8

Mesh Form Modeling

Introducing the Mesh Form Modeler

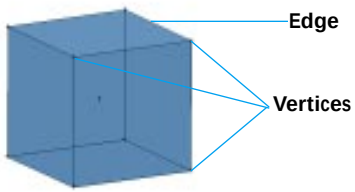
The **Mesh Form** modeler lets you sculpt three-dimensional objects by directly manipulating their surfaces.

When you use the **Mesh Form** modeler, you're not limited to creating objects that can only be modeled as extrusions, you can model objects by directly edit an object's surface.

You can start with a predefined object, such as a sphere or cube, or use the Polymesh modeling tools to generate extrusions, sweeps, lathed objects, and lofted objects. Once you've created an object, you can reshape and refine it by editing the points that define its surface.

Mesh Form Modeling Concepts

Three-dimensional objects can be described as sets of vertices, edges and polygons. A *vertex* defines a position in three-dimensional space and an *edge* is the line that connects two vertices. For example, eight vertices and twelve edges describe a cube. Each face of the cube is a filled polygon.



A Mesh Form object's surface is defined by its vertices.

A *polyline* is a selected set of connected edges. A polyline that forms a closed loop is referred to as a *closed* polyline. A closed polyline is not equivalent to a polygon—a closed polyline might encompass several polygons. However, if you fill a closed polyline that doesn't encompass any other edges or vertices, it becomes a polygon.

A collection of vertices, edges and the polygons that they form is called a *polymesh*. A polymesh can form a closed volume, such as a cube, or an open object resembling a sheet of wire mesh.

Polymesh modeling is the process of creating three-dimensional objects by directly manipulating vertices, edges and polygons. Instead of modeling all objects as extrusions, you can "sculpt" objects by changing the number and location of their vertices, edges and polygons.

By combining the modeling techniques used in the **Free Form** modeler with the ability to directly edit vertices and edges, the **Mesh Form** modeler makes it easy to create complex models. For example, you can use the **Mesh Form** modeler to create a complex cross section and extrusion path, extrude an object, and then directly edit the object's vertices and edges to refine its appearance.

The following sections explain how extruding, sweeping, lathing and lofting differ in the **Mesh Form** modeler. For an introduction to these modeling concepts, refer to"Free Form Modeling" on page 109.

Extruding and Sweeping

When a cross section is *extruded* along a path, its orientation does not change—at every point along the path, the extrusion's cross section is parallel to the original cross section.

When an object is extruded along a path, the cross sections remain parallel to the original cross section.

In contrast, when a cross section is *swept* along a path, its orientation changes so that the cross section of the sweep is always perpendicular to the path..

When an object is swept along a path, the cross sections remain perpendicular to the path.

With the **Mesh Form** modeler, you can:

- Extrude and sweep open and closed polylines selected from existing polymesh objects.

- Extrude and sweep 3-dimensional cross sections.
- Specify complex 3D extrusion and sweep paths using polylines.
- Use selected edges of existing polymesh objects as sweep paths.

For more information about creating extrusions and sweeps with the **Mesh Form** modeler, see "Extruding and Sweeping Polygon and Polyline Cross Sections" on page 164.

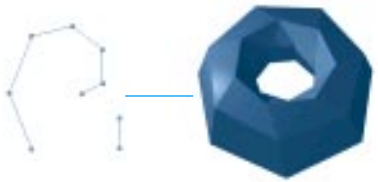
Extruded polygon cross section.

This extruded object was created with the Mesh Form modeler.

Lathing

When you lathe an object with the **Mesh Form** modeler, you specify both the lathe profile and the lathe axis. Unlike the **Free Form** modeler, you do not specify a cross section; all lathed objects created with the **Mesh Form** modeler have circular cross sections.

The **Mesh Form** modeler creates lathed objects by revolving the lathe profile around the specified lathe axis.



Polyline lathe profile and resulting object.

The **Mesh Form** modeler enables you to:

- Define 3-dimensional lathe profiles.
- Use closed polylines as lathe profiles.
- Use any edge in a polymesh object as the lathe axis.

For more information about lathing with the **Mesh Form** modeler, see "Lathing with Polygon and Polyline Profiles" on page 166.

This object was created by rotating a lathe profile around a lathe axis.

Lofting

Lofting, also known as skinning, is the process of stretching a surface over several cross sections to construct a complex object. In the **Mesh Form** modeler, you can easily:

- Create 3-dimensional cross sections.
- Use open and closed polylines selected from existing polymesh objects as cross sections.

The **Mesh Form** modeler performs a straight extrusion from one cross section to the next. Unlike the **Free Form** modeler, the **Mesh Form** modeler only supports one shape or object for each cross section. For more information about lofting with the **Mesh Form** modeler, see "Modeling with Polygon and Polyline Cross Sections" on page 166.

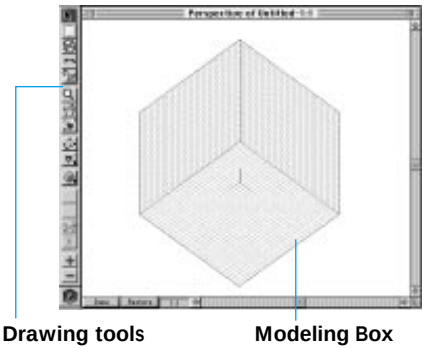
A Loft object is created by stretching a skin over a series of cross sections.

This object was created by lofting several cross sections of different sizes and shapes.

The Mesh Form Modeling Window

You work in the **Mesh Form** modeling window whenever you edit a Polymesh model. You can also open imported models and models created with other modelers in the **Mesh Form** modeler.

When you create a new Mesh Form model by dragging the **Mesh Form Modeling** tool to the scene window, the **Mesh Form** modeling window opens automatically. Your scene's **Perspective** window is temporarily replaced by the **Mesh Form** modeling window, which displays a close-up view of the objects in the model.



The Mesh Form modeling window is used to edit polymesh models.

To create a Mesh Form object:

Drag the **Mesh Form** tool into the **Perspective** or **Time Line** window.

To edit an existing mesh form model:

In the **Scene** window, double-click the model you want to edit.

The model is opened in the **Mesh Form** modeling window.

To use the Mesh Form modeler to edit an imported model or a model created in a different modeler:

1. Select the model you want to edit.
2. Choose **Edit menu▸ Jump In Another Modeler**. The **Choose another Modeler** dialog appears.
3. Select **Mesh Form modeler** from the **Available Modelers** list.
4. Specify the fidelity for the conversion using the **Fidelity** slider.

   The default, 100% divides the object's surface into the recommended number of polygons. A higher percentage generates more polygons, providing more points of control. A lower percentage generates fewer polygons. Regardless of the fidelity of the conversion, some data may be lost and the model altered.
5. Click **OK** to convert the model and open it in the **Mesh Form** modeling window.

When a model is opened in a different modeler than the one it was created in, the model is converted. This conversion can alter the object's appearance.

When the **Mesh Form** modeling window is open, special commands are enabled in the menus and a new set of modeling tools appears in the toolbar, replacing the object creation and camera manipulation tools.

The **Hierarchy** window automatically switches to the **Masters** tab when the **Mesh Form** modeling window is open. Changes you make in the **Mesh Form** modeler affect Master objects, not individual copies of objects. For more information on Master objects, refer to "Working with Master Objects" on page 266.

By default, opening the **Mesh Form** modeling window also opens the **Properties** palette. The tabs in the **Properties** palette provide direct access to both object and tool properties, as well as action attributes you can use to alter the effects of certain operations. For example, the **Action Modifier** tab allows you to change the number of sides in a newly created cylinder.

The **Properties** palette is not automatically displayed if the Properties checkbox has been disabled in the **Mesh Form Modeler Preferences** dialog. See "Setting Preferences for the Mesh Form Modeler" on page 141 for more information.

When you're done editing your model, you can return to the **Scene** window by choosing **File menu▸ Jump Out** or clicking **Done** at the bottom of the **Mesh Form** modeling window. If you want to return to the **Scene** window without preserving your changes, click **Restore**.

Features of the Modeling Window

The **Mesh Form** modeling window contains the mesh form model you're editing. The window displays the objects in the model, the Drawing plane, and a tri-color axis-indicator.

Mesh Form Drawing plane in default position with orientation axes.

The Drawing Plane

All drawing takes place on the two-dimensional Drawing plane displayed in the **Mesh Form** modeling window. Like the **Free Form** modeling window, the planes of the modeling box can be displayed, but the objects' profiles are not projected onto the planes. By default, only the Drawing plane is displayed.

A tri-color axis indicator is located in the center of the Drawing plane when you open the **Mesh Form** modeling window. The X axis is displayed in pink, the Y axis is displayed in red, and the Z axis is displayed in blue.

This indicator shows the orientation of the model's X, Y and Z axes and identifies its origin. All X, Y, Z coordinates for the model are relative to the origin of the axis indicator.

As you move the Drawing plane and the objects in the model, the axis indicator helps you determine the orientation of the objects and your point of view.

If you get confused about which way is up, you can always return to the initial view by choosing **View menu▸ Preset Position▸ Reference**.

Setting Preferences for the Mesh Form Modeler

In the **Mesh Form Modeler Preferences** dialog, you can set preferences for the display of the **Properties** palette, the default welding tolerance, and the grid.

By default, the **Properties** palette is always displayed when the **Mesh Form** modeler is open and Ray Dream Studio automatically switches to the appropriate tab for the current operation. You should normally leave these options enabled—the

Properties palette is integral to the operation of many polymesh modeling features.

The default tolerance value is used when you weld vertices and when vertices are welded as part of a Boolean operation. Vertices are welded if the distance between them is less than or equal to the default tolerance.

By specifying grid settings in the **Mesh Form Modeler Preferences** dialog, you can set up the grid for the **Mesh Form** modeler without affecting the grid settings used for the **Scene** window and other modelers. For more information see "Setting up the Grid" on page 150.

Working in the Mesh Form Modeling Window

The **Mesh Form** modeler lets you freely move the Drawing plane to any plane in the model. When you move the Drawing plane, you often need to change your viewpoint to get a better view of the objects you're working with.

You can use the preset viewing positions in the **View** menu to change your viewpoint, like you can in the **Free Form** modeler.

When you're viewing and editing your model, you'll also frequently want to change between the wireframe editing mode and the preview modes. The **Mesh Form** modeler provides the same preview modes as the **Free Form** modeler.

Changing the Drawing Plane

When editing your model, you can easily move and orient the Drawing plane using the **View** menu and keyboard shortcuts.

To move the Drawing plane to a preset position:

Choose **View menu▸ Send Drawing Plane To▸** and select the position you want: **Left**, **Right**, **Top**, **Bottom**, **Front** or **Back**.

These positions are relative to the Drawing plane's reference position, the position it is in when the **Mesh Form** modeling window is opened.

To align the Drawing plane with a selection:

1. Select the vertex, polygon, or group of vertices with which you want to align the Drawing plane.
2. Choose **View menu▸ Send Drawing Plane To▸ Selection**.

   If the selection is a single vertex, Ray Dream Studio centers the Drawing plane on that vertex without changing the plane's orientation.

   If the selection is a group of vertices or a polygon, Ray Dream Studio moves the Drawing plane to the plane shared by those vertices. If the vertices lie in different planes, the Drawing plane is moved so that the selected points are as near to the Drawing plane as possible.

To move the Drawing plane so that you look directly at it from the current viewpoint:

Choose **View menu▸ Send Drawing Plane To▸ Screen**.

To move the Drawing plane to a particular position:

1. Choose **View menu▸ Send Drawing Plane To▸ Position**. The **Move Drawing Plane** dialog appears.
2. Specify the X, Y, Z coordinates to which you want to move the center of the Drawing plane.

   Ray Dream Studio centers the Drawing plane on that vertex without changing the plane's orientation.

To rotate the Drawing plane:

Choose **View menu▸ Rotate Drawing Plane▸** and select the direction you want to rotate the Drawing plane: **Left**, **Right**, **Front** or **Back**.

The direction of rotation is specified in relation to the current view of the Drawing plane.

To move the Drawing plane back to its original position:

Choose **View menu▸ Reset Drawing Plane**.

The Drawing plane is returned the position it's in when the **Mesh Form** modeling window is opened.

Drawing plane in different positions around an object.

You can also move the Drawing plane by **Command-clicking**/**Ctrl-clicking** when the **Selection** tool or **Sphere of Attraction** tool is active.

To move the Drawing plane to a polygon:

1. Choose the **Selection** tool, **Sphere of Attraction** tool, **Trackball Rotation** tool or **2D Rotation** tool.

2. **Command-click**/**Ctrl+click** the polygon to which you want to move the Drawing plane.

   This moves the Drawing plane to the plane that the polygon is on. If the polygon's vertices aren't all on the same plane, the Drawing plane is moved to the plane that best represents the polygon.

To move the Drawing plane to a vertex:

1. Choose the **Selection** tool, **Sphere of Attraction** tool, **Trackball Rotation** tool or **2D Rotation** tool.

2. **Command-click**/**Ctrl+click** the vertex to which you want to move the Drawing plane.

   Ray Dream Studio centers the Drawing plane on that vertex without changing the plane's orientation. The current selection is not affected.

Changing your Point of View

As you edit your model, you'll frequently change your point of view. For example, when you move the Drawing plane, you often change your viewpoint so you're looking at the Drawing plane. (It can be easier to draw and rotate objects if you're looking directly at the Drawing plane.)

Without changing your point of view to examine an object from all sides, it can be difficult to determine the object's position relative to other objects in the model. When you perform a Boolean operation such as subtraction, this is particularly important—you need to be sure that the objects are actually overlapping for it to work.

To look directly at the Drawing plane:

Choose **View menu▸ Preset Position▸ Drawing Plane** or press **Command-5**/**Ctrl+5**.

To move your viewpoint back to where it was when the Mesh Form modeling window was first opened:

Choose **View menu▸ Preset Position▸ Reference** or press **Command-0**/**Ctrl+0**.

To move your viewpoint to the Top, Bottom, Left, Right, Front or Back:

Choose **View menu▸ Preset Position▸** and select the position you want: **Top**, **Bottom**, **Left**, **Right**, **Front** or **Back**.

You can also move between these preset positions using keyboard shortcuts:

Top: **Command-8/Ctrl+8**
Bottom: **Command-2/Ctrl+2**
Left: **Command-4/Ctrl+4**
Right: **Command-6/Ctrl+6**
Front: **Command-1/Ctrl+1**
Back: **Command-3/Ctrl+3**

To return your viewpoint to the previous position:

Choose **View menu▸ Preset Position▸ Last**.

You can also change your viewpoint with the **Camera Dolly** tool. For more information, refer to "Camera Dolly Tool" on page 146.

Selecting a Preview Mode

By default, the **Mesh Form** modeler displays a Wireframe view of the objects in the model. To view the effects of operations such as emptying a polygon or sharpening edges, you must view the object in one of the preview modes.

To switch preview modes:

Choose **View menu▸** and choose a different preview mode: **Preview**, **Shaded Preview**, **Better Preview**.

Using the Window Controls

Three controls are provided at the bottom of the **Mesh Form** modeling window:

- **Done** returns to the scene window, updating the model with your changes.
- **Restore** returns to the scene window without preserving any modifications to the model.
- **Zoom level** indicates the zoom factor at which the window contents are currently displayed. To change the zoom level, choose a different scale factor from the pop-up.

Working on the Mesh Form Drawing Plane

To create objects with the **Mesh Form** modeler, you use the **Polyline** tool and the Polymesh primitive tools to draw polymeshes, cross-sections, extrusion paths and lathe axes and profiles.

Like the **Free Form** modeler, you always work on a single Drawing plane. However, you can freely move the Drawing plane to any location in the model.

In the **Mesh Form** modeler, all vertices are connected by straight lines. Unlike the **Free Form** modeler, you cannot draw Bézier curves.

This section describes the tools provided in the **Mesh Form** modeler.

Mesh Form Modeler Arranging Tools

The arranging tools provided in the **Mesh Form** modeler are designed to make it easy to manipulate your polymesh objects. In addition to the arranging tools available in the **Scene** window, the **Mesh Form** modeler provides a **Marquee Selection** tool.

Selection Tool

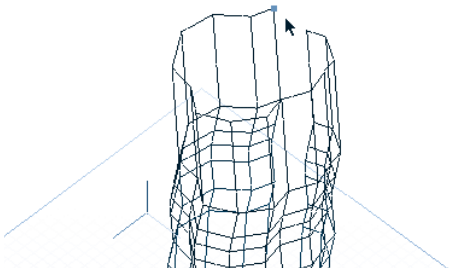
Use the **Selection** tool to select and move vertices, edges, polygons and entire objects. You can also use the **Selection** tool to select and resize objects. For more information about the **Selection** tool, refer to "The Arranging Tools" on page 224.

Selected vertices and edges are highlighted in red. When you select an entire object, its bounding box is displayed and all of its edges are highlighted.

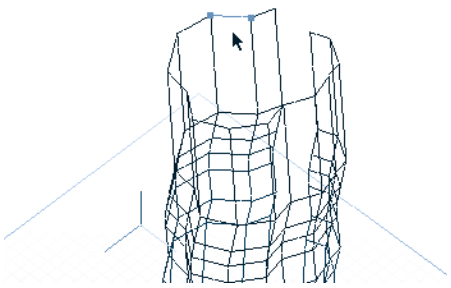
To select a vertex or edge:

1. Choose the **Selection** tool from within the **Mesh Form** modeler.

2. Click the vertex or edge you want to select.



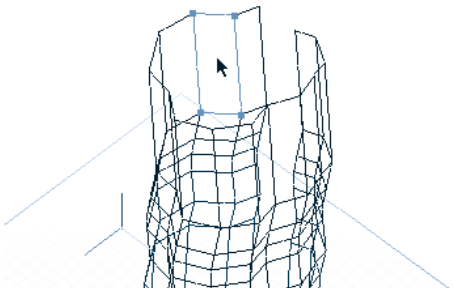
An object with a selected vertex.



An object with a selected edge.

To select a polygon:

1. Choose the **Selection** tool from within the **Mesh Form** modeler.
2. Click in the middle of the polygon you want to select.

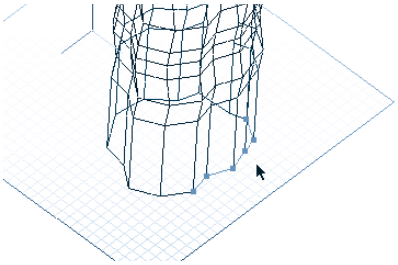


An object with a selected polygon.

To select an edge and all connected edges in the same direction:

1. Choose the **Selection** tool from within the **Mesh Form** modeler.
2. Double-click an edge of the polygon.

   An adjoining edge is considered to lie in the same direction if the angle formed between the selected edge and the adjoining edge is equal to or less than the **Angle of Selection Propagation** specified in the **Properties palette: Tool Options tab**. If the adjoining edge lies in the same direction, it is selected and the angles formed between it and any adjoining edges are evaluated. In this way, the selection propagates until there are no more adjoining edges that meet the selection criteria.



An object with all of the edges in a particular direction selected.

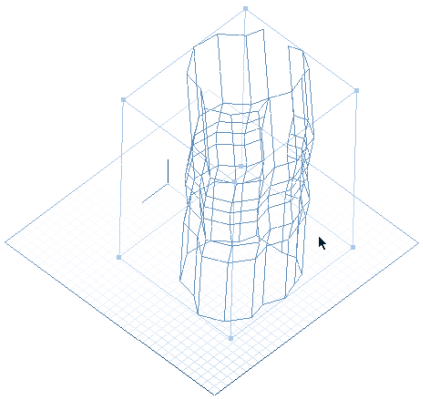
To select a group of objects, edges, and vertices:

1. Choose the **Selection** tool from within the **Mesh Form** modeler.
2. Drag until the marquee encloses the objects you want to select. You must begin the drag outside of the object—to select a group of edges and vertices within an object, use the **Marquee Selection** tool.

   To extend a selection, hold down the **Shift** key before selecting additional objects. To remove an object from the selection, hold down the **Shift** key and reselect the object.

To select an entire object:

1. Choose the **Selection** tool from within the **Mesh Form** modeler.
2. Double-click any vertex or polygon in the object or triple-click any edge.



Double-click any vertex or polygon to select an entire object.

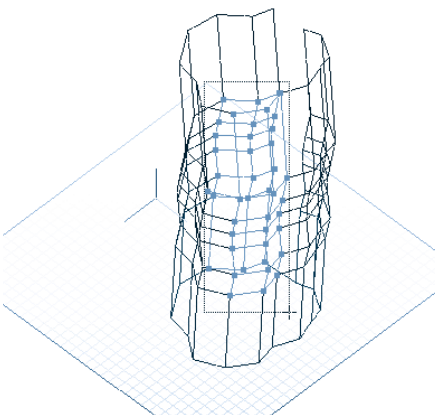
Marquee Selection Tool

Use the **Marquee Selection** tool to select groups of objects, vertices or edges. You must use the **Marquee Selection** tool if you want to select a group of vertices or edges within an object.

To use the Marquee Selection tool to select a group of objects:

1. Choose the **Marquee Selection** tool from within the **Mesh Form** modeler.

2. Drag until the marquee surrounds the objects, edges and vertices you want to select.

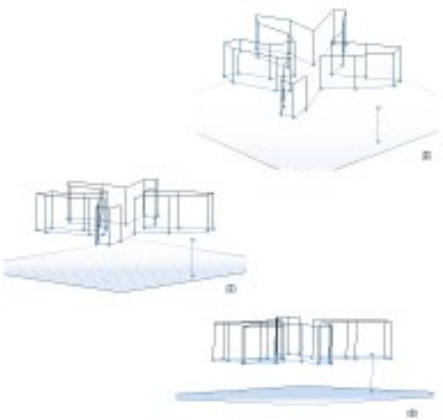


A group of vertices & edges within an object selected.

To extend the selection, hold down the **Shift** key before selecting additional vertices. To remove an object from the selection, hold down the **Option**/**Alt** key and reselect the object.

Camera Dolly Tool

Use the **Camera Dolly** tool to move your viewpoint around the model. This allows you to determine the spatial relationships between objects in the model.



A series of views of an object in the Mesh Form modeling window from different positions set with the Camera Dolly tool.

To change your view point:

1. Choose the **Camera Dolly** tool from within the **Mesh Form** modeler.

2. Drag in the **Mesh Form** modeler until you have the desired view point.

You can also dolly the camera with the numeric keypad: **8** and **2** dolly the viewpoint up and down, **4** and **2** dolly the viewpoint left and right, and **1** and **3** rotate the viewpoint around the Drawing plane axis. In Windows, **Numlock** must be on to dolly the camera with the keypad.

The **View** menu allows you to change your viewpoint to several preset positions. For more information, refer to "Changing the Drawing Plane" on page 142.

Hand Tool

Use the **Hand** tool to adjust your view of the window contents. The **Hand** tool lets you scroll your view up, down, left or right without using the scrollbars. Press the spacebar to temporarily invoke the **Hand** tool when another tool is active.

To use the Hand tool:

1. Choose the **Hand** tool from within the **Mesh Form** modeler.

2. Drag within the **Mesh Form** modeling window to move the window's contents left, right, up, or down.

Zoom Tool

Use the **Zoom** tool to magnify or reduce the window's view. You can also zoom in and out with **Command- +/Ctrl+ +** and **Command- –/Ctrl+ –**. To switch to a particular magnification level, use the **Zoom level** pop-up at the bottom of the **Mesh Form** modeling window.

To use the Zoom tool:

1. Choose the **Zoom** tool from within the **Mesh Form** modeler.

2. Click in the **Mesh Form** modeling window to zoom in.

   Option-click/Alt+click in the **Mesh Form** modeling window to zoom out.

   Drag with the **Zoom** tool to zoom in on a particular item.

Plane Display Tool

Use the **Plane Display** tool to change the plane display in the **Mesh Form** modeling window.

When you drag an object in the **Mesh Form** modeling window, gray altitude lines show the object's position relative to the visible planes. Because of the potential complexity of **Mesh Form** models, 2D projections of the objects in the model are not displayed on the visible planes.

To use the Plane Display tool:

1. Choose the **Plane Display** tool from within the **Mesh Form** modeler.

2. Click on the representation of the plane you want to show or hide.

   Option-click/Alt+click on the representation of a plane in the **Plane Display** tool to select it as the Drawing plane.

Mesh Form Modeler Drawing Tools

The **Mesh Form** modeler provides several tools that you can use to create and edit objects in the **Mesh Form** modeling window:

- **Polyline** tool
- **Sphere of Attraction** tool
- **Add Vertex** tool
- **Delete** tool
- **Polymesh Primitive** tool
- **Extrude** tool

- **Sweep** tool
- **Lathe** tool
- **Loft** tool
- **Increase Action Modifier**
- **Decrease Action Modifier**

Polyline Tool

Use the **Polyline** tool to draw two and three-dimensional polylines. The polylines can be open or closed.

A polygon and a polyline drawn with the Polyline tool.

Polylines can be used as cross sections, extrusion and sweep paths, and lathe profiles.

When drawing with the **Polyline** tool, you add one vertex at a time. Edges are automatically drawn between each vertex.

The **Polyline** tool is not a Bézier drawing tool; points in a polyline or polygon are always connected by straight lines.

Sphere of Attraction Tool

Use the **Sphere of Attraction** tool to attract a group of vertices in an object. The **Sphere of Attraction** tool behaves like a magnet, pulling the vertices and edges within its sphere away from their original locations.

You can set properties for the **Sphere of Attraction** tool on the **Properties palette: Tool Options tab**. The tool options allow you to control:

- The shape of the attraction curve.
- The radius of the sphere of attraction.
- Whether nearby edges and vertices are attracted or only the selected vertices and edges are attracted.

Add Vertex Tool

Use the **Add Vertex** tool to add vertices to existing edges. This is useful when you need more control over the object than is provided with the existing vertices.

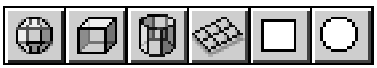
Delete Tool

Use the **Delete** tool to remove vertices and edges from an existing object. You can also use the **Delete** tool to empty a polygon.

Removing a vertex also removes any edges connected to the vertex.

Removing an edge does not affect the vertices that it connected.

Emptying a polygon doesn't affect the vertices or edges surrounding the polygon. It simply converts the polygon to a closed polyline by removing the polygon face.



Polymesh Primitive Tools

Use the **Polymesh Primitive** tools to quickly create standard objects of any size:

- **Sphere** tool—create a sphere.
- **Cube** tool—create a cube
- **Cylinder** tool—create a cylinder.
- **Mesh** tool—create a 2D array of vertices.
- **Rectangle** tool—create a 2D rectangle.
- **Ellipse** tool—create a 2D ellipse.

You can set properties for the **Sphere**, **Mesh**, **Cylinder** and **Ellipse** tools, on the **Properties palette: Tool Options tab**. These properties affect all subsequent objects created with the tool.

- **Mesh tool options** allows you to specify the number of vertices in new meshes. The number of vertices doesn't affect the size of the mesh.
- **Sphere tool options** allows you to specify the number of polygons in new spheres. A greater number of polygons creates a smoother sphere.
- **Cylinder tool options** allows you to specify the number of sides in new cylinders. The more sides that a cylinder has, the smoother its surface.
- **Ellipse tool options** allows you to specify the number of edges in the ellipse. The more edges an ellipse has, the smoother its circumference.

The actual number of polygons or sides in an object might differ from the value you specify in the **Tool Options** or **Action Modifiers** tab. For example, if you specify 59 as the number of polygons in a sphere and create a sphere, that sphere might actually contain 60 polygons. The **Properties palette: Numerical tab** displays the actual values for a particular object.

To change newly created objects, you can edit the options in the **Action Modifiers** tab.

Extrude Tool

Use the **Extrude** tool to create an extrusion from a profile and an extrusion path. For more information, refer to "Extruding and Sweeping" on page 138.

Sweep Tool

Use the **Sweep** tool to create a sweep object from a profile and a sweep path. For more information, refer to "Extruding and Sweeping" on page 138.

Lathe Tool

Use the **Lathe** tool to create a lathed object from a lathe profile and a lathe axis. For more information, refer to "Lathing" on page 139.

Loft Tool

Use the **Loft** tool to stretch a skin over a group of selected polylines. For more information, refer to "Lofting" on page 139.

Action Modifier Tools

Use the **Action Modifier Increase** and **Decrease** tools to modify the result of the last action. These tools provide a shortcut to the functions provided by the **Properties palette: Action Modifier tab**. They have different effects depending on what the last action was. The **+** and **–** keys have the same effect as the **Action Modifier** tools.

When an object is created with the **Sphere**, **Cylinder**, **Mesh** or **Ellipse** tool, the **Action Modifiers** can be used to smooth or sharpen the object by increasing or decreasing the number of polygons, edges or vertices defining the object.

For example, when you create a cylinder, you can select the **Increase Action Modifier** tool to add more sides to the cylinder. Similarly, you can use the **Decrease Action Modifier** tool to reduce the number of vertices in a newly created mesh.

When you create objects with the **Extrude**, **Sweep**, and **Lathe** commands, the **Action Modifiers** can be used to change which object is used as the cross section or profile.

When you use the **Boolean Operations** command, the operation defaults to the previous operation type (**Union**, **Intersection** or **Subtraction**). You can use the **Action Modifiers** to change operation types.

The **Action Modifiers** can also be used in conjunction with the **Sphere of Attraction** tool: the **Action Modifiers** increase and decrease the radius of the sphere of attraction.

For more information, refer to "Modifying the Last Action" on page 150.

Setting up the Grid

You can use the grid to precisely position objects on the Drawing plane. When **Snap To** is enabled, objects are automatically snapped to the nearest grid intersection when they are dragged. By changing the grid, you can control where objects are snapped.

You can control the grid used in the **Mesh Form** modeler independently of the grid used in the **Perspective** window and other modelers. To set up the grid for the **Mesh Form** modeler, you change the grid options in the **Mesh Form Modeler** preferences.

When you return to the **Perspective** window, the grid settings revert to the settings last specified in the **Grid** dialog.

To make global changes to the grid settings, choose **View menu▸ Grid**. For more information, refer to "Changing Grid Options and Color" on page 226.

To set up the grid for the Mesh Form modeler:

1. Choose **File menu▸ Preferences** or press **Command-Shift-P/Ctrl+Shift+P**. The **Preferences** dialog appears.
2. Choose **Mesh Form Modeler** from the pop-up.
3. In the **Grid Settings**, specify the grid spacing increment and choose a unit from the pop-up.

   The **Spacing** increment is also used for "nudging" (moving an object with an **Arrow** key).
4. Change the **Draw a Line Every** value to control how many grid lines are drawn.

   This value sets the number of increments between grid lines. When set to 1, there is one increment for every grid line and nudging an object moves it to the next grid line.
5. Change the **Number of Steps** to control the size of the grid.

   The size of the grid is the number of steps multiplied by the spacing increment. For example, if you want to multiply the grid frequency by 2, you need to double the number of steps and reduce the spacing increment by half.
6. If you want to hide the grid lines, disable **Show Grid**.

   The grid doesn't have to be displayed for **Snap to Grid** to work.
7. Enable **Snap to Grid** if you want objects to "jump" to the nearest grid increment when you drag them.

Modifying the Last Action

When you're creating new objects or performing complex actions such as **Boolean Operations**, you might not get the results you want on the first try. To make it easier to modify the results, the **Mesh Form** modeler provides a special feature for modifying the last action.

You can use the **Action Modifier** tools to step through changes, or you can enter values directly in the **Properties palette: Action Modifiers tab**. The action modifiers are not available for all operations, but do allow you to change:

- Newly created spheres, cylinders and meshes

- Newly created extrusions, sweeps, and lathed objects.
- Objects modified with the **Sphere of Attraction** tool.
- Objects created with the Boolean operations.

In most cases, the options that you can modify in the **Action Modifier** tab correspond to the Drawing tool's options.

Creating Polymesh Objects

A polymesh object is any polymesh created in the **Mesh Form** modeler, or created with another modeler and opened in the **Mesh Form** modeler.

Instead of just being able to manipulate an object's profile or cross section, you can manipulate any part of a Polymesh object's surface. You have complete control over all of the vertices and edges that describe the object.

This section describes how to create objects by drawing with the **Polyline** tool, using the **Polymesh Primitive** tools, and duplicating existing objects. For information about editing Polymesh objects, refer to "Working with Selections" on page 153, "Working with Vertices" on page 154, "Working with Polymesh Objects" on page 156 and "Transforming Polymesh Objects and Selections" on page 161.

To create more complex objects, you can generate extrusions, sweeps, lathed objects lofted objects in the **Mesh Form** modeler. For more information, refer to "Using Standard Modeling Techniques to Create Complex Polymesh Objects" on page 164. The **Mesh Form** modeler also allows you to generate complex objects by performing Boolean operations on existing objects. For more information. refer to "Using Boolean Operations to Create Complex Polymesh Objects" on page 167.

Drawing with the Polyline Tool

With the **Polyline** tool, you can draw open and closed polylines. The cursor changes to indicate when you have completed a polyline by closing it or clicking twice on its end point.

To draw an open polyline:

1. Choose the **Polyline** tool from within the **Mesh Form** modeler.
2. Click in the **Mesh Form** modeling window to add each vertex in the polyline.

   Vertices are added to the current Drawing plane. Hold down the **Option**/**Alt** key to draw vertices perpendicular to the Drawing plane.

   Edges are automatically drawn to connect the vertices. To constrain the polyline to 45° angles, hold down the **Shift** key.
3. Click the last vertex again to finish the polyline.

To draw a closed polyline:

1. Select the **Polyline** tool from within the **Mesh Form** modeler.
2. Click in the **Mesh Form** modeling window to add each vertex in the polyline.
3. Close the polyline by clicking again on the first vertex.

To create polygons, you can fill closed polylines. For more information, refer to "Creating and Filling Holes in an Object" on page 158.

Drawing with the Polymesh Primitive Tools

You can use the **Polymesh Primitive** tools to create an object that you can "sculpt" with the editing tools. The cube, sphere, or cylinder is like a block of clay that you can reshape into a finished object.

To draw an object:

1. Choose the **Sphere**, **Cube**, **Mesh**, **Rectangle** or **Ellipse** tool from within the **Mesh Form** modeler.

   These tools all share the same space on the toolbar and are considered **Polymesh Primitive** tools.

2. Click the Drawing plane to add the object. You can drag to create an object of a particular size.

   Hold down the **Shift** key to constrain a new mesh or rectangle to a square, or to constrain a new ellipse to a circle.

Duplicating Polymesh Objects

You can duplicate an object with the **Edit** menu commands **Duplicate** and **Duplicate with Symmetry**.

When you choose **Duplicate**, a second copy of the object is created at the same location as the original.

When you choose **Duplicate with Symmetry**, the copy created mirrors the original object. In the **Mesh Form** modeler, the Drawing plane is used as the mirror plane. This allows you to control where the mirrored object is placed by moving the Drawing plane in relationship to the object you're duplicating.

To duplicate an object:

1. Select the object you want to duplicate.
2. Choose **Edit menu▸ Duplicate** or press **Command-D/Ctrl+D**.

To duplicate an object with symmetry:

1. Adjust the Drawing plane so that when used as the mirror plane, it will reflect the appropriate image.

   For example, if you have modeled the fuselage of an airplane and one wing, you can duplicate the wing and place it in the correct location if you move the drawing place so that it bisects the fuselage vertically.

2. Select the object you want to mirror.
3. Choose **Edit menu▸ Duplicate with Symmetry** or press **Command-Option-D/Ctrl+Alt+D**.

Objects can be duplicated with symmetry.

For more information about **Duplicate** and **Duplicate with Symmetry**, refer to "Duplicating Objects" on page 247.

Specifying Object Properties

The **Properties palette: Numerical tab** displays the properties of the selected object, vertices, edge or polygon.

You can use the **Numerical** tab to:

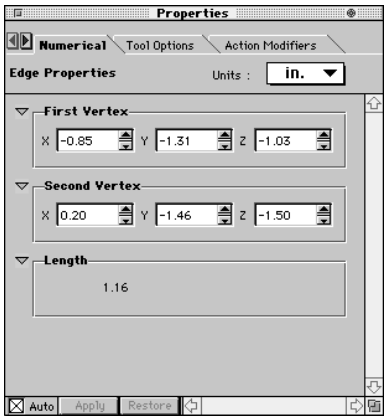
- Move selected vertices to particular X, Y, Z coordinates.
- Move selected objects to particular X, Y, Z coordinates.

When one vertex is selected, the **Numerical** tab displays the X, Y and Z coordinates of the vertex.

When two discontinuous vertices are selected, the **Numerical** tab displays the distance between the vertices and the vertices' X, Y and Z coordinates.

When an edge is selected, the **Numerical** tab displays the length of the edge and the X, Y and Z coordinates of the edge's vertices. In addition, the tab displays a set of radio buttons that indicates the edge's current smooth setting. **Smooth** indicates that the Smooth command has been applied to the edge, **Automatic** indicates that the smooth setting is calculated from

the crease angle, and **Sharp** indicates that the **Sharpen** command has been applied to the edge.



Properties palette with Numerical tab visible and an edge selected.

When a polygon is selected, the **Numerical** tab displays the coordinates of the polygon's center and the number of vertices in the polygon.

When one polymesh object is selected, the **Numerical** tab displays the number of vertices and edges in the object; the number of polygons or sides in the object, and the current crease angle.

When multiple objects are selected, the **Numerical** tab displays the number of selected vertices, edges, polygons and polymeshes.

To specify object properties in the Numerical Properties tab:

1. Select the object whose properties you want to change.
2. Choose **Properties palette: Numerical** tab.
3. Directly edit the displayed values.

   By default, all values are specified in inches. To change units, select the units pop-up and choose **ft**, **cm**, **m**, **mm**, or **pts**.
4. Click **Apply**.

   If **Auto** is enabled, the changes are applied automatically.

Working with Selections

To make it easier to work with complex polymesh objects, the **Mesh Form** modeler allows you to save and restore , invert , and hide selections.

Saving and Restoring Selections

When you're working with complex objects, it's often convenient to save selections of groups of objects so that you can easily reselect them.

You can only have one saved selection at a time.

To save the current selection:

Choose **Selection menu▸ Save Selection**.

To restore the saved selection:

Choose **Selection menu▸ Restore Selection**.

Inverting the Current Selection

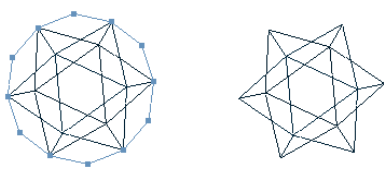
Inverting the selection selects only those items that are not part of the current selection.

To invert the current selection:

Choose **Selection menu▸ Invert**.

Hiding Selections

When you're editing a complex object, you might want to hide parts of the object to make it easier to view and select the vertices and edges you want to work with.



Selected vertices hidden using the Hide Selection command.

To hide a selection:

1. Select the vertices and edges you want to hide.
2. Choose **View menu▸ Hide Selection**.

To reveal hidden vertices in an object:

1. Select the object.
2. Choose **View menu▸ Reveal Vertices**.

Working with Vertices

The real power of the **Mesh Form** modeler lies in the fact that you can directly edit polymesh objects. By moving vertices and edges, adding vertices, removing selected vertices and edges, and joining separate objects, you can model just about anything you can imagine.

Adding and Removing Vertices

Adding a vertex provides you with another point that you can manipulate to modify the object.

You can add and remove individual vertices with the **Add** and **Remove Vertex** tools. You can also remove selected items, including vertices, by pressing the **Delete**/**Backspace** key.

Removing a vertex also removes any edges connected to that vertex.

Vertices removed using the Decimate command.

To add a vertex:

1. Select the **Add Vertex** tool from within the **Mesh Form** modeler.
2. Click an edge where you want to add the vertex. The new vertex is highlighted in red.

   You can drag with the **Add Vertex** tool to add and immediately move a new vertex.

To remove a vertex:

1. Select the **Delete** tool from within the **Mesh Form** modeler.
2. Click the vertex you want to remove. Removing a vertex also removes the edges that connected the vertex to other vertices.

Selected vertices can be removed with the **Delete**/**Backspace** key and the **Edit menu▸ Delete command**.

You can also remove edges with the **Remove Vertex** tool. Deleting an edge does not affect the vertices.The result is the same as selecting the edge and choosing **Selection menu▸ Unlink**.

Linking and Unlinking Vertices

You can close or extend a polyline by linking two vertices. Linking vertices creates an edge between them. Unlinking vertices removes the edge that connects them, but does not affect the vertices themselves.

Closing a polyline does not turn it into a polygon. If you want to create a polygon from a closed polyline, select it and choose **Selection menu▸ Fill Polygon**.

To link vertices:

1. Select the vertices you want to link.
2. Choose **Selection menu▸ Link**.

An edge is created to connect the vertices. If the two vertices are part of the same polygon, the polygon is divided into two smaller polygons.

To unlink vertices:

1. Select the vertices you want to unlink.
2. Choose **Selection menu▸ Unlink**.

The edge connecting the two vertices is removed. You can also unlink two vertices by clicking the edge with the **Delete** tool.

Moving Vertices and Edges

The power of polymesh modeling lies in the ability to change an object by directly positioning its vertices and edges.

You can use the **Object Selection** tool to drag any selection to a new location. For example, you can move a polygon by clicking in its center and dragging it.

When you drag a selection in the **Mesh Form** modeling window, the selection is moved in relationship to the current Drawing plane. Gray altitude lines show the object's position relative to the visible planes.

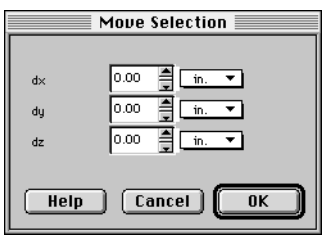
Repositioning Vertices

In the **Mesh Form** modeler, you can precisely reposition vertices by:

- Offsetting a vertex from its current location with the **Move** command.
- Changing the coordinates of a vertex with the **Properties palette: Numerical tab**.

To move vertices numerically:

1. Select the vertex or vertices you want to move.
2. Choose **Selection menu▸ Move**. The **Move** dialog appears.



Use the Move dialog to move vertices numerically.

3. Enter the amounts you want to move the vertices in the X, Y and Z directions and click **OK**.

To move a vertex to an exact location:

1. Select the vertex you want to move.
2. Choose **Properties palette: Numerical** tab.
3. Specify the X, Y, Z coordinate for the vertex and click **Apply**.

If **Auto** is enabled in the **Properties** palette, the changes are automatically applied.

Moving Vertices with the Sphere of Attraction Tool

You can selectively move vertices in an object with the **Sphere of Attraction** tool. This tool behaves like a magnet, attracting the vertices within its sphere of influence.

The **Properties palette: Tool Options tab** allows you to change the shape of the attraction curve, adjust the radius of the tool's sphere of influence, and specify an attraction mode.

You can set the attraction curve to one of four profiles: **Cubic spline**, **Linear**, **Spiky** or **Bumpy**.

There are two attraction modes:

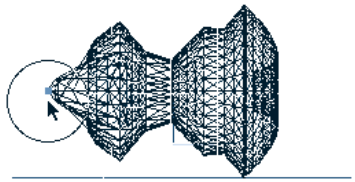
- Move selection, attract other vertices. Selected vertices are moved like they would be with the **Selection** tool, other vertices within the sphere of attraction are moved towards the location of the selected vertices.

- Attract only selected vertices. Selected vertices are attracted with the **Sphere of Attraction** tool, other vertices are not affected.

To move a group of vertices:

1. Choose the **Sphere of Attraction** tool from within the **Mesh Form** modeler.
2. In the **Properties palette: Tool Options tab**, select an attraction curve: **Cubic spline**, **Linear**, **Spiky** or **Bumpy**.
3. Specify the radius of the sphere of attraction.
4. Select an attraction mode by enabling **Move selection**, **attract other vertices** or **Attract only selected vertices**.
5. With the **Sphere of Attraction** tool, select the vertices you want to move or attract.
6. Drag the **Sphere of Attraction** tool in the direction you want to move the vertices.

   To constrain the move operation to the direction perpendicular to the Drawing plane, hold down the **Option**/**Alt** key.



Deforming an object with the sphere of attraction tool.

Welding Vertices

You can join separate objects by welding the vertices where they meet.

Normally, if two vertices are within a specified distance from each other, they are welded when you use the **Weld** command. However, if welding the vertices would cause a single edge to be shared by more than two polygons, the vertices are not joined.

Two objects to join by welding vertices.

To weld vertices:

1. Select the vertices to be welded.
2. Choose **Selection menu▸ Weld**. The **Weld** dialog appears.
3. Indicate how close the vertices must be to be welded and click **OK**.

   Use Default Tolerance welds the vertices if the distance between them is within the default tolerance specified in the **Mesh Form Modeler** preferences.

   Use Custom Tolerance allows you to specify the maximum distance vertices can be from each other and still be welded.

   Weld every selected vertex welds the selected vertices no matter how far apart they are.

   Welded vertices are joined into a single vertex.

Working with Polymesh Objects

The **Mesh Form** modeler provides a number of ways to manipulate an object's surface without directly editing individual vertices and edges. This section describes how you can:

- Adjust the position of vertices, edges, and polygons to align two objects.
- Add depth to an object's surface to give it a visible shell.
- Create and fill holes in an object's surface.

- Smooth or sharpen an object's surface.
- Increase the number of polygons that describe an object's surface, giving you more control over its shape and appearance.

Aligning Polymesh Objects

You can adjust the alignment of two objects by aligning part of one object with part of another. Using the **Adjust** command, you can align vertices, edges, or polygons. For example, you could use **Adjust** to snap a lid on a can by selecting one vertex on the lid and the corresponding vertex on the can.

To align a vertex in one object with the vertex in another:

1. Select the two vertices you want to align.
2. Choose **Polymesh menu▸ Adjust**. The **Adjust** dialog appears.
3. Specify which vertex is the anchor, the one that should remain in its current position.

   In the **Mesh Form** modeling window, the vertex highlighted in blue is the anchor. Click one of the blue anchor arrows in the **Adjust** dialog to select the other vertex as the anchor.
4. When you've selected the anchor, click **OK** to align the vertices.

To align an edge in one object with the edge in another:

1. Select the two edges you want to align.
2. Choose **Polymesh menu▸ Adjust**. The **Adjust** dialog appears.
3. Use the blue Anchor arrows to specify which edge is the anchor, the one that should remain in its current position.

   In the **Mesh Form** modeling window, the edge highlighted in blue is the anchor. To select the other edge as the anchor, click one of the blue anchor arrows.
4. When you've selected the anchor, click **OK** to align the edges.

   The edge specified as the anchor isn't moved. The other edge is aligned and centered along the anchor edge.

To align a polygon in one object with the polygon in another:

1. Select the two polygons you want to align.
2. Choose **Polymesh menu▸ Adjust**. The **Adjust** dialog appears.
3. Use the blue Anchor arrows to specify which polygon is the anchor, the one that should remain in its current position.

   In the **Mesh Form** modeling window, the polygon highlighted in blue is the anchor. To select the other polygon as the anchor, click one of the blue anchor arrows.
4. When you've selected the anchor, click **OK** to align the polygons.

   The polygon specified as the anchor isn't moved. The other polygon is centered with the anchor polygon.

Adding Thickness to an Object

To add thickness to an object, you can perform a straight extrusion on all or part of its surface. To make this easy, the **Mesh Form** modeler provides an **Add Thickness** command.

When you use this command, a straight extrusion with the specified depth is performed on each polygon in the selection.

Object with added thickness.

To add thickness to an object:

1. Select the part of the object to which you want to add thickness.
2. Choose **Selection menu▸ Add Thickness**. The **Add Thickness** dialog appears.
3. Specify how thick you want the surface to be and then click **OK**.

Creating and Filling Holes in an Object

Polymesh objects do not have to be completely solid. You can cut holes in an object by emptying polygons on the object's surface.

You can also cut away parts of an object by using the **Boolean Subtraction** operation. For more information see "Using Boolean Operations to Create Complex Polymesh Objects" on page 167.

Emptying a polygon to create a hole in an object.

To create a hole in an object:

1. Select the polygons you want to remove to create the hole.
2. Choose **Selection menu▸ Empty Polygon**.

   You can also empty polygons with the **Delete** tool.

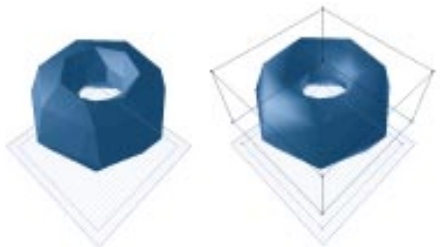
Filled and empty polygons appear the same in the **Wireframe** view. To view the hole, switch to one of the preview modes: **Preview**, **Preview Shaded**, or **Better Preview**.

To fill a hole in an object:

1. Select the closed polyline that you want to fill.
2. Choose **Selection menu▸ Fill Polygon**.

Smoothing and Sharpening Edges in an Object

When an object such as a sphere is rendered, the individual polygons are shaded to appear smooth. In some cases, you do not want smooth shading from one polygon to the next—the edge shared by the polygons might represent a crease in the object's surface.



Sharpened and smoothed edges of an object.

The **Mesh Form** modeler provides two different ways to smooth or sharpen edges on an object's surface:

- Smoothing or sharpening selected parts of an object with the **Smooth** and **Sharpen** commands.
- Smoothing or sharpening an entire object by increasing or decreasing its crease angle.

Setting the crease angle allows you to control smoothing and sharpening for an entire object. Polygons on the object's surface that meet at an angle less than the crease angle, are shaded smoothly. Edges where polygons meet at an angle greater than the crease angle, are rendered as creases in the object's surface.

To adjust the crease angle:

1. Select the object.
2. Choose **Polymesh menu▸ Set Crease Angle**. The **Crease Angle** dialog appears.
3. Enter a value in degrees for the crease **Angle**.
4. Enable the **Override edge settings** checkbox to override the effects of the **Smooth Edges** and **Sharpen Edges** commands.
5. Click **OK** to set the crease angle.

You can view the results in one of the preview modes.

To smooth edges in an object:

1. Select the edges you want to smooth.
2. Choose **Polymesh menu▸ Smooth Edges**.

You can view the results in one of the preview modes.

To sharpen edges in an object:

1. Select the edges you want to sharpen.
2. Choose **Polymesh menu▸ Sharpen Edges**.

You can view the results in one of the preview modes.

To determine an edge's smooth state:

Select the edge and check the **Properties palette: Numerical tab**.

Controlling the Number of Vertices and Edges Used to Describe an Object

The **Mesh Form** modeler provides three commands that allow you to change the number of vertices and edges used to describe an object: **Triangulate**, **Subdivide**, and **Decimate**.

When a polygon is triangulated, edges are added to divide the polygon into smaller, triangular polygons.Triangulating a polygon doesn't affect the number of vertices in the polygon. When a polygon is subdivided, it's triangulated and then vertices are added to divide each triangle into four smaller triangles. Triangulating a three-sided polygon has no effect, but you can subdivide a triangle.

Decimating an object reduces the number of vertices and edges in the object.

You can triangulate, subdivide, or decimate an entire object or just selected portions of the object.

An object with added vertices using the Subdivide command.

Triangulating an Object

When you edit an object, you might create some large, odd-shaped polygons. When rendered, these polygons can make the object look blocky. To create more natural looking transitions across the surface of the object, you can use triangulate to add edges that you can adjust to create a smoother shape.

Triangulate can also be used in conjunction with the **Decimate** command to produce more satisfactory results.

An odd-shaped polygon triangulated.

To triangulate selected polygons:

1. Select the polygons you want to triangulate.
2. Choose **Selection menu▸ Triangulate Polygon**.

Subdividing an Object

Subdividing an object adds vertices and edges to give you finer-grain control over an object's surface.

To subdivide selected polygons:

1. Select the polygons you want to subdivide.
2. Choose **Selection menu▸ Subdivide**.

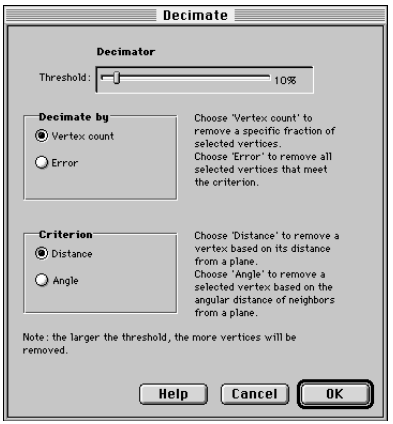
Decimating an Object

Decimating an object is an easy way to simplify imported models that contain more detail than you need. In some situations, though, decimating an object is counter-productive—you often want more control over an object's surface, not less.

To get the best results when you're decimating an object, you might want to alternate decimating the object and triangulating the object. For information about triangulating, refer to "Triangulating an Object" on page 160.

To decimate an object:

1. Select the object or portion of an object that you want to decimate.
2. Select **Selection menu▸ Decimate**. The **Decimate** dialog appears.



Use the Decimate dialog to decrease the number of vertices in your object.

3. Adjust the **Threshold** slider to specify the percentage of vertices to be removed.

   The higher the threshold, the more vertices will be removed.

4. Select the decimate technique to be used by enabling either **Vertex count** or **Decimate**.

   Vertex count removes the percentage of vertices specified in the **Threshold** slider.

Decimate removes the vertices that meet the decimate criteria, up to the threshold percentage.

5. Select the decimate criteria by enabling either **Distance** or **Angle**.

   Distance causes vertices to be removed based on their distance from the planes shared by their neighbors.

   Angle causes vertices to be removed based on the angles formed by the polygons connecting the vertices to their neighbors.

6. Click **OK** when you've finished specifying the **Decimate** options.

Transforming Polymesh Objects and Selections

The **Mesh Form** modeler provides a number of ways to move, scale and rotate polymesh objects or parts of polymesh objects.

You can transform them interactively using the **Selection** , **Trackball Rotation** or **2D Rotation** tools. You can also transform them numerically using **Selection menu▸Rotate**, **Resize**, **or Move**.

For 3-dimensional objects, you can specify exact dimensions using the **Resize** command. Similarly, you can specify the exact location of a vertex by editing its coordinates on the **Properties palette: Numerical tab**.

Moving an Object or Selection

You can move any selection simply by dragging it to a new location. For more precise positioning, use the **Move** command or the **Properties palette: Numerical tab**.

You can also use the Arrow keys to nudge objects.

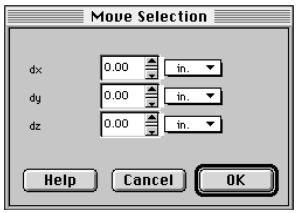
If you hold down the **Option**/**Alt** key, the object moves perpendicular to the Drawing plane when it's dragged or nudged. For more information, refer to "Positioning Objects" on page 234.

The **Mesh Form** modeler also allows you to offset selected polygons from an object's surface.

To move an object or selection numerically:

1. Select the object or portion of an object that you want to move.

2. Choose **Selection menu▸ Move**. The **Move** dialog appears.



Use the Move dialog to move an object or sections to a specific position in the Modeling window.

3. Specify the amounts you want to move the object in the X, Y and Z directions and click **OK**.

   Positive values increase the selection's distance from the origin; negative values move the selection closer to its origin. (The axis indicator identifies the origin for the model.)

   By default, the values are specified in inches. Use the units pop-up to select a different unit of measure.

To offset the surface of an object:

1. Select the polygons that you want to offset from the object.

2. Choose **Selection menu▸ Offset**. The **Offset** dialog appears.

3. Specify the amount you want to move the selected polygons.

   The surface is expanded like a balloon. Each selected polygon is moved outward, perpendicular to the plane defined by the polygon.

Flattening Selections

In some cases, you might want to move the vertices in a polygon, edge, or other selection to the same plane. This is called *flattening* the selection. The plane that the vertices are flattened to depends on the locations of the selected vertices.

To flatten a group of vertices, edges and polygons:

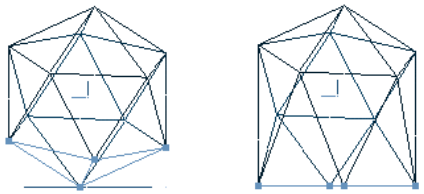
1. Select the objects you want to flatten.
2. Choose **Selection menu▸ Flatten**.

Moving Selections to the Drawing Plane

Instead of flattening selected vertices to an arbitrary plane, you might want to move them to all to the Drawing plane.

To move a group of vertices, edges or polygons to the Drawing plane:

1. Select the objects you want to move to the Drawing plane.
2. Choose **Selection menu▸ Move to Drawing Plane**.



Selected vertices sent to the Drawing plane.

Scaling an Object or Selection

You can drag the corner of an object's bounding box to scale it, scale the current selection by specifying X,Y,Z scale factors with the **Resize** command, or change an object's size by specifying new X,Y,Z dimensions with the **Set Size** command.

To scale an object:

1. Select the polymesh you want to scale.
2. With the **Selection** tool, drag one of the object's bounding box corners. Drag away from the object's center to enlarge it; drag towards the object's center to reduce it.

   To scale the object around its center, hold down the **Command**/**Ctrl** key. To constrain the scale operation to equal proportions, hold down the **Shift** key. To constrain the scale operation to a direction perpendicular to the Drawing plane hold down the **Option**/**Alt** key.

Scaling an object by dragging a corner of its bounding box.

To scale an object or selection numerically:

1. Select the object or portion of an object that you want to scale.
2. Choose **Selection menu▸ Resize**. The **Resize** dialog appears.

Use the Resize dialog to scale an object or selection numerically.

3. Enter the X, Y and Z scale factors and click **OK**.

   The scale factors are specified in percentages. For example, to reduce an object to half its original size in all dimensions, specify X, Y and Z scale factors of 50%.

To set the size of an object:

1. Select the object whose size you want to set.

   You can only set the size of 3-dimensional objects. To resize objects whose vertices all lie on the same plane, use the **Resize** command.

2. Choose **Polymesh menu▸ Set Size**. The **Set Polymesh Size** dialog appears.

3. Enter the new X, Y, and Z dimensions for the object and click **OK**.

   The object is resized so that its bounding box matches the dimensions you specify.

Rotating an Object or Selection

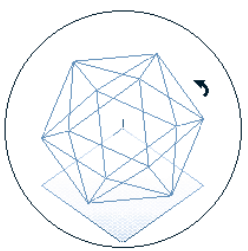
You can rotate an object freely in three dimensions, or in relationship to the Drawing plane. With the **Rotate** command, you can rotate an object a specific amount around the X, Y, or Z axis.

To free rotate an object in three dimensions:

1. Choose the **Trackball Rotation** tool from within the **Mesh Form** modeler.

2. Drag to rotate the object to a new orientation.

   The cursor must be over the object you want to rotate when you begin dragging. You can **Shift-click** other objects to rotate them at the same time.



Rotating an object with the Trackball Rotation tool.

To free rotate an object relative to the Drawing plane:

1. Choose **View menu▸ Preset Position▸ Drawing Plane**.

   Objects are rotated with respect to the current Drawing plane. It is easier to observe the effect of the rotation if you are looking directly at the Drawing plane.

2. Choose the **2D Rotation** tool from within the **Mesh Form** modeler.

3. Drag to rotate the object to a new orientation.

   The cursor must be over the object you want to rotate when you begin dragging. You can **Shift-click** other objects to rotate them at the same time. To constrain the rotation to 45° increments, hold down the **Shift** key while you drag.

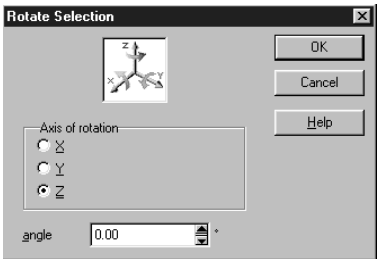
To rotate an object or selection numerically:

1. Select the object or portion of an object that you want to rotate.

2. Choose **Selection menu▸ Rotate**. The **Rotate Selection** dialog appears.

3. Select the axis of rotation.

The rotation is constrained to one axis of rotation.



Use the Rotate dialog to rotate an object or selection rotate using a specific axis and angle.

4 Specify the angle of rotation and click **OK**.

The angle of rotation is specified in degrees. Positive values rotate the object clockwise around the axis of rotation (looking away from the origin), negative values rotate the object counterclockwise.

Using Standard Modeling Techniques to Create Complex Polymesh Objects

You can use the standard modeling techniques introduced with the **Free Form** modeler to create complex objects in the **Mesh Form** modeler. The **Mesh Form** modeler supports:

- Extrusions
- Sweeps
- Lathed objects
- Lofted objects

For general information about these techniques, refer to "Free Form Modeling" on page 109.

You should use the **Mesh Form** modeler to create these types of objects when you want to:

- Edit the surface of the resulting object.
- Create extrusions or sweeps with 3-dimensional cross sections or sweep paths.
- Use the resulting object to perform Boolean operations.

If the object you are modeling is easier to describe using Bézier curves, you can create the object in the **Free Form** modeler and then edit it in the **Mesh Form** modeler.

For more information about editing Free Form models in the **Mesh Form** modeler, refer to "Working in the Mesh Form Modeling Window" on page 142.

This section describes how to use the **Mesh Form** modeler to create extrusions, sweeps, lathed objects and lofted objects.

You cannot extrude, sweep, loft, or lathe polygons with the **Mesh Form** modeler. If you want to use a polygon in an existing polymesh object as a cross section, convert the polygon to a closed polyline by emptying it.

Extruding and Sweeping Polygon and Polyline Cross Sections

Extruding or sweeping a polygon creates an object similar to that created with the **Free Form** modeler. You can use an open or closed polyline to define the cross section of an extrusion or sweep. Using an open polyline as a cross section creates a shell with the shape of the polyline.

The cross section can be a separate polyline object, or a set of selected edges in a larger object.

The extrusion or sweep path is also defined by a polyline. The vertices of the extrusion path do not need to lie in the same plane, allowing you to easily define complex, three-dimensional extrusion paths.

Like cross sections, the extrusion path can be defined by a separate polyline object or a set of selected edges in a larger object.

When a cross section is extruded, the orientation of the cross section remains constant along the extrusion path. When a cross section is swept along a path, the orientation of the cross section changes so that it always remains perpendicular to the path.

The same cross section extruded and swept.

To create a straight extrusion:

1. Create a cross section using the **Polyline** tool or select an existing polyline to use as the cross section.
2. With the cross section selected, choose **Selection menu▸ Extrude**. The **Extrude Options** dialog appears.
3. Specify the depth of the straight extrusion and click **OK**.

To create a complex extrusion:

1. Create a cross section using the **Polyline** tool or select an existing polyline to use as the cross section.
2. Draw the extrusion path with the **Polyline** tool or select an existing polyline to use as the path.
3. Select the cross section and extrusion path.
4. Choose **Selection menu▸ Extrude**.
5. Use the blue arrows in the **Properties palette: Action Modifier tab** to change which selection is used as the extrusion path.

   In the **Mesh Form** modeling window, the object selected as the extrusion path is highlighted in blue and the cross section is highlighted in red. The starting vertex in the extrusion path is also highlighted in blue.

   To change the object selected as the extrusion path, click one of the double arrows. To change the starting point on the selected extrusion path, use the single arrows.
6. When the extrusion path is set, click **Apply** to generate the extrusion.

   If **Auto** is enabled in the **Properties** palette, the changes are automatically applied.

To create a sweep:

1. Create a cross section using the **Polyline** tool or select an existing polyline or polygon to use as the cross section.
2. Draw the sweep path with the **Polyline** tool or select an existing polyline to use as the path.
3. Select the polygon and the polyline.
4. Choose **Selection menu▸ Sweep**.
5. Use the blue arrows in the **Properties palette: Action Modifier tab** to set the extrusion path.

   In the **Mesh Form** modeling window, the object selected as the sweep path is highlighted in blue and the cross section is highlighted in red. The starting vertex in the sweep path is also highlighted in blue.

   To change the object selected as the sweep path, click one of the double arrows. To change the starting point on the selected path, use the single arrows.

6. When the sweep path is set, click **Apply** to generate the extrusion.

   If **Auto** is enabled in the **Properties** palette, changes are automatically applied.

Modeling with Polygon and Polyline Cross Sections

Lofting enables you to stretch a surface over a series of cross sections. In the **Mesh Form** modeler, these cross sections can be defined by open or closed polylines.

Like the cross sections used for extrusions and sweeps, these cross sections can be separate polyline objects or selected edges in a larger object.

You can define as many cross sections as you need, but all of the cross sections for a single lofted object must be either open polylines or closed polylines, you cannot mix them. To be lofted, the cross sections must lie on different planes.

In certain situations, not all of the cross sections you define are used. This might happen if two of the cross sections lie very close to the same plane—one of them is used and the other ignored.

Two polylines and the object that results when they're lofted.

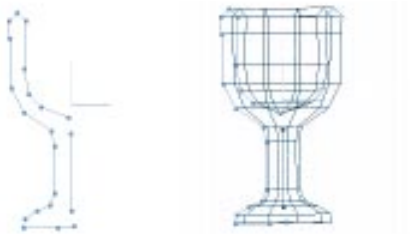
To loft an object:

1. Create the cross sections with the **Polyline** tool or choose existing polylines to use as cross sections.
2. Select the cross sections.
3. Choose **Selection menu▸ Loft**.

Lathing with Polygon and Polyline Profiles

When you lathe objects in the **Mesh Form** modeler, you control both the lathe profile and the lathe axis. The lathed object is created by revolving the profile around the specified axis. The lathe profile is always rotated a full 360 degrees around the axis.

Both polylines and polygons can be used as lathe profiles. The lathe axis can by defined by any edge.



A polyline lathe profile and the object that results from Lathing.

To lathe an object:

1. Create the lathe profile with the **Polyline** tool, or select a set of connected edges to use as the lathe profile.
2. Create a lathe axis with the **Polyline** tool or select an existing edge to use as the axis.

   The lathe axis must be a line defined by two vertices.
3. Select the lathe profile and the lathe axis.

   If you do not select a lathe axis, Ray Dream Studio revolves the selected lathe profile around the axis formed by drawing a line from the first vertex in the profile to the last vertex in the profile. In this case, the lathe profile must be an open polyline.
4. Choose **Selection menu▸ Lathe**.

5. Use the blue arrows in the **Properties palette: Action Modifier tab** to set the lathe axis.

   In the **Mesh Form** modeling window, the object selected as the lathe axis is highlighted in blue, and the lathe profile is highlighted in red.

   To change the object selected as the lathe axis, click one of the blue arrows in the **Properties palette: Action Modifiers tab**.

6. Specify the number of steps for the lathed object.

   A greater number of steps produces a smoother object.

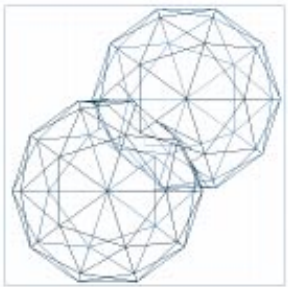
7. Click **Apply** to generate the extrusion.

   If **Auto** is enabled in the **Properties** palette, changes are automatically applied.

Using Boolean Operations to Create Complex Polymesh Objects

The Boolean operations; **Union**, **Subtraction** and **Intersection** are used to produce a complex object from two simpler objects. Boolean operations are performed on two overlapping volumes. Both volumes should be closed—holes in the surface of a volume can prevent Boolean operations from producing the desired results.

The *union* of two objects is an object whose surface encompasses the visible surfaces of both objects. For example, if you spray-paint two overlapping spheres, the painted surface represents the union of the two spheres.



Two objects joined using the Boolean Union.

If you take the *intersection* of two objects, the resulting object is the volume shared by both objects. For example, if you take the intersection of two overlapping spheres, the resulting object resembles a flying saucer.

Result of two objects joined using Boolean Intersection.

When you *subtract* object B from object A, the parts of object A that are encompassed by object B are removed. For example, if you have two overlapping spheres and subtract one from the other, the resulting object resembles a sphere with a large crater.

Boolean subtraction is similar to the concept of compounding shapes in the Free Form modeler. However, compounding shapes only enables you to create holes through extruded objects. Boolean subtraction enables you to work directly with 3D objects and remove overlapping volumes.

Results of two objects joined using Boolean Subtraction.

Note: When you perform a Boolean operation, you lose the UV coordinates of the original objects and surface shading can become much more complex.

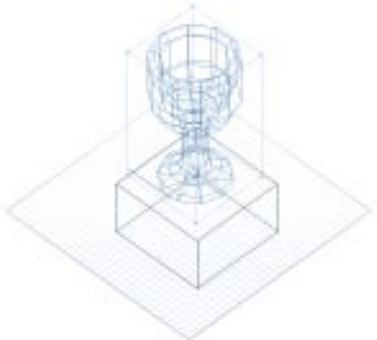
Using Boolean operations enables you to quickly produce certain types of complex models. For example, suppose that you want to create a cylindrical hole through a sphere that originates on the top of the sphere and exits to the sphere's left side.

Using normal modeling techniques, this would be nearly impossible, but with Boolean subtraction it's easy. You could:

1. Extrude a circle along a path defined by a polyline to form an object that looks like a bent pipe.
2. Align the sphere and the cylinder object.
3. Subtract the cylinder object from the sphere.

The object that results when you Boolean Subtract a bent pipe from a sphere.

Before performing a Boolean operation, it is important to verify that the objects are aligned the way that you want them. You should look at the objects from a variety of viewpoints to verify that their alignment will produce the intended results. You might also want to check the **Properties palette: Numerical tab** to verify the location of particular vertices in an object.



Some objects that appear to adjacent when viewed from reference....

...may not be adjacent when viewed from another perspective.

When you use the **Boolean Operation** command, Ray Dream Studio automatically performs the last selected Boolean operation on the selected objects. You use the **Properties palette: Action**

Modifiers tab to switch between the **Union**, **Intersection**, and **Subtraction** operations.

If you enable **Auto** in the **Properties** palette, you'll be able to see the results immediately when you switch between operations.

To join two objects:

1. Align and select the objects you want to join.
2. Choose **Polymesh menu▸ Boolean Operation**.

   Ray Dream Studio automatically performs the last selected Boolean operation.
3. On the **Properties palette: Action Modifiers tab**, enable **Union**.
4. If **Auto** is not enabled in the **Properties** palette, click **Apply** to perform the union.

To create an object that is the intersection of two objects:

1. Align and select the objects.
2. Choose **Polymesh menu▸ Boolean Operations**.

   Ray Dream Studio automatically performs the last selected Boolean operation.
3. On the **Properties palette: Action Modifiers tab**, enable **Intersection**.
4. If **Auto** is not enabled in the **Properties** palette, click **Apply** to perform the intersection.

To subtract one object from another:

1. Align and select the objects.
2. Choose **Polymesh menu▸ Boolean Operations**.

   Ray Dream Studio automatically performs the last selected Boolean operation.
3. Enable **Auto** at the bottom of the **Properties** palette.

   When **Auto** is enabled, you can immediately view the difference between the two subtraction operations.
4. On the **Properties palette: Action Modifiers tab**, enable **Subtract A from B** or **Subtract B from A**.

Shading Polymesh Objects

In some situations, you need to specify the mapping mode for a model to get the results you want. The **Mesh Form** modeler provides additional control by allowing you to specify how shaders are mapped to individual objects in a model.

Specifying an Object's Mapping Mode

In addition to the three projection mapping modes supported at the scene level, the **Mesh Form** modeler supports a custom mode that allows you to specify UV coordinates for particular vertices. For more information about mapping modes, refer to "Advanced 3D Paint Topics" on page 191.

If you specify mapping modes for individual objects in the **Mesh Form** modeler, and then specify a projection mapping mode for the entire model at the scene level, the modes you specified in the **Mesh Form** modeler are overridden. To use the settings specified in the **Mesh Form** modeler, use the **Parametric Mapping** mode at the scene level.

To change an object's mapping mode:

1. Select the object.
2. Choose **Properties palette: Mapping mode tab**.
3. Choose a mapping mode from the tab pop-up: **Custom**, **Box/Face**, **Cylindrical**, or **Spherical**.

   Custom specify the technique to be used to map the UV coordinates to the selected vertex or vertices. For more information, refer to "Defining a Custom Mapping Mode for an Object" on page 170.

   Box/Face choose the face you want to map onto.

   Cylindrical or **Spherical** choose the orientation of the mapping primitive.

Defining a Custom Mapping Mode for an Object

When you choose **Custom mapping** mode in the **Properties palette: Mapping mode** tab you can specify how UV coordinates from the shader should be applied to the selected vertex or group of vertices.

There are two options for applying uv coordinates to the selection:

- **Interpolate** sets the U or V value for the selected vertex or vertices using the UV values for the nearest vertices that are specified.
- **Keep Current Value** locks the current specified U or V value.

When you enable **Wrap**, the shader is wrapped around the object from the specified U or V coordinate.

To view the UV coordinates that are set for a particular vertex:

1. Select the vertex and choose **Polymesh menu▸ Shader Mapping**.
2. In the **Properties palette: Mapping mode** tab, select **Custom**.

   The current U and V values are displayed in the **Specify** fields.