What are NURBS?

NURBS (Non-Uniform Rational B-Splines) are one geometry type you can use to create 3D curves and surfaces in Maya. The other geometry types that Maya provides are polygon and subdivision surfaces.

- *Non-Uniform* refers to the *parameterization* of the curve. Non-Uniform curves allow, among other things, the presence of multi-knots, which are needed to represent Bezier curves.
- *Rational* refers to the underlying mathematical representation. This property allows NURBS to represent exact conics (such as parabolic curves, circles, and ellipses) in addition to free-form curves.
- *B-splines* are piecewise polynomial curves (splines) that have a parametric representation.

NURBS are useful for constructing many types of organic 3D forms because of the smooth and minimal nature of the curves they use to construct surfaces. NURBS surface types are widely used in the fields of animation, games, scientific visualization, and industrial design.

The NURBS 3D data type can easily be exported to CAD software applications by exporting the surfaces using the IGES file format. In addition, Maya can import many types of bezier and NURBS data types from many CAD software applications using the Autodesk® Direct Connect® translator plug-in.

If your requirements are to use the polygon surface type in your scenes you can initially construct your surfaces using NURBS and then convert them to polygons.

NURBS modeling overview

To use NURBS in Maya you can do one of the following:

- Construct 3D models using NURBS primitives.

  Primitives are simple 3D objects created in the shape of common geometric forms such as cubes, spheres, cones, and so on. Primitives can be a great starting point for many 3D shapes. You can modify the attributes of NURBS primitives to modify their shape. You can also modify NURBS primitives by trimming away portions of their forms, beveling their edges, or by sculpting them into different shapes using the Maya Artisan sculpting tools.

- Construct NURBS curves that define the basic outline of the 3D form you wish to construct and then use the curves as a basis for constructing your NURBS surfaces.

  Maya provides several options for constructing and modifying NURBS curves and surfaces:

  - You can draw curves by placing control vertices, or edit points. The curve drawing tools are found in the **Create** menu.

- The features for editing NURBS curves are used by first selecting the Surfaces menu set, and then selecting the desired curve editing feature from the **Edit Curves** menu.
- The features for creating NURBS surfaces are used by first selecting the Surfaces menu set, and then selecting the desired surface creation feature from the **Surfaces** menu set.
- The features for modifying NURBS surfaces are used by first selecting the Surfaces menu set, and then selecting the desired surface editing feature from the **Edit NURBS** menu set.

Drawing curves/ creating curves

To draw a NURBS curve by placing CVs

1. Select Create > CV Curve Tool.
2. Click to place the CVs.
   - The first CV looks like a hollow box. The second CV looks like a letter U. Maya draws hulls between the CVs as you place them.
   - For each CV after the third one you place, Maya draws the shape of the curve.
   - To remove the last CV you placed, press Delete.
   - To switch to editing CVs, press Home or Insert. A manipulator appears on the previous CV. Use the manipulator to move the CV, press Delete to delete a segment, or click another CV to edit it. Press Home or Insert again to return to adding CVs.
3. Press Enter to finish the curve.

Alternatively, you can use edit points if you want the curve to pass through certain points. It calculates the positions of CVs based on where you want the edit points.

To draw a NURBS curve by placing edit points

1. Select Create > EP Curve Tool.
2. Click to place the edit points.
   - For each edit point after the first one you place, Maya draws the shape of the curve.
   - To switch to editing edit points, press Home or Insert. A manipulator appears on the previous point. Use the manipulator to move the point, press Delete to delete a segment, or click another point to edit it. Press Home or Insert again to return to adding point.

3. Press Enter to finish the curve.

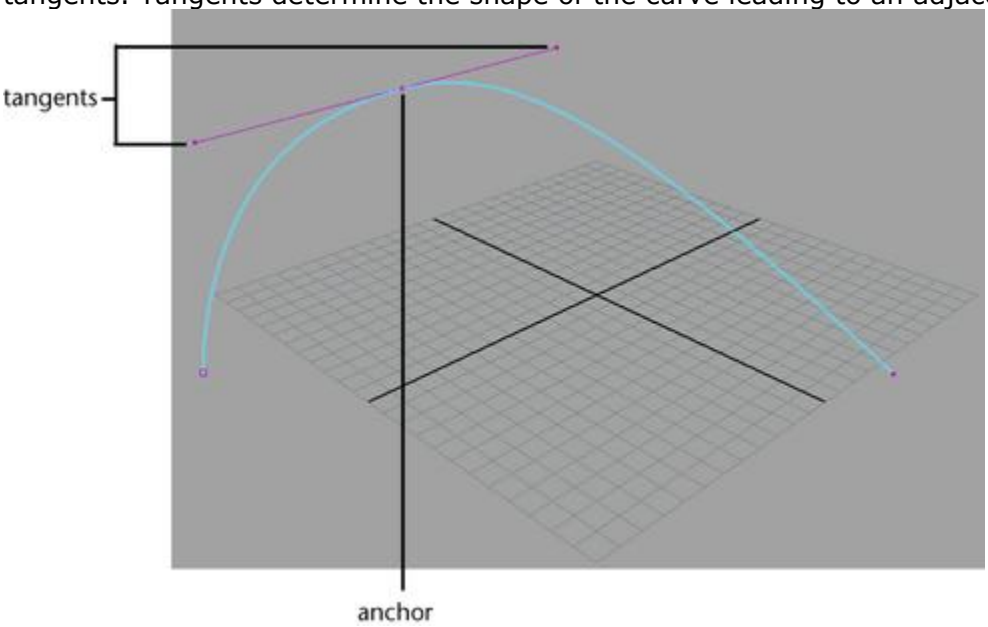
Draw a NURBS curve freehand

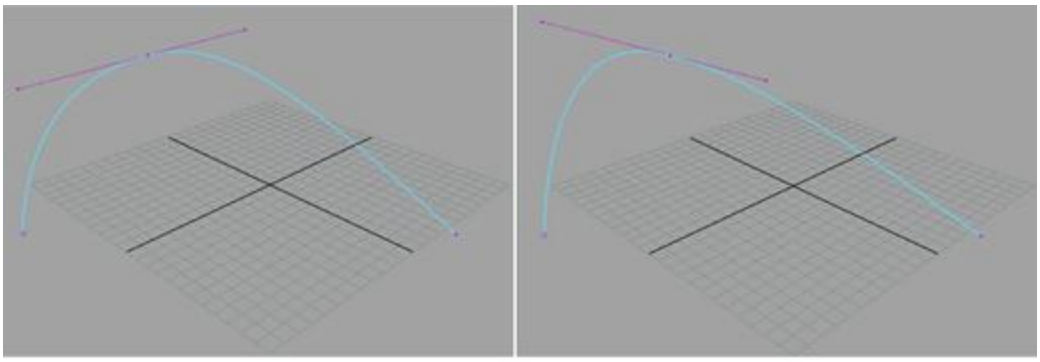
1. Select Create > Pencil Curve Tool.
2. Drag to sketch a curve. When you release the mouse button Maya creates the curve.
3. The **Pencil Curve tool** creates a curve with a large number of data points. Use Edit Curves > Rebuild Curve to simplify the curve.

- As you draw the curve, Maya puts points in the view if they are at least five screen pixels from the previous point.
- If you sketch in an orthographic view (front, top, or side), Maya creates the curve on the view plane at the origin. If you sketch in the perspective view, Maya creates the curve on the grid plane.

Bezier curves

Bezier curves are a subset of NURBS curves that are composed of two types of control vertices, *anchors* and *tangents*. Anchors lie on the curve and determine the origin of tangents. Tangents determine the shape of the curve leading to an adjacent anchor.





Moving the tangents affects the curve

Since Bezier curves are a subset of NURBS curves, you can perform the majority of NURBS operations to Bezier curves as well. You can also perform NURBS operations on combinations of Bezier curves and NURBS curves. In general, an operation involving all Bezier curves results in a Bezier curve while operations involving a combination of Bezier and NURBS curves results in a NURBS curve.

Create a Bezier curve

To create a Bezier curve

1. Select Create > Bezier Curve Tool or click the **Bezier Curve Tool** icon () in the **Curves** shelf.
2. Do one of the following:
   - To place an anchor, click the scene.
   - To place an anchor and manipulate its tangent, click and drag the mouse on the scene.
   - To add an anchor to the existing curve while preserving its shape, click anywhere on the curve.
   - To delete an anchor, select it and press Delete.
   - To close the curve, hold Ctrl + Shift and click the first anchor of the curve.
3. If you choose another tool, then select the curve and return to the **Bezier Curve Tool**, you can append additional anchors to the most recently created anchor.
4. When you have finished placing anchors, press Enter to end the curve and exit the **Bezier Curve Tool**. If you want to draw additional curves, you can also press 'g' to end the current curve, but remain in the tool.

To append anchors to the end of an existing curve

1. Select the curve you want to append to.

2. Select Create > Bezier Curve Tool or click the **Bezier Curve Tool** icon () in the **Curves** shelf.
3. Click the last anchor in the curve.

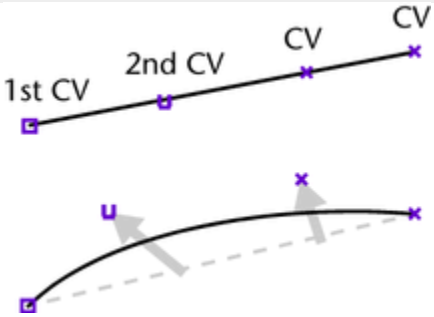
   The last anchor is always the end point of the curve that is not yellow.
4. Click (or click-drag) anywhere in the scene.

   An anchor appears and is connected to the curve.

Components of NURBS curves

The easiest way to display and select a curve component is to press on an object, choose the component type, then select the component.

CVs



CVs (*control vertices*) control how the curve is "pulled" from a straight line between edit points. They are the most basic and important means for controlling the shape of a curve. Lines between consecutive CVs form the control *hull*.

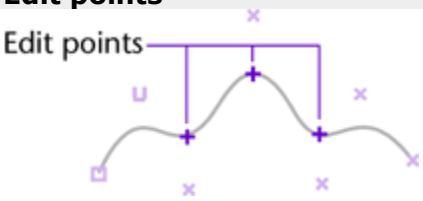
The number of CVs is equal to the degree of the curve plus one. So, for example, a degree 3 curve has four CVs per span. To increase the number of CVs to gain more control over curve shape, you can increase the number of spans by inserting edit points or increase the curve's degree.

Maya draws CVs differently to let you tell the difference between the start and the end of a curve. The first CV (at the start point of the curve) is drawn as a box. The second CV is drawn as a small "U", to show the increasing U dimension from the start point. All other CVs are drawn as small dots.

Multiple spans

Longer and more complex curves require more than a single span curve. As you draw what appears to be a single long curve, the application is actually adding several curve spans together.

Edit points



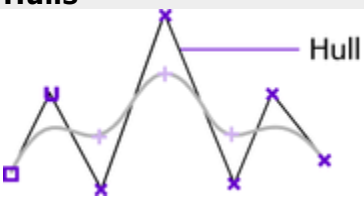
You can tell when a curve is made from multiple spans in several ways. One is to look for edit points on the curve. Edit points mark the connection point between two spans. Maya draws edit points as small Xs.

Unlike the on-curve control points of Bezier curves (used in many 2D illustration programs), NURBS edit points are not usually used for editing curves. CVs control the shape of a NURBS curve, and edit points are just indicators of how many spans a curve has.

There are, however, a few tasks that use edit points:

- If you want more control in a curve, you can insert an edit point to increase the number of spans in the curve and give you more CVs to work with.
- You can also delete edit points to decrease the number of spans in a curve (and probably change the shape of the curve).
- It is possible to move edit points to change the shape of a curve, but you should avoid doing this except for minor adjustments.

Hulls



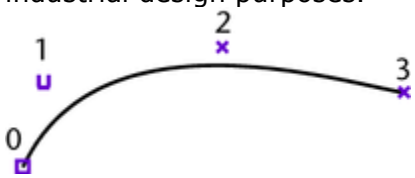
As a curve gets more spans/edit points, you might lose track of the order of the CVs. To show the relationship between CVs, Maya can draw lines between them. These lines are called hulls.

Hulls are useful:

- To show the order of CVs in a crowded scene.
- To show the shape of the CVs.when your object is so crowded with CVs that you can't determine exactly which adjacent CVs will be affected when you tweak part of a model.
- To select an entire row of CVs at once.

Degree of NURBS curves and surfaces

- Degree is a mathematical property of a curve or of a surface that controls how many CVs per span are available for modeling. The degree is always represented mathematically as a positive whole number. Degree can be thought of as the curve or surface's degree of freedom to bend. A degree 1 curve connects its edit points with straight lines in a polygonal fashion. A degree 2 curve can have one bend between edit points, and so on.
- Maya has the ability to create curves with a degree of 1, 2, 3, 5, or 7. The default degree in Maya is 3, which has four CVs for the first curve span. A curve degree of 3 is sufficient for almost any modeling task. You may want to use degree 5 or 7 curves if you are producing 3D surfaces for subsequent export to a CAD application for industrial design purposes.



- Surfaces can have different degrees across their width and length. For example, a surface could be degree 3 along its width, and degree 5 along its length.
- The degree of your curves can affect data transfer to other software packages. Some other packages cannot accept curves with degree higher than 3.

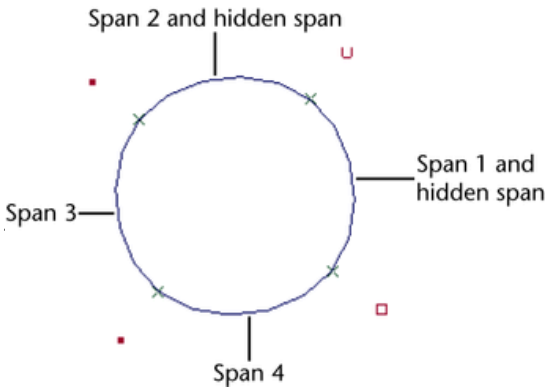
Periodic, closed, and open geometry

A NURBS curve or surface can have a periodic, closed, or open form. The form affects the how the object deforms.

Curves

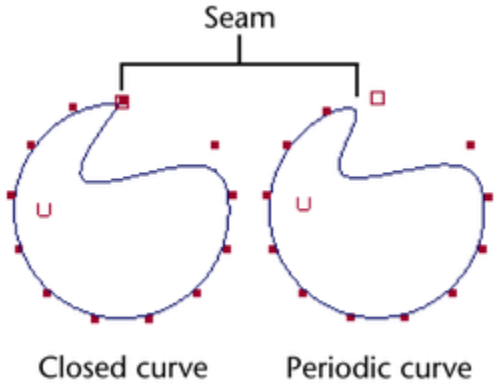
- An *open curve* usually has its start and end edit points in different positions—it typically doesn't form a loop. If you snap the start and end edit points of an open curve to the same position, it's still an open curve, because you can still drag these points away from each other.
- A *closed curve* is a loop with coinciding start and end edit points. Where start and end edit points meet is also called a *seam*. If you move the start edit point, the end edit point moves with it (and vice versa).
- A *periodic* curve is also a loop with a seam, but it has two unseen spans at the end of the curve that overlap the first two spans. The unseen spans help maintain continuity along the seam.

For example, suppose you create a circle primitive with four spans (sections). A circle primitive is a periodic curve. If you display the circle's edit points, you'll see only four spans. There are actually six spans, but the last two overlap the first two.



In contrast to a periodic curve, a closed curve can have a sharp corner at the seam because it lacks the extra spans.

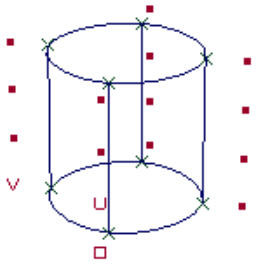
The figure below shows similar closed and periodic curves, both originally circles. For each, we moved the CV next to the seam inward. The periodic curve keeps its continuity, but the closed curve's tangency is broken.



To see whether a curve is periodic, closed, or open, select the object, display the **Attribute Editor**, and examine the contents of the **Form** text box.

Note that if you use Edit Curves > Open/Close Curves to "close" an open curve, you create a periodic rather than a closed curve. To create a closed curve, use Edit Curves > Detach Curves on any edit point of a periodic curve.

NURBS surfaces



Periodic and closed surfaces work like their curve counterparts, except they have two parametric directions (U and V) instead of one (U).

If you create a surface from a periodic curve, the surface is periodic in one direction (U or V).

To see whether a surface is periodic, closed, or open, select the object, display the **Attribute Editor**, and examine the contents of the **Form U** and **V** text boxes. A surface is considered periodic whether it's periodic in U, V, or both.

If you use Edit NURBS > Open/Close Surfaces on an open surface, you create a periodic rather than a closed surface. To create a closed surface, use Edit NURBS > Detach Surfaces on an isoparm of a periodic surface.

Make a curve or surface open or closed

To...	Do this

Join the ends of a curve together to make a periodic (closed) curve.	Select an open curve and choose Edit Curves > Open/Close Curves.
Make a periodic (closed) curve non-periodic.	Select any Edit point and choose Edit Curves > Detach Curves.

Join edges of a surface to make a periodic (closed) surface.	Select an open surface and choose Edit NURBS > Open/Close Surfaces > ❐. Click **U**, **V**, or **Both** to choose which edges to join.
Move the seam of a closed (periodic) curve.	Select an curve point on the curve and choose Edit Curves > Move Seam. The seam will move to the edit point nearest your selected point.
Move the seam of a closed (periodic) surface.	Select an isoparm on the surface and choose Edit NURBS > Move Seam. The seam will move to the patch isoparm nearest your selected isoparm.
Change the direction in which a surface is periodic.	Select the surface and choose Edit NURBS > Open/Close Surfaces > ❐. Click **U**, **V**, or **Both** to choose which edges are periodic.

Reverse the direction of a curve or surface normals

To...	Do this
Reverse the direction of a curve.	Select the curve and choose Edit Curves > Reverse Curve Direction.
Reverse the direction(s) and normals of a surface.	Select the surface and choose Edit NURBS > Reverse Surface Direction > ❐and choose the surface direction to reverse, or swap to swap U and V.

Join curves or surfaces together

To...	Do this
Join curves at the ends that are closest.	Select the curves and choose Edit Curves > Attach Curves.
Join two surfaces at the edges that are closest.	Select the surfaces. To move the surfaces together, choose Edit NURBS > Attach Surfaces. To fill the distance between the surfaces with new surface area, choose Edit NURBS > Attach Without Moving.
Join two curves at specific points.	Select a curve point on each curve where you want them to join and choose Edit Curves > Attach Curves.
Join two surfaces at specific isoparms.	Select an isoparm on each surface where you want them to join and choose Edit NURBS > Attach Surfaces.

Edit Curves > Attach Curves

Joins NURBS curves together at their endpoints to form a new curve. You can select two or more curves for attaching.

Edit Curves > Attach Curves > ❐

Attach Method

Select what the appearance of the point at which two curves are joined.

Connect

Joins the curves with minimal curvature smoothing at the join point.

Blend

Smooths the curvature at the join point based on the **Blend Bias** value.

Multiple Knots

Keep creates multiple knots at the join points. This lets you break the curvature continuity at the join points.

Remove discards multiple knots at the join points. This creates smooth curvature at the join points.

Blend Bias

Tunes the continuity at the join point.

Insert Knot

This option is available only when you use the **Blend** option. In conjunction with the **Insert Parameter** value, **Insert Knot** lets you match the blend region to the original curves more closely.

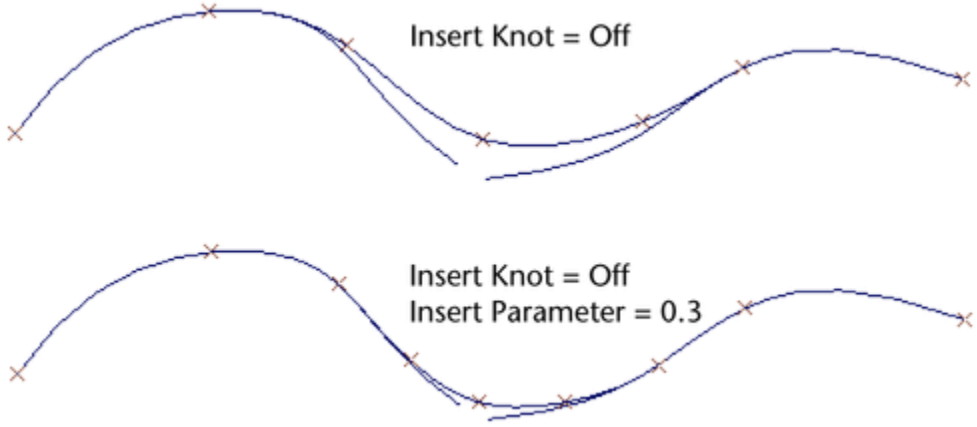
This option has significant effect only if the original curves are not aligned precisely (they approach each other at an angle) and have lengthy distances between the last two knots on each original curve near the join points.

Insert Knot creates two extra knots near the join points. Each is within one span of the points being joined from the original curves. You can adjust the positioning of the extra knots with the **Insert Parameter** value.

Insert Parameter

Adjusts the positioning of the knots added when you turn on **Insert Knot**. The closer the value is to 0 (without reaching 0), the closer the blend shape resembles the curvature of the original curves at the join point. This occurs because the added knots are inserted closer to the end knots nearest the blend point. Valid values are from 0 to 1.

The following figures show the same blended curve resulting from two identical input curves. The top blended curve has **Insert Knot** turned off. The bottom blended curve has **Insert Knot** turned on with an **Insert Parameter** value of 0.3. The closer **Insert Parameter** is to 0, the closer the blended curve resembles the end shape of the original curves.



To adjust this option interactively, create the blended curve with **Insert Knot** turned on. Then select the curve, display the **Channel Box**, select attachCurve in the **INPUTS** section, and edit the **Parameter** option.

Keep Originals

Keeps the original curves after creating the attached curve. Do not turn this option off if **construction history** is on; the attached curve might deform oddly if you scale or otherwise modify it.

If you want to scale the attached curve without altering its basic shape, make sure **construction history** and **Keep Original** are both off, or both on.

Editing the resulting curve attributes

To view and edit the options of an attached curve, select the curve, display the **Channel Box**, and select attachCurve in the **INPUTS** section. The following option is the only one not available in the options window:

Reverse 1 & 2

Attach Curves attaches the two ends of the curves that are closest. You can use these options to change which ends are attached. Turn the options on and off in various combinations until you get the desired result.

Edit NURBS > Attach Surfaces

Joins two surfaces together into a single surface.

Edit NURBS > Attach Surfaces > ❐

Attach Method

Connect attaches the selected surfaces without distorting them.

Blend creates a continuous surface joining the original surfaces. It yields a less obvious attachment, but also might add some distortion as the blend tries to achieve continuity across the attachment.

Multiple Knots

The **Multiple Knots** options are used to specify whether the multiple knots at the join point are kept or removed after the attach is done.

Use **Keep** to keep the multiple knots created at the join point as a result of the attach. This is the default.

Use **Remove** to remove the multiple knots at the join point. The shape of the geometry can be changed if required.

Blend Bias

Use **Blend Bias** to alter the amount of continuity for the new surface; high values may distort the tangency of the original surfaces.

Insert Knot

This option is available only if you select the blend method of attachment. In conjunction with the **Insert Parameter** value, **Insert Knot** lets you make the blend region match the original surface curvature more closely.

This option has significant effect only if the original surfaces are not aligned precisely and have lengthy distances between the last two spans on each original surface near the attachment area.

Insert Knot creates two additional spans near the attachment area. Each is within one span of the points being joined from the original surfaces. You can adjust the positioning of the extra spans with the **Insert Parameter** value.

Tip

If you create the initial surfaces carefully, an attach usually gives the desired results without knot insertion. If you do an attach with **Multiple Knots** set to **Remove** but need more local control, you can undo and repeat the attach with **Keep** turned on.

Insert Parameter

This option adjusts the positioning of the spans added when you turn on **Insert Knot**. The closer the value is to 0 (without reaching 0), the closer the blend shape resembles the curvature of the original spans in the attachment area. This occurs because the added spans are inserted closer to the spans closest to the blend points. Valid values are from 0 to 1.

To adjust this option interactively, first create the blended surface with **Insert Knot** turned on. Next, select the blended surface, display the **Channel Box**, and select attachSurface in the **INPUTS** section. Try different values for **Parameter** until you see the desired surface curvature.

Keep Original

Retains the original surface after the attach is performed. Do not turn this option off if construction history is turned on. If you do, the attached surface might deform oddly if you manipulate it later.

Notes

- **Attach Surfaces** does not work if the surfaces have the same name. Rename surfaces to have unique names prior to using **Attach Surfaces**

Split a curve or surface (detach)

To...	Do this
Split a curve at some point.	Select the curve point at which you want to split the curve and choose Edit Curves > Detach Curves. When construction history is on, you can select the detach node and use the **Show Manipulator tool** to edit the detach point.
Split a surface at an isoparm.	Select the isoparm at which you want to split the surface and choose Edit NURBS > Detach Surfaces. You can select multiple isoparms to split the surface into multiple parts.

	Select the curves in the view where they overlap, then choose Edit Curves > Cut Curve.
Split a curve wherever it crosses another curve in a view.	You cannot split a curve with an isoparm or curve-on-surface. Use Edit Curves > Duplicate Surface Curves to create an new curve from the isoparm or curve-on-surface you want to use.

Edit NURBS > Detach Surfaces

Splits a surface into multiple surfaces at the selected isoparms.

- Split a curve or surface (detach)

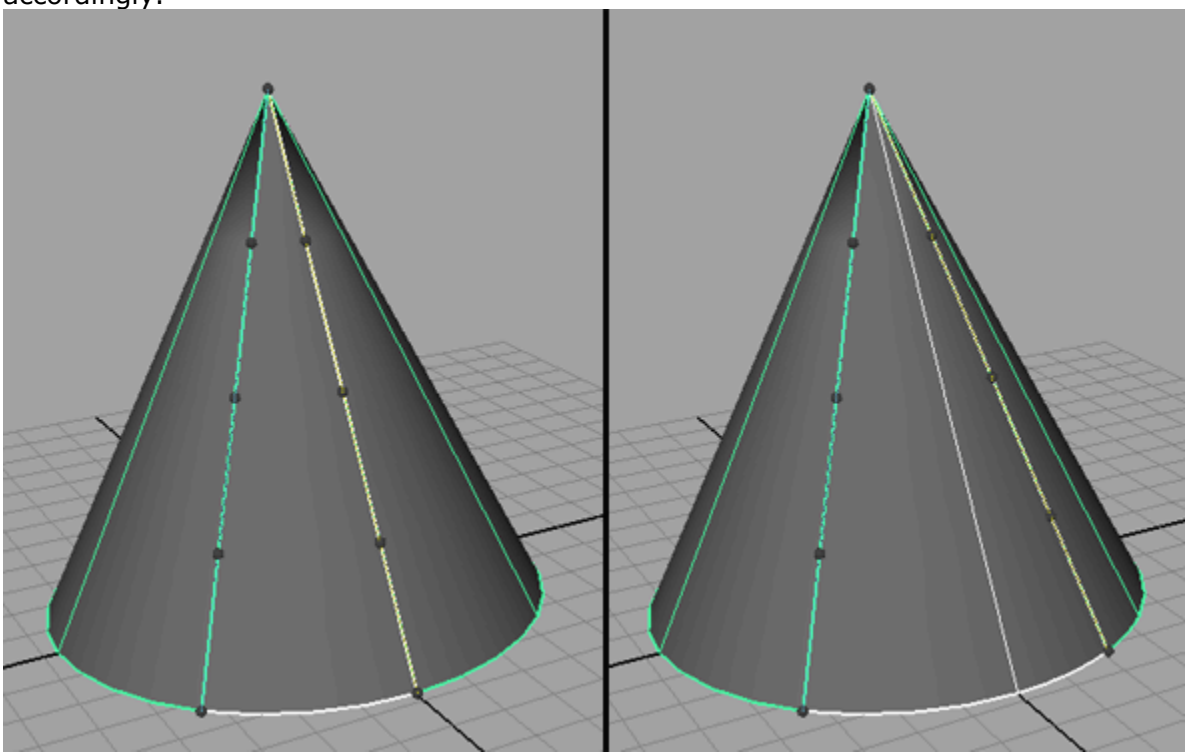
Edit NURBS > Detach Surfaces > ❐

Keep Original

If **Keep Original** is on when you perform the detach, the original curve or surface is retained.

Changing the detach position

You can edit the area of detachment with the **Show Manipulator Tool**. Select the detached curve and the detachSurface node in the **Channel Box**, then select the **Show Manipulator Tool**. If you drag the black manipulators, the area of detachment grows and shrinks accordingly.



Insert additional edit points/isoparms in a curve or surface to add more CVs

To...	Do this
Insert an edit point in a curve to add more CVs.	Select the curve point at which you want to insert the edit point and choose Edit Curves > Insert Knot.
Insert an isoparm in a surface to add more CVs.	Select the isoparm at which you want to insert a new patch isoparm and choose Edit NURBS > Insert Isoparms. You can select multiple isoparms to insert at once.

When the **Keep Original** option is on in the option box (Edit Curves > Insert Knot > ❐or Edit NURBS > Insert Isoparms > ❐) you can select the **Show Manipulator tool** to reposition the new edit point or isoparm after you insert it.

Edit NURBS > Insert Isoparms > ❐

Insert Location

At Selection lets you create isoparms at the current position, effectively creating a subdivision of the surface. This option enables the **Multiplicity** options.

Between Selections creates isoparms between your choice of selected isoparms, or between all U or V isoparms. For instance, if you select a pair of isoparms and turn on **Between Selections**, Maya creates the isoparm halfway between the pair.

Note that if you turn on **Between Selections** and set **Multiplicity** (see the following option) to a value greater than 1, Maya creates the multiple isoparms spaced out evenly between the selected isoparms.

Use all Surface Isoparms

If you select the entire surface and select **Between Selections**, you must turn on U or V for the **Use all Surface Isoparms** option. U creates isoparms between all U isoparms; V creates isoparms between all V isoparms. If you select a pair of specific isoparms rather than the entire object, Maya ignores whether you choose U or V. Isoparms will be inserted only between the selected isoparms.

Multiplicity

Lets you insert multiple isoparms at the selected positions as described in the following paragraphs. The new isoparms do not change the shape of the surface.

The **Set to** option lets you insert an absolute number of isoparms according to the **Multiplicity** value. For example, if **Multiplicity** is 3 and **At Selection** is turned on,

three isoparms will be inserted at the position regardless of whether it already has an isoparm.

The **Increase by** option lets you add an additional number of isoparms to the position according to the **Multiplicity** value.

Rebuilding Curves and Surfaces

Match the topology of one curve to another

1. Select the curve you want to rebuild and then the curve it should match.
2. Choose Edit Curves > Rebuild Curve > ❐.
3. Set **Rebuild Type** to **Match Knots**.
4. Click **Rebuild**.

Reduce the complexity of a curve or surface

Reduce the complexity of a curve

1. Select the curve.
2. Choose Edit Curves > Rebuild Curve > ❐.
3. Set **Rebuild Type** to **Reduce**.
4. To use the global tolerance set in the preferences, click **Global**. To set a tolerance manually, click **Local** and enter a tolerance value.

   The tolerance controls how close points on the reduced curve must be to the original. Higher numbers allow more reduction by loosening how closely the reduced curve must match the original.
5. Click **Rebuild**.

Reduce the complexity of a surface

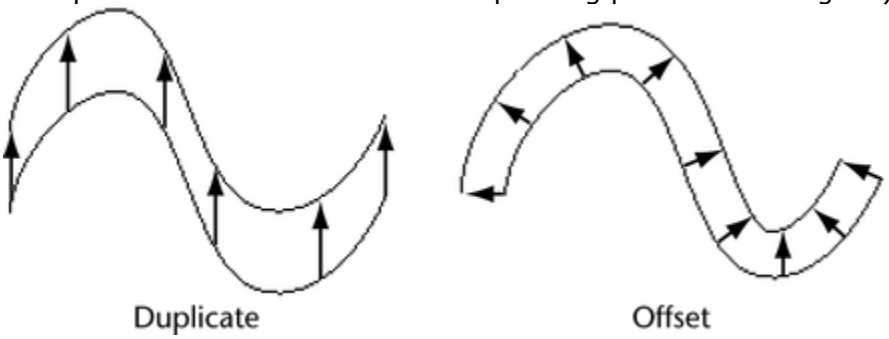
1. Select the surface.
2. Choose Edit NURBS > Rebuild Surfaces > ❐.
3. Set **Rebuild Type** to **Reduce**.
4. To use the global tolerance set in the preferences, click **Global**. To set a tolerance manually, click **Local** and enter a tolerance value.

The tolerance controls how close points on the reduced curve must be to the original. Higher numbers allow more reduction by loosening how closely the reduced curve must match the original.

5. Click **Rebuild**.

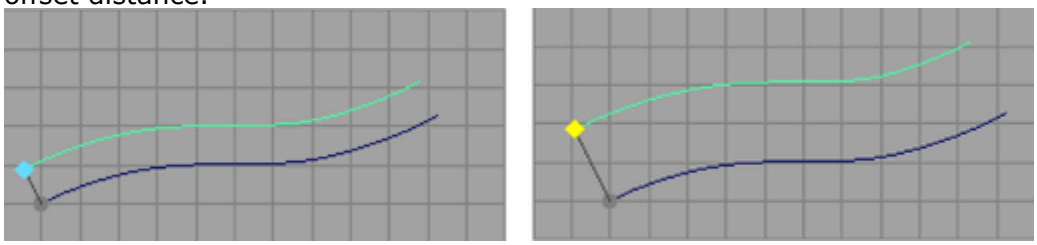
Create an offset copy of a curve or surface

Creates a copy of a curve or surface that is offset from the original (every point on the copy is a specific distance from the corresponding point on the original).



Create an offset copy of a curve

1. Do one of the following:
   - Select a curve or isoparm, then choose Edit Curves > Offset > Offset Curve.
   - Select a curve-on-surface, then choose Edit Curves > Offset > Offset Curve On Surface.
2. An offset curve is created at a default offset distance of 1.0.
3. In the toolbox, click the **Show Manipulator tool** and use the manipulator to change the offset distance.

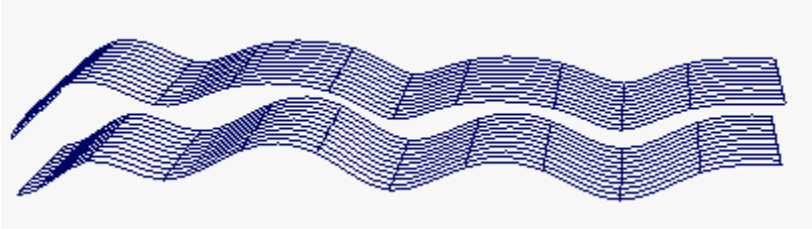


Create an offset copy of a surface

1. Select the surface.
2. Select Edit NURBS > Offset Surfaces > ❐.
3. Do one of the following:
   - To preserve surface curvature, set **Method** to **Surface Fit**.

- To preserve CV layout, set **Method** to **CV Fit**.

4. Enter a distance to offset. You can change the distance interactively in the channel box or attribute editor after you offset.
5. Click **Offset**.



Create a curve-on-surface

Maya provides several techniques for creating a curve-on-surface:

- Draw a curve-on-surface by placing edit points
- Project a curve onto a surface along the view direction
- Project a curve onto a surface along the surface's normals
- Intersect two surfaces to create a curves on surface

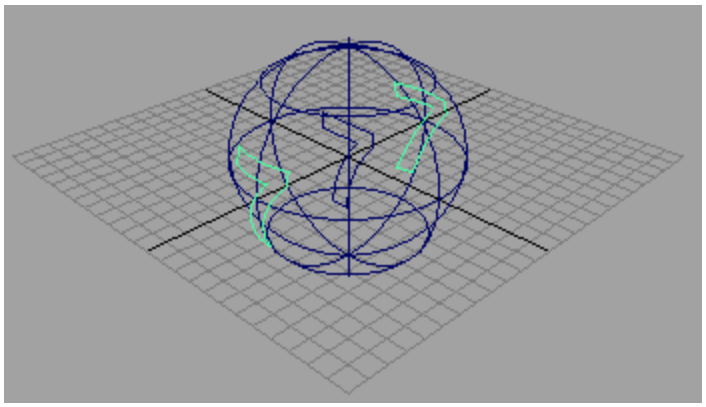
Draw a curve-on-surface by placing edit points

1. Select the surface on which you want to draw a curve-on-surface.
2. In the Status Line, click the "**Make the selected object live**" icon.
3. Choose Create > CV Curve Tool or Create > EP Curve Tool.
4. Draw a curve on the live surface.
5. When the curve is finished, click the "**Make selected object live**" icon again.

Project a curve onto a surface along the view direction

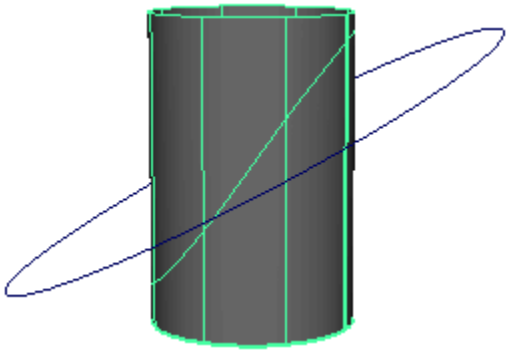
1. Select a surface and one or more curves.

   Select the objects in a view pointing in the direction you want to project. For example, if you want to project along Y, select the objects in the **Top** view.
2. Select Edit NURBS > Project Curve on Surface > ❐and set **Project Along** to **Active View**.
3. Click **Project**.



Project a curve onto a surface along the surface's normals

1. Select a surface and one or more curves.
2. Select Edit NURBS > Project Curve on Surface > ❐and set **Project Along** to **Active View**.
3. Click **Project**.



Intersect two surfaces to create a curves on surface

1. Select two surfaces.
2. Select Edit NURBS > Intersect Surfaces.

   The default is to create curves-on-surface on both surfaces. To only create curves-on-surface on the first or second surface, open the option box (Edit NURBS > Intersect Surfaces > ❐) and set the **Create Curves For** option.

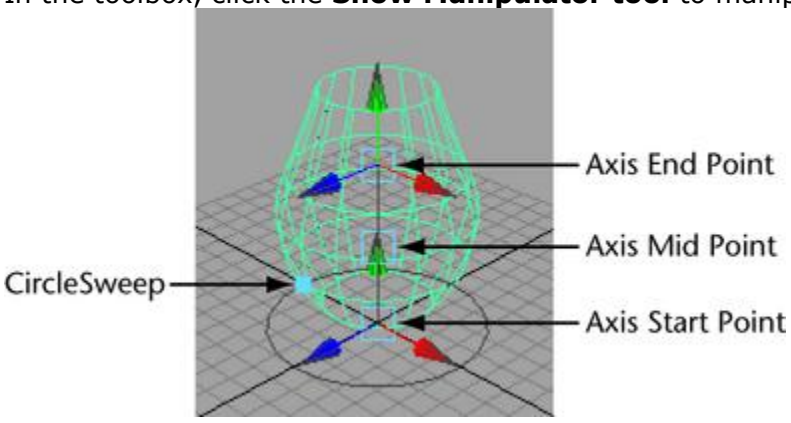
Notes

- If a curve on surface has been created using project curve or intersect surfaces with construction history enabled, performing delete components on such curves before deleting construction history may create data loss when saving into a file. Delete construction history before deleting components.

Creating Surfaces

Create a surface using Revolve

1. Draw a curve representing the cross-section (or "profile") of the surface you want to create.
2. Select the curve and choose Surfaces > Revolve > ❐.
3. Set the revolve options:
   - Choose the initial axis around which to sweep the surface.
   - If you only want to revolve a subsection of the curve, set **Curve Range** to **Partial**.
4. In the toolbox, click the **Show Manipulator tool** to manipulate the surface.



If you turn on the **Partial** option to revolve a subsection of the curve, you can control which part of the curve Maya revolves by selecting the subcurve node in the channel box and editing the minValue and maxValue attributes. If you have the **Show Manipulator tool** selected, handles appear on the curve to allow you to drag the values.

Tips

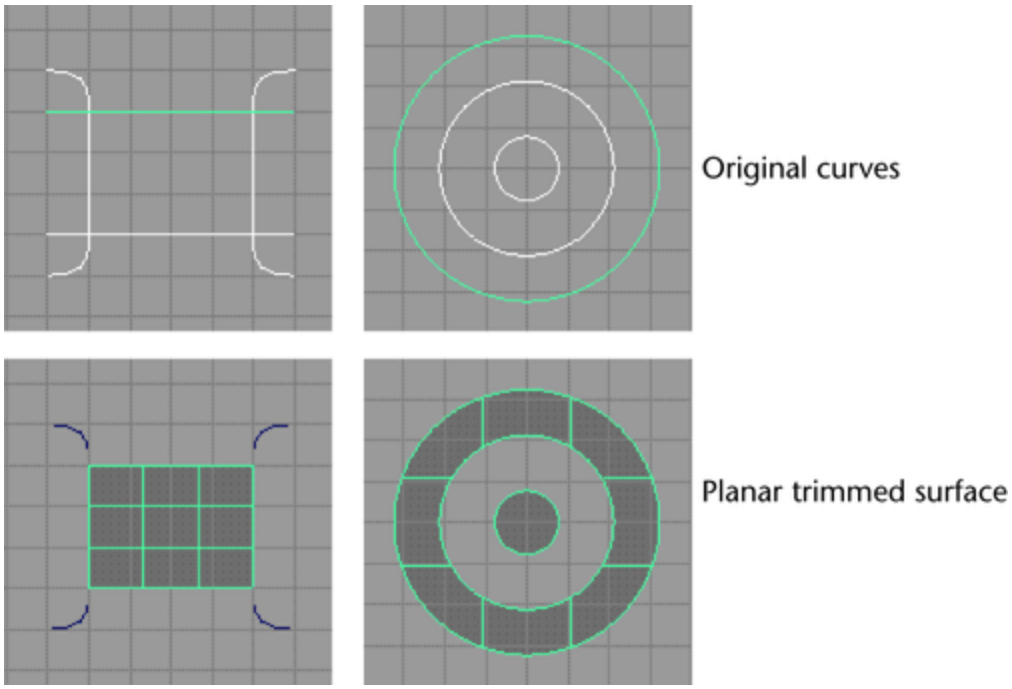
- If you move the axis endpoints, the axis direction is modified. However, if you move the axis midpoints, the radius of the revolved surface is modified without affecting the axis direction.

Create a flat surface inside a curve

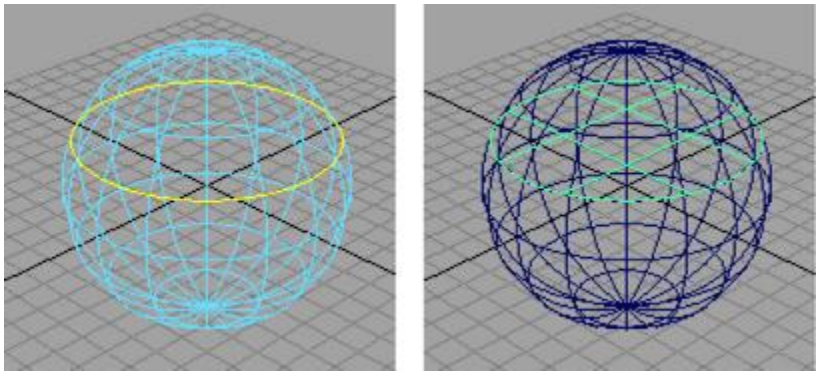
The Planar action creates a flat, trimmed NURBS surface inside a curve.

1. Select a closed, planar curve, or multiple curves that form a closed, planar region.

   You can select multiple curves that form an enclose region by overlapping. They do not need to be connected end-to-end.



2. Choose Surfaces > Planar.



Notes

- You can use the **Keep Outside** attribute to create a trimmed surface with a hole cut of the enclosed region instead of a trimmed surface inside the enclosed region.
- You can edit the input curves to change the shape of the surface, but the surface must remain planar.
- Although a planar surface can include cut-out areas and holes, all curves must be co-planar even if they appear to create separate parts of the surface.

Extrude and bevel a surface from a curve

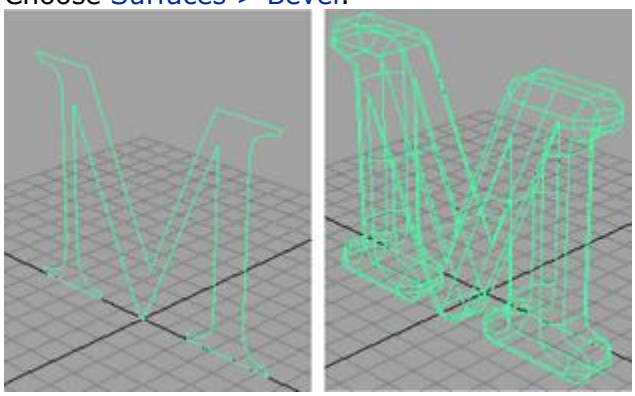
Use Surfaces > Bevelto create an extruded surface with a beveled edge from any curve, including text curves and trim edges. For example, to create a ledge on a building, or the rolled edges on an upholstered chair.

Create a simple extrude and bevel

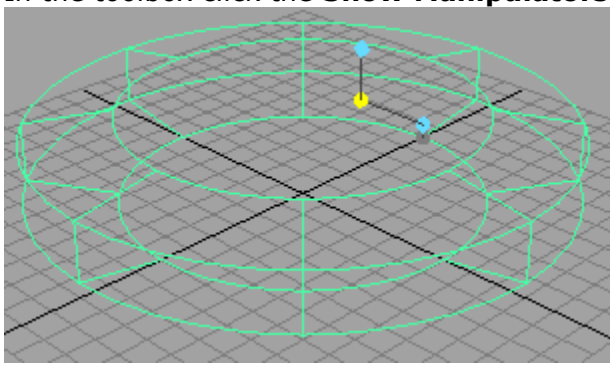
1. Select the curve.

   You can create beveled surfaces from normal 3D curves, isoparms, and surface edges.

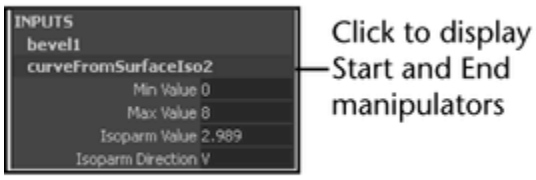
2. Choose Surfaces > Bevel.

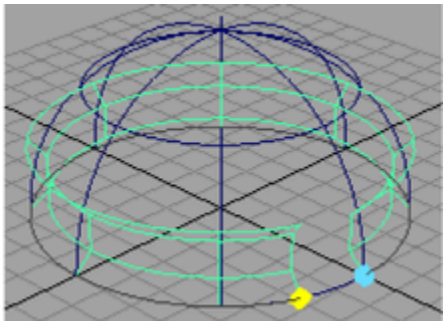


3. In the toolbox click the **Show Manipulators tool** to manipulate the beveled surface.



   If you turned on the **Partial** option in the **Bevel Options** window, click the curve or isoparm heading in the channel box to show additional attributes for using only a subsection of the curve.





Bevel Plus

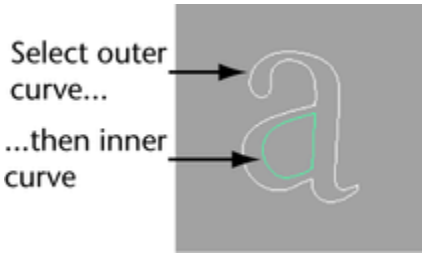
Bevel Plus has various features beyond Surfaces > Bevel operation:

- Creates a completely solid surface, including a cap on either end of the beveled curve. The surface will not break when you deform it, which is ideal for flying logos.
- Gives you various style options for the bevel shape.
- Gives you more control over the tessellation of the surface.

Bevel Plus is useful for creating solid letters and logos.

To bevel with Bevel Plus

1. Select a single curve. For shapes with a hole (such as a letter a), select the outer curve first and the inner curve second.

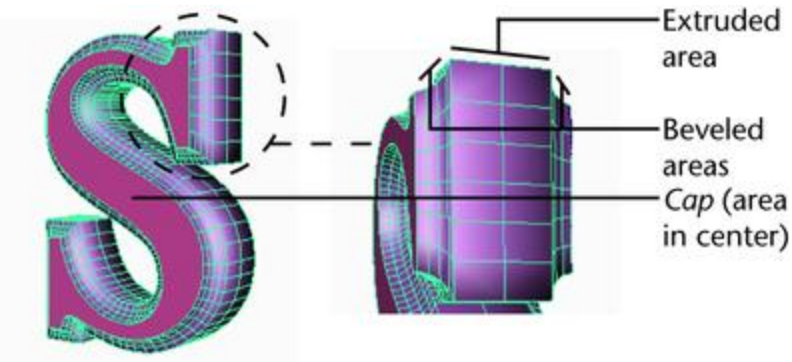


2. Choose Surfaces > Bevel Plus > ❐.
3. Set the options.
4. Click **Bevel**.

Surfaces > Bevel Plus

Lets you create beveled transition surfaces with a much higher degree of control than regular **Bevel**.

As you edit the **Bevel Plus** options, refer to the following figure, showing the parts of the surface created by **Bevel Plus**:



Attach Surfaces

This option is enabled if you set the **Output Geometry** option to **NURBS**. When **Attach Surfaces** is on, Maya attaches the beveled areas and the extruded area together to form one NURBS surface. When it is off, Maya creates separate NURBS patches for each area.

For example, you might turn off **Attach Surfaces** so you can easily apply a different material to the patches in the beveled area than the patch in the extruded area.

Create Bevel: At Start, At End

Turns beveling on or off at either end of the resulting surface. **At Start** controls the portion closest to the curve and **At End** controls the portion furthest from the curve.

Bevel Width

Specifies the width of the beveled area as viewed from the front of the resulting surface.

Bevel Depth

Specifies the depth of the beveled area as viewed from the top or side of the resulting surface.

Extrude Distance

Specifies the distance of the extruded portion of the geometry, excluding the beveled areas.

Create Cap: At Start, At End

Turns on or off the creation of surfaces that cap the center area on either end of the beveled surface. **At Start** controls the portion closest to the curve and **At End** controls the portion furthest from the curve.

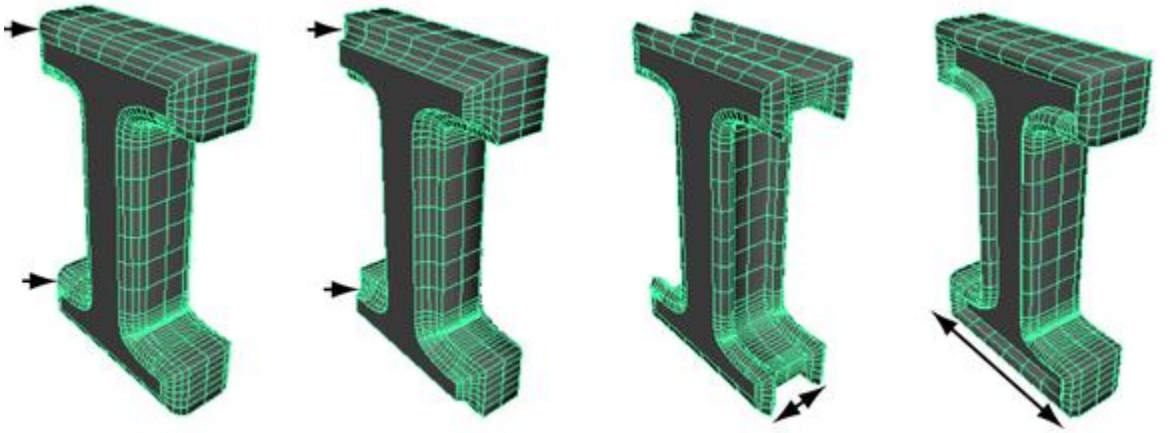
Bevel inside curves

Turns on beveling inside the curve rather than outside it. Turning this option on gives you greater control over the overall size of the beveled surface since you are guaranteed the resulting surface will be no larger than the original curve.

Bevel inside curves: off Bevel inside curves: on

Outer Bevel Style, Inner Bevel Style

1. The bevel style controls the overall look of the beveled surface. For example, **Straight Out** creates a straight beveled edge extending outward from the original curve.
2. You can switch between styles and compare the results by accessing the **outerStyleCurve** or **innerStyleCurve** attribute from the **Attribute Editor** or **Channel Box**.
3. The following figure illustrates some of the terms used in the bevel style names:



4. Convex Out Concave Out Straight Side Edge Straight Front Edge
5. **Same as Outer Style**
6. The **Outer** and **Inner** style are for letters or art that have an outer curve and an inner curve, such as the letter O. By default, they share the same bevel style, but you can make them different by turning off the **Same As Outer Style** option.

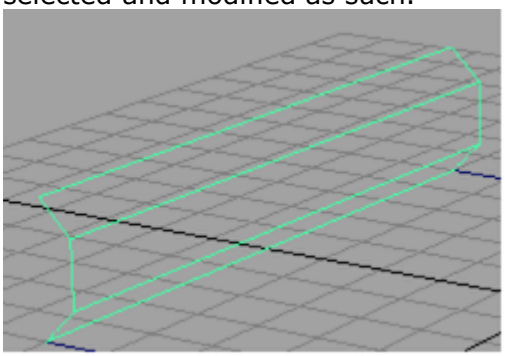
Surfaces > Bevel

Creates beveled transition surfaces from a profile curve.

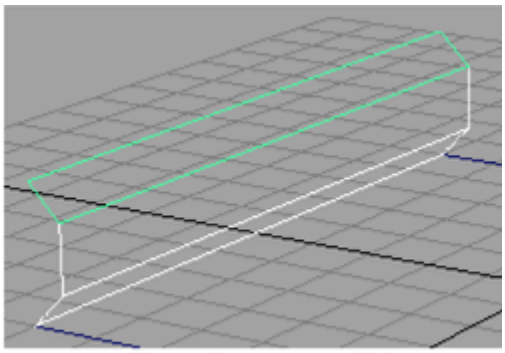
Surfaces > Bevel > ❐

Attach Surfaces

This option attaches each part of the bevel surface. If off, the surfaces are not attached. For example, if **Attach Surfaces** is off and you create a bevel with **Bevel** set to **Both**, three surfaces are created. These surfaces are independent and can be selected and modified as such.



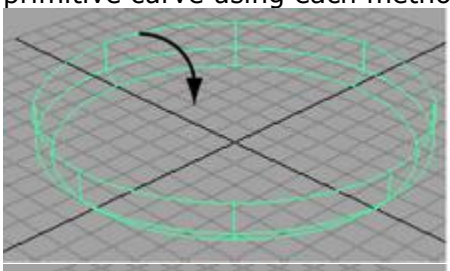
Attach Surfaces = On



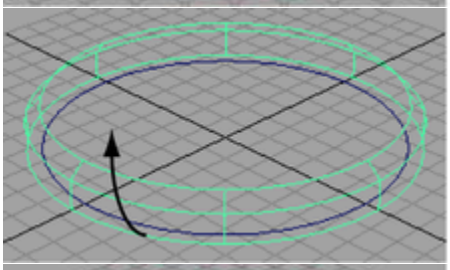
Attach Surfaces = Off

Bevel

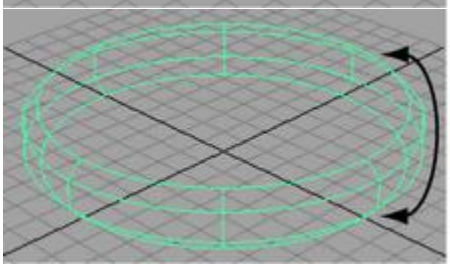
Specifies whether the beveled surface area is applied to the top, bottom, or both sides of the original curve or isoparm. The following example uses a NURBS circle primitive curve using each method.



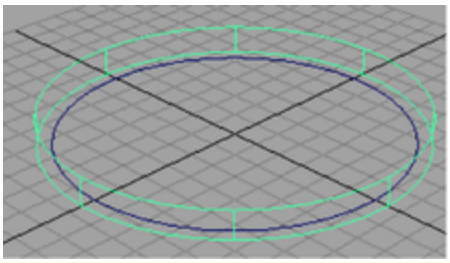
Top Side
The bevel is created from the top of the circle.



Bottom Side
The bevel is created from the bottom of the circle.



Both
The bevel is created from both the top and bottom of the circle. Default setting.



Off
Only the extrude part of the bevel surface is created.

Note

Setting the Bevel option to **Off** disables the bevel option controls (**Bevel Width**, **Bevel Depth**, **Bevel Corners**, and **Bevel Cap Edge**). If you do this, you can use **Bevel** for simple extrusions.

Bevel Width

The **Bevel Width** value specifies the initial width of the bevel as viewed from the front of the curve or isoparm.

Bevel Depth

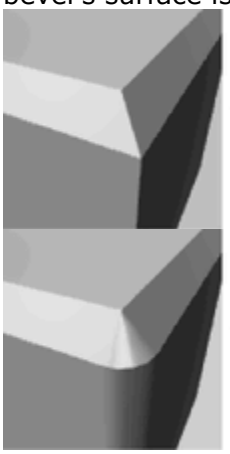
The **Bevel Depth** value sets the initial depth of the bevel part of the surface. The combination of **Bevel Width** and **Bevel Depth** sets the bevel angle.

Extrude Height

The **Extrude Height** value specifies the height of the extruded portion of the surface, not including the bevel surface area.

Bevel Corners

The **Bevel Corners** options specify how corners in the original construction curves are handled in the beveled surface. Note that if the curves are degree 1 or 2, the bevel's surface is cubic (degree 3).

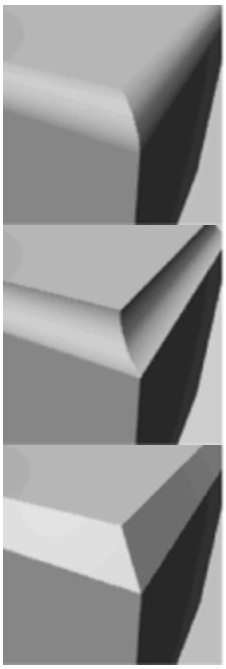


Straight
The bevel is created with linear, or straight, corners.

Circular Arcs
The bevel is created with rounded, or circular arc corners.

Bevel Cap Edge

The **Bevel Cap Edge** options set the shape of the beveled part of the surface.



Convex
The bevel is created with a convex edge.

Concave
The bevel is created with a concave edge.

Straight
The bevel is created with a straight edge.

Use Tolerance

The **Use Tolerance** options let you create a bevel within a specified tolerance of the original input curves.

Global tolerance

When this option is set, Maya uses the **Positional** value in the **Settings** part of the **Preferences** window.

Local tolerance

Local tolerance lets you enter a new value to override the value in the **Preferences** window.

Curve Range

Use the **Curve Range** options if you are creating a bevel from a curve.

Complete

This option uses the entire curve for the bevel operation.

Partial

This option lets you use a segment of the curve for the bevel.

Output Geometry

Specifies the type of geometry created. (**Subdiv** means subdivision surfaces.)

Input Curve

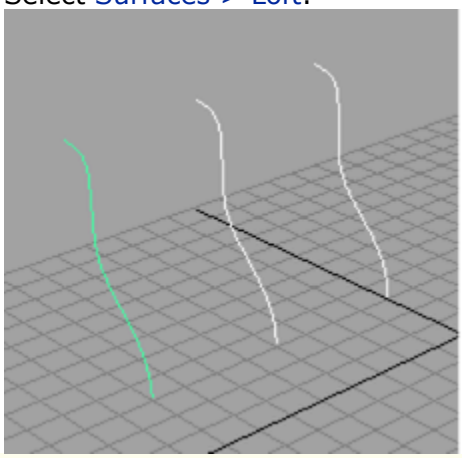
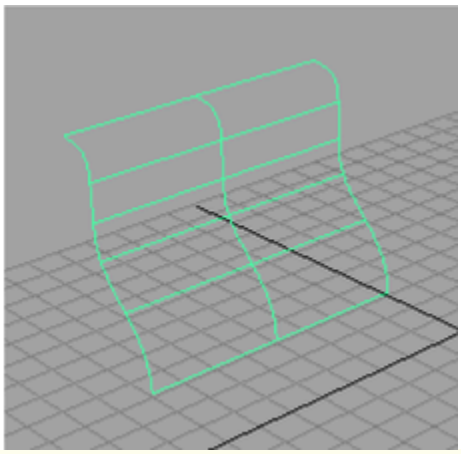
The **Input Curve** information is read-only. It gives you access to the history of the curves or isoparms you used to create the bevel surface. Click the arrow buttons to select the curve and open its section of the editor.

Skin a surface across profile curves

You can use the **Loft** action to create a surface between a series of cross-section or "profile" curves. The profile curves can be normal 3D curves, surface isoparms or edges, trim edges, or curves-on-surface.

To make a surface between profile curves

1. Pick the profile curves in order.
2. Select Surfaces > Loft.

Tip

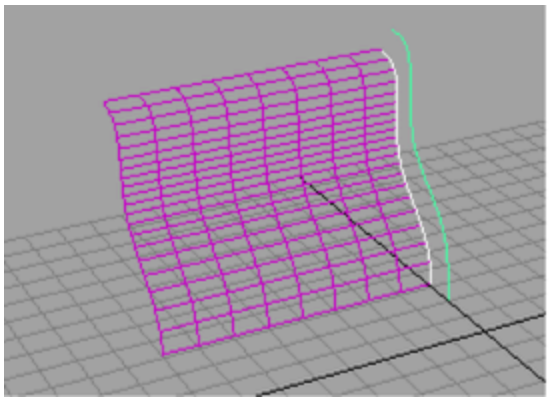
If you need a uniform transition of the surface as it lofts through each profile curve (for example, a boat hull), space the curves evenly.

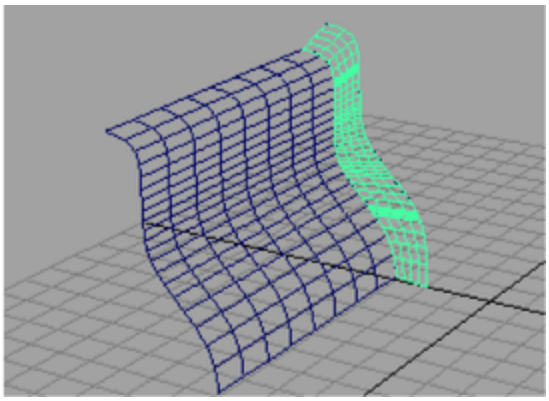
To add additional curves to a lofted surface

1. Select one of the curves you used to create the lofted surface.

   Maya displays the lofted surface in the construction history color to show its connection to the curve.

2. Select the curve you want to add, then select Surfaces > Loft.





Sweep a profile curve along a path curve

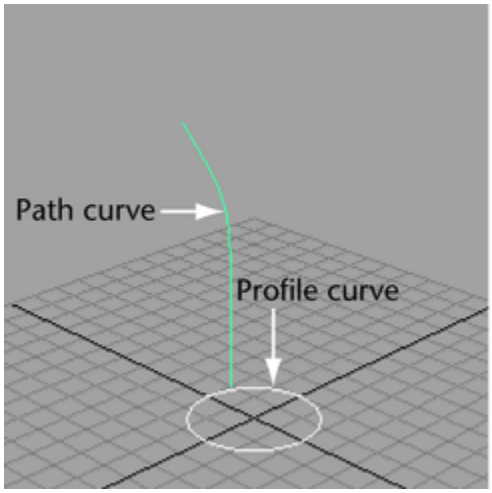
The **Extrude** action creates a surface by sweeping a cross-section (or "profile") curve along a path curve. The curves can be normal 3D curves, surface isoparms or edges, trim edges, or curves-on-surface. The ends of the extruded surface are open; however, you can create caps at each end using Surfaces > Planar.

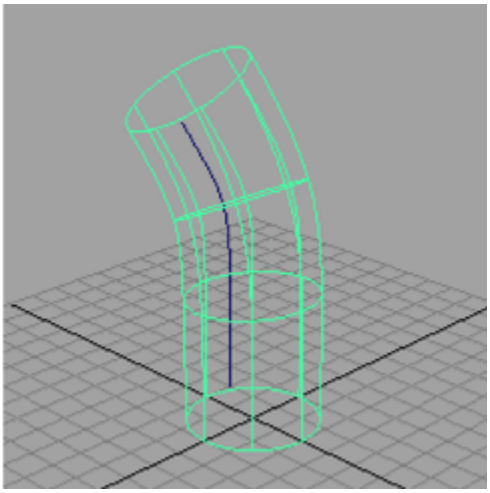
To extrude a profile curve along a path curve

1. Select the profile curve or curves. Then select the path curve.

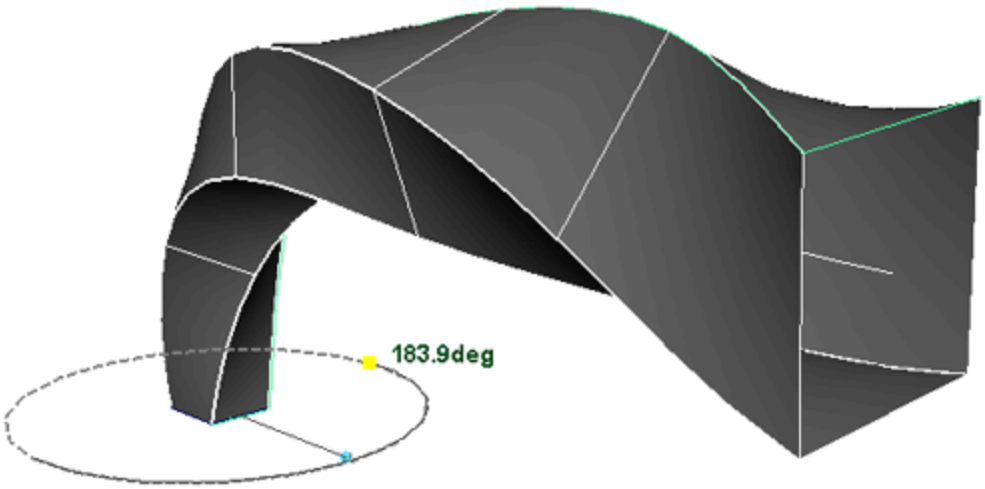
   Maya uses the key curve (the last curve you select) as the path.

2. Select Surfaces > Extrude.





3. Select the extrude node and choose the **Show Manipulators tool** to manipulate the extrude.



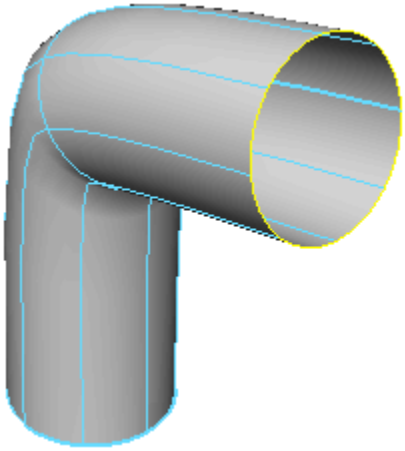
TipIf the path curve changes direction abruptly, the cross section may twist around the path.

If this happens, insert edit points in the path curve so its direction change is spread out across more CVs.

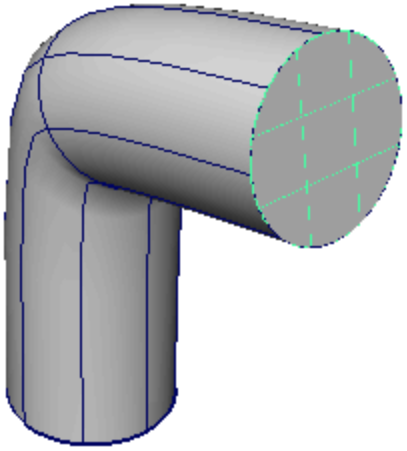
To cap the end of an extruded surface

1. Select the isoparm at the end of the extruded surface.

   To do this, press on the extruded surface, and choose **Isoparm** from the marking menu. Then click the end of the extruded surface.



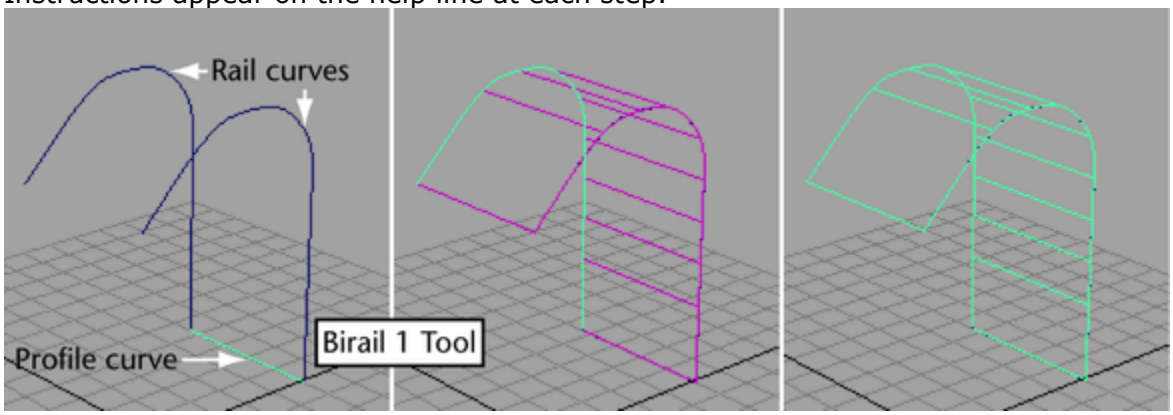
2. Select Surfaces > Planar to create a cap.

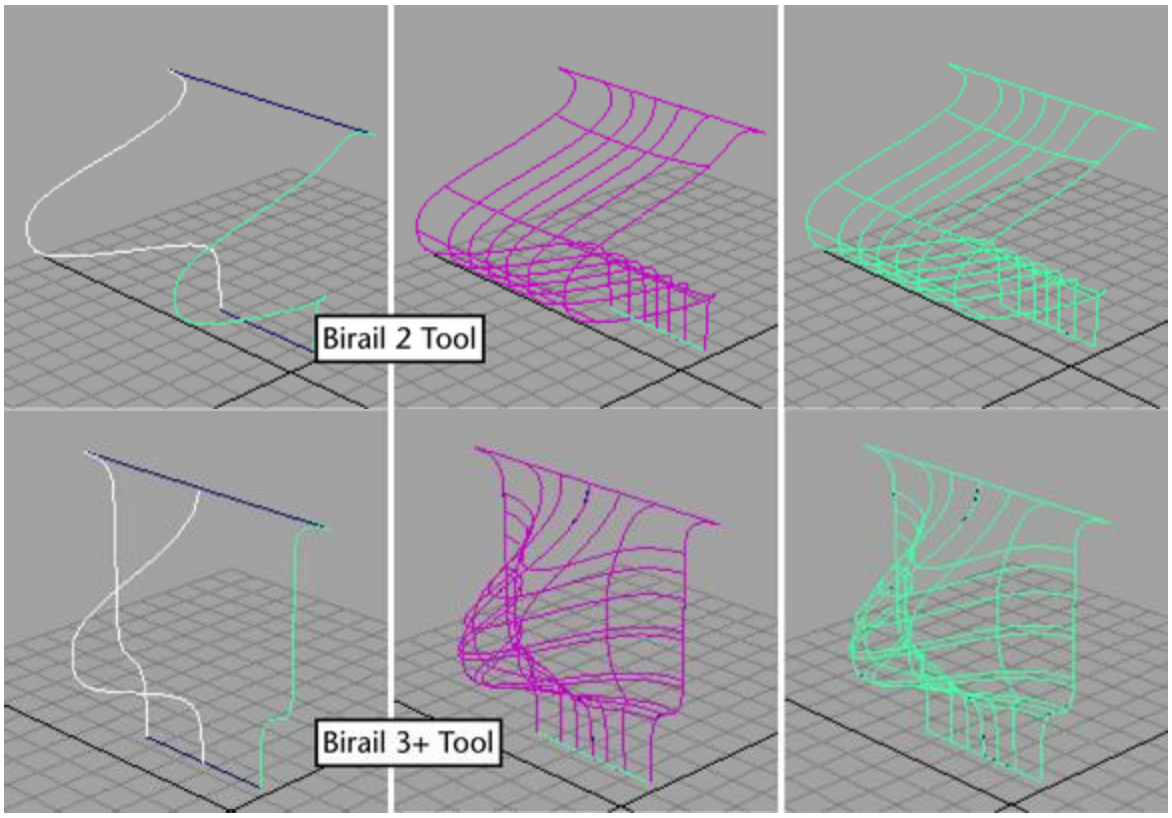


Sweep one or more profile curves along two path curves (birail)

1. Select Surfaces > Birail > **Birail n Tool** based on how many profile curves you want to use (1, 2, or 3-or-more).
2. Click the curve(s) you want to use a profile curves, then click the two rail curves.

   Instructions appear on the help line at each step.





Create a fillet between two surfaces

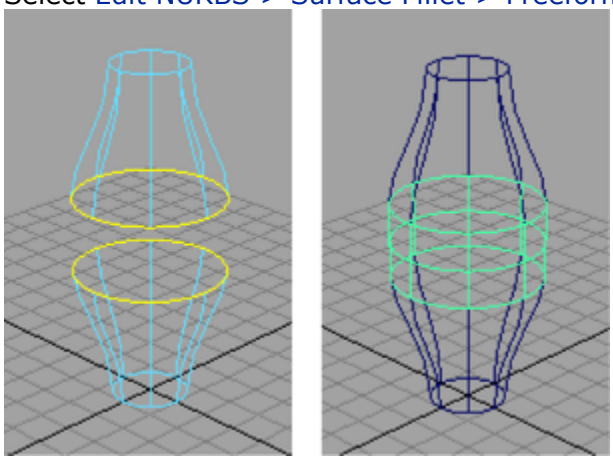
Create a circular fillet

1. Select two intersecting surfaces.
2. Select Edit NURBS > Surface Fillet > Circular Fillet > ❐.
3. Do any of the following:
   - Use the channel box, attribute editor, or **Show Manipulator tool** to change the radii.
   - Select one of the surfaces and choose Edit NURBS > Reverse Surface Direction to change which side of the surface the fillet is built on.

Create a freeform fillet

1. Select an isoparm or curve-on-surface on each surface as the start and end points of the fillet.

2. Select Edit NURBS > Surface Fillet > Freeform Fillet.



3. Do any of the following:

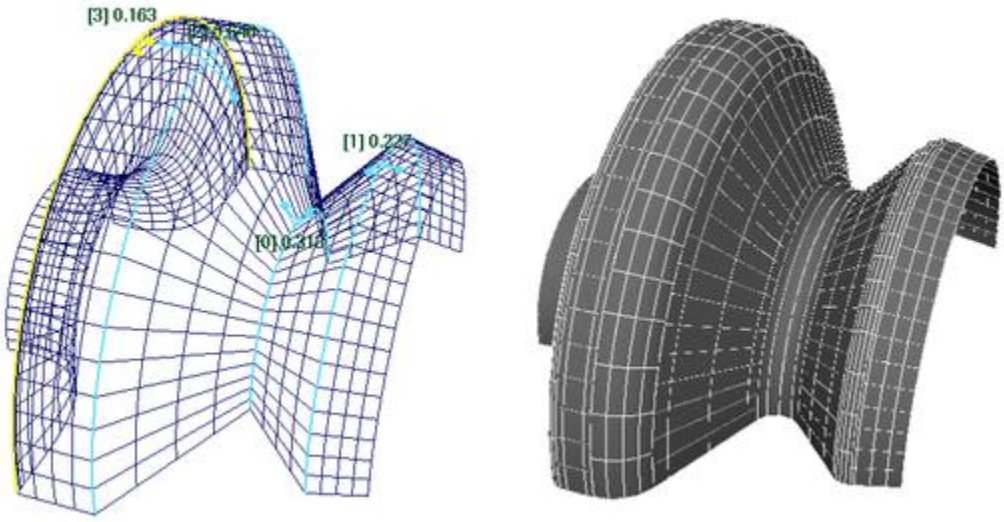
   - Use the channel box, attribute editor, or **Show Manipulator tool** to edit the fillet.
   - To manipulate the isoparms used to create the fillet, select the one of the curveFromSurface nodes.

Round off the meeting point between two

1. Select Edit NURBS > Round Tool.
2. Drag a selection box across the common edges between surfaces.
3. When you click a common edge, a radius manipulator appears. Drag the handles at the ends of the manipulator arms to change the rounding radius.

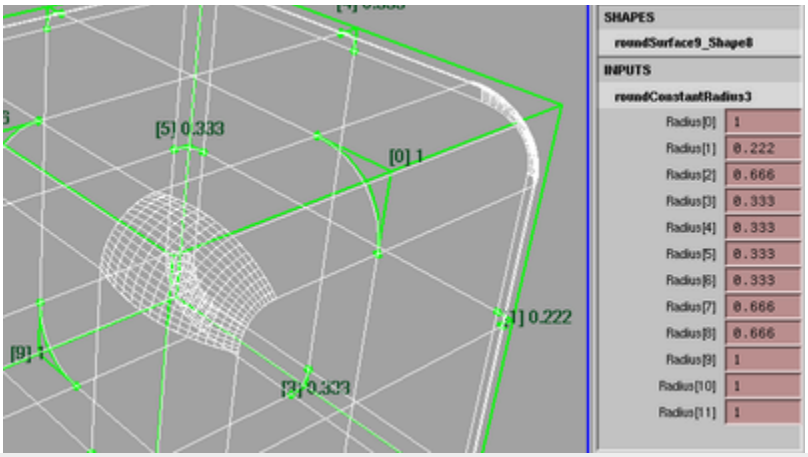
   To deselect an edge, click the manipulator on the edge and press Delete.

4. When you are done marking edges to be rounded, press Enter.



You can edit the radii of the fillets after you create them by selecting the **Round** node and using the channel box, attribute editor, or **Show Manipulator tool**.

If a fillet cannot be built with the current radius, the manipulator for that edge is drawn in red.



Notes

- Overlapping radii will fail or create unpredictable results.

  You can correct this by editing the radii with the **Show Manipulator tool** after the fillets are created. If the angle between the two surfaces is less than 15 degrees or greater than 165 degrees, the fillets produced might be inadequate.

- The edges you round must be from separate surfaces.
- If the edges have different lengths, a fillet surface will be created only for the shorter edge.
- Corners are points where pairs of edges meet. You cannot use the **Round Tool** on more than three pairs of corners.

  For example, you can use the **Round Tool** on all edges of a cube, but you can not use it on the tip of a pyramid, where four edge pairs meet at the top.

- Acute corners may fail as the fillets begin to self-intersect.
- The radius manipulator approximates the profile of the fillet only when the surfaces meet at an angle of nearly 90 degrees.

Trim or untrim a NURBS surface

Trimming removes (actually hides) any region of a surface that is bounded or bisected by a curves-on-surface. Trimming a surface lets you create complex edges and holes in NURBS surfaces. You must create curves-on-surface before you can trim the surface.

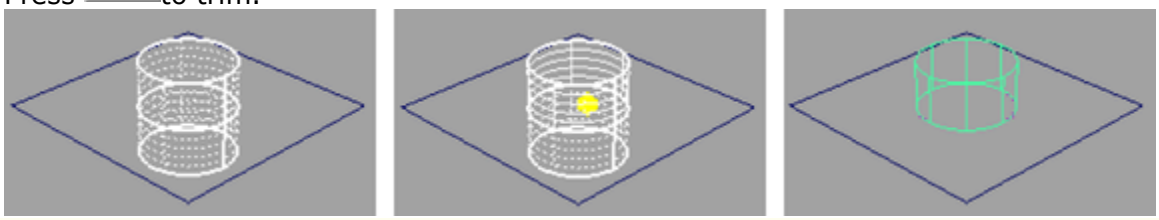
Trim a surface

1. Choose Edit NURBS > Trim Tool.
2. Click the surface you want to trim.

   A "trim grid" appears on the surface.
3. Click the regions (defined by curves-on-surface) of the surface you want to keep (you do not need to hold Shift to click multiple regions).

   As you click, regions that will be trimmed away are dotted, and regions that will be kept are solid.

   If you want to change the tool so you click the parts of the surface you want to trim off, open the option box (Edit NURBS > Trim Tool > ❐) and set **Selected State** to **Discard**.
4. Press Enter to trim.



Tip

A seam can divide a region in two. Make sure when you click a region bisected by the seam that both sides are marked.

Untrim a surface

1. Select the surface or surfaces you want to untim.
2. Choose Edit NURBS > Untrim Surfaces.

   The default is to remove all trims from the surface, restoring it to its original state. To only reverse the most recent trim operation, open the option box (Edit NURBS > Untrim Surfaces > ❐) and set **Untrim** to **Last**.

If you turned on the **Shrink Surface** option when you trimmed the surface, **Untrim** cannot restore the original shape of the surface.

Notes

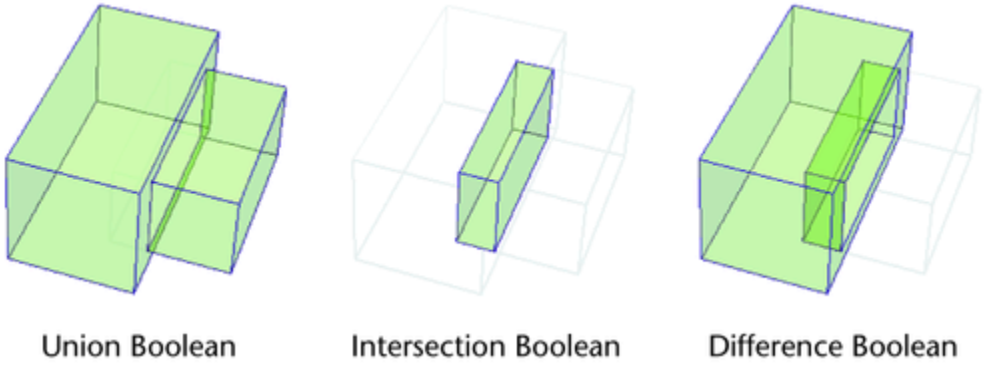
- If a NURBS primitive cone or cylinder with cap(s) is to be involved in a subsequent trimming operation, they must be created with the **Extra transform on caps** option set to on, or the surface for trim will only be selectable in the **Outliner**/**Hypergraph** and not in the view

NURBS Booleans

Booleans are a feature you can use to trim multiple NURBS surfaces in one operation. Booleans provide a faster workflow by letting you trim multiple surfaces at once versus having to intersect each surface separately.

Three types of boolean operations possible in Maya:

- **Union booleans** - Combines two or more objects and discards the regions that overlap.
- **Intersection booleans** - Combine two or more objects and keeps only the regions that overlap.
- **Difference booleans** - Combines two or more objects and subtracts the overlapping region from the first object.



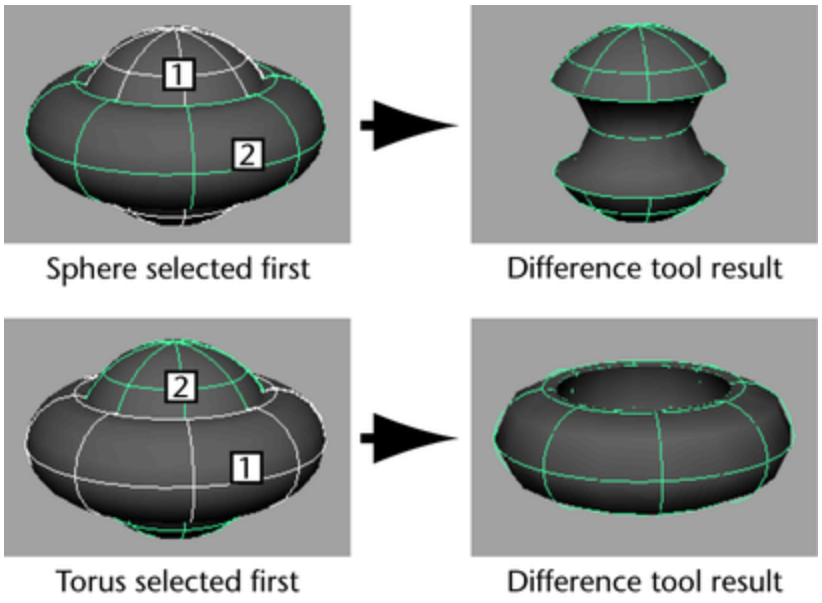
Perform boolean operations on surfaces

Boolean operations are actions that trim surfaces to create the appearance of a union, intersection, or subtraction between two objects.

To perform a boolean operation on a surface

1. Choose an action from the Edit NURBS > Booleans submenu.
   - Union trims the surfaces so they appear to be merged.
   - Difference trims the surfaces so that the volume of the second surface appears to be subtracted from the first.
   - Intersection trims the surfaces so that only their shared volume remains.
2. Click the first surface and press Enter. Then click the second surface.

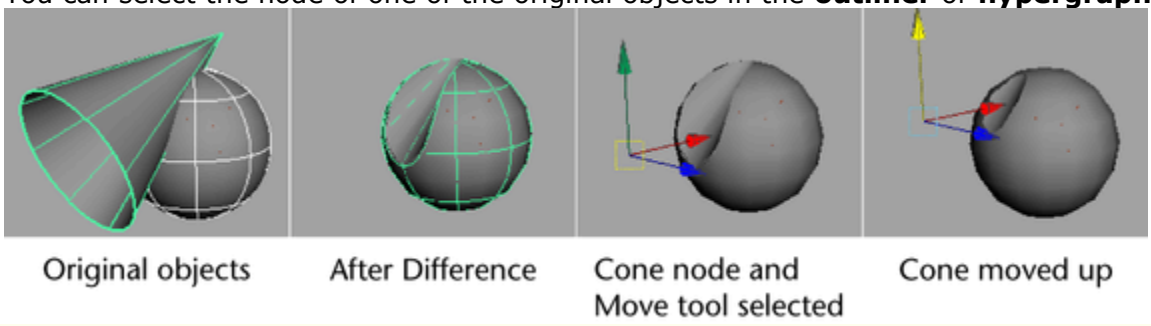
   The order in which you click the surfaces only matters for the **Difference** tool. Maya subtracts the second surface you click from the first.



Maya groups the combined surfaces.

You can make the following adjustments after creating the **Boolean** shape:

- To change the **Boolean** operation, such as changing **Difference** boolean to an Intersection boolean, select the boolean node in the **Channel Box** and change the **Operation** option.
- You can select the node of one of the original objects in the **outliner** or **hypergraph**.



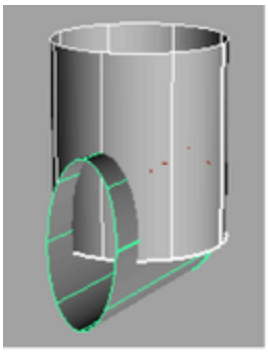
Note

The only way to retrieve the original objects after a **Boolean** operation is to use **Undo**.

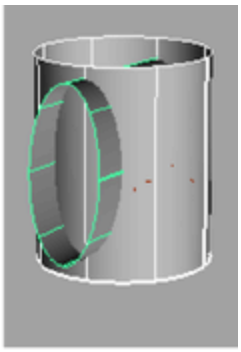
Troubleshooting boolean operations

If you get a "not a valid NURBS shell" error it means the boolean tool cannot create meaningful geometry from the surfaces you clicked.

For example, in the following illustration, the horizontal cylinder does not enclose a space that can be combined with the vertical cylinder. If you move the horizontal cylinder up, the boolean actions will work.



Boolean impossible



Boolean possible

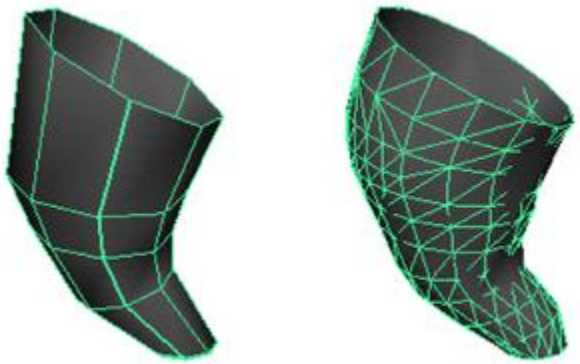
Convert NURBS surfaces to a polygon mesh

You can convert a NURBS surface to a polygon mesh whether it was created in Maya or imported into Maya from another 3D application. Trimmed surfaces are also converted in the process.

If the NURBS surface has a texture applied to it, this texture is assigned to the new polygonal object. The NURBS to Polygons action bakes the NURBS UV values onto the corresponding polygonal vertices.

To convert NURBS to polygons

1. Select the NURBS surface and choose Modify > Convert > NURBS to Polygons. A polygonal representation of the surface is created at the same position as the NURBS surface.



If you convert the NURBS surface with construction history on, you can edit the NURBS surface and the polygonal surface will be recreated to match.

Notes

- If a NURBS surface is converted into a polygonal object using the NURBS To Polygons feature, and if the history of the NURBS surface is modified to generate an invalid (Null) NURBS surface, the following warning message displays:

```
Warning: nurbsTesselate1 (Nurbs Tesselate Node): invalid input NURBS
surface.
```

and the NURBS To Polygons operation will not be successfully performed. The resulting polygonal object will continue to be the last valid (computed) polygonal surface that was visible.

- In some cases when converting multiple NURBS patches to a single polygonal mesh you may notice strange shading effects on the mesh. This is because of the normals. To correct the shading due to normals, see Fill holes in a polygon mesh.
- NURBS to polygon conversion does not take the Fix Texture Warp attribute (which adjusts a texture's UV parameters so the texture does not rely on a NURBS object's UV parameterization) into account.