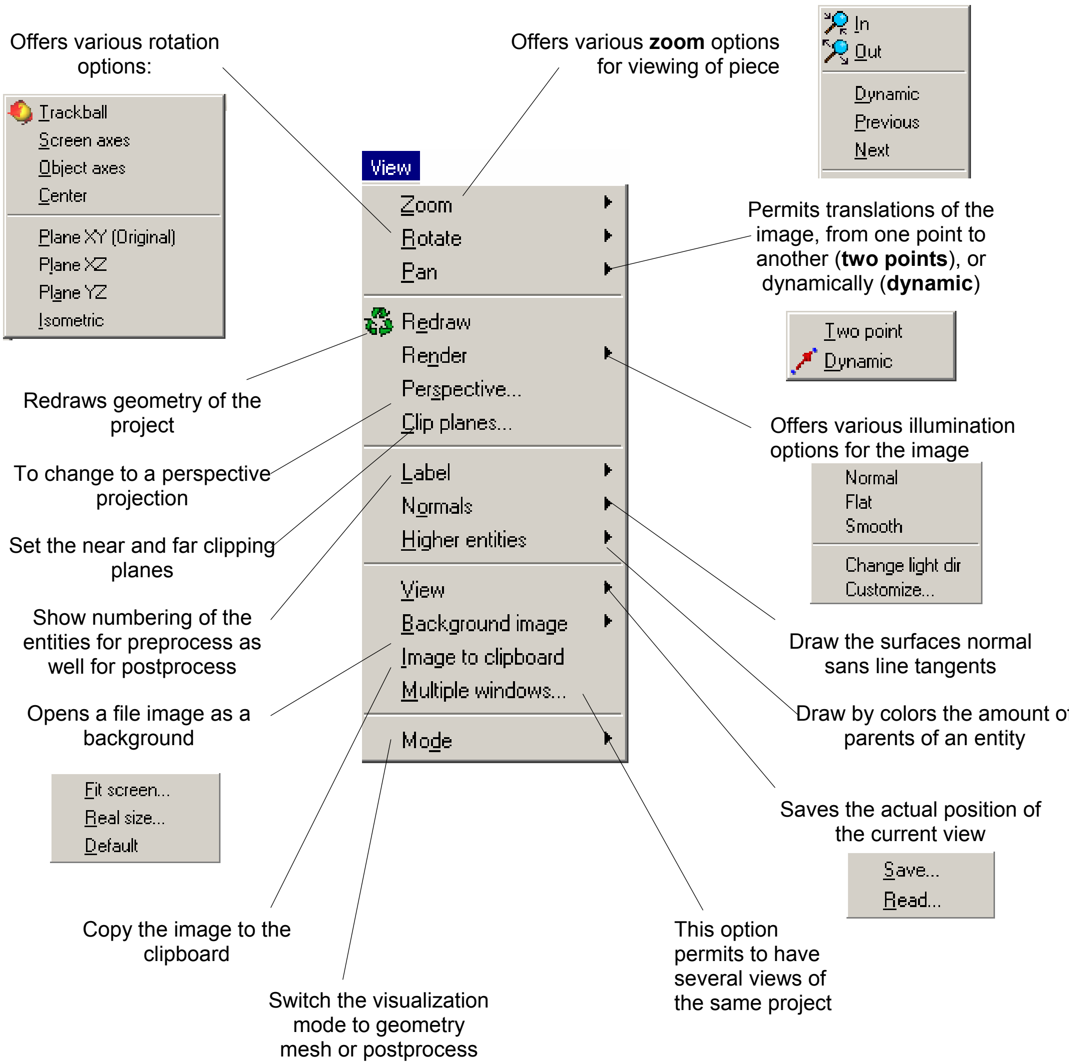
Files

Two main types of functions can be controlled in this menu: 1) the handling of files (i.e. create, read, save, etc.) of **GiD** projects; and, 2) the importing and exporting of files.



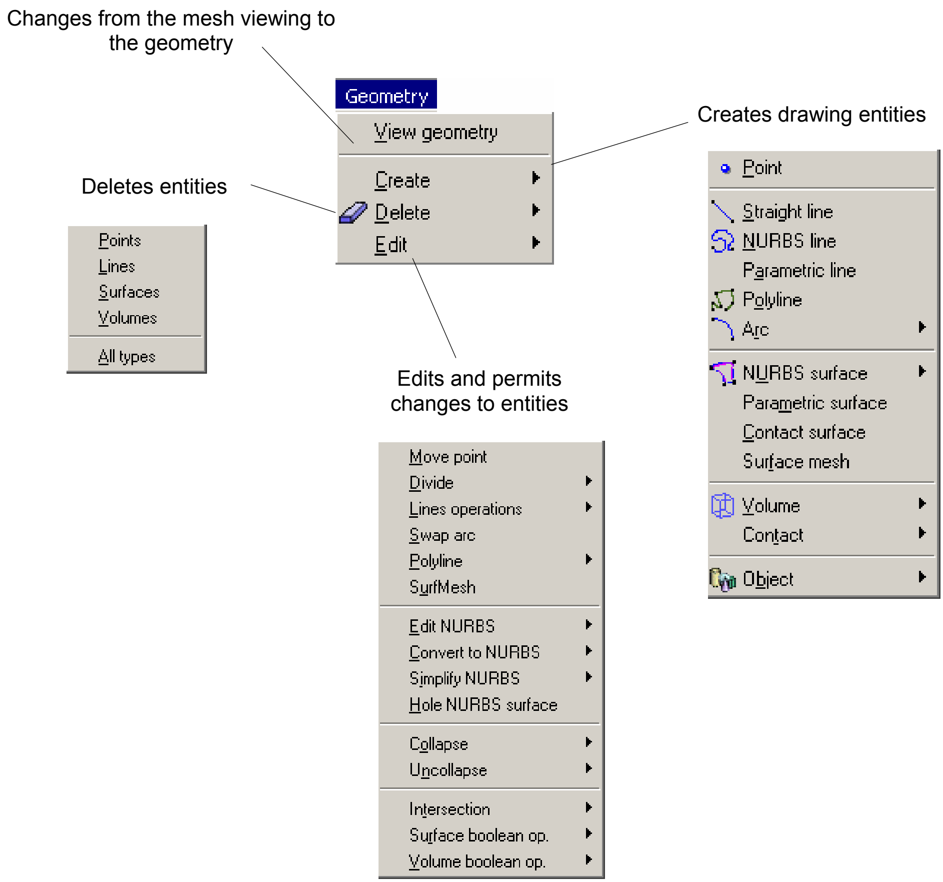
View

In the view menu (also available from the mouse menu) there are all the visualization commands. These commands change the way to display the information in the graphical window, but they do not change any definition of the geometry or any other data.



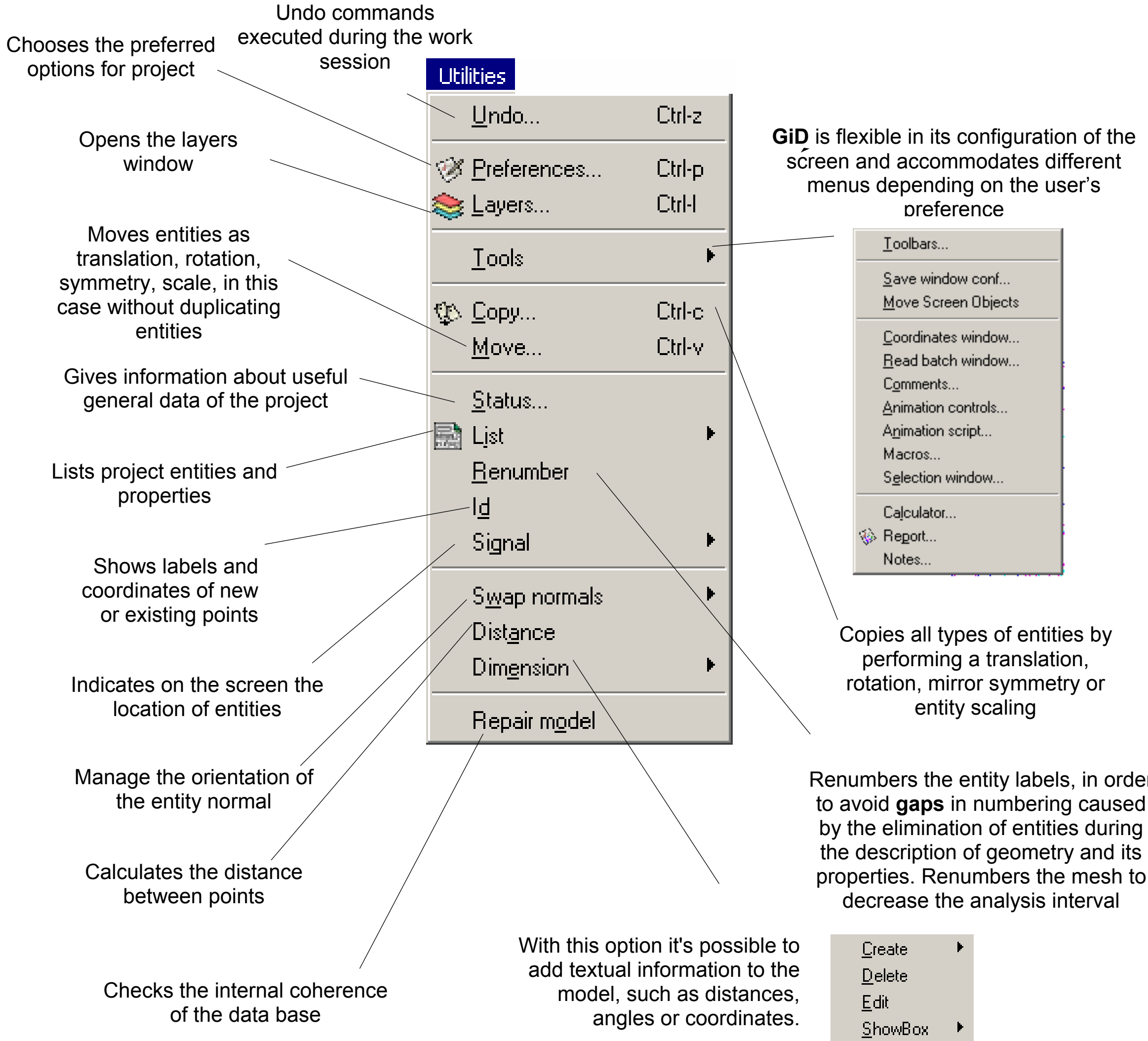
Geometry

Geometry permits the user to create, delete, edit and model geometry.



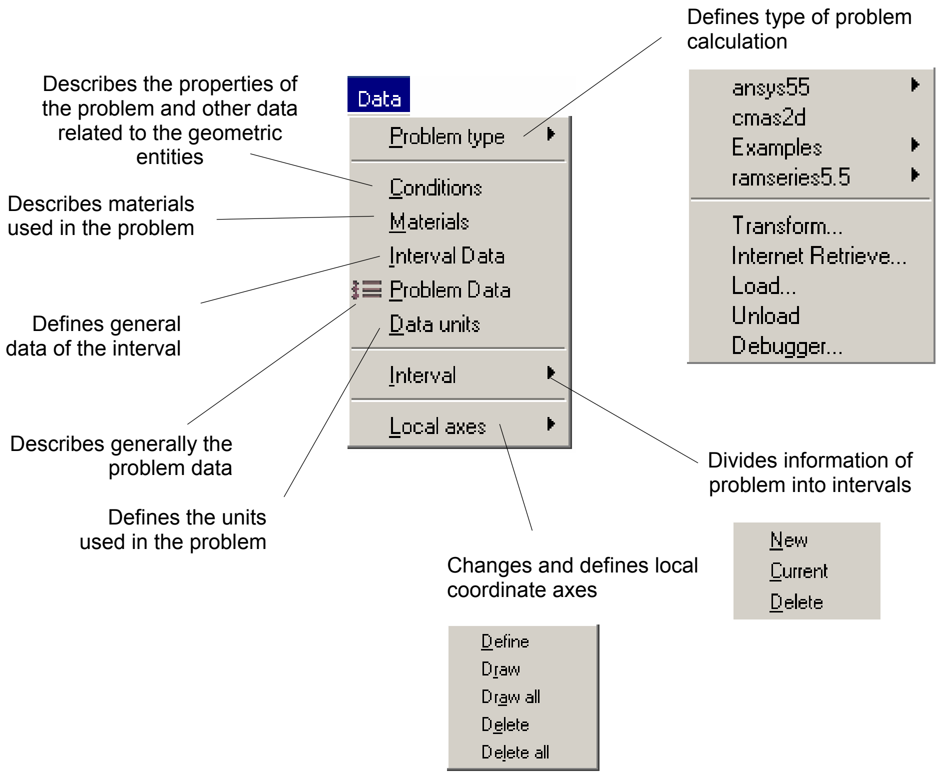
Utilities

In the **Utilities** menu, **GiD** allows the user to define preferences or perform operations on both the geometry and the mesh entities.



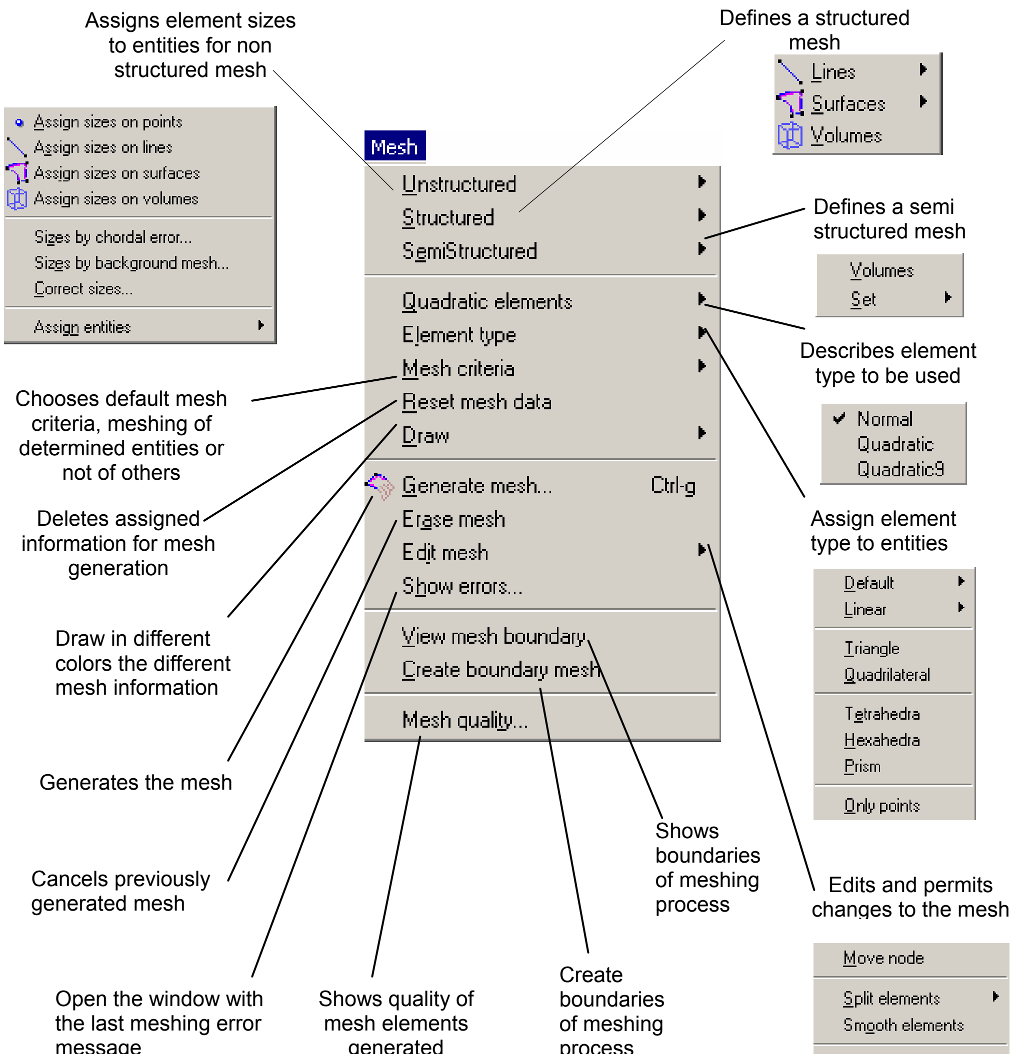
Data

This menu allows access to the definition of all data related to materials, boundary conditions, etc., which will be necessary for the calculations that follow. The form of this data will depend on the type of the analysis to be performed.



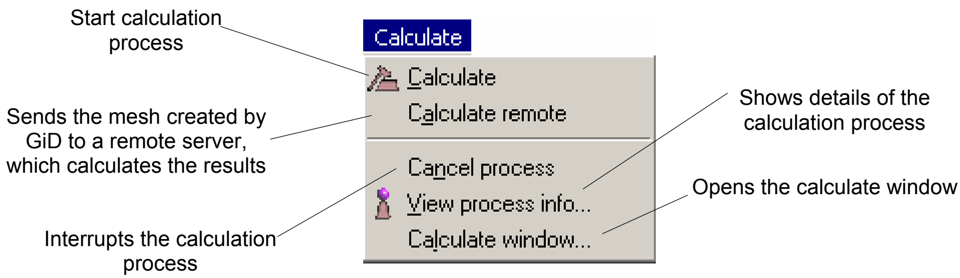
Mesh

Mesh permits the user to generate and edit the mesh, as well as to select mesh creation preferences.



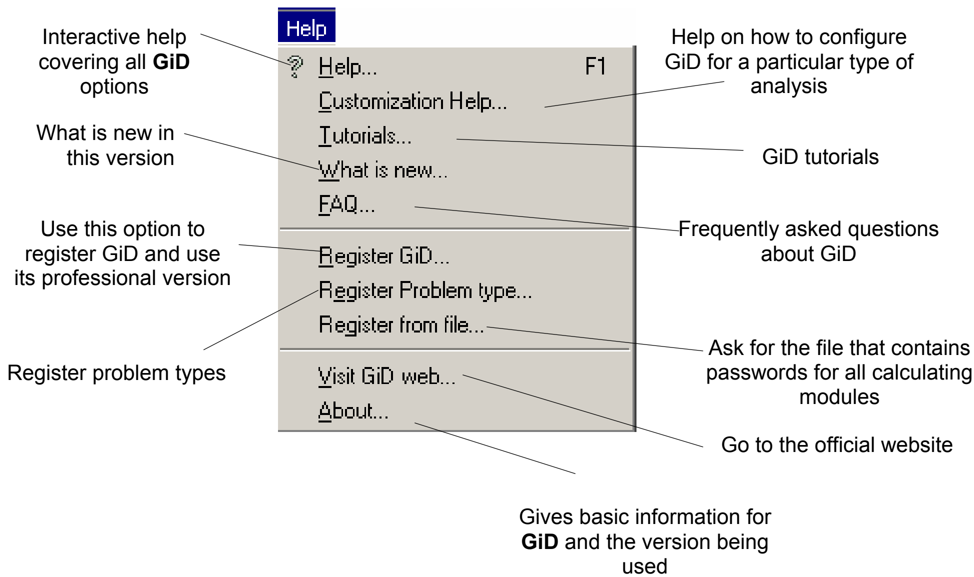
Calculate

This command calculates the problem, according to the type of problem defined. This option requires a previously activated *interface* between **GiD** and the corresponding calculation program.



Help

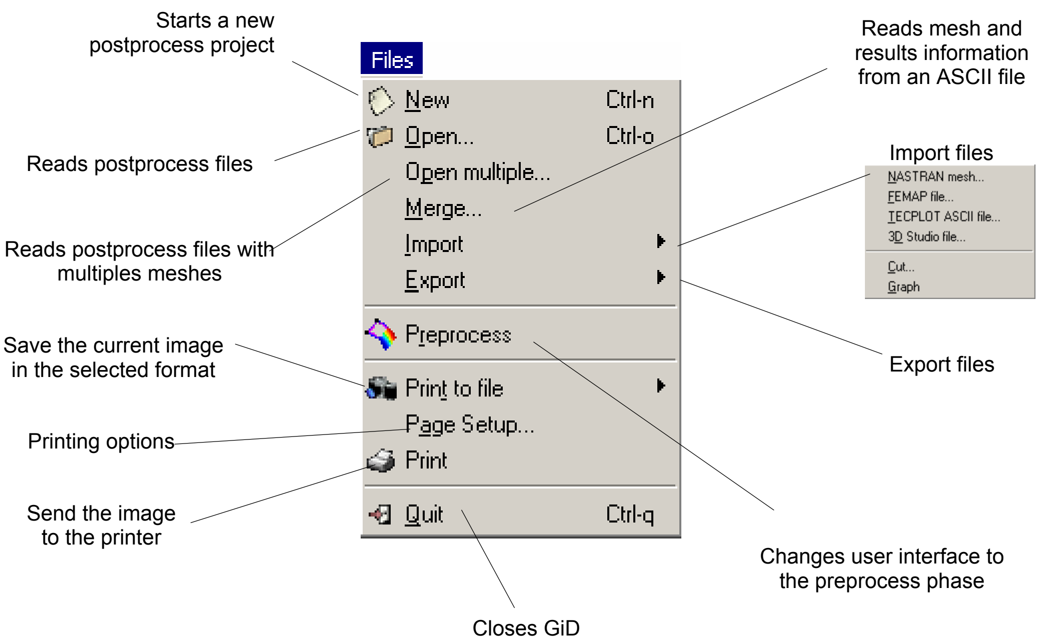
This menu permits the user to obtain different types of help and information about **GiD**.



GiD Postprocess

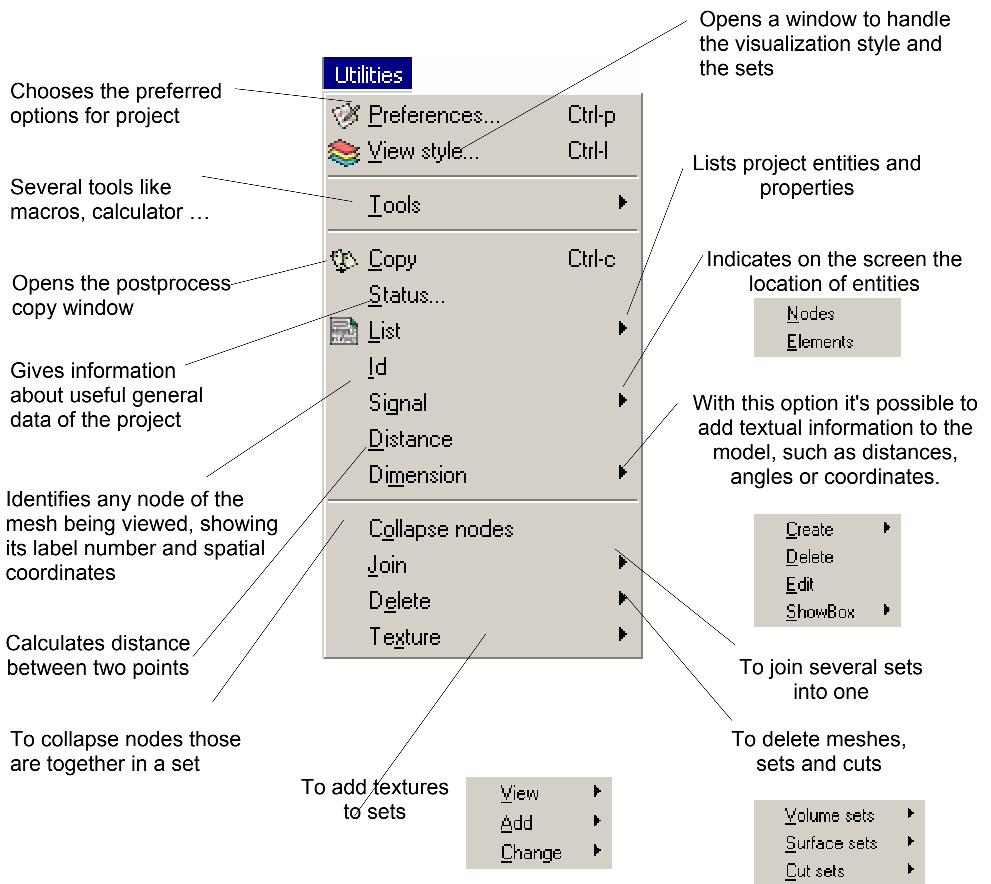
Files

This **Top Menu** of the postprocess phase is the same of that as the preprocess phase and has the same name. The user can read and save files, save screen images, return to preprocess phase options and exit the program.



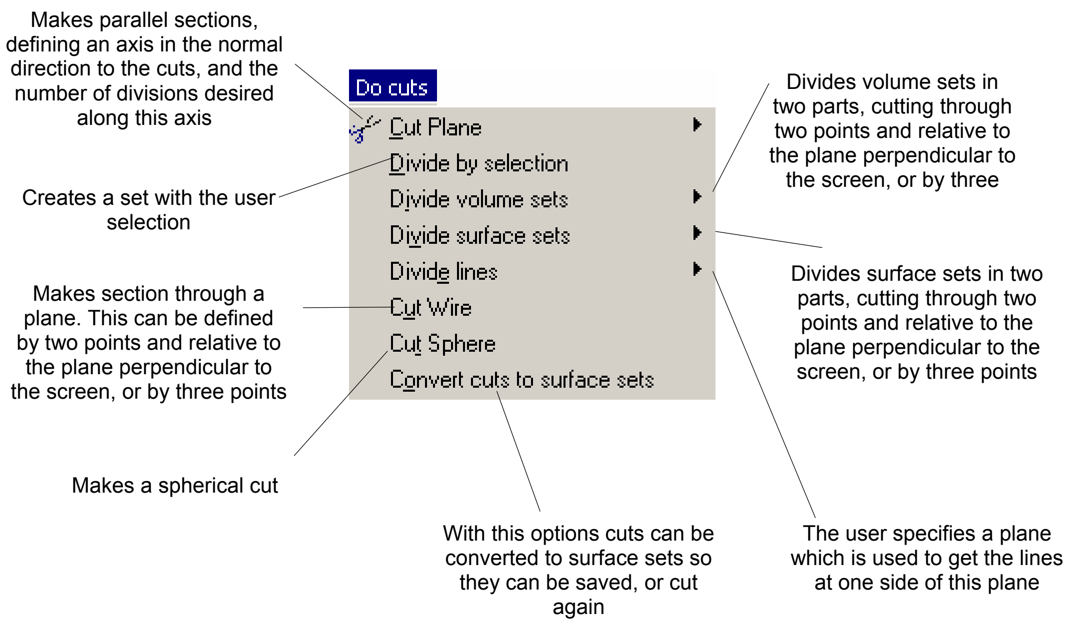
Utilities

In the postprocess phase, the **Utilities** command permits the user to obtain information about entities.



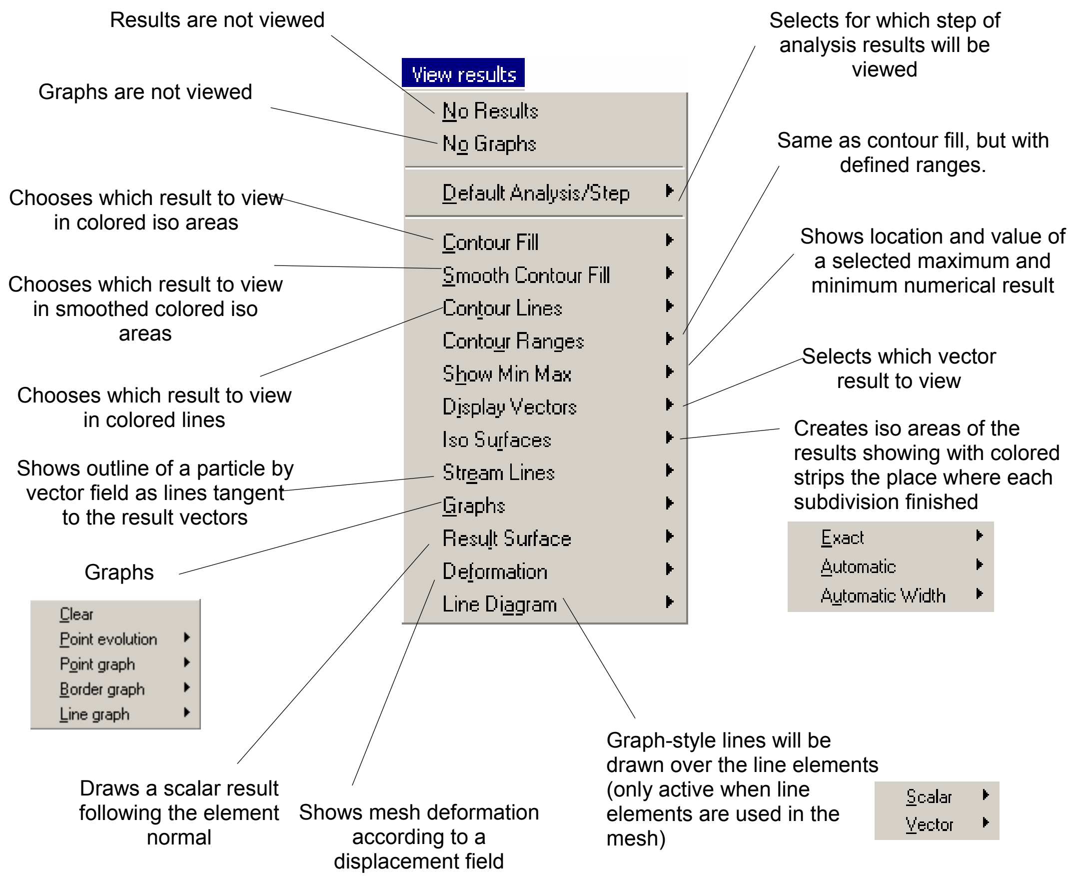
Do cuts

With the option **Do cuts** the user can make cuts through entities.



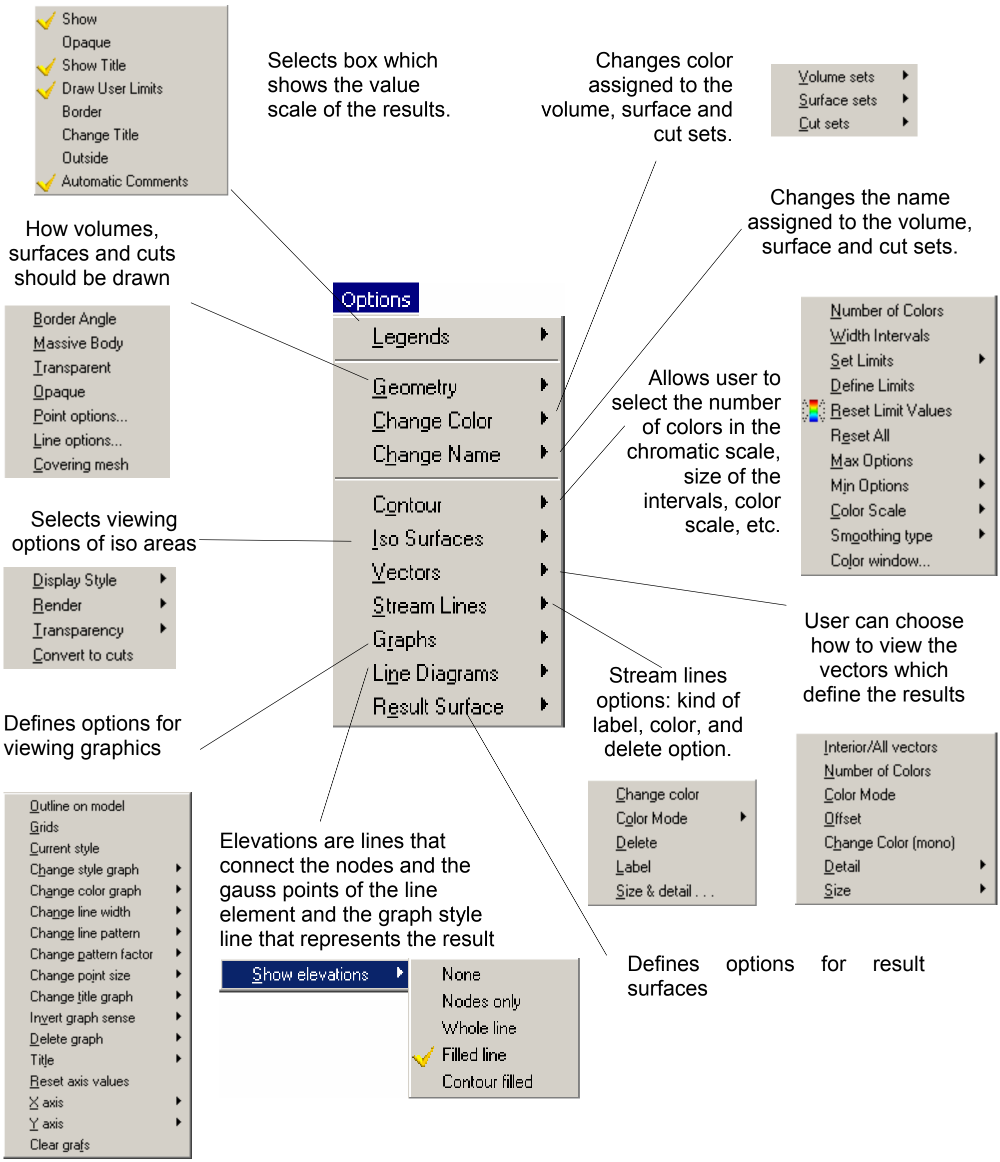
View results

This option permits the user to choose the viewing type in which the results of the postprocess calculation will be presented.

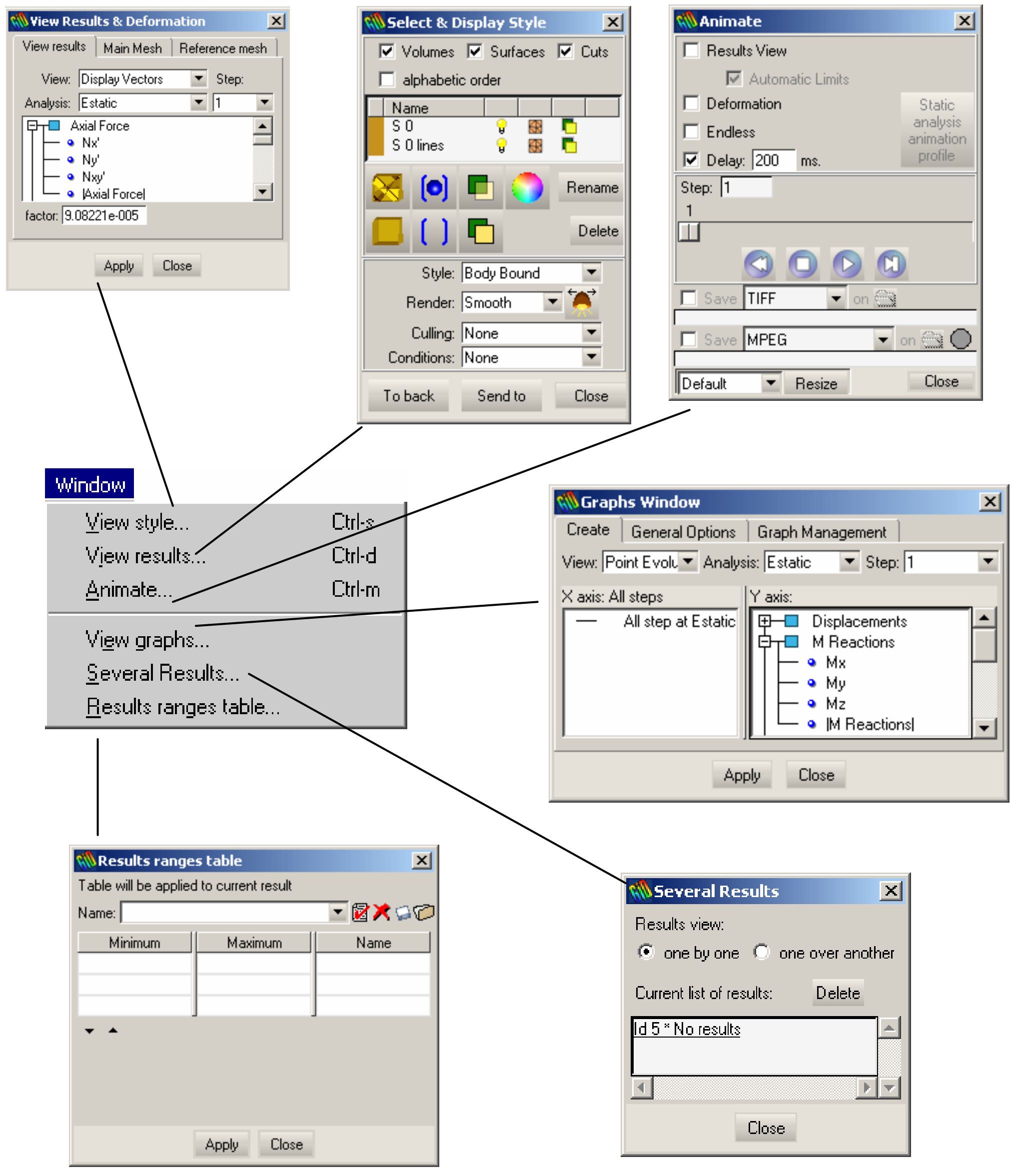


Options

Options permit the user to make choices related to the presentation of results: for example, color changes, number of result subdivisions, etc.



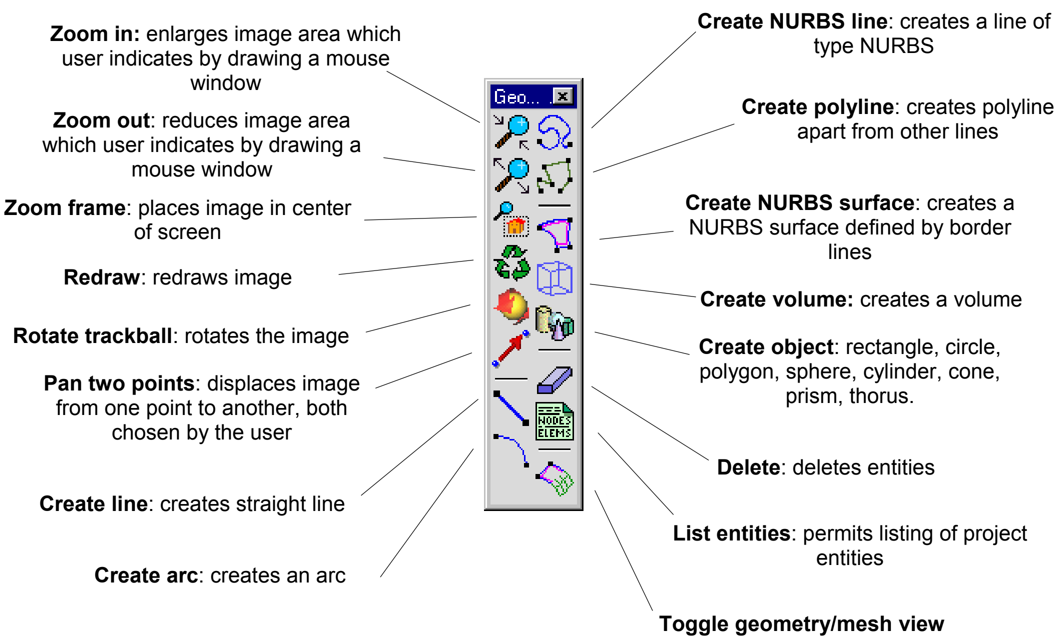
Postprocess windows



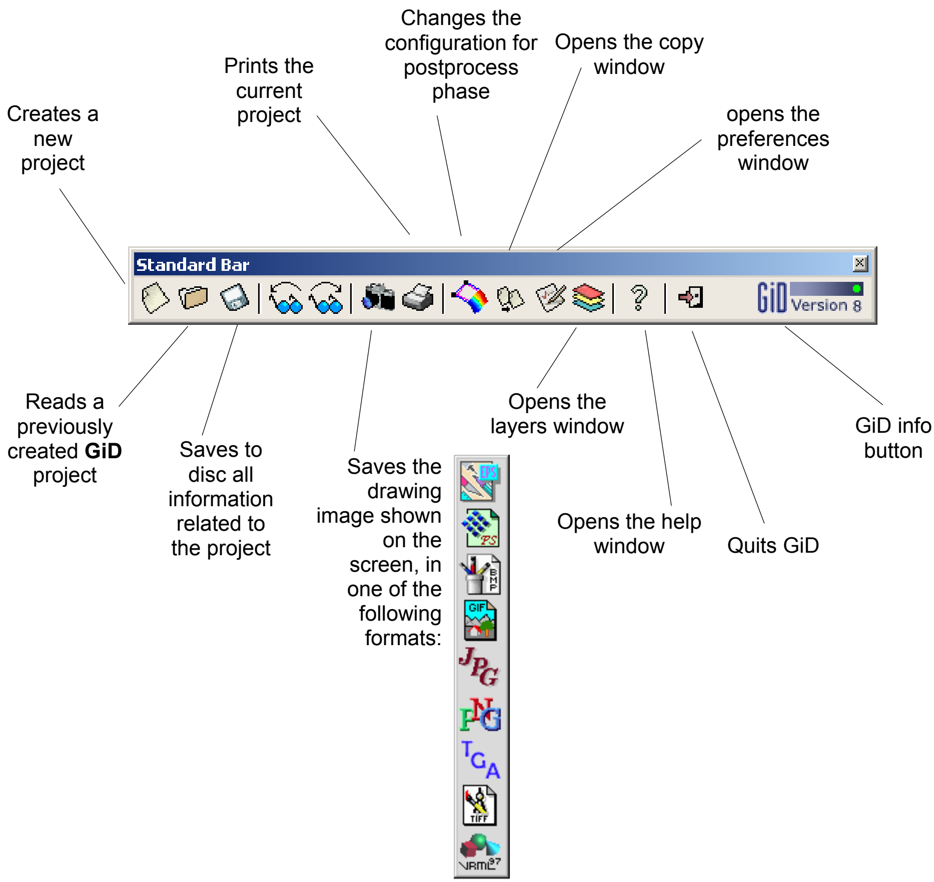
2. TOOLBARS

Option **Utilities→Graphical→Toolbars** opens a window where it's possible to configure the toolbars position or switch them on and off.

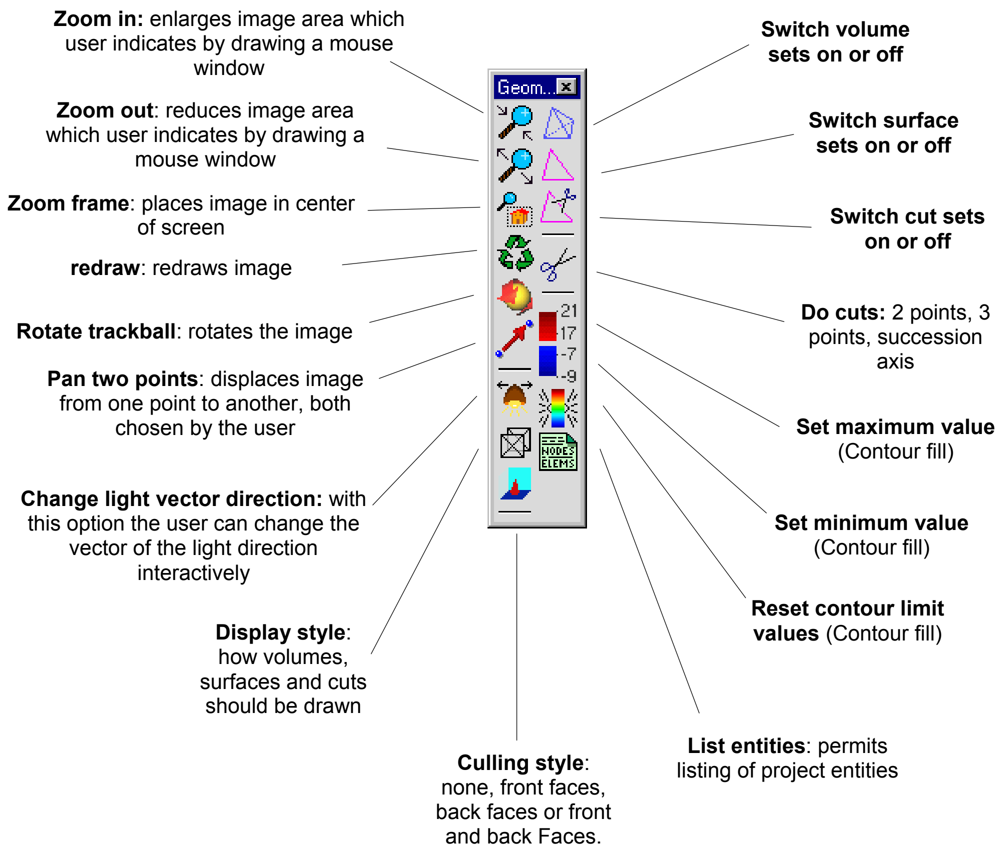
Geometry and View operations
(preprocess)



Standard toolbar

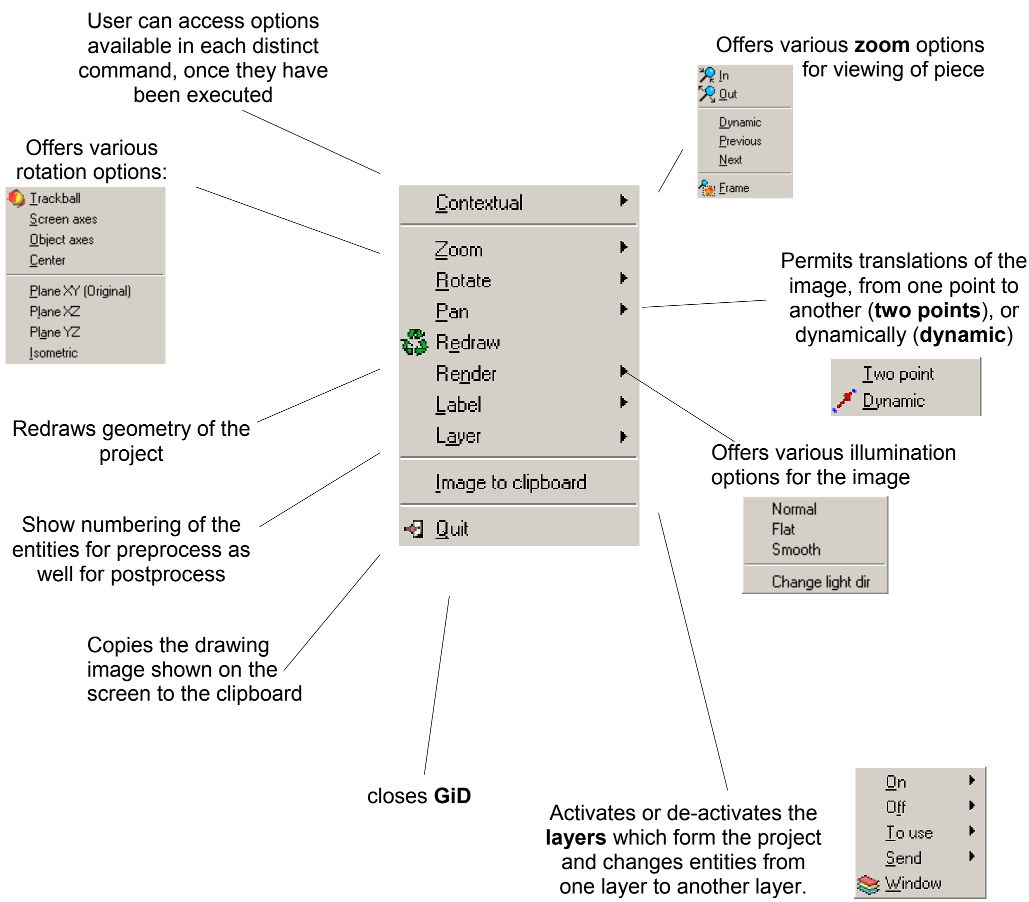


Geometry and View operations
(postprocess)



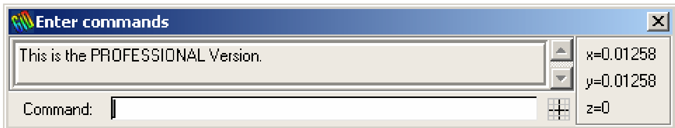
3. MOUSE MENU

The **Mouse Menu** is the auxiliary menu which appears by clicking on the right mouse button while the cursor is over the **GiD** screen.
The **Mouse Menu** permits the user to quickly access various image placement and viewing commands, to facilitate easy management and definition of the project.
Furthermore, the **Mouse Menu** contains the **Contextual** menu, which permits the user to access to all options available in previously performed commands. The option **Contextual** is only available after the user has performed a command from the **Top Menu**.



4. COMMAND LINE

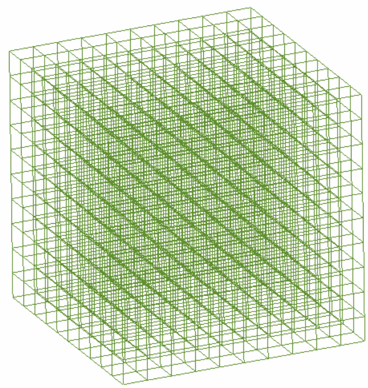
The **Command Line** option allows the user to directly enter all executable **GiD** commands, without accessing the commands through drop-down menus.



These commands should be written following the order which **GiD** would use to define them, according to the **Right buttons** menus.
A side comment in reference to the **Command Line**: **GiD** does not distinguish between the use of capital and small letters. In addition, in cases where ambiguities do not exist, commands need not be written in entire words, but can be written with the primary characters of each word.

INITIATION TO GID

With this example, the user is introduced to the basic tools for the creation of geometric entities and mesh generation.



FIRST STEPS

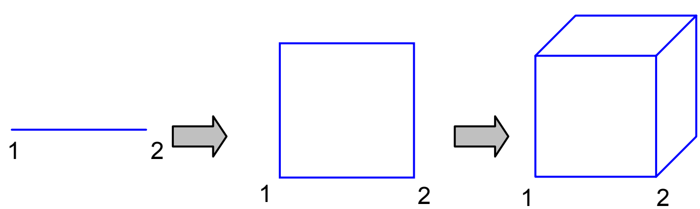
Before presenting all the possibilities that **GiD** offers, we will present a simple example that will introduce and familiarize the user with the **GiD** program.

The example will develop a finite element problem in one of its principal phases, the preprocess, and will include the consequent data and parameter description of the problem. This example introduces creation, manipulation and meshing of the geometrical entities used in **GiD**.

First, we will create a line and the mesh corresponding to the line. Next, we will save the project and it will be described in the **GiD** data base form. Starting from this line, we will create a square surface, which will be meshed to obtain a surface mesh. Finally, we will use this surface to create a cubic volume, from which a volume mesh can then be generated.

1. CREATION AND MESHING OF A LINE

We will begin the example creating a line by defining its origin and end points, points 1 and 2 in the following figure, whose coordinates are (0,0,0) and (10,0,0) respectively.
It is important to note that in creating and working with geometric entities, **GiD** follows the following hierarchical order: point, line, surface, and volume.

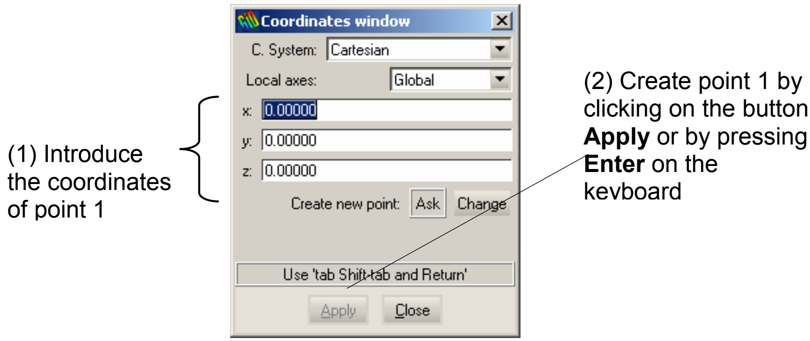


To begin working with the program, open **GiD**, and a new **GiD** project is created automatically. From this new database, we will first generate points 1 and 2.

Next, we will create points 1 and 2. To do this, we will use an **Auxiliary Window** that will allow us to simply describe the points by entering coordinates. It is accessed by the following sequence: **Utilities→Tools→Coordinates Window**

Then, from the Top Menu, select **Geometry→Create→Point**

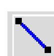
In the coordinate window opened previously, the following indicated steps should be used:



And create point 2 in the same way, introducing its coordinates in the **Coordinates Window**.

The last step in the creation of the points, as well as any other command, is to press **Escape**, either via the **Escape** button on the keyboard or by pressing the central mouse button. Select **Close** to close the **Coordinates Window**.

Now, we will create the line that joins the two points. Choose from the **Top Menu**: **Geometry→Create→Straight line.** Option in the **Toolbar** shown below can also be used.



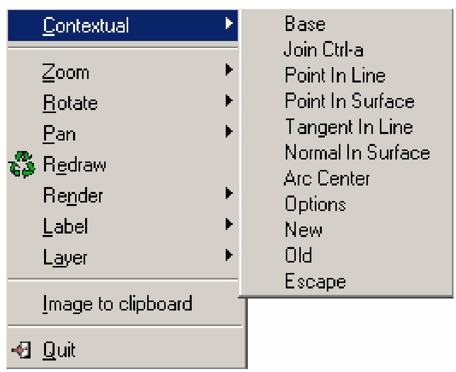
Next, the origin point of the line must be defined. In the **Mouse Menu**, opened by clicking the right mouse button, select **Contextual→Join C-a.**

NOTE: With option Join, a point already created can be selected on the screen. The command No Join is used to create a new point that has the coordinates of the point that is selected on the screen. We can see that the cursor changes form for the Join and No Join commands.

- Cursor during use of **Join** command
- Cursor during use of No **Join** command

Now, choose on the screen the first point, and then the second, which define the line. Finally, press **Escape** to indicate that the creation of the line is completed.

NOTE: It is important to note that the Contextual submenu in the Mouse Menu will always offer the options of the command that is currently being used. In this case, the corresponding submenu for line creation, has the following options:

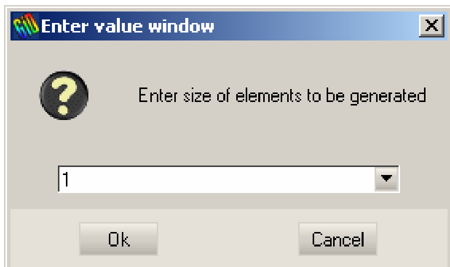


Once the geometry has been created, we can proceed to the line meshing. In this example, this operation will be presented in the simplest and most automatic way that **GiD** permits. To do this, from the **Top Menu** select: **Mesh→Generate mesh.**

And an **Auxiliary Window** appears, in which the size of the elements should be defined by the user.

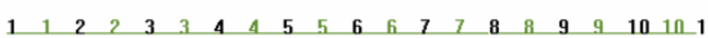
NOTE: The size of an element with two nodes is the length of the element. For, surfaces or volumes, the size is the mean length of the edge of the element.

In this example, the size of the element is defined in concordance with the length of the line, chosen for this case as size 1.



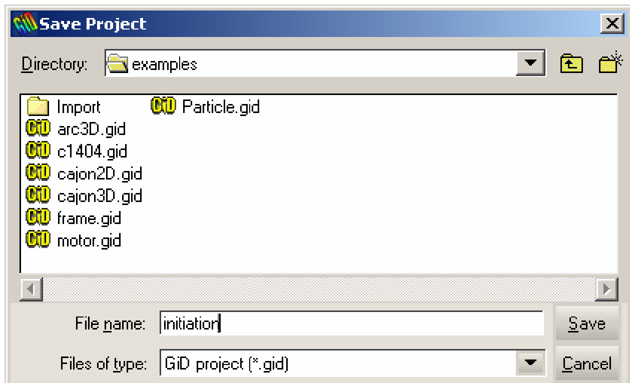
Automatically **GiD** generates a mesh for the line. The finite element mesh is presented on the screen in a green color.

The mesh is formed by ten linear elements of two nodes. To see the numbering of the nodes and mesh elements, select from the **Mouse Menu: Label→All,** and the numbering for the 10 elements and 11 nodes will be shown, as below.



Once the mesh has been generated, the project should be saved. To save the example select from the **Top Menu: Files→Save.**

The program automatically saves the file if it already has a name. If it is the first time the file has been saved, the user is asked to assign a name. For this, an **Auxiliary Window** will appear which permits the user to browse the computer disk drive and select the location in which to save the file. Once the desired directory has been selected, the name for the actual project can be entered in the space titled **File Name**.



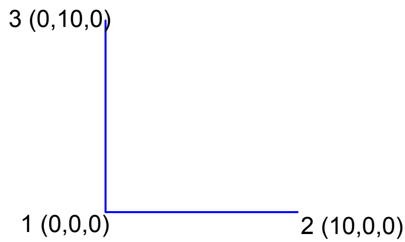
NOTE: Next, the manner in which **GiD** saves the information of a project will be explained. **GiD** creates a directory with a name chosen by the user, and whose file extension is **.gid**. **GiD** creates a set of files in this directory where all the information generated in the present example is saved. All the files have the same name of the directory to which they belong, but with different extensions. These files should have the name that **GiD** designates and should not be changed manually.

Each time the user selects option **save** the database will be rewritten with the new information or changes made to the project, always maintaining the same name.
To exit **GiD**, simply choose **Files→Quit.**

To access the example, **ejemplo.gid**, simply open **GiD** and select from the **Top Menu: Files→Open.** An **Auxiliary Window** will appear which allows the user to access and open the directory **iniciación.gid**.

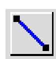
2. CREATION AND MESHING OF A SURFACE

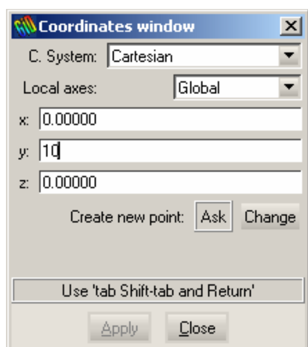
We will now continue with the creation and meshing of a surface.
First, we will create a second line between points 1 and 3.



We will now generate the second line. We will now use again the **Coordinates Window** to enter the points. (**Utilities→Tools→Coordinates Window**)

Select the line creation tool in the toolbar. Enter point (0,10,0) in the **Coordinates Window** and click **Apply**.

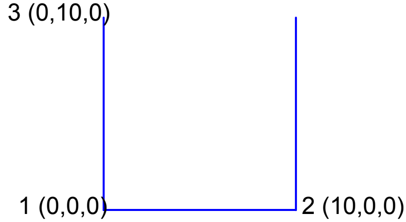


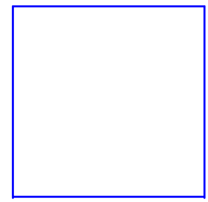


With option **Join** (Contextual mouse menu) click over point 1. A line should be created between (0,10,0) and (0,0,0). Press **Escape**.

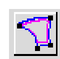
With this, a right angle of the square has been defined. If the user wants to view everything that has been created to this point, the image can be centered on the screen by choosing in the **Mouse Menu: Zoom→Frame**. This option is also available in the toolbar.

Finish the square by creating point (10,10,0) and the lines that join this point with points 2 and 3.

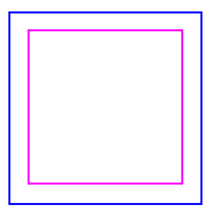




Now, we will create the surface that these four lines define. To do this, access the create surface command by choosing: **Geometry→Create→NURBS surface→By contour**. This option is also available in the toolbar:

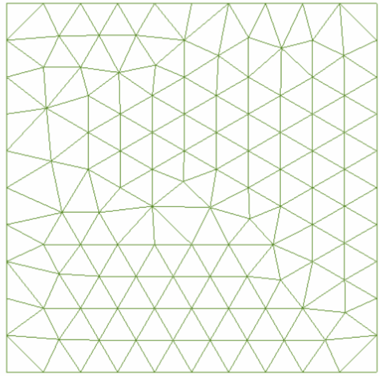


GiD then asks the user to define the 4 lines that describe the contour of the surface. Select the lines using the cursor on the screen, either by choosing them one by one or selecting them all with a window. Next, press **Escape**.
As can be seen below, the new surface is created and appears as a smaller, magenta-colored square drawn inside the original four lines.



Once the surface has been created, the mesh can be created in the same way as was done for the line. From the **Top Menu** select: **Mesh→Generate mesh.**

An **Auxiliary Window** appears which asks for the maximum size of the element, in this example defined as 1.

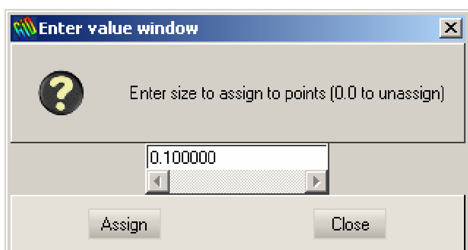


We can see that the lines containing elements of two nodes have not been meshed. Rather the mesh generated over the surface consists of planes of three-nodded, triangular elements.

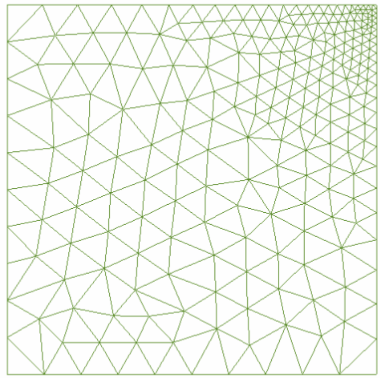
NOTE: GiD meshes by default the entity of highest order with which it is working.

GiD allows the user to concentrate elements in specified geometry zones. Next, a brief example will be presented in which the elements are concentrated in the top right corner of the square.

This operation is realized by assigning a smaller element size to the point in this zone than for the rest of the mesh. Select the following sequence: **Mesh→ Unstructured→Assign sizes on points.** The following dialog box appears, in which the user can define the size:



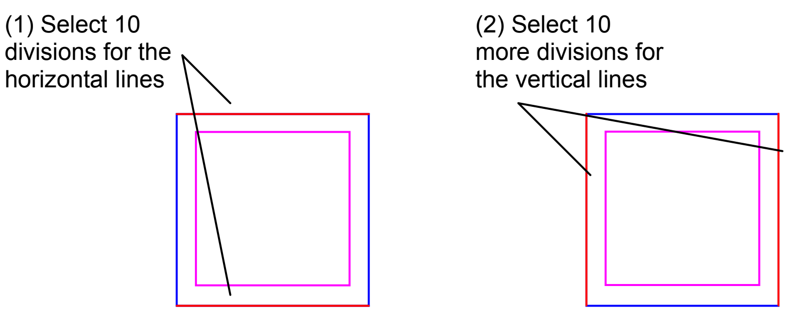
We must now regenerate the mesh, canceling the mesh generated earlier, and we obtain the following:



As can be seen in the figure above, the elements are concentrated around the chosen point. Various possibilities exist for controlling the evolution of the element size, which will be presented later in the manual.

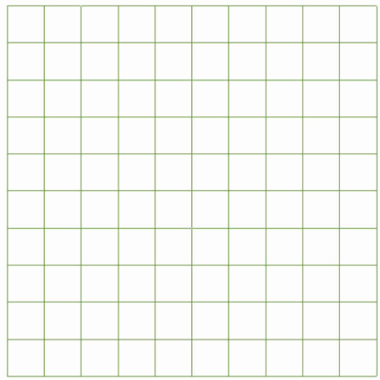
To generate a surface mesh in which the elements are presented uniformly, the user can select the option for a structured mesh. This guarantees that the same number of elements appears around a node and that the element size is as uniform as possible. To generate this type of mesh, choose: **Mesh→Structured→Surfaces.**

Using this command, the user should first select the **4-sided NURBS surface** that will be defined by the mesh. Then, the number of subdivisions for the surface limit lines should be entered. Pairs of lines define the partitions in the following way:

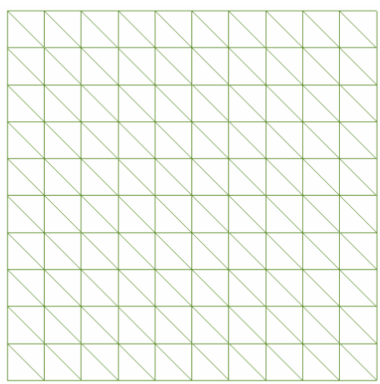


NOTE: GiD only generates structured meshes for surfaces of the type **4-sided surface** or **NURBS surface**.

When this has been done, the mesh is generated in the same way as the unstructured mesh, by choosing **Mesh→Generate mesh.**
Assign a general element size of 1, though in this case it is not necessary.



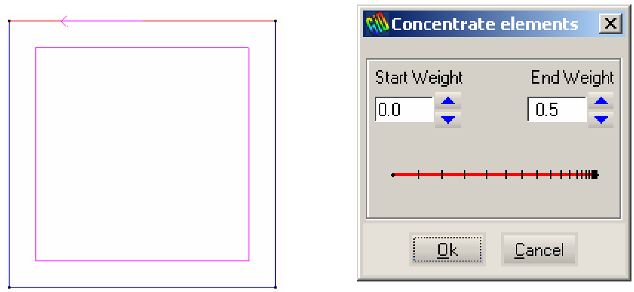
We can see here that the default element type used by **GiD** to create a structured mesh is a square element of four nodes rather than a three-nodded, triangular element. To obtain triangular elements, the user can specifically define this type of element, by choosing **Mesh→Element type→Triangle,** and selecting the surface to mesh as a triangular element. Regenerate the mesh, and the following figure is obtained:



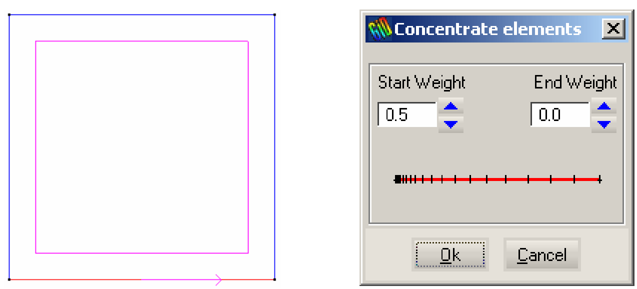
GiD also allows the user to concentrate elements in structured meshes. This can be done by selecting **Mesh→Structured→Lines→Concentrate elements**

First, we must select the lines that need to be assigned an element concentration weight. The value of this weight can be either positive or negative, depending on whether the user wants to concentrate elements at the beginning or end of the lines. Next, a vector appears which defines the start and end of the line and which helps the user assign the weight correctly.

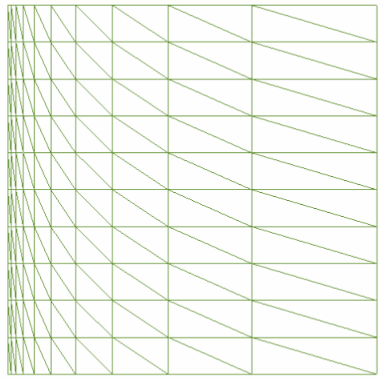
Select the top line and assign a weight of 0.5 to the end of the line:



Select the bottom line and assign a weight of 0.5 to the beginning of the line:



From these operations, we obtain the following mesh:



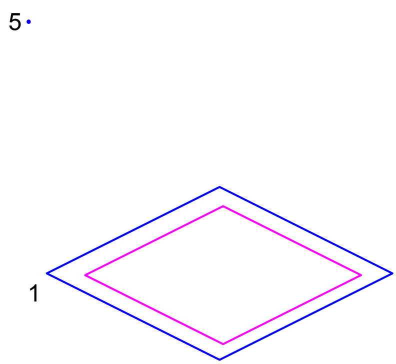
We can see that in the figure above, the elements are concentrated in the left zone of the square.

3. CREATION AND MESHING OF A VOLUME

We will now present a study of entities of volume. To illustrate this, a cube and a volume mesh will be generated.
Without leaving the project, save the work done up to now by choosing **Files→Save,** and return to the geometry last created by choosing **Geometry→View geometry.**

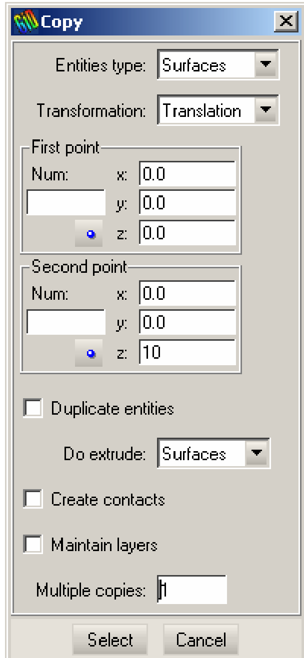
In order to create a volume from the existing geometry, firstly we must create a point that will define the height of the cube. This will be point 5 with coordinates (0,0,10), superimposed on point 1. To view the new point, we must rotate the figure by selecting from the **Mouse Menu, Rotate→Trackball.** This option is also available in the toolbar:

Rotate the figure until the following position is achieved:



Next, we will create the upper face of the cube by copying from point 1 to point 5 the surface created previously. To do this, select the copy command, **Utilities→Copy.**

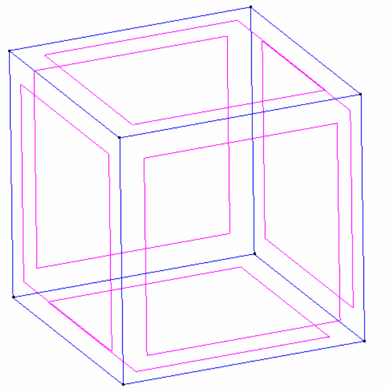
In the **Copy** window, we define the translation vector with the first and second points, in this case (0,0,0) and (0,0,10). Option **Do extrude surfaces** must be selected; this option allows us to create the lateral surfaces of the cube.



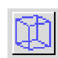
NOTE: If we look at the **Copy Window,** we can see an option called **Duplicate entities**. By activating this option, when the entities are copied (in this case from point 1 to point 5) **GiD** would create a new point (point 6) with the same coordinates as point 5.

If the user does not choose option **Duplicate entities**, point 6 will be merged with point 5 when the entities are copied. By labeling the entities we could verify that only one point has been created.

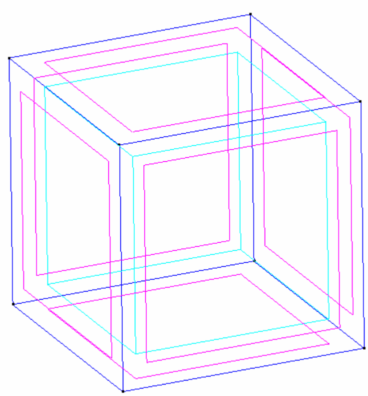
Finishing the copy command for the surface, we obtain the following surfaces:



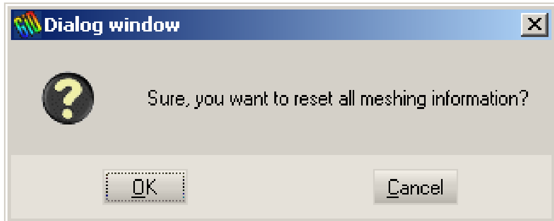
Now, we can generate the volume delimited by these surfaces. To create the volume, simply select the command **Geometry→Create→Volume→By contour**. This option is also available in the toolbar:



Select all the surfaces. **GiD** automatically generates the volume of the cube. The volume viewed on the screen is represented by a cube with an interior color of sky blue.



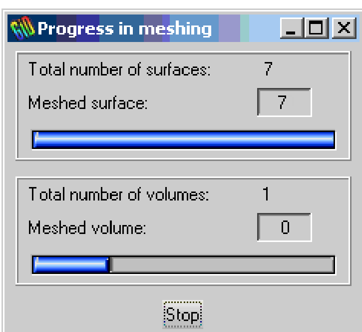
Before proceeding with the mesh generation of the volume, we should eliminate the information of the structured mesh created previously for the surface. Do this by selecting **Mesh→Reset mesh data,** and the following dialog box will appear on the screen:

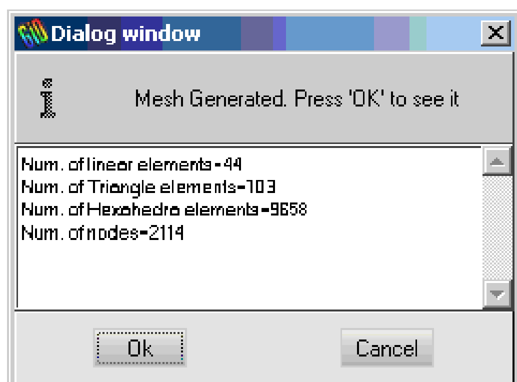


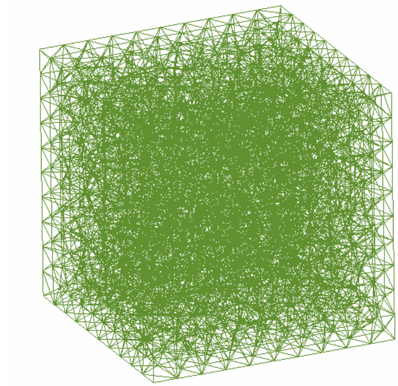
In which the user is asked to confirm the erasure of the mesh information.

NOTE: Another valid option would be to assign a size of 0 to all entities. This would eliminate all the previous size information as well as the information for the mesh, and the default options would become active.

Next, generate the mesh of the volume by choosing **Mesh→Generate mesh.** Another **Auxiliary Window** appears into which the size of the volumetric element must be entered. In this example, the value is 1.

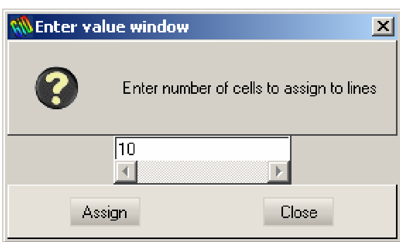


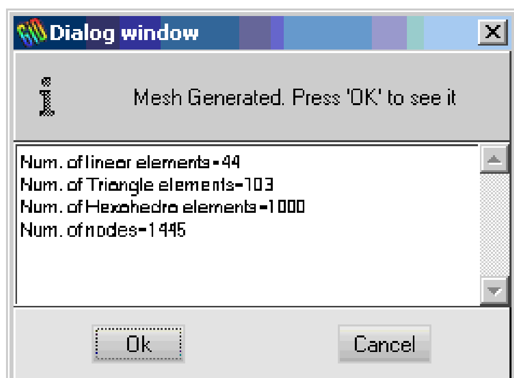


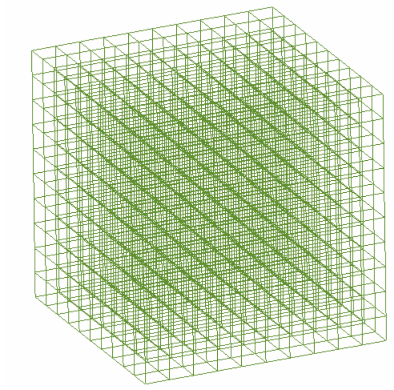


The mesh generated above is composed of tetrahedral elements of four nodes, but **GiD** also permits the use of hexahedral, eight-nodded structured elements.
We will generate a structured mesh of the volume of the cube. This is done by selecting **Mesh→Structured→Volumes.**

Now select the volume to mesh and enter the number of partitions in its edges which will be created. Then, create again the mesh.







NOTE: GiD only allows the generation of structured meshes of 6-sided volumes.

With this example, the user has been introduced to the basic tools for the creation of geometric entities and mesh generation.

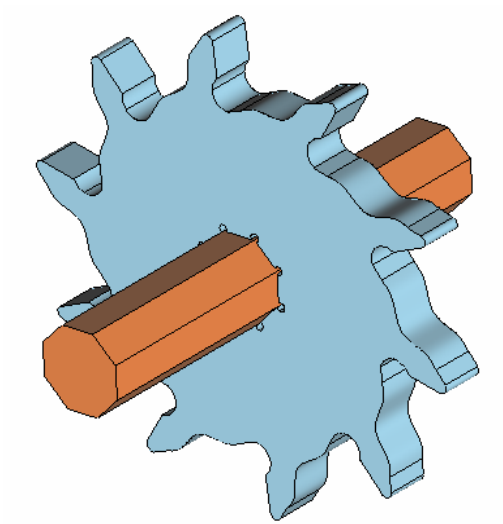
CASE STUDY 1

IMPLEMENTING A MECHANICAL PART

The objective of this case study is implementing a mechanical part in order to study it through meshing analysis. The development of the model consists of the following steps:

- Creating a profile of the part
- Generating a volume defined by the profile
- Generating the mesh for the part

At the end of this case study, you should be able to handle the 2D tools available in GiD as well as the options for generating meshes and visualizing the prototype.



1. WORKING BY LAYERS

1.1. Defining the layers

A geometric representation is composed of four types of entities, namely points, lines, surfaces, and volumes.

A layer is a grouping of entities. Defining layers in computer-aided design allows us to work collectively with all the entities in one layer.

The creation of a profile of the mechanical part in our case study will be carried out with the help of auxiliary lines. Two layers will be defined in order to prevent these lines from appearing in the final drawing. The lines that define the profile will be assigned to one of the layers, called the “profile” layer, while the auxiliary lines will be assigned to the other layer, called the “aux” layer. When the design of the part has been completed, the entities in the “aux” layer will be erased.

1.2. Creating two new layers

1. Open the layer management window. This is found in **Utilities→Layers**.
2. Create two new layers called “aux” and “profile.” Enter the name of each layer in the **Layers** window (Figure 1) and click **New**.
3. Choose “aux” as the activated layer. To do this, click on “aux” to highlight it and then click on the **Layer To Use** button. (Next to this button the name of the activated layer will appear, “aux” in the present case.) From now on, all the entities created will belong to this layer.

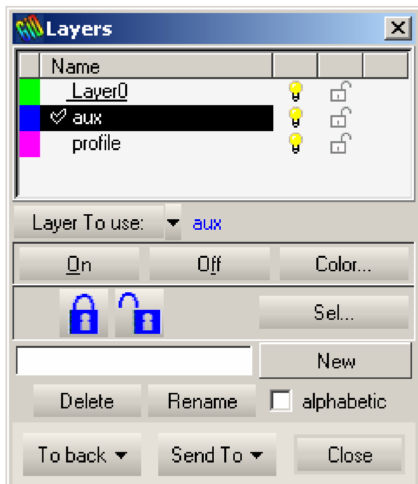


*Figure 1. The **Layers** window*

2. CREATING A PROFILE

In our case, the profile consists of various teeth. Begin by drawing one of these teeth, which will be copied later to obtain the entire profile.

2.1. Creating a size-55 auxiliary line

1. Choose the **Line** option, by going to **Geometry→Create→Straight line** or by going to the GiD Toolbox[1].
2. Enter the coordinates of the beginning and end points of the auxiliary line[2]. For our example, the coordinates are (0, 0) and (55, 0), respectively. Besides creating a straight line, this operation implies creating the end points of the line.
3. Press **ESC**[3] to indicate that the process of creating the line is finished.
4. If the entire line does not appear on the screen, use the **Zoom Frame** option, which is located in the GiD Toolbox and in **Zoom** in the mouse menu.

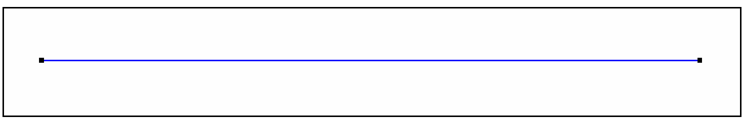


Figure 2. Creating a straight line

NOTE: The **Undo** option, located in **Utilities→Undo**, enables you to undo the most recent operations. When this option is selected, a window appears in which all the operations to be undone can be selected.

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[1] The GiD Toolbox is a window containing the icons for the most frequently executed operations. For information on a particular tool, click on the corresponding icon with the right mouse button.

[2] The coordinates of a point may be entered on the command line either with a space or a comma between them. If the Z coordinate is not entered, it is considered 0 by default. After entering the numbers, press **Return**. Another option for entering a point is using the **Coordinates Window**, found in **Utilities→Tools→Coordinates Window**.

[3] Pressing the **ESC** key is equivalent to pressing the center mouse button.

2.2. Dividing the auxiliary line near "point" (coordinates) (40, 0)

1. Choose **Geometry→Edit→Divide→Lines→NearPoint.** This option will divide the line at the point ("element") on the line closest to the coordinates entered.
2. Enter the coordinates of the point that will divide the line. In this example, the coordinates are (40, 0). On dividing the line, a new point (entity) has been created.
3. Select the line that is to be divided by clicking on it.
4. Press **ESC** to indicate that the process of dividing the line is finished.

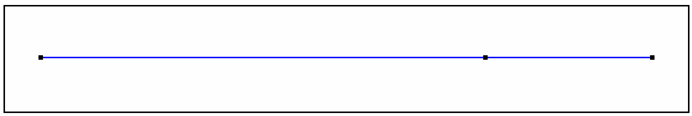

Figure 3. Division of the straight line near "point" (coordinates) (40, 0)

2.3. Creating a 3.8-radius circle around point (40, 0)

1. Choose the option **Geometry→Create→Object→Circle**.
2. The center of the circle (40, 0) is a point that already exists. To select it, go to Contextual→**Join Ctrl-a** in the mouse menu (right-click). The pointer will become a square, which means that you may click an existing point.
3. The Enter Normal window appears. Set the normal as Positive Z and press OK.
4. Enter the radius of the circle. The radius is 3.8[4]. Two circumferences are visualized; the inner circumference represents the surface of the circle.
5. Press **ESC** to indicate that the process of creating the circle is finished.

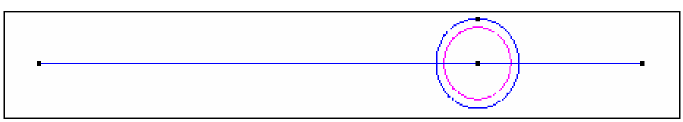

Figure 4. Creating a circle around a point (40, 0)

[4] In GiD the decimals are entered with a point, not a comma.

2.4. Rotating the circle -3 degrees around a point

1. Use the **Move** window, which is located in **Utilities→Move**.
2. Within the **Move** menu and from among the **Transformation** possibilities, select **Rotation**. The type of entity to receive the rotation is a surface, so from the **Entities Type** menu, choose **Surfaces**.
3. Enter -3 in the **Angle** box and check the **Two dimensions** box. (Provided we define positive rotation in the mathematical sense, which is counter-clockwise, -3 degrees equates to a clockwise rotation of 3 degrees.)
4. Enter the point (0, 0, 0) under **First Point**. This is the point that defines the center of rotation.
5. Click **Select** to select the surface that is to rotate, which in this case is that of the circle.
6. Press **ESC** (or **Finish** in the **Move window**) to indicate that the selection of surfaces to rotate has been made, thus executing the rotation.

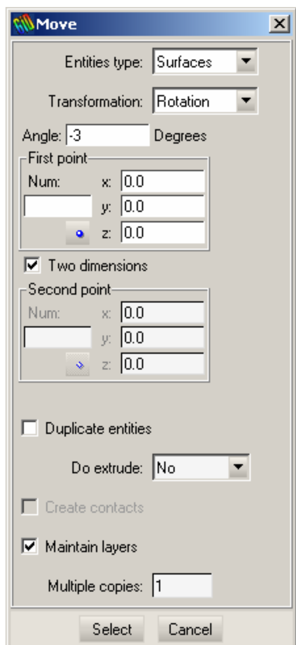

Figure 5. The Move window

2.5. Rotating the circle 36 degrees around a point and copying it.

1. Use the **Copy** window, located in **Utilities→Copy**.
2. Repeat the rotation process explained in section 2.4, but this time with an angle of 36 degrees (see Figure 6).

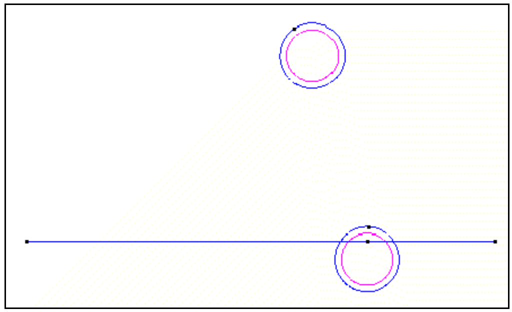

Figure 6. Result of the rotations

NOTE: The **Move** and **Copy** operations differ only in that **Copy** creates new entities while **Move** displaces entities.

2.6. Rotating and copying the auxiliary lines

1. Use the **Copy** window, located in **Utilities→Copy** (see Figure 9).
2. Repeat the rotating and copying process from section 2.5 for the two auxiliary lines. Select the option **Lines** from the **Entities type** menu and enter an angle of 36 degrees.
3. Select the lines to copy and rotate. Do this by clicking **Select** in the **Copy** window.
4. Press **ESC** to indicate that the process of selecting lines is finished, thus executing the task (see Figure 7).

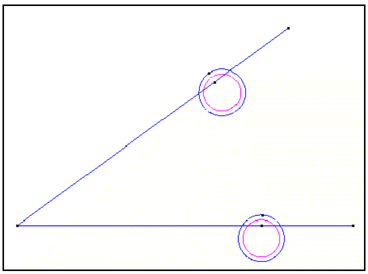

Figure 7. Result of copying and rotating the line.

Rotate the line segment that goes from the origin to point (40, 0) by 33 degrees and copy it (see Figure 8).

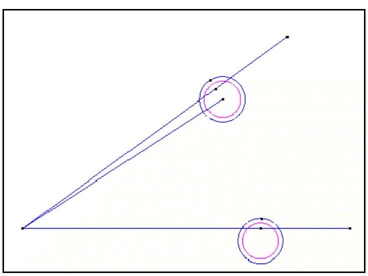

Figure 8. Result of the rotations and copies

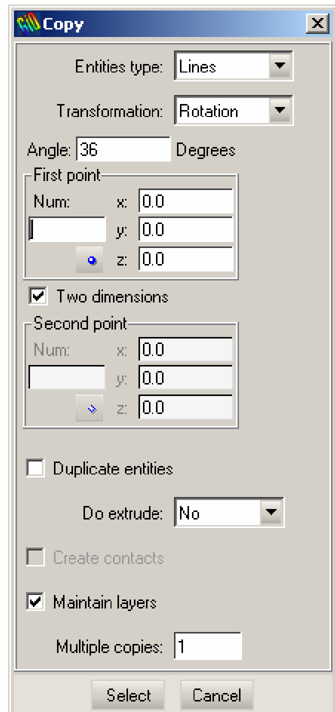

Figure 9. The copy window

NOTE: In the **Copy** and **Move** windows, the option **Pick** may be used to select existing points with the mouse.

2.7. Intersecting lines

Choose the option **Geometry→Edit→ Intersection→Line-line**.

Select the upper circle resulting from the 36-degree rotation executed in section 2.5.

Select the line resulting from the 33-degree rotation executed in section 2.6 (see Figure 10).

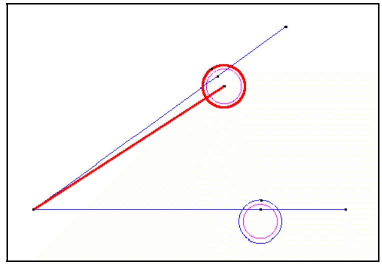
Figure 10. The two lines selected

Press **ESC** to conclude the intersection of lines.

Create a line between point (55, 0) and the point generated by the intersection. To select the points, use the option **Join Ctrl-a** in the **Contextual** menu.

Choose the option **Geometry→Edit→ Intersection→Line-line** in order to make another intersection between the lower circle and the line segment between point (40, 0) and point (55, 0) (see Figure 11).

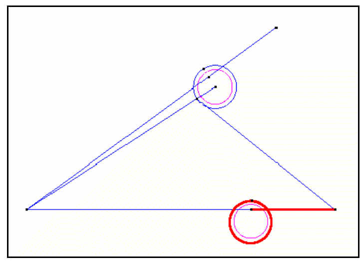
Figure 11. Intersecting lines

Then continue selecting to make an intersection between the upper circle and the farthest segment of the line that was rotated 36 degrees (see Figure 12).

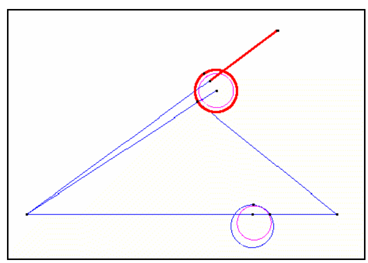
Figure 12. Intersecting lines

2.8. Creating an arc tangential to two lines

1. Choose **Geometry→Create→Arc→Fillet curves**.
2. Enter a radius of 1.35 in the command line (see footnote 2 on page 4).
3. Now select the two line segments shown in Figure 13. Then press **ESC** to indicate that the process of creating the arcs is finished.

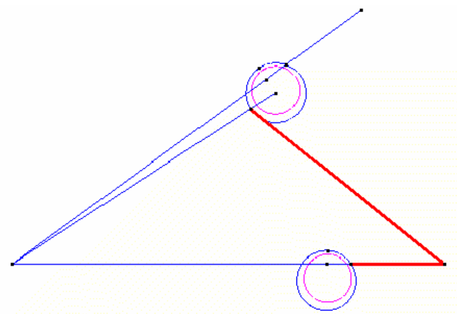

Figure 13. The line segments to be selected

2.9. Translating the definitive lines to the "profile" layer

1. Select the "profile" layer in the **Layers** window. The auxiliary lines will be eliminated and the "profile" layer will contain only the definitive lines.
2. In the **Sent To** menu of the **Layers** window, choose **Lines** in order to select the lines to be translated. Select only the lines that form the profile (Figure 14). To conclude the selection process, press the **ESC** key or click **Finish** in the **Layers** window.

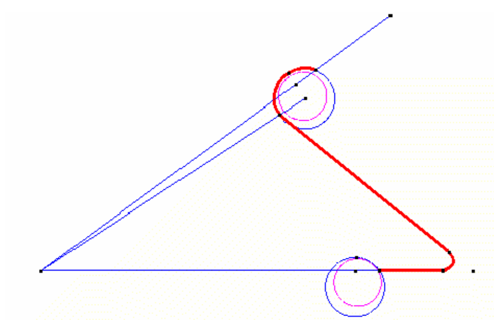

Figure 14. Lines to be selected

2.10. Deleting the "aux" layer

1. Click **Off** the profile layer.
2. Choose **Geometry→Delete→All Types** (or use the GiD Toolbox).
3. Select all the lines and surfaces that appear on the screen. (The click-and-drag technique may be used to make the selection.)
4. Press **ESC** to conclude the selection of elements to delete.
5. Select the "aux" layer in the **Layers** window and click **Delete**.
6. Select the "profile" layer.

NOTE: When a layer is clicked **Off**, GiD reminds you of this. From this moment on, whatever is drawn does not appear on the screen since it is in the hidden layer.

NOTE: To cancel the deletion of elements after they have been selected, open the mouse menu, go to **Contextual** and choose **Clear Selection**.

NOTE: Elements forming part of higher level entities may not be deleted. For example, a point that defines a line may not be deleted.

NOTE: A layer containing information may not be deleted. First the contents must be deleted.

2.11. Rotating and obtaining the final profile

1. Make sure that the activated layer is the "profile" layer. (Use the option **Layer To use.**)
2. In the **Copy** window, select the line rotation (**Rotation**, **Lines**).
3. Enter an angle of 36 degrees. Make sure that the center is point (0, 0, 0) and that you are working in two dimensions.
4. In the **Multiple Copies** box enter 9. This way, 9 copies will be made, thus obtaining the 10 teeth that form the profile of the model (9 copies and the original).
5. Click **Select** and select the profile. Press the **ESC** key or click **Finish** in the **Copy** window in order to conclude the operation. The result is shown in Figure 15.

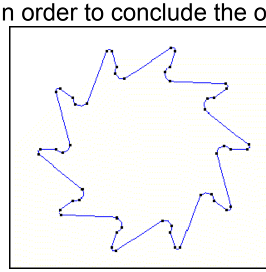

Figure 15. The part resulting from this process

2.12. Creating a surface

1. Create a NURBS surface. To do this, select the option **Geometry→ Create→NURBS Surface→By Contour.** This option can also be found in the GiD Toolbox.
2. Select the lines that define the profile of the part and press **ESC** to create the surface.
3. Press **ESC** again to exit the function. The result is shown in Figure 16.

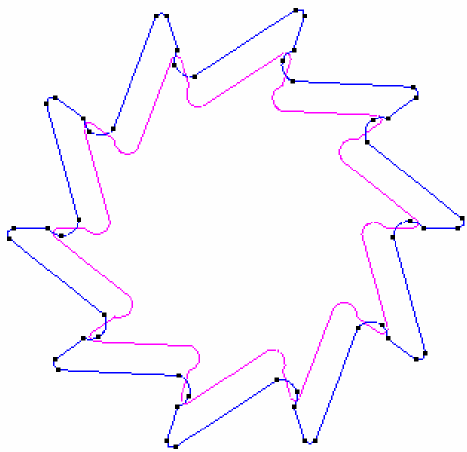

Figure 16. Creating a surface starting from the contour

NOTE: To create a surface there must be a set of lines that define a closed contour.

3. CREATING A HOLE IN THE PART

In the previous sections we drew the profile of the part and we created the surface. In this section we will make a hole, an octagon with a radius of 10 units, in the surface of the part. First we will draw the octagon.

1. Select from the menu **Geometry→Create→Object→Polygon** to create a regular polygon.
2. Enter 8 as the number of sides of the polygon.
3. Enter (0,0,0) as the center of the polygon.
4. Enter or select (0,0,1) (*Positive Z*) as the normal of the polygon.
5. Enter 10 as the radius of the polygon and press **ENTER**. Press **ESC** to finish the action.

We get the result as shown in figure 20. As we only need the boundary we should remove the associated surface. Select the option **Geometry→Delete→Surfaces** and then select the surface of the octagon. Press **ESC** to finish.

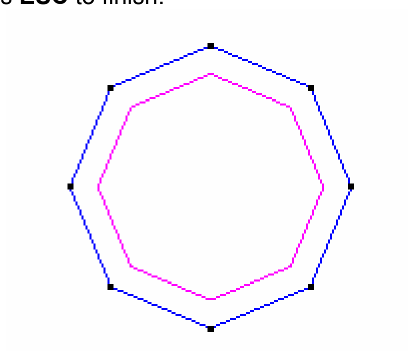

Figure 17. Regular 8-sided polygon

3.1. Creating a hole in the surface of the mechanical part

1. Choose the option Geometry→**Edit→Hole NURBS Surface**.
2. Select the surface in which to make the hole (Figure 18).
3. Select the lines that define the hole (Figure 19) and press **ESC**.

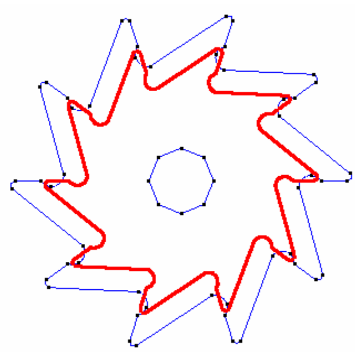

Figure 18. The selected surface in which to create the hole

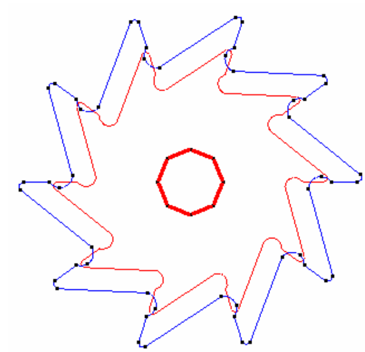

Figure 19. The selected lines that define the hole

4. Again, press **ESC** to exit this function.

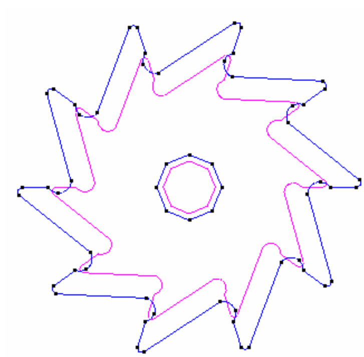

Figure 20. The model part with the hole in it

4. CREATING VOLUMES FROM SURFACES

The mechanical part to be constructed is composed of two volumes: the volume of the wheel (defined by the profile), and the volume of the axle, which is a prism with an octagonal base that fits into the hole in the wheel. Creating this prism will be the first step of this stage. It will be created in a new layer that we will name “prism”.

4.1. Creating the “prism” layer and translating the octagon to this layer

1. In the **Layers** window, type the name of the new layer and click **New**.
2. Select the “prism” layer and click **Layer To use** to choose it as the activated layer.
3. Choose **Lines** in the **Sent To** menu in the **Layers** window. Select the lines that define the octagon. Press **ESC** to conclude the selection.
4. Select the “profile” layer and click **Off** to deactivate it.

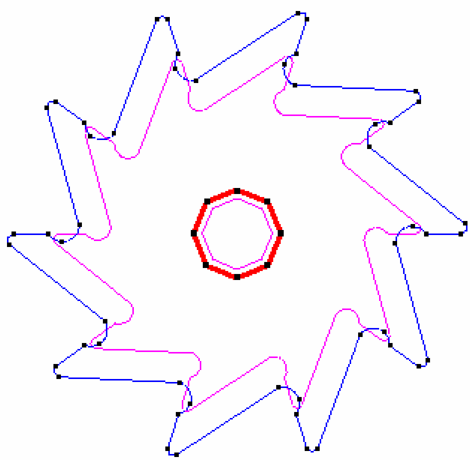

Figure 21. The lines that form the octagon

4.2. Creating the volume of the prism

1. First copy the octagon a distance of -50 units relative to the surface of the wheel, which is where the base of the prism will be located. In the **Copy** window, choose **Translation** and **Lines**. Since we want to translate 50 units, enter two points that define the vector of this translation, for example (0, 0, 0) and (0, 0, 50). (Make sure that the Multiple Copies value is 1, since last time the window was used its value was 9).
2. Choose **Select** and select the lines of the octagon. Press **ESC** to conclude the selection.

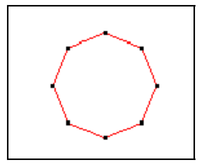

Figure 22. Selection of the lines that form the octagon

3. Since the Z axis is parallel to the user's line of vision, the perspective must be changed to visualize the result. To do this, use the **Rotate Trackball** tool, which is located in the GiD Toolbox and in the mouse menu.

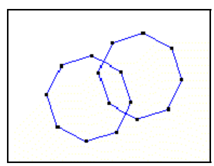

Figure 23. Copying the octagon and changing the perspective

4. Choose **Geometry→Create→NURBS surface→By contour**. Select the lines that form the displaced octagon and press **ESC** to conclude the selection. Again, press **ESC** to exit the function of creating the surfaces.

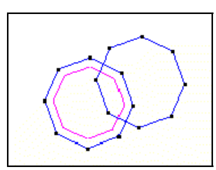

Figure 24. The surface created on the translated octagon

5. In the **Copy** window, choose **Translation** and **Surfaces**. Make a translation of 110 units. Enter two points that define a vector for this translation, for example (0, 0, 0) and (0, 0, -110).
6. To create the volume defined by the translation, select **Do Extrude Volumes** in the **Copy** window.
7. Click **Select** and select the surface of the octagon. Press **ESC**. The result is shown in Figure 25.

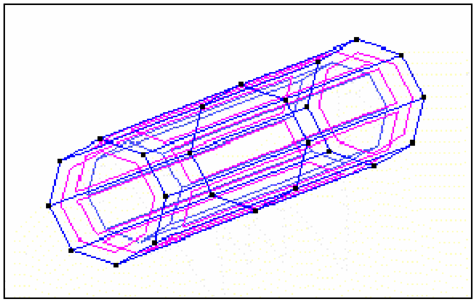

Figure 25. Creation of the volume of the prism

8. Choose the option **Render→Flat** from the mouse menu to visualize a more realistic version of the model. Then return to the normal visualization using **Render→ Normal**.

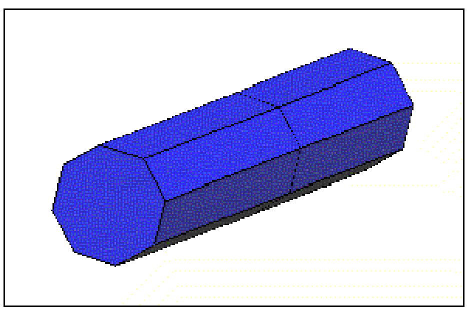

Figure 26. Visualization of the prism with the option Render→Flat.

NOTE: The **Color** option in the **Layers** window lets you define the color of the selected layer. This color is then used in the rendering of elements in that layer.

4.3. Creating the volume of the wheel

1. Visualize the “profile” layer and activate it. The volume of the wheel will be created in this layer. Deactivate the “prism” layer in order to make the selection of the entities easier.
2. In the **Copy** window, choose **Translation** and **Surfaces**. A translation of 10 units will be made. To do this, enter two points that define a vector for this translation, for example (0, 0, 0) and (0, 0, -10).
3. Choose the option **Do Extrude Volumes** from the **Copy** window. The volume that is defined by the translation will be created.
4. Make sure that the **Maintain Layers** option is not checked.
5. Click **Select** and select the surface of the wheel. Press **ESC**.
6. Select the two layers and click them **On** so that they are visible.
7. Choose **Render→Flat** from the mouse menu to visualize a more realistic version of the model (Figure 27).

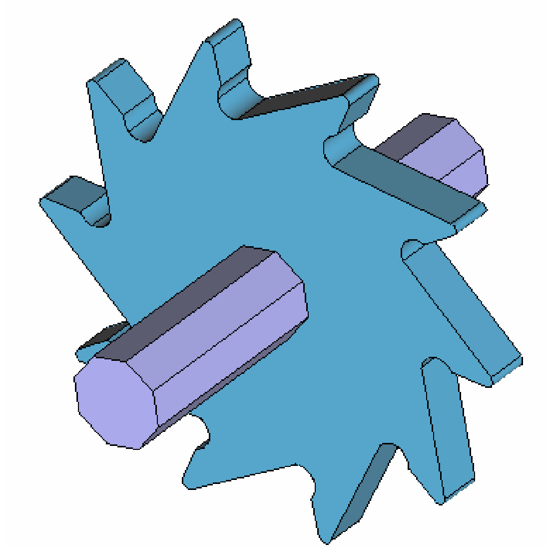

Figure 27. Image of the wheel

5. GENERATING THE MESH

Now that the part has been drawn and the volumes created, the mesh may be generated. First we will generate a simple mesh by default.

Depending on the form of the entity to be meshed, GiD performs an automatic correction of the element size. This correction option, which by default is activated, may be modified in the **Meshing** card of the **Preferences** window, under the option **Automatic correct sizes**. Automatic correction is sometimes not sufficient. In such cases, it must be indicated where a more precise mesh is needed. Thus, in this example, we will increase the concentration of elements along the profile of the wheel by following two methods: 1) assigning element sizes around points, and 2) assigning element sizes around lines.

5.1. Generating the mesh by default

1. Choose **Mesh→Generate Mesh**.
2. A window comes up in which to enter the maximum element size of the mesh to be generated (Figure 28). Leave the default value given by GiD unaltered and click **OK**.

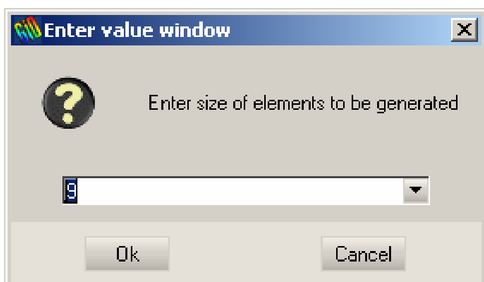

Figure 28. The window in which the maximum element size is entered

3. A window appears showing how the meshing is progressing. Once the process is finished, another window opens with information about the mesh that has been generated (Figure 29). Click **OK** to visualize the resulting mesh (Figure 30).

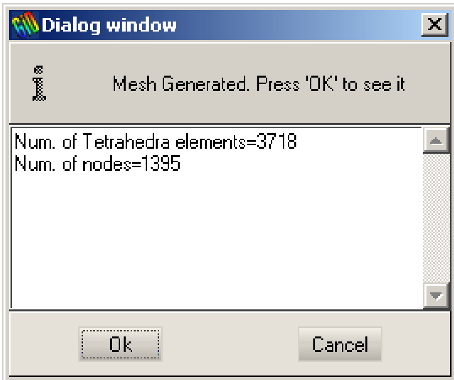

Figure 29. The window with information about the mesh generated

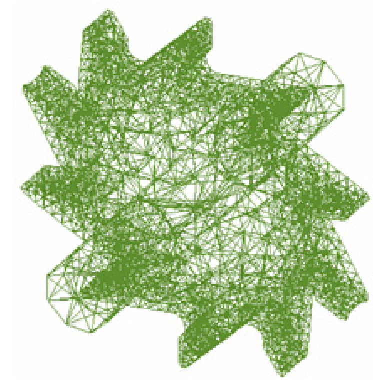

Figure 30. The mesh generated with default settings

4. Use the **Mesh→View mesh boundary** option to see only the contour of the volumes meshed without the interiors (Figure 31). This visualization mode may be combined with the various rendering methods.

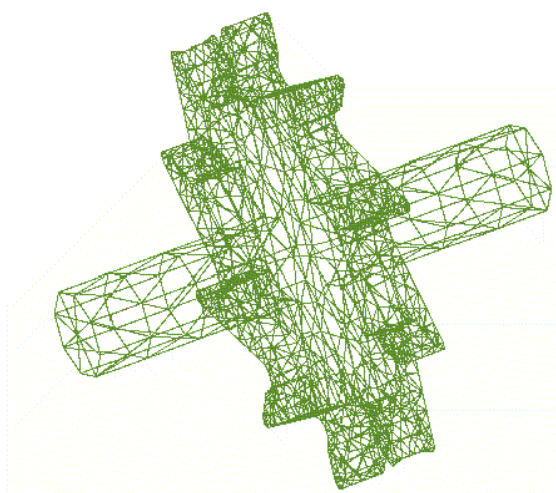

Figure 31. Mesh visualized with the **Mesh→View mesh boundary** option

5. Visualize the mesh generated with the various rendering options in the **Render** menu, located in the mouse menu.

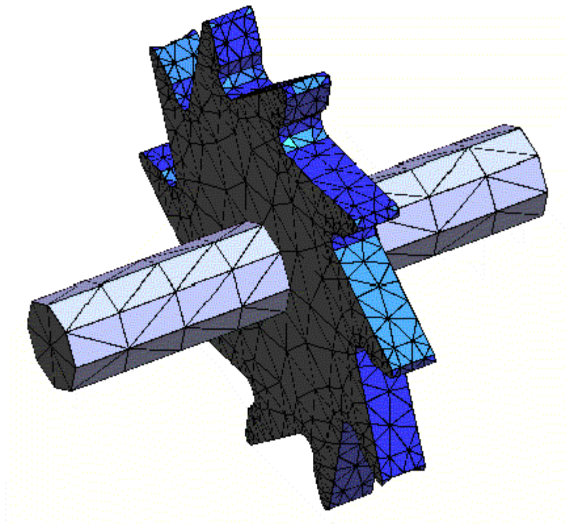

*Figure 32. Mesh visualized with **Mesh→View mesh boundary** combined with **Render→Flat**.*

6. Choose **View→Mode→Geometry** to return to the normal visualization.

NOTE: To visualize the geometry of the model use **View→Mode→Geometry**. To visualize the mesh use **View→Mode→Mesh**.

5.2. Generating the mesh with assignment of size around points

1. Enter view **rotate angle -90 90 ESC**[5] in the command line. This way we will have a side view.

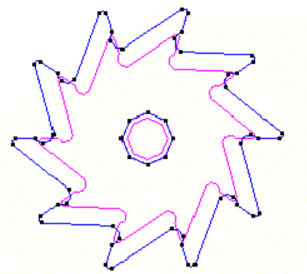

Figure 33. Side view of the part.

2. Choose **Mesh→Unstructured→Assign sizes on points**. A window appears in which to enter the element size around the point to be selected. Enter 0.7.
3. Select only the points on the wheel profile (Figure 34). One way of doing this is to select the entire part and then deselect the points that form the prism hole. Press **ESC** to conclude the selection process.

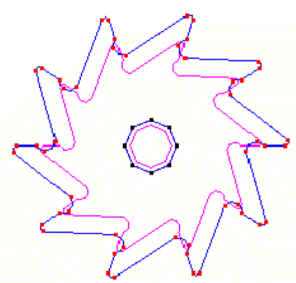

Figure 34. The selected points of the wheel profile

4. Choose **Mesh→Generate mesh.**

---

[5] Another option equivalent to **view rotate angle -90 90** is **Rotate→Plane XY**, located in the mouse menu.

5. A window opens asking if the previous mesh should be eliminated (Figure 35). Click **Yes**. Another window appears in which the maximum element size should be entered. Leave the default value unaltered.

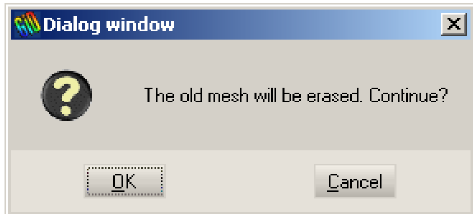

Figure 35

6. A third window shows the meshing process. Once it has finished, click **OK** to visualize the resulting mesh (Figure 36).

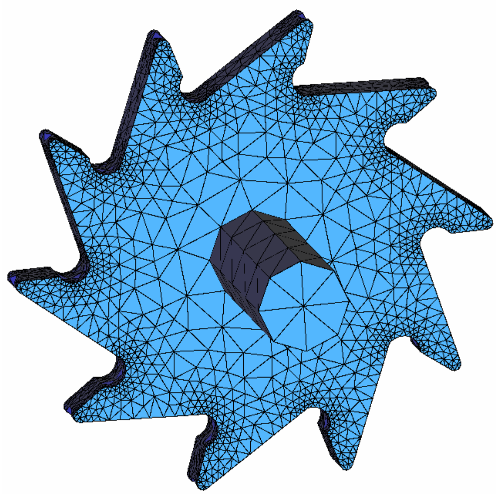

Figure 36. Mesh with assignment of sizes around the points on the wheel profile

7. A greater concentration of elements has been achieved around the points selected.
8. Choose **View→Mode→Geometry** to return to the normal visualization.

5.3. Generating the mesh with assignment of size around lines

1. Open the **Preferences** window, which is found in **Utilities**, and select the **Meshing** card. In this window there is an option called **Unstructured Size Transitions** which defines the size gradient of the elements. A high gradient number means a greater concentration of elements on the wheel profile. To do this, select a gradient size of 0.8. Click **Accept**.
2. Choose **Mesh→Reset mesh data** to delete the previously assigned sizes from section 5.2.
3. Choose **Mesh→Unstructured→Assign sizes on lines**. A window appears in which to enter the element size around the lines to be selected. Enter size 0.7. Select only the lines of the wheel profile (Figure 37) in the same way as in section 5.2.

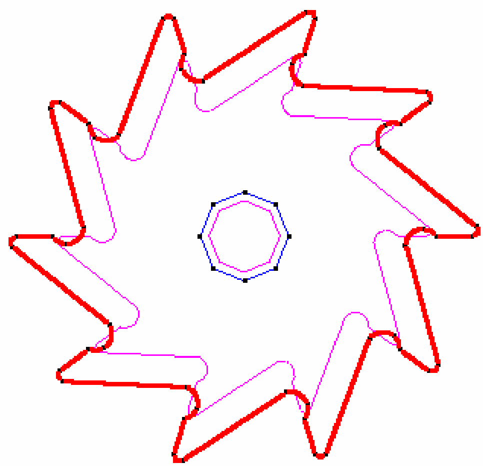

Figure 37. Selected lines of the wheel profile

4. Choose **Mesh→Generate mesh**. A window appears asking if the previous mesh should be eliminated. Click **Yes**.
5. Another window opens in which the maximum element size should be entered. Leave the default value unaltered.

6. A greater concentration of elements has been achieved around the selected lines. In contrast to the case in section 5.2, this mesh is more accurate since lines define the profile much better than points do (Figure 38).

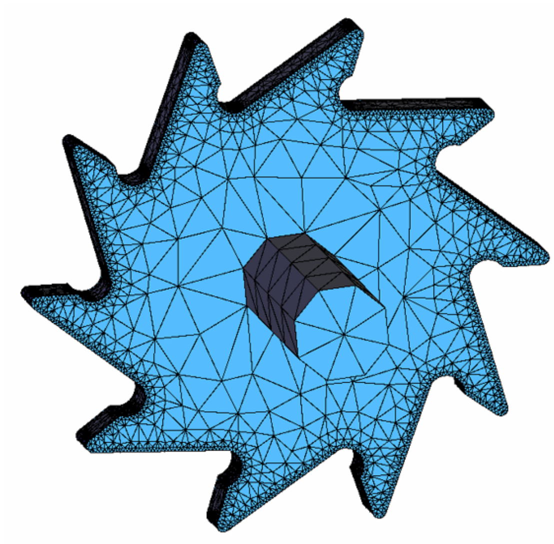

Figure 38. Mesh with assignment of sizes around lines

6. OPTIMIZING THE DESIGN OF THE PART

The part we have designed can be optimized, thus achieving a more efficient product. Given that the part will rotate clockwise, reshaping the upper part of the teeth could reduce the weight of the part as well as increase its resistance. We could also modify the profile of the hole in order to increase resistance in zones under axle pressure.

To carry out these optimizations, we will use new tools such as NURBS lines. The final steps in this process will be generating a mesh and visualizing the changes made relative to the previous design.
This example begins with a file named “optimizacion.gid”.

6.1. Modifying the profile

1. Choose **Read** from the **Files** menu and open the file “optimizacion.gid”.
2. The file contents appear on the screen. In order to work more comfortably, select **Zoom In,** thus magnifying the image. This option is located both in the GiD Toolbox and in the mouse menu under **Zoom**.

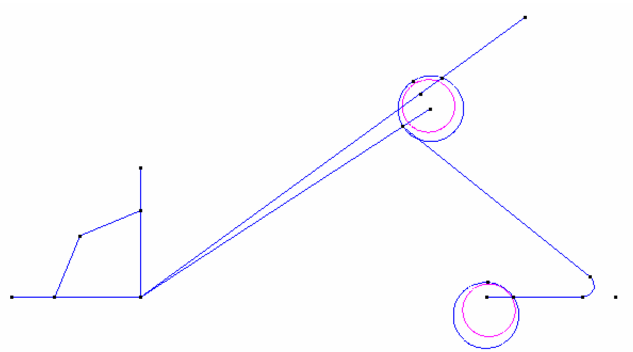

Figure 39. Contents of the file “optimizacion.gid”.

3. Make sure that the “aux” layer is activated.
4. Choose **Geometry→Edit→Divide→Lines→Num Divisions**. This option divides a line into a specified number of segments.
5. A window comes up in which to enter the number of partitions. Enter 8.
6. Select the line segment from the upper part of a tooth (Figure 39) and press **ESC**.

7. Using the option **Geometry→Create→Point**, and create a point with the coordinates (40, 8.5).

8. Choose **Geometry→Create→NURBS line** to create a NURBS curve. The NURBS line to be created will pass through the two first points which have been created on dividing the line at point (40, 8.5) and by the two last points of the divided line.

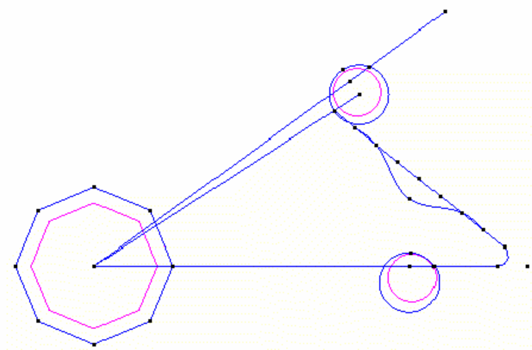

Figure 40. Optimizing the design

9. Select the first point through which the curve will pass. To do this use **Join Ctrl-a**, located in **Contextual** in the mouse menu.

10. One at a time, select the rest of the points except the last one. Use **Join Ctrl-a** each time in order to ensure that the line passes through the point.

11. Before selecting the last point, choose **Last Point** in the **Contextual** menu. Then finish the NURBS line. The result is shown in Figure 40.

12. Send the new profile (See Figure 41) to the “profile” layer and eliminate the auxiliary lines.

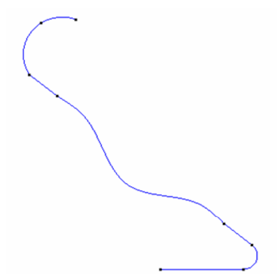

Figure 41. Optimizing the design

13. Repeat the process explained in sections 2.11 and 2.12 to create the wheel surface: use the rotation tool to create the entire profile and, using **Geometry→ Create→NURBS Surface→By contour**, select it to create a NURBS surface.
14. Repeat the processes explained in section 3 (except section 3.1) and sections 4.1 and 4.2 to create the prismatic volume.

6.2. Modifying the profile of the hole

1. Move the lines of the octagon placed in the profile surface to the “profile” layer (with the **Send To** button).
2. Click **Off** the “prism” layer. Hiding it simplifies the space on the screen.
3. Choose **Geometry→Create→Object→Circle**.
4. Enter (-10.5, 0) as the center point. Enter a normal to the **XY** plane (Positive Z) and a radius of 1.5.
5. From the Toolbox, use the **Delete→Surfaces** tool to delete the surface of the circle so that only the line is left. This way the **Geometry→Edit→ Intersection→Multiple Lines** option may be used to intersect the circle (circumference). Select only the circle and the two straight lines that intersect it.
6. Choose **Copy** from the **Utilities** menu and make seven copies (**Multiple copies**=7), rotating the circle -45 degrees.
7. Using the intersection options, delete the auxiliary lines leaving only the valid lines, thus obtaining the new profile of the hole. The result is illustrated in Figure 42.
8. Create the hole in the surface of the wheel using **Geometry→Edit→Hole NURBS Surface** (the result is shown in Figure 43).

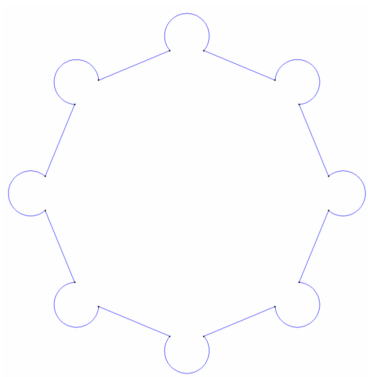

Figure 42. The new hole profile

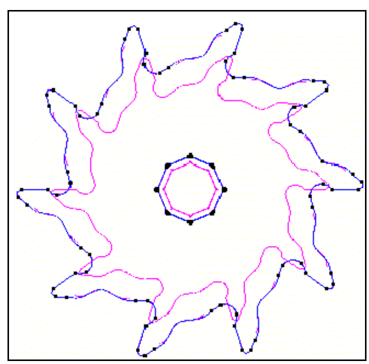

Figure 43. The surface of the new optimized design

6.3. Creating the volume of the new design

Repeat the same process as in section 4.3:

1. In the **Copy** window, choose **Translation** and **Surfaces**. Enter two points that define a translation of 10 units, for example (0, 0, 10) and (0, 0, 0). (Make sure that the Multiple Copies value is 1).
2. Choose **Do Extrude Volume** in the **Copy** window.
3. Click **Select** and select the surface of the wheel. Press **ESC**.

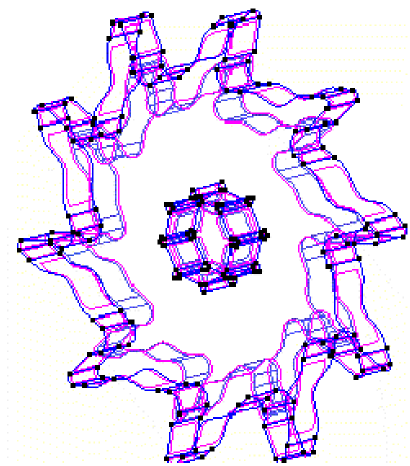

Figure 44. The volume of the optimized design

4. Click **On** the “prism” layer.

7. GENERATING THE MESH FOR THE NEW DESIGN

Generating the mesh for the optimized design is more complex. In this geometry it is especially important to obtain a precise mesh on the surfaces around the hole and on the surfaces of the teeth.
Initially, we will generate a simple mesh by default. Then we will generate a mesh using Chordal Error[6] to obtain a more accurate result.

7.1. Generating a mesh for the new design by default

1. Choose the option **Mesh→Generate mesh**.
2. A window appears in which to enter the maximum element size for the mesh to be generated. Leave the default value provided by GiD unaltered and click **OK**.

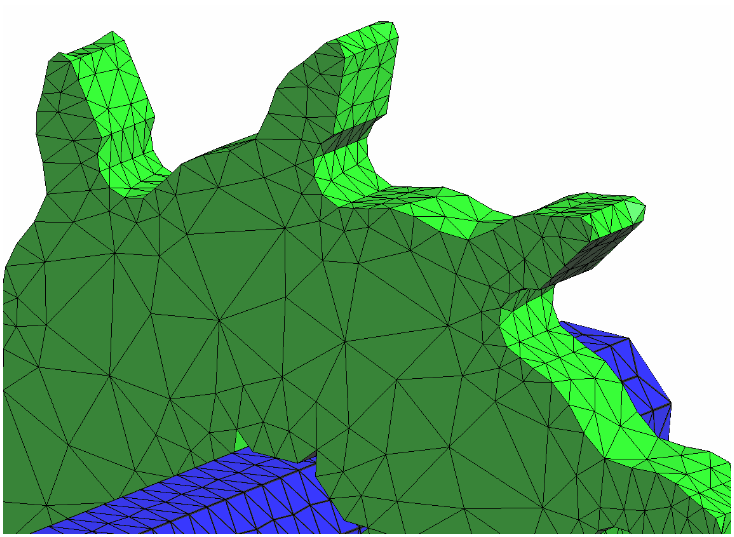

Figure 45. A detail of the mesh generated by default

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[6] The Chordal Error is the distance between each element generated by the meshing process and the real profile.

7.2. Generating a mesh using "Chordal Error"

1. Choose **Mesh→Unstructured→Sizes by Chordal error**.
2. Provide the values shown in figure 46.

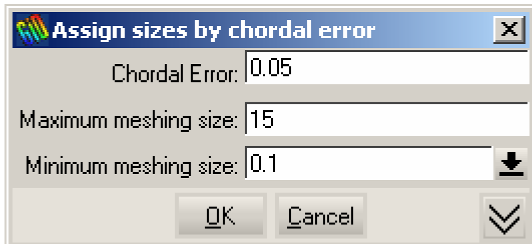


Figure 46. Chordal error windows

3. Choose **Mesh→Generate mesh**.
4. A greatly improved approximation has been achieved in zones containing curves and, more specifically, along the wheel profile and the profile of the hole (see Figure 47).

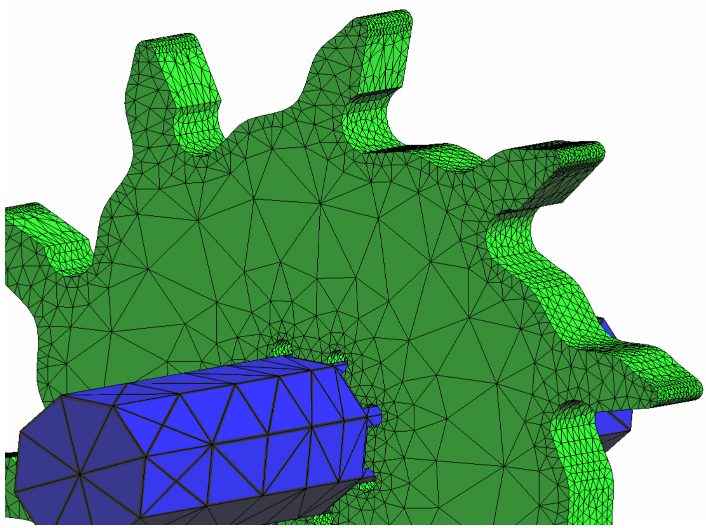


Figure 47. A detail of the mesh generated using Chordal Error

CASE STUDY 2

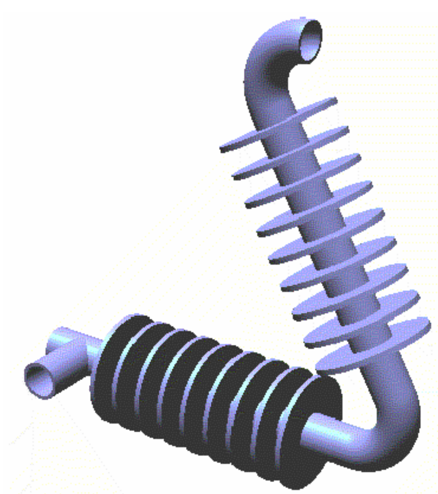
IMPLEMENTING A COOLING PIPE

This case study shows the modeling of a more complex piece and concludes with a detailed explanation of the corresponding meshing process. The piece is a cooling pipe composed of two sections forming a 60-degree angle.

The modeling process consists of four steps:

- Modeling the main pipes
- Modeling the elbow between the two main pipes, using a different file
- Importing the elbow to the main file
- Generating the mesh for the resulting piece

At the end of this case study, you should be able to use the CAD tools available in GiD as well as the options for generating meshes and visualizing the result.



1. WORKING BY LAYERS

Various auxiliary lines will be needed in order to draw the part. Since these auxiliary lines must not appear in the final drawing, they will be in a different layer from the one used for the finished model.

1.1. Creating two new layers

Open the layer management window, which is found in the **Utilities→Layers** menu.
Create two new layers called “aux” and “ok”. Enter the name for each layer in the Layers window (Figure 1) and click **New**.
Choose “aux” as the activated layer. To do this, click on "aux" to highlight it and then click on the **Layer To Use** button. (The name of the activated layer will appear next to the button, "aux" in this case.) From now on, all the entities created will belong to this layer.

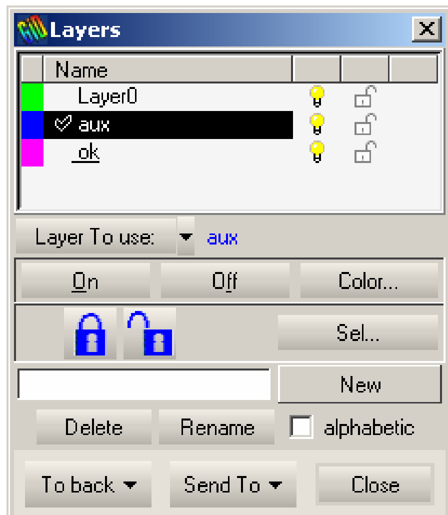


Figure 1. The ***Layers*** *window*

2. CREATING THE AUXILIARY LINES

The auxiliary lines used in this project are those that make it possible to determine the center of rotation and the tangential center, which will be used later to create the model.

2.1. Creating the axes

1. Choose the **Line** option, by selecting **Geometry→Create→Straight line**[1].
2. Enter the coordinate (0, 0) in the command line.
3. Enter the coordinate (200, 0) in the command line.
4. Press **ESC**[2] to indicate that the process of creating the line is finished.
5. If the entire line does not appear on the screen, use the option **Zoom Frame,** which is located in the GiD Toolbox and in **Zoom** in the mouse menu.
6. Again, choose **Line**. Draw a line between points (0, 25) and (200, 25). The result is shown in Figure 2.

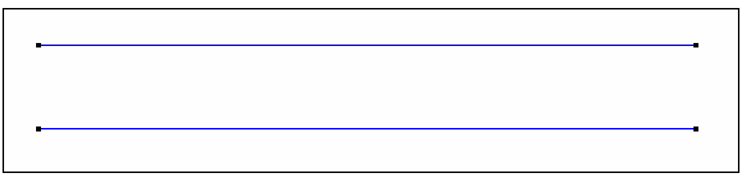


Figure 1

7. Go to the **Copy** window (Figure 4), which is found in **Utilities→Copy**.
8. Choose **Rotation** from the **Transformation** menu and **Lines** from the **Entities Type** menu.
9. Enter an angle of -60 degrees and click on **Two dimensions**.

[1] This option can also be found in the GiD Toolbox.

[2] Pressing the **ESC** key is equivalent to pressing the center mouse button.

10. Enter point (200, 0, 0) in **First Point**. This is the point that defines the center of rotation.
11. Click **Select** to select the first line we drawn.
12. After making the selection, press **ESC** (or **Finish** in the **Copy** window) to indicate that the selection of lines to be rotated is finished. The result is shown in Figure 3.

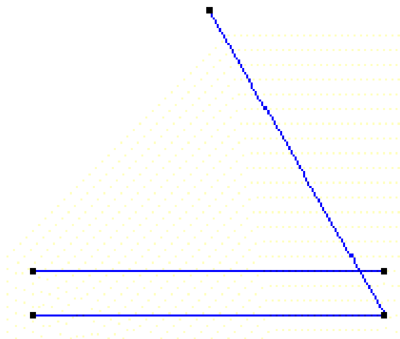


Figure 2. Creating the axes

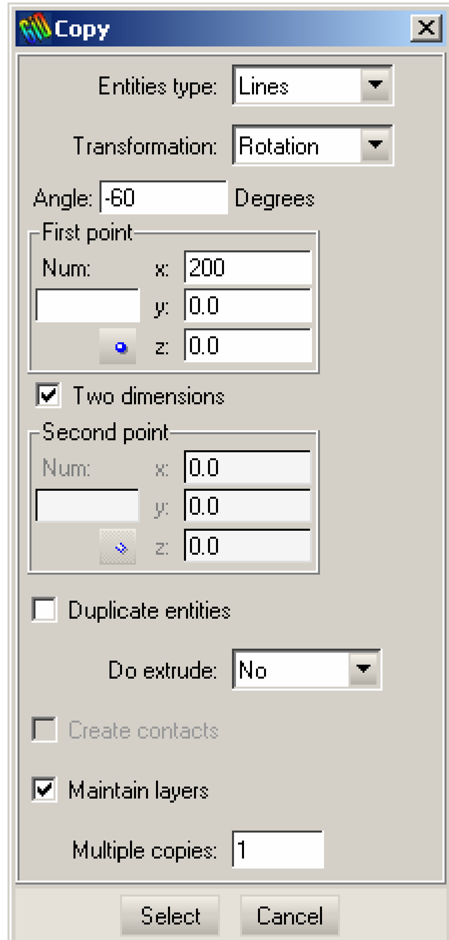


Figure 3. The **Copy** window

2.2. Creating the tangential center

1. Choose the menu option **Geometry→Create→Straight line.** On the mouse menu, choose **Contextual** and use **Join Ctrl-a** to select points (0, 0) and (0, 25). Press **ESC.**
2. In the **Copy** window, choose **Rotation** from the **Transformation** menu and **Lines** from the **Entities Type** menu. Enter an angle of 120 degrees, and the coordinates (0, 25, 0) in **First point** also check the **Two dimensions** option. Finally select last line created.
3. In the **Copy** window, choose **Translation** from the **Transformation** menu and **Lines** from the **Entities Type** menu. The translation vector for the translation to be made is the line just created. As the first point of the translation, select the point farthest from this line segment. For the second point, select the other point of the line (Figure 5).

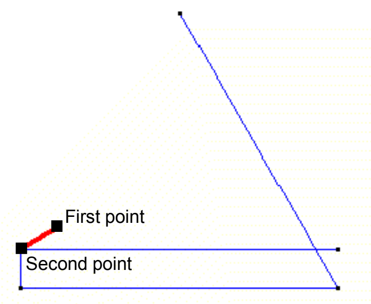


Figure 4. The line segment selected is the translation vector.

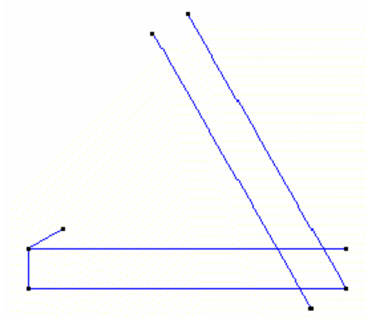


Figure 5. Result of the translation with copy

4. Click **Select** to select the line segment that forms an angle of -60 degrees with the horizontal. Press **ESC** to indicate that the selection has been made.
5. Choose **Geometry→Edit→Intersection→Line-line**.
6. Select the two inner lines.
7. Click **Yes** to confirm that there is an intersection and that, therefore, the shortest distance between the two entities is 0. The intersection between the two entities (lines) creates a point. This point will be the tangential center.
8. Press **ESC** to indicate that the process of intersection between lines is finished.

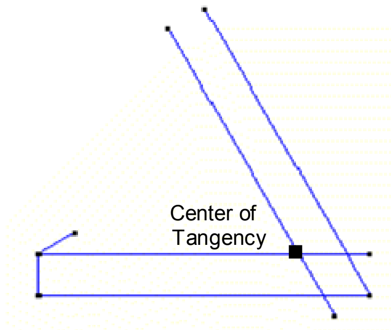


Figure 6. The auxiliary lines

NOTE: The **Undo** option allows you to undo the operations most recently carried out. If an error is made, go to **Utilities→Undo**; a window appears where you can select all the options to be eliminated.

3. CREATING THE FIRST COMPONENT PART

In this section the entire model, except the T junction, will be created. The model to be created is composed of two pipes forming a 60-degree angle. To start with, the first pipe will be created. This pipe will then be rotated to create the second pipe.

3.1. Creating the profile

1. Select the **ok** layer and click on **Layer To use**. From now on, all entities created will belong to the **ok** layer.
2. Choose the Line option, located in **Geometry→Create→Straight line**.
3. Enter the following points: (0, 11), (8, 11), (8, 31), (11, 31), (11, 11) and (15, 11). Press **ESC** to indicate that the process of creating lines is finished.

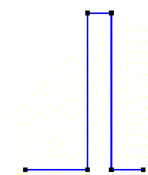


Figure 7. Profile of one of the disks around the pipe

4. From the **Copy** window, choose **Lines** and **Translation**. A translation defined by points (0, 11) and (15, 11) will be made. In the **Multiple copies** option, enter 8 (the number of copies to be added to the original). Select the lines that have just been drawn.

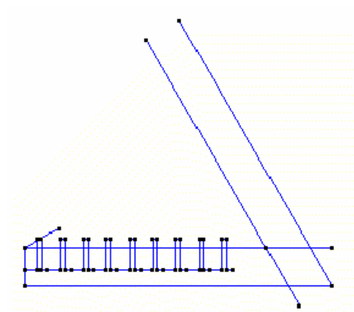


Figure 8. The profile of the disks using **Multiple copies**

5. Choose **Line**, located in **Geometry→Create→Straight line.** Select the last point on the profile (at the right part of the profile) using the option **Join Ctrl-a**, which is in the **Contextual** menu in the mouse menu. Now choose the option **No join Ctrl-a**. Enter point (200, 11). Press **ESC** to finish the process of creating lines.
6. Again, choose the **Line** option and enter points (0, 9) and (200, 9). Press **ESC** to conclude the process of creating lines (Figure 10).

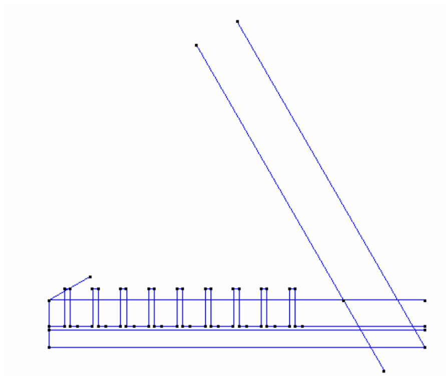


Figure 9. Creating the lines of the profile

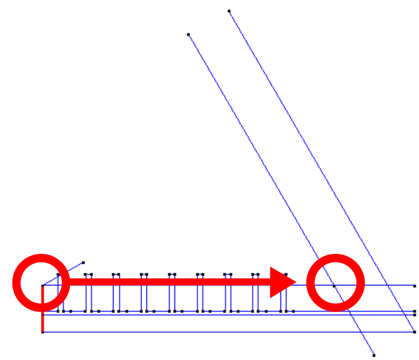


Figure 10. Copy of the vertical line segment starting at the origin of coordinates

7. From the **Copy** window, choose **Lines** and **Translation**. As the first and second points of the translation, enter the points indicated in Figure 11. Click **Select** and select the vertical line segment starting at the origin of coordinates. Press **ESC**.
8. Choose **Geometry→Edit→Intersection→Multiple lines.** Select the last two lines created and the vertical line segment coming down from the tangential center (see Figure 12). Press **ESC**.

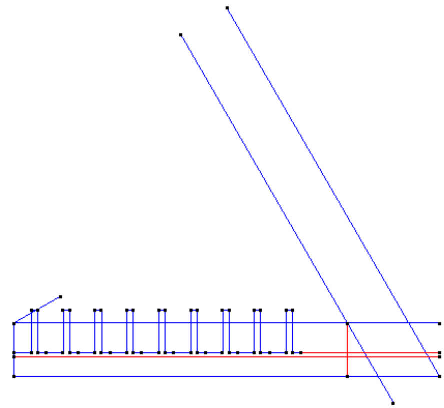


Figure 11. Selecting the lines to intersect

9. Choose **Geometry→Delete→All Types**. (This tool may also be found in the GiD Toolbox.) Select the lines and points beyond the vertical that passes through the tangential center. Press **ESC**. They will be deleted and the result should look like that shown in Figure 13.

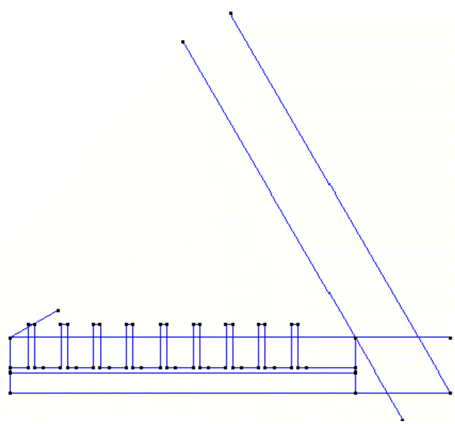


Figure 12. Profile of the pipe and the auxiliary lines

3.2. Creating the volume by revolution

1. Rotation of the profile will be carried out in two rotations of 180 degrees each. This way, the figure will be defined by a greater number of points.
2. From the **Copy** window, select **Lines** and **Rotation**. Enter an angle of 180 degrees and from the **Do extrude** menu, select **Surfaces**. The axis of rotation is that defined by the line that goes from point (0, 0) to point (200, 0). Enter these two points as the **First Point** and **Second Point**. Be sure to enter 1 in **Multiple Copies**.
3. Click **Select.** For an improved view when selecting the profile, click **Off** the “aux” layer. Press **ESC** when the selection is finished. The result should be that illustrated in Figure 14.

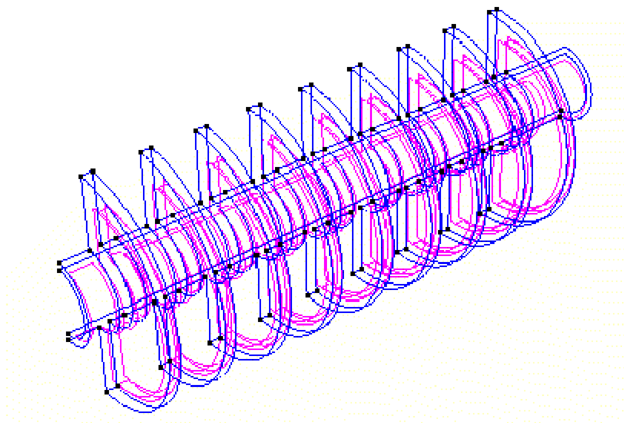


Figure 13. Result of the first step in the rotation (180 degrees)

4. Repeat the process, this time entering an angle of –180 degrees.
5. To return to the side view (elevation), choose **Rotate→Plane XY**.
6. Choose **Render→Flat** from the mouse menu to visualize a more realistic version of the model. Return to the normal visualization with **Render→Normal**. This option is more comfortable to work with.

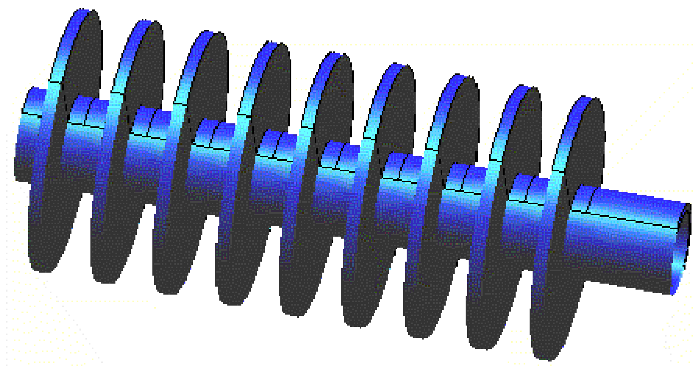


Figure 14. The pipe with disks, created by rotating the profile.

NOTE: To select the profile once the first rotation has been performed, first select all the lines and then delete those that do not form the profile. Use the option **Rotate→Trackball** from the mouse menu to rotate the model and make the process of selection easier.

3.3. Creating the union of the main pipes

1. Choose the **Zoom→In** option from the mouse menu. Magnify the right end of the model.
2. Make sure the "aux" layer is visible.
3. From the **Copy** window, select **Lines** and **Rotation**. Enter an angle of 120 degrees and from the **Do extrude** menu, select **Surfaces**. Since the rotation may be done in 2D, choose the option **Two Dimensions**. The center of the rotation is the tangential center.

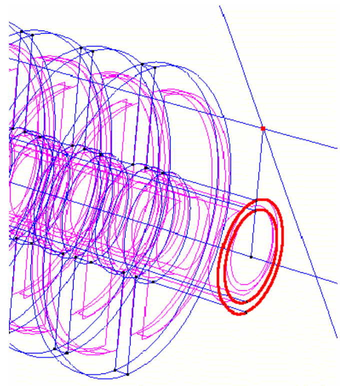


Figure 15. The magnified right end of the model, and the lines to be selected

4. Click **Select** and select the four lines that define the right end of the pipe (see Figure 16). Press **ESC** when the selection is finished.

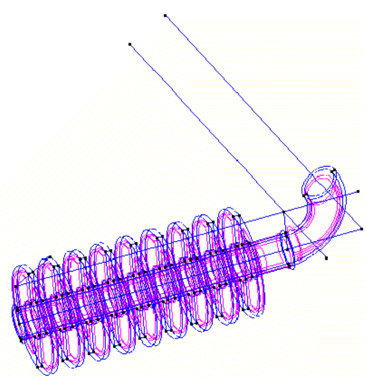


Figure 16. Result of the rotation

3.4. Rotating the main pipe

1. From the **Copy** window, select **Surfaces** and **Rotation**. Enter an angle of -60 degrees. Since the rotation may be done in 2D, choose the **Two Dimensions** option. The center of the rotation is the intersection of the axes, namely point (200, 0). Ensure the **Do Extrude** menu is set to **No**.
2. Click **Select** and select all the surfaces except those defining the elbow of the pipe. Press **ESC** when the selection is finished.

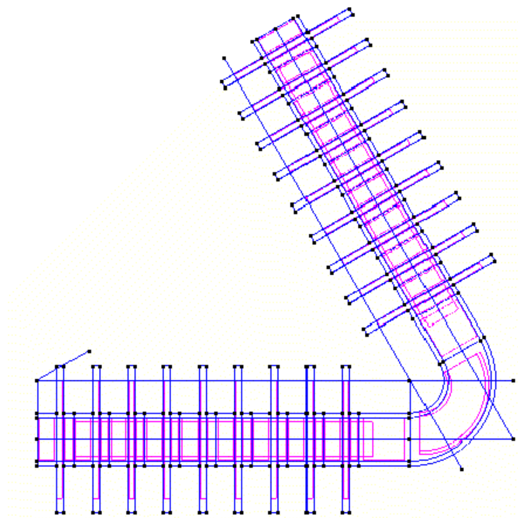


Figure 17. Geometry of the two pipes and the auxiliary lines

3.5. Creating the end of the pipe

1. From the **Copy** window, select **Surfaces** and **Rotation**. Enter an angle of 180 degrees. Since the rotation may be done in 2D, choose the option **Two Dimensions**. The center of rotation is the upper right point of the pipe elbow. Make sure the **Do Extrude** menu is set to **No**.
2. Click **Select** and select the surfaces that join the two pipe sections.
3. In the **Move** window, select **Surfaces** and **Translation**. The points defining the translation vector are circled in Figure 19.
4. Click **Select** and select the surfaces to be moved. Press **ESC.** The result should be as is shown in Figure 20.

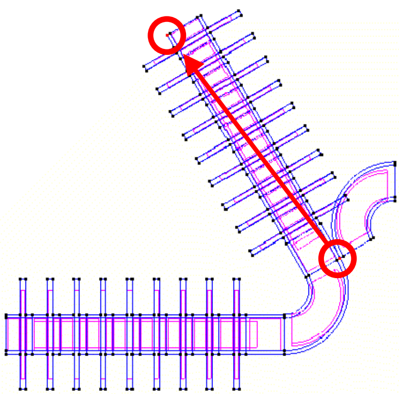


Figure 18. The circled points define the translation vector.

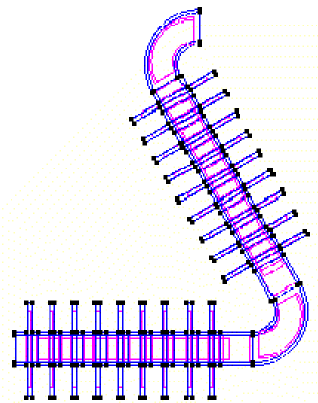


Figure 19. The final position of the translated elbow.

5. Choose **Geometry→Create→NURBS surface→By contour** and select the four lines that define the opening of the pipe (Figure 21). Press **ESC**.
6. From the **Files** menu, choose **Save** in order to save the file. Enter a name for the file and click **Save**.

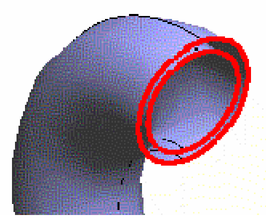


Figure 20. Opening at the end of the pipe

4. CREATING THE SECOND COMPONENT PART: THE T JUNCTION

Now, an intersection composed of two pipe sections will be created in a separate file and the surfaces will be trimmed. Then this file will be imported to the original model to create the entire piece.

4.1. Creating one of the pipe sections

1. Choose **Files→New**, thus starting work in a new file.
2. Choose **Geometry→Create→Point** and enter points (0, 9) and (0, 11). Press **ESC** to conclude the creation of points.
3. From the **Copy** window, select **Points** and **Rotation**. Enter an angle of 180 degrees and from the **Do extrude** menu, select **Lines**. The axis of rotation is the x axis. Enter two points defining the axis, one in **First Point** and the other in **Second Point**, for example, (0, 0, 0) and (100, 0, 0) (Figure 22).
4. Click **Select** and select the two points just created.
5. Repeat the process, this time entering an angle of –180 degrees, thus creating the profile of the pipe section with a second rotation of 180 degrees. The rotation could have been carried out in only one rotation of 360 degrees. However, in the present example, each circumference must be defined between two points (Figure 23).

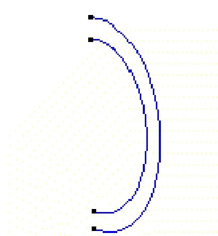


Figure 21. The result of the first 180-degree rotation.

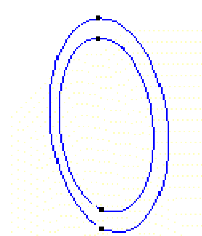


Figure 22. The combined result of the first rotation and the second rotation of –180 degrees, thus obtaining the profile of the pipe section.

6. From the **Copy** window, choose **Lines** and **Translation**. In **First Point** and **Second Point**, enter the points defining the translation vector. Since the pipe section must measure 40 length units, the vector is defined by points (0, 0, 0) and (-40, 0, 0).
7. From the **Do extrude** menu, choose the **Surfaces** option.

8. Click **Select** to select the lines that define the cross-section of the pipe. Press **ESC** to conclude the selection process.

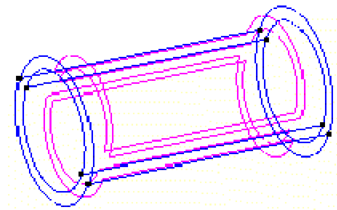


Figure 23. Creating a pipe by extruding circumferences

4.2. Creating the other pipe section

1. Choose **Geometry→Create→Point** and enter points (-20, 9) and (-20, 11). Press **ESC** to conclude the creation of points.
2. From the **Copy** window, select **Points** and **Rotation**. Enter an angle of 180 degrees and from the **Do extrude** menu, select **Lines**. Since the rotation can be done on the **xy** plane, choose **Two Dimensions**. The center of rotation is the coordinates (-20, 0, 0).
3. Click **Select** and select the two points just created. Repeat the process, this time entering an angle of -180 degrees.
4. From the **Copy** window, select **Lines** and **Translation**. In **First Point** and **Second Point** enter the points defining the translation vector. Since this pipe section must also measure 40 length units, the vector is defined by points (0, 0, 0) and (0, 0, 40).
5. From the **Do extrude** menu, select the **Surfaces** option.
6. Click **Select** to select the lines that define the cross-section of the second pipe. Press **ESC** to conclude the selection.

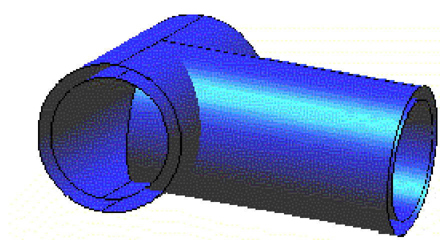


Figure 24. A rendering of the two intersecting pipes

4.3. Creating the lines of intersection

1. Choose **Geometry→Edit→Intersection→Surface-surface**.
2. Select the outer surfaces of each pipe, thus forming the intersection of the two surfaces selected.
3. Repeat the process to obtain the four lines of intersection.

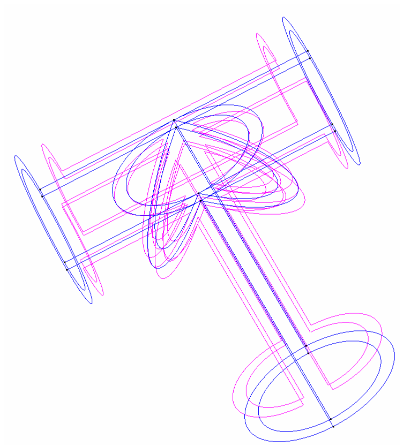


Figure 25. Creating lines of intersection between the surfaces

4.4. Deleting surfaces and lines

1. Choose **Geometry→Delete→Surfaces** and select the small surfaces inside the first pipe. Press **ESC** to conclude the process of selection.
2. Choose **Geometry→Delete→Lines**. Select the lines defining the end of the second pipe (foreground) that are still inside the first pipe (background). The result is shown in Figure 27.

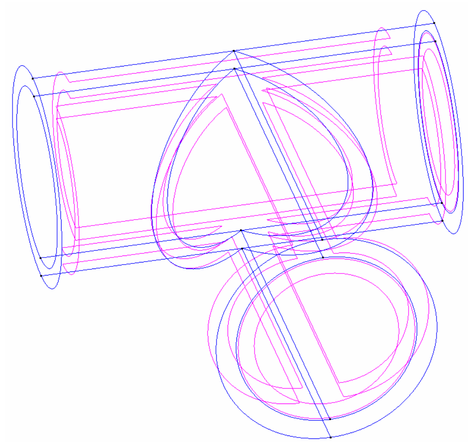


Figure 26. Final configuration after deleting surfaces and lines

4.5. Closing the volume

1. The model now has three outlets. The two farthest from the origin of coordinates must be closed. The third will be connected to the rest of the piece when the T junction is imported.
2. Choose **Geometry→Create→NURBS Surface→By contour** and then select the lines defining the outlet in the foreground of Figure 28. Press **ESC** (see Figure 28).

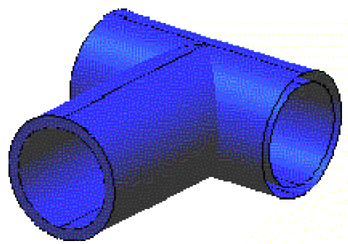


Figure 27. Creating a NURBS surface to close the outlet in the foreground

3. Repeat the process for the other outlet to be closed.
4. From the **Files** menu, select **Save** to save the file. Enter a name for the file and click **Save**.

5. IMPORTING THE T JUNCTION TO THE MAIN FILE

The two parts of the model have been drawn. Now they must be joined so that the final volume may be created and a mesh of the volume may be generated.

5.1. Importing a GiD file

1. Choose **Read** from the **Files** menu. Select the file where the first part, created in section 3, was saved. Click **Open**.
2. Choose **Files→Import→Insert GiD geometry** from the menu. Select the file where the second part, created in section 4, was saved. Click **Open**.
3. The T junction appears. Bear in mind that the lines which define the end of the first pipe (background) of the T junction, and which have been imported, were already present in the first file. Notice that the lines overlap. This overlapping will be remedied by collapsing the lines.
4. Choose the option **Geometry→Edit→Collapse→Lines**. Select the overlapping lines and press **ESC.**

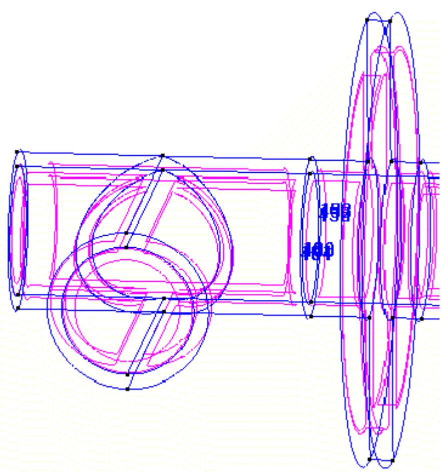


Figure 28. Importing the T junction file to the main file.
Some points are duplicated and must be collapsed.

5.2. Creating the final volume

1. Choose **Geometry→Create→Volume→By contour** and select all the surfaces that define the volume. Press **ESC** to conclude the selection process.
2. Choose **Render→Smooth** to visualize a more realistic version of the model.

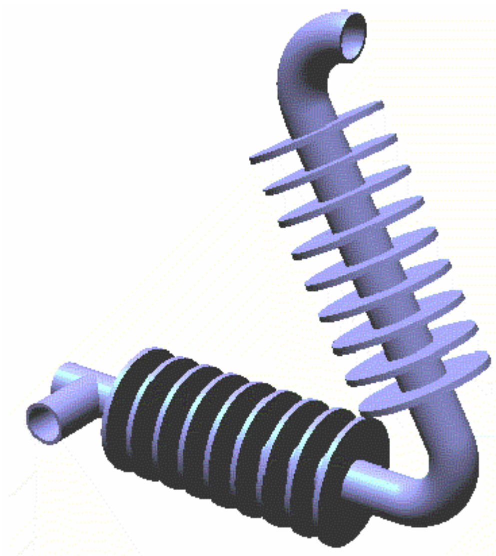


Figure 29. A rendering of the finished piece of equipment

6. GENERATING THE MESH

Now that the model is finished, it is ready to be meshed. The mesh will be generated using **Chordal Error** in order to achieve greater accuracy in the discretization of the geometry. The chordal error is the distance between the element generated by the meshing process and the real profile of the model. By selecting a sufficiently small chordal error, the elements will be smaller in the zones with greater curvature.

6.1. Generating the mesh using Chordal Error

1. Choose the option Mesh→Unstructured→Sizes by Chordal error.
2. Enter 1 for the minimum element size.
3. Enter 15 for the maximum element size.
4. Enter 0.2 for the chordal error.
5. Choose Mesh→Generate mesh.
6. A window opens in which to enter the maximum element size of the mesh to be generated. Leave the default value provided by GiD unaltered and click **OK**.
7. When the meshing process is finished, a window appears with information about the mesh that has been generated. Click **OK** to visualize the mesh.
8. Choose **Mesh→View Mesh Boundary** to see only the contour of the volumes meshed but not the interiors.
9. The visualization may be rendered using the various options in the **Render** menu, located in the mouse menu.

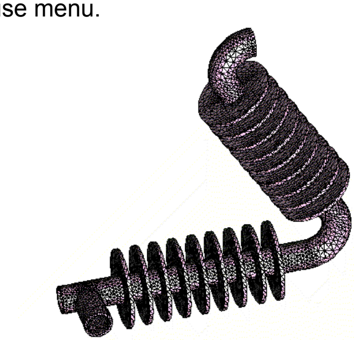


Figure 30. The mesh generated for the piece

NOTE: By default GiD corrects element size depending on the form of the entity to mesh. This correction option may be deactivated or reactivated in the **Meshing** card in the **Preferences** window under the option **Automatic correct sizes**.

6.2. Generating the mesh by assignment of sizes on surfaces

1. Choose **Mesh→Unstructured→Assign sizes on surfaces**. A window opens in which to enter the element size for the surfaces to be selected. Enter size 1.
2. Select the surfaces of the elbow.
3. Choose Mesh→Generate mesh.
4. A window appears asking whether the previous mesh should be eliminated. Click **Yes**.
5. Another window appears in which the maximum element size should be entered. Leave the default value provided by GiD unaltered and click **OK**.
6. Choose **Mesh→View Mesh Boundary** to see only the contour of the meshed volumes but not the interiors (Figure 32).

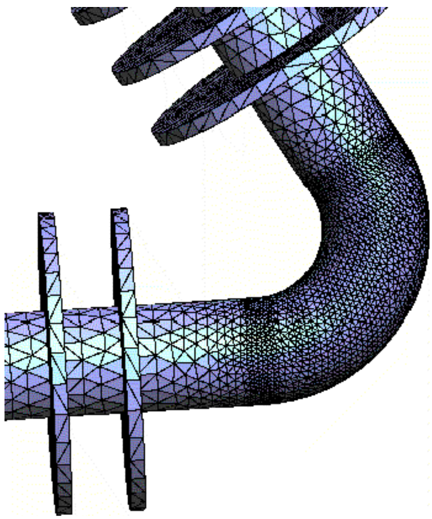


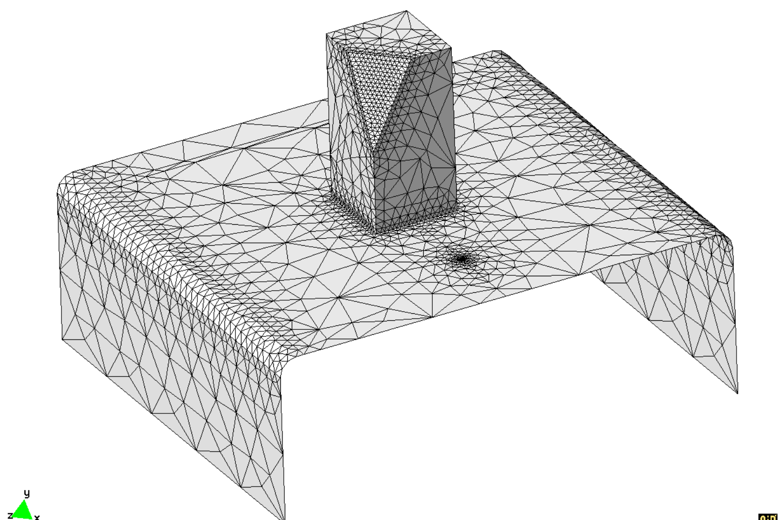
Figure 31. The mesh with a concentration of elements on the surfaces of the elbow

7. A greater concentration of elements has been achieved on the selected surfaces.

ASSIGNING ELEMENT SIZES FOR GENERATING THE MESH

The objective of this example is to mesh a mechanical piece using the various options in GiD for assigning sizes to elements, and the different surface meshers available. In this example a mesh is generated for each of the following methods for assigning sizes, using different surface meshers:

- Assigning sizes around points
- Assigning sizes around lines
- Assigning sizes on surfaces
- Assigning sizes with Chordal Error



1. INTRODUCTION

In order to carry out this example, start by opening the project "ToMesh4.gid". This project contains a geometry that will be meshed using four different methods, each one resulting in a different density of elements in certain zones.

1.1. Reading the initial project

1. In the **Files** menu, select **Read**. Select the project "ToMesh4.gid" and click **Open**.
2. The geometry appears on the screen. It is a set of surfaces.
3. Select **Render→Flat** from the mouse menu[1].
4. Select **Rotate→Trackball** from the mouse menu. (This tool is also available within the GiD Toolbox.) Make several changes in the perspective so as to get a good idea of the geometry of the object.
5. Finally, return to the normal visualization, selecting **Render→Normal**. This mode is more user-friendly.

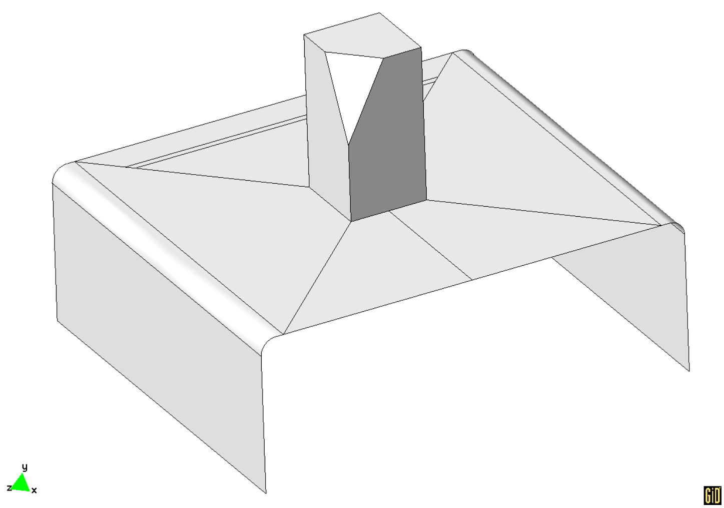


Figure 1. Contents of the project "ToMesh4.gid".

[1] The mouse menu appears when the right mouse button is clicked.

2. ELEMENT- SIZE ASSIGNMENT METHODS

GiD automatically corrects element sizes according to the shape of the entity to be meshed and its surrounding entities. This default option may be deactivated and reactivated by going to the **Mesh** menu, selecting **Preferences**[2], and then **Automatic correct sizes**[3].

Sometimes, however, this type of correction is not sufficient and it is necessary to indicate where on the mesh greater accuracy is needed. In these cases, GiD offers various options and methods allowing sizes to be assigned to elements. Five examples are shown to illustrate the default method and the four other methods.

2.1. Assignment using default options

1. Select **Mesh→Generate Mesh**.
2. A window appears showing the maximum element size. Leave this default size unaltered and click **OK**.
3. A meshing process window opens. Then another window appears with information about the mesh generated. Click **OK** to visualize the mesh (see Figure 2).

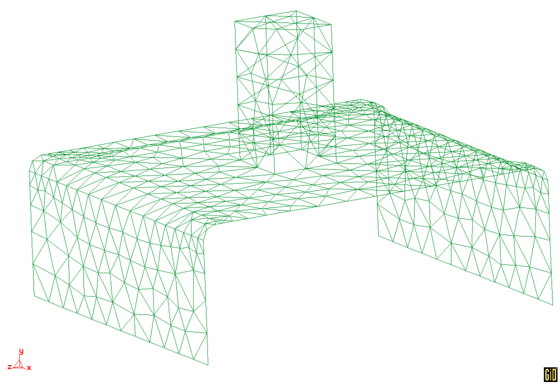


Figure 2. Meshing by default.

[2] The **Preferences** option can also be found in the **Utilities** menu.

[3] Automatic correct sizes automatically executes the options **Assign sizes→By geometry and Assign sizes→Correct sizes**.

Note that in the zone highlighted in Figure 3, elements are smaller than in the rest of the model. This is because of the shape of the surface placed there. When all meshing preferences are set to their default levels, as for this example, the RFAST surface mesher is used. In this way, geometrical entities are meshed hierarchically: first of all lines are meshed, then the surfaces, and finally the volumes. The line elements size depends on the shape of surfaces (as can be seen in this example). Later on we will see an example using RJUMP mesher, where element sizes are distributed differently.

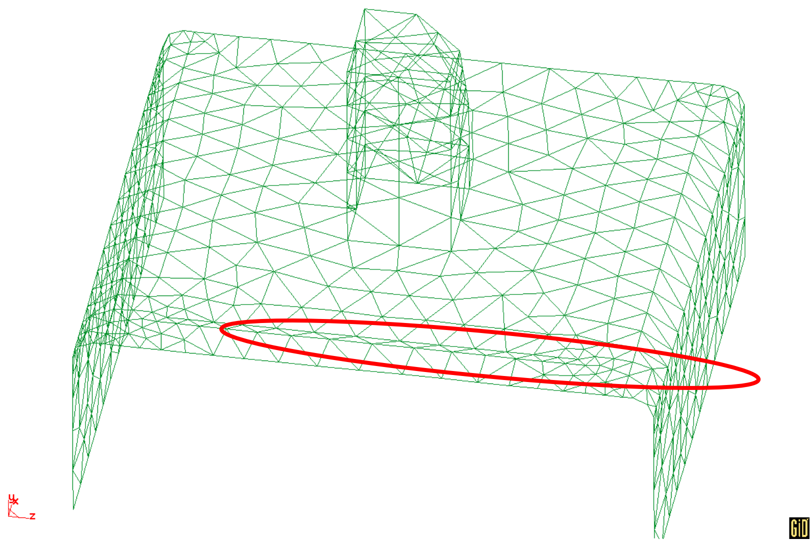


Figure 3. Meshing by default. Zone where elements are smaller because of the surface shape.

2.2. Assignment around points

1. Select **Mesh→Unstructured→Assign size on points**. A window appears in which to enter the element size around the points to be chosen. Enter 0.1 and click **OK**.
2. Select the point indicated in Figure 4. Press **ESC**[4] to indicate that the selection of points is finished.
3. Select **Mesh→Generate Mesh**.
4. A window opens asking whether the previous mesh should be eliminated. Click **Yes**.
5. GiD then asks you to enter the maximum element size. Leave the default value unaltered and click **OK**.

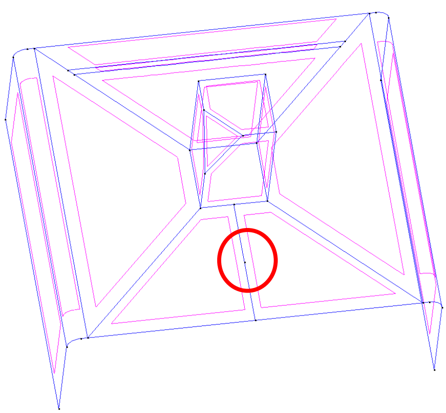


Figure 4. Geometry of the model. The point around which the mesh will be concentrated.

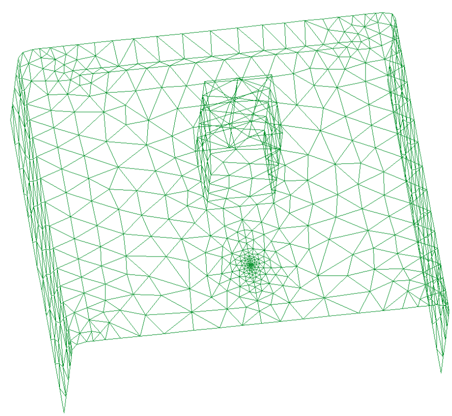


Figure 5. The mesh with a concentration of elements around the point.

6. A concentration of elements appears around the chosen point, given the selected size (0.1) of these elements (see Figure 5).
7. Go to **Utilities** and open **Preferences.** Click **Meshing**. In the window that appears there is the option **Unstructured Size Transitions**. This option defines the transition gradient of element sizes (size gradient), whose values are between 0 and 1. The greater the size gradient, the greater the change in space. To test this, enter the value 0.4 and click **Accept**.
8. Again, select **Mesh→Generate Mesh**.

---

[4] Instead of pressing the **ESC** key, the center mouse button or the mouse wheel can also be used.

9. A window opens asking whether the previous mesh should be eliminated. Click Yes.
10. GiD then asks you to enter the maximum element size. Leave the default value unaltered and click **OK**.

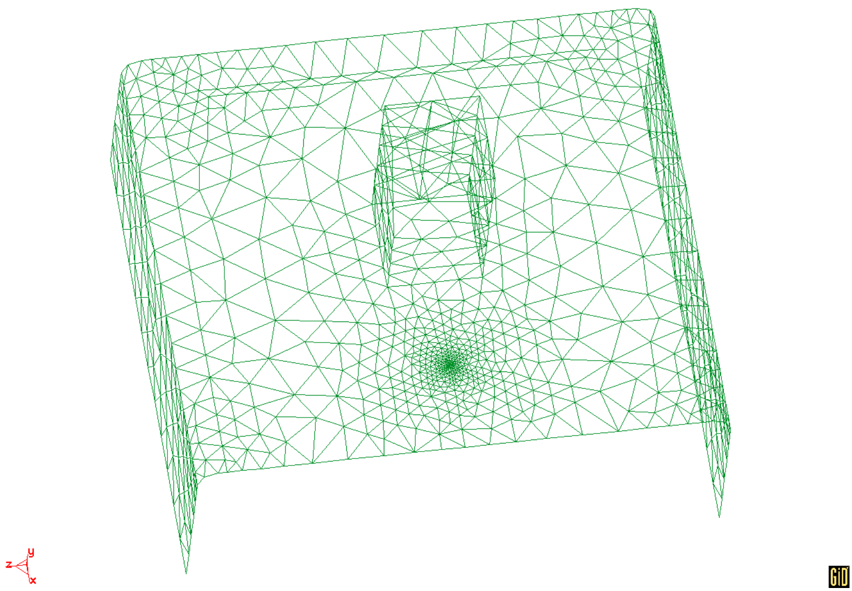


Figure 6. Mesh with the elements concentrated around a point, with a size gradient of 0.8.

11. The size gradient (0.4) results in a higher density around the point (see Figure 6).
12. Now go back and enter 0.6 in **Unstructured Size Transitions**. This will result in a mesh more suitable for our objectives. Click **Accept**.

2.3. Assignment around lines

1. Select **Mesh→Unstructured→Assign size on lines**. In the window that appears, enter the size of the elements around the lines that will be chosen. Enter 0.5 and click **OK**.
2. Select the lines defining the base of the prism (i.e. lines 1, 2, 3, 4 and 40). To see entity numbers select **Label** from the mouse menu or from the **View** menu. If you wish geometrical entity labels to be displayed, the view mode has to be set to Geometry using **View→Mode→Geometry** (this option may also be found in the GiD Toolbox), and the render mode must be set to **Normal**. Press **ESC**.
3. Select **Mesh→Generate Mesh**.
4. A window opens asking if the previous mesh should be eliminated. Click **Yes**.
5. Another window appears in which you may enter a maximum element size. Leave the default value unaltered and click **OK**. This results in a high concentration of elements around the chosen lines, given that the selected element size (0.5) is much smaller than that of the rest of the elements in the model (see Figure 7).

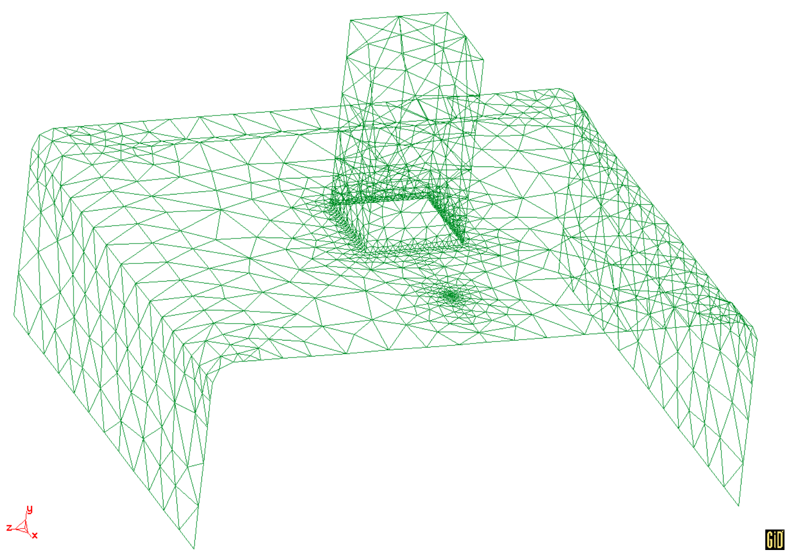


Figure 7. Mesh with a concentration of elements around lines.

2.4. Assignment on surfaces

1. Select **Mesh→Unstructured→Assign size on surfaces**. In the window that appears, enter the size of the elements to be assigned on the surfaces that will be chosen. Enter 0.5 and click **OK**.
2. Select the triangular surface resulting from the section of one of the vertexes of the prism (surface number 1). Press **ESC**.
3. Select **Mesh→Generate Mesh**.
4. A window opens asking if the previous mesh should be eliminated. Click **Yes**.
5. Another window appears in which you can enter the maximum element size. Leave the default value unaltered and click **OK**. This results in a high concentration of elements on the chosen surface; due to the value selected (0.5) (see Figure 8).

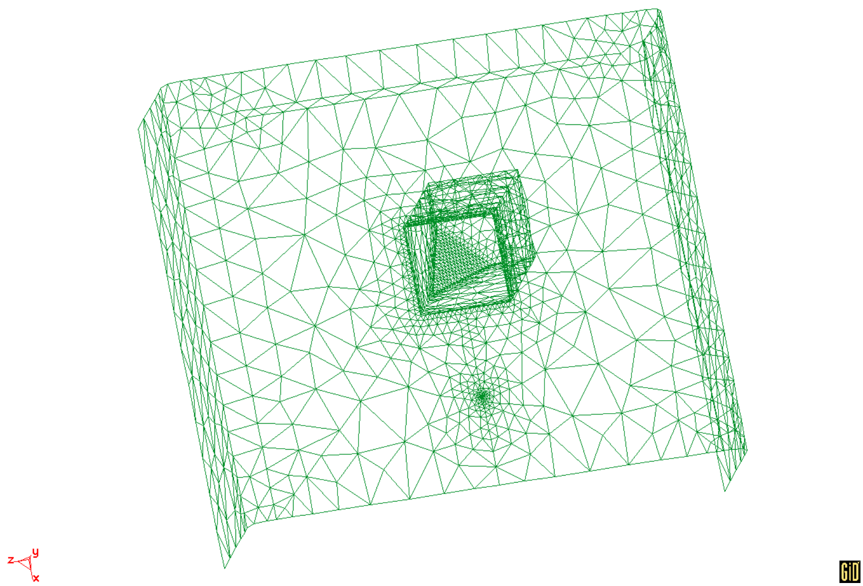


Figure 8. Mesh with a concentration of elements on a surface.

2.5. Assignment with Maximum Chordal Error

1. Select **Mesh→Unstructured→Sizes by chordal error**….
2. GiD asks for the minimum element size. Enter 0.1.
3. GiD asks for the maximum element size. Enter 10.
4. Enter the chordal error. This error is the maximum distance between the element generated and the real object (geometry). Enter 0.05 and press **OK**.
5. Select **Mesh→Generate Mesh**.
6. A window opens asking if the previous mesh should be eliminated. Click **Yes**.
7. Another window appears in which you can enter a maximum element size. Leave the default value unaltered and click **OK**. This results in a high concentration of elements in curved areas. Now our approximation is significantly improved (see Figure 9).

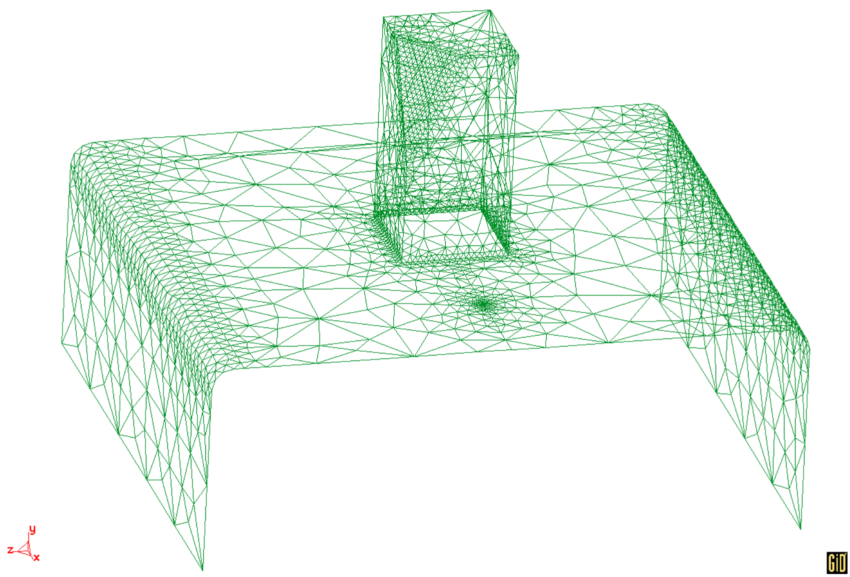


Figure 9. Mesh using sizes assignment by chordal error. Here, there is a greater concentration of elements in the curved zones.

3. RJUMP MESHER

3.1. RJump default options

The RJump mesher is a surface mesher that meshes patches of surfaces (in 3D space) and is able to skip the inner lines of these patches when meshing. By default, the RJump mesher skips the contact lines between surfaces that are tangent enough, and points between lines that are tangent enough. By selecting **Mesh→Draw→ Skip entities (Rjump)**, the entities that RJump is going to skip and the ones that it is not going to skip are displayed in different colors. In this chapter we will see the properties of this mesher.

1. Select **Mesh→Reset mesh data** to reset all mesh sizes introduced previously.
2. A window appears advising that all the mesh information is going to be erased. Press **OK**.
3. Go to **Utilities** and open **Preferences.** Click **Meshing**. In the window that appears you can choose between the three surface meshers available in GiD (RFast, RSurf and RJump). Select **RJump** mesher. Click **Accept**.
4. Select Mesh→Generate Mesh.
5. A window opens asking if the previous mesh should be eliminated. Click **Yes**.
6. Another window appears in which you can enter a maximum element size. Leave the default value unaltered and click **OK**. This results in a mesh where contact lines between surfaces that are tangent enough do not have nodes; contact points between lines tangent enough are also skipped when meshing (see Figure 10).

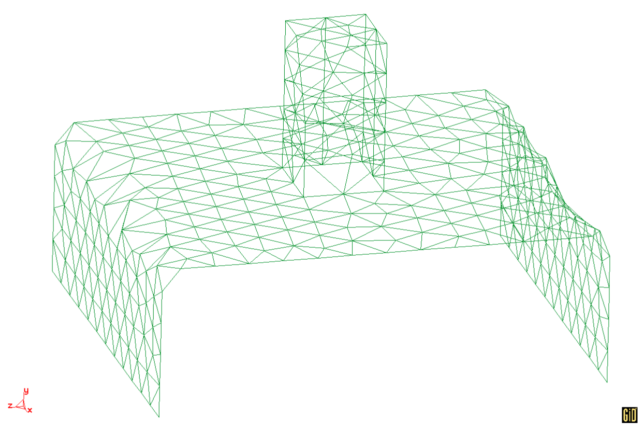


Figure 10. Mesh using the RJump mesher.

Note that the smaller elements shown in Figure 3 do not appear in this mesh, because of the properties this mesher.

7. Using the RJump mesher it is possible to assign sizes to different entities. As an example, select **Mesh→Unstructured→Size by chordal error…**.
8. GiD asks for the minimum element size. Enter 0.1.
9. GiD asks for the maximum element size. Enter 10.
10. Enter the chordal error. This error is the maximum distance between the element generated and the real object. Enter 0.05 and press **OK**.
11. Again, select **Mesh→Generate Mesh**.
12. A window opens asking if the previous mesh should be eliminated. Click **Yes**.
13. Another window appears in which you can enter a maximum element size. Leave the default value unaltered and click **OK**. This results in a high concentration of elements in curved areas, without the nodes in the lines and points that mesher skips. Now our approximation is significantly improved (see Figure 11).

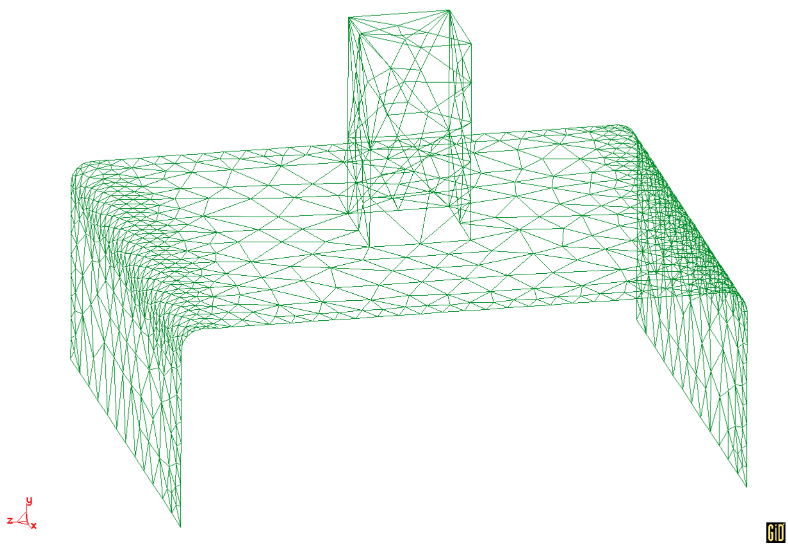


Figure 11. Mesh using the RJump mesher and assigning sizes by chordal error.

3.2. Force to mesh some entity

If there is a line or a point that the RJump mesher would usually skip, but that you wish to be meshed, you can specify the entity so that it is not skipped. As an example, we will force Rjump to mesh line number 43, in order to concentrate elements around point number 29, as it was done in chapter 2.2.

1. Select **Mesh→Mesh criteria→No skip→lines**, and select line number 43. Press **ESC**.
2. Select **Mesh→Draw→ Skip entities (Rjump)** to display the entities that will and will not be skipped in different colors. As is shown in Figure 12, line 43 will now not be skipped; the rest of the lines are unaffected, and RJump will either skip or mesh them according to its criteria.

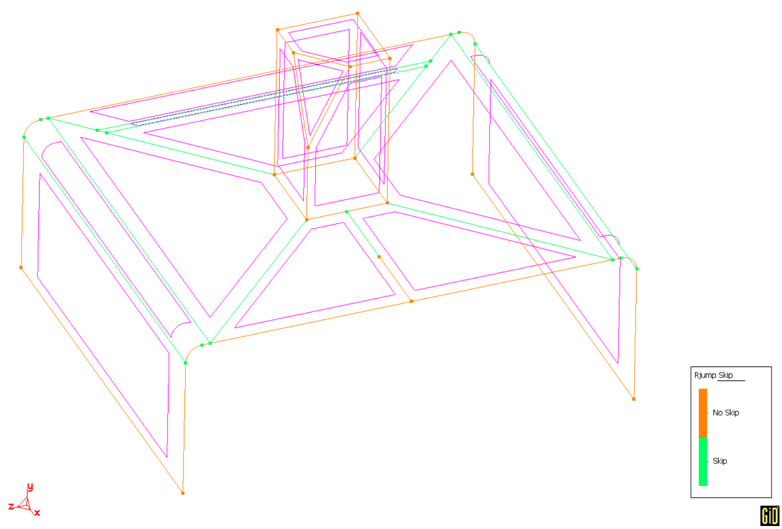


Figure 12. Entities that will be skipped and not skipped using the RJump mesher.

3. Select **Mesh→Unstructured→Assign size on points**. A window appears in which to enter the element size around the points to be chosen. Enter 0.1 and click OK.
4. Select the point indicated in Figure 4 (point number 29). Press **ESC** to indicate that the selection of points is finished.
5. Select **Mesh→Generate Mesh**.
6. A window opens asking if the previous mesh should be eliminated. Click **Yes**.

7. Another window appears in which you can enter a maximum element size. Leave the default value unaltered and click **OK**. This results in a mesh like the one obtained before (in Figure 10), but with high concentration of elements around point number 29. Note that there are nodes on line number 43 because we have forced RJump not to skip this line (see Figure 13).

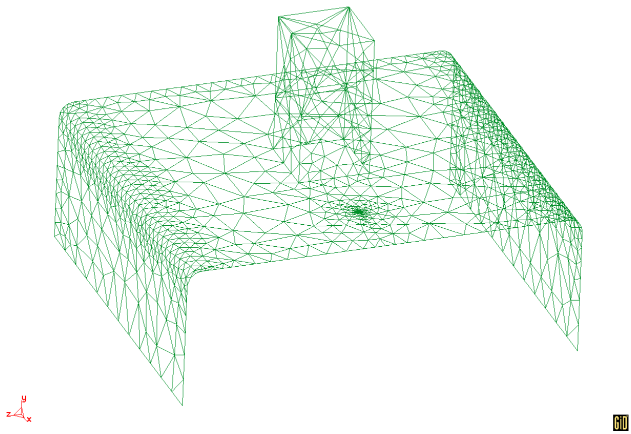


Figure 13. Mesh using the RJump mesher, assigning sizes by chordal error and forcing an entity to be meshed.

In this last example we have forced the mesher not to skip an entity, but it may be interesting in some models to allow the mesher only to skip a few entities, meshing almost all or them. In this case, a different surface mesher can be selected (in the **Preferences** window). One option is the RSurf mesher which meshes everything except the entities that you ask it to skip, using the **Mesh→Mesh criteria→Skip** command. Here, because RJump is not selected, no entity will be skipped automatically according to tangency with neighboring entities. The next example shows how to work with this mesher.

8. Select **Mesh→Reset mesh data** to reset all mesh sizes introduced previously.
9. A window opens advising that all the mesh information is going to be erased. Press **OK**.
10. Go to **Utilities** and open **Preferences.** Click **Meshing**. In the window that appears you can choose between the three surface meshers available in GiD (RFast, RSurf and RJump). Select the **RSurf** mesher. Click **Accept**.
11. Select **Mesh→Mesh criteria→Skip→lines**, and select lines 48 and 53. Press **ESC**.
12. Select **Mesh→Generate Mesh**.

13. A window opens asking if the previous mesh should be eliminated. Click **Yes**.
14. Another window appears in which you can enter a maximum element size. Leave the default value unaltered and click **OK**. The result is a mesh similar to the first example obtained in chapter 2 (see Figure 2), but the smaller elements highlighted in Figure 3 do not appear because lines 48 and 53 (which were meshed before) are now skipped when meshing (see Figure 14).

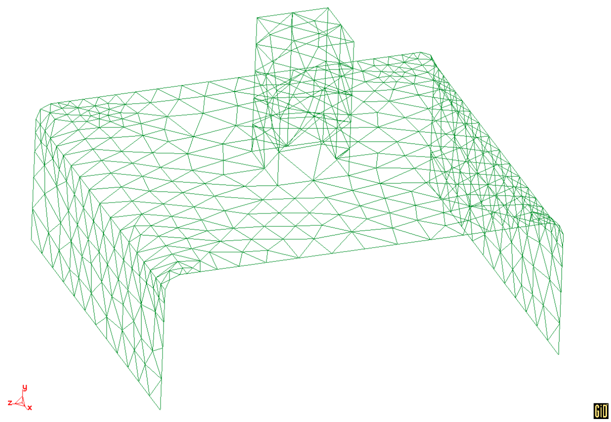
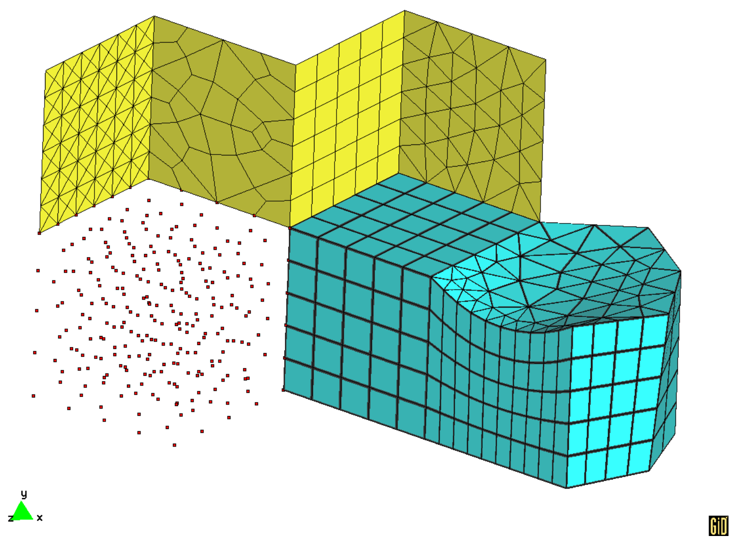


Figure 14. Mesh using the RSurf mesher, with some lines skipped.

METHODS FOR GENERATING THE MESH

The objective of this example is to mesh a model using the various options available in GiD for controlling the element type in structured, semi-structured and unstructured meshes. It also presents how to concentrate elements and control the distribution of mesh sizes.
The six methods covered are:

- Generating a mesh using tetrahedra
- Generating a volume mesh using points
- Generating a mesh using quadrilaterals
- Generating a structured mesh on surfaces and volumes
- Generating a semi-structured volume mesh
- Generating a mesh using quadratic elements



1. INTRODUCTION

In order to carry out this example, start from the project "ToMesh3.gid". This project contains a geometry that will be meshed using different types of elements.

1.1. Reading the initial project

1. In the **Files** menu, select **Read**. Select the project “ToMesh3.gid” and click **Open**.
2. The geometry appears on the screen. It is a set of surfaces and three volumes. Select **Render→Flat** from the mouse menu[1] or from the **View** menu. In Figure 1 shows the geometrical model loaded.
3. Select **Rotate→Trackball** from the mouse menu. (This option is also available in the GiD Toolbox.) Make several changes in the perspective so as to get a good idea of the geometry involved.

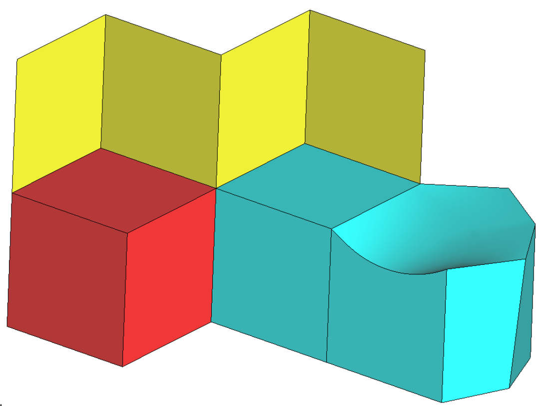


Figure 1. Contents of the project “ToMesh3.gid”.

4. Finally, return to the normal visualization **Render→Normal**. This mode is more user-friendly.

---

[1] The mouse menu appears when the right mouse button is clicked.

2. GENERATING THE MESH - TYPES OF MESHES

Using GiD the mesh may be generated in different ways, depending on the needs of each project. The two basic types of meshes are the structured[2] mesh and the unstructured mesh. For volumes only there is one additional type, the semi-structured[3] mesh. For all these types of mesh a variety of elements may be used (linear ones, triangles, quadrilaterals, tetrahedra, hexahedra, prisms, spheres or points). In this tutorial you will become familiarized with the mesh-generating combinations available in GiD.

2.1. Generating the mesh by default

1. Select **Mesh→Generate mesh**.
2. A window comes up in which to enter the maximum element size for the mesh to be generated. Leave the default value unaltered and click **OK**.
3. A meshing process window comes up. Then another window appears with information about the mesh generated. Click **OK** to visualize the mesh.
4. The result is the mesh in Figure 2. There are various surfaces and volumes. By default, mesh generation in GiD obtains unstructured meshes of triangles on surfaces and tetrahedra on volumes.
5. Select **Render→Flat** to see the mesh in render mode. As is shown in Figure 3, volume meshes are represented a little bit differently from surface meshes, although in both cases triangles are shown. If the triangles you see are the boundary of a volume mesh, they are shown with black edges that are thicker than surface meshes triangles. If the triangles form a boundary volume mesh and, at the same time, a triangle surface mesh (this can be obtained if surfaces are selected with the option **Mesh→Mesh criteria→Mesh→Surfaces**), the wider edges are colored with the color of the surface layer. Examples of these different kinds of render are shown in Figure 3.

---

[2] A structured mesh is one in which each node is connected to a constant number of elements.
[3] A semi-structured volume mesh is one in which you can distinguish a fixed structure in one direction, i.e. there is a fixed number of divisions. However, within each division the mesh need not be structured. This kind of mesh is only practical for topologically prismatic volumes.

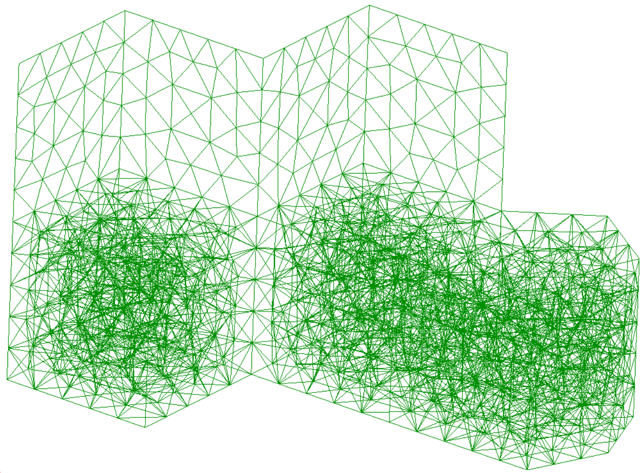


Figure 2. Generating the mesh by default.

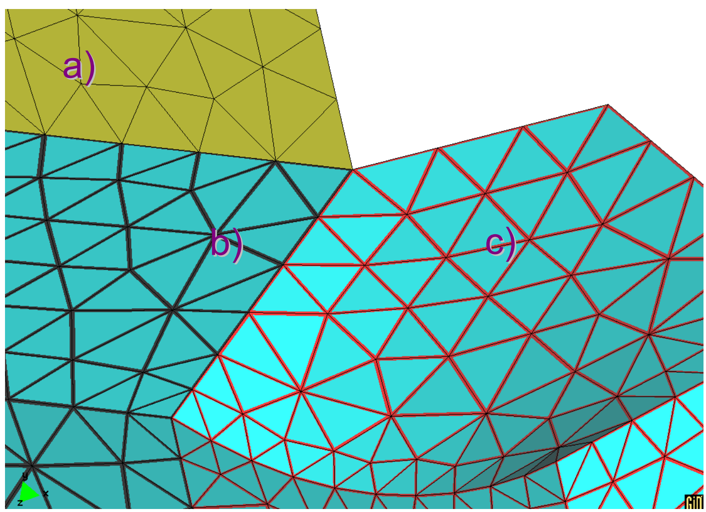


Figure 3. Different render styles: a) surface mesh, b) volume mesh, c) surface mesh and volume mesh together (surface layer is red and volume layer is blue).

2.2. Generating the mesh using points

1. Select **Mesh→Element type→Only points**. Select volume number one and press **ESC**[4]**.** To see entity numbers select **Label** from the mouse menu or from the **View** menu. If you wish the geometrical entity labels to be displayed, the view mode needs to be changed to Geometry using **View→Mode→Geometry** (this option may also be found in the GiD Toolbox). Select **Render→Normal** to see the labels.
2. Select **Mesh→Generate mesh**.
3. A window comes up asking whether the previous mesh should be eliminated. Click **Yes**.
4. Another window appears in which to enter the maximum element size. Leave the default value unaltered and click **OK**. The result is a mesh as illustrated in Figure 4.

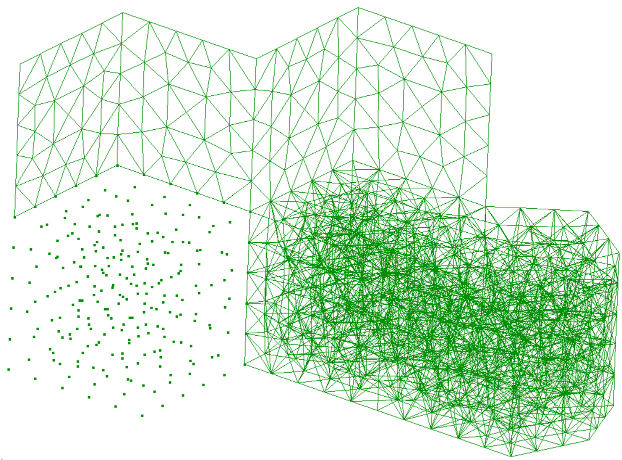


Figure 4. Generating a mesh on a volume using points.

5. Now volume number one is meshed using only the generated nodes.

---

[4] Instead of pressing the **ESC** key, the center mouse button or the mouse wheel can also be used.

2.3. Generating the mesh using quadrilaterals

1. Select **Mesh→Element type→Quadrilateral**. Select surface number 10.
2. Select **Mesh→Generate mesh**.
3. A window comes up asking whether the previous mesh should be eliminated. Click **Yes**.
4. Another window appears in which the maximum element size can be entered. Leave the default value unaltered and click **OK**. The result will be the mesh illustrated in Figure 5.

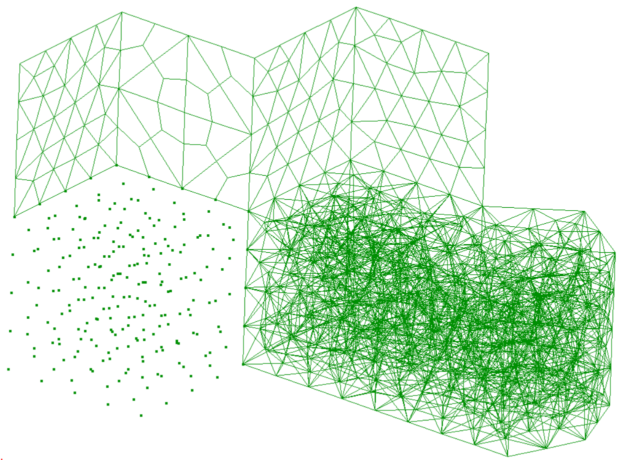


Figure 5. An unstructured mesh generated using quadrilaterals.

5. The surface is meshed with quadrilaterals, forming an unstructured mesh.

2.4. Generating a structured mesh (surfaces)

1. To mesh surfaces with a structured mesh, select the option **Mesh→Structured→Surfaces→Assign**.
2. Select surfaces 11 and 12 and press **ESC**.
3. A window appears in which to enter the number of divisions that the lines to be selected will have. Enter 4.
4. Select the lines defining the boundaries of the surfaces[5]. Press **ESC**.
5. Another window appears in which to enter the number of divisions on the lines. In this case, all the lines have already been defined with the same number of divisions. Therefore, click **Cancel**.
6. Select **Mesh→Element type→Triangle**. Select surface 12.

NOTE: The edges of surfaces meshed with an unstructured quadrilateral mesh must always be divided into an even number of segments. So, if these surfaces share edges with a structured surface mesh, the edges of the structured surface must also be divided into an even number of segments. In this example, therefore, lines are divided into 4 segments.

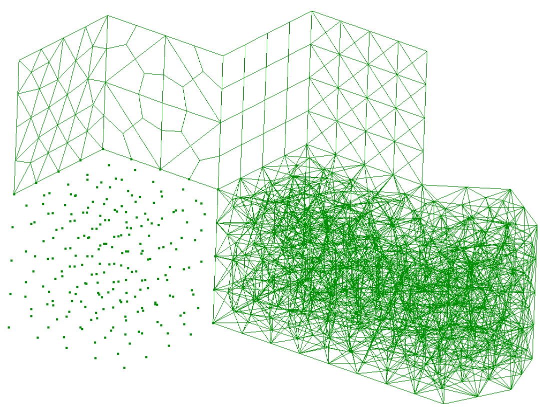


Figure 6. Structured mesh of quadrilateral and triangular elements on surfaces.

[5] When selecting a line, **GID** automatically selects all lines parallel to it.

7. Select **Mesh→Generate mesh**.
8. A window comes up asking whether the previous mesh should be eliminated. Click **Yes**.
9. Another window appears in which to enter the maximum element size. Leave the default value unaltered and click **OK**. The result is the mesh shown in Figure 6.
10. As seen in Figures 6 and 7, GiD can obtain surface structured meshes made of quadrilaterals or triangles. There are two kinds of structured mesh that use triangles: the one shown in Figure 6 is obtained when the **Utilities→Preferences→Meshing→Symmetrical structured triangles** option is set. If this option is not set, the mesh presented in Figure 7 is produced (with fewer nodes than if using the previous option).

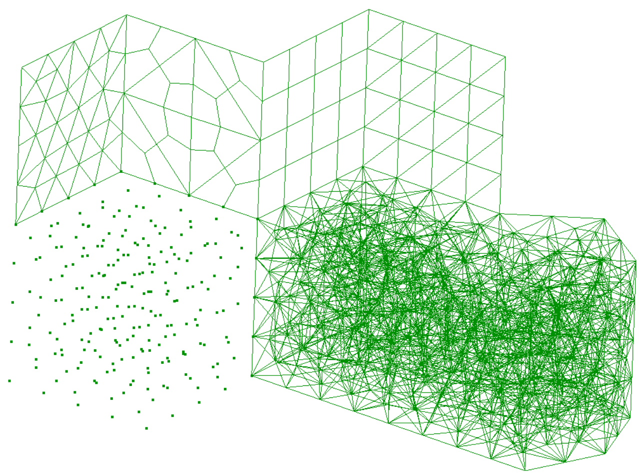


Figure 7. Structured mesh of quadrilateral and triangular elements on surfaces, with the option Symmetrical structured triangles not set.

2.5. Generating structured meshes (volumes)

1. To mesh volumes with a structured mesh, select the option **Mesh→Structured→Volumes**.
2. Select volumes 1 and 2 and press **ESC**[6].
3. A window appears in which to enter the number of divisions that the lines to be selected will have. Enter 6.
4. Select lines of both volumes parallel to the **X**- and **Z**-axes. GiD automatically selects all the lines in each volume parallel to these in order to create the structured mesh. Press **ESC**.
5. Another window appears in which to enter the number of divisions on the lines. Divide the lines parallel to the **Y**-axis into 8 segments. Enter 8 and click **OK**.
6. Select an edge of volume 1 or 2 parallel to the **Y**-axis and press **ESC**. Again, the line-division window comes up. Since we have already finished the assignments, click **Cancel**.

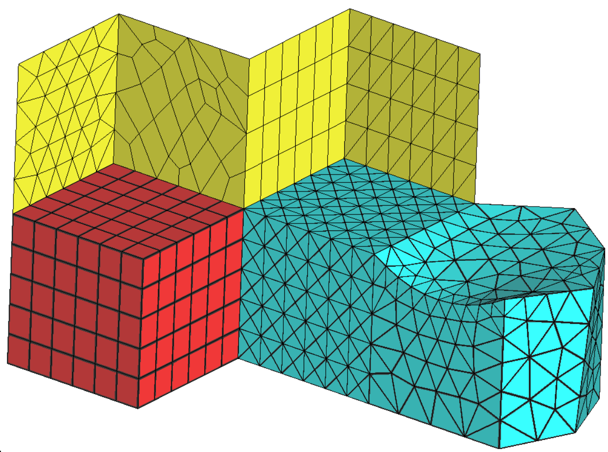


Figure 8. Structured volume mesh of hexahedra and tetrahedra.

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[6] Only volumes that are topologically cubic can be meshed with a structured mesh.

7. For structured volumes, GiD generates hexahedron meshes by default, but tetrahedron structured meshes can also be assigned. Select **Mesh→Element type→Tetrahedra** and then select volume number 2.
8. Select **Mesh→Generate mesh**.
9. A window appears asking whether the previous mesh should be eliminated. Click **Yes**.
10. Another window comes up in which to enter the maximum element size. Leave the default value unaltered and click **OK**. The result is the mesh shown in Figure 8.
11. GiD can obtain volume structured meshes made of hexahedra, tetrahedra or prisms. As can be seen in Figures 8 and 9, there are two kinds of tetrahedron structured mesh: the one shown in Figure 8 is obtained when the option **Utilities→Preferences→Meshing→Symmetrical structured tetrahedra** is set. If this option is not set, the mesh presented in Figure 9 is produced (with fewer nodes than if using the previous option; also, it is not topologically symmetrical).

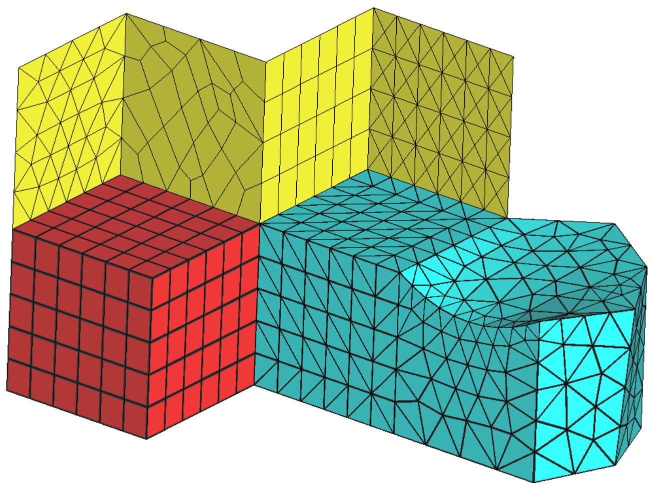

Figure 9. Structured volume mesh of tetrahedra with the option Symmetrical structured tetrahedra not set.

2.6. Generating semi-structured meshes (volumes)

1. To mesh volumes with a semi-structured mesh, select the option **Mesh→SemiStructured→Volumes**.
2. A window appears in which to enter the number of divisions for the direction in which it is structured (the prismatic one). Enter 8.
3. Select volume 3 and press **ESC**[7]. As volume 3 is prismatic in one direction only (i.e. parallel to **Y**-axis) GiD will automatically detect this fact and will select it to be the direction in which the semi-structured volume mesh is structured.
4. Another window appears in which to enter the number of divisions in the direction of the structure. In this case we do not want to select any more volumes, so click **Cancel**.
5. Select **Mesh→Generate mesh**.
6. A window appears asking whether the previous mesh should be eliminated. Click **Yes**.
7. Another window appears in which to enter the maximum element size. Leave the default value unaltered and click **OK**. The result is the mesh shown in Figure 10.

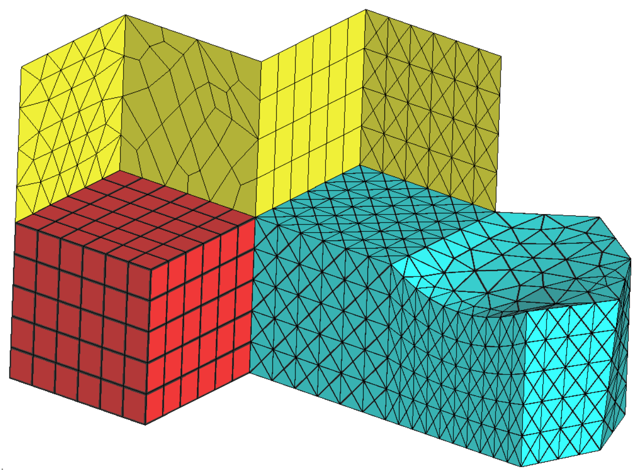

Figure 10. Semi-structured volume mesh of tetrahedra.

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[7] Only volumes that are topologically prismatic can be meshed with a semi-structured mesh.

As can be seen, volume 3 has been meshed with tetrahedra. Semi-structured volumes are meshed with prisms, by default. However, in this case it was not possible because of volume 2, which has tetrahedra assigned and shares one surface with volume 3. In the following steps a hexahedron mesh is produced.

8. Select **Mesh→Element type→Hexahedra.**
9. Select volumes 2 and 3 and press **ESC**.
10. Select **Mesh→Generate mesh**.
11. A window opens asking whether the previous mesh should be eliminated. Click **Yes**.
12. Another window appears in which to enter the maximum element size. Leave the default value unaltered and click **OK**. The result is the mesh shown in Figure 11.

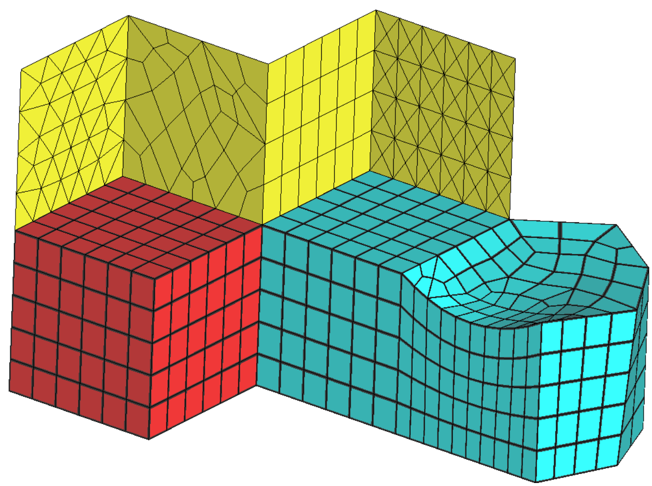


Figure 11. Semi-structured volume mesh of hexahedra.

In case of volume number 3 there is only one direction in which it can possibly be structured (i.e. in the direction of the prism). If the volume is prismatic in more than one direction, there are two ways to choose between them: selecting one top surface (**Mesh→SemiStructured→Set→Master surface**) or the direction of the structure (**Mesh→SemiStructured→Set→Structured direction**). The following example explains this procedure.

13. Select the option **Mesh→SemiStructured→Volumes**.
14. A window opens in which to enter the number of divisions in the structured direction (prismatic). Enter 6.
15. Select volume 1 and press **ESC**.
16. Select **Mesh→SemiStructured→Set→Structured direction**.

17. Select one line parallel to the **X**-axis of volume number 1 (for example line number 11)[8] and press **ESC**.
18. Select **Mesh→Unstructured→Assign Entities→Surfaces.**
19. Select surfaces 1 and 6 and press **ESC**[9].
20. Select **Mesh→Generate mesh**.
21. A window opens asking whether the previous mesh should be eliminated. Click **Yes**.
22. Another window appears in which to enter the maximum element size. Leave the default value unaltered and click **OK**. The result is the mesh shown in Figure 12.

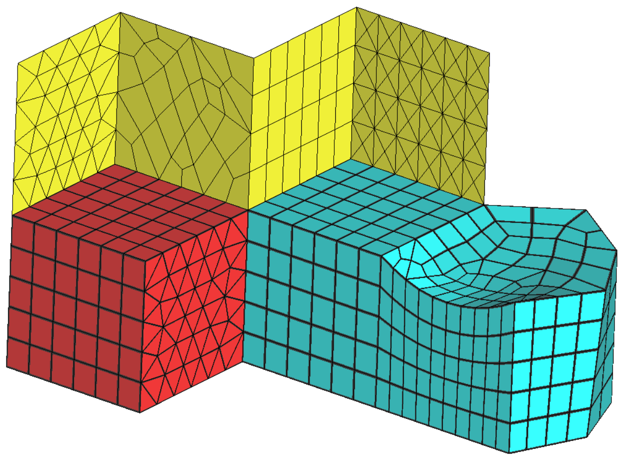


Figure 12. Semi-structured volume mesh of prisms and hexahedra.

NOTE: As can be seen, by selecting different element types for different geometrical entities, several kinds of meshes can be generated. Remember always to take care over the compatibility between element types in shared geometrical entities.

[8] Volume number one have not been selected as semi-structured, but GiD will assign this mesh criteria to it automatically when selecting one of its lines to be a structured direction.

[9] It's necessary to set one top surface of the volume "unstructured" because, otherwise, volume 1 will become totally structured. It is because all contour surfaces of this volume have been assigned as structured automatically when assigning previously this kind of mesh to the volume (step 2 of chapter 2.5).

2.7. Concentrating elements and assigning sizes

1. Select **Mesh→Structured→Lines→Concentrate elements**.
2. Select some structured lines, for example lines 3 and 23. Press **ESC**.
3. A window comes up in which to enter two values for the concentration of elements. Positive values concentrate the elements and negative values spread them. Enter 1 as **Start Weight** and –0.5 as **End Weight**[10].
4. Select **Mesh→Generate mesh**.
5. A window opens asking whether the previous mesh should be eliminated. Click **Yes**.
6. Another window appears in which to enter the maximum element size. Leave the default value unaltered. The result is the mesh shown in Figure 13.

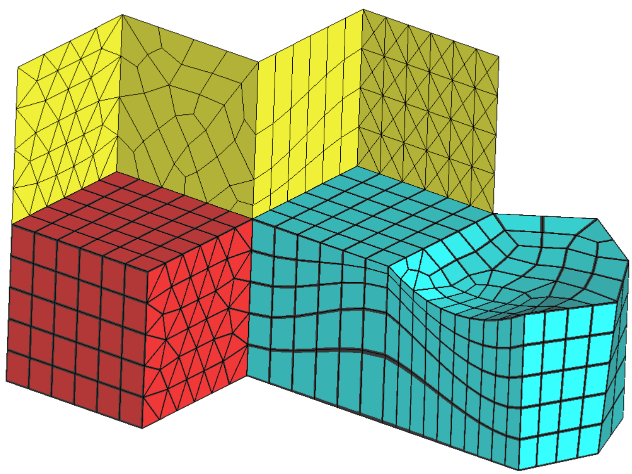


Figure 13. Concentration of elements on lines 3 and 23.

It is also possible to assign sizes to geometrical entities, so that mesh elements can be concentrated in certain zones. In the following steps some examples are given.

---

[10] Start Weight and End Weight refer to the start point and end point of the line, oriented as it is drawn when you select it.

7. Select **Mesh→Unstructured→Assign sizes on points**.
8. A window appears in which to enter the size to be assigned to points. Enter “0.1”.
9. Select point number 11 and press **ESC**.
10. Another window appears in which to enter the size to be assigned to points. In this case, we do not want to assign sizes to any other points, so click Cancel.
11. Select **Mesh→Unstructured→Assign sizes on lines**.
12. A window appears in which to enter the size to be assigned to lines. Enter “0.5”.
13. Select line number 21 and press **ESC**.
14. Another window appears in which to enter the size to be assigned to lines. In this case, we do not want to assign sizes to any more lines, so click Cancel.
15. Select **Mesh→Generate mesh**.
16. A window appears asking whether the previous mesh should be eliminated. Click **Yes**.
17. Another window appears in which the maximum element size should be entered. Leave the default value unaltered. The result is the mesh shown in Figure 14.

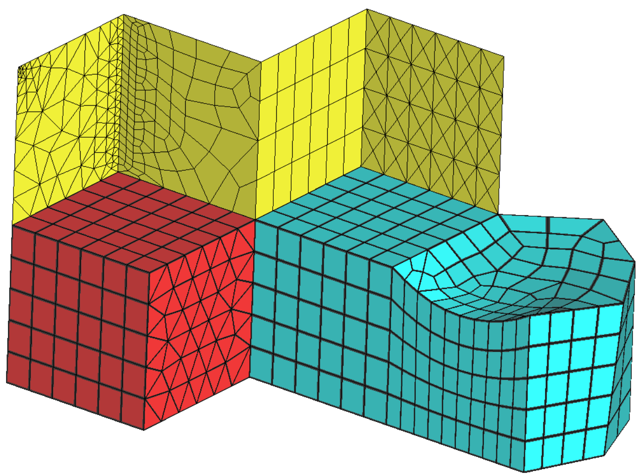


Figure 14. Unstructured size assigned in point 11 and line 21.

2.8. Generating the mesh using quadratic elements

1. Select **Zoom→In** from the mouse menu (this option may also be found in the GiD Toolbox or in the **View** menu). Enlarge one area of the mesh (e.g. the zone near point number 3).
2. Select **Label→All in→Points**. The result is shown in Figure 15.

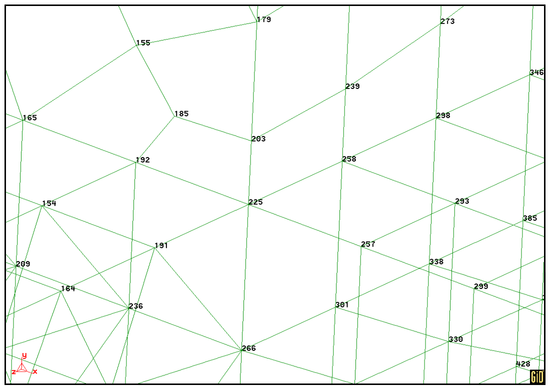


Figure 15. Each number identifies a node. There is a node for each element vertex.

3. The node identifiers created by generating the mesh appear on the screen. There is one identifier for each vertex of each element.
4. Select **Mesh→Quadratic elements→Quadratic**.
5. Select **Mesh→Generate mesh**.
6. A window opens asking whether the previous mesh should be eliminated. Click **Yes**.
7. Another window appears in which the maximum element size should be entered. Leave the default value unaltered and click **OK**.
8. Once the mesh has been generated, select **Label→All in→Points**. The result is shown in Figure 16. Now, there are not only nodes at the vertices, but also at the midpoints of the edges of the elements.
9. Select **Mesh→Quadratic elements→Quadratic9**.
10. Select **Mesh→Generate mesh**.

NOTE: By default GiD meshes with first degree (linear) elements. To find out which mode GiD is working in, select **Mesh→Quadratic elements**, and it is the flagged option.

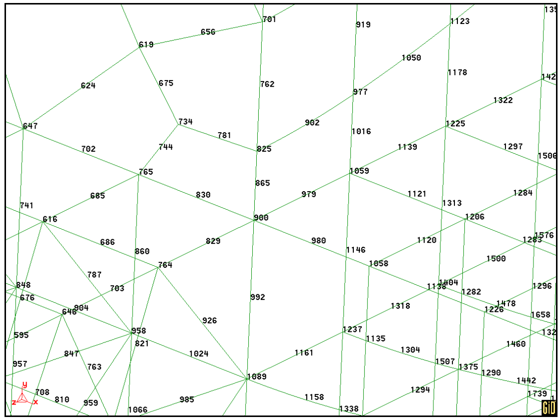


Figure 16. Each number identifies a node. There is a node at each element vertex and at the midpoint of each edge.

11. A window opens asking whether the previous mesh should be eliminated. Click **Yes**.
12. Another window appears in which the maximum element size should be entered. Leave the default value unaltered.
13. Select **Label→All in→Points** (see Figure 17).
14. Notice that the four-sided elements (quadrilaterals) also have a node in the center, in addition to the nodes at the vertices and midpoints of the edges. Similarly, hexahedra also have a node at their center point.

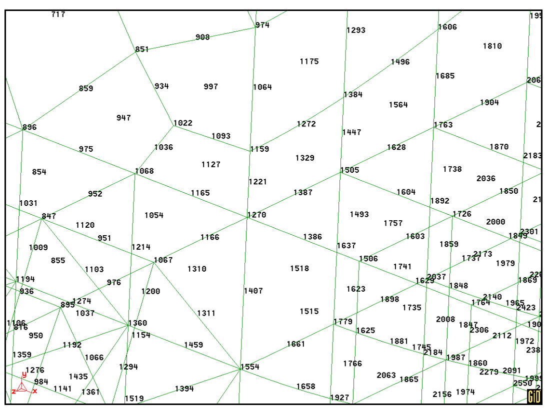


Figure 17. Each number identifies a node. There is a node at each vertex, at the midpoint of each edge and in the center of quadrilaterals and hexahedra.

A POST-PROCESS CASE STUDY

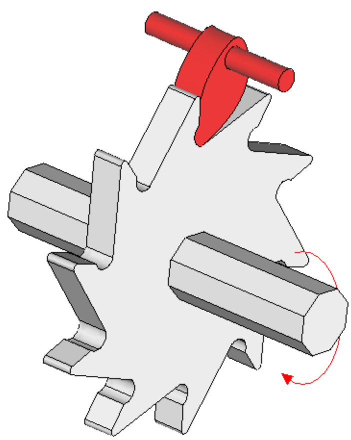
POST-PROCESSING A RATCHET WHEEL

The objective of this case study is to run a post-process analysis of a steel ratchet wheel subjected to a set of forces. We will observe the stresses on the material and the resulting deformations.

The analysis is carried out in four steps:

- Redefining the part
- Entering conditions and materials
- Generating the mesh for the entire part and calculating the stresses
- Visualizing the results

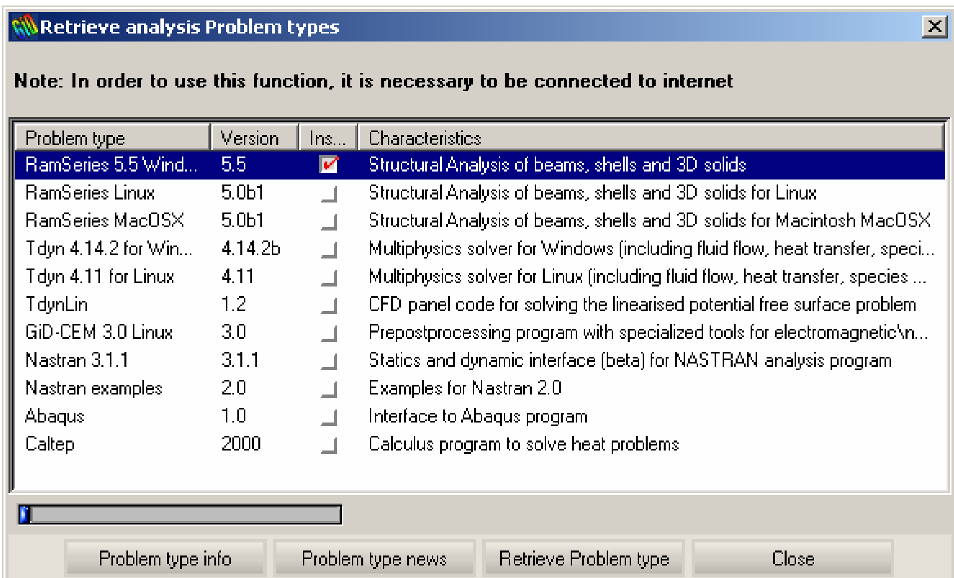
By the end of this study, you should be able to run a structural analysis of a model subjected to external forces and visualize the results in GiD Post-process.



1. INTRODUCTION

The model in this study will be the one created in Tutorial 1, located in the file "pieza.gid". The geometry in this file will be the object of this post-process study.

In order to follow this tutorial, the calculating module **Ramsolid**[1] must be installed. To install **Ramsolid**, select **Data→Problem type→Internet Retrieve**. A window with the available modules will appear. Select **RamSeries Windows**, which contains **Ramsolid**, and click **Retrieve Problem type** to install it.



NOTE: You can find the finished model on the GiD CD-ROM or on the GiD web page: http://www.gidhome.com/support.

[1] For further information on Ramsolid, consult www.compassis.com

1.1. Reading the initial file

1. From the **Files** menu, choose the option **Read**. Select the file named “pieza.gid” and click **Open**. The geometry in Figure 1 appears on the screen.
2. Choose **Render→Flat** from the mouse menu.
3. Choose **Rotate→Trackball** from the mouse menu. (This tool is also located in the GiD Toolbox.) Make a few changes to the perspective in order to get an idea of the geometry under study.

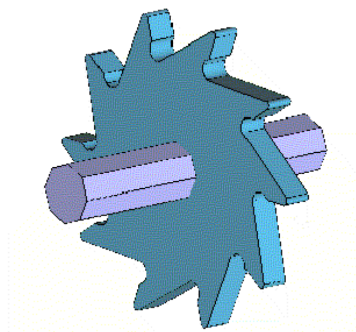


Figure 1. Contents of the “pieza.gid” file

4. Return to the normal visualization by selecting **Render→Normal**. This mode is more comfortable to work with.

2. CREATING A SINGLE VOLUME

When you carry out a stress test which involves the different volumes that define a structural solid, Ramsolid requires these volumes to share the surfaces of interaction, that is, these surfaces must belong to both volumes.

Since the geometry of this study is formed by two volumes with separate surfaces, the volumes must be connected. To do this, we will delete the existing volumes (those of the axle and the wheel) and create one new volume as a union of the two.

2.1. Deleting volumes and surfaces

1. Choose **Geometry→Delete→Volumes**[2].
2. Select the two volumes in the file. Press **ESC**[3].
3. Choose **Geometry→Delete→Surfaces**[2]. Select[4] the surfaces shown in Figure 2 and Figure 3 and press **ESC**.
4.

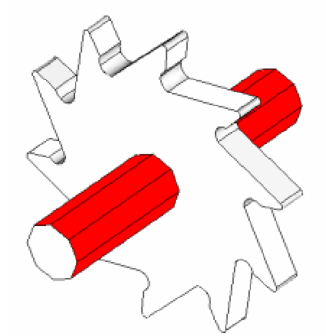


Figure 2. The axle surfaces to select

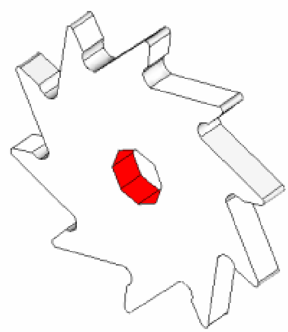


Figure 3. The wheel surfaces to select

[2] This option may also be found in the GiD Toolbox.

[3] Pressing the **ESC** key is equivalent to clicking the center mouse button.

[4] To facilitate the selection of these surfaces, deactivate any unnecessary layers.

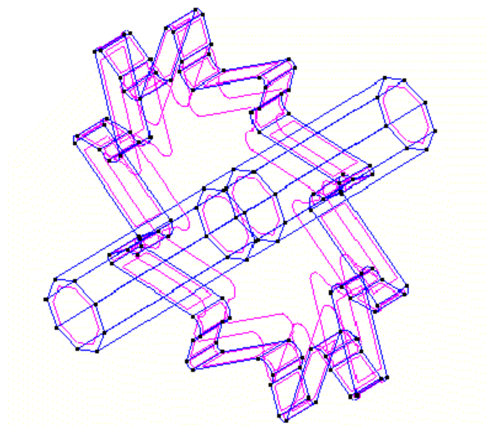


Figure 4. The result after deleting volumes and surfaces

2.2. Creating new surfaces and the final volume

1. Choose the option **Utilities→Copy**; the Copy window appears. In this window choose **Translation** and **Lines**. The translation vector of the required translation is the line segment shown in Figure 5. Enter as First Point and Second Point the two points defining this vector. These points are also shown in Figure 5.

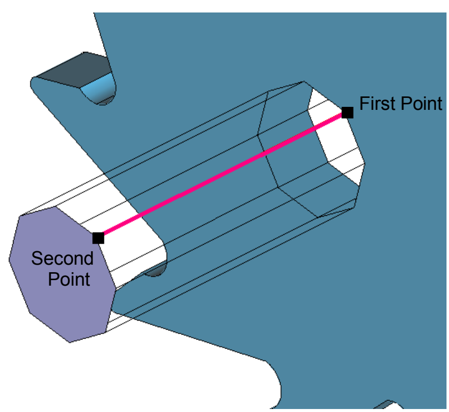


Figure 5. The translation vector and the points that define it

2. Choose the option **Surfaces** from the **Do Extrude** menu in the **Copy** window.
3. Verify that the "**Duplicate entities**" option is unchecked, and then click **Select** and select the lines defining the hole in the wheel. Press **ESC**. (See Figure 6.)

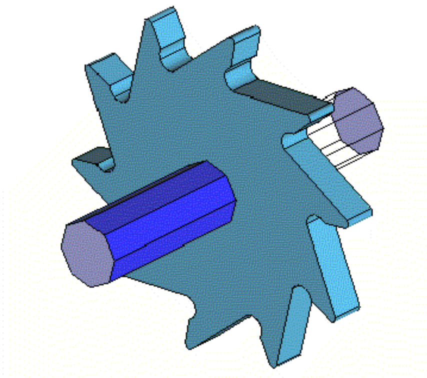


Figure 6. Visualization of the new surfaces created at one end of the axle

4. Repeat the process to create the surfaces at the other end of the axle.
5. When all the surfaces have been created, thus defining a new part (axle and wheel as one), choose **Geometry→Create→Volume→By contour**[2] and select all the surfaces. Press **ESC**.

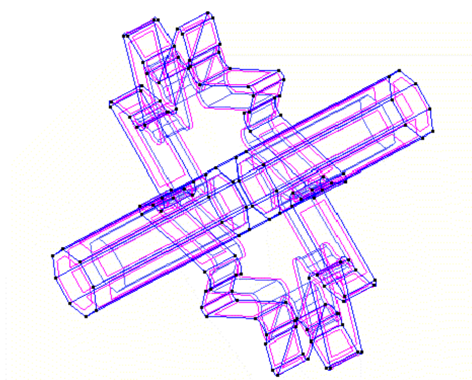


Figure 7. Visualization of the new volume

6. Choose **Geometry→Delete→Lines** and select all the lines in the model. Press **ESC**.
7. Only the lines not contained by the volume will be deleted.

3. CALCULATING WITH RAMSOLID

Since this is a 3D problem, the calculating module “Ramsolid 5.5” will be used to run it. First we must load the problem type **ramsolid** which is located in **Data→Problem type.**

Note: Your Ramsolid version can be different to the related 5.5, but the steps to follow will be analogous.

The object of the study is a ratchet wheel that permits rotation of the axle in only one direction. The aim is to study how the part behaves when subjected to external forces, especially when the wheel is in equilibrium. In this condition, rotation is blocked by the pole, which resists the rotating force coming from the axle. At the same time, the pole exerts an equal and opposite force on one of the teeth. This system is illustrated in Figure 8.

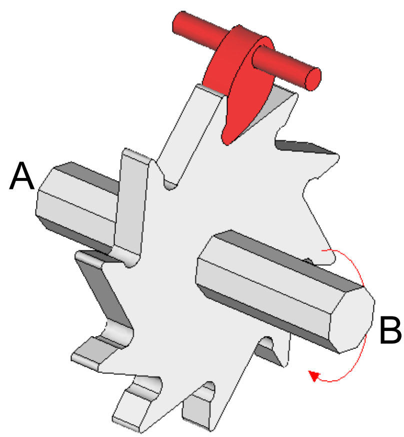
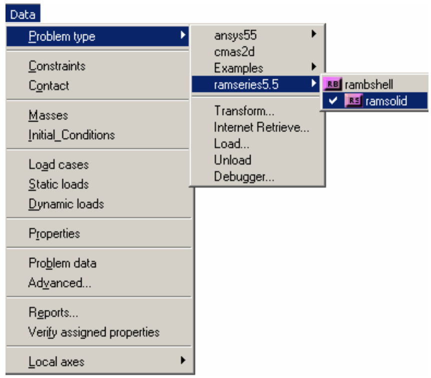


Figure 8. Ratchet wheel and (in red) pole

In order to simulate this condition, the following simplification will be made: the ends of the axle will be blocked and pressure will be applied to the surfaces of the tooth where the pole resists rotation. The material is steel.

3.1. Defining the problem: materials and conditions

1. Since this is a three-dimensional solid problem, choose the option **Data→Problem type→RamSeries5.5→ramsolid**.



2. Choose **Data→Constraints**. A window appears in which the problem constraints are entered.

3. We are dealing with constraints acting on surfaces: the **surface** symbol  must be clicked

Figure 9. The Constraints window.

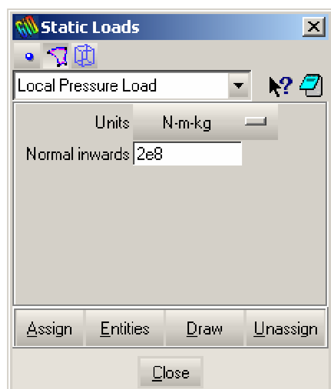


Figure 10. The Static Loads window with the Local Pressure Load option selected over surfaces.

4. In the **Constraints** window, click **Assign**. Select the two surfaces that are the ends of the axle then press **ESC** (or **Finish** in the **Constraints** window).

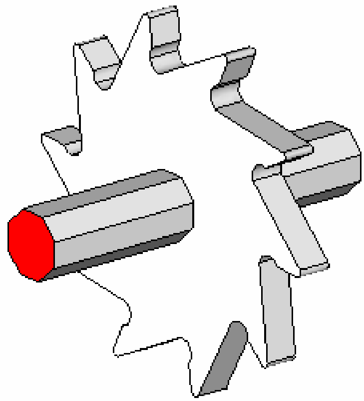


Figure 11. Selecting the surfaces that are the ends of the axle

5. Choose the **Draw** option from the menu in the **Constraints** window. Then select the **colors** option (see Figure 12).

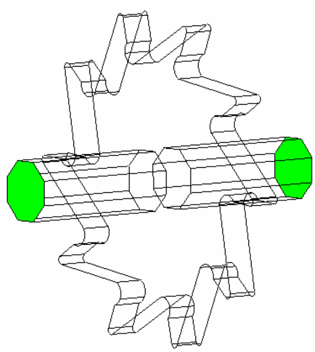


Figure 12. Visualization of the condition applied to the surfaces under pressure

6. Click **Data→Static loads** and select **surfaces.**

7. From the pull-down menu select **Local Pressure Load**. This option enables you to define the surfaces under pressure[5] and specify the value of the pressure. Enter 2e8 having selected **N-m-kg** in the units menu (see Figure 10). Click **Assign** and select the surfaces which will be subject to pressure.

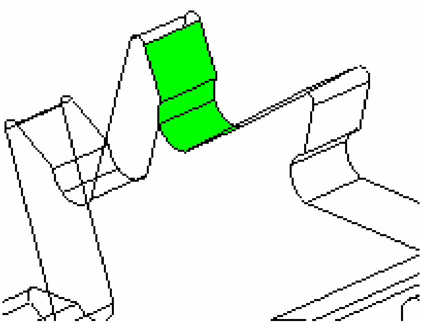


Figure 13. Surface of a tooth under pressure

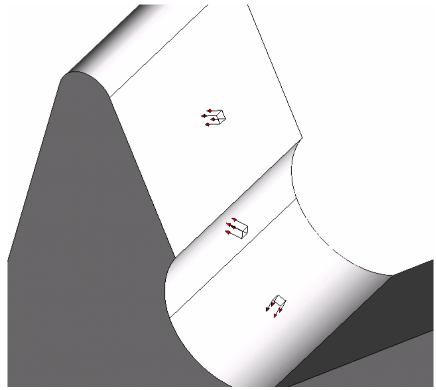


Figure 14. Visualization of the condition applied to the surfaces under pressure

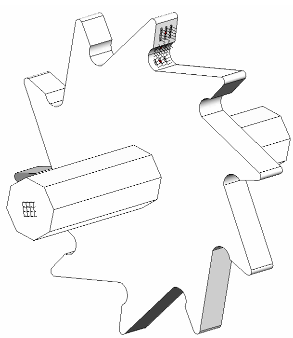


Figure 15. Visualization of all the conditions entered

[5] Pressure is applied to a surface in the direction of the normal to the surface. If the surface is part of a volume, a positive pressure value indicates a force towards the interior of the volume.

8. The next step is specifying the material of the part. Choose **Data→Properties**. The **Properties** window appears. We want to simulate steel, so enter the corresponding values of its Young's Modulus (**E**), Poisson Ratio (**nu**) and **Specific weight**. Make sure you have selected **N-m** in the units menu.

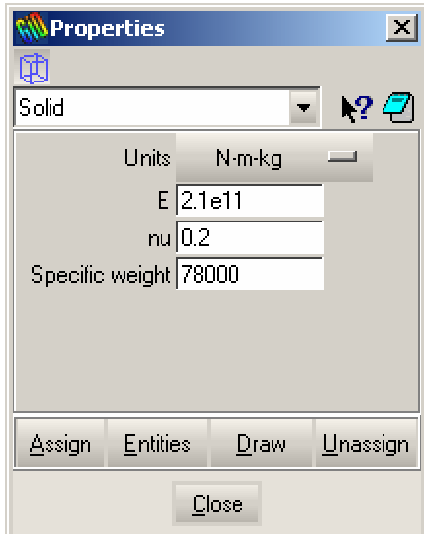


Figure 16. The Properties window

9. Click **Assign** and select the volume of the part. Press **ESC** when the selection is finished.

10. Choose the **Problem Data** option from the **Data** menu. The **Problem Data** window appears. In the **Units** card, make sure that **Mesh units** is set to **m**, and that **Results units** is set to **N-m-kg**. In the **Gravity** card, we can change the direction in which gravity acts. Leave this as the default value (**Z direction**). Press **Accept Data** to finish.

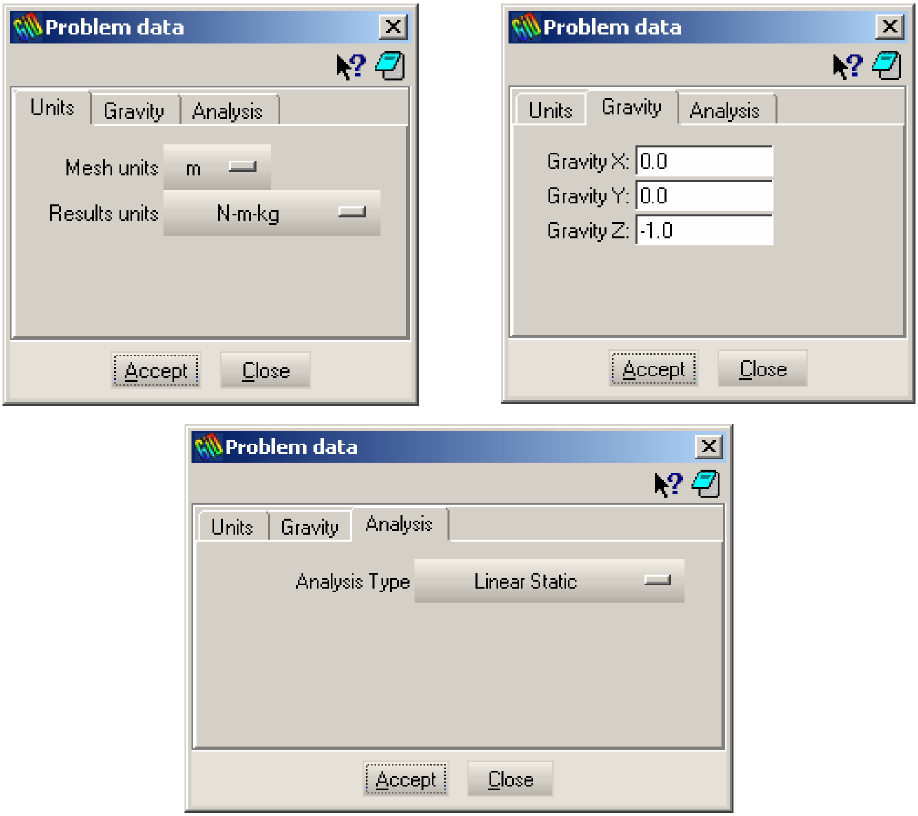


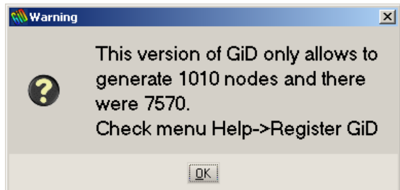
Figure 17. The Problem Data window

NOTE: GiD enables you to define intervals. An interval is a set of conditions of the kind entered in this section. Depending on the calculation mode, intervals may be used for different reasons. By default, only one interval is used.

In the **Data** menu, there is a submenu labeled **Intervals** where intervals can be managed: **New** (for creating a new interval), **Current** (for selecting the current interval), and **Delete** (for deleting the current interval).

3.2. Generating the mesh and running calculations

1. Choose **Mesh→Generate mesh**.
2. A window appears in which to enter the desired element size for the mesh to be generated. Leave the default value provided by GiD unaltered and click **OK**. When using an evaluation version, this may cause a problem if the number of mesh elements generated exceeds the number permitted for unregistered copies of GiD.



3. If you obtain a message like the one above, you can get a temporary trial password, or try generating fewer elements by changing the meshing preferences and selecting a larger element size.
   a. Select the option **Mesh→Reset mesh data** to clear all previously assigned sizes.
   b. Open the **Preferences** window (**Utilities→Preferences**) and select the **Meshing** card. Set the value for **Unstructured size transition** to 0.9, click **Accept** and then **Close.**
   c. Select the option **Mesh→Generate mesh** and set the size to 10.
4. Once the meshing process has concluded, a window appears with information about the mesh that has been generated. Click **OK** to visualize it.
5. Another window shows the meshing process. When the process is finished, use **Mesh→Vies mesh boundaries** to see just the contours of the volumes that have been meshed, not their interiors. This visualization mode may be combined with one of the various rendering methods (see Figure 18).

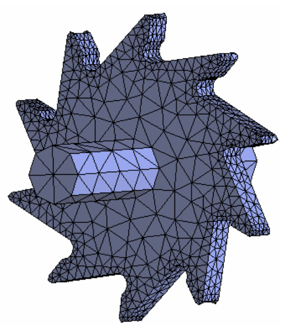


Figure 18. Meshing the part with default settings

6. Now we can begin to perform the calculations. Choose the **Calculate** option from the **Calculate** menu. The Ramsolid calculating module begins the process[6] which is run in background. When the process finishes, a new window appears.

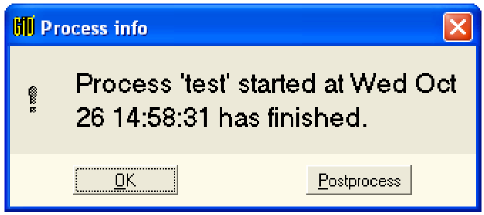


Figure 19.The Process info window

7. Click on **Postprocess** in order to analyze the results.
8. Select **View results→Displacements→|Displacements**.

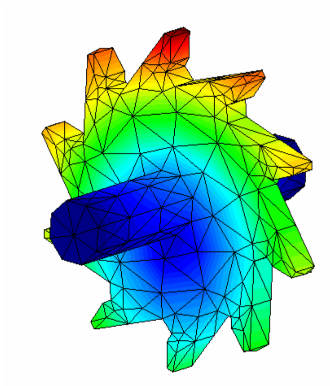


Figure 20. Displacement results

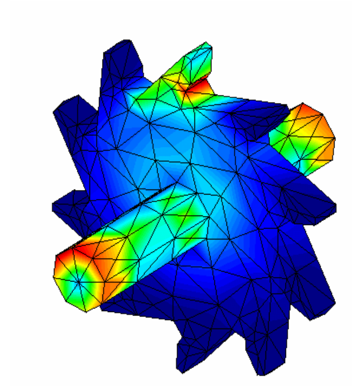


Figure 21. Von Misses results.

9. Instead of displacements, we can choose **View results→Von Misses**
10. Calculating the stresses on the part is especially significant when the surfaces around the tooth are under pressure. It is important that the mesh on these surfaces is sufficiently accurate. Accordingly, a smaller sized element will be assigned to these surfaces.

[6] For further information about the calculation process, select Calculate Window. A window appears indicating the moment when the calculation began and its PID. To close this window, click Kill.

11. Before we continue we need to obtain temporary passwords for both GiD and Ramseries in order to work with larger meshes. If you already have the passwords skip this step, if not, follow these steps:
    a. Obtain a temporary password for GiD at: http://www.gidhome.com/password
    b. Obtain a temporal password for Ramseries at: http://www.compassis.com.
12. Return to GiD Preprocess, go to **Utilities→Preferences→Meshing** and press **Reset**. Another possibility is to select the menu option **Mesh→Reset mesh data**.

NOTE: On the **Meshing** card in the **Preferences** window, there is an option labeled **Unstructured size transitions**, which defines the transition gradient of element sizes (size gradient), the gradient values being between 0 and 1; the greater the size gradient, the greater the change in space. The default value for this element size is 0.6.

1. Choose **Mesh→Unstructured→Surfaces**. A window appears in which to enter the element size for the surfaces to be selected. Enter size 1.
2. Select the surfaces under pressure and the surfaces around them.

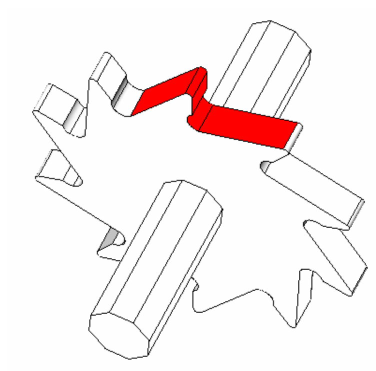


Figure 22. Selecting the surfaces to be assigned size 1 elements

3. Choose **Mesh→Generate mesh**.
4. A window appears asking whether the previous mesh should be eliminated. Click **Yes**. Another window opens in which the maximum element size should be entered. Leave the default value unaltered.

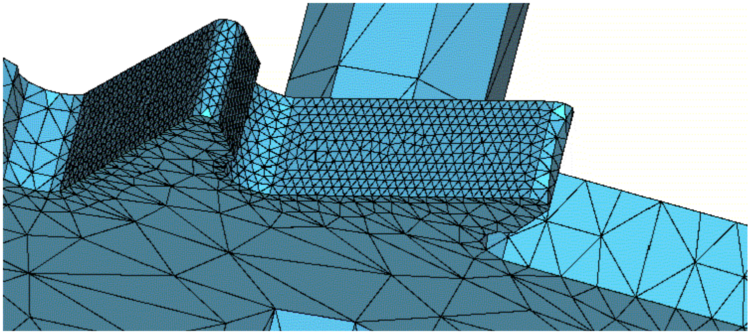


Figure 23. Concentration of elements on the selected surfaces

5. Now the calculation can be run. Choose the **Calculate** option from the **Calculate** menu[7].
6. Wait until a window appears stating that the calculation is finished.

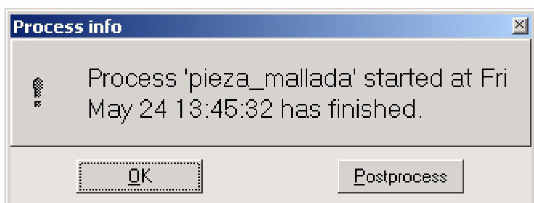


Figure 24. The Process info window

NOTE: The greater the accuracy of the mesh, the greater the accuracy of the calculation and representation in post-processing. Nevertheless, bear in mind that for a large number of elements, the total calculation time can be rather long.

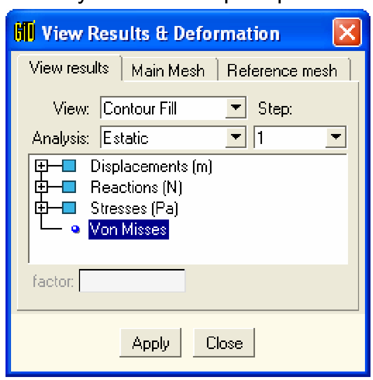
[7] The calculation process runs in the background. You can continue working with GiD, albeit at a slower pace.

4. POST-PROCESSING THE PART

Once the calculation has been run, the post-process study may begin. GiD Post-process enables you to visualize the results based on the analysis.

4.1. Visualizing the results

1. Select **Files→Postprocess**.
2. From the **Windows** menu, choose the **View Results** option. By default, no result is visualized when you enter the post-processing component.



3. Select Contour Fill in the **View** combo box and **Von Misses** from the list of available results.

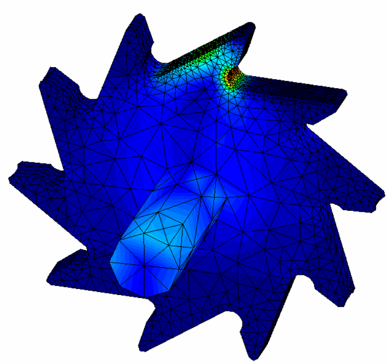


Figure 25. Visualization of the VON MISSES calculation

4. The **View** menu and the **Results** menu may be combined in order to see the various calculations with each one of the visualization methods. For example, select **Windows→View style** and **Hidden Bound** in the **Style** combo box. Then in the **View results** window select **Contour Lines** from the **View** combo box and from the list of results select the **Sx** component of the **Stresses** result. Click **Apply**.

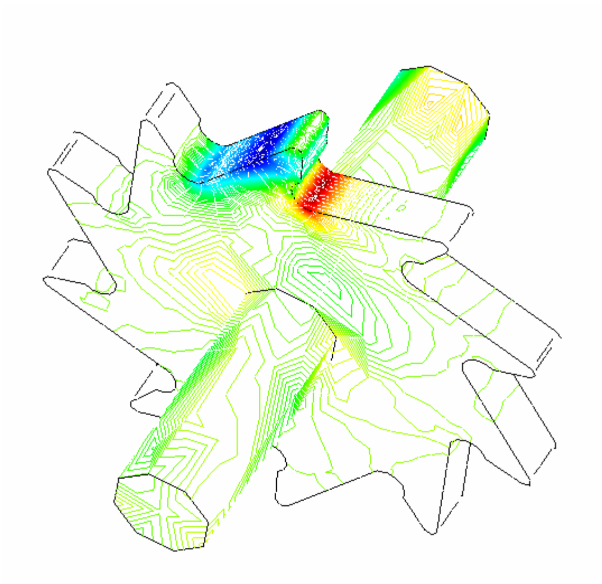


Figure 26. Visualization of the X component of the NODAL STRESS calculation using Contour Lines

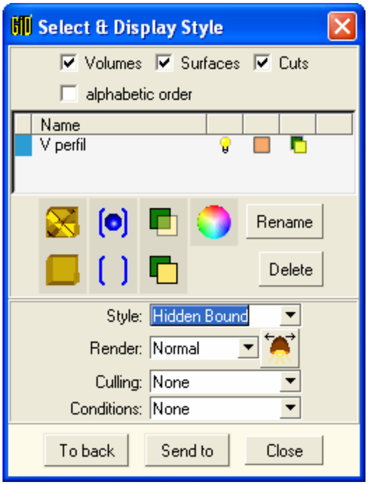


Figure 27. View Style window

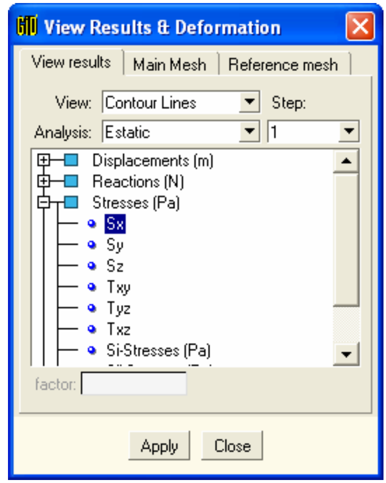


Figure 28. View Results window

5. Return to the visualization of the **Von Misses** calculation by using the **Contour Fill** option.
6. The part will be rendered with a scale of colors covering the range of calculated values (Figure 29). In this example only one interval of the total results range is of interest. The scale of colors must be adapted so that the lower limit is 5.5e7 and the upper limit is 1e9 (Figure 30).
7. Choose **Options→Contour→Define Limits**[8]. The **Contour Limits** window appears (Figure 31). Enter 1e9 in the box labelled **Max** and 5.5e7 as the **Min** value, then click **Apply**.

[8] This option is also available in the post-process Toolbox (Figure 31).

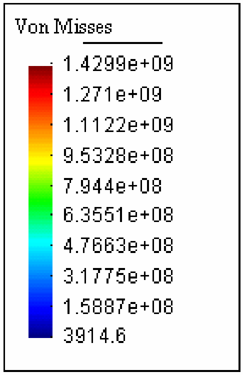


Figure 29. The color scale for the default values

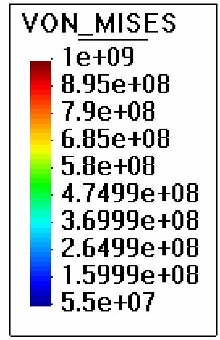


Figure 30. The color scale with the new limits for representing the VON MISSES calculation

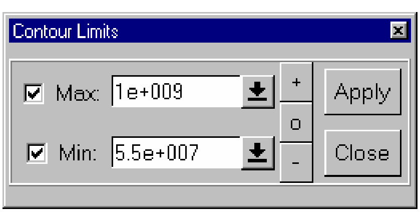


Figure 31. The Contour Limits window

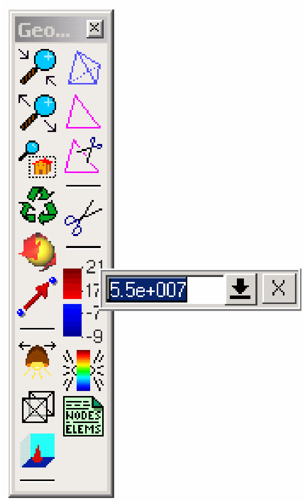


Figure 32. Entering the lower limit in the post-process Toolbox

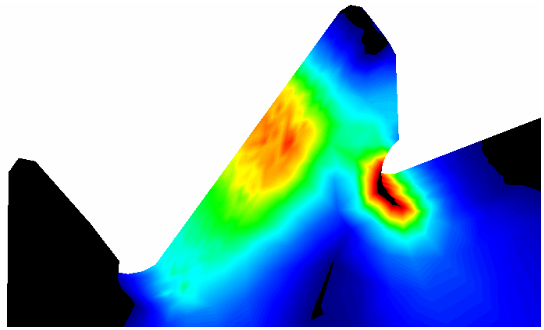


Figure 33. Visualization using the new color scale

8. The color scale is distributed between the values 1e9 and 5.5e7. All values outside this range are colored black. The way in which these values are shown can be changed. For example, select these options:

Options→Contour→Min Options→Out Min Color→Min Color and

Options→Contour→Max Options→Out Max Color→Transparent.

Those values below the visualization range are now represented in the same color as the minimum value. Those values greater than the maximum value are not drawn; they are perceived as transparent.

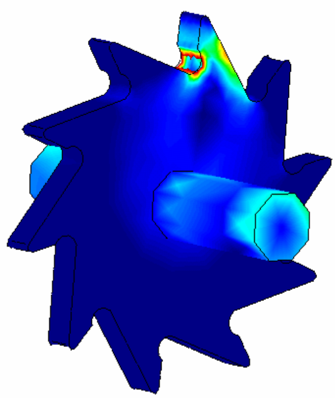


Figure 34. Visualization using the color scale established in step 8. The calculated values in transparent zones are greater than 1e9.

9. To return to the initial visualization limit values, choose **Options→ Contour→Reset Limit Values**.
10. Visualizing the results using vectors is also an option. A vector is drawn for each element of the mesh. In the **View Results** window, choose **Display Vectors** from the **View** combo box and **Stresses** from the results available. Then choose the **S_i** (the great main stress). Click **Apply**. Magnify the zone indicated in Figure 35.

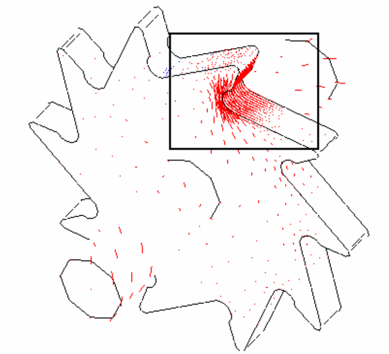


Figure 35. Visualization of the results using vectors

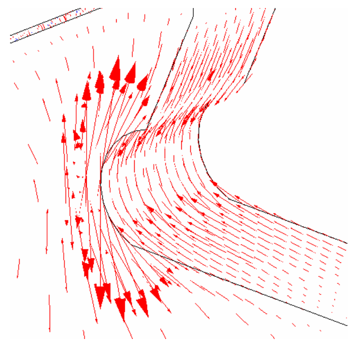


Figure 36. Si main stresses detail

11. Now select the **All** component from the **Stresses** result. Click **Apply**; the result is shown in Figure 388. Red vectors indicate traction (tensile stress) and blue vectors indicate compression.

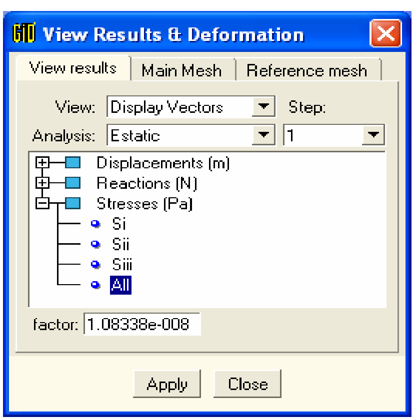


Figure 37. Result and scale selection

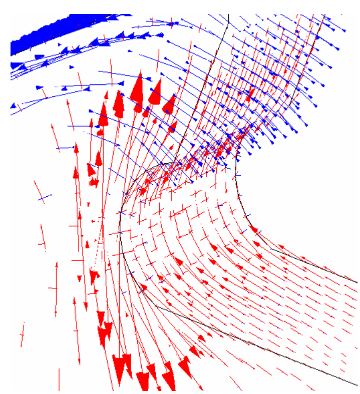


Figure 38. Visualization of all stresses

4.2. Modes of visualization

1. Choose **Windows→View Style**. A window labeled **Select & Display Style** appears in which the options for visualizing the geometry can be changed. This window is composed of various menus, each characterizing some aspect of the visualization of the model. Options from all these menus can be combined to achieve a suitable visualization.

NOTE: In the post-processing component, the elements of the mesh are classified into **Meshes**, **Sets** and **Cuts**. A new **Set** is created for each group of surfaces that share the same material, while there is a **Mesh** for each group of volumes sharing the same material. **Cuts** are sections made into the geometry during post-processing.

The categories **Meshes**, **Sets** and **Cuts** are at the top of the “Select & stile” window. For each category a color can be chosen using the **Color** option. Each one may be clicked **On** or **Off**[9], or deleted (**Del**). In the present example there is only one volume and therefore only one **Mesh** appears. It is named “Mesh1”.

The **Style**, **Render**, **Culling** and **Conditions** menus as well as the **Massive** and **Transparent** options affect the visualization of the entire mesh.

2. Try out the various options offered in the **Style**[9] menu. Click **Apply** to see the results.
3. Try out the various options offered in the **Culling**[9] menu combined with the **Conditions** menu and the **Transparent** and **Massive** options. Click **Apply** to see the results.

---

[9] This option is also located in the post-process **Toolbox**. For further information about the tools in the Toolbox, click on the corresponding icon with the right mouse button.

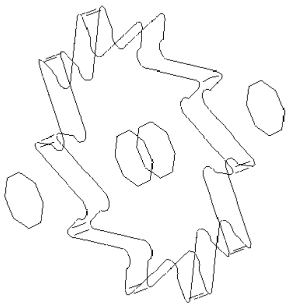


Figure 39. Visualization using Style→Boundaries

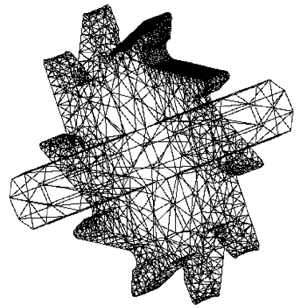


Figure 40. Visualization using Style→All Lines

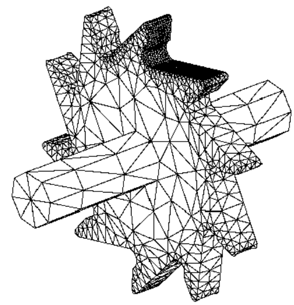


Figure 41. Visualization using Style→Hidden Lines

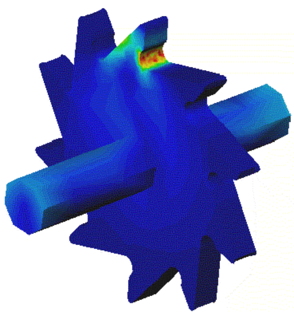


Figure 42. Visualization using Style→Body

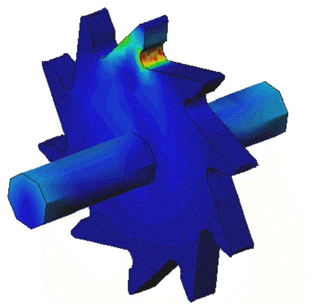


Figure 43. Visualization using Style→Body Bound

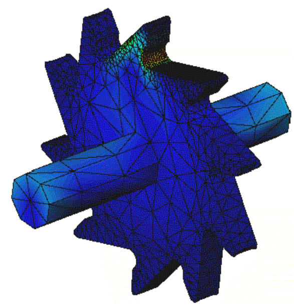


Figure 44. Visualization using Style→Body Lines

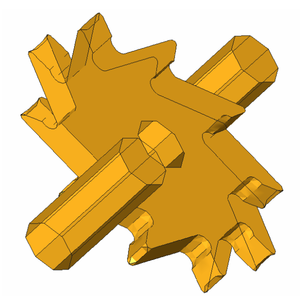


Figure 45. Culling→Front Faces.

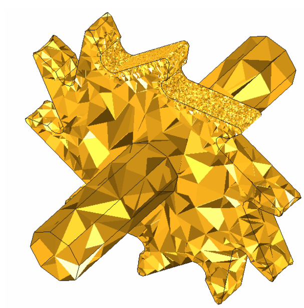


Figure 46. Culling→Front Faces with the Massive option

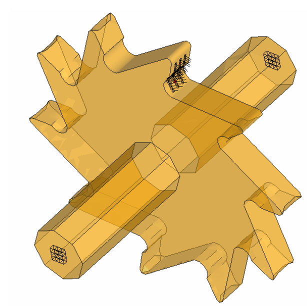


Figure 47. Culling→None, Conditions→Geometry and the Transparent option

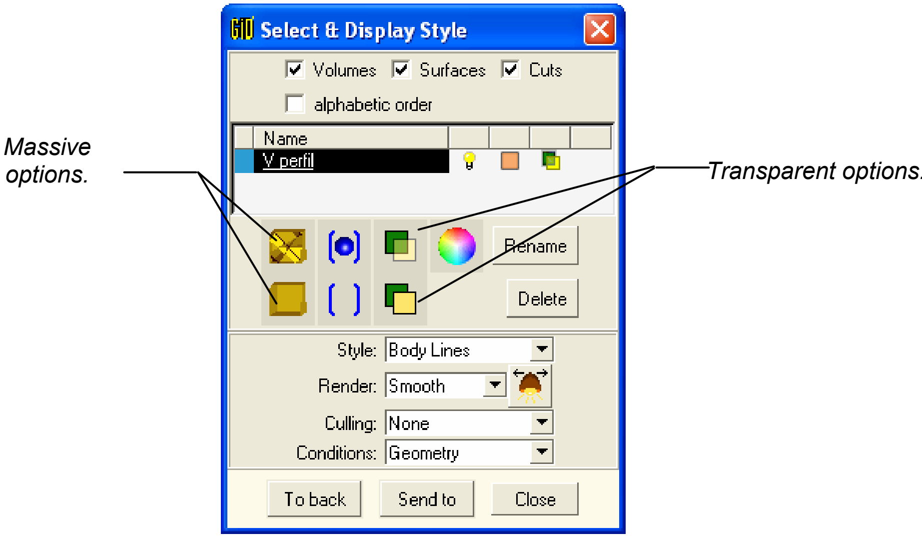


Figure 48. The Massive and Transparent options in the Display Style window

4.3. Visualizing the deformed geometry

1. Choose **Windows→View results**. The **View Results & Deformation** window appears.
2. From the **Style** menu in the **Select & Display Style** window, select **Boundaries**.
3. From the **Mesh Deformation** window, select **Deformation**, under the heading **Main Geometry**. Under the heading **Reference Geometry** select **Original**. Click **Apply**. In order to better distinguish the two geometries, select **Body Bound** from the **Style** menu in the **Select & Display Style** window.

NOTE: Changes carried out in the **Select & Display Style** window do not affect the reference geometry (in **Reference Geometry** in the **Mesh Deformation** window).

NOTE: The **factor** box in the **Mesh Deformation** window indicates the multiplication factor of the real deformation.

NOTE: In the **Steps** boxes in the **Mesh Deformation** window, the steps to be visualized can be selected.

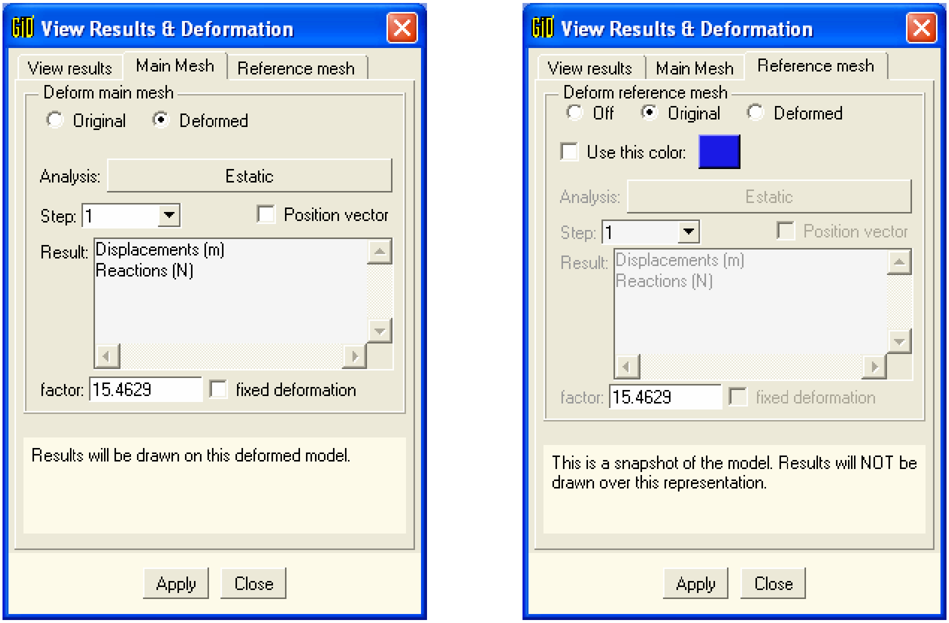


Figure 49. The Mesh Deformation window

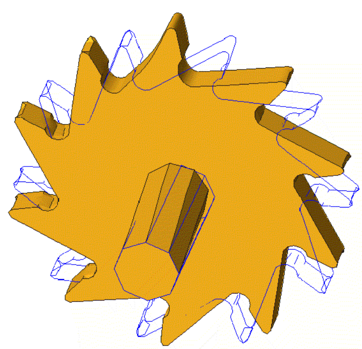


Figure 50. The (yellow) deformed geometry (Body Bound) versus the original geometry (Boundaries)

4. Now the deformed geometry can be visualized. For example, in the **View Results** window, select **Contour Fill** and **NODAL V.MISES** then click **Apply**.

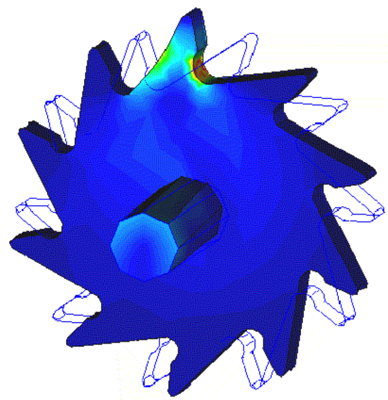


Figure 51. Visualizing the results of the deformed mesh (colored)

4.4. Cuts and divisions

1. In GiD Post-process, you can cut or divide the mesh to visualize the results within the interior of the part. Begin the cutting process by choosing **Do cuts→Cut plane→3 points**[10].

2. Using the **Join Ctrl-a** option in the **Contextual** menu, located in the mouse menu, select the three points indicated in

3. A **Cut** is made (see Figure 54). To visualize it, click **Off** "V perfil" in the **Select & Display Style** (Figure 53).

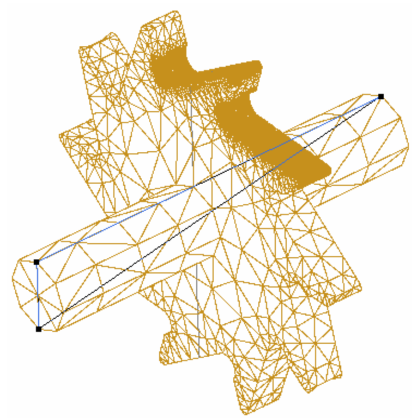


Figure 52. The cutting plane defined by three points

[10] Another option is Do cuts→Cut plane→2 points. Here, the cutting plane is the plane perpendicular to the screen that passes through the line defined by the 2 points. The cutting options are also located in the post-process Toolbox.

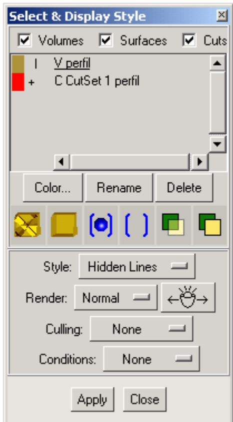


Figure 53. "V perfil" is Off.

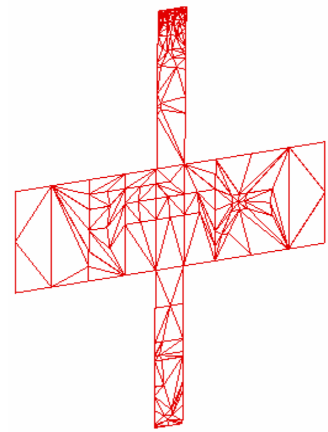


Figure 54. The section resulting from the cut

NOTE: The sections (**Cuts**) made in the original mesh also deform when the mesh deforms. And vice versa, the cuts made in the deformed mesh deform when the mesh returns to its original state.

4. Starting from the **View Results** window, select **Contour Lines** from the **View** menu, and select **Von Misses** from the **Results** available in the list. Click **Apply**, thus visualizing the results within the cut (Figure 55).

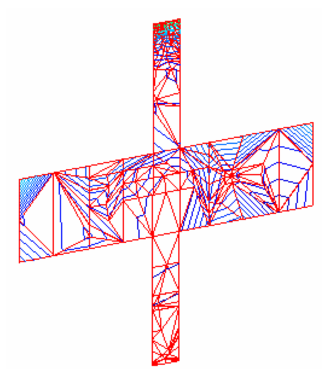


Figure 55. Visualizing the results within the cut

5. From the mouse menu, choose **Label→Select→Results.** Select several nodes, thus obtaining the numerical value of the VON MISSES module for each node selected.

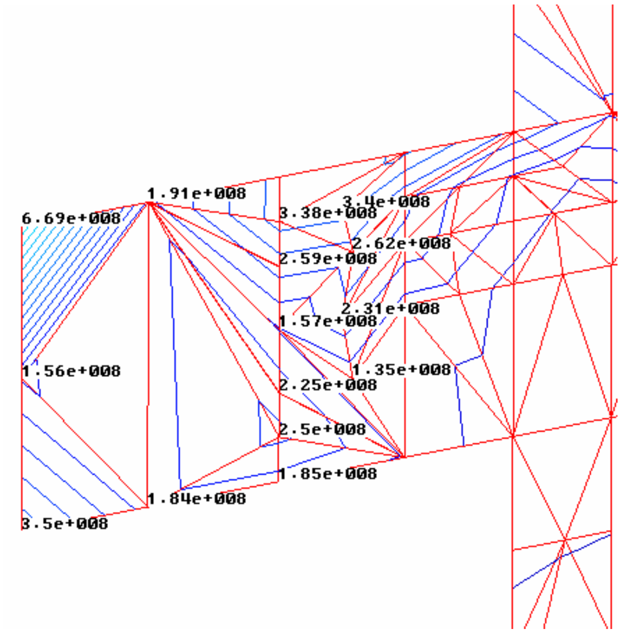


Figure 56. Visualizing the numerical values of the VON MISSES module

6. To return to the previous visualization, choose **Label→Off** from the mouse menu.
7. In the **Select & Display Style** window (Figure 53), click “Cut1” **Off** and “V perfil” **On**. Choose **Rotate→planeXZ** from the mouse menu.
8. Choose **Do cuts→Cut Plane→Succession**. This tool enables you to make a specific number of equidistant cross-sections along an axis. Enter two points to define the axis (see Figure 57).

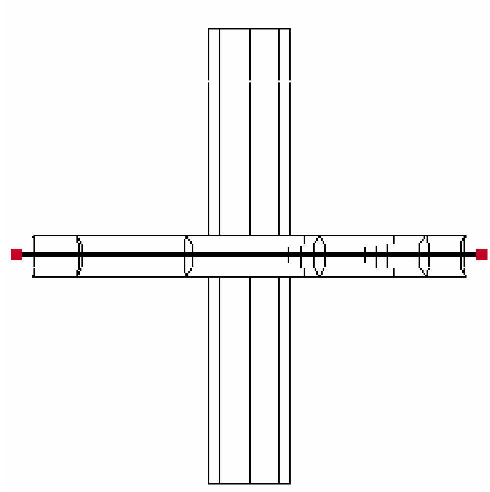


Figure 57. Defining the axis

9. A window appears in which the number of cuts to make can be entered. For the present example, enter 20. In the **Select & Display Style** window (Figure 59), click “V perfil” **Off**.

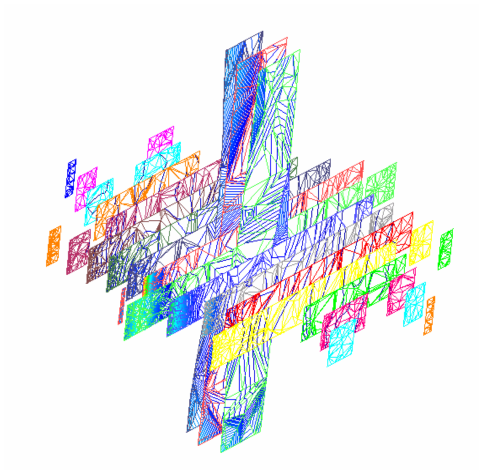


Figure 58. Cuts made using Do cuts→Cut Plane→Succession with no visualization of the results

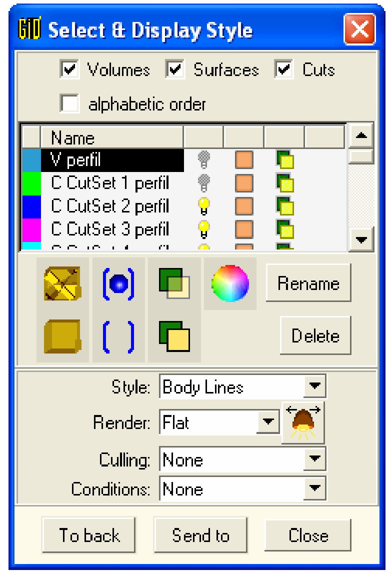


Figure 59. The Select & Display Style window with a list of all the cuts made

10. Use the **View Results** window and the **Select & Display Style** window to visualize results in the cuts that have been made.
11. **NOTE**: With the option **Files→save cut**, the cuts may be saved in a file in order to be used during another GiD session.
12. In the **Select & Display Style** window, select all the cuts and click **Del** to delete them. Click “V perfil” **On**. Choose the **Rotate→planeXY** option from the mouse menu.
13. Choose **Do cuts→Divide volume sets→2 points**. Using this option the mesh is divided by a plane, without cutting the elements. (The plane may be defined by two or three points and the right or left portion of the model may be selected. A new mesh is created that contains the selected portion.

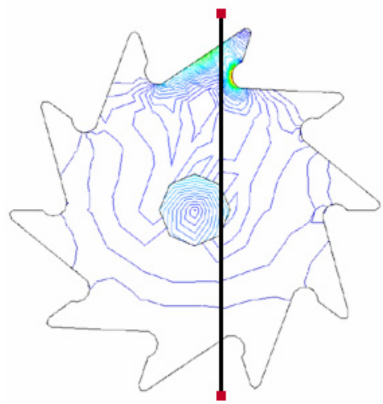


Figure 60. The cutting line

14. Enter two points to define the plane that will divide the part, as shown in Figure 60. Click on the right portion of the model to indicate that this is the side to select. After clicking “V perfil” **Off**, the result will be that shown in Figure 61.

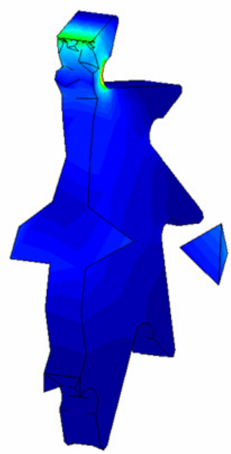


Figure 61. A visualization of the divided volume using Von Misses and Contour Fill

NOTE: The dividing tools are classified in three groups: **Divide volume sets**, **Divide surface sets** and **Divide lines**. In the three cases, entities may be divided by defining 2 or 3 points.

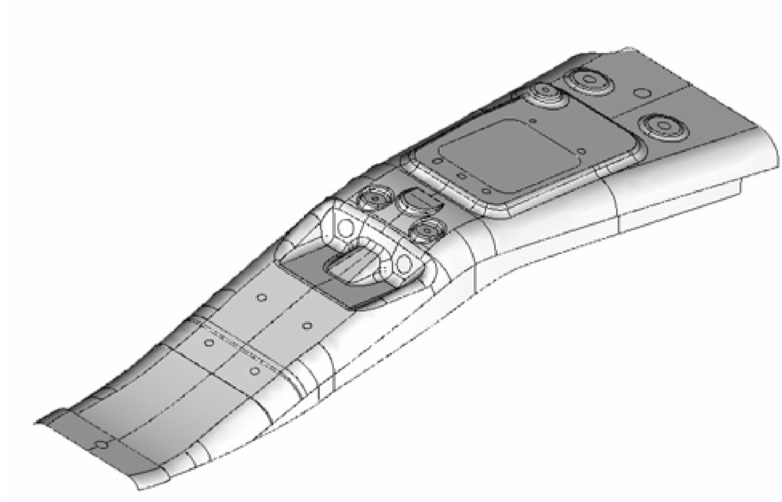
IMPORTING FILES: A CASE STUDY

IMPORTING FILES

The objective of this case study is to see how GiD imports files created with other programs. The imported geometry may contain imperfections that must be corrected before generating the mesh.

For this study an IGES formatted geometry representing a stamping die is imported. These steps are followed:

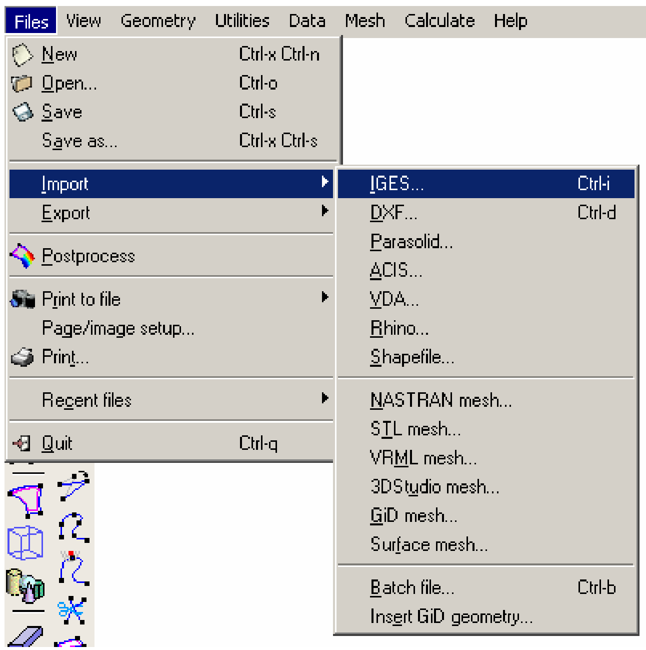
- Importing an IGES-formatted file to GiD
- Correcting errors in the imported geometry and generating the mesh
- Generating a conformal mesh and a non-conformal mesh



1. IMPORTING AN IGES FILE

GiD is designed to import a variety of file formats. Among them are standard formats such as IGES, DXF, or VDA, which are generated by most CAD programs. GiD can also import meshes generated by other programs, e.g. in NASTRAN or STL formats.

1. Select **Files→Import→IGES** …



2. Select the IGES-formatted file "base.igs" and click **Open**.

The file importing process is not always error-free. Sometimes the original file has incompatibilities with the format required by GiD. These incompatibilities must be overcome manually. This example deals with various solutions to the difficulties that may arise during the importing process.

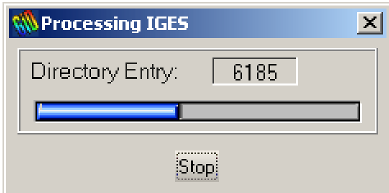


Figure 1. Reading the file.

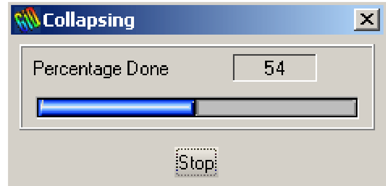


Figure 2. Collapsing the model.

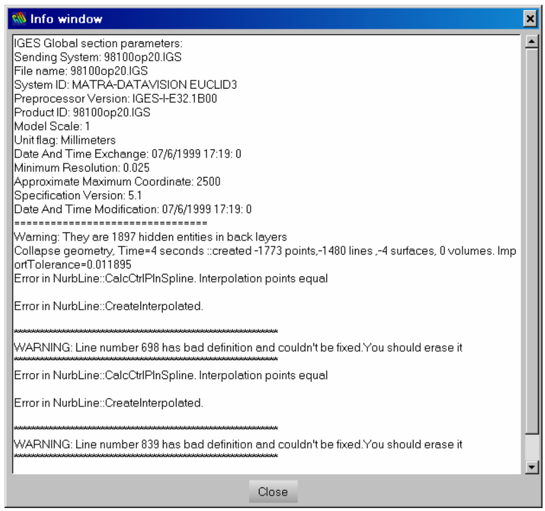


Figure 3. Importing process information.

3. After the importing process, the IGES file that GiD has imported appears on the screen.

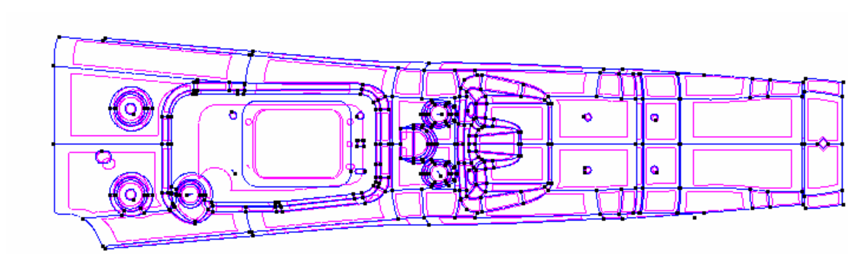


Figure 4. File "base.igs" imported by GiD.

NOTE: One of the operations in the importing process is collapsing the model (Figure 3). We say that two entities collapse when, the distance between them being less than the **Import Tolerance**, they become one.

The **Import Tolerance** value may be modified by going to the **Utilities** menu, opening **Preferences**, and bringing up the **Exchange** card. By default, the **Automatic import tolerance value** is selected. With this option selected, GiD computes an appropriate value for the **Import Tolerance** based on the size of the geometry.

Collapsing the model may also be done manually. This option is found in **Geometry→Edit→ Collapse→Model**.

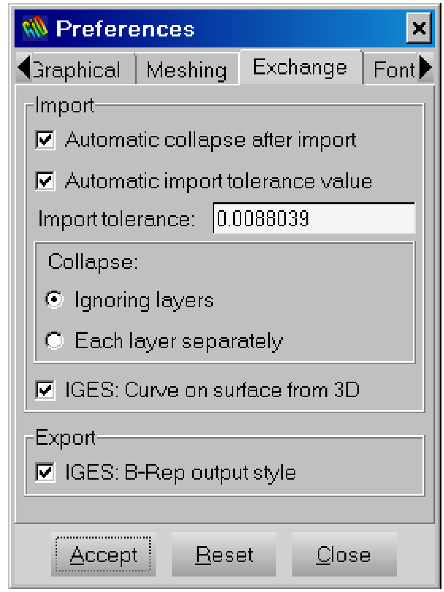


*Figure 5. The **Preferences** window*

2. CORRECTING ERRORS IN THE IMPORTED GEOMETRY

The great diversity of versions, formats, and programs frequently results in differences (errors) between the original and the imported geometry. With GiD these differences might give rise to imperfect meshes or prevent meshing altogether. In this section we will see how to detect errors in the imported geometry and how to correct them.

NOTE: Importing the same file with different versions of GiD might produce slight variations in the results. For this study we recommend using, from now on, the file "imported48.gid", which contains the original IGES file translated into GiD format.

2.1. Meshing by default

1. Select **Mesh→Generate Mesh**.

2. A window comes up in which to enter the maximum element size for the mesh to be generated. Leave the default value provided by GiD unaltered and click **OK**.

3. When the **GiD** finishes the meshing process, an error message appears (see Figure 7). This error is due to a defect in the imported geometry. As the window shows, there have been errors meshing surface number 124 and 149.

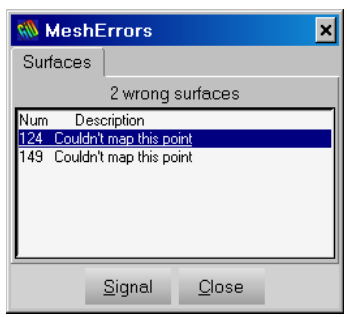


Figure 6. Dialog window warning of an error found when meshing surface 124.

4. In this part of the tutorial we focus on repairing surface number 124; the other surface (number 149) can be corrected by following the same steps a second time. (It is apparent that the two problems are similar because they are symmetrical surfaces.)

5. To locate surface 124, select the line "**124 couldn't map this point**" in the dialog box and press the **Signal** button (the same effect is obtained by double-clicking over the message with the left mouse button).

NOTE: If user clicks the right button over a message in the Mesh Errors window, three options are displayed: "**Signal problematic point**", "**More help…**" or "**List…**" The first option is the same as the Signal button, while the "**List…**" option presents a list of the problematic geometrical entities to make selection easier when performing some common procedures (like sending the entities to a separate layer, erasing the entities, etc…). The "**More help…**" option gives advice about to correct the geometrical model so the mesh can be generated.

NOTE: The **Mesh Errors** window can be recovered while dealing with the model by selecting the "**Show errors…**" option in the **Mesh** menu.

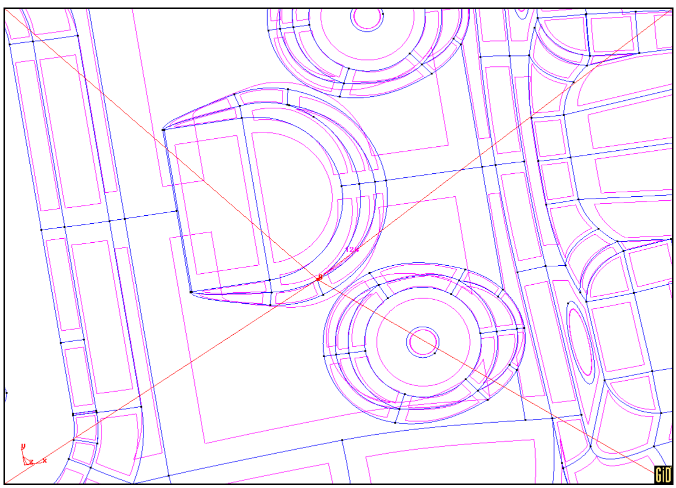


Figure 7. Signaling the surface number 124.

NOTE: The identifiers of the entities vary each time the instruction ***Mesh→Generate Mesh*** is executed.

2.2. Correcting surfaces

1. With the **View→Zoom→In**[1] option on the mouse menu, magnify the zone around surface 124.

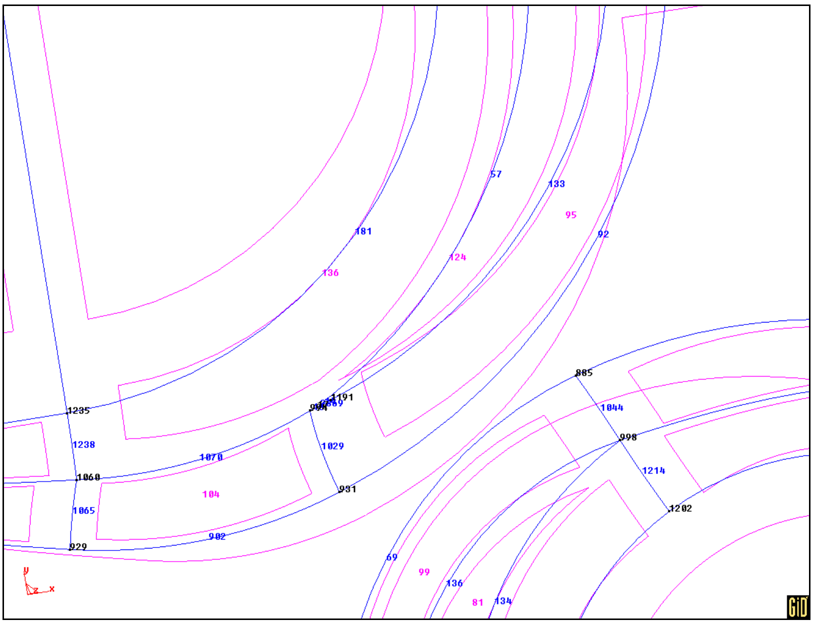


Figure 8. An enlargement of the zone around the surface 124.

2. Select **Label→All** from the contextual menu. On inspection we see a blur of numbers due to a high concentration of entities at one end of the surface. Magnify this zone even further (Figure 9).

[1] This option is also found in the GiD Toolbox.

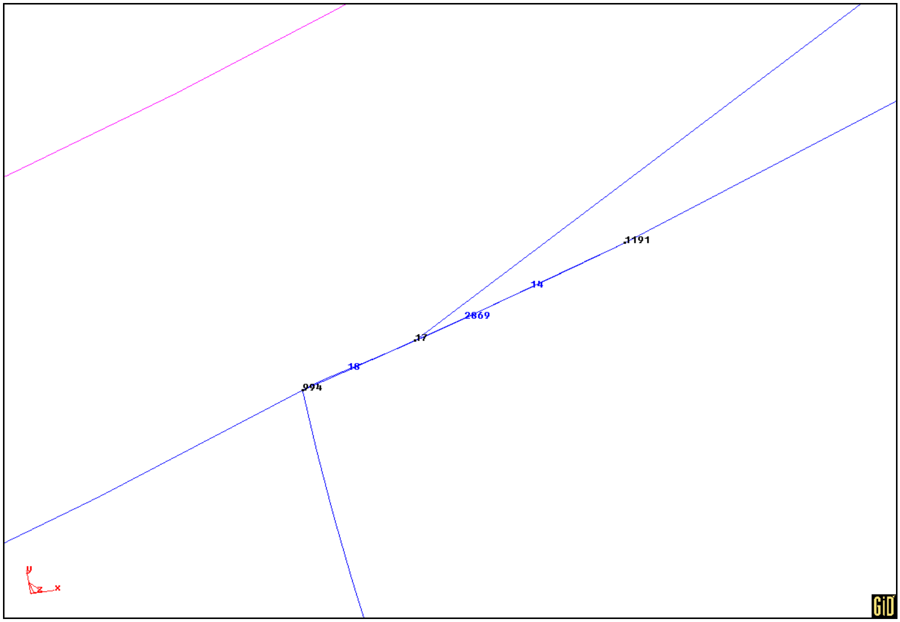


Figure 9. A second enlargement of the blurred zone

3. Several line segments are superimposed over each other, thus creating an incorrect surface boundary. Select **Geometry→Edit→Divide→Lines→ Near point** and then select point 17 (to select it, go to **Contextual** in the mouse menu, then select the option **Join C-a**). Point 17 is the point at which to make the cut.

4. Then select line 2869. Press **ESC**. After the cut is made, the result will be as illustrated in Figure 11.

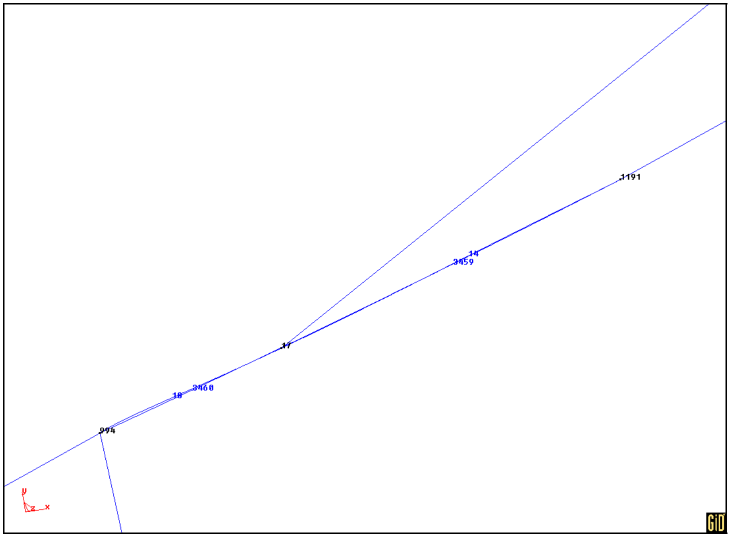


Figure 10. The zone after cutting line 2869 at point 17.

5. Now that the lines are precisely connected, a local collapse may be executed. Select **Geometry→Edit→Collapse→Lines**. Then select the lines that appear on the screen.

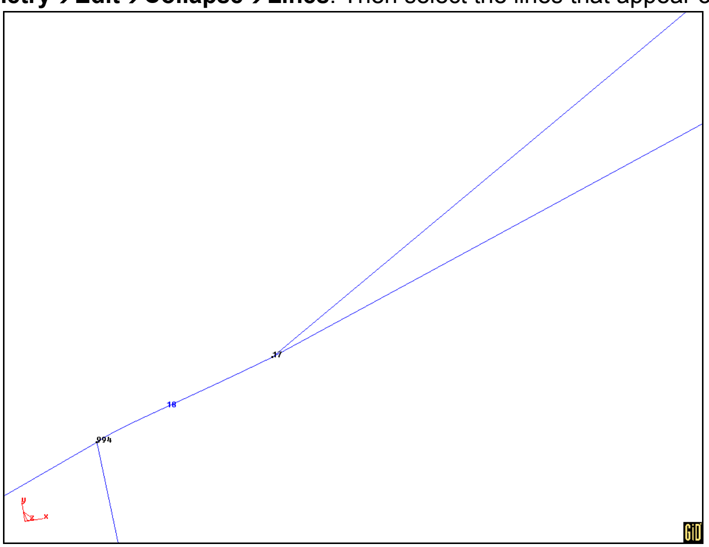


Figure 11. The situation after collapsing the lines

6. After the collapse, the surface boundary is correct and the surface may be drawn with the new boundary. The labels are no longer needed, so click **Label→Off** in the contextual menu.
7. Select **Geometry→Create→NURBS surface→Trimmed**. Select surface 124. Then select the lines defining the recently repaired boundary. Press **ESC**.

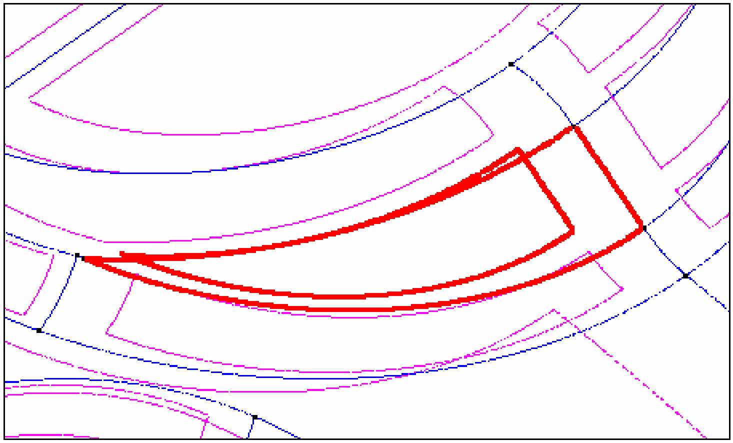


Figure 12. Surface 123 with its new boundary.

8. Select **Geometry→Delete→Surfaces**. Select surface 124 and press **ESC**.

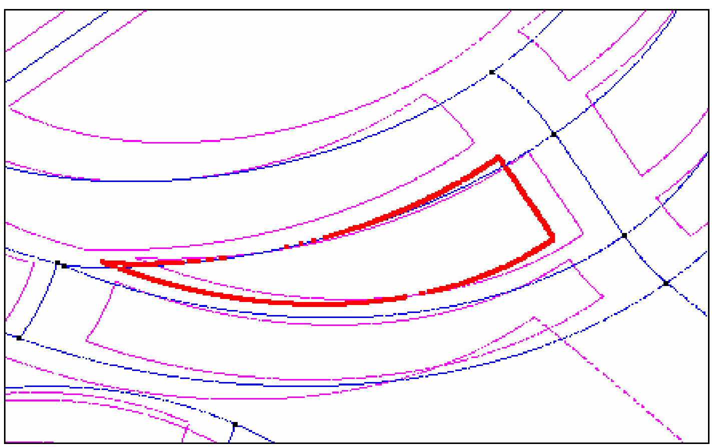


Figure 13. The surface to be eliminated.

9. Correct surface 149 by going through the same steps as with surface 124.

10. To begin the second example in this section, mesh the geometry again with **Mesh→Generate Mesh**.

11. A window comes up in which to enter the maximum element size for the mesh to be generated. Leave the default value provided by GiD and click **OK**.

12. The mesh generating process may be carried out with no further errors found.

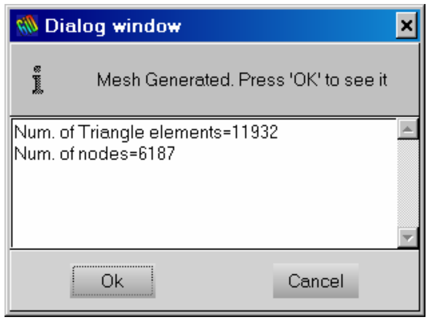


Figure 14. Window with information about the meshing process.

13. The imported piece is now meshed. (Figure 16)

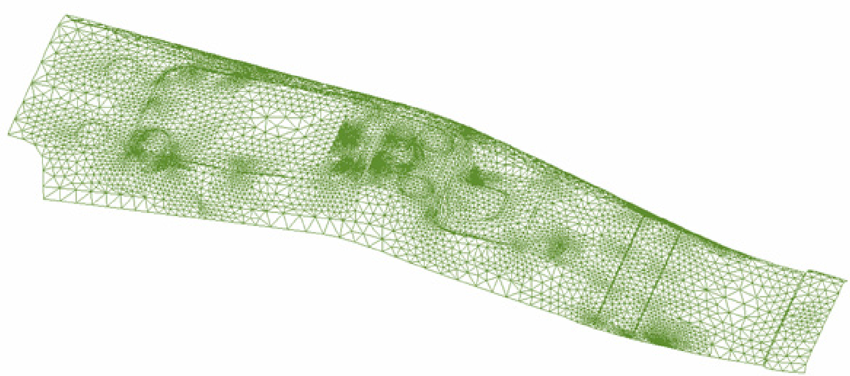


Figure 15. A mesh of the imported geometry.

3. THE CONFORMAL MESH AND THE NON CONFORMAL MESH

In the previous section, after correcting some errors, we were able to mesh the imported geometry, thus obtaining a non-conformal mesh. A conformal mesh is one in which the elements share nodes and sides. To achieve this condition, contiguous surfaces (of the piece) must share lines and points of the mesh. Most calculating modules require conformal meshes; however, some modules accept non-conformal meshes. A non-conformal mesh normally requires less computation time since it generates fewer elements.

3.1. Global collapse of the model

1. The option **Mesh→View mesh boundary** shows the boundary of all the surfaces of the conformal elements.
2. After generating the mesh, select **Mesh→View mesh boundary**. This will result in the image pictured in Figure 17.

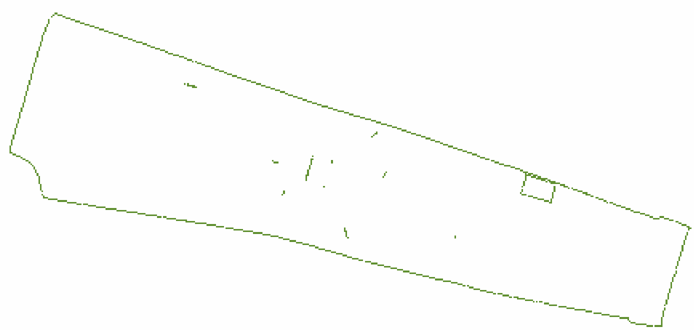


Figure 16. Visualization of the boundary of the generated mesh.

3. Visualization of the boundaries shows that in the interior of the piece some surfaces are isolated.
4. To generate a conformal mesh, first execute a global collapse of the model.
5. The GiD collapse depends upon the **Import tolerance**. Two entities are collapsed (converted into one) when they are separated by a distance less than the **Import tolerance** parameter. To test this, enter a new value for the **Import tolerance** parameter.

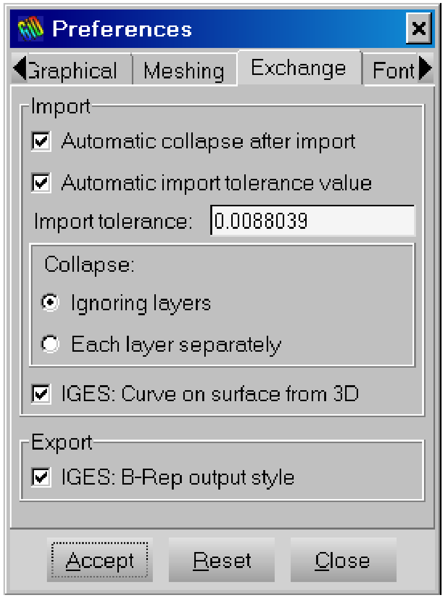


Figure 17. The Preferences window.

6. Go to **Utilities**, open **Preferences**, and bring up the **Exchange** card. Enter 0,15 for the **Import tolerance value**. Click **Accept**.
7. Select Geometry→Edit→Collapse→Model.
8. Select **Mesh→Generate** and then visualize the results with **Mesh→View mesh boundary**.

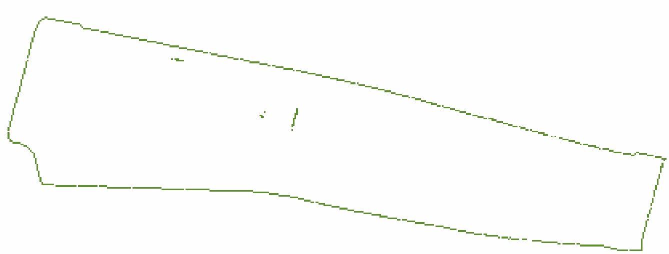


Figure 18. The mesh after the collapse.

9. Some of the contiguous surfaces in the interior of the model have now being joined. However, there are still some surfaces that prevent the mesh from being completely conformal. These surfaces must be modified manually.

3.2. Correcting surfaces and creating a conformal mesh

1. With the option **View→Zoom→In**, magnify the zone illustrated in Figure 20.

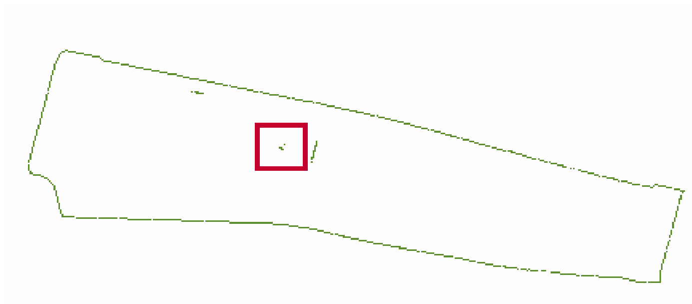


Figure 19. Zone in the mesh to zoom in.

2. Select **View→Mode→Geometry** to visualize the geometry of the piece.

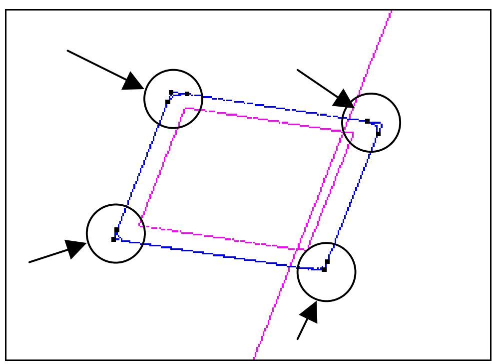


Figure 20

3. An image like that shown in Figure 21 appears. There is a rectangular surface that does not fit within the boundaries of a rounded-corner surface (a hole, in this case). We will suppose that the problematic surface is planar. This way, it can be erased and recreated in order to fit the rounded-corner boundary.

4. Select **Geometry→Delete→Surfaces**. Select the problematic surface and press **ESC**. Select **Geometry→Delete→Lines**. Select the lines forming the problematic surface and press **ESC**[2].
5. Use the option **Geometry→Delete→Points** to erase the points that do not belong to any surface.
6. With **Geometry→Create→NURBS surface→By contour**, create a new surface. The result is shown in Figure 22.

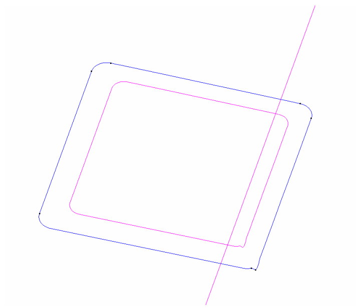


Figure 21

7. Visualize the mesh again using **Mesh→View mesh boundary** and magnify the zone indicated in Figure 23.

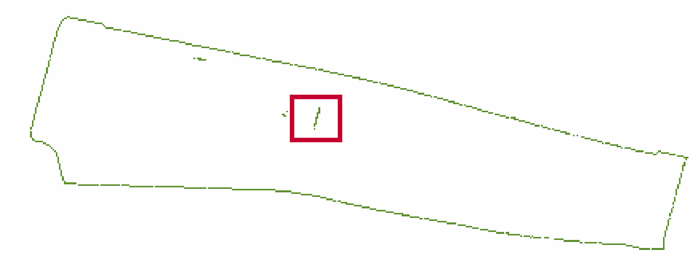


Figure 22

8. Select **View→Mode→Geometry**.
9. In this example, the situation involves a contour of four lines that does not correspond to any real surface (of the piece). These lines were too far apart to be collapsed (Figure 24).

[2] In this case, all the visible lines may be selected since the program will only eliminate those which do not have entities covering them, that is, those which belong to the problematic vertices.

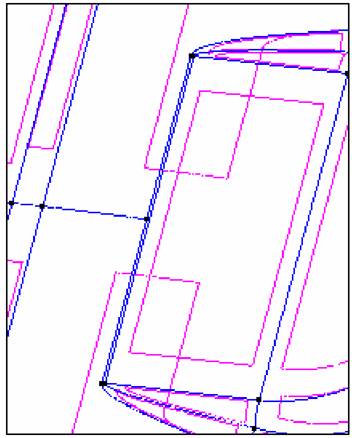


Figure 23

10. Select **Geometry→Create→NURBS surface→By contour**. Select the lines. Press **ESC**.
11. Magnify the zone indicated in Figure 25.

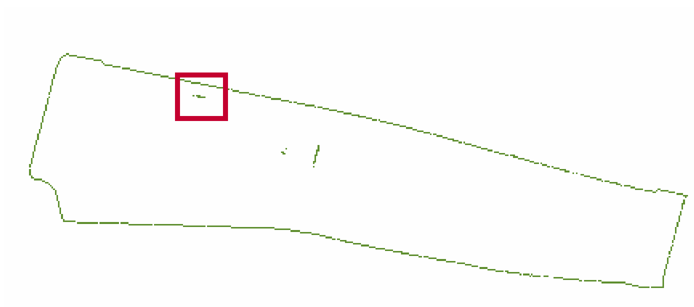


Figure 24

12. There are two surfaces that overlap each other at one end. (Figure 26)

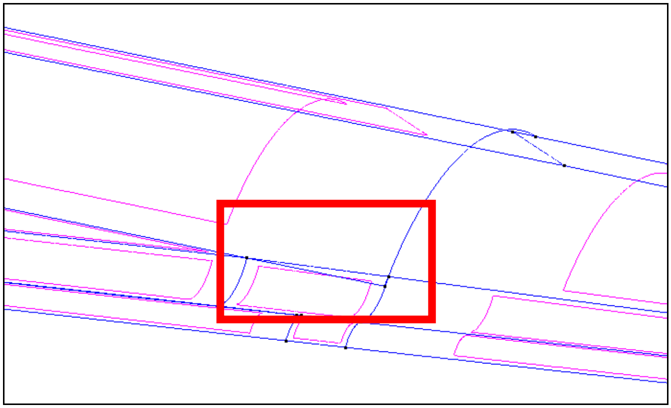


Figure 25. The magnified zone with two overlapping surfaces.

13. In this case the best solution for correcting the boundary is to trim the overlap. Select **Geometry→ Create→NURBS Surface→Trimmed**.
14. Select the surface to be trimmed. Then select the new boundary (Figure 27).

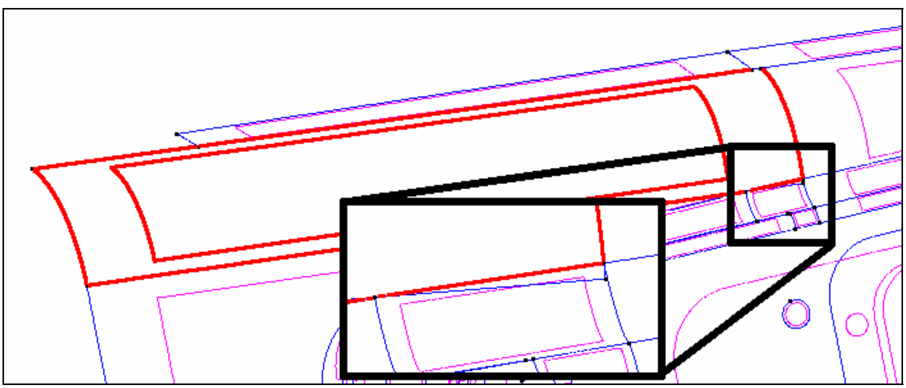


Figure 26. The surface to be trimmed and the new boundary.

15. Select **Geometry→Delete→Surfaces**. Select the original surface (Figure 28). Press **ESC**.

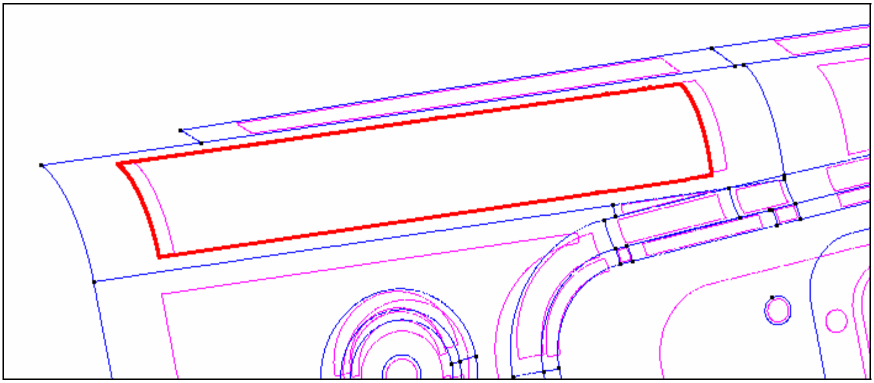


Figure 27. The original surface to be deleted.

16. Use **Geometry→Delete→Lines** and **Geometry→Delete→Points** to select the lines and points that belong to the surface that has been trimmed and which no longer belong to any surface (Figure 29).

Figure 28. Lines and point that no longer belong to any surface.

17. Select **Mesh→Generate Mesh**. Then visualize the result using the option **Mesh→View mesh boundary**.

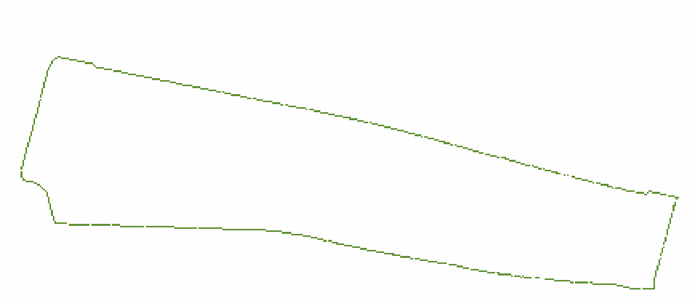


Figure 29. The mesh visualized with the option Mesh→View mesh boundary.

18. A conformal mesh has been achieved.

3.3. Creating a non-conformal mesh

NOTE: Non-conformal meshes may be used with some calculating modules, i.e. stamping a plate. Using non-conformal meshes significantly reduces the number of elements in the mesh. This cuts down on computation time.

1. Select **View→Mode→Geometry**.
2. Select **Geometry→Edit→Uncollapse→Surfaces**. Select all the surfaces in the model. Press **ESC**. A sufficient number of lines is created so that no surface (of the object) shares lines with any contiguous surface.
3. Select **Mesh→Generate Mesh**. When the mesh has been generated, a window appears with information about the mesh (Figure 31). The result is a non-conformal mesh composed of far fewer elements than the meshes generated in the previous section: about 5000 elements instead of the 20.000 needed to generate the conformal mesh.

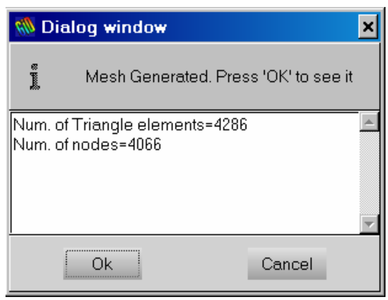


Figure 30. A window containing information about the generated mesh.

4. Visualize the result using **Mesh→View mesh boundary**.

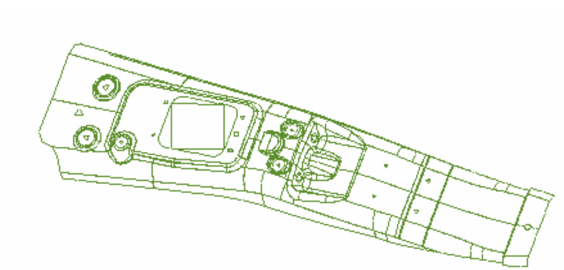


Figure 31. The mesh visualized using Mesh→View mesh boundary.

3.4. Optimizing a non-conformal mesh

NOTE: By using **Chordal Error**, the geometry may be discretized with great precision. The chordal error is the distance between the elements generated by the meshing program and the profile of the real object. Entering a sufficiently small chordal error results in small elements in zones where there is greater curvature. Accordingly, the approximation of the mesh may be improved in zones with greater curvature by using the option “Chordal Error.”

“Chordal Error” generates an increased number of elements in zones where there is curvature. One way of obtaining accurate meshes with few elements is using structured elements in zones where there is curvature. The option **Allow automatic structured**, located in **Preferences**, may be combined with the option of limiting the chordal error, thus achieving an accurate mesh with fewer elements. It only makes sense to use **Allow automatic structured** when working with a non-conformal mesh.

NOTE: The option **Allow automatic structured** generates highly distorted elements that might, with some calculating modules, lead to erroneous results. In the case of stamping a plate, we recommend using **Allow automatic structured** with the calculating modules.

1. Open **Utilities→ Preferences**.
2. On the **Meshing** card, activate the option **Allow automatic structured** and enter the value of 0,9 in the box labeled **Unstructured size transitions**. Click **Accept**. The option **Unstructured size transitions** defines the size gradient of the elements (the value ranging from 0 to 1). The greater the value, the faster the variation of the element sizes in space and so there will be fewer elements in the mesh.

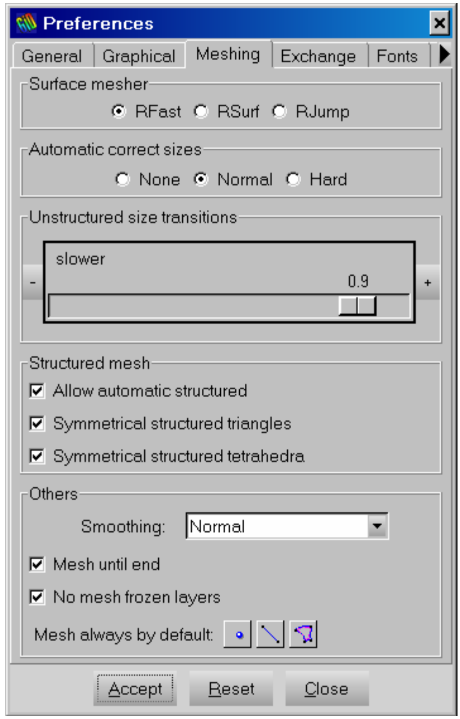


Figure 32. The Preferences window.

3. Select **Mesh→Unstructured→Sizes by Chordal error** and set the values as shown in Figure 34.

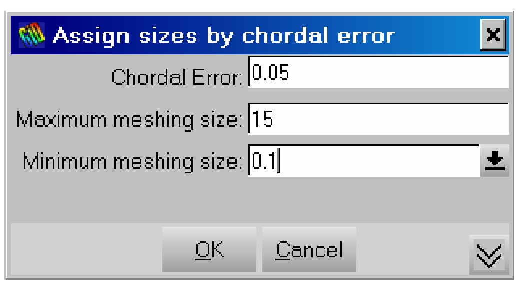


Figure 33. Defining unstructured size by chordal error.

4. Select **Mesh→Generate Mesh**.

5. A window comes up in which to enter the maximum element size. Leave the default value unaltered and click **OK**.
6. Once the process of generating the mesh is finished, a window appears with information about the generated mesh. Click **OK** to visualize the mesh.

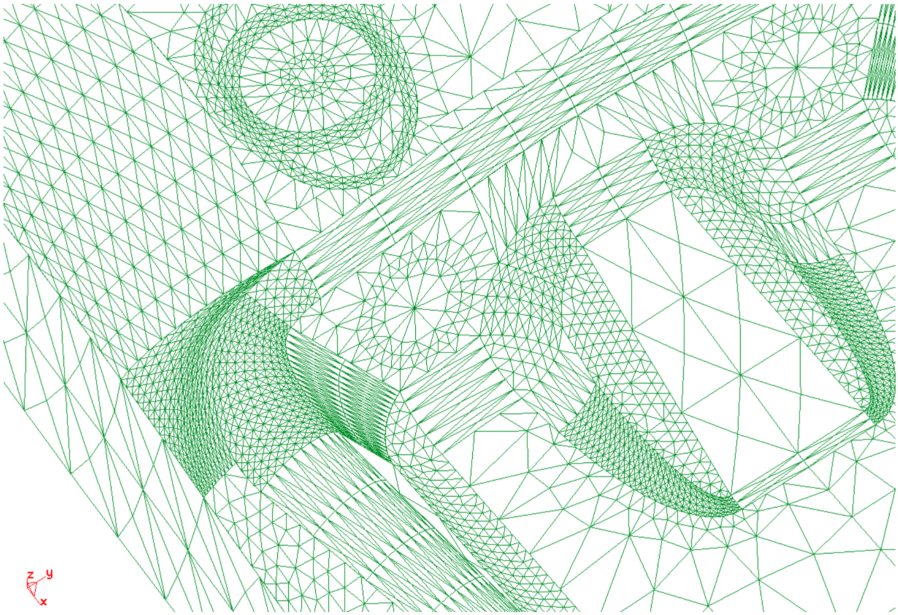


Figure 34. An optimized non-conformal mesh. Structured elements are present on the curved surfaces.

GiD PROBLEM TYPE: AN EXAMPLE

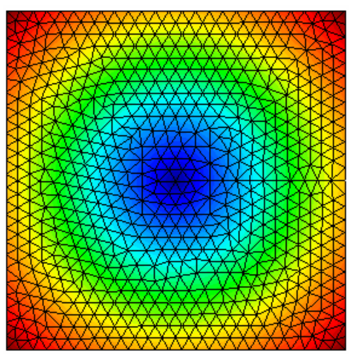
DEFINING A PROBLEM TYPE

This chapter takes you through the steps involved in defining a *problem type* using GiD. A *problem type* is a set of files configured by GiD so that the program can prepare data to be analyzed.

A simple example has been chosen which takes us through all the associated configuration files while using few lines of code. Particular emphasis is given to the calculation of the centers of mass for two-dimensional surfaces – a simple formulation both conceptually and numerically.

The tutorial is composed of the following steps:

- Starting the problem
- Creating the materials definition file
- Creating the general configurations file
- Creating the conditions definition file
- Creating the data format file
- Creating the calculating program file and the execution files
- Executing the calculating module and visualizing the results using GiD



By the end of the example, you should be able to create a calculating module that will interpret the mesh generated in GiD Preprocess. The module will calculate values for each element of the mesh and store the values in a file in such a way as they can be read by GiD Post-process.

1. INTRODUCTION

Our aim is to solve a problem that involves calculating the center of gravity (center of mass) of a 2D object. To do this, we need to develop a calculating module that can interact with GiD.

1.1. The problem: center of mass

The center of mass ($\boldsymbol{x_{CM}},\boldsymbol{y_{CM}}$) of a two-dimensional body is defined as

$$\boldsymbol{x}_{CM} = \frac{\iint_S \rho(\boldsymbol{x},\boldsymbol{y}) \cdot \boldsymbol{x} \cdot \partial \boldsymbol{x} \cdot \partial \boldsymbol{y}}{\iint_S \rho(\boldsymbol{x},\boldsymbol{y}) \cdot \partial \boldsymbol{x} \cdot \partial \boldsymbol{y}} \qquad \boldsymbol{y}_{CM} = \frac{\iint_S \rho(\boldsymbol{x},\boldsymbol{y}) \cdot \boldsymbol{y} \cdot \partial \boldsymbol{x} \cdot \partial \boldsymbol{y}}{\iint_S \rho(\boldsymbol{x},\boldsymbol{y}) \cdot \partial \boldsymbol{x} \cdot \partial \boldsymbol{y}}$$

where $\rho(\boldsymbol{x},\boldsymbol{y})$ is the density of the material at point ($\boldsymbol{x},\boldsymbol{y}$) and $\boldsymbol{S}$ is the surface of the body.
If we consider the N gravitational forces as $\boldsymbol{p_i} = \boldsymbol{g}\ \boldsymbol{m_i}$, each one concentrated on point ($\boldsymbol{x_i},\boldsymbol{y_i}$), the new center of mass will be modified as follows:

$$x_{CM} = \frac{\iint_S \rho \cdot x \cdot \partial x \cdot \partial y + \sum_{i=1}^{N} m_i \cdot x_i}{\iint_S \rho \cdot \partial x \cdot \partial y + \sum_{i=1}^{N} m_i} \qquad y_{CM} = \frac{\iint_S \rho \cdot y \cdot \partial x \cdot \partial y + \sum_{i=1}^{N} m_i \cdot y_i}{\iint_S \rho \cdot \partial x \cdot \partial y + \sum_{i=1}^{N} m_i}$$

To solve the problem numerically, the integrals will be transformed into sums:

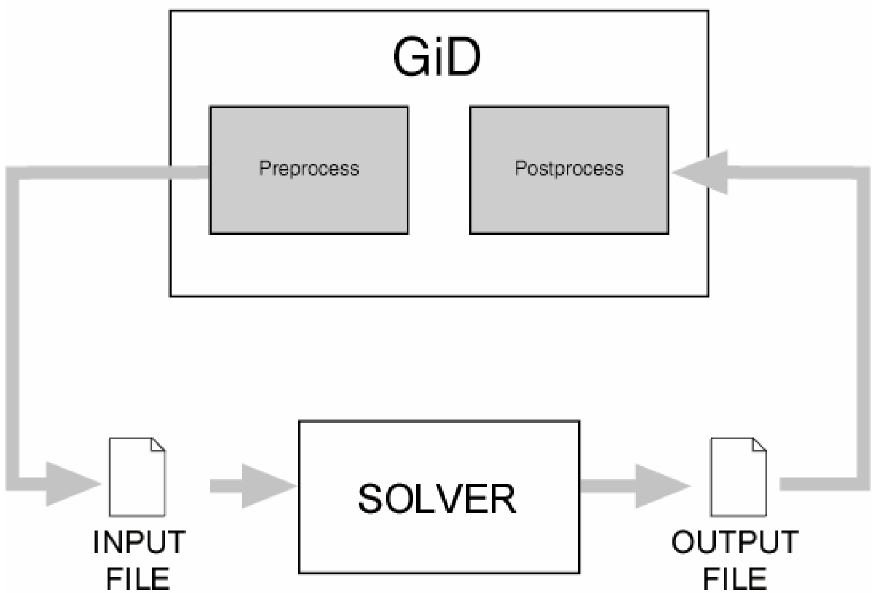
$$x_{CM} = \frac{\sum_{elm} \rho_{elm} V_{elm} \cdot x_{elm} + \sum_{i=1}^{N} m_i \cdot x_i}{\sum_{elm} \rho_{elm} V_{elm} + \sum_{i=1}^{N} m_i} \qquad y_{CM} = \frac{\sum_{elm} \rho_{elm} V_{elm} \cdot y_{elm} + \sum_{i=1}^{N} m_i \cdot y_i}{\sum_{elm} \rho_{elm} V_{elm} + \sum_{i=1}^{N} m_i}$$

Each of the N elements is treated as concentrated weight whose mass N_1 is defined as the product of the (surface) density and the surface of the element.

1.2. Interaction of GiD with the calculating module

GiD Preprocess makes a discretization of the object under study and generates a mesh of elements, each one of which is assigned a material and some conditions. This preprocessing information in GiD (mesh, materials, and conditions) enables the calculating module to generate results. For the present example, the calculating module will find the distance of each element relative to the center of mass of the object.

Finally, the results generated by the calculating module will be read and visualized in GiD Post-process.



GiD must adapt these data to deal with them. Materials, boundary and/or load conditions, and problem data in general must be defined.

GiD configuration is accomplished through text formatted files. The following files are required:

a) **.prb**: configuration of the general parameter
.mat: configuration of materials and their properties
.cnd: configuration of the conditions imposed on the calculation

b) **.bas**: (template file) the file for configuring the format of the interchange that mediates between GiD data and the calculating module. The file for interchanging the data exported by GiD has the extension **.dat**. This file stores the geometric and physical data of the problem.

c) **.bat**: the file that can be executed in batches called from GiD. This file initiates the calculating module.

The calculating module (in this example **cmas2d.exe**) solves the equations in the problem and saves the results in the results file. This module may be programmed in the language of your choice.

GiD Post-process reads the following files generated by the calculating module:

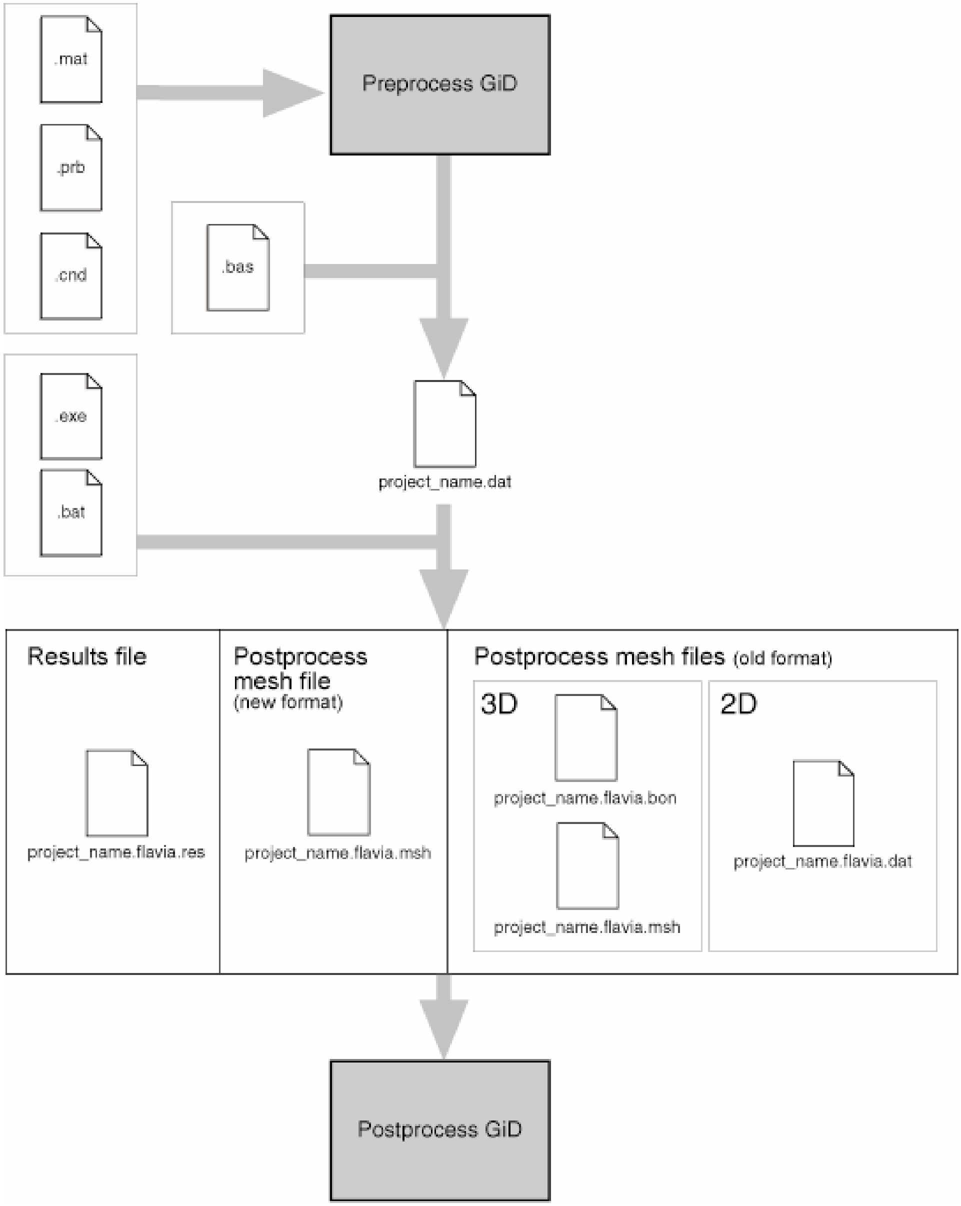
a) ***project_name*.flavia.res**: results file.

Each element of the mesh corresponds to a value.

b) ***project_name*.flavia.msh**: file containing the post-process 2D mesh.

If this file does not exist, GiD uses the preprocess mesh in the postprocess.

Diagram depicting the files system:



2. IMPLEMENTATION

2.1. Creating the Subdirectory for the Problem Type

Create the subdirectory "cmas2d.gid". This subdirectory has a **.gid** extension and will contain all the configuration files and calculating module files (.prb, .mat, .cnd, .bas, .bat, .exe).

NOTE: In Windows systems, if you want the problem type to appear in the GiD **Data→Problem type** menu, create the subdirectory within "Problemtypes", located in the GiD folder – for instance, **C:\GiDWin\Problemtypes\cmas2d.gid**

2.2. Creating the Materials File

1. Create the materials file "cmas2d.mat". This file stores the physical properties of the material under study for the problem type. In this case, defining the density will be sufficient.

2. Enter the materials in the "cmas2d.mat" file using the following format:

> **MATERIAL**: Name of the material (without spaces)
>
> > **QUESTION**: Property of the material. For this example, we are interested in the density of the material.
> > **VALUE**: Value of the property
> > …
>
> **END MATERIAL**
>
> **…**

3. In GiD, the information pertaining to the "cmas2d.mat" file is managed in the materials window (Figure 1), located in **Data→Materials**.

cmas2d.mat

```
MATERIAL: Air
QUESTION: Density
VALUE: 1.01
END MATERIAL

MATERIAL: Steel
QUESTION: Density
VALUE: 7850
END MATERIAL

MATERIAL: Concrete
QUESTION: Density
VALUE: 2350
END MATERIAL
```

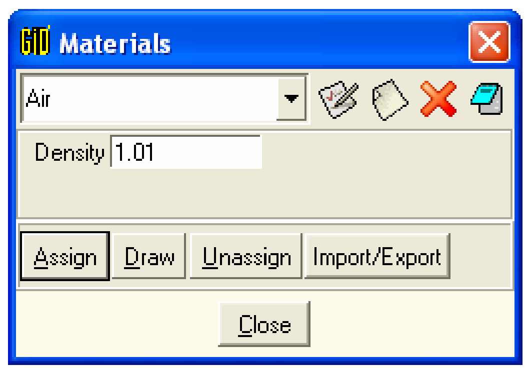


*Figure 1. The GiD **Materials** window, for assigning materials*

2.3. Creating the General File

1. Create the "cmas2d.prb" file. This file contains general information for the calculating module, such as the units system for the problem, or the type of resolution algorithm chosen.
2. Enter the parameters of the general conditions in "cmas2d.prb" using the following format:

PROBLEM DATA

QUESTION: Name of the parameter. If the name is followed by the `#CB#` instruction, the parameter is a display-type menu. The options in the menu must then be entered between parentheses and separated by commas. For example, `Unit_System#CB#(SI,CGS,User)`.
VALUE: The default value of the parameter.
…

END GENERAL DATA

3. In GiD, the information in the "cmas2d.prb" file is managed in the materials window (Figure 2), which is located in **Data→Problem Data**.

Cmas2d.prb

```
PROBLEM DATA
QUESTION:
Unit_System#CB#(SI,CGS,User)
VALUE: SI
QUESTION: Title
VALUE: Default_title
END GENERAL DATA
```

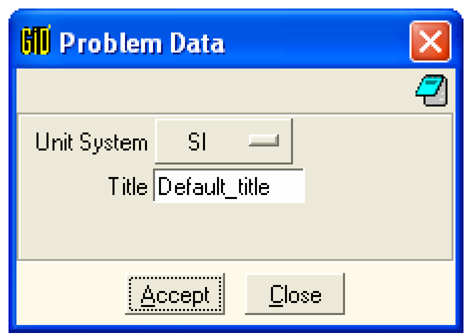


*Figure 2. The GiD **Problem Data** window, for configuring of the general conditions of the cmas2d module*

2.4. Creating the Conditions File

1. Create the "cmas2d.cnd" file, which specifies the boundary and/or load conditions of the problem type in question. In the present case, this file is where the concentrated weights on specific points of the geometry are indicated.
2. Enter the boundary conditions using the following format:

> **CONDITION**: Name of the condition
> **CONDTYPE**: Type of entity to which the condition is to be applied. This includes the parameters "over points," "over lines," "over surfaces," and "over volumes". In this example the condition is applied "over points."
> **CONDMESHTYPE**: Type of entity of the mesh to which the condition is to be applied. The possible parameters are "over nodes", "over body elements" or "over face elements". In this example, the condition is applied on nodes.
>> **QUESTION**: Name of the parameter of the condition
>> **VALUE**: Default value of the parameter
>> …
>
> **END CONDITION**
> …

3. In GiD, the information in the "cmas2d.cnd" file is managed in the conditions window (Figure 3), which is found in **Data→ Conditions**.

cmas2d.cnd

```
CONDITION: Point-Weight
CONDTYPE: over points
CONDMESHTYPE: over nodes
QUESTION: Weight
VALUE: 0
END CONDITION
```

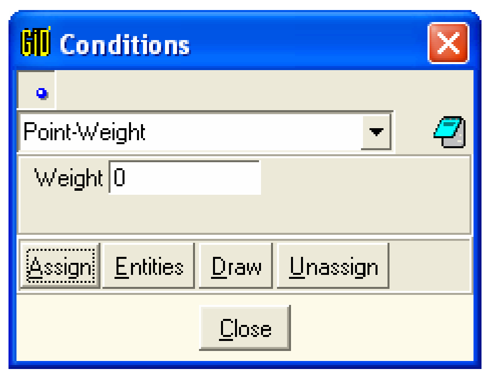


*Figure 3. The GiD **Conditions** window, for assigning the cmas2d boundary and load conditions*

2.5. Creating the Data Format File (Template file)

1. Create the "cmas2d.bas" file. This file will define the format of the **.dat** text file created by GiD. It will store the geometric and physical data of the problem. The **.dat** file will be the input to the calculating module.

NOTE: It is not necessary to have all the information registered in only one **.bas** file. Each **.bas** file has a corresponding **.dat** file.

Write the "cmas2d.bas" file as follows:

2. The format of the **.bas** file is based on commands. Text not preceded by an asterisk is reproduced exactly the same in the **.dat** file created by GiD. A text preceded by an asterisk is interpreted as a command.

Example:

.bas file

```
%%%% Problem Size %%%%
Number of Elements & Nodes:
*nelem *npoin
```

→

.dat file

```
%%%% Problem Size %%%%
Number of Elements & Nodes:
5379 4678
```

The contents of the "cmas2d.bas" file must be the following:

.bas file

```
==================================================================
                        General Data File
==================================================================

%%%%%%%%%%%%%%%%%% Problem Size  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Number of Elements & Nodes:
*nelem *npoin
```

In this first part of the "cmas2d.bas" file, general information on the project is obtained.

***nelem**: returns the total number of elements of the mesh.
***npoin**: returns the total number of nodes of the mesh.

```
Coordinates:
  Node        X                Y
*set elems(all)
*loop nodes
*format "%5i%14.5e%14.5e"
*NodesNum *NodesCoord(1,real) *NodesCoord(2,real)
*end nodes
```

This command provides a rundown of all the nodes of the mesh, listing their identifiers and coordinates.

*__loop__, *__end__: commands used to indicate the beginning and the end of the loop. The command *__loop__ receives a parameter.

*__loop nodes__: the loop iterates on nodes
*__loop elems__: the loop iterates on elements
*__loop materials__: the loop iterates on assigned materials

*__set elems(all)__: the command to include all the elements of the mesh when making the loop.

*__format__: the command to define the exit format for numerical expressions. This command must be followed by the numerical format expressed in C.

*__NodesNum__: returns the identifier of the present node
*__NodesCoord__: returns the coordinates of the present node
*__NodesCoord (n, real)__: returns the **x**, **y** or **z** coordinate in terms of the value **n**:
n=1 returns the **x** coordinate
n=2 returns the **y** coordinate
n=3 returns the **z** coordinate

```
Connectivities:
    Element    Node(1)   Node(2)   Node(3)     Material
*loop elems
*format "%10i%10i%10i%10i%10i"
*ElemsNum *ElemsConec  *ElemsMat
*end elems
```

This provides a rundown of all the elements of the mesh and a list of their identifiers, the nodes that form them, and their assigned material.

*__ElemsNum__: returns the identifier of the present element

*__ElemsConec__: returns the nodes of an element in a counterclockwise order

*__ElemsMat__: returns the number of the assigned material of the present element

```
Begin Materials
N° Materials=  *nmats
```

This gives the total number of materials in the project

*__nmats__: returns the total number of materials

```
Mat.           Density

*loop materials
*format "%4i%13.5e"
*set var PROP1(real)=Operation(MatProp(Density, real))
*MatNum *PROP1
*end
```

This provides a rundown of all the materials in the project and a list of the identifiers and densities for each one.

*__MatProp__ (density, real): returns the value of the property "density" of the material in a "real" format.

*__Operation__ (expression): returns the result of an arithmetic expression. This operation must be expressed in C.

***Set var** PROP1(real)=**Operation**(**MatProp**(Density, real)): assigns the value returned by **MatProp** (which is the value of the density of the material) to the variable PROP1 (a "real" variable).

***PROP1**: returns the value of the variable PROP1.

*__MatNum__: returns the identifier of the present material

```
Point conditions
*Set Cond Point-Weight *nodes
*set var NFIX(int)=CondNumEntities(int)
Concentrate Weights
*NFIX
```

This provides the number of entities that have been assigned a particular condition.

*__Set Cond__ Point-Weight ***nodes**: this command enables you to select the condition to work with from that moment on. For the present example, select the condition "Point-Weight".

*__CondNumEntities__(int): returns the number of entities that have been assigned a certain condition.

*__Set var__ NFIX(int)= **CondNumEntities**(int): assigns the value returned by the command **CondNumEntities** to the NFIX variable (an "int" variable).

*__NFIX__: returns the value of the NFIX variable.

```
Potentials Prescrits:
   Node  Tipus
   Valor/Etiqueta
*Set Cond Point-Weight *nodes
*loop nodes *OnlyInCond
*NodesNum     *cond(1)
*end
```

This provides a rundown of all the nodes assigned the condition "Point-Weight" with a list of their identifiers and the first "weight" field of the condition in each case.

***loop nodes** ***OnlyInCond**: executes a loop that will provide a rundown of only the nodes that have been assigned a condition.

***cond**(1): returns the number 1 field of a condition previously selected with the ***set cond** command. The field of the condition may also be selected using the name of the condition, for example **cond**(weight).

cmas2d.bas

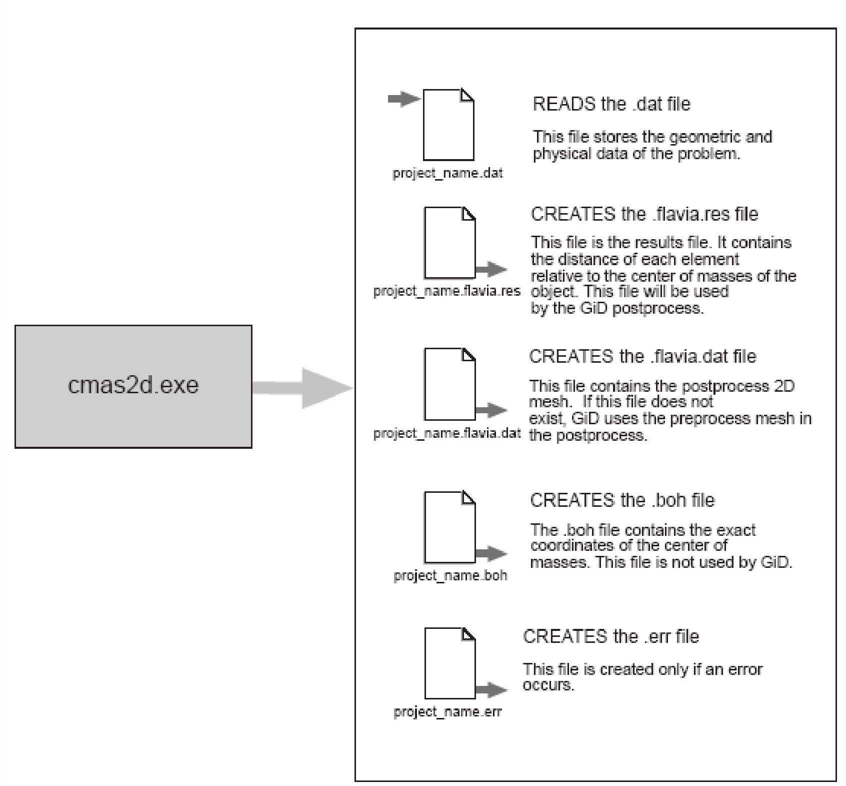
```
==================================================================
                        General Data File
==================================================================

%%%%%%%%%%%%%%%%%% Problem Size  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Number of Elements & Nodes:
*nelem *npoin
%%%%%%%%%%%%%%%%%%% Mesh Database  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Coordinates:
  Node        X                Y
*set elems(all)
*loop nodes
*format "%5i%14.5e%14.5e"
*NodesNum *NodesCoord(1,real) *NodesCoord(2,real)
*end nodes
.................................................................
Connectivities:
    Element    Node(1)   Node(2)   Node(3)     Material
*loop elems
*format "%10i%10i%10i%10i%10i"
*ElemsNum *ElemsConec *ElemsMat
*end elems
.................................................................
Begin Materials
N° Materials=  *nmats
Mat.          Density
.................................................................
*loop materials
*format "%4i%13.5e"
*set var PROP1(real)=Operation(MatProp(Density, real))
*MatNum *PROP1
*end
.................................................................
Point conditions
*Set Cond Point-Weight *nodes
*set var NFIX(int)=CondNumEntities(int)
Concentrate Weights
*NFIX
.................................................................
Potentials Prescrits:
   Node  Tipus
   Valor/Etiqueta
*Set Cond Point-Weight *nodes
*loop nodes *OnlyInCond
*NodesNum     *cond(1)
*end
```

2.6. Creating the Execution file of the Calculating Module

1. Create the file "cmas2d.c". This file contains the code for the execution program of the calculating module. This execution program reads the problem data provided by GiD, calculates the coordinates of the center of mass of the object and the distance between each element and this point. These results are saved in a text file with the extension **.flavia.res**.
2. Compile and link the "cmas2d.c" file in order to obtain the executable **cmas2d.exe** file.

   The calculating module (cmas2d.exe) reads and generates the files described below.



NOTE: The "cmas2d.c" code is explained in the appendix.

2.7. Creating the Execution File for the Problem Type

Create the "cmas2d.bat" file. This file connects the data file(s) (***.dat***) to the calculating module (the **cmas2d.exe** program). When the GiD **Calculate** option is selected, it executes the .**bat** file for the problem type selected.

When GiD executes the .bat file, it transfers three parameters in the following way:

(parameter 3) / ***.bat** (parameter 2) / (parameter 1)

parameter 1: project name

parameter 2: project directory

parameter 3: *Problem type* location directory

NOTE: The **.bat** file as used in Windows is explained below.

```
del %2\%1.boh
del %2\%1.flavia.res
del %2\%1.flavia.dat
```

This deletes results files from any previous calculations to avoid confusion.

```
rem OutputFile: $2/$1.boh
```

A comment line such as "`rem OutputFile: file_name.log`" *means that the contents of the file indicated will be shown if the user clicks **Output View** in **Calculate→Calculate window** (Figure 4).*

*In this example the **.boh** file is shown. This file contains the coordinates of the center of mass.*

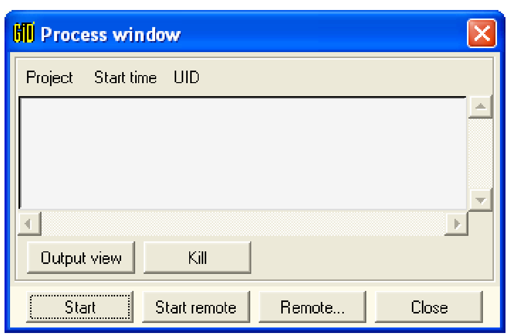


*Figure 4. The **Process** window.*

```
rem ErrorFile: $2/$1.err
```

A comment line such as "`rem ErrorFile: file_name.err`" *means that the indicated file will contain the errors (if any). If the **.err** file is present at the end of the execution, a window comes up showing the error. The absence of the **.err** file indicates that the calculation is considered satisfactory.*
*GiD automatically deletes the **.err** files before initiating a calculation to avoid confusion.*

```
$3/cmas2d.exe $2/$1
```

Executing the cmas2d.exe file.

cmas2d.bat

```
@ECHO OFF
del %2\%1.boh
del %2\%1.flavia.res
del %2\%1.flavia.dat
rem OutputFile: %2\%1.boh
rem ErrorFile: %2\%1.err
%3\cmas2d.exe %2\%1
```

3. EXECUTING THE CALCULATING MODULE

In order to more easily understand the way the calculating module works, simple problems with limited practical use have been chosen. Although these problems do not exemplify the full potential of the GiD program, the user may intuit their answers and, therefore, compare the predicted results with those obtained in the simulations.

3.1. Executing the calculation for an object made of homogeneous material

1. From the **Files** menu, select **Read**. Select the file “ToMesh2d.gid” and click **Open**.

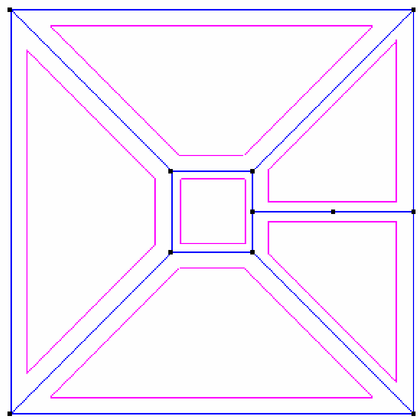


Figure 5. Contents of the "ToMesh2d.gid" file.

2. Choose the option **Data→Problem type→Cmas2d**.
3. Choose **Data→Materials**. The materials window is opened (Figure 6). From the **Materials** menu in this window, choose the option **Air**.

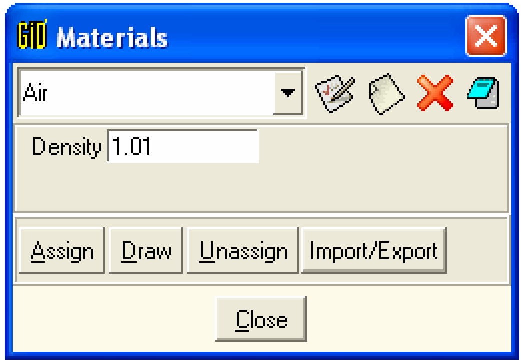


*Figure 6. The **Materials** window*

4. Click **Assign→Surfaces** and select all the surfaces. Press **ESC** when this step is finished.
5. Choose the **Mesh→Generate** option.
6. A window appears in which to enter the maximum element size for the mesh to be generated. Enter 2 and click **OK**. The mesh shown in Figure 7 will be obtained.

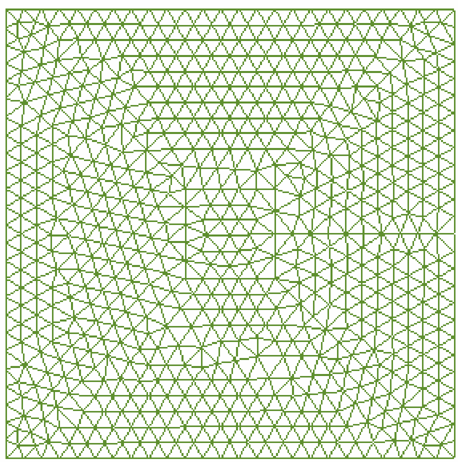


Figure 7. The mesh of the object

7. Now the calculation may be initiated. Choose the **Calculate** option from the **Calculate** menu, thus executing the calculating module.
8. Wait until a box appears indicating that the calculation has finished (Figure 8).

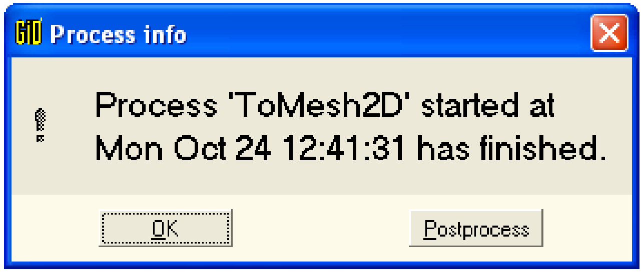


Figure 8. Process information box

9. Choose the option **Files→Postprocess**.
10. From the **Windows** menu, choose the **View Results** option (Figure 9). A window appears from which to visualize the results. By default, no result is visualized on entering the postprocessing component.
11. From the **View** combo box in the **View Results** window, choose the **Contour Fill** option. A set of available result are displayed.

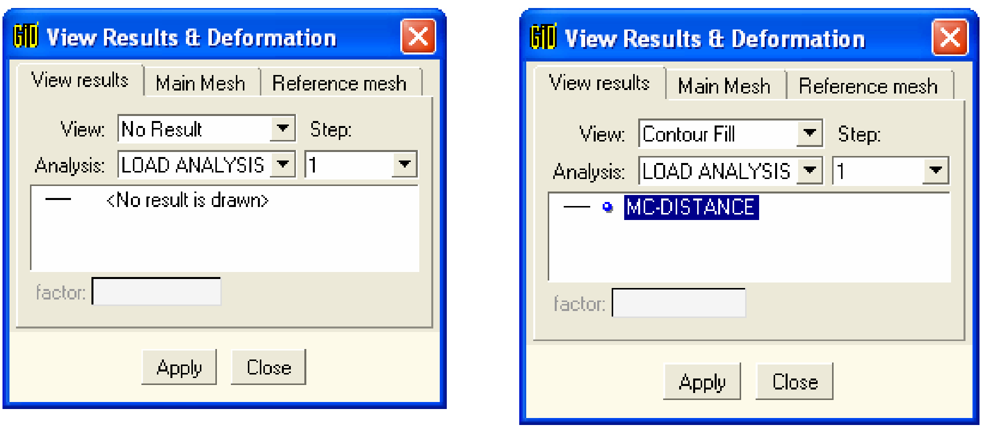


*Figure 9. The **View Results** window .*

12. Now choose the **MC-DISTANCE** result and click **Apply**. A graphic representation of the calculation is obtained (see Figure 10).

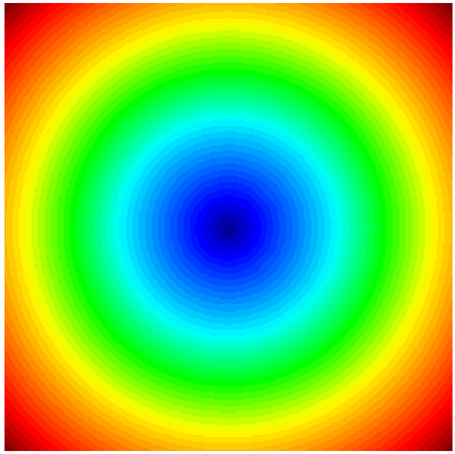


*Figure 10. Visualizing the distance (**MC-DISTANCE**) from the center of mass of the object to each element, for an object of homogeneous material*

13. The results shown on the screen reproduce those we anticipated at the outset of the problem: the center of mass of an object made of homogeneous material coincides with its geometric center. The ***.boh*** file will provide the exact coordinates of this point.

3.2. Executing the calculation for an object made of heterogeneous material

1. Choose the **Files→preprocess** option.
2. Choose the **Data→Materials** option. The **Materials** window is opened. From the **Materials** menu in this window, choose **Steel** (Figure 11).

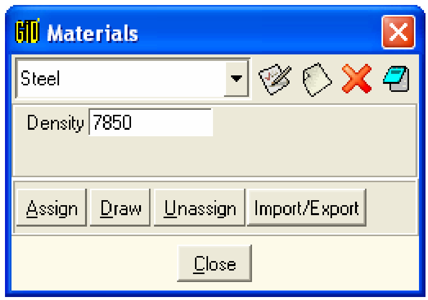


*Figure 11. The **Materials** window, with "Steel" selected*

3. Click **Assign→Surfaces** and select the surface indicated in Figure 12. Press **ESC** when this step is finished.

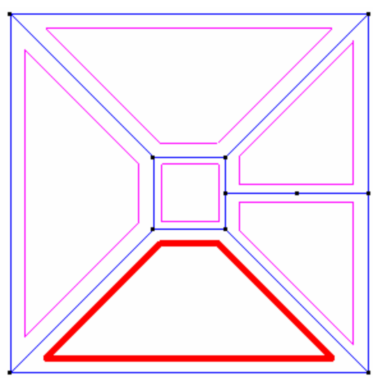


Figure 12 Assigning the material "Steel" to the surface indicated

4. Choose the **Mesh→Generate** option.

5. A window appears in which to enter the maximum element size for the mesh to be generated. Enter 2 and click **OK**.
6. Choose the **Calculate** option from the **Calculate** menu, thus executing the calculating module.
7. Choose the **Files→Postprocess** option.
8. Visualize the new results.

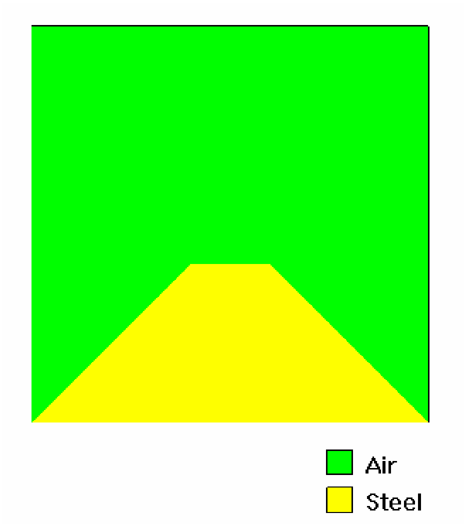


Figure 13. Visualizing the materials making up the object

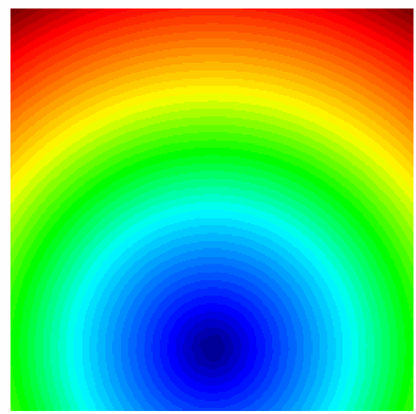


*Figure 14. Visualizing the distance (**MC-DISTANCE**) from the center of mass of the object to each element, for an object of heterogeneous material*

9. As anticipated, the center of mass is displaced toward the material with greater density.

3.3. Executing the calculation for an object of heterogeneous material and subject to external point- weight

1. Choose the **Files→preprocess** option.
2. Choose the **Data→Conditions** option. A window is opened in which the conditions of the problem should be entered (Figure 15).
3. Since the condition to be entered acts over points, select **over points** from the **Type** menu in the **Conditions** window.

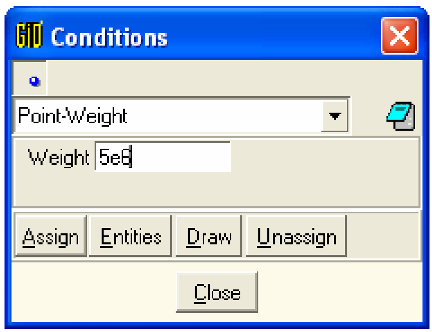


*Figure 15. The **Conditions** window*

4. Enter the value **5e6** in the **Weight** box. Click **Assign** and select the point indicated in Figure 16. Press **ESC** when this step is finished.

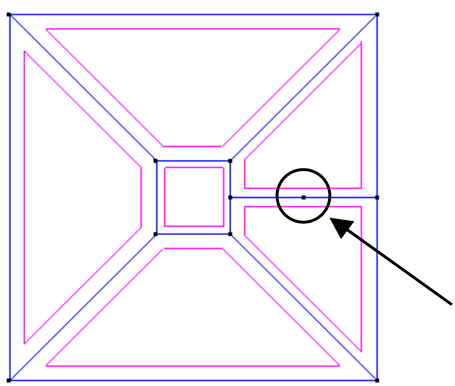


Figure 16. The point subject to external weight

5. Choose **Mesh→Generate mesh**.

6. A window appears in which to enter the maximum element size for the mesh to be generated. Enter 2 and click **OK**.
7. Choose the **Calculate** option from the **Calculate** menu, thus executing the calculating module.
8. Choose the **Files→Postprocess** option.
9. Visualize the new results.

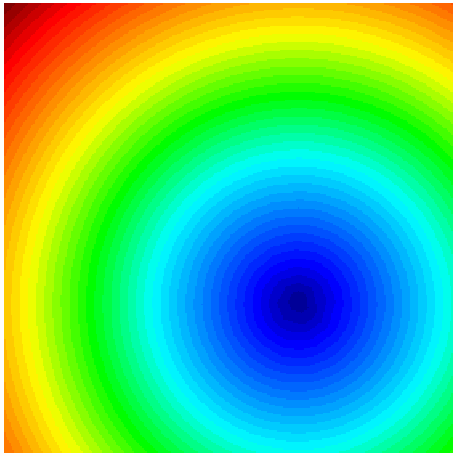


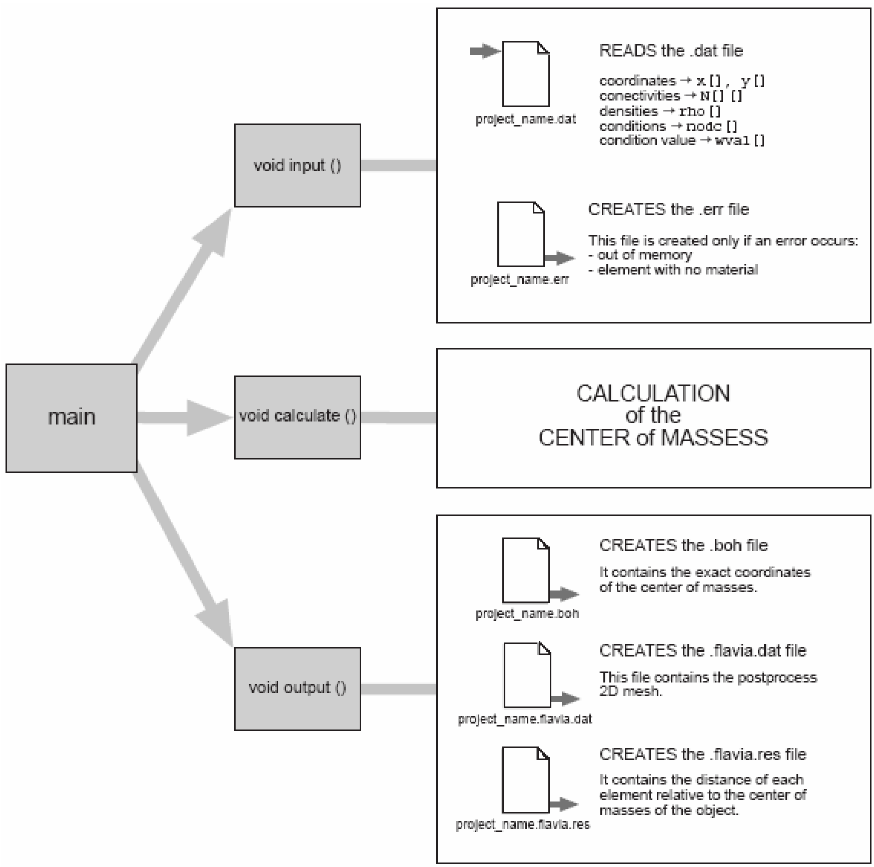
*Figure 17. Visualizing the distance (**MC-DISTANCE**) from the center of mass to each element, for an object of heterogeneous material subject to point weight*

10. Now the condition is external point-weight. As anticipated, the new center of mass is displaced toward the point under weight.

4. APPENDIX

4.1. The program code for the calculating module

1. The structure of the program that calculates the center of mass (cmas2d.c) is the following:



NOTE: In this example, a code for the program will be developed in C. Nevertheless, any language of choice may be used.

2. The code of the program that calculates the center of mass (cmas2d.c) is as follows:

The cmas2d.c file

```
#include <stdio.h>
#include <stdlib.h>
#include <fcntl.h>
#include <string.h>
#include <math.h>


#define MAXMAT 10000
#define MAXCND 10000

char projname[1024];
int i, ielem, inod, icnd;
double *x, *y
int *N, *imat;
int  nodc[MAXCND];
double rho[MAXMAT], wval[MAXCND];
int Nelem, Nnod, Nmat, Ncnd;
double x_CG, y_CG


void input(void);
void calculate(void);
void output(void);
```

Declaration of variables and constants used in the program.

```
void main (int argc, char *argv[])
 {
   void input(void);
   void calculate(void);
   void output(void);

   strcpy (projname, argv[1]);
   input();
   calculate();
   output();
 }
```

The main program.
The main program is called from the cmas2d.bat file and has as its parameters the name of the project. This name is stored in the '`projname`*' variable.*

*The main program calls the **input ()**, **calculate ()** and **output ()** functions.*

*The **input** function reads the .dat file generated by GiD. The .dat file contains information about the mesh. The **calculate** function read and processes the data and generates the results. The **output** function creates the results files.*

```
void input ()
 {
   char filedat[1024], sau1[1024], sau2[1024];
   FILE* fp;
   Int aux,j;

   Void jumpline (FILE*);

   Strcpy(filedat, projname);
   Strcat(filedat,".dat");
   fp = fopen(filedat, "r");
```

*The **input()** function.*
The first part of the input function links the project name with the .dat extension, thus obtaining the name of the file that is to be read. This file is opened in order to be read.
*The **jumpline(FILE*)** function is declared. This function reads 80 bytes of the file that it receives as a parameter. It will also be used to jump lines of the text when reading the .dat file.*

```
for (i=0;  i<6; i++)
     jumpline (fp);
   fscanf(fp, "%d %d", &Nelem, &Nnod);
```

The first six lines of the .dat file are jumped over since these are lines of information for the user (see .bas file). Then the total number of elements and nodes of the project are read and stored in the variables `Nelem` *and* `Nnod` *respectively.*

```
   x=(double *) malloc((Nnod+1)*sizeof(double)); if (x==NULL) {error=1;}
   y=(double *) malloc((Nnod+1)*sizeof(double)); if (y==NULL) {error=1;}


   N=   (int *) malloc((Nelem+1)*3*sizeof(int)); if (N==NULL) {error=1;}
   imat=(int *) malloc((Nelem+1)*sizeof(int));   if (N==NULL) {error=1;}

   if (error)
   {
      strcpy(fileerr, projname);
      strcat(fileerr,".err");
      ferr = fopen(fileerr, "w");
      fprintf(ferr, "\n \n \n ***** ERROR: Not enough memory. ***** \n");
      fprintf(ferr, "(Try to calculate with less elements)\n");
```

```
      exit(1);
     }

   for (i=0;  i<6; i++)
     jumpline (fp);
```

Space is reserved for storing the coordinates of the nodes (pointers `x`*,* `y`*), the connectivities (pointer* `N`*), and the materials corresponding to each element (pointer* `imat`*).*
In case of error (insufficient memory), a file is created with the extension .err. This file contains information about the error and the program is aborted.

The next six lines are jumped over.

```
/* reading the coordinates */
   for (inod=1; inod<=Nnod; inod++)
       fscanf (fp, "%d %lf %lf", &aux, &x[inod], &y[inod]);

   for (i=0;  i<6; i++)
     jumpline (fp);
```

The ***coordinates*** *of the nodes are read and stored in the* `x` *and* `y` *variables. The node identifier indexes the tables of coordinates.*

```
/* reading connectivities */
   for (ielem=1; ielem<=Nelem; ielem++){
     fscanf (fp, "%d", &aux);
     for(j=0;j<3;j++) fscanf (fp, "%d", &N[(ielem-1)*3+j]);
     fscanf (fp, "%d", &imat[ielem]);
     if (imat[ielem]==0)
      {strcpy(fileerr, projname);
       strcat(fileerr,".err");
       ferr = fopen(fileerr, "w");
       fprintf(ferr,"\n \n \n **ERROR: Elements with no material!!**\n");
       exit(1);
      }
   }
```

The ***connectivities*** *are read and the* `N` *variable is saved. This variable is a* Nelem x 3- *size table with two fields. The nodes (3 nodes) forming the element are saved in the first field. The element identifiers are saved in the second.*

All the elements are checked, ensuring that they have been assigned a material. If the identifier of the material is 0 (meaning that no material has been assigned to the element), an ***.err*** *file is created containing information about the error and the program is aborted.*

```
   for (i=0;  i<5; i++)
     jumpline (fp);
   fscanf(fp, "%s %s  %d",sau1, sau2, &Nmat );

   for (i=0;  i<3; i++)
     jumpline (fp);

   /* reading density of each material */
   for (i=1; i<=Nmat; i++)
       fscanf (fp, "%d %lf", &aux, &rho[i]);


   for (i=0;  i<4; i++)
     jumpline (fp);

   /* reading conditions*/
   fscanf(fp, "%d", &Ncnd);

   for (i=0;  i<6; i++)
     jumpline (fp);

   for (icnd=1; icnd<=Ncnd; icnd++)
     {
       fscanf (fp, "%d %lf", &nodc[icnd], &wval[icnd]);
       jumpline (fp);
     }

   fclose (fp);
 }
```

Reading the remaining information in the .dat file.

*The **total number of materials** is read and stored in the* `Nmat` *variable.*
*The **density** of each material are read and stored in the* `rho` *table. The material identifier indexes the densities.*

*The **total number of conditions** is read and stored in the* `Ncnd` *variable.*

*The **nodes associated with a condition** are read and stored in the* `nodc` *table indexed by the condition identifier. The **value of the condition** is stored in* `wval`*, another table indexed by the condition identifier.*

```
void calculate ()
 {
   double v,aux1,aux2,aux3;
   int n1, n2, n3;
   int mat;
   double x_CGi, y_CGi;
   double x_num=0, y_num=0, den=0;
```

*The **calculate()** function. This is the function that calculates the center of mass.*
Declaration of the local variables used in calculate().

```
   for (ielem=1; ielem<=Nelem; ielem++)
     {
       n1= N[0+(ielem-1)*3];
       n2= N[1+(ielem-1)*3];
       n3= N[2+(ielem-1)*3];

       /* Calculating the volume (volume is the area, provided we
          are dealing with 3D surfaces) */

      v=fabs(x[n1]*y[n2]+x[n2]*y[n3]+x[n3]*y[n1]-x[n1]*y[n3]-x[n2]*y[n1]-
x[n3]*y[n2])/2;


       /* The geometric center of the element is calculated */

       x_CGi= (x[n1]+x[n2]+x[n3])/3;
       y_CGi= (y[n1]+y[n2]+y[n3])/3;

       /* sums are calculated*/
       mat= imat[ielem];
       x_num+= rho[mat]*v*x_CGi;
       y_num+= rho[mat]*v*y_CGi;

       den+= rho[mat]*v;
   }
```

Main loop of the calculating function.
The identifiers of the nodes of the present element are saved in `n1`, `n2`, `n3`.
This loop makes a rundown of all the elements in the mesh. The volume is calculated for each element. (Here, the volume is the area, provided we are dealing with 3D surfaces.) The volume calculations are stored in the `v` *variable.*
The geometric center of the element is calculated (coinciding with the center of gravity) and the coordinates are stored in the `x_Cgi` *and* `y_Cgi` *variables*.

The numerator sums are calculated. When the loop is finished, the following sums are stored in the `x_num` *and* `y_num` *variables:*

$$\text{x\_num} = \sum_{elm} \rho_{elm} V_{elm} \cdot x_{elm}$$

$$\text{y\_num} = \sum_{elm} \rho_{elm} V_{elm} \cdot y_{elm}$$

The denominator sum is calculated. When the loop is finished, the following sum is stored in the `den` *variable:*

$$\text{den} = \sum_{elm} \rho_{elm} V_{elm}$$

```
/* point weights */
   for (icnd=1; icnd<=Ncnd; icnd++)
     {
       inod= nodc[icnd];
       x_num+= wval[icnd]*x[inod];
       y_num+= wval[icnd]*y[inod];

       den+= wval[icnd];
     }
```

Then, the calculations associated with point-weights are run using a loop that makes a rundown of all the conditions.

The results are added to the `x_num`, `y_num`, *and* `den` *variables, as seen in the formulae:*

$$\text{x\_num} = \sum_{elm} \rho_{elm} V_{elm} \cdot x_{elm} + \boxed{\sum_{i=1}^{N} m_i \cdot x_i}$$

$$\text{y\_num} = \sum_{elm} \rho_{elm} V_{elm} \cdot y_{elm} + \boxed{\sum_{i=1}^{N} m_i \cdot y_i}$$

The value of point-weights is added to the variable `den`.

$$\text{den} = \sum_{elm} \rho_{elm} V_{elm} + \boxed{\sum_{i=1}^{N} m_i}$$

```
    x_CG= (x_num/den);
    y_CG= (y_num/den);

  }
```

Finally, the result of dividing the `x_num` *and* `y_num` *variables by the* `den` *variable is stored in the* `x_CG` *and* `y_CG` *variables.*

`x_CG` **=** `(x_num/den)` → `x_CG` **=** $\dfrac{\sum_{elm} \rho_{elm} V_{elm} \cdot x_{elm} + \sum_{i=1}^{N} m_i \cdot x_i}{\sum_{elm} \rho_{elm} V_{elm} + \sum_{i=1}^{N} m_i}$

`y_CG` **=** `(y_num/den)` → `y_CG` **=** $\dfrac{\sum_{elm} \rho_{elm} V_{elm} \cdot y_{elm} + \sum_{i=1}^{N} m_i \cdot y_i}{\sum_{elm} \rho_{elm} V_{elm} + \sum_{i=1}^{N} m_i}$

```
void output()
 {
   char filedat[80];
   FILE *fp, *fptest;
   float raiz;
   double pot;
```

The ***output()*** *function.*
*The output() function creates three files: .**flavia.dat**, **.flavia.res**, and .**boh.***

The project mesh is stored in the ***.flavia.dat*** *file. The mesh is a 2D surface.*
The results to be visualized in GiD Post-process are stored in the ***.flavia.res*** *file. It is this file that stores the data which enables GiD to represent the distance of each point from the corresponding center of mass.*

*The numerical value of the center of mass is saved in the .**boh** file. The accuracy of this value is directly proportional to the element size.*

```
   strcpy(filedat, projname);
   strcat(filedat,".boh");
   fptest = fopen(filedat, "w");
   fprintf (fptest, "FILE: %s\n", projname);
   fprintf (fptest, "CMAS2D\n2D routine to calculate the mass center
            of an heterogeneus object. \n January 2000\t
            Rienzi Gianfranco\t\t\t\tCIMNE\n");
   fprintf (fptest, "\n\n\t====> mass center: %lf %lf \n", x_CG, y_CG);
```

*Creating the .**boh** file.*
The .boh extension is added to the project name and a file is created that will contain the numerical value of the position of the center of mass, which in turn is stored in the `x_CG` *and y* `y_CG` *variables of the program.*

```
/* writing .flavia.dat */
   strcpy(filedat, projname);
   strcat(filedat,".flavia.dat");
   fp = fopen(filedat, "w");
   fprintf (fp, "FILE: %s\n", projname);
   fprintf (fp, "\n");
   fprintf (fp, "CMAS\n");
   fprintf (fp, "Routine to calculate the mass center of an object.\n");
   fprintf (fp, "\t\t\t\t\tCIMNE\n");
   fprintf (fp, "2000 G. Rienzi\n");
   fprintf (fp, " %6d %6d      3\n", Nelem, Nnod);
   fprintf (fp, "\t\tNODES\n");
   for (inod=1; inod<=Nnod; inod++)
     fprintf (fp, " %6d %14.6e %14.6e \n", inod, x[inod], y[inod]);
   fprintf (fp, "\t\tCONECTIVITIES\n");
   for (ielem=1; ielem<=Nelem; ielem++)
       fprintf (fp, " %6d %6d %6d %6d %6d\n", ielem,    N[0+(ielem-1)*3],
N[1+(ielem-1)*3], N[2+(ielem-1)*3], imat[ielem]);

   fclose (fp);
```

*Creating the **.flavia.dat** file.*
The .flavia.dat file contains information about a 2D surface. The .flavia.dat file has a particular format which must remain intact if GiD is to read it. The format of this file is the following:

- *There are 6 header lines for entering general information about the project. For this example, enter the following information:*

```
FILE: "project_name"
       CMAS
Program for calculating the center of mass
              CIMNE
2000 G. Rienzi
```

- *Then enter the number of elements and nodes in the mesh using the following format:*

  Number of elements (`Nelem`) number of nodes (`Nnod`) element type (3).

  A type-3 element means it is a three-node triangle.

- *The next line is for general information. For this example, enter the following text:*

  `NODES`

- *Then list the coordinates of all the nodes using the following format:*

  Node identifier (`inod`) x coordinate (`x[inod]`) y coordinate (`y[inod]`)

- *The next line is for general information. For this example, enter the following text:*

  `CONECTIVITIES`

- *To conclude, list the connectivities between nodes. For each element, list these variables:*

  Element identifier (`ielem`)
  1st node (`N[0+(ielem-1)*3]`)
  2nd node (`N[1+(ielem-1)*3]`)
  3rd node (`N[2+(ielem-1)*3]`)
  material (`imat[ielem]`)

```
/* writing .flavia.res */
   strcpy(filedat, projname);
   strcat(filedat,".flavia.res");
   fp = fopen(filedat, "w");
   fprintf (fp, "MC-DISTANCE    2    1    1    1    0\n");
   for (inod=1; inod<=Nnod; inod++)
     {
       /* distance from the center of masses */
       raiz= (x_CG-x[inod])*(x_CG-x[inod]) + (y_CG-y[inod])*(y_CG -
y[inod]);
       pot = sqrt ((double)raiz);
       fprintf (fp, " %6d %14.6lf\n", inod, pot);
     }
   fclose (fp);
   fclose (fptest);
   free(x);
   free(y);
   free(N);
   free(imat);
```

*Creating the **.flavia.res** file. The output data (results) are stored in this file.*

The format of the .flavia.res file is as follows:

- *On the first line, enter the variables defining the type of result. The first parameter of the line is the title appearing in the GiD post-process menu. For this example, the title* `MC-DISTANCE` *has been chosen.*
  Then enter the values `2 1 1 1 0`.
  The first parameter is the type of analysis: 2 corresponds to a load analysis.
  The second parameter is the number of steps in the calculation. In this example there is 1 step.
  The third parameter is the type of result: 1 corresponds to a scalar result.
  The fourth parameter is the position associated to the results: 1 means the results are associated with nodes.
  The fifth parameter is a description of each component: 0 means there is no description.

- *To conclude, list the results (distance from the center of mass) in the following format:*

  Node identifier (`inod`*) associated result (*`pot`*)*

```
/* jumpline function */
void jumpline (FILE* filep)
 {
   char buffer[80];

   fgets(buffer, 80, filep);
 }
```

*Executing the **Jumpline** function.*

Cmas2d.c

```
#include <stdio.h>
#include <stdlib.h>
#include <fcntl.h>
#include <string.h>
#include <math.h>

#define MAXMAT 10000
#define MAXCND 10000

char projname[1024];
int i, ielem, inod, icnd;
double *x, *y;
int *N, *imat;
int  nodc[MAXCND];
double rho[MAXMAT], wval[MAXCND];
int Nelem, Nnod, Nmat, Ncnd;
double x_CG, y_CG;

void input(void);
void calculate(void);
void output(void);

void main (int argc, char *argv[])
{
   strcpy (projname, argv[1]);
   input();
   calculate();
   output();
}

void input ()
{
   char filedat[80], sau1[80], sau2[80];
   FILE* fp;
   int aux,j;

   void jumpline (FILE*);

   strcpy(filedat, projname);
   strcat(filedat,".dat");
   fp = fopen(filedat, "r");


   for (i=0;  i<6; i++)
     jumpline (fp);
   fscanf(fp, "%d %d", &Nelem, &Nnod);
```

```
x=(double *) malloc((Nnod+1)*sizeof(double)); if (x==NULL) {error=1;}
y=(double *) malloc((Nnod+1)*sizeof(double)); if (y==NULL) {error=1;}

N=   (int *) malloc((Nelem+1)*3*sizeof(int)); if (N==NULL) {error=1;}
imat=(int *) malloc((Nelem+1)*sizeof(int));   if (N==NULL) {error=1;}

if (error)
{
   strcpy(fileerr, projname);
   strcat(fileerr,".err");
   ferr = fopen(fileerr, "w");
   fprintf(ferr, "\n \n \n *****  ERROR: Not enough memory. ***** \n");
   fprintf(ferr, "(Try to calculate with less elements)\n");

   exit(1);
 }

for (i=0;  i<6; i++)
  jumpline (fp);

/* reading the coordinates*/
for (inod=1; inod<=Nnod; inod++)
    fscanf (fp, "%d %lf %lf", &aux, &x[inod], &y[inod]);



for (i=0;  i<6; i++)
  jumpline (fp);

/* reading connectivities */

for (ielem=1; ielem<=Nelem; ielem++){
  fscanf (fp, "%d", &aux);
  for(j=0;j<3;j++) fscanf (fp, "%d", &N[(ielem-1)*3+j]);
  fscanf (fp, "%d", &imat[ielem]);
  if (imat[ielem]==0)
      {
       strcpy(fileerr, projname);
       strcat(fileerr,".err");
       ferr = fopen(fileerr, "w");
       fprintf(ferr, "\n \n \n **ERROR: Elements with no material!!** \n");
       exit(1);
      }
}

for (i=0;  i<5; i++)
  jumpline (fp);
fscanf(fp, "%s %s  %d",sau1, sau2, &Nmat );
```

```
   for (i=0;  i<3; i++)
     jumpline (fp);

   /* reading density of each material */
   for (i=1; i<=Nmat; i++)
       fscanf (fp, "%d %lf", &aux, &rho[i]);

   for (i=0;  i<4; i++)
     jumpline (fp);

   /* reading conditions */
   fscanf(fp, "%d", &Ncnd);

   for (i=0;  i<6; i++)
     jumpline (fp);

   for (icnd=1; icnd<=Ncnd; icnd++)
     {
       fscanf (fp, "%d %lf", &nodc[icnd], &wval[icnd]);
       jumpline (fp);
     }

   fclose (fp);
}

void calculate ()
{
   double v, aux1,aux2,aux3;
   int n1, n2, n3;
   int mat;
   double x_CGi, y_CGi;
   double x_num=0, y_num=0,  den=0;

   for (ielem=1; ielem<=Nelem; ielem++)
     {
       n1= N[0+(ielem-1)*3];
       n2= N[1+(ielem-1)*3];
       n3= N[2+(ielem-1)*3];

       /* Calculating the volume (volume is the area,
          provided we are dealing with 3D surfaces) */

      v=fabs(x[n1]*y[n2]+x[n2]*y[n3]+x[n3]*y[n1]-x[n1]*y[n3]-x[n2]*y[n1]-
x[n3]*y[n2])/2;

       /* The geometric center of the element is calculated */

       x_CGi= (x[n1]+x[n2]+x[n3])/3;
       y_CGi= (y[n1]+y[n2]+y[n3])/3;

     /* sums are calculated */
```

```
        mat= imat[ielem];
        x_num+= rho[mat]*v*x_CGi;
        y_num+= rho[mat]*v*y_CGi;

        den+= rho[mat]*v;
      }

    /* point weights */
    for (icnd=1; icnd<=Ncnd; icnd++)
      {
        inod= nodc[icnd];
        x_num+= wval[icnd]*x[inod];
        y_num+= wval[icnd]*y[inod];

        den+= wval[icnd];
      }

    x_CG= (x_num/den);
    y_CG= (y_num/den);
}

void output()
 {
    char filedat[1024];
    FILE *fp, *fptest;
    double raiz;
    double pot;
    strcpy(filedat, projname);
    strcat(filedat,".boh");
    fptest = fopen(filedat, "w");
    fprintf (fptest, "FILE: %s\n", projname);
    fprintf  (fptest,  "CMAS2D\n2D  routine  to  calculate  the  mass  center  of  an
heterogeneus object.\nJanuary 2000\tRienzi Gianfranco\t\t\t\tCIMNE\n");
    fprintf (fptest, "\n\n\t====> mass center: %lf %lf \n", x_CG, y_CG);

     /* writing .flavia.dat */
    strcpy(filedat, projname);
    strcat(filedat,".flavia.dat");
    fp = fopen(filedat, "w");
    fprintf (fp, "FILE: %s\n", projname);
    fprintf (fp, "CMAS\n");
    fprintf (fp, "Routine to calculate the mass center of an object.\n");
    fprintf (fp, "\t\t\t\t\tCIMNE\n");
    fprintf (fp, "2000 G. Rienzi\n");
    fprintf (fp, "\n");

    fprintf (fp, " %6d %6d      3\n", Nelem, Nnod);

    fprintf (fp, "\t\tNODES\n");
    for (inod=1; inod<=Nnod; inod++)
      fprintf (fp, " %6d %14.6e %14.6e\n", inod, x[inod], y[inod]);
```

```
   fprintf (fp, "\t\tCONECTIVITIES\n");

   for (ielem=1; ielem<=Nelem; ielem++){
     fprintf (fp, " %6d %6d %6d %6d %6d\n", ielem, N[0+(ielem-1)*3], N[1+(ielem-
1)*3], N[2+(ielem-1)*3], imat[ielem]);
   }

   fclose (fp);

   /* writing .flavia.res */
   strcpy(filedat, projname);
   strcat(filedat,".flavia.res");
   fp = fopen(filedat, "w");
   fprintf (fp, "MC-DISTANCE    2    1    1    1    0\n");
   for (inod=1; inod<=Nnod; inod++)
     {
       /* distance from the center of masses */
       raiz= (x_CG-x[inod])*(x_CG-x[inod]) + (y_CG-y[inod])*(y_CG-y[inod]);
       pot = sqrt (raiz);
       fprintf (fp, " %6d %14.6lf\n", inod, pot);
     }
   fclose (fp);
   fclose (fptest);
   free(x);
   free(y);
   free(N);
   free(imat);
}

/* jumpline function */
void jumpline (FILE* filep) {

   char buffer[1024];
   fgets(buffer, 1024, filep);

}
```