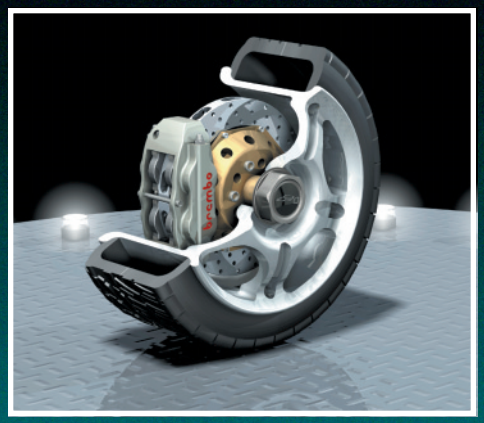

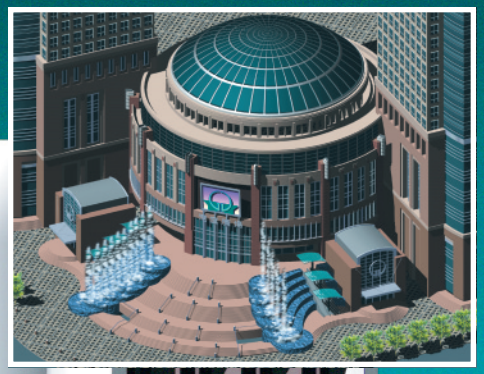

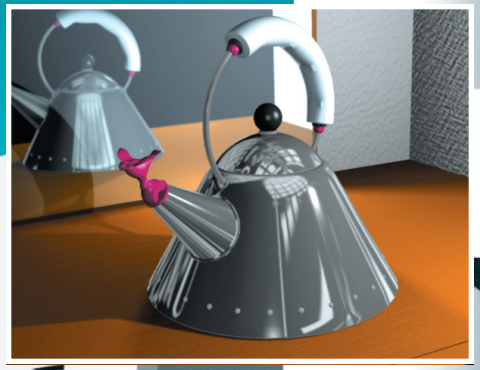

formZ

Demo Mini User's Manual

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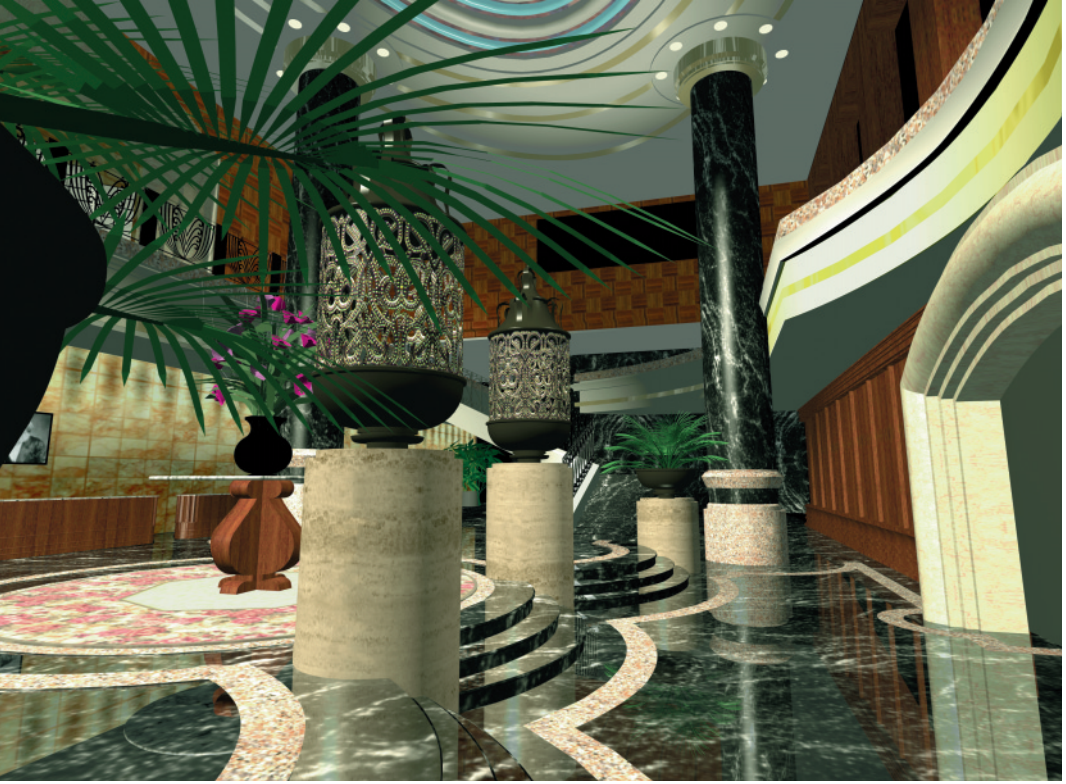

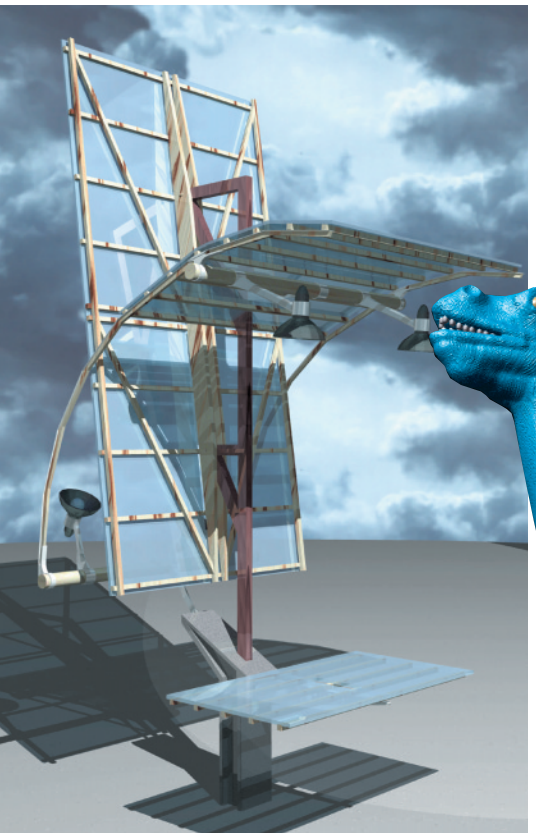

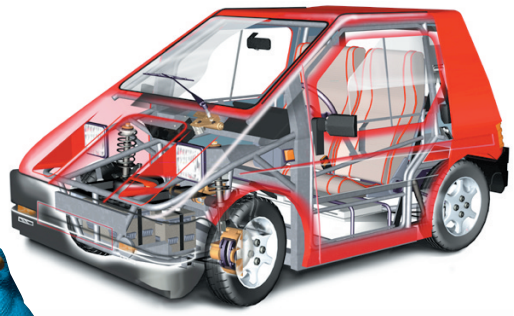

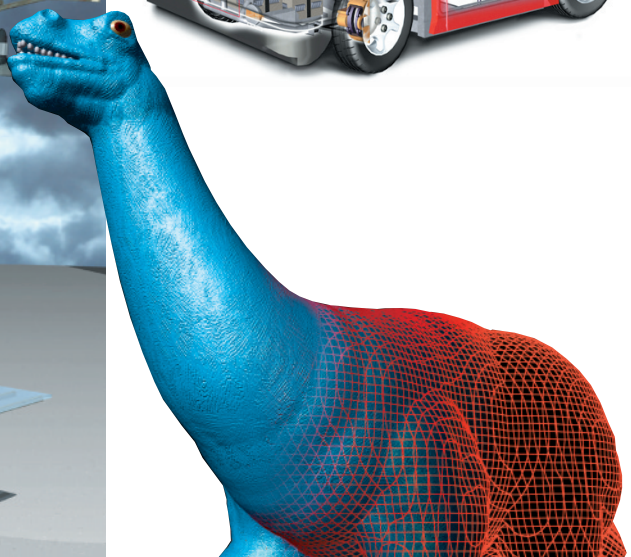

form•Z Demo

Mini User's Manual

Table of Contents

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form•Z Demo 2.9 Mini User's Manual

SIXTH EDITION: April 1997

This manual was created electronically using Adobe PageMaker® on an Apple Macintosh® computer.

All illustrations in this manual, including the models on the cover, were created using **form•Z**.

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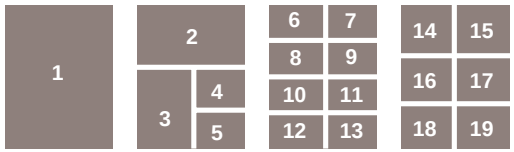
COVER CREDITS



1. Le Corbusier's Ronchamp, by Mark Niemi, auto•des•sys Inc., Columbus, Ohio.
2. Hyatt Hong Kong, by Teresa Williams, See^3, Culver City, California.
3. Chair at Venice Beach, by Christopher Campbell, California State Polytechnic University, Pomona, Department of Architecture, Pomona, California.
4. Kewett Electric Car, by Trini Andi Shack, Blackpool and the Fylde College, Lancashire, England.
5. Dino, by Alberto Scirocco, auto•des•sys, Inc., Columbus, Ohio.
6. Star Trek Poster, by Roger Harris, Kent, England.
7. Cake Pan, by Chris Yessios, auto•des•sys, Inc., Columbus, Ohio.
8. Outlet Valves, by Real Time Visualization, Lancashire, England.
9. Pen Light, by Pharma Design Inc., Warren, New Jersey .
10. Ceramics, by STEM, Limited, Coventry, England.
11. Swiss Army Knife, by Dave Teich, Mind of the Machine, Roosevelt, New Jersey .
12. Castle, by Chuck Carter, Carter/Reactor Inc., St. George, Utah.
13. Resfar Booth, by Martin Gately, kaos events limited, London, England.
14. Maclaren Formula One, by Steven Kerswell, Blackpool and the Fylde College, Lancashire, England.
15. Wheel, by Real Time Visualization, Lancashire, England.
16. Western Athletic Club in Northern California, DES Architects and Engineers, Redwood City, California.
17. Grand Gateway at Xu Hui, by Callison Architecture, Seattle, Washington.
18. Tea Pot, by Kaubisch GmbH, Munich, Germany.
19. Educational Electronic Toy, by IDEC Co. Ltd., Tokyo, Japan.

All models built with **form•Z** and rendered with **form•Z RenderZone** except 2, 11, 18, 19 which were rendered with ElectricImage.

About form•Z Demo

WELCOME to **form•Z RenderZone Demo**, the demonstration version of the 3D form synthesizer with photorealistic rendering. This is a partial version of **form•Z** that will allow you to experience the interface and most of the modeling and rendering capabilities of the program. It does not contain the drafting and it does not allow you to save or print. For a more complete evaluation of the program you may want to order the **form•Z RenderZone Evaluation** package, which is an essentially complete version and comes with a complete set of User's Manuals.

Note that, while there are two versions of our software there is only one demo version, **form•Z RenderZone Demo**. Any mentions of **form•Z Demo** refer to the same demo version. The features of **form•Z RenderZone Demo** are summarized in two documents. This **form•Z Mini Manual** discusses the interface and modeling features. The advanced rendering features are discussed in the companion document **form•Z RenderZone Mini Manual**.

How to use this manual

You should use this Mini User's Manual in conjunction with the **form•Z Quick Reference Guide** which contains a comprehensive list of all the tools, menu items, and dialogs of the system.

This mini manual is intended to give you a "quick" overview of the modeling features of **form•Z**. Admittedly, this is done at the risk of under-representing the power of the program. All the examples are at the simplest possible level. Our hope is that most of the users of **form•Z RenderZone Demo** will venture on to levels of modeling sophistication beyond those covered in this manual. We hope that you will enjoy "discovering" the power of **form•Z**.

The presentation of the material is done in the order in which the iconic tools appear in the tool palette, from top to bottom. There are a few exceptions. The insertions, even though they are controlled by tools on the first row, are discussed at the very end. This is simply because using them requires an understanding of features discussed later. The reference planes are discussed at the beginning. Also, the Move tool is needed and used a few times before it is discussed in detail. The menu commands are discussed in no particular order, whenever their functionality is needed for the execution of an example.

This manual is written mostly as a tutorial. When you move from one example to the next, you should either **Undo** or **Clear** (both in the **Edit** menu) what you were doing earlier, even when such an instruction is not given explicitly.

Getting help

As you run **form•Z RenderZone Demo**, quick summary information about specific tools and commands can also be obtained through the **Help** menu, which contains items leading to information about the different areas of the program.

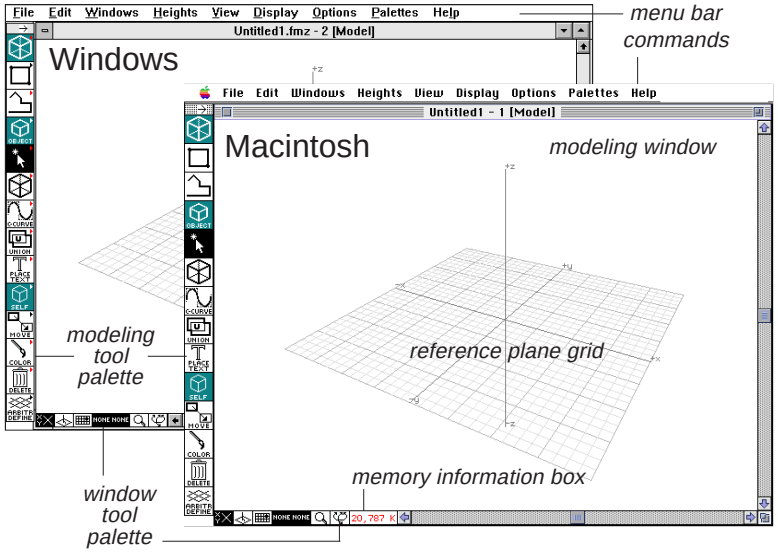
Communicating with form•Z

form•Z is organized by projects. Each project has its own windows. There are two types of windows: ***modeling*** and ***drafting*** windows. (The drafting module is not included in the demo version of the program). When you launch **form•Z RenderZone Demo** by double clicking on its application icon, it opens a new project and a new window, as shown below. You can also launch the program by double clicking on the icon of a previously saved project. While you cannot save in the demo version, a few sample projects are provided with your demo disk and you can also start the program by double clicking on them.

You communicate with **form•Z** through the ***menu bar commands*** or ***items*** at the top of the screen, the ***tool palette*** (or ***iconic menu***) on the left, ***floating palettes*** dedicated to particular operations, and the ***window tool palette*** found on the lower margin of each window. If you are running a Macintosh, the red number in the same margin is the ***memory box*** which shows you the computer memory currently available to your **form•Z** work session. Windows systems use virtual memory and no memory box is displayed for them.

A variety of ***dialog boxes*** are also used to set parametric options. The dialog that affects a tool can be invoked from the tool by double clicking on its icon or by clicking on its icon while pressing ***option*** (Mac) or ***ctrl***+***shft*** (Windows).

The screen also contains a ***graphics window*** which occupies most of the screen. Shown in the window are three ***orthogonal*** or ***Cartesian axes*** and a ***grid***. The grid represents the active ***reference plane***, where objects can be drawn.



You execute a menu bar command in the standard manner: position the cursor of the mouse on the title of the menu, press the button, drag the cursor to the desired item, and release the button. Some of the menu items pop out sub-menus (or hierarchical menus). You select an item from a sub-menu by dragging the mouse to the desired item, and then releasing the mouse button. The menu items that end with three dots (**...**) invoke dialogs. All the other items execute an operation. The menu items that have an asterisk (*****) after their name execute an operation which is affected by options selected from a dialog. To invoke that dialog, select the item while pressing the ***option*** key under Mac OS or the ***ctrl+shft*** keys on Windows.

Iconic tools are selected in a similar fashion. Pressing the mouse on an icon of the tool palette pops out more icons, any of which can be selected by dragging the mouse to it. Dragging the mouse beyond the last icon tears the icons off as an independent palette which can be positioned anywhere on your screen. You can also turn icons off and shorten your tool palette. This is done in the **Help** environment. Within the modeling help window, you can turn a tool off or on by double clicking on its icon.

The tool palette contains fourteen rows of tools which are color-coded. All the icons shown in black are ***operators***. When they are executed, they typically cause a visible affect on what is currently shown on the screen. Except for the icons on the fourteenth (last) row, all black coded icons operate on objects. The icons on the last row operate on the reference planes. The operators are mutually exclusive. When a new one is selected, the previously active operator is deselected.

The teal and magenta colored icons are ***modifiers***. They are used to set the system to a certain state or mode which affects the behavior of the operators. The modifiers are mutually exclusive within their own rows. There are three rows with modifiers. The icons on the first row tell the program what ***type*** of an object to generate (or what type of an insertion operation to execute). They work in conjunction with the drawing tools on the second and third rows. They essentially tell the system what to do with the shapes drawn by the user.

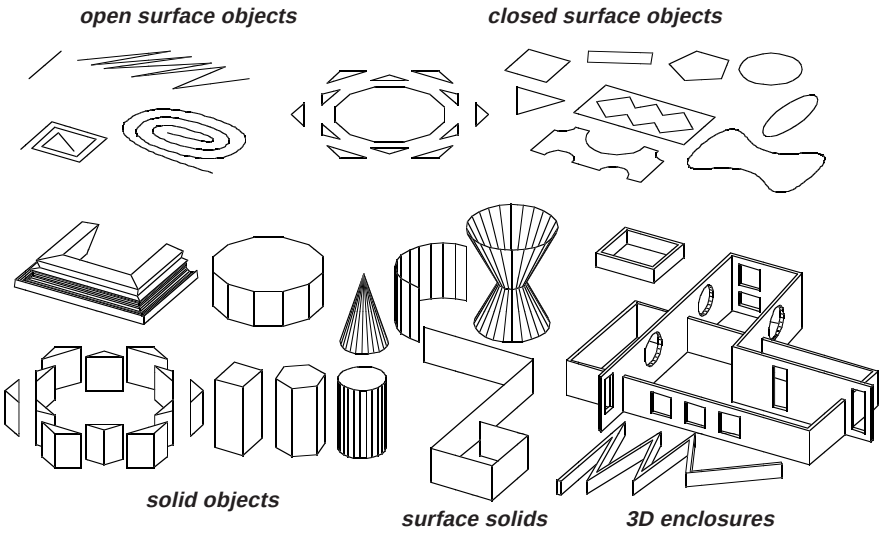
On the 4th row are the ***topological level*** modifiers: ***point***, ***segment***, ***outline***, ***face***, ***object***, ***group***, and the special level ***hole*** or ***volume***. **form•Z** has the ability to apply most of its operations to any of these levels. On the 10th row are the ***self/copy*** modifiers. When executing a geometric transformation (move, rotate, scale, or mirror) they tell the system whether to execute it on the object itself, on a single copy, or whether to produce multiple copies.

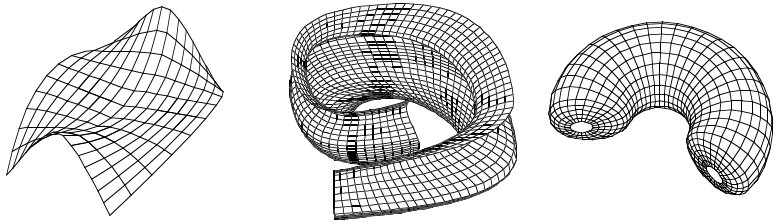
All objects can be generated graphically or through numeric input, which is handled by the ***Prompts*** palette. Graphic and numeric input can also be mixed. As you draw an object, you can place the mouse cursor in the Prompts palette and type a number, instead of clicking it in the graphics window. The Prompts palette also informs you about the steps required by an operation and what input is expected next.

About form•Z and its types of objects

form•Z is a general purpose ***solid*** and ***surface modeler***, which offers the tools to generate, manipulate, and sculpt objects directly in 3D space.

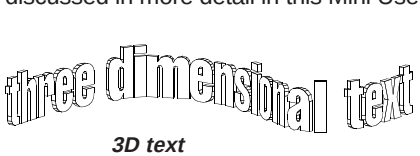
The basic types of modeling objects are ***surfaces*** and ***solids***. A surface object can be a simple open or closed line or a meshed surface. An object is solid when it is completely enclosed, which makes it ***well-formed***. Variations of these basic types are the ***surface solids***, which are two-sided surfaces that are completely enclosed but contain no volume, and the ***enclosures***, which can be surface or solid objects, and which are double line ("wall") objects that contain space. The ***controlled curves*** and the ***controlled meshes*** are curved objects which internally carry the control parameters that generated them, and therefore their forms can be easily changed after their initial creation.



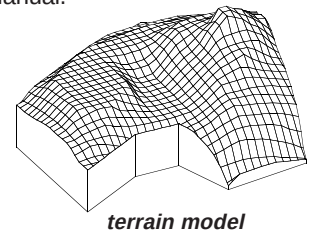


The models on the previous page that illustrate the different types of objects available in **form•Z** also show the variety of 2D shapes and 3D forms that can be generated directly with the tools of the program. These basic forms can be composed into more complex forms using operations such as the Booleans. In addition, tools are available for the direct creation of complex forms, such as those illustrated below.

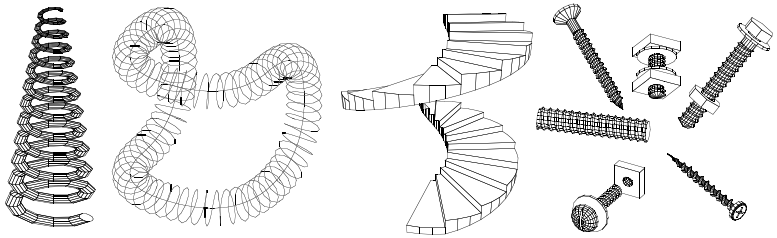
Three types of ***terrain models*** trimmed to a site's boundary can be generated from contour lines. Both 2D and 3D ***text*** can be generated from outline fonts (TrueType and PostScript), and can be placed in straight lines or along freely unfolding control lines. Solid, surface, and wire ***helixes*** and ***coils***, as well as ***spiral stairs***, ***screws***, and ***bolts***, can be generated directly as special types of objects of revolution. A variety of spherical objects, including the ***Platonic solids***, the ***soccer ball***, lathed and geodesic ***spheres***, can be created directly with a few clicks. The ***metaformz*** are special parametric objects that blend smoothly when they overlap. The generation of these objects is discussed in more detail in this Mini User's Manual.



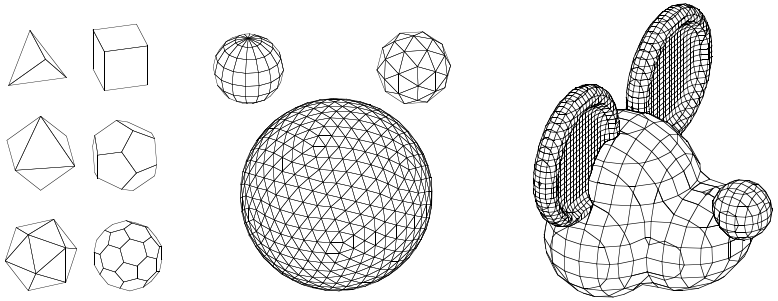
3D text



terrain model



helix and coil *spiral stair* *screws and bolts*



Platonic solids, soccer ball, and spheres *metaformz*

Reference planes, grids, and their palette

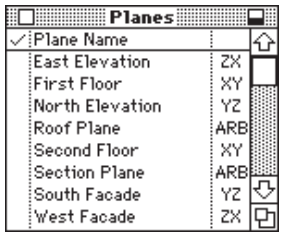
The three ***orthogonal axes*** and the ***grid*** are shown in the graphics window in the current view. From the **View** menu select the **Top** item and observe the result. Try some of the other **View** items to see how your view changes. When in one of the 3D views, select **Perspective** and see how the image of your grid changes. In **form•Z** you can work in one of four available 3D view types: ***axonometric***, ***isometric***, ***oblique***, and ***perspective. Panoramic*** is also available as a special 3D view. You may try them all, however, axonometric views are used almost exclusively in this manual. Select **Axonometric** to go back to an axonometric view.

The grid represents the active ***reference plane***, where objects can be drawn. To get a sense of scale, the default grid is 64 feet by 64 feet (20x20 meters in metric). It is colored using two shades of teal. Each of the small squares is 2 feet by 2 feet and the larger squares are 8 feet by 8 feet. (In metric, they are 50x50 cm and 1x1 m.) You can adjust these intervals through the **Window Setup** dialog, which you can invoke from the **Windows** menu. You can also change the scale of your image using items in the **Display** menu. Observe how the ends of the axes are marked with plus (+) and minus (-) signs to indicate their directions. The reference plane can be any of the Cartesian planes (XY, YZ, or ZX) or a plane generated by a user anywhere in 3D space. Reference planes may be switched through the first (left most) icon of the window palette (, , ,).

User defined reference planes are created using the Define Arbitrary Plane tool ( ), the first tool on the last row of the tool palette, and three points, two segments, or a face of an object you have created. To use three points set the topological level to Point ( ), select the Define Arbitrary Plane tool, and click on any three points. To use two segments or a face, you execute the operation in an analogous manner. (Since you may not have created any objects yet, try this as soon as you do).

The last row in the tool palette also contains tools which allow you to create a perpendicular plane ( ), to move ( ) or rotate ( ) a plane, to move its origin ( ), to extend its boundaries ( ), and to reset ( ) it.

When you select from the window palette you invoke the most recently defined arbitrary plane. You can also store reference planes in the ***Planes*** palette (which you can invoke from the **Palettes** menu), and assign names to them. Click in the Plane Name column of the palette, type the name you desire, and then click in the column (away from the name) again. After a plane has been named and entered in the palette, you can invoke it by simply clicking in front of its name.



Mouse movement and the perpendicular lock

When you use the mouse to draw, its positions are mapped onto the active reference plane (or to positions parallel to the reference plane). You can read the values of these positions in the Coordinates and the Prompt palettes. If you select the Perpendicular switch (, second icon in the window palette), the mouse will move in a direction perpendicular to the current reference plane.

Snapping

By selecting the Grid Snap icon (, 3rd in the window palette), you can lock the motions of the mouse to the nearest grid line. By default, the snapping parameter is 2'. It can be changed in the **Grid Snap Options** dialog, which you can invoke by double clicking on the Grid icon.

Directional snaps, which lock the motions of the mouse to the horizontal, vertical, diagonal, or other directions, are available in the 4th position of the window palette (, , ,). The 5th position contains a variety of object snaps, which allow you to lock the mouse to the nearest point, segment, mid-point, etc. (, , , , , , , , ,).

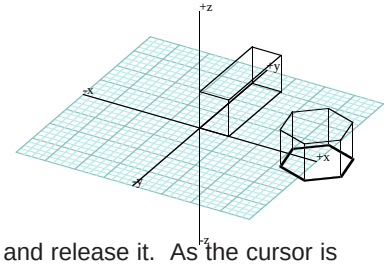
Zooming and panning

Using one of the tools in the 6th position of the window palette, you can zoom in and out, pan, fit your image to the screen, etc. There are five zoom tools. The magnifying glass ( ) tool zooms in and out relative to the point where you click. You can also zoom in and out by drawing a rectangular frame to delineate the area that will be zoomed (,), or by applying an incremental factor (,). By default, you draw the zoom frame from center to perimeter. Place the cursor at the center of the area you wish to delineate, and drag the mouse outwards. This rubber bands a rectangle until you release the mouse. You can also select the option that will allow you to draw the zoom rectangle from corner point to corner point.

When you execute a Zoom by Frame operation and the **Continuous Window Tool Control** option is selected in the **Preferences** dialog (**Edit** menu), the modeling tool palette is grayed out indicating that the window icons have control. This allows you to execute any number of zooms sequentially. To exit the zoom mode, click the mouse on any of the modeling or window tools. When you execute an incremental zoom, by default the system applies a 75% and a 133% scaling factor for zooming out and in, respectively. You can define your own scaling factors by invoking the **Zoom Options** dialog.

There are two tools for panning: the Hand ( ) and the Pan ( ) tools. Also available are window tools for returning to the previous zoom/pan setting ( ), returning to the initial setting ( ), or automatically scaling the view in a manner that fills the screen ( ).

Generating objects



To generate a rectangular object:

- From the first row of the tool palette, select the 3D Extrusion modifier ( ).
- From the 2nd row select Rectangle ( ).
- Click the mouse on the reference grid and release it. As the cursor is moved a rectangular shape is rubber banded and follows the motion of the mouse. Click again. An extruded rectangle is generated.

To generate a hexagonal extrusion:

- While the selection on the first row remains as before, select the Polygon tool ( ) from the 2nd row of the tool palette.
- Click the mouse where you want the center of your hexagon to be, then move it and click again to determine the size of hexagon.

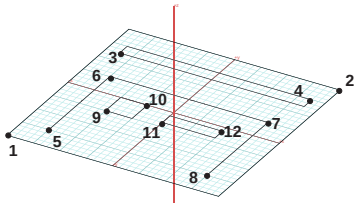
Note that in **form•Z** you do not drag the mouse when you draw a shape. You release it and click again for the next point. This offers two advantages over the "drag" method: it gives you the opportunity to execute other operations, such as zooming, while you are drawing, and it allows you to rest your arm between input points, whenever precision is required.

The two objects you just generated have the same height, which is 10' - 0". A different height can be used by selecting another number from the **Heights** menu. The height value can be positive or negative. You can use the **Custom...** item in the **Heights** menu to enter heights that are not included in the preset list. The custom heights are typed in the **Custom Height** dialog which appears when **Custom...** is selected. To add a height to the **Heights** menu, click on the **Add To Menu** button of the dialog. Custom heights can be selected as any other height item.

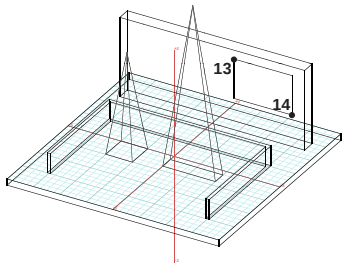
Height values already in the **Heights** menu can be removed or changed using **Edit Menu...**, at the bottom of the **Heights** menu. When selected, the **Heights Menu** dialog appears. Selecting a value in its heights list places it in the numeric field where it can be changed. Clicking on the **Add** button adds the new value to the heights list. Clicking on **Remove** removes the height from the list. The content of the **Heights** menu can be saved by clicking on **Save...** and previously saved heights files can be retrieved by clicking on **Load...**. **form•Z** is currently shipped with three height files, preset at three different levels of magnitude.

You can also select the **Graphic/Keyed** item (1st item in the **Heights** menu) to enter the heights of your objects interactively (graphically or numerically). When you do, as soon as you draw the base of your object, a 3D object is rubber banded and its top face follows the motion of the mouse, which is locked to a direction perpendicular to the reference plane or to a surface of an object, depending on the option selected in the **Extrusion/Convergence Direction** dialog. When you click again, the height of your object is determined. To enter a height numerically, you type it in the Prompts palette next to the "Height :" prompt, and press return. The following examples illustrate the different methods for entering heights.

- **Clear** (**Edit**) and turn on Grid Snap ( ).
- From the **Heights** menu select -2'-0".
- Select the 3D Extrusion ( ) modifier and the Rectangle ( ) tool.
- Click on **1** and **2** to draw a rectangle the size of the grid. A 3D object is extruded on the negative side of the reference plane.

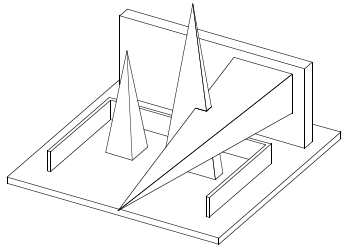


- From the **Heights** menu select **Custom...**.
- In the **Custom Height** dialog that is invoked, type 24', and click on **Add to Menu**. The 24' height is added to the **Heights** menu and becomes the active height.
- With 3D Extrusion and Rectangle still selected, click on **3** and **4**.

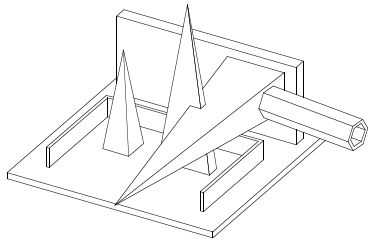


- From **Heights**, select **Graphic/Keyed**.
- Select the 3D Enclosure ( ) and Vector Line ( ) tools.
- Click on **5**, **6, 7**, and double click on **8**. A 3D enclosure (wall object) is rubber banded and moves perpendicular to the grid.
- Watch the height value in the Prompts palette and click when it is 6'-0".
- Select the 3D Converged Solid ( ) and Rectangle ( ) tools.
- Click on **9** and **10**. When the pyramid is as high as ours, click again.
- Click on **11** and **12**, then click again when the height of the second pyramid is roughly as ours.

You will next create objects by drawing on other existing objects.



- Double click on the 3D Convergence ( ) tool to invoke the **Extrusion/Convergence Direction** dialog. Select the **Perpendicular To Surface** option.
- Select the Snap to Face ( ) window tool.
- With 3D Convergence ( ) and Rectangle ( ) selected, draw a rectangle on the front face of the tall cuboid (click on **13** and **14**). A pyramid is rubber banded in a direction perpendicular to the surface on which you drew.
- Click again to complete the object.



Create a hexagonal 3D Enclosure on the side of the previous pyramid, as shown.

Note that the images on your screen look different from the ones we show on this page. Our images are plotted in what is known as the hidden line mode, which does not display the lines that are behind other objects. The display types available in **form•Z** are discussed on page 14.

Undoing, redoing, and deleting

If you make a mistake or, for some reason, you do not want one or more of the objects you created, you can select the **Undo** command from the **Edit** menu, which will cause them to disappear. If after you undo you change your mind, you can select the **Redo** item (also in the **Edit** menu) to bring the most recent object back.

form•Z offers you unlimited undos, the ability to execute any number of sequential undos in one step, and the ability to determine the depth of the undo records, that is, how many undo steps are saved. You can also optionally save the undo records when you save your projects (but saving is not available in this Demo version of **form•Z**). In this Mini Manual the undos will be used with their default settings. That is, one operation will be undone each time you select **Undo**. When we need to undo more than one operation, we explicitly instruct you to execute the **Undo** two or more times.

When drawing lines, arcs, or curves (see page 16) you can also select the **Undo** item to cancel the most recently entered point. Or you may undo individual points by using its key-equivalent command: ***command+Z*** on the Macintosh or ***ctrl+Z*** on Windows.

You can also delete an object by selecting the Delete tool () and clicking on it (with the topological level set to Object). You can achieve the same result by selecting (picking, see page 17) the object and then pressing the ***delete*** key on the Macintosh or the ***backspace*** key on Windows. Note that while the **Undo** and Delete commands may appear to produce the same result, they are distinctly different operations. In addition to deleting complete objects, you can also delete entities at other topological levels, such as points, segments, and faces.

Viewing

As already discussed in the Reference Planes section, modeling scenes can be displayed in 3D views, or as orthographic projections (front, back, top, bottom, right, or left elevation). These items and preset 3D views are selected from the **Views** menu, which also contains the **Custom View Angles...** item. It invokes a dialog where any view angles can be entered.

There are also interactive graphic methods for determining the position of the viewer. The **Edit Cone Of Vision** item (bottom of **Views** menu) invokes the Cone of Vision environment where the position of the viewer and a variety of other viewing parameters are manipulated with the mouse.

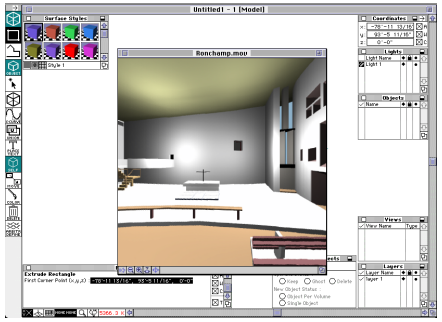
From the window palette, the Rotate View () and Set View () tools can be used to graphically manipulate the view. The Match View () tool can be used to match the view to that of a background image (underlay).

To use the Rotate View tool, you first click on the reference plane axis around which you wish to rotate the view. The next mouse click rubber bands your view and the third click generates it. When using the Set View tool, your first click rubber bands your view. The motion of the mouse represents the motion of the viewer who can move to the right, left, up, or down, and your view is adjusted accordingly.

Viewing QuickTime VR™ movies

In **form•Z** you can create, save, export and even view two types of QTVR movies: panoramic and object movies. While saving is disabled in the Demo version of **form•Z**, you can view a few sample movies that were produced with **form•Z** and are shipped with the Demo version. We do one example below.

• From the **File** menu click on **View File...**. This invokes the standard File Open dialog. Search for a folder labeled "VR Samples" and open it. Then double click on the movie file labeled "Ronchamp.mov."



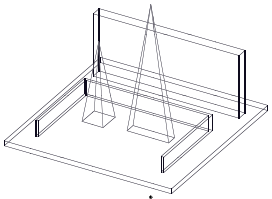
This opens a QTVR window, on top of your current windows. It displays a view of the interior of the Ronchamp Chapel, as shown. You can click and drag on the image to browse around the interior of the chapel. You can also use the Zoom in and out tools (lower left margin of the QTVR window) to move closer or farther.

The movie you are playing is of the ***panoramic*** type. That is, behind the QTVR window is a panoramic image, such as the one shown below. This is derived by placing the viewer (camera) in the middle of a scene (or interior space), rotating it at even increments, and rendering pieces of the environment, which are then pasted together into a single image. The other type of movie that is available, the object movie, is essentially the reverse. A camera moves around a scene taking shots towards the center of the scene.

For both types of movies any of the display modes available in **form•Z** (ranging from wire frames to ray tracings) can be used. These are discussed in the next section. Note that panoramic images can also be produced and saved by themselves, regardless of whether they are used for a movie or not. However, this is not possible for object movies, which can only be saved as movies.

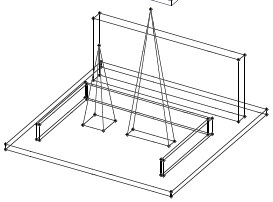
Plotting and rendering

The objects you have created have been sofar displayed with all their lines visible (wire frame). You will now try the other plotting and rendering methods available in **form•Z**. The objects you created in the most recent example should still be on your screen. **Undo** twice to simplify the scene,. To see your objects better, you will also turn off the grid and the axes.

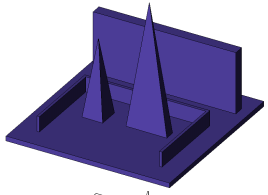


• Select **Window Setup...** (**Windows** menu).
• In the **Window Setup** dialog deselect **Show World Axis, Show Reference Plane Axis**, and **Show Grid**. Your image should be as shown with all its lines visible.

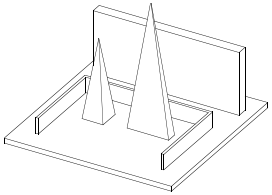
Note that all the display commands in the **Display** menu have asterisks at the ends of their names indicating that there is a dialog that affects their execution. This dialog can be invoked by clicking on them while pressing the ***option*** key on the Macintosh or ***ctrl+shft*** on Windows.



• Invoke the **Wire Frame Options** dialog. In it select **Show Points**. Your image should appear as shown, with the points (vertices) of the displayed objects marked with a diamond.

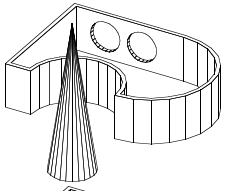


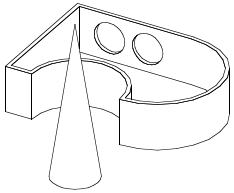
• From the **Display** menu, select **Quick Paint***. Your image is now rendered in color. All the objects have the same color, which was automatically assigned to them when they were created. The color can be changed using the Color tool (on the 12th row).



• From the **Display** menu, select **Hidden Line***. Your image is now plotted with lines, as for the wire frame. However, only the lines that are not covered by other surfaces are plotted.

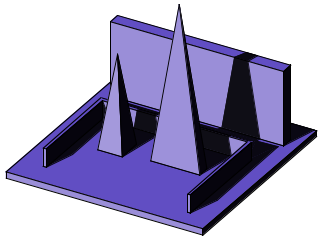
The **Hidden Line Options** dialog also contains the **Hide Edges With Angle Greater Than** option. When on and **Hidden Line*** (**Display** menu) is executed, edges with angles greater than the value entered in the dialog's numeric field (which can be any value between 0° and 180°) will not be shown. This is illustrated by the images on the left. For the top image the **Hide Edges With Angle Greater Than**option was deselected. For the lower, the option was selected and 140° (default) was entered in its field.



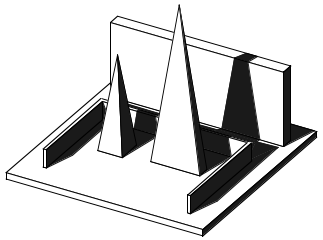


Note that we are not suggesting that you generate these objects since they involve material we have not yet covered. However, you will know how to create them after just a few more pages. When you do, you may generate a hidden line plot to verify how the **Hide Edges** option works.

You will next do a surface rendering with shadows.



•Select **Sun Position...** (**View** menu).
• In the **Sun** dialog enter 30° in the **Sun Altitude** and -15° in the **Sun Azimuth** fields.
• In the **Display** menu, select **Surface Render*** while pressing the ***option*** key on the Macintosh or the ***ctrl+shft*** keys on Windows.
• In the **Surface Rendering Options** dialog that is invoked, select **Render With Shadows** and click on **OK**.
• Invoke the **Surface Rendering Options** dialog again and deselect the **Show Color** option. Both renderings should be the color versions of the ones we show.

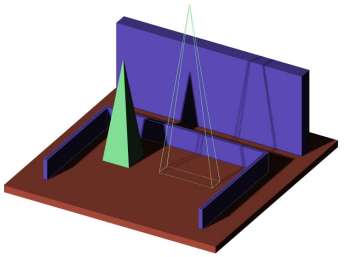


You will next use **Shaded Render*** to render some of your objects shaded and some as wire frames.

• Double click on the Set Rendering Attributes (RENDER ATTRIBS) tool (12th row) to invoke the **Object Rendering Options** dialog. In it select **Object Renders As Wireframe**.
• With the Set Rendering Attributes tool click on the enclosure object.
• Invoke the **Object Rendering Options** dialog again and deselect **Object Renders As Shaded Surface**.
• With the Set Rendering Attributes tool click on the larger pyramid.

You may also want to change the color of the base slab to brown and of the pyramids to green.

• Double click on "Light 1" in the Lights palette and when the **Lights Parameters** dialog is invoked turn on **Shadows**.
• Select **Shaded Render*** while pressing ***option*** or ***ctrl+shft***. In its dialog select **Render With Shadows**, **Render Using Antialiasing**, and click on **OK**. Observe the result.

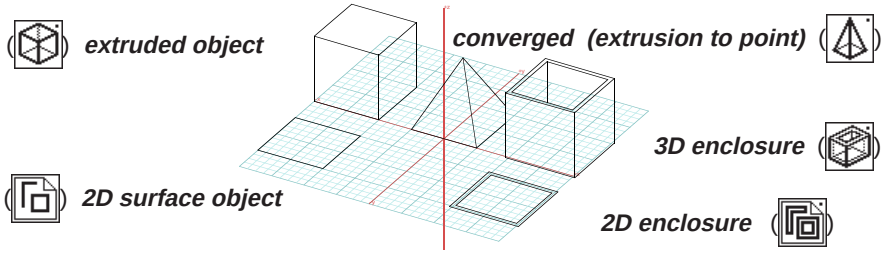


The **Display** menu also contains the **RenderZone*** and **QuickDraw 3D*** items. The former produces the most precise renderings and is discussed in the **form•Z RenderZone** Mini Manual. **QuickDraw 3D*** produces shaded images that can be manipulated dynamically. However, for QD3D to work well, high end PPCs and accelerators are recommended.

Return to **Wire Frame*** display, and reactivate the **Show World Axis** and **Show Grid** options before continuing with this tutorial.

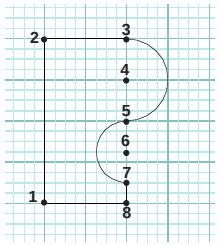
Object types

To review and sample all the types of objects that can be generated in a direct manner, select all the teal modifiers on the first row, one at a time, and for each draw a rectangle, any polygonal shape, or a circle. You can select polygons other than hexagons by invoking the **Polygon Options** dialog directly from the tool. You can also select more than the default 24 segments for the circles by invoking the **Arc/Circle/Ellipse Resolution** dialog. You will generate:



Drawing objects

The tools on the 3rd row can be used to draw open lines or closed shapes for the generation of free form objects. These tools can be combined by switching from one to another during the drawing process. This allows you to mix straight lines with arcs and curves. You can draw the shape shown to the right, as follows:



- Select **Top** from the **View** menu.
- Select the 2D Surface Object modifier (1st on 1st row).
- Select the Draw Vector Line icon and click the mouse on point **1**, then on **2** and **3.**
- While at **3**, switch icons and select the Arc, Clockwise, Endpoint-Last tool. Do not worry about the rubber-band following the mouse as you go to select the new icon. It will fall in place as soon as you return to the graphics window. Click the mouse on point **4** (the center of the first arc) and then on **5**.
- While at **5**, select the Arc, Counterclockwise, Endpoint-Last icon, then click on point **6** (the center of the second arc), and then on **7**.
- While at **7**, select the Draw Vector Line operator again and triple click on point **8**. The shape is closed and the drawing process is completed.

A ***double click*** of the mouse generates an ***open*** line. A ***triple click*** creates a ***closed*** shape. You can also close a shape by returning to the first point and double clicking. Try the other drawing tools on the 3rd row. If you make a mistake as you draw, you can cancel individual points by selecting **Undo** (or by pressing ***command+Z*** on the Macintosh or ***ctrl+Z*** on Windows).

Picking

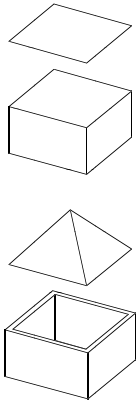
Objects or parts of objects can be picked using the Pick tool (selection arrow,), on the 5th row of the tool box. Selected entities are highlighted with red. The highlight color can be changed in the **System Colors** dialog, which you can invoke from the **Options** menu. Whether a complete object or a part of an object (point, segment, outline, face, or hole) is picked is determined by the selection of the topological level from the 4th row of the tool box. Points ( ), segments ( ), objects ( ), and groups ( ) are picked with a single mouse click. Outlines ( ), faces ( ), and holes/volumes ( ) may be picked with one or two mouse clicks, depending on which option is selected in the **Pick Options** dialog. With the **Clicking Inside Boundaries** option you click the mouse once inside the boundary of a face, outline, or hole. With the **Clicking On Edges** option you need to click the mouse on two segments of the face, outline, or hole. While the single point pick is frequently more convenient to use, it is less general than the two point pick. You can only use it to pick front facing entities. The two point pick allows you to pick faces, outlines, and holes anywhere.

Note that by default, you do not need to hold the ***shift*** key down in order to select more entities. You can select any number of entities by clicking directly on them. You deselect a selected entity by picking it again. You deselect all the selected entities (clear your picks) by clicking away from a selectable entity. However, if you prefer to press the ***shift*** key in order to select additional entities, you can turn on the **Use Shift Key For Multiple Pick** option in the **Pick Options** dialog.

A number of entities at the same topological level (such as all points) can also be picked by delineating an area that contains them. Select the appropriate topological level, click the mouse away from a selectable entity and drag it to another position. A rectangular frame will be rubber banded until you release the button. As soon as you do, all the entities contained in the rectangle are selected. You can also select the **Lasso** option in the **Pick Options** dialog to delineate the pick area by drawing a free form line.

In **form•Z**, you can execute operations using either a ***prepick*** or a ***postpick*** method for the selection of the operand objects. The postpick is incorporated into the operators: you select the operator and then the entity or the entities to which the operation will be applied. To use the prepick method, you activate the Pick operator and then select any number of entities (which, for most operations, may even be at different topological levels). You then select the desired operator and click the mouse once again. For most of the operations, the last mouse click is anywhere on the graphics screen and away from a selectable entity. For operations that involve two types of entities, the last click picks the second entity. For example, the objects of revolution (lathing) are derived by rotating a source shape around an axis. The source shape(s) may be prepicked, but the axis must be picked at the end, after the selection of the operator.

Derivative objects



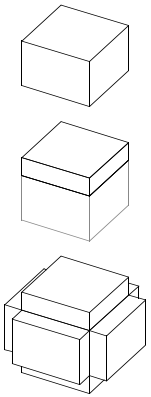
Using the tools on the 6th row, you can derive new objects from other objects, such as a 3D extrusion from a surface object.

• Draw a 2D rectangle, as shown. Then, from the 6th row of the tool palette, select the Derivative 3D Extrusion operator ( ) and, with topological level at Object, click the mouse on the rectangle. A 3D extruded object is generated from the rectangle.

• **Undo** and repeat the operation after selecting the 3D Convergence operator ( ).

• **Undo** again and repeat the operation after selecting the 3D Enclosure operator ( ).

Derivative objects can also be generated from parts of other objects, such as faces.



• Generate a cube, as shown, and set topological level to Face ( ).

• From the **Heights menu**, select a lower height than the one used for the cube. Select the Derivative Extrusion operator ( ), and click on two segments of the top face of the cube (assuming that the **Click On Edges** option is currently selected in the **Pick Options** dialog). A cuboid is generated from the top face of the original cube. You can also generate one derivative object from each face of the cube with a single operation.

• **Undo** and set the topological level back to Object.

• Invoke the **Extrusion/Convergence Direction** dialog (double click on the Extrusion tool), select **Perpendicular to Surface**, and close the dialog (click on **OK**).

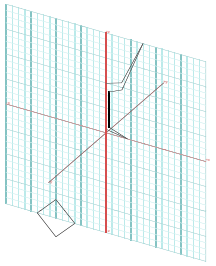
• With the Derivative Extrusion tool selected, click on the cube. A new object is generated for each face of the cube.

Ghosting the operands

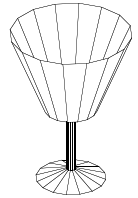
When an object is used for an operation, such as to generate a derivative object, the original object may be ghosted (the default), deleted, or left as it is. These options are selected from the **Status Of Objects** palette, which is displayed on your screen by default. If it is not currently displayed, you can open it from the **Palettes** menu. Note that the **Status Of Objects** parameters may be set to have a global effect (when the checkbox in the palette is on) or to independently affect individual tools. In the latter case the **Status Of Objects** palette is context sensitive and always displays the setting of the active tool.

Any object may also be ghosted or unghosted by the user, using the Ghost ( ) or the Unghost ( ) tools on the 12th row of the tool palette. Ghosted objects are shown in light gray and remain inactive until they are unghosted. You can also select the **Hide Ghosted** item (**Edit** menu) to make the ghosted objects invisible.

Objects of revolution



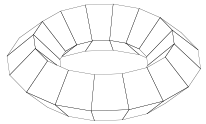
Objects of revolution are generated from shapes that are rotated about an axis. The axis can be one of the Cartesian axes, an axis of a reference plane, or any segment of an existing object. Four types of objects can be generated using the Object of Revolution tool: ***lathed objects***, ***helical objects***, ***screws*** and ***bolts***, and ***spiral stairs***. You will first do a few examples of lathed objects.



• Switch the reference plane and grid to the ZX, by selecting from the window icons and make sure Grid Snap ( ) is on.

• Draw an open 2D shape, as shown (top shape). The first and the last points of your shape should be on the Z axis.

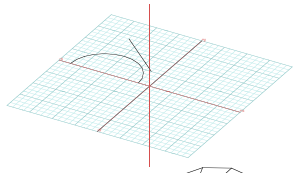
• Set the topological level to Object, select the Object of Revolution tool ( ), click on the shape you drew, and then on the Z axis. The result should be as shown.



To generate a torus, use a closed shape, such as the diamond shown, to repeat the operation. The resulting object should be as shown.

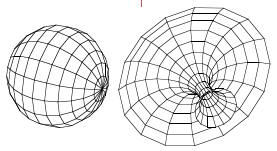
Spheres can be created as objects of revolution.

• **Clear** and **Clear All Ghosted**.



• Switch to the XY reference plane, and Grid Snap ( ) should be on.

• With the Arc, Clockwise, Endpoint-Last tool ( ) draw a semicircle, as shown, with its end points on the X axis.

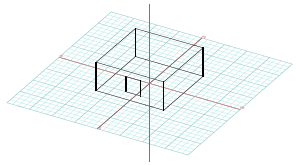


• With the Line tool ( ) draw a line next to the arc.

• With the Object of Revolution tool selected, click on the arc and on the X axis, to produce a sphere.

• **Undo** and click on the arc again, then click on the line. A different object is created, as shown.

You can also revolve shapes around segments of objects.

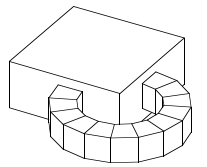


• Generate a cuboid, roughly as shown.

• Activate the Snap to Face ( ) window tool and draw a rectangle on the front face of the cuboid.

• Deactivate the Snap to Face tool.

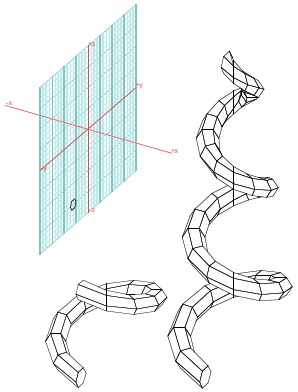
• Invoke the **Revolution Options** dialog and in the **Revolution Angle** field enter 270°.



• With the Object of Revolution tool selected, click on the rectangle, then on the front vertical edge of the cuboid. The result should be as shown.

Solid and surface helixes are also generated by selecting a source shape and an axis about which the shape is revolved. For helixes, the source shape is also moved along the axis as it is revolved.

- On the YZ plane, draw a hexagon, roughly as shown.
- Invoke the **Revolution Options** dialog, select **Solid/Surface Helix**, and click on **OK**.
- Click on the hexagon, then on the Z axis.

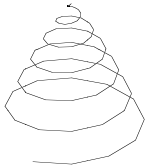


With helixes, both the source shape and the path it follows can be scaled by setting the proper parameters in the **Helix Options** dialog, which is invoked from the **Revolution Options** dialog. You will next generate a helix by scaling the width (radius) of the path.

- **Undo** to return to the original hexagon.
- In the **Revolution Options** dialog, select **Helix Options...**. In the dialog invoked, enter 3 in the **# Of Cycles** field, and next to **Length**, select **Per Cycle**. The value in the **Length** field should be the default 20'. Select **Scale Path** and enter 0.25 in the **Width** field. Click on **OK**.
- Click on the hexagon, then on the Z axis, and observe the result.

Note that the parameters you selected produced a helix that consists of three cycles, and that the length of each cycle is 20'. The radius of the path at the end of the helix is one fourth of the radius at the beginning, due to the 25% scaling factor you entered.

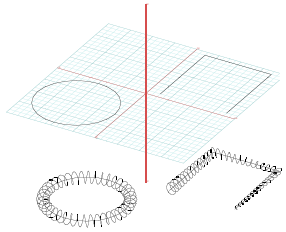
You will next generate a wire helix and scale the width and length of its path.



- **Undo** to clear the screen.
- Invoke the **Revolution Options** dialog, and select **Wire Helix About Axis**. In the **Helix Options** dialog, select **Scale Path**, **Width** = 0.1, and **Length** = 0.75.
- Close the dialog, and click on the Z axis.

Note that a wire helix is generated by a single click on the axis of revolution. Where you click is significant and determines the starting point of the wire helix.

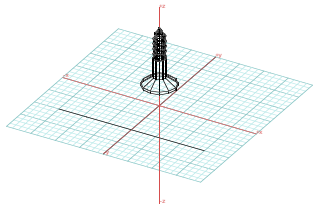
- **Undo,** and select the XY plane from the window tools. Draw a circle and a rectangular open shape, as shown.
- Select **Wire Helix Along Path** (**Revolution Options** dialog).
- Invoke the **Helix Options** dialog, and in the **Wire Helix Radius** field enter 2'. Make certain that the **By Cycles** option is selected, and in the **# Of Cycles** field enter 40. Close both dialogs.
- With the Object of Revolution tool selected, click on the circle.
- Click on the open shape and observe the result.



Note how the radius of the path of the open wire helix has been scaled by 25%, the parameter you entered earlier. Also note that the length of the helix along path is not scaled; it extends from one end of the path to the other.

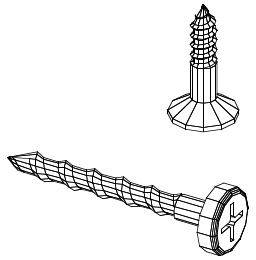
Screws and bolts are composite objects, the main part of which, the body, is generated as a helical object of revolution. The other parts, the neck and the head, are optional, as is the tip, which is a tapered end of the body.

- **Clear** the screen.
- Invoke the **Revolution Options** dialog, select **Screw/Bolt**, and click on **OK**.
- With the Object of Revolution tool active, click on the Z axis.



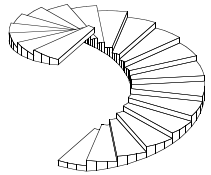
Observe the result. Where you click is significant, as it defines the origin of the screw/bolt. The direction of the axis or segment clicked determines the direction of the screw/bolt. You can set the parameters for the screw/bolt in the **Screw/Bolt Options** dialog, invoked from the **Revolution Options** dialog.

- **Undo**, then draw a line from right to left as shown.
- From the **Revolution Options** dialog, invoke the **Screw/Bolt Options** dialog. In the **Body Length** field, enter 30', and select the third head shape and **Phillips**. Exit the dialog.
- With the Object of Revolution tool active, click on the line you drew, and observe the result.



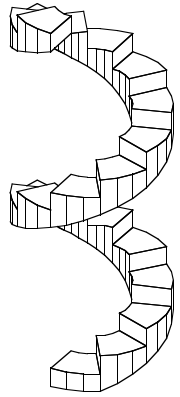
To conclude this section, you will generate two spiral stairs.

- **Undo** as many times as necessary to clear the screen.
- Invoke the **Revolution Options** dialog, and select **Spiral Stair**.
- Click on the Z axis, and observe the result.



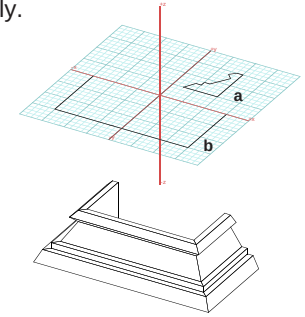
As with the other objects of revolution, spiral stairs can be generated along any axis or segment, and in any direction. Their parameters can be set in the **Spiral Stair Options** dialog, invoked from the **Revolution Options** dialog.

- **Undo** and invoke the **Spiral Stairs Options** dialog. In the **Inside Radius** field, enter 4', in the **Total Height** field, enter 40', and select **By # Of Steps**. Under **Length Control**, select **By Total Angle**, and in its field enter 720°. Exit the dialog.
- With the Object of Revolution tool active, click on the Z axis. Observe the result.



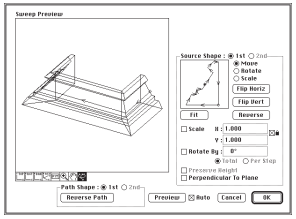
Sweeps along paths

Solid or surface objects can be generated by "sweeping" one 2D shape (called the ***source*** shape) along another 2D shape (called the ***path*** shape). Four variations of swept objects can be created, either directly or in a preview mode. You will first create a sweep directly.



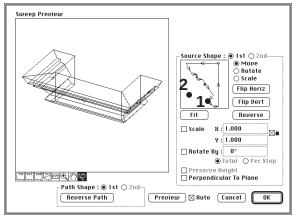
- Draw shapes **a** and **b**, as shown.
- Double click on the Sweep Along Path (SWEEP) tool to invoke the **Sweep Along Path Options** dialog.
- In the dialog deselect the **Show Preview** option, and select **Axial Sweep**.
- With topological level at Object and the Sweep Along Path tool selected, click on shape **a** (*source*), and then on **b** (*path*). Observe the result.

You have just generated what is called an ***axial sweep*** for which either or both the source and the path shapes can be open or closed. You executed the operation directly. The Sweep Along Path tool can also be executed in a manner that allows you to preview the result of the operation and to manipulate the placement of the profile (source) shape relative to the path shape.



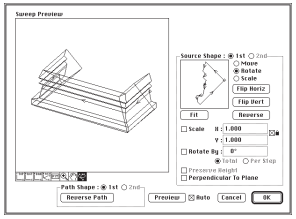
- **Undo**, invoke the **Sweep Along Path Options** dialog and in it select **Show Preview**.
- With the Sweep tool selected, click on source shape **a**, then on path **b**.

The **Sweep Preview** dialog appears as shown. Its large window (left) contains a preview of the object as it will be generated if you click on **OK**. Its small window shows an image of the source shape as it is placed on the path shape. The preview dialog also contains a number of button commands, which you will use in the next example.



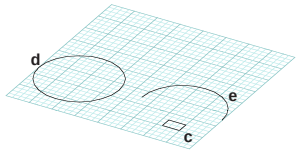
- Click on **Flip Horiz**. Observe the changes.
- Select **Rotate**.
- Click in the source shape preview window (point **1**), start moving the mouse (slowly to be able to observe the effect), then release the mouse on point **2**. Click on **Fit** to fit the source in the window.

You have rotated your source shape, which has changed the overall shape of the sweep object. If you are satisfied with what you have, click on **OK** to exit the preview mode and generate your object in its final form.

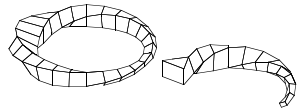


Note that there are a number of other buttons in the preview dialog for manipulating the source shape, path, and the view angle of your object. You should experiment with them.

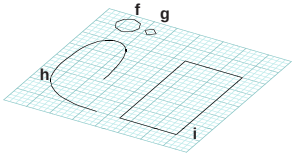
You will next generate sweeps using the scale and rotate options in the **Sweep Along Path Options** dialog. Note that these options can also be set in the **Sweep Preview** dialog.



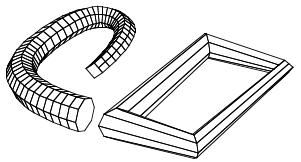
- **Undo** to clear the screen. Generate a circle, an arc, and a rectangle, roughly as shown.
- Invoke the **Sweep Along Path Options** dialog, and select **Scale Source** by 0.25, and **Rotate Source By** 360°. Click on **OK**.
- Click on source shape **c**, then path **d**.
- Select the Unghost tool(UNGHOST), and click on **c**.
- Select the Sweep Along Path tool, and click on **c**, then **e**. Observe the result.



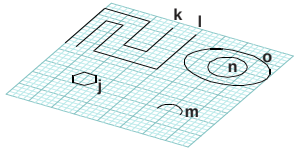
Sweeps can also be generated from two different source shapes, as you will do next.



- **Undo** to clear the screen, and draw four shapes, roughly as shown. Note that **f** is a hexagon, and **g** is a diamond (4-sided polygon).
- Invoke the **Sweep Along Path Options** dialog. Select **Two Source Sweep**, and deselect **Show Preview**, **Scale**, and **Rotate**.
- With the Sweep tool active, click on **f** and **g**, then on path **h**.
- Unghost source shapes **f** and **g**, and repeat the sweep operation with path **i**.

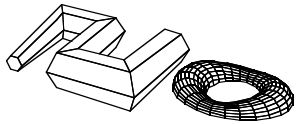


You will next generate a sweep using a single source shape, and two paths.

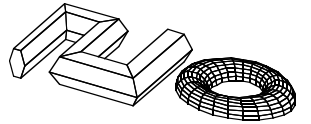


- **Undo** to clear the screen. Draw six shapes, roughly as shown.
- Invoke the **Sweep Along Path Options** dialog, and select **Two Path Sweep**.
- Click on source **j**, then on paths **k** and **l**.
- Click on source shape **m**, then on paths **n** and **o**. Observe the results.

Note that the path shapes should be drawn in the same direction, or the resulting object will have intersecting faces.

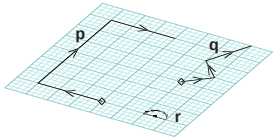


- **Undo** to return to the original objects. Invoke the **Sweep Along Path Options** dialog, and select **Preserve Height of Source**.
- Repeat the sweeps as above, and observe the results.

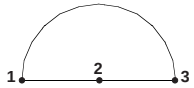


You will next generate another type of sweep, called a **Boundary Sweep**.

• Draw shapes **p**, **q**, and **r**, as shown. Notice the directions marked on shapes **p** and **q** and draw them in the same direction. Shape **r** is a closed semicircle. You can draw it by using the Arc, Clockwise, Endpoint-Last tool and clicking on points **1** and **2**, and then triple clicking on **3**.



• Invoke the **Sweep Along Path Options** dialog and select the **Boundary Sweep** option. Deselect the **Show Preview** option.



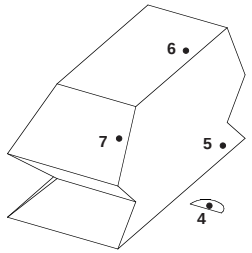
• With the Sweep tool selected, click on source shape **r**, then on path **p**. The program beeps and an error message is issued indicating that boundary sweeps only accept open source shapes.

• Click on shape **q**, then on path **p**. The result is a solid object derived by connecting the ends of the path.

You can also execute sweeps using the faces of existing objects as paths.

• From the **Sweep Along Path** dialog, select **Axial Sweep** again and the **First Point** alignment option.

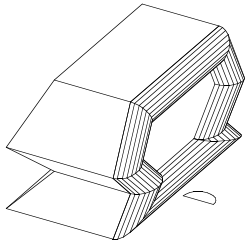
• In the **Status Of Objects** palette select **Keep**.



This will retain the original objects, rather than ghosting them, which will allow you to execute the operation more than once without having to unghost the objects.

• From the **Pick Options** dialog select **Clicking Inside Boundaries**. This option will allow you to select faces with a single mouse click.

• Set the topological level to Face.
• With the Sweep tool active, click on **4** and **5**.
• Next, click on **4** and **6**.
• Finally, click on **4** and **7**.

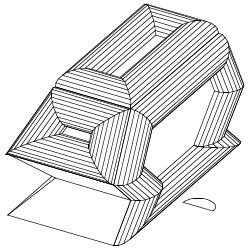


The resulting objects should be as shown.

We shall next use some other objects to illustrate the skinning operation. But then we shall use the object we generated here to illustrate the Section operation.

• **Undo** three times to return to the basic solid object.

• From the File menu select **New [Model]**. A new modeling window, most likely labeled **Untitled 2-1 [Model]**, covers the previous. You will work on this for the next exercise.



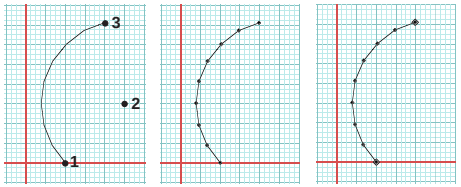
Skinning

The skinning operation resembles the sweeps in that source profiles are swept along paths. However, any number of sources may be swept along any number of paths, which allows you to more accurately outline the 3D form that you wish to generate. Skinning is both more flexible and more restrictive than the sweeps. There are two types of skinning operations and each can be executed in two different modes. You will do an example of each.

• From the **View** menu select **Right Side**.

• Turn on the Grid Snap ( ).

• Select the Arc, Clockwise, End-point-Last ( ) tool and click on points **1** and **2**. Then double-click on **3**. An arc is drawn, as shown.



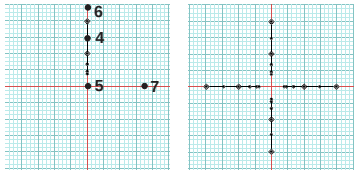
• From the **Display** menu select **Wire Frame*** while pressing ***option*** (Mac) or ***ctrl+shft*** (Windows). This invokes the **Wire Frame Options** dialog. In it select **Show Points** and **Show Marked Points**. As soon as you click on **OK** and exit the dialog, the arc is displayed with its points shown. The arc has no marked points yet. You will mark two of its points next.

• Double-click on the Topological Attributes ( ) tool to invoke its dialog, and in it select **Set/Clear Point Marker**.

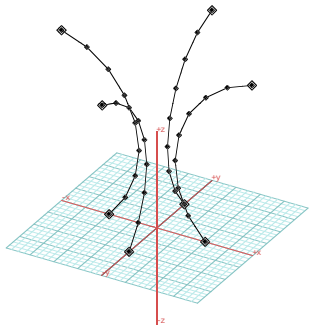
• With the Topological Attributes tool active click on each of the end points of the arc. As soon as you do, a larger diamond than that used for the regular points is displayed on the points you just clicked on, indicating that these points are marked. You will soon see how these marked points are used by the skinning operation.

• From the **View** menu select **Top**.

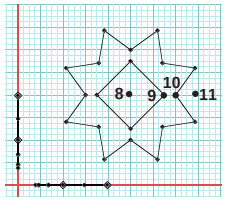
• Double-click on the Multi-Copy ( ) icon to invoke the **Transformation Multi-Copy** dialog. For **# Of Copies** enter 3.

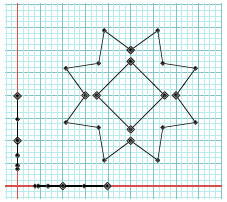


• Select the Rotate ( ) tool and click on points **4** (picks the arc), **5** (center of rotation), **6** (start of rotation), and **7** (rotation angle). Three rotated copies of the original arc are generated. These are the four paths that will be used for a skin operation. Note that the points you marked on the original have been transferred to the copies.



• To see them better, from the **View** menu select **z=30° x=60°**. Then, from the same menu select **Top** again.





You will next draw a diamond and a star to be used as source shapes.

• Double-click on the Polygon (N) icon and in its dialog make certain that **Polygon By # Of Segments** is selected and select the diamond (second icon from the left) or enter 4 in its alpha field.

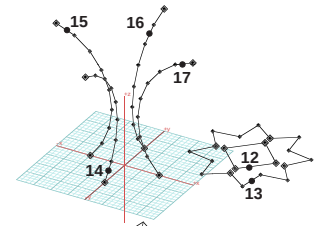
• With Polygon selected click on **8** and **9**. This draws a diamond, our first source shape, as shown.

• Invoke the **Polygon Option** dialog again, enter 8 in the **# Of Segments** field, select **Polygon Pattern**, and select the upper left icon under this option.

• With the Polygon tool active click on **8**, **10**, and **11**. This generates a star, the second source shape we shall use.

We next need to mark four points on each of our source shapes. We need to mark one point for each of the paths. This will tell the program which point of the source will be placed on a path.

• With the Topological Attributes tool (and **Set/Clear Point Marker** still selected in its dialog) click on all four points of the diamond and on corresponding points of the star shape, as shown. After the process of marking points is completed, you are ready to execute the skinning operation.



• Double-click on the Skin (SKIN) tool to invoke its dialog. In the dialog select the following settings:

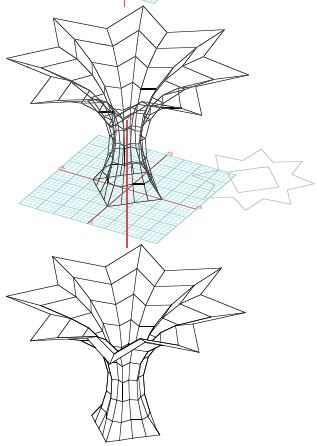
• **Skin Along Paths** is on

• **# Sources** is set to 2 and **# Of Paths** is set to 4.

• In the **Placement Type** box select **By Anchor Points**.

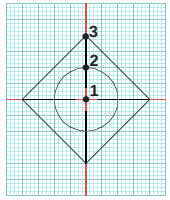
• In the **Point Pairing** box select **Insert New Points As Needed**.

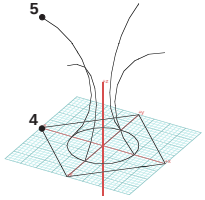
• Generate a 3D view and with the Skin tool active click on points **12** through **17**. The first two clicks select the two sources and the subsequent four clicks select the four paths. The skinned object is created after the last click, as shown.

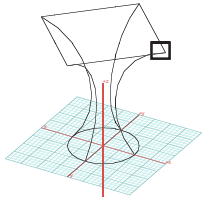


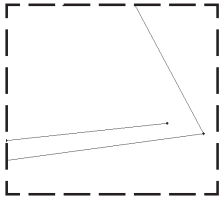
Note that it took just one step to derive the skinned object. It took many more steps to prepare and properly position and mark the shapes that were used for the skinning. This is typical for the Skin operation. For the example we just did, while the path shapes were in the position where the skinned object was created, the sources were not. The program placed the sources on the paths before executing the operation. It used the points that were marked on both the sources and the paths when placing the sources. This type of execution is called placement **By Anchor Points**, which is the option you selected in the **Skin Options** dialog. The alternative method is placement **By Current Position** which requires that the sources are placed on the paths exactly where they will be skinned. We shall do such an example next.

• **Undo** and delete the source shapes (the diamond and the star). Keep the four paths so that we can use them again. From the **View** menu select **Top**. You are now ready to draw two new source shapes.









• With the Circle by Center and Radius tool click on **1** and **2** to draw a circle.

• Invoke the **Polygon Option** dialog and select the diamond (**# Of Segments** = 4). Deselect **Polygon Pattern**.

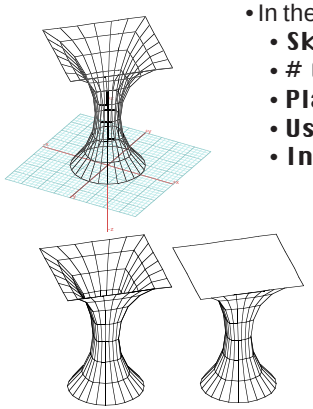
• With the Polygon tool active click on **1** and **3**. A diamond is drawn, as shown. Note that points **2** and **3** are at the end points of the path.

• From the **View** menu, select **z=30° x=60°**. In the 3D view you can see that both source shapes have been drawn on the XY reference plane, as expected. The first points of your paths also lie on that plane and they coincide with four points of the circle, which is proper. Next you will move the second source shape (the diamond) up to the plane where the end points of the paths are.

• Turn on the Perpendicular switch, and select Snap to Point (POINT).

• Make sure that Self (SELF) is selected from the 10th row modifiers.

• With the Move (MOVE) tool active, click on **4** and **5**. This moves the diamond shape up. Do the points of the diamond lie exactly on the end points of the paths? The answer to this question is significant. Whether they are or not will determine how the skinning operation will be executed. In our example they are not. We confirm this by zooming in at one of the points of the diamond, as shown in the detail. Therefore, we shall execute the operation using tolerances.



• In the **Skin Options** dialog select the following settings:

- **Skinning Along Paths** is on.
- **# Of Sources** is set to 2 and **# Of Paths** is set to 4.
- **Placement Type** is set to **By Current Position**.
- **Use Tolerance** is on and its value is set to 2'.
- **Insert New Points As Needed** is turned on.

• With the Skin tool click on the two source shapes and then on the four paths. An object is generated right after the sixth click. Do a hidden line plot.

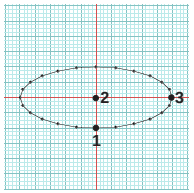
• **Undo**, invoke the **Skin Options** dialog and in it select **Close At Ends Of Open Paths**.

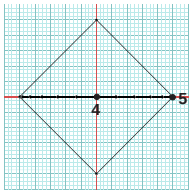
• Repeat the operation, do a hidden line plot, and observe how the result differs from the previous.

The two Skin examples we did to this point were of the **Skinning Along Paths** type. We shall next execute a type called **Cross Skinning**.

• From the **Edit** menu, **Clear** and **Clear All Ghosted** to start fresh and from the **View** menu select **Front**.

• With the Ellipse by Major and Minor Radius ( ) tool active click on **1**, **2**, and **3**. An ellipse is drawn.

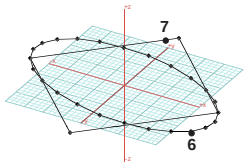




• From the **View** menu select **Top**.

• Invoke the **Polygon Options** dialog and select the Diamond (**# Of Segments** = 4). Make sure **Polygon Pattern** is off.

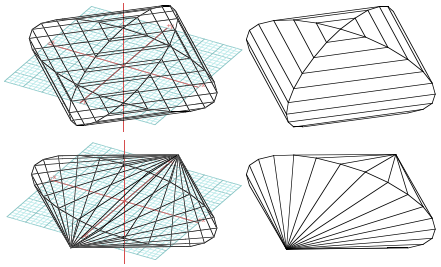
• With the Polygon ( ) tool active click on **4** and **5**.



• From the **View** menu select **Z=30° X=60°**. In the 3D view you can see the two shapes you drew. Note that they have two coincident points, which is appropriate. One of the shapes will be used as a source and the other as a path.

• Invoke the **Skin Options** dialog and select the following settings:
  • **Cross Skinning** is on and **# Of Sources** is 1.
  • **Placement Type** is **By Current Position** and **Use Tolerance** is off.

• With the Skin ( ) tool click on **6** and **7**. The shape you picked first (the ellipse) is used as the source and the shape you picked second (the diamond) is used as a path. The result is as shown.



• **Undo** and with the Skin tool click on **7**, then on **6**. Now the diamond is used as source and the ellipse as path, producing a different object, as shown.

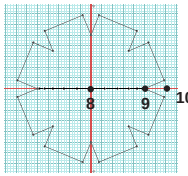
To do one more example, **Undo** twice and from the **View** menu select **Top**.

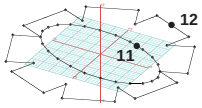
• In the **Polygon Options** dialog, set **# Of Segments** to 8, select **Polygon Pattern,** and select the left pattern on the second row.

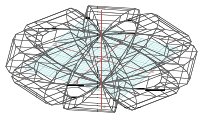
• With the Polygon ( ) tool click on **8**, **9**, and **10**. A gear like shape is drawn.

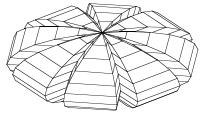
You should still have the ellipse. Generate a 3D view to see them better.

• With the Skin ( ) tool (and the settings in the **Skin Options** dialog as before) click on **11** and **12**. The ellipse is used as a source and the gear shape as a path, producing the 3D object shown.





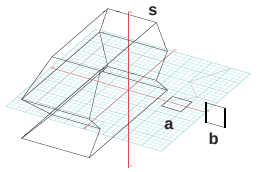




Sections of solids

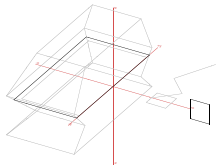
Using the Section tool ( ) on the 6th row, you can derive both 2D or 3D ***sections*** of solid objects, and sets of 2D sections called ***contour lines***. For these examples you will use the object derived with the sweep operation.

From the **File** menu select **Close** (and when you are asked to save say "no"). This makes the previous window, where the swept object (call it ***s***) is the active window. We are ready to proceed.



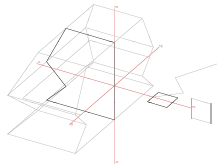
• With the XY reference plane active ( ) draw square **a**, roughly as shown.

• Switch to the ZX reference plane ( ) and draw square **b**.



• Select the Section tool and, with topological level set to Object, click on object **s**, then on square **a**. The result should be as shown.

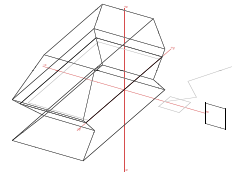
• **Undo** and repeat the operation, this time clicking on **s**, then on **b**.



You have derived a horizontal and a vertical 2D section of object **s**. The positions of the sections were determined by surface objects **a** and **b**, which function as cutting planes. You will next repeat the operation and derive 3D sections of the same object.

• **Undo**.

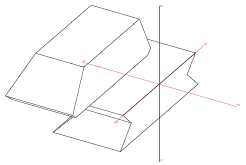
• Invoke the **Section Options** dialog (double click on the Section tool) and select **3D**.



• Select the Section tool, click on **s**, then on **a**. The result should be as shown.

Your original object has been split into two pieces. To verify this, you will move one of the pieces.

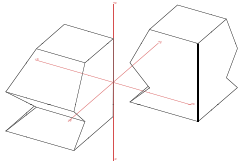
• From the 11th row, select the Move ( ) tool.



• Click on a segment of the top piece of your object. You notice that it is rubber banded and follows the motion of the mouse.

• After moving the mouse by about one large grid square to the left, click again. This moves the top piece. (The Move tool and the other geometric transformations are discussed on page 58.)

• **Undo** twice and repeat the operation, but this time click on **s** and then on **b**. This produces a vertical cut through your object. Again, use the Move tool to pull the two pieces apart, as shown.



• **Undo** twice.

You will now use the same object to generate contour lines. These are sets of 2D sections that are generated with a single operation. They are always parallel to the reference plane. First, rotate the object by 90°, as shown.

• From the window tool palette, select the XY reference plane, if it is not already active.

• Invoke the **Section Options** dialog, select **Contours**, and click on **OK**.
• With the Section tool active, click on object **s.**

Observe the result, which is shown in both wire frame and hidden line. The contour lines are parallel to the XY plane and are at increments of 2', which is the default distance set in the **Section Options** dialog.

• **Undo**, activate the YZ reference plane and click on **s**.

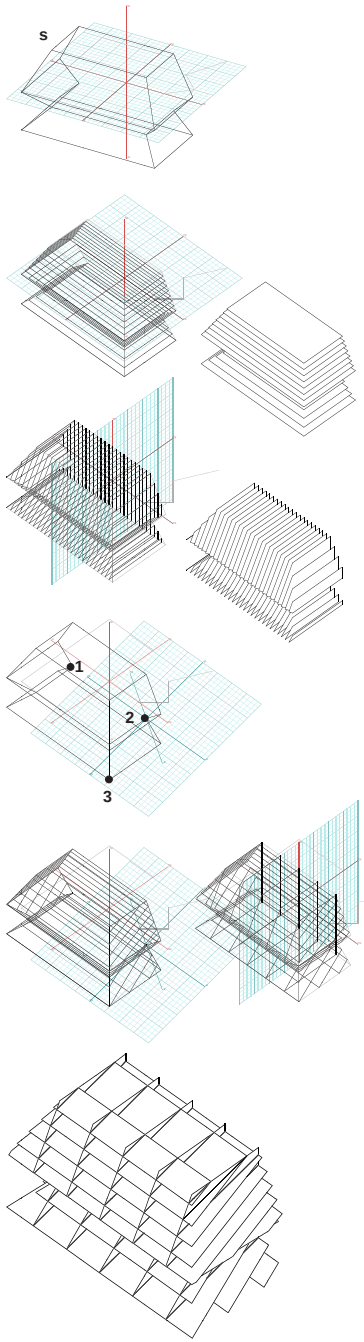
Observe the result. The contours are now parallel to the YZ plane. You can also generate contours parallel to the ZX plane or any arbitrary plane, which you will do next. You will first define a new arbitrary plane and then generate contours parallel to it.

• **Undo.**
• Set the topological level to Point.
• Activate the Define Reference Plane tool (last row of the tool palette) and click on points **1**, **2**, and **3**. The arbitrary reference plane is generated and its grid is displayed as shown.

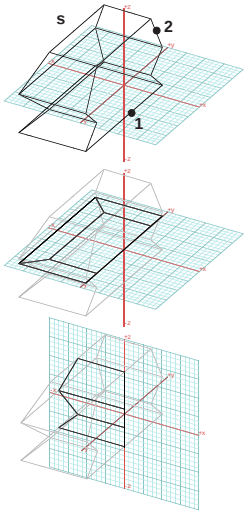
• Invoke the **Section Options** dialog and in the **Use Contour Increment** field enter 3'.
• Click on **s** and observe the result.

Without undoing, you will next generate contours parallel to YZ. You will first unghost the object to be able to pick it again.

• Select the Unghost tool and click on **s**.
• Invoke the **Section Options** dialog, and in its **Use Contour Increment** field enter 10'.
• With the Section of Solid tool selected click on object **s**. The result, plotted in hidden line mode, should be as shown.



Projection and unfolded objects



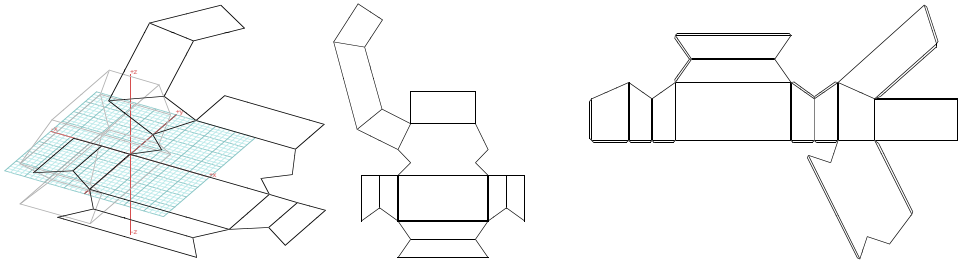
The Projection (PROJCTN) tool allows you to derive three variations of objects from projections of other objects.

• **Undo** four times to return the swept object **s** to its original form. We shall use it to illustrate the Projection tool.

• Double-click on the Projection (PROJCTN) tool to invoke the **2D Projection Type** dialog and in it select **Orthographic Projection**. XY should be the active reference plane.
• With the Projection tool click on object **s.** It is projected onto XY and one or more new objects are created.
• **Undo**, select the ZX Reference Plane (ZX), and with the Projection tool click on **s**.

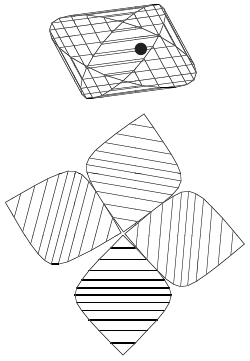
You have derived 2D objects from the projections of solid **s** on two reference planes. The other projection type, **Projection Of View**, derives objects from the projection of a 3D view on to the reference plane. You may want to try it. We shall next derive *unfolded projections*.

• **Undo** and in the **2D Projection Type** dialog select **Unfolded Projection**. Leave all the other options at their default settings.
• With the Projection tool click on **1**. Observe how object **s** is unfolded. It is shown below, left, in both a 3D and ortho view.
• **Undo**; in the **2D Projection Type** dialog select **Generate Connectors**.
• With the Projection tool click on **2**. An ortho view of the result is shown, below, right.



Note that the second time you selected **s** by clicking on a different segment (2) than the first time (1). Observe that each time **s** has unfolded differently. Where you click determines the beginning of the unfolding and clicking on different segments produces different unfolded patterns.

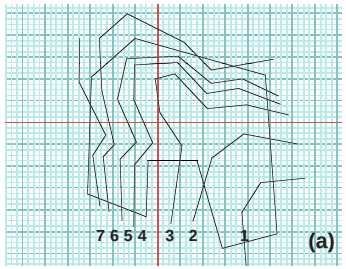
The second unfolded pattern also includes connectors at some of the edges. These can be used to reconnect edges if the pattern is printed on cardboard and is refolded to construct a physical model.



Finally, you may want to experiment with unfolding other objects. For example, the object you generated with the Cross Skinning operation a few sessions back is unfolded as shown, when you click on the segment marked with the bullet.

Terrain models

Three types of terrain models can be derived from contour lines and the boundaries of a site. The contour lines may be open or closed. The site should be a closed shape. Both contours and site are 2D surface objects, which can be imported or can be drawn in **form•Z**.

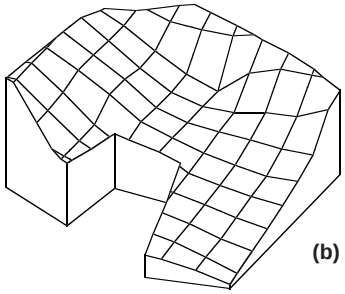


• Draw a site and a few contour lines, roughly as shown in **(a)**.

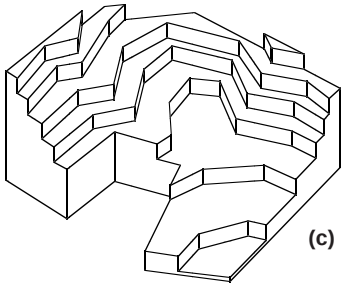
• Invoke the **Terrain Model Options** dialog and select **Adjust Heights**.

• With the Pick ( ) tool click on the contour lines in the order shown (**1** through **7**).

• Select the Terrain Model ( ) operator, then click on the site. The result should be as shown in **(b)** from a **z=30° x=60°** view.



You have created a mesh terrain model using the default increments (8') for the mesh grid. These increments can be changed in the **Mesh Options** dialog, which can be invoked from the **Terrain Model Options** dialog or from the Mesh tool. Since all your contours were at 0 height, you also told the system to assign elevations at 4' increments. You will next repeat the operation two more times using exactly the same options, except for the type of model.

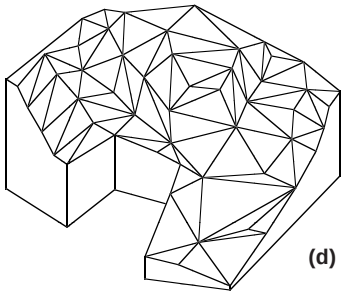


• Invoke the **Terrain Model** dialog and select **Stepped Model**.

• **Undo** and repeat the operation. The result should be as shown in **(c)**.

• Invoke the dialog once again and select **Triangulated Contour Model**.

• **Undo** and repeat the operation. The result should be as shown in **(d)**.



Terrain models can also be generated on faces of solids and the three types can be mixed, allowing the incorporation of landscape features such as roads and flat areas. More details would be beyond the scope of this Mini Manual. However, if terrain modeling is your main area of interest, call us at auto•des•sys and we shall be glad to send you more detailed instructions.

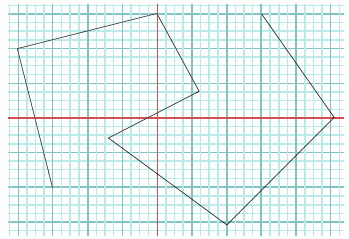
Controlled curves (c-curves)

Ten different types of curves can be generated using the Create/Edit C-Curve ( ) tool (first on the 7th row of the tool palette). These curves are generated from vector lines, called ***control lines***, which are drawn first. Their shape is also affected by other controls, such as ***weights*** and ***knots***, and the parameters which are selected from the **Controlled Curve Options** dialog. They are called controlled curves because they are internally stored with the controls and parameters that generated them, which makes it easy to edit and reshape them after their initial generation.

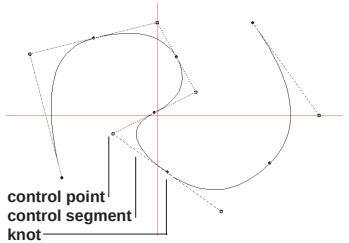
In the dialog, the types of curves are organized into two groups. The upper group includes the NURBS, B-Splines, and three variations of Bezier. These curves allow more extensive control of their parameters, but they have higher computational demands and are slower. The lower group includes two types of "quick" Bezier and three variations of tangent curves. These curves are restricted to the 2nd and 3rd degrees (the highest exponent in the mathematical formula that generates them). Their generation is thus faster and more interactive. Except for very specialized applications, the quick curves will do the job in most cases.

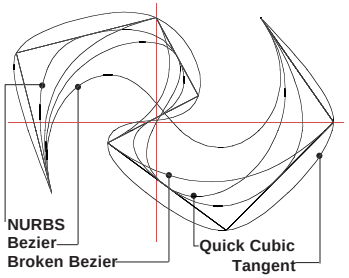
• Draw a vector line roughly as shown.

• Select the C-Curve tool and click on it.



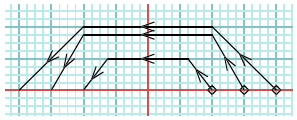
By default, the system has generated a quick quadratic curve (composite 2nd degree Bezier) and has entered the c-curve edit mode. As you move the mouse about the control line the mouse cursor changes. For example, it becomes , , and when you are on a point, a segment, and a knot, respectively (see labels on the right). When the cursor changes and you click, you select the corresponding entity which starts to move. The next mouse click repositions the selected entity. You can continue editing the shape of the curve until you double click (or you click on the tool palette) which exits the edit mode. Different special keys on the keyboard can be used to access additional editing operations. In the **Controlled Curve Options** dialog you can also select the **Construct Directly** option which causes the curves to be generated without editing. Try both options and repeat the operation once for each type of curve to observe the differences. Some examples are shown on the right.





Controlled meshes (c-meshes)

Meshes are surfaces subdivided to smaller pieces, usually called ***patches***. **form•Z** offers you plain meshes (discussed in the next section) and controlled meshes (***c-meshes***). The latter are similar to the c-curves in that they are internally stored with the controls that generate them, and thus can easily be edited and reshaped after their initial creation. There are two tools that operate on c-meshes: Create C-Mesh (), used to generate new meshes, and Edit C-Mesh (), used to reshape existing c-meshes.

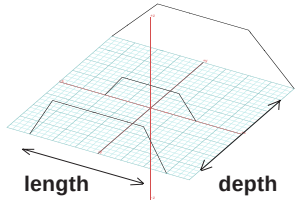


• From the **View** menu select **Front** to go to the ZX projection view and draw three lines. The lines should be drawn in the same direction as shown.

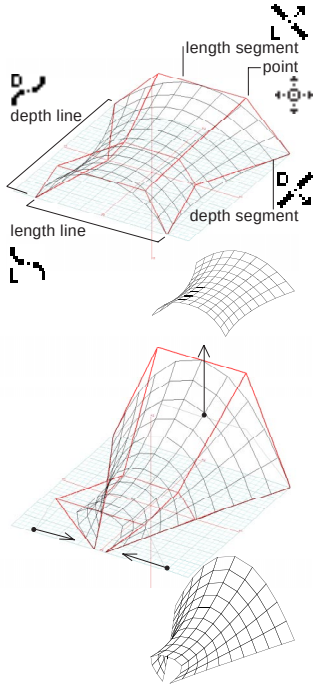
• Next select the 30/60 view and move two of the lines to position them roughly as shown.

• With topological level at Object, use the Pick tool to pick the three lines from back to front.

• Select the Create C-Mesh tool and click the mouse in the graphics window.



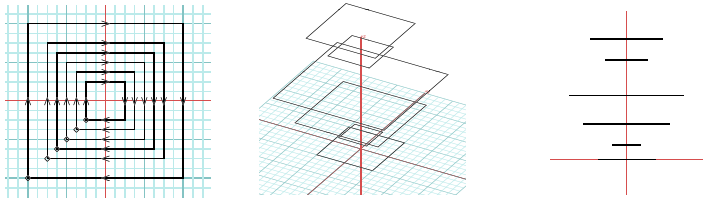
A mesh appears on your screen and on top of it another structure (shown in red) called the ***control net***. The system enters the c-mesh edit mode. The net is for the c-meshes what the control lines are for the c-curves. Its parts can be moved interactively to reshape the mesh. As you move your mouse around the net, you again notice that its cursor changes. It becomes when on a point, when on a length segment, and when on a depth segment. When you press the ***control*** key on the Macintosh or the ***ctrl+alt*** keys on Windows as you place the cursor on a length or depth segment, it changes to and , respectively, indicating that the complete length and depth lines are selected. The direction along the control lines picked for the generation of the mesh is called the ***length*** of the mesh. The direction across the control lines is called its ***depth***. The distinction is significant, especially when you select parameters from the **Controlled Mesh Options** dialog. In the example, we used the default parameters. While in the edit mode, we moved the two front corner points in the X direction, and the middle segment at the rear of the net up, after selecting the Perpendicular switch from the window tools.



Note that while in the c-mesh edit mode the tool palette is grayed out to indicate that it is inactive. The window palette remains active and its operators complement the c-mesh editing process. You exit the edit mode by double clicking away from the mesh or by clicking on the tool palette. When you do, the mesh reappears in its final form and without its controls.

The Edit C-Mesh tool can be used to reenter the c-mesh edit mode in order to manipulate the shape of the mesh further. You do this by selecting the Edit C-Mesh tool, and clicking on the mesh. You also want to be sure to select **Adjust To New Parameters** in the **Controlled Mesh Options** dialog. Both the Create and Edit C-Mesh tools can be used in a direct fashion, without editing, as you will do in the next example.

• Switch to the **Top** view and draw six concentric squares, roughly as shown. The first point of each square should be the lower left corner. Then switch to a 3D view (such as the 30/60) and, after selecting the Perpendicular switch, move and position the squares roughly as shown. You may also go to the **Front** view to move them there, as we show to the right.



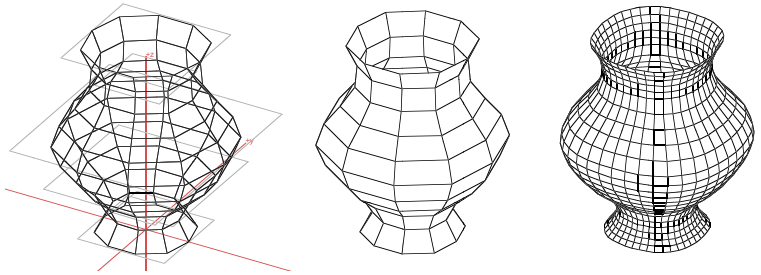
• Invoke the **Controlled Mesh Options** dialog (double click on either of the c-mesh tools) and in it select **Construct Directly**. Click on the **Type Of Object...** button to invoke its dialog and in it select **Two Sided**.

• Make sure that your topological level is set to Object, and use the Pick tool to select the squares in order (bottom to top).

• Select the Create C-Mesh tool and click the mouse anywhere in the graphics window. A meshed "vase" appears on your screen directly and the system does not enter the edit mode. Below, it is shown in wire frame (left) and hidden line (center) plots. You will next increase its density.

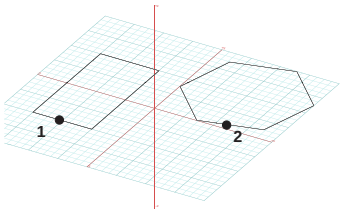
• Invoke the dialog again and in the **# Of Segments** field in the **Mesh Length** column enter 40. In the same field of the **Mesh Depth** column enter 5 and select the **Per Segment** option.

• **Undo**, and execute the operation again. The result should be as shown.

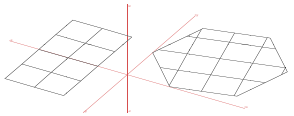


Plain meshes

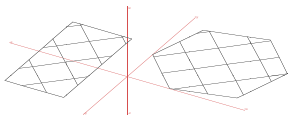
Plain meshes are generated on closed surface objects (2D shapes) or on the faces of solids, using the Mesh tool (MESH).



- On the XY plane, draw a rectangle and a hexagon, roughly as shown.
- With topological level on Object, select the Mesh tool and click on **1**, then **2**. Where you clicked determined the direction of the mesh. The density of the mesh is controlled by parameters in the **Mesh Options** dialog.

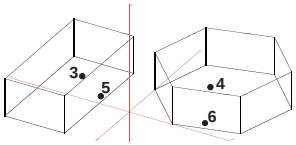


- Invoke the **Mesh Options** dialog (double click on the tool), and select **From Angle**.
- With the Mesh tool active, click on **1** and **2**.

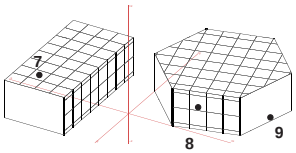


Observe the result. With the **From Angle** option selected, where you pick the object is insignificant. The mesh direction is determined by the **Altitude** and **Azimuth** parameters.

Undo to clear the screen (4 times), then generate two solid versions of your previous objects.

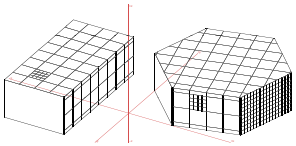


- Invoke the **Pick Options** dialog (double click on the Pick tool) and select the **Clicking Inside Boundaries** option (the single click face pick option).
- Set the topological level to Face.
- Invoke the **Mesh Options** dialog and set the **X**, **Y**, and **Z** fields to 4'. Select **Center On Line**, and **From Picked Segment**.
- With the Mesh tool active, click on point **3**, then **4**, then **5** and **6**. Observe the results.

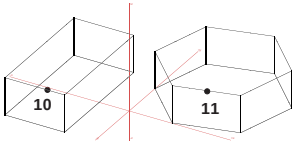


- Invoke the **Mesh Options** dialog again and set the **X**, **Y**, and **Z** fields to 1'.
- With the Mesh tool active, click on **7**, **8**, and **9**. Observe the results.

Undo to return to the original objects. You will now generate meshes on the complete objects.



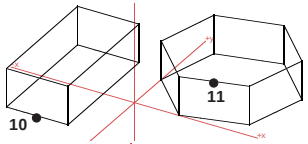
- Set the topological level to Object.
- Invoke the **Mesh Options** dialog and set the **X**, **Y**, and **Z** fields to 4'.
- With the Mesh tool selected, click on each of the objects (points **10** and **11**).



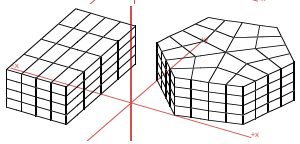
Smooth meshes

Smoothly curved meshes can also be generated on faces or complete objects using the Smooth Mesh (SMOOTH MESH) tool. You will do a few examples in this session.

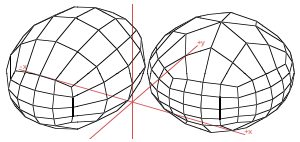
- **Undo** twice to return to the original objects used in the previous section.



- Invoke the **Smooth Meshing** dialog and in it:
  - deselect **Edit**,
  - set **Maximum # Of Subdivisions** to 2, and
  - select **Keep Flat**.
- With the Smooth Mesh tool active, click on **10**, then on **11** and observe the results.

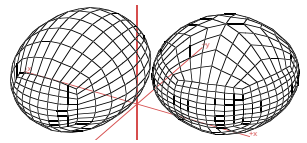


The two solids are meshed in a different manner than they were in the previous example. They are meshed by subdividing its faces as many times as indicated by the **# Of Subdivisions** parameter, rather than imposing a rectangular grid, as is done by the Mesh tool.



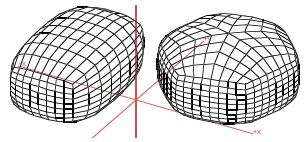
- **Undo** twice, invoke the **Smooth Meshing Options** dialog and select **Smooth**. Keep all the other options at their default values.
- With the Smooth Mesh tool click on **10** and **11**.

Observe the result. The same mesh is generated as before, but the mesh is now also curved resulting in smoothly displaced surfaces.



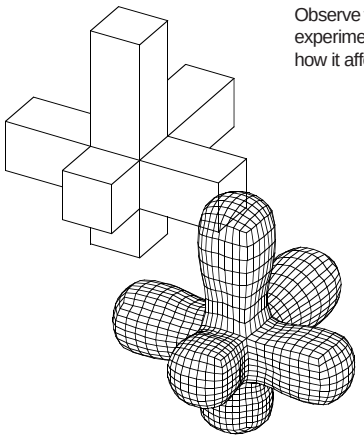
- **Undo** twice and in the **Smooth Meshing Options** dialog set **Maximum # Of Subdivisions** to 3.
- With the Smooth Mesh tool click on **10** and **11**.

Observe that now the faces are subdivided three times resulting in a deeper mesh.



- **Undo** twice and in the **Smooth Meshing Options** dialog set **Curvature** to 5%.
- With the Smooth Mesh tool click on the objects.

Observe that 5% curvature produces less rounded objects. You may want to experiment with a value at the other end, that is, something like 90% and see how it affects the roundness of the resulting mesh.

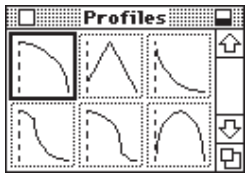


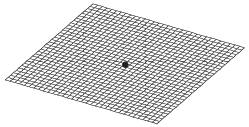
The examples we did so far in this session are relatively simple. More complex objects can also be smooth meshed, as shown by the last example. The 3D cross-like object is derived from three cuboids unioned together. You may want to come back and do this example after you learn about the Booleans, which are covered a bit later in this Mini Manual. Once you have the 3D cross object, you smooth mesh it by simply clicking on it with the Smooth Mesh tool. We used **Maximum # Of Subdivisions** 3 and **Curvature** 50%. All the other options were with their default values.

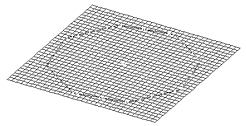
Deformations

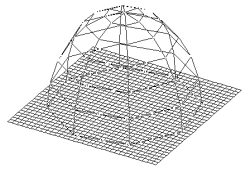
Three types of deformation can be applied to surfaces and objects using the Deform tool: ***mesh movements***, ***point disturbances*** and ***object deformations***. The deformation type is selected from the **Deformation Options** dialog, invoked directly from the Deform tool (DEFORM).

You will first do a mesh movement, whose form will be determined by a profile selected from the Profiles palette. A ***profile*** is a 2D open shape that is drawn in the usual manner, and then stored in the Profiles Library using the Define Profile tool (DEFINE PROFILE). Saved profiles are accessible through the Profiles Palette shown on the right. In the **Palettes** menu, select the **Profiles** item. When the Profiles palette appears, it contains six default profiles. For this example, use the upper left profile to execute a mesh movement. Click in the upper left box. The box is highlighted to indicate the active profile.



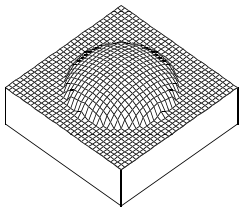


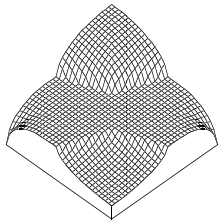


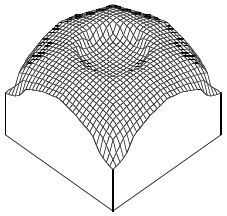


- Draw a square on the boundaries of the grid and, after selecting 2' increments in the **Mesh Options** dialog, generate a mesh as shown.
- Select the Perpendicular switch ( ).
- Select the Deform tool (DEFORM) and click on the point marked. This rubber bands a polygon.
- Position the polygon roughly as shown and click again. This rubber bands a 3D bell shape, which follows the perpendicular motion of the mouse.
- Position it at the desired height and click again. This regenerates the surface, an area of which has been moved smoothly, following the shape of the profile.

You can apply multiple mesh moves on one surface, as two of the examples below show. You can also apply ***linear*** mesh moves as opposed to the ***radial*** just executed. These and other options are selected from the **Move Mesh Options** dialog, invoked from the **Deformation Options** dialog.

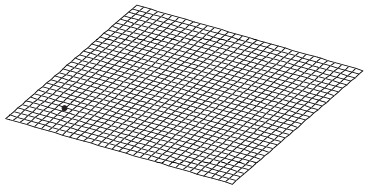




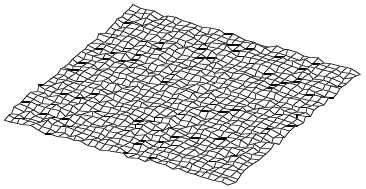


The Deform tool can also be used to generate both random and regular disturbances to surfaces and objects.

- **Undo** to return to your original meshed square.
- Invoke the **Deformation Options** dialog, and select **Disturb Points**. Click on the mesh, and observe the results.

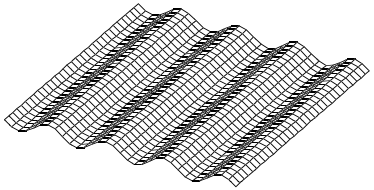


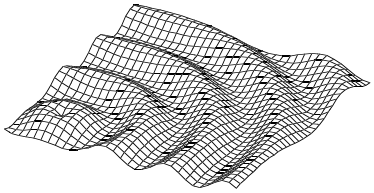
You have applied a **Random Disturbance** to the points of the mesh, the default option in the **Disturb Point Options** dialog.

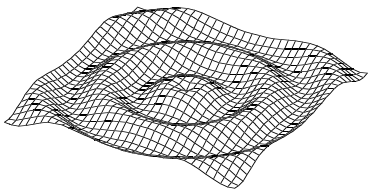


You will next execute wave disturbances, first of a linear, then of a circular shape.

- **Undo**, and invoke the **Deformation Options** dialog. Click on the **Disturb Point Options...** button to invoke the respective dialog, and select **Wave Disturbance**. Exit the dialog.
- With the Deform tool active, click on the mesh, near the point marked with the dot. A linear wave, which is the default type, is generated.
- **Undo**. Invoke the **Disturb Point Options** dialog, and next to **Type**, select **Circular**. Exit the dialog.
- Click on the point marked with the dot again. Observe the result.
- **Undo**, and in the **Disturb Point Options** dialog, select **Through Centroid**.
- With the Deform tool active, click on the marked point again, and observe the result.



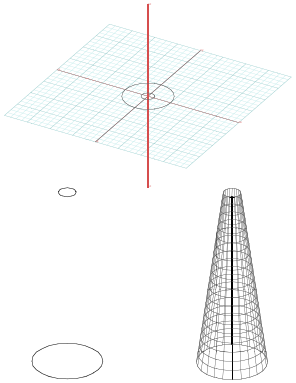




Note that in the previous example, where you clicked was significant, and determined the center of the wave. In the second example, it was not significant, and the center of the wave was positioned at the centroid of the surface.

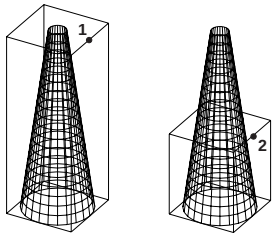
The **Disturb Points** operation can be used to apply both random and regular point disturbances to both surfaces and objects. The operation works best on relatively dense meshes.

Using the Deform tool, objects can be deformed interactively, both individually, and as groups of selected objects. **Undo** to clear the screen, and generate the shown conic mesh as follows:



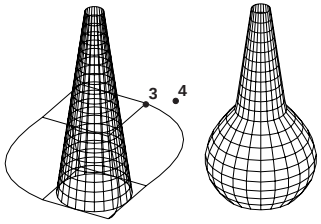
- Draw two concentric circles as shown (make certain that they are drawn in the same direction).
- Turn on the Perpendicular Switch, then, with the Move tool active, move the small circle up roughly as shown.
- In the **Controlled Mesh Options** dialog, select **Construct Directly**. Under **Mesh Length**, select **At Control Points** and deselect **Smooth**. For **Mesh Depth**, select **# Of Segments**, and in its field enter 20'.
- With the Create C-Mesh tool active, click on the large and then on the small circle.

The resulting meshed cone should be roughly as shown. You can now apply some deformations to it.



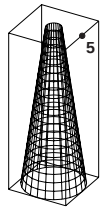
- Invoke the **Deformation Options** dialog, and select **Deform Object**, and **Bulge**. Exit the dialog, and click on the object.

A bounding box appears which defines the area that will be deformed. This box can be rotated and its top and bottom ends can be moved. You will next move its top end.

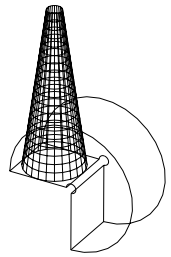


- While pressing the ***option*** key on the Macintosh or the ***ctrl+shft*** keys on Windows, place the cursor on one of the horizontal edges of the top of the box. When the cursor changes to ⇳ , click on **1**.
- Move the cursor down, and click on **2**. This moves the top end of the bounding box down.
- Position the cursor on one of the corner points of the top end of the bounding box (causing the cursor to change to ✥), and click on **3**.
- Move the cursor away and click on **4**.

Observe how the **Bulge** operation deformed the lower portion of your object. You will next bend your object.



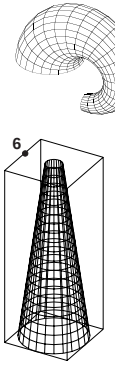
- **Undo**, invoke the **Deformation Option** dialog, and select **Radial Bend**.
- Click on the object.
- When the bounding box appears, click on a segment of its top end (point **5**).
- As the bounding box rubber bands, move the mouse in a circular direction until the bounding box makes about a 270° turn (three quarters of a circle), and click.



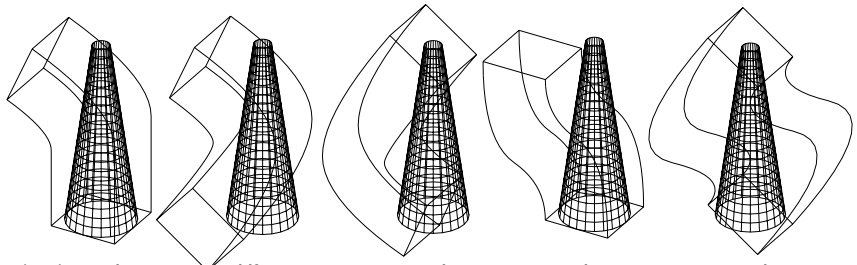
Observe how the object has been bent.

You will next bend your object in a different way.

- **Undo**, and in the **Deformation Options** dialog select **Bezier Bend**.
- Click on the object to select it.
- When the bounding box appears, click on a segment of its top end (point **6**), and move the mouse in different directions to observe how it deforms.
- Press the ***shift*** key, and move the mouse again. Do not click the mouse yet.
- Press the ***control*** key on the Macintosh or the ***ctrl+alt*** keys on Windows and move the mouse.
- Press the ***option*** key on the Macintosh or the ***ctrl+shft*** keys on Windows and move the mouse.
- Press the ***command*** key on the Macintosh or the ***ctrl*** key on Windows, move the mouse until you get a deformed shape that you like, and click.

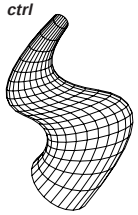


Your meshed cone is deformed and takes a shape analogous to the deformed bounding box.



Macintosh:	***no key***	***shift***	***control***	***option***	***command***
Windows:	***no key***	***shift***	***ctrl+alt***	***ctrl+shft***	***ctrl***

You have just observed how different types of Bezier bendings can be executed by pressing different keys while your bounding box is rubber banded.

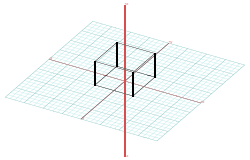


You have tried three of the seven available object deformations. You may wish to experiment with the others on your own.

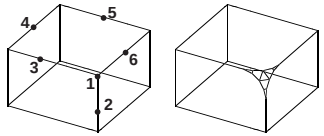
Rounding

Vertices and edges, including concave corners, can be rounded individually or simultaneously using the **Plain Rounding** method. **Controlled Rounding** is also available, which allows you to preview the effects of the rounding parameters, then edit and interactively change them. In addition, **Plain** and **Controlled Rounding** can be used to derive different results.

The Rounding tool (ROUND) will be illustrated by the following examples.

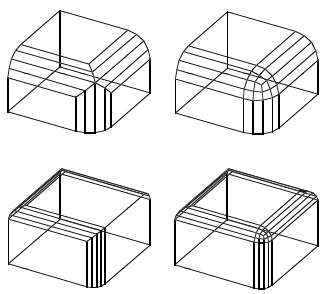


- Generate an 8' x 8' x 10' cuboid, as shown.
- Invoke the **Rounding Options** dialog. Select **Plain Rounding** and **Corner Point**.
- With topological level set to Point and the Round tool active, click on point **1**.
- **Undo**, invoke the **Rounding Options** dialog, select **Edge** and repeat the operation.
- **Undo**, in the **Rounding Options** dialog select **Edges & Points** and repeat the operation.



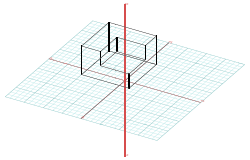
Observe the results which should be as shown.

- **Undo**, invoke the **Rounding Options** dialog and in the **Use Radius** field type 2'.
- Set the topological level to Segment and with the Pick tool active, click on points **2**, **3**, **4**, and **5**, to prepick the respective segments.
- Activate the Round tool and click on the screen.
- **Undo**, preselect segments as before but this time also include segment **6**, and with the Round tool active click on the screen.

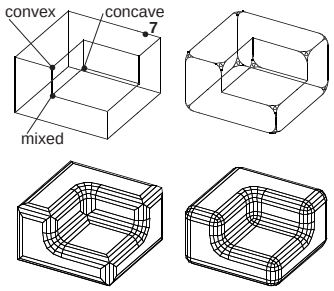


Observe the results. Points can only be rounded when the segments that converge to them are also rounded.

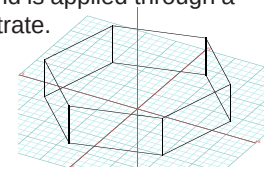
The Rounding tool can also handle concave points. To illustrate, first create an object roughly as shown (two cuboids differenced). Such an object contains ***convex***, ***concave***, and ***mixed*** points that behave differently when rounding is applied to them.



- In the **Rounding Options** dialog select **Corner Point**. (**Plain Rounding** is still selected).
- With topological level at Object and the Round tool active click on your object (point **7**).
- **Undo**, in the **Rounding Options** dialog select **Edge**, and repeat the operation.
- **Undo**, in the **Rounding Options** dialog select **Edges & Points**, and repeat the operation.

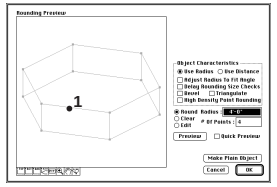


Plain rounding can apply only one type of operation at a time, and only uniform parameters. In contrast, controlled rounding allows you to mix rounding types and parameters, and remembers the rounding parameters applied earlier and allows you to change them. **Controlled Rounding** is selected from the **Rounding Options** dialog and is applied through a preview dialog, as the following examples will illustrate.



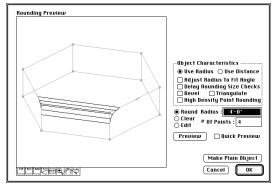
- Generate an extruded hexagon, roughly as shown.
- Invoke the **Rounding Options** dialog and select **Controlled Rounding**.
- With the Round tool active, click on the hexagon.

The **Rounding Preview** dialog appears. It consists of a preview window where the hexagon is shown, buttons, and numeric fields. The **Round Radius** option should be selected, 4'-0" should appear in its field, and 4 in the **# Of Points** field.



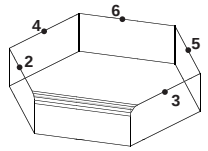
- Click on point **1**, then on the **Preview** button.

Observe the result. When you clicked on the front top segment of your hexagonal solid, it was highlighted. When you selected **Preview** your object was redrawn with its front top edge rounded.



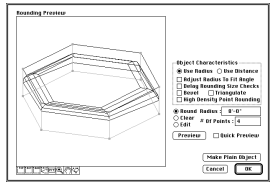
- In the **Round Radius** field enter 2', click on point **1** again, and click on **Preview**. Then click on **OK**.

The **Rounding Preview** dialog goes away and your object is generated as it was in the preview.

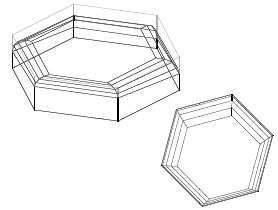


- With the Round tool active, click on the object.

The **Rounding Preview** dialog appears again and your hexagonal solid is shown in the preview as it was the last time you closed the dialog. You will next round the remaining segments of the top face, by applying different rounding parameters.



- Change the **Round Radius** field to 4'-0" and click on **2** and **3**.
- Change the **Round Radius** field to 6'-0" and click on **4** and **5**.
- Change the **Round Radius** field to 8'-0" and click on **6**.
- Click on **Preview**, then click on **OK**.

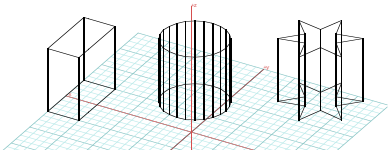


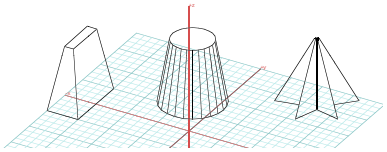
You have rounded the segments of the top face of your object by applying variable size radii, starting with 2' and going up to 8'. Variable rounding radii can only be applied through controlled rounding.

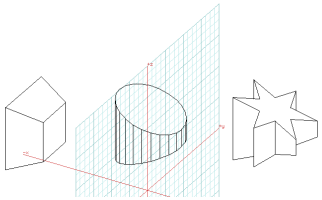
Draft angles

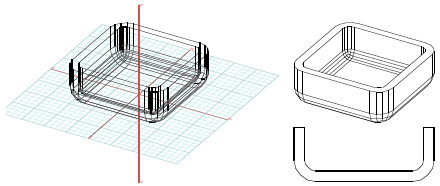
The draft angles are slight tapers that are applied to faces of objects, to facilitate their manufacturing when injection molding is used. In **form•Z** they can be applied using the Draft Angle (DRAFT ANGLE) tool. While this tool is intended to be used on models that are exported for molding, it can also be used to derive tapered forms, as the following example illustrates.

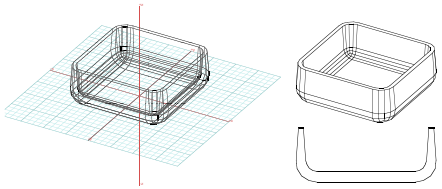
- From the **Edit** menu, **Clear** to start fresh.
- With the XY Reference Plane active, draw a cuboid, a cylinder, and an extruded star (patterned polygon), roughly as shown. They are all 20' high.
- Double-click on the Draft Angle (DRAFT ANGLE) tool to invoke the **Draft Angle Options** dialog. In it set **Inclination Angle** to 10˚. Leave all the other options with their default values.
- With the Draft Angle tool active, click on each of the three objects and observe the results.
- **Undo** three times.
- Select the YZ Reference Plane.
- Invoke the **Draft Angle Options** dialog and in it select **At Minimum Of Objects/Faces** and set **Inclination Angle** to 20˚.
- With the Draft Angle tool click on each of the objects and observe the results.











You have created shapes which are otherwise hard to generate. You have actually used the Draft Angle tool in a rather exaggerated mode. The example on the left shows a more typical use of draft angles.

A "shell" object is created as shown. This is a 3D enclosure with its bottom closed and its lower edges and points rounded. We apply a draft angle by clicking on it with the respective tool, while the XY Reference Plane is active. Applying a draft angle to its open (top) ends makes pulling it off the molding form easier.

Spherical objects

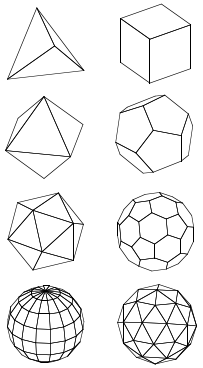
The eight types of spherical objects shown below can be generated with the Spherical Objects tool (SPHERIC), using one of three available placement methods. You will first generate a geodesic sphere, using the **Origin And Uniform Scale** method (default).

- With the Spherical Object tool active, click in the graphics window, then move the mouse.

If you move the mouse quickly, a bounding box is rubber banded. If you move it slowly, a spherical object is rubber banded. In both cases, as you move the mouse the size of the object grows or shrinks.

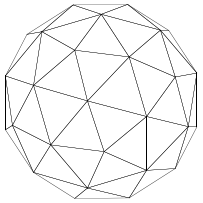
- When you have the desired size, click again.

This generates a geodesic sphere, as shown. You will next repeat the operation and generate a higher density sphere.

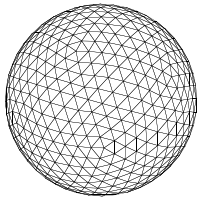


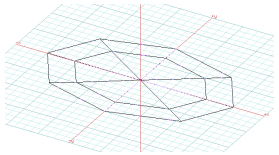
- Invoke the **Spherical Solid Options** dialog. Make sure that the **# Of Levels** option is selected, and in its field enter 3. Repeat the operation as above. After the second click of the mouse, and a momentary pause, a geodesic sphere of higher density is generated.

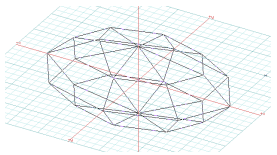
You will next generate a lathed sphere using the **Center & Radius, Height, Rotation** method, which allows you to scale any of the dimensions of the sphere independently of the others to produce elliptical shapes.

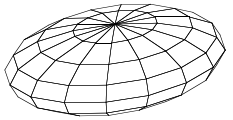


- In the **Spherical Solid Options** dialog, select **Revolved Sphere** and the **Center & Radius, Height, Rotation** method.
- Click in the graphics window. A 2D shape is rubber banded.
- Click the mouse again when you have reached the shape you desire. A 3D shape is rubber banded. Click again. The size and shape of your object is defined, and the motion of the mouse rotates the object about the Z axis.
- When you are satisfied with its position, click again.







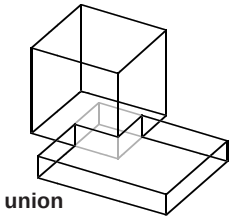


This completes the operation. Note that when the final sphere is generated, its density is determined by the values entered in the **Length** and **Depth Resolution** fields, while a lower density is used for the rubber banded form.

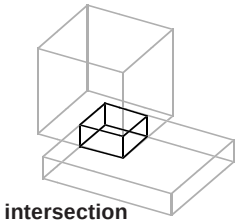
Boolean operations

Generate two cuboids, as shown. Make the first higher than the second by selecting different height values from the **Heights** menu. Make sure that the two volumes partially overlap.

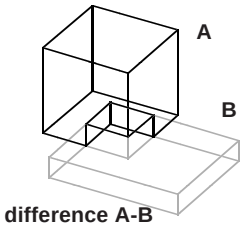
- Select the Union operator (UNION), then click on each of the two objects, and observe the result.
- **Undo** and repeat the operation after selecting the Intersection operator (INTSCTN).
- **Undo** again and repeat the operation by selecting the Difference operator (DIFRNC). As shown by the last two images, the difference is sensitive to the order in which the objects are selected, and will give different results, depending on which object is selected first.



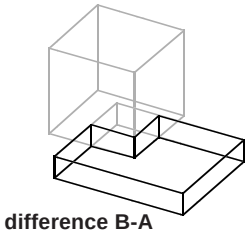
union



intersection



difference A-B

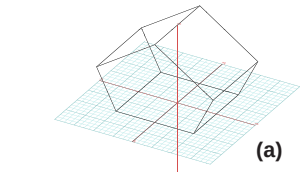


difference B-A

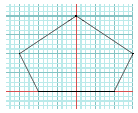
The Boolean operations can also be used with 2D surface objects. However, surface and solid objects cannot be mixed.

The Boolean Split (SPLIT) is a composite operation. It can be executed in a one or two way mode, as selected from the **Split Options** dialog. As an example, turn on the Grid Snap and generate the object shown below in **(a)**. It is drawn in **Front** view, as shown in **(b)**. Then use the Rotate tool to make one more copy, as shown in **(c)**. Try to be as accurate as you can in order to produce the results we show.

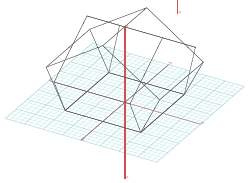
- Invoke the **Split Options** dialog and select **Two Way**.
- Select the Split tool and click on each of the two objects. To be able to see the result, move the pieces roughly as we did in **(e)**.



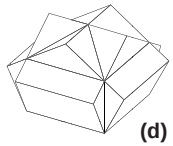
(a)



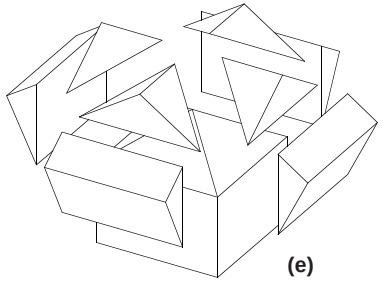
(b)



(c)



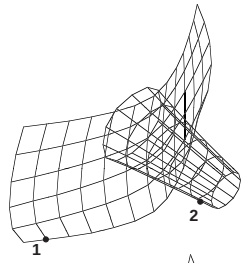
(d)



(e)

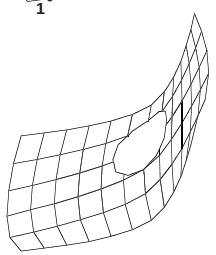
Trimming and stitching

From the Trim & Stitch (TRIM STITCH) tool you can invoke the **Trim, Split & Stitch** dialog from which eleven different variations of these operations can be selected.

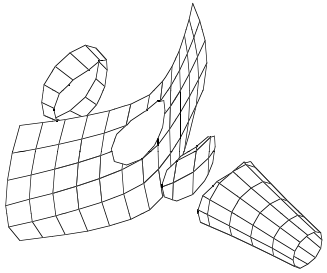


Note that these operations resemble the Booleans in that they calculate the intersection of objects. However, you have to tell them which pieces to return for the result, which you do by where you click.

- Generate two surface (single sided) meshes, roughly as shown to the right. Make certain that the cylindrical mesh penetrates the open surface.
- Set the topological level to Object.
- Select the Trim & Stitch tool and click on point **1**, then **2**. Actually the position of the second click is insignificant for this operation. However, the position of the first click is very significant since it determines which portion of the first surface will be kept after it is trimmed by the second.

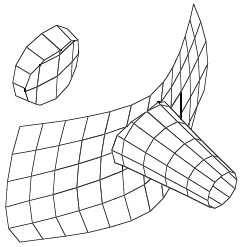


- Invoke the **Trim, Split & Stitch** dialog and select **Split** in the **Both Objects** column.
- **Undo** and repeat the operation. Observe the results. To be able to better tell what happened, move the resulting pieces apart.

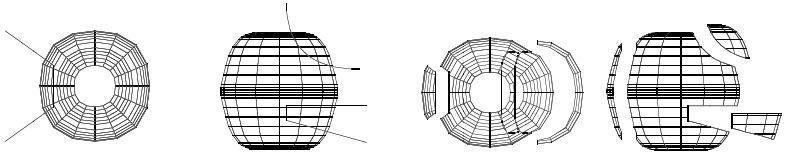


The trim operation cuts a piece away, while the split operation cuts a mesh into two or more pieces. When an option in the **Both Objects** column is selected, then the operation is executed two ways. That is, each object is trimmed or split by the other.

- Invoke the **Trim, Split & Stitch** dialog and select **Trim & Stitch** in the **Both Objects** column.
- **Undo** and repeat the operation. Observe the results. Corresponding pieces of the two meshes have been joined together, which is the result of the stitch operation.



You can also trim or split a mesh using a line as a second object. This is illustrated below. You can also apply these operations to solid objects or combined surface and solid objects.



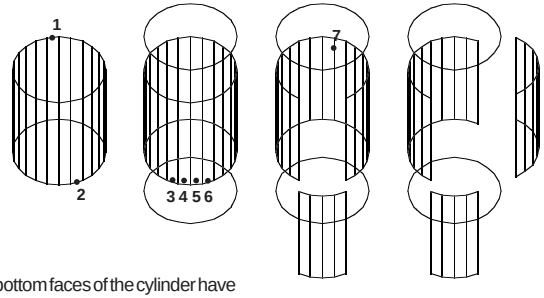
Joining and separating

After the Boolean and the Trim & Stitch tools on the 8th row of the tool palette are the Join (JOIN) and Separate (SEPARAT) tools. Join merges two or more objects into one, without calculating their intersections, which the Booleans do. That is, one or more objects become "volumes" of a single object. Separate does exactly the opposite; when applied to objects that consist of more than one volumes, it produces a separate object for each of the volumes. However, the Separate operation can also be used to "split" an object into pieces, as illustrated by the following examples.

• Draw a cylinder, roughly as shown. It's exact size does not really matter.

• Double click on the Separate tool to invoke the **Separate Options** dialog. In it select **Along Stitch**.

• With the Separate tool active, click on **1** and then on **2**.



There is no visible effect, but the top and bottom faces of the cylinder have been separated. To see them, turn on the Perpendicular Switch and with the Move tool move them up and down as we show.

• Invoke the **Pick Options** dialog and select **Clicking Inside Boundaries**.

• On the 4th row, set the topological level to Face (FACE).

• With the Pick ( ) tool active click on **3**, **4**, **5**, and **6**. The faces on which these points lie turn red indicating that they have been selected.

• In **Separate Options** dialog select **At Boundary Of Selected Faces**.

• With the Separate tool active, click somewhere in the graphics window.

Again, there is no immediate visible result. However, the four preselected faces have been separated and have become an independent object. To see them, move them as we did in the example before.

• In the **Separate Options** dialog select **Along Selected Segments**.

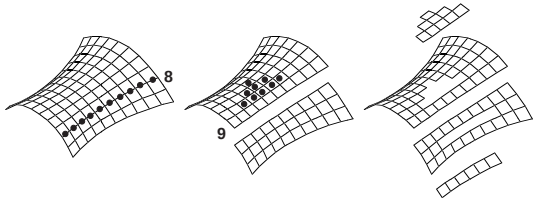
• With the Separate tool click on **7**.

The main body of the cylinder has been separated to two pieces. Move one, as we show, to see the result.

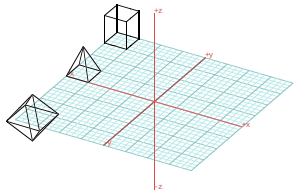
To do a few more examples, generate the meshed surface you did for the c-mesh example, earlier (page 34). It should be roughly as shown below.

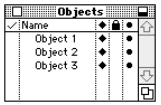
• With topological level at Segment (SEGMNT) preselect the sequence of segments labeled **8**. **Along Selected Segments** should still be on in the **Separate Options** dialog. With the Separate tool click in the window.

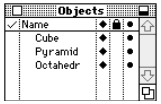
• Preselect the group of faces labeled **9**, select **At Boundary Of Faces** in the dialog and with the Separate tool click in the graphics window.



Move the pieces that were separated, as we did, to see them better.







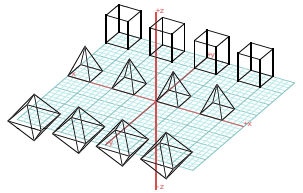
Grouping and ungrouping

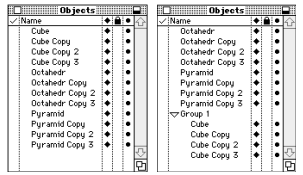
The Group (GROUP) operation links a number of objects, without transforming them into a single object. While Group does not produce a visible effect, its effects can be observed in the Objects palette, as we see below.

• Generate a cube, a pyramid, and an octahedron roughly as shown. Their size and shape are not really important for this example. Observe how they are listed in the Objects palette with default names "Object 1", "Object 2", etc. Change the names to "Cube", "Pyramid", and "Octahedr" (or whatever names you prefer) to make them easier to distinguish. You change these names by clicking on a name field in the Objects palette to highlight them, typing a new name, and clicking in the palette away from the name you just changed.

• Make three copies from each of the objects; observe how the names are listed in the palette.

• While pressing ***option*** (Mac) or ***ctrl+shft*** (Wins) click on the palette to invoke the **Objects** dialog. In it click on **Sort**. The names have been sorted.





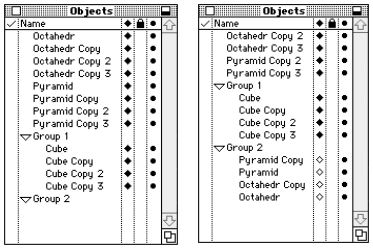
• Make sure that topological level is at Object (OBJECT) or Group (GROUP); with Pick preselect the four cubes.

• With the Group (GROUP) tool click in the window.

While no visible change can be observed on the objects (other than that they are not highlighted anymore) there is a visible change in the Objects palette. A group called Group 1 has been created and the four cubes have been placed in it.

You can also execute grouping operations by working directly in the palette.

• Click under the last name in the Objects palette. The name Group 2 appears. Click under it to complete the creation of a new group, which is initially empty. You will next put some objects into this group.

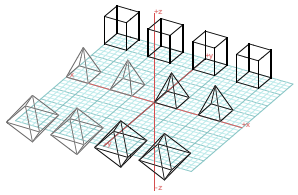


• Click on "Octahedr", drag it onto "Group 2", and release it. It is placed into Group 2 as shown.

• Drag "Octahedr Copy", "Pyramid", and "Pyramid Copy" into "Group 2".

• In the Objects palette, click in the column in front of "Group 2". Check marks are displayed in front of "Group 2" and its members, which are also highlighted red in the graphics window.

• With the Ghost (GHOST) tool, click in the window.

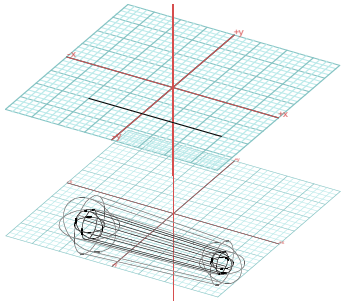


The four objects in Group 2 are ghosted. They are displayed in the gray ghost color and the diamonds in the visibility column of the objects palette have been switched to white diamonds.

In **form•Z**, groups, which may be structured at any depth, facilitate a variety a operations, such as exporting. In addition, they take a special meaning when used in conjunction with metaformz, as illustrated in the next section.

Metaformz

The metaformz, which include the metaballs, are a special type of parametric objects that have the ability to blend smoothly together, when they overlap. Thus they lend themselves nicely for the modeling of irregular, organic forms. As an example, we shall model a bone.



• Use the Vector Line tool to draw a line, roughly as shown.

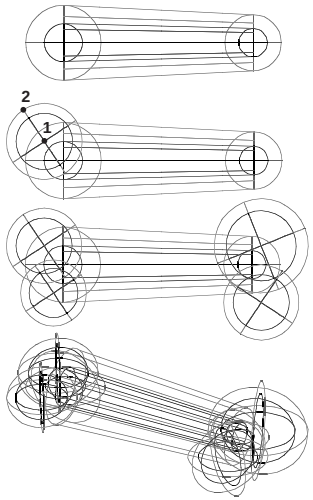
• With the Derive/Edit Metaformz tool click on the line. This causes the **Metaformz Parameters** dialog to be invoked. In it select **Conic Tube** (from the **Metaformz Type** pop up menu, and enter 8' and 6' in the **Radius 1** and **Radius 2** fields, respectively. Observe the result.

You have derived a metaform of type conic tube from a single line. This metaform is displayed through wire frames, which is its unevaluated representation. It will soon be evaluated to derive its meshed surface. However, before we evaluate it we shall generate four more metaformz. These will be metaballs, which are spherical shapes generated directly, as opposed to being derived from other objects (as the conic tube was).

• From the **View** menu select **Top** (take another look at the conic tube).

• Double click on the Create Metaballs tool to invoke the **Metaball Type** dialog. In it select **Ball** (if not already selected) and enter 3 for **Weight**.

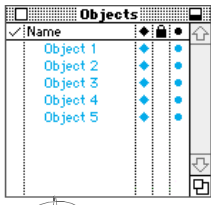
• With the Create Metaballs tool click on **1** and **2**. This creates a metaball, as shown in an ortho view.



• Continue and with the Create Metaballs tool generate three more metaballs, roughly as shown.

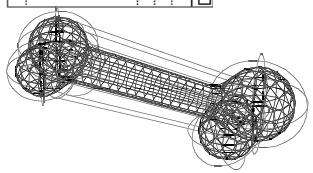
• From the **View** menu select **z=30° x=60°**.

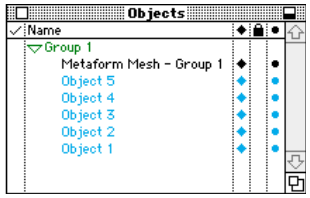
You now have a 3D view of your five metaformz. Note that, in the Objects palette their names are displayed blue, which distinguishes them from the regular **form•Z** objects.

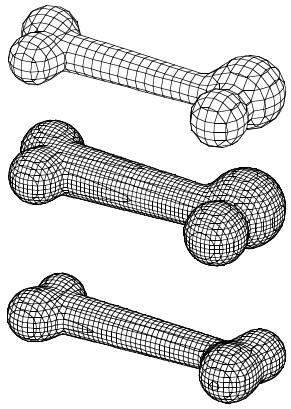


• Click in front of each name in the Objects palette to select the five metaformz.

• With the Group tool click in the window. The **Metaformz Evaluation Parameters** dialog is invoked. Leave all options at their default settings and click **OK**.







Your five metaformz have been evaluated into a continuous mesh, which smoothly blends all five metaformz. Also note the changes made in the Objects palette. The five metaformz have been placed under Group 1 (as expected), and at the top of the group a new name "Metaform Mesh - Group 1" has appeared. This is the name of the evaluated metaformz, while the group name (Group 1) is the name of the unevaluated group of metaformz.

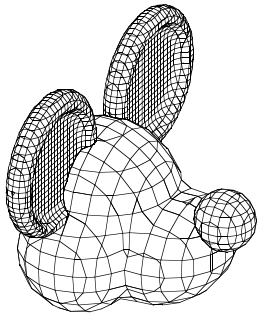
• From the **Display** menu select **Hidden Line*** to see the blended shape better.

• With the Metaformz Evaluate tool click on the evaluated metaformz. When the **Metaformz Evaluation Parameters** dialog is invoked change the **Threshold** value to 90% and the **Mesh Resolution** to 1'.

As soon as you exit the dialog, the metaformz are reevaluated. Generate a hidden line plot again and observe the effects of the options you just changed.

Next, you may move slightly any of the four metaballs or use the Scale tool to resize them. Assuming you have not changed the default option in the **Metaformz Evaluation Options** dialog, each time you execute one of these operations your metaformz will be reevaluated and the blended mesh will change. We show a version of our bone, after applying a number of Scale and Move operations.

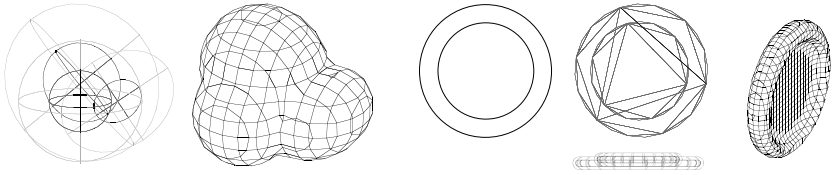
The latter paragraph describes the typical metaformz modeling process, which is mostly visual. That is, you create a few metaformz, you evaluate them, you visually inspect the results, you make changes, you reevaluate them, and so on, until a satisfactory shape has been derived.



As another example we show a head of a mouse. The main head is derived from four metaballs, evaluated as for the example above.

The ears are modeled and evaluated a bit differently. You start with two circles. You use the Derive/Edit Metaformz tool and derive metaformz of type ***sheet*** from them. For the first sheet you use **Weight** = 1; for the second you use **Weight** = -1. You move the second sheet so that it overlaps the first just a bit. When the two are evaluated together, the second metaform has a ***subtractive*** effect, creating the "ear", as shown.

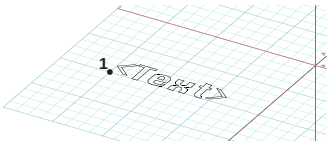
Finally note that the "nose" is a single metaball and that the ears and the nose are kept as independent objects. That is, they are not grouped with the rest of the head.

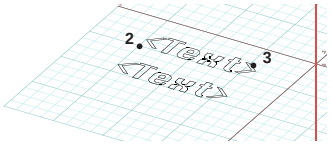


3D text

Three tools on the 9th row of the modeling tool palette allow you to place and edit 3D text (PLACE TEXT, EDIT TEXT, TEXT LINE EDIT). Text can be generated as ***plain*** or ***object*** text, which can be a one or two-sided ***surface*** or ***solid*** object. Text objects are typically generated as controlled objects which can be edited and changed after their initial creation.

The type of text is selected in the **Text Placement** dialog, which can be invoked directly from the Place Text tool (double click on it). The Place Text tool (PLACE TEXT) is used to create a new text entity. Controlled text objects are edited and changed using the Edit Text tool (EDIT TEXT). Text can also be created along or between control lines, whose shape can be changed using the Text Line Edit tool (TEXT LINE EDIT). When using the Place Text and Edit Text tools, when the mouse is clicked on the screen, the **3D Text Editor** dialog appears, where the text string is typed and other options are selected. You will first generate plain and then object text.

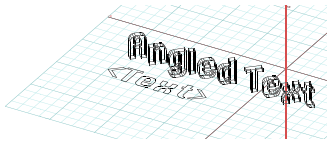




- Invoke the **Text Placement** dialog, and under **Plain Text** select **Text At Point**.
- With the Place Text tool active, click on **1**.
- When the **3D Text Editor** dialog appears, ignore it and click on **OK**. Observe the result.
- Invoke the **Text Placement** dialog again and under **Text As Object** select **Text At Point**.
- Click on point **2**.
- In the **3D Text Editor** dialog under **Object Type** select **Surface**, and click on **OK**.

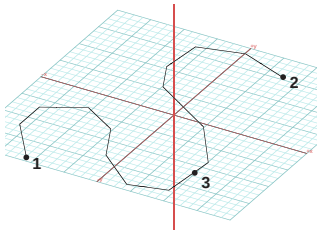
Observe the results. Two text strings that spell "<Text>" (in the default font) are plotted on the screen. "<Text>" is the default string that shows up in the text field of the **3D Text Editor** dialog. Since you did not change it, it was plotted as is. The two text entities shown on the screen look identical, but are of different types. The lower is plain text, while the upper string is object text, which can be changed to a solid object. You will next change the text string, change the text to a solid object, and rotate the individual characters.

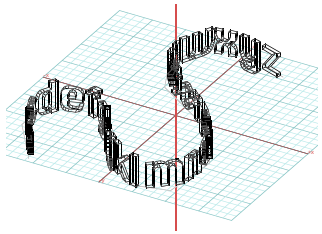
- Select the Edit Text icon and click on point **3** to select the text object.
- When the **3D Text Editor** dialog appears, in its text field type "Angled Text." You do this using the standard text editing procedures.



- From the **Object Type** pop-up menu, select **Solid**, turn on the **Standing (Perp To Plane)** option, in the **Character Angle** field type 45°, and click on **OK**.

Observe the result.

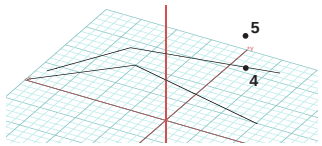




Text can also be placed along a control line, which you will do next. You will first draw the line, and then place the text.

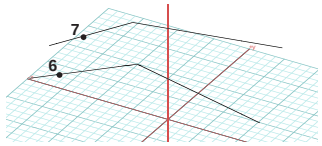
- Using the Vector Line tool, draw a line roughly as shown. It begins at point **1** and ends at **2** (the direction is significant).
- Invoke the **Place Text** dialog, and under **Text As Object Along Path**, select **On Line**, **Scale Height & Width**, and **Bezier Smooth Line**. Click on **OK**.
- With the Place Text tool active, click on the line (point **3**).
- When the **3D Text Editor** dialog appears, type the alphabet in its text field. **Solid** and **Standing (Perp to Plane)** should still be selected. Click on **OK**.

Observe the result. You will next generate text between two control lines.



- **Undo** or Delete to clear the screen.
- On the XY reference plane, draw two open lines from left to right, roughly as shown.
- Turn the Perpendicular switch (PERPENDICULAR) on by clicking on it. It is in the window tool palette.
- Select the Move tool and click on **4**, then **5**.

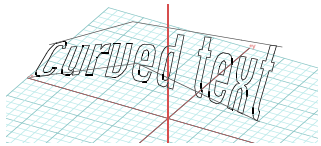
This moves the top control line up in a direction perpendicular to the XY plane.



- Turn off the Perpendicular switch.

These are the two control lines between which you will place text.

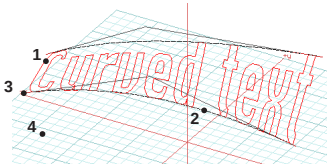
- Invoke the **Place Text** dialog and under **Text As Object Along Path**, select **Between Lines**. Select **Bezier Smooth Line** and click on **OK**.
- With the Place Text icon active, click on **6** and **7** to select the two lines between which the text will be generated. The **3D Text Editor** dialog appears.
- In the text field of the dialog, type "Curved text." From the **Object Type** pop-up menu select **Surface**, and click on **OK**.



Observe the results. Your text string has been generated following the control lines, and is unfolding in 3D space.

You will next edit and change the shape of your control lines, and watch how the shape of your text will also change.

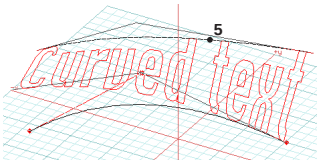
• Select the Text Line Edit tool, and click on the text object (point **1**).



You have entered a line edit mode: the tool palette is grayed out, and the control lines of your curved text appear.

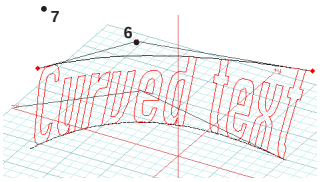
• Click on **2** to select the bottom control line.

The cursor changes to and the control points of your line appear. In the Text Line Edit mode, you edit the control lines that determine the shape of your text object. These are edited the same way as common control lines (see page 33 of this Manual). You will first move the left endpoint of the bottom line.



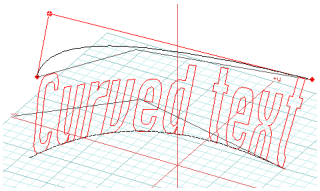
• Click on **3**, then **4**.

This reshapes the curvature of the line, roughly as shown. The shape of the text has not yet changed. It will change if you click once on the screen, click on the other control line to select it, or double click on the screen to exit the edit mode.



• Click on **5** to select the other control line.

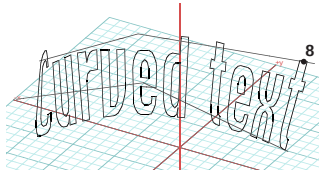
The text is regenerated in its new shape, the lower control line returns to normal, and the upper control line is now shown with its control points which can be moved.



• Click on **6** to select the middle point of the line, then click on point **7** to reposition it.

• Double click on the screen.

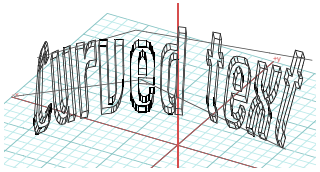
You have exited the Line Edit mode and your text object has been generated in its final form. Note that it is a surface object. To complete this example, you will edit the text object once again to change it to a solid object.



• With the Text Edit tool selected, click on the text object (point **8**).

• In the **3D Text Editor** dialog, from the **Object Type** pop-up menu select **Solid**. In the **Depth** field type 1'-6" and click on **OK**.

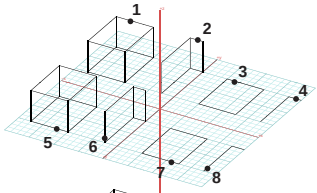
Your 3D text is regenerated as a solid object.



Parallel objects

The Parallel Object tool ( ) in the 6th row of the tool palette can be used to derive parallel objects from other objects. The original object can be a solid, a one or two-sided surface, or an open vector line. Both single and double parallel objects can be created. The type of parallel object to be created, as well as a number of other parameters, is selected from the **Parallel Objects** dialog which can be invoked directly from the Parallel Object tool (double click on the icon). In this section you will first generate single and double parallel objects from different types of objects, and you will then combine parallel objects with mesh generating procedures to create a free flowing ribbon.

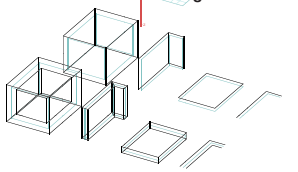
• Use the appropriate object generating tools to create two cuboids, two surface solids, two rectangles, and two open lines, roughly as shown.



• Invoke the **Parallel Objects** dialog and make certain that the defaults **Single Parallel (Surface)** and **Out** are selected.

• With Parallel Object active click on **1**, **2**, **3**, and **4** (on each of the objects on the back row).

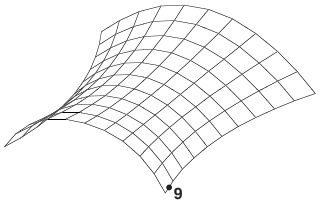
Observe the results. Parallel copies of the original objects have been generated at a preset distance.



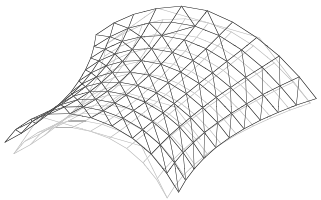
• Invoke the **Parallel Objects** dialog again and select **Double Parallel** and **Center**.

• Click on **5**, **6**, **7**, and **8**.

Observe the result. Parallel surfaces have been generated on both sides of the original objects and, except for the open line, they are connected to form a single solid object.

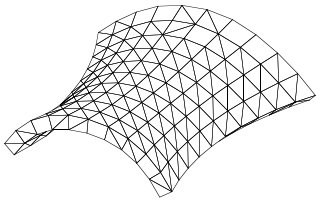


For the next example, recreate the mesh from page 34 of this Manual, as shown. Select the control lines back to front so that the positive (visible) side of the mesh is on the top.



• Invoke the **Parallel Objects** dialog and select **Single Parallel (Surface)**, **Out** and in the **Wall Offset: Out** field type 4'.

• With the Parallel Object tool active, click on **9** and observe the result.

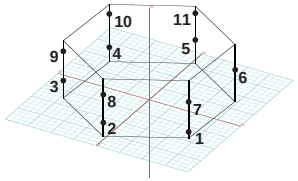


• Invoke the **Parallel Objects** dialog and select **Double Parallel**, **Center,** and in the **Wall Offset: Out** and **In** fields enter 2'.

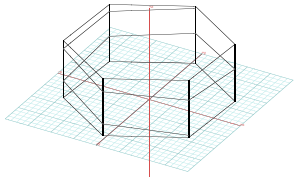
• **Undo** and with the Parallel Object tool active click on **9** again.

As the previous example showed, objects need not be planar, for the Parallel Object operation will automatically triangulate any non planar surfaces. When generating parallel objects from open lines, the lines are not required to be planar either, as the next example will show. You will first draw an open line in 3D space, will then derive two more parallel lines, and you will then use these three lines to create a freely flowing "ribbon."

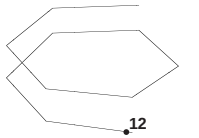
• Select 20' from the **Heights** menu and generate a hexagonal extrusion, as shown.
• Turn on Snap to Segment (window tools).
• With the Vector Line tool active, click on vertical segments of the hexagonal solid to draw the 3D line as shown (click on **1** through **11**).
• With the Delete tool click on the hexagonal solid to delete it since it is no longer needed.



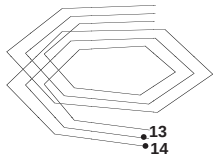
After you turn off the reference grid, your 3D line should be roughly as shown.



• Invoke the **Parallel Objects** dialog. Select **Double Parallel**, **Center,** and in the **Wall Offset: Out** and **In** fields enter 5'. Under **Status of Objects...**, select **Keep**.
• With the Parallel Object tool active, click on point **12** to select the 3D line.

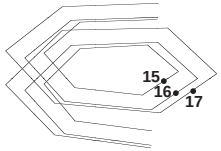


Parallel lines are generated on each side of the original line, roughly as shown.

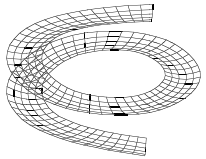


• Turn off Snap to Segment (if you haven't yet) and turn on the Perpendicular switch.
• With the Move tool active, click on **13** and **14**.

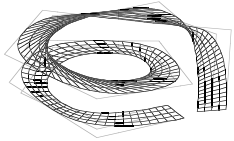
You have moved the original line a bit to introduce a curvature to the mesh you will be deriving next.



• Invoke the **Controlled Mesh Options** dialog. Enter **# Of Segments** 80 for **Length** and 5 for **Depth**. Also select **Construct Directly**, and under **Status of Objects...** select **Ghost**.
• Use the Pick tool to preselect the three lines (click on **15**, **16**, and **17**).
• With Create C-Mesh active click on the screen.



Observe the result. Before the last step, you could have slightly moved a few of the control points (topological level at Point) in different directions to make your ribbon less regular. This was done with the last image shown. You may wish to **Undo** and experiment a bit.

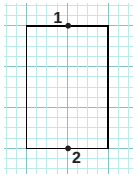


Editing lines

The 3D Line Edit tool (

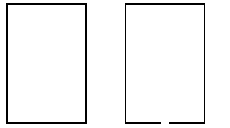
) in the 9th row of the tool palette can be used to break, connect, join, trim, round, and bevel open or closed vector lines. The type of editing operation is selected from the **Line Editing Options** dialog that is invoked directly from the Line Edit tool. The Line Edit operations are useful primarily for correcting data that may have been imported from other applications.

• From the **View** menu select **Top** and draw a 2D rectangle, as shown.
• Invoke the **Line Editing** dialog and verify that **Break** is selected.
• With the Line Edit tool active, click on point **1**.



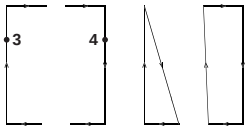
Even though you have actually broken the top segment of the rectangle, nothing different is visible.

• Invoke the **Line Editing** dialog and turn on **Offset: Left** and **Right.**
• With the Line Edit tool active, click on point **2**.

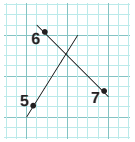


The bottom segment of the rectangle has been broken, and you can see it because offsets have been applied to the break point. To verify that the rectangle has been split into two pieces, use the Move tool to move the right portion, as shown.

• In the **Line Editing** dialog select **Close Line** and **Join**, and with the Line Edit tool active click on **3**.
• In the **Line Editing** dialog, next to **Close Line** select **Connect**, and with the Line Edit tool active click on **4**. Observe the result.



• Draw two open lines, roughly as shown.
• In the **Line Editing** dialog select **Trim Segments** and with the Line Edit tool active click on **5**, then **6**.
• **Undo**, and with Line Edit active click on **5**, then **7**.

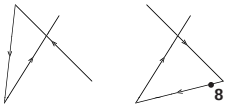


Observe the results. The lines have been trimmed to their points of intersection. Where the mouse is clicked determines the portion of the segment that is retained.

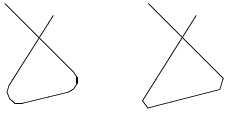
• **Undo**. In the **Line Editing** dialog select **Connect Segments**, and with Line Edit active click on **5**, then **6**.
• **Undo** and with Line Edit active click on **5**, then **7**.

Observe the result. The ends of the segments where the mouse is clicked are connected with new segments.

• In the **Line Editing** dialog select **Fit Fillet**, in the **Radius** field enter 2' and click on **8**.
• **Undo**. In the **Line Editing** dialog select **Bevel**, and with Line Edit active click again on **8**.



You first rounded and then beveled the corner points.



Moving, rotating, scaling, and mirroring

To move an object, select the Move operator ( ) from the 11th row of the tool box, set the topological level to Object ( ), and click on the object. The object is rubber banded and follows the motion of the mouse. Position it at the desired location and click the mouse again. This is the post-pick method. To use the pre-pick method, select any number of objects using the Pick operator ( ), then select the Move operator, click in the graphics window to start the motion, and click again to complete the motion. You can also move parts of objects, such as points, segments, outlines, or faces. You move parts of objects the same way, except that you set the topological level to the desired object part: Point ( ), Segment ( ), Outline ( ), or Face ( ).

When moving an object, you can move the object itself or copies of the object. This is determined by the selection of one of the Self/Copy modifiers on the 10th row of the tool palette. Self ( ) moves the object itself, Copy ( ) moves a copy, and Repeat Copy ( ) repeats the first motion as many times as the mouse is clicked. A double click of the mouse terminates the copying sequence. Multi-Copy ( ) automatically makes a certain number of copies (default number is 6) with a single click of the mouse. The number of copies desired is set in the **Transformation Multi-Copy** or the **Input Options** dialog.

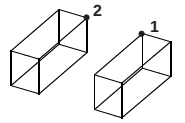
To execute a ***rotation***, (1) select the Rotation operator ( ), (2) click on the object to select it, (3) click to define the center of rotation, (4) click to define the start of the rotation, and (5) click to define the end of the rotation. The object is rubber banded after the 4th click.

To execute a ***scale*** operation, (1) select the Scale operator (or), (2) click on the object to select it, (3) click to define the base of the scale, (4) click to define the start of the scaling, and (5) click to define the end of the scaling. The object is rubber banded after the 4th click. Note that there are two Scale operations. The first applies an independent scaling factor in each direction. The second applies the same factor to all three directions.

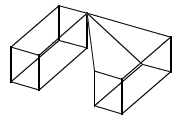
To execute a ***mirror*** or ***reflection*** operation, (1) select the Mirror operator ( ), (2) click on the object to select it, (3) click to define the axis and to start the reflection, and (4) click to define the end of the reflection. The object is rubber banded after the 3rd click.

The descriptions above apply the post-pick method. With the pre-pick method any number of entities are selected first, and then the desired operator is selected. The remaining steps are the same.

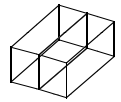
Attachments



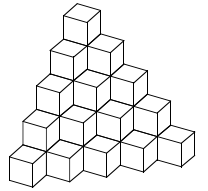
You can attach parts of an object, a complete object, or copies of an object, to another object. All the variations are executed with the Attach ( ) tool. To experience the operation, generate two cuboids as shown.



- Invoke the **Attach Options** dialog and select **Object Part**.
- Set the topological level to Point.
- Select the Attach operator and click on points **1** and **2**. Observe the result.



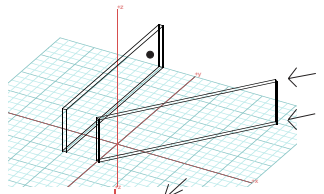
- Invoke the **Attach Options** dialog and select **Entire Object**.
- **Undo** and repeat the operation.



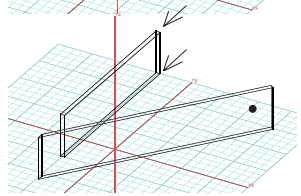
Next, set the Self/Copy mode to Copy and generate the shown composition by executing a number of point-to-point attachments.

You can also execute segment-to-segment attachments by setting the topological level to Segment, and face-to-face attachments by setting the topological level to Face. How the segments are selected when executing a segment-to-segment attachment is significant. The point of the first segment which is closest to its pick point is attached to the point of the second segment closest to its pick point. If you are not careful, a twisted result may be produced. With face-to-face attachments, how the faces are picked is significant. A number of justification options are available for the attachments, and are selected from the **Attach Options** dialog.

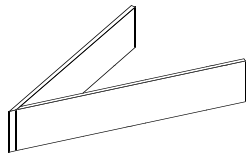
Extending segments

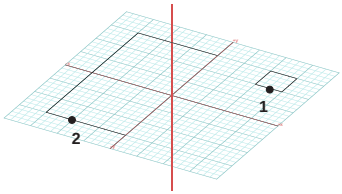


Segments (edges) of objects can be extended to their intersection with a surface, using the Extend Segment tool ( ). To illustrate the operation, generate two single wall enclosures, roughly as shown.



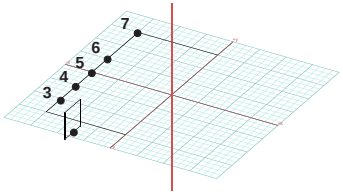
- Set the topological level to Segment and use the Pick tool to select the four horizontal segments of the front object.
- Switch the topological level to Face, select the Extend tool, and click on the face marked with the black dot (assuming the single point face pick option is still selected).
- Repeat the operation by picking the horizontal segments of the other object and the front face of the front object.



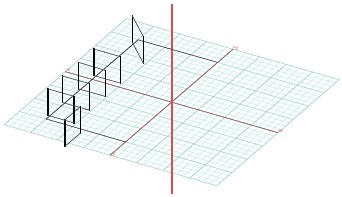


Placing shapes on lines

The Place () tool is used to position open or closed shapes (called ***source shapes***) on the segments or points of lines (called ***placement lines***). This tool is affected by the Self/Copy modifier. You can place a shape itself, a copy of the shape, or multiple copies. To do a few examples, draw two shapes as shown.

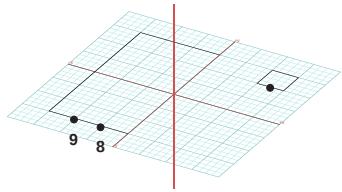


- Select the Place tool and with topological level at Object and the Self/Copy mode at Self, click on point **1**, then on **2**. The square has been placed on a segment of the line.
- Set the Self/Copy mode to Copy.
- Invoke the **Place On Segment/Point Options** dialog and select **Snap**.
- With the Place tool selected, click on the square, and then on points **3**, **4**, **5**, **6**, and **7**. Then double click.

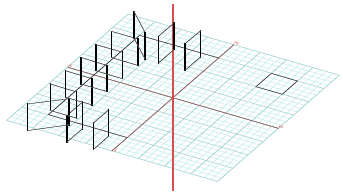


A copy of the square was placed at each point you clicked. When you clicked on point **7**, the program snapped to the corner point and placed the square at the bisector of its angle. It also adjusted its size. The double click was needed to exit the copy mode.

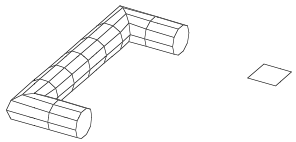
Next, you will execute a multi-placement. **Undo** six times to return to the original shapes.



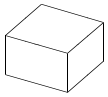
- Set the Self/Copy mode to Multi-Copy.
- Invoke the **Transformation Multi-Copy** dialog by double clicking on the Multi-Copy tool. In the **# Of Copies** field, enter 10, and click on **OK**.
- With the Place tool selected, click on the square, then on points **8** and **9**. Ten copies are placed by repeating the distance of the two points you selected. The copies placed on the corner points are properly adjusted.



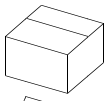
Next, select the placed squares and use the Create C-Mesh tool to generate a mesh such as shown. (Select **At Control Lines** and deselect **Smooth** for the **Mesh Depth**.) Given the special significance that the placement operation has for the meshes, the **Generate C-Mesh** option can be selected in the dialog to generate a mesh as soon as the placement is completed.



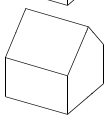
Insertions

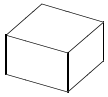


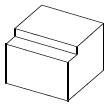
The insertions are controlled by the magenta modifiers on the first row of the tool box. Generate a cube as shown. To insert a segment on its top face, select the Insert Segment icon (), then select the Draw Vector Line icon and draw a segment as shown. Move the newly inserted segment to verify that it has become part of the object's structure. The Insert Segment operation is the only one which does not require a face to be preselected. All the other insertions have that requirement.

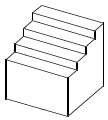


To insert one or more faces, **Undo** as many times as necessary to return to the original cube. Then, by setting the topological level to Face, select its top face (it should turn red), select the Insert Face modifier (), select a 4' height from the **Heights** menu, select the Draw Vector Line operator, and draw a line from one segment of the picked face to the other. Observe the result. You can also draw a closed shape, such as a rectangle, to execute a face insertion. If the insertion shape crosses the boundaries of the selected face, the system will automatically execute a Boolean union. After the completion of the operation one of the new faces is returned picked (red). You can double click away from the object to reverse the pick (to cause the other face to be selected). You can continue inserting on the picked face to possibly produce a staircase, as shown.

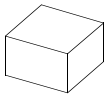


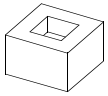




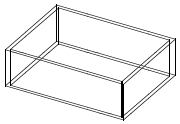


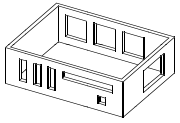
Again, **Undo** to return to the original cube. To insert a hole, select the top face of the cube, select the Insert Hole operator (), select a negative height from the **Heights** menu, select the Draw Rectangle icon, and draw a rectangle as shown. Observe the result. If the height is large enough, the hole will be drilled all the way through the object. A negative height is needed because the hole is drilled towards the inside of the object. The hole insertion is executed as a boolean difference.





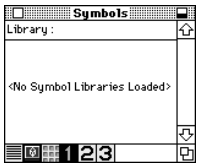
The Insert Opening () tool inserts "holes" directly (does not use a Boolean). It is faster, but the hole needs to be completely contained within the boundary of the face. The opening is drilled all the way through the object. Generate an enclosure, as shown, set the topological level to Face (make certain that the one point face pick option is still selected), select the Insert Opening tool, select the Draw Rectangle tool, and draw rectangles on the walls of your enclosure. You notice that the operation is executed even though you did not preselect a face. This is made possible by the one point face pick. The face is picked from the first point you draw.





Symbols

Symbols is a method by which entities which must be repeated in a project may be entered into Libraries and then placed as instances as many times as is appropriate.



There are four tools for symbols:

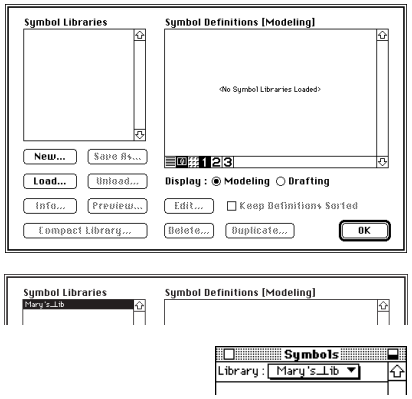
Define Symbol

Place Symbol

Edit Symbol Definition

Explode Symbol

If the Symbols palette does not appear on your screen, open it (select **Symbols** from the **Palettes** menu). It should appear with the note "No Symbol Libraries Loaded" displayed.



To define a new symbol you need to have a Symbol Library open (loaded). You may already have a Symbol Library which you can load and then add symbols to it or place symbols from it. However, now you will start a new Library in which you will save two symbol definitions.

- Click on the top bar of your symbol palette (next to the word "Library:").
- When the **Symbol Definitions** dialog appears, click on **New...**.
- When the **New Name** dialog appears, enter a name and click on **OK**.

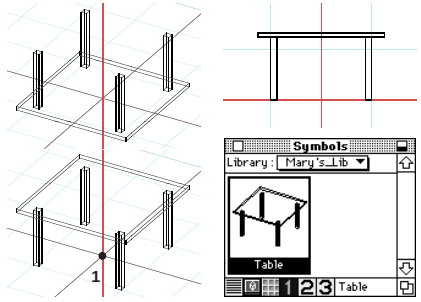
We entered "Mary's_Lib". You notice that the name you type appears in the **Symbol Libraries** window of the dialog. When you click **OK**, the dialog closes and the name you typed appears in the title of your Symbols palette. Mary's_Lib is empty. You will next save a symbol definition in it.

- Generate five rectangular extrusions that represent a table, as shown.

We did it by working in 1:1 scale, setting the snapping module to 3", turning grid snapping on, and using heights 2'-6" for the legs, and 2" for the top piece of the table. The latter was first created on the XY reference plane and then moved to the top of the legs. You will next define a symbol that consists of the objects you just created.

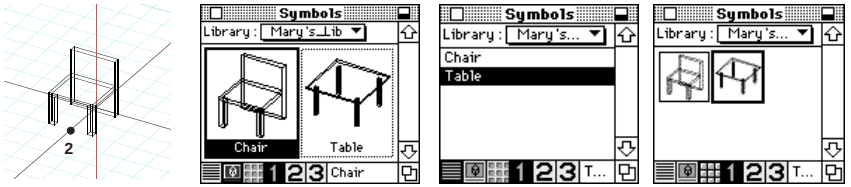
- Preselect the five objects.
- Select the Define Symbol tool and click on point **1** (origin of XY plane).
- When the **Name** dialog appears, enter "Table," and click on **OK**.

The symbol you just defined appears in the Symbols palette, as shown.

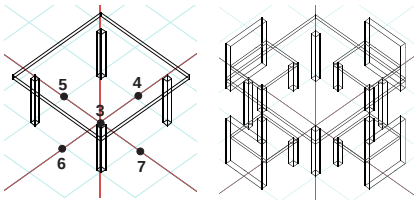


Where you click (point **1**) when you define a symbol is very significant. It establishes the position of the ***symbol origin***. When placing the symbol, where you click in the graphics window will define the location of the symbol origin and, therefore, the position of the symbol.

You will next define one more symbol. To better see what you are doing, delete the previous symbol (select the Delete tool and click on it). Generate the model of a chair, roughly as shown, then define it as a symbol by repeating the previous process. Click on point **2** to establish its origin, and enter "Chair" for its name. When the process is complete, the second symbol appears next to the first in the palette.

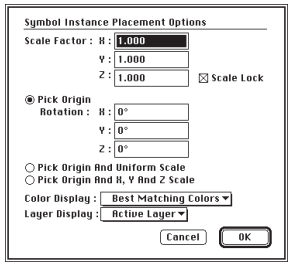


On the lower margin of your palette there are a few small icons. Click on the first (left to right), then click on the third and observe how your palette changes. This shows you that there are three formats in which your symbols can be displayed in the palette, including one which shows only their names. You will next place instances of the symbols you just defined. Delete the chair symbol to start with a clear project.

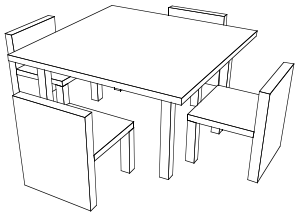


- Click on the Table symbol in the palette to make it active.
- Select the Place Symbol tool.
- Click on point **3** (origin of XY Plane).

A symbol instance is placed as shown.



- Make the Chair symbol active.
- Click on point **4**.
- Double click on the Place Symbol tool to invoke the **Symbol Instance Placement Options** dialog. In its **Rotation: Z:** field enter 90°.
- Click on point **5**.
- Invoke the **Placement** dialog again and for **Rotation: Z:** enter 180°. Then click on point **6**.
- Enter -90° in the Z rotation field of the dialog, click on **7**, and observe the result.



The symbols offer conveniences, save memory, and allow project-wide manipulations. Symbols are available in both the modeling and drafting modules of **form•Z**, and there are many options and variations by which they can be defined, placed, and edited.

Features not covered in this Mini Manual

As already mentioned, **form•Z RenderZone Demo** is a partial version and does not include some major parts of **form•Z**, namely the drafting module and all the export facilities, including saving **form•Z** project files.

• The drafting module is intended to support the modeling tasks. You can transport images of 3D models into the drafting, where you can further refine and annotate them with associative dimensions, titles, or notes. Drawings can also be created directly in drafting, transported into modeling and used as base shapes for the creation of 3D models.

• **form•Z** models can be saved and exported through DXF, EPS, FACT, IGES, Illustrator, OBJ, RIB, STL, VRML, 3GDF, and TIFF file formats under both Mac OS and Windows. On the Macintosh you can also save PICT files, as well as QTVR and on Windows 3DS, BMP, and Metafile file formats. They can also be imported using most of these formats.

In addition to the features missing from **form•Z RenderZone Demo**, a variety of other capabilities that are available in it have not been discussed in this Mini Manual. The most important are:

• The Query tool that allows you to request information about objects and to measure distances. It can also be used to change the shapes of controlled objects (curves and meshes) by changing their parameters.

• The ability to define and apply Macro Transformations, which are composite geometric transformations (move, rotate, resize, and mirror).

• The Cone of Vision function which allows you to manipulate the viewing parameters of a scene, including 3D clipping, with precision.

• The Underlay item which allows you to import bit-mapped images in both the modeling and the drafting modes, in order to trace shapes over them or to use them as backgrounds for modeling scenes.

• The Imager utility that allows you to batch render or print a number of **form•Z** projects in a sequence.

• The ability to save your selection of optional parameters as well as a variety of other system settings in your own Preference files and to tell the system to use your parameters next time you run **form•Z**.

• The ability to copy holes, a rare but very convenient feature.

It should also be noted that even the features that have been discussed in this Mini Manual have not been covered in full detail. **form•Z RenderZone Demo** is intended to give you an overview of how the program works, and to allow you to verify how easy it is to use. If you have not been able to make a conclusive evaluation, you may consider ordering the **form•Z Evaluation** package, which is essentially a complete but time-limited version of the program. If, on the other hand, you have already been able to appreciate the power and friendliness of **form•Z**, we would certainly like to invite you to join the rapidly growing community of **form•Z** users.