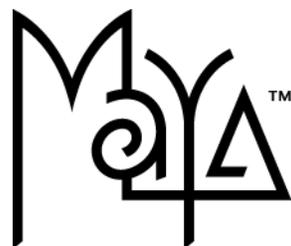




NURBS Modeling

Version 6



© Copyright 2004 Alias Systems, a division of Silicon Graphics Limited ("Alias"). All images © Copyright Alias unless otherwise noted. All rights reserved.

Inside cover image created by Yiqun Chen.

Alias is a registered trademark and the swirl logo, the Maya logo, Conductors, Trax, IPR, Maya Shockwave 3D Exporter and MEL are trademarks of Alias in the United States and/or other countries worldwide. Maya is a registered trademark of Silicon Graphics, Inc. in the United States and/or other countries worldwide, used exclusively by Alias. SGI, IRIX, Open GL and Silicon Graphics are registered trademarks of Silicon Graphics, Inc. in the United States and/or other countries worldwide. mental ray and mental images are registered trademarks of mental images GmbH & CO. KG. in the United States and/or other countries. Lingo, Macromedia, Director, Shockwave and Macromedia Flash are trademarks or registered trademarks of Macromedia, Inc. Wacom is a trademark of Wacom Co., Ltd. NVidia is a registered trademark and Gforce is a trademark of NVidia Corporation. Linux is a registered trademark of Linus Torvalds. Intel and Pentium are registered trademarks of Intel Corporation. Red Hat is a registered trademark of Red Hat, Inc. ActiveX, Microsoft and Windows are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries. Mac, Macintosh and QuickTime are trademarks of Apple Computer, Inc., registered in the United States and other countries. Adobe, Adobe Illustrator, Photoshop and Acrobat are either registered trademarks or trademarks of Adobe Systems Incorporated. UNIX is a registered trademark, licensed exclusively through X/Open Company, Ltd. AutoCAD, Discreet Logic, Inferno and Flame are either registered trademarks or trademarks of Autodesk, Inc. in the USA and/or other countries. OpenFlight is a registered trademark of MultiGen Inc. Java is a registered trademark of Sun Microsystems, Inc. RenderMan is a registered trademark of Pixar Corporation. Softimage is either a registered trademark or trademark of Avid Technology, Inc. in the United States and/or other countries. All other trademarks, trade names, service marks, or product names mentioned herein are property of their respective owners.

This document contains proprietary and confidential information of Alias, and is protected by Federal copyright law and international intellectual property conventions and treaties. The contents of this document may not be disclosed to third parties, translated, copied, or duplicated in any form, in whole or in part, or by any means, electronic, mechanical, photocopying, recording or otherwise, without the express prior written consent of Alias. The information contained in this document is subject to change without notice. Neither Alias, nor its affiliates, nor their respective directors, officers, employees, or agents are responsible for any damages of any kind arising out of or resulting from the use of this material, including, without limitation, any lost profits or any other direct, indirect, special, incidental, or consequential damages or for technical or editorial omissions made herein.



Table of contents

1	Background	11
About	NURBS	11
	Brief history of splines	11
	Mathematical representations of curves	12
	NURBS	13
	Object properties	14
	Degree	14
	Parameters and parameterization	14
	Normals	17
	Periodic, closed, and open	17
	Modeling concepts	20
	Curvature	20
	Continuity	20
	Curves	21
	Curve components	21
	Moving edit points vs. moving CVs	23
	Multi-knots and CV multiplicity	24
	Constructing quality curves	24
	Surfaces	25
	Surface components: CVs, isoparms, and patches	26
2	Creating curves	27
How do I?	Create and edit models	27
	Create curves	27
	Draw curves	27
	Create a curve from a surface edge, isoparm, or curve-on-surface	28
	Create arcs	29
	Create a fillet curve between two existing curves	30
	Create a degree 3 curve to match degree 1 (scan) data	31
Reference	Menus	32
	Create	32
	Create > CV Curve Tool	32

Table of Contents

	Create > EP Curve Tool	33
	Create > Pencil Curve Tool	34
	Create > Arc Tools > Three Point Circular Arc, Two Point Circular Arc	34
	Modeling menu set.	34
	Edit Curves	34
	Edit Curves > Duplicate Surface Curves	34
	Edit Curves > Curve Fillet	35
	Edit Curves > Fit B-spline	37
3	Creating NURBS surfaces.	39
How do I?	Create and edit models	39
	Create NURBS surfaces	39
	Create a flat surface inside a curve	39
	Skin a surface across profile curves	40
	Sweep a profile curve along a path curve	42
	Sweep one or more profile curves along two path curves (birail)	43
	Create a surface within bounding curves	44
	Create a surface from four boundary curves that maintains continuity (square)	46
	Sweep out a surface by rotating a curve around an axis	46
	Extrude and bevel a surface from a curve	47
	Create a new surface from patches of an existing surface	49
	Create NURBS transition surfaces	50
	Round off the meeting point between two edges	50
	Create a fillet between two surfaces	51
	Create a surface between two sets of boundary curves	52
Reference	Menus	53
	Create	53
	Create > NURBS Primitives	53
	Modeling menu set.	57
	Surfaces	57
	Surfaces > Revolve	57
	Surfaces > Loft	61

Table of Contents

Surfaces > Planar	65
Surfaces > Extrude	67
Surfaces > Birail > Birail 1 Tool, Birail 2 Tool, Birail 3+ Tool	73
Surfaces > Boundary	76
Surfaces > Square	78
Surfaces > Bevel	79
Surfaces > Bevel Plus	82
Edit NURBS	87
Edit NURBS > Duplicate NURBS Patches	87
Edit NURBS > Round Tool	88
Edit NURBS > Surface Fillet > Circular Fillet	88
Edit NURBS > Surface Fillet > Freeform Fillet	91
Edit NURBS > Surface Fillet > Fillet Blend Tool	91
4 Editing NURBS	99
How do I?	
Create and edit models	99
Reshape NURBS curves and surfaces	99
Reshape a curve or surface manually	99
Align a curve with a curve or surface	102
Align surface edges	104
Smooth a curve	105
Lock or unlock the length of a curve	105
Straighten, smooth, curl or bend a curve	106
Extend a curve	107
Extend a surface	108
Select curve CVs: first, last or all	109
Edit NURBS curves and surfaces	110
Join two curves or surfaces together (attach)	110
Split a curve or surface (detach)	111
Insert additional edit points/isoparms in a curve or surface to add more CVs	111
Create an offset copy of a curve or surface	112
Reverse the direction of a curve or surface normals	113
Reduce the complexity of a curve or surface	114

Table of Contents

	Control multi-knots and CV hardness	115
	Automatically add spans to areas of a curve with high curvature . .	117
	Convert a curve or surface to uniform parameterization	117
	Convert a surface to non-rational geometry	117
	Change a curve or surface's degree or number of spans/patches . .	118
	Make a curve or surface open or closed.	119
	Match the topology of one curve to another	120
Reference	Tools	120
	Toolbox	120
	Soft Modification tool	120
	Menus	121
	Display	121
	Display > NURBS Components > Custom	121
	Display > NURBS Smoothness	121
	Modeling menu set.	123
	Edit Curves	123
	Edit Curves > Extend > Extend Curve	123
	Edit Curves > Extend > Extend Curve on Surface	125
	Edit Curves > Add Points Tool	126
	Edit Curves > Offset > Offset Curve, Offset Curve on Surface	126
	Edit Curves > Attach Curves	128
	Edit Curves > Detach Curves	130
	Edit Curves > Align Curves	131
	Edit Curves > Open/Close Curves	132
	Edit Curves > Move Seam	133
	Edit Curves > Cut Curve	133
	Edit Curves > Intersect Curves	134
	Edit Curves > Insert Knot	135
	Edit Curves > Reverse Curve Direction	136
	Edit Curves > Rebuild Curve	136
	Edit Curves > Smooth Curve	139
	Edit Curves > CV Hardness	139
	Edit Curves > Curve Editing Tool	140

Table of Contents

Edit Curves > Project Tangent	141
Edit Curves > Modify Curves > Lock Length	142
Edit Curves > Modify Curves > Unlock Length	143
Edit Curves > Modify Curves > Straighten	143
Edit Curves > Modify Curves > Smooth	144
Edit Curves > Modify Curves > Curl	145
Edit Curves > Modify Curves > Bend	145
Edit Curves > Modify Curves > Scale Curvature	146
Edit Curves > Selection > Select Curve CVs	147
Edit Curves > Selection > Select First CV on Curve	147
Edit Curves > Selection > Select Last CV on Curve	147
Edit Curves > Selection > Cluster Curve	148
Edit NURBS	148
Edit NURBS > Extend Surfaces	148
Edit NURBS > Offset Surfaces	149
Edit NURBS > Selection > Select Surface Border	149
Edit NURBS > Attach Surfaces	150
Edit NURBS > Attach Without Moving	151
Edit NURBS > Detach Surfaces	151
Edit NURBS > Align Surfaces	153
Edit NURBS > Open/Close Surfaces	159
Edit NURBS > Move Seam	161
Edit NURBS > Insert Isoparms	161
Edit NURBS > Reverse Surface Direction	163
Edit NURBS > Rebuild Surfaces	164
Edit NURBS > Surface Editing > Surface Editing Tool, Break Tangent, Smooth Tangent	168
Edit NURBS > Selection	168
5 Trimming	171
About NURBS	171
Curves-on-surface.....	171
Trimming.....	172
How do I? Create and edit models	172

Table of Contents

	Trim a NURBS surface	172
	Create a curve-on-surface	172
	Trim or untrim a NURBS surface	174
	Perform boolean operations on surfaces	175
Reference	Menus	177
	Modeling menu set.	177
	Edit NURBS	177
	Edit NURBS > Project Curve on Surface	177
	Edit NURBS > Intersect Surfaces	179
	Edit NURBS > Trim Tool	180
	Edit NURBS > Untrim Surfaces	181
	Edit NURBS > Booleans > Union Tool, Subtract Tool, Intersect Tool	181
6	Stitching.	183
How do I?	Create and edit models	183
	Lock points or edges on NURBS surfaces together (stitching)	183
	Automatically stitch multiple surfaces together	183
	Manually stitch surface edges together	185
	Manually stitch surface points together	186
Reference	Menus	186
	Modeling menu set.	186
	Edit NURBS	186
	Edit NURBS > Stitch > Stitch Surface Points	186
	Edit NURBS > Stitch > Stitch Edges Tool	188
	Edit NURBS > Stitch > Global Stitch	191
7	The Sculpt Surfaces tool	195
About	NURBS	195
	The Sculpt Surfaces tool	195
How do I?	Create and edit models	198
	Reshape NURBS surfaces with the Sculpt Surfaces tool. ..	198
	Push or pull a surface with the Sculpt Surfaces tool	198

Table of Contents

	Smooth a surface with the Sculpt Surfaces tool	198
	Selectively erase back to a previous state with the Sculpt Surfaces tool	199
	Sculpt according to an attribute map	199
	Sculpt across seams and surface edges	200
	Keyframe sculpting changes	200
Reference	Menus	201
	Modeling menu set.	201
	Edit NURBS	201
	Edit NURBS > Sculpt Surfaces Tool	201
8	Customization	207
How do I?	Customize Maya	207
	Switch NURBS operations between actions and tools	207

Table of Contents

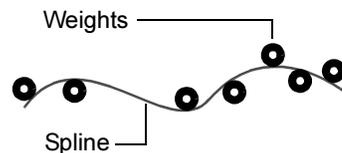
1 Background

About

NURBS

Brief history of splines

Splines are types of curves, originally developed for ship-building in the days before computer modeling. Naval architects needed a way to draw a smooth curve through a set of points.



The solution was to place metal weights (called *knots*) at the control points, and bend a thin metal or wooden beam (called a *spline*) through the weights.

The physics of the bending spline meant that the influence of each weight was greatest at the point of contact, and decreased smoothly further along the spline. To get more control over a certain region of the spline, the draftsman simply added more weights.

This scheme had obvious problems with data exchange! People needed a mathematical way to describe the shape of the curve. *Cubic Polynomials Splines* are the mathematical equivalent of the draftsman's wooden beam. Polynomials were extended to *B-splines* (for Basis splines), which are sums of lower-level polynomial splines.

❖ "Mathematical representations of curves" on page 12

Then B-splines were extended to create a mathematical representation called NURBS, which are used by Maya.

❖ "NURBS" on page 13

1 | Background

About > Mathematical representations of curves

Mathematical representations of curves

Polynomial equations

Starting with the simplest mathematical representation, we all remember from geometry class that we can represent a (two dimensional) line with an equation like $y = 2x$. For each value of x , we multiply it by 2 to get the value of y , and plot the two values on a graph.

The generalized form of this type of equation is $ax + by = c$. The expression to the left of the equals sign is called a *polynomial* (“poly” means many. It refers to the fact that the expression has more than one term).

We can make more complicated expressions where x is multiplied by itself, as $y = x * x * x$. Instead of writing out all the x s in a term, we usually just count them and write the count as a superscript. The superscript is called “the exponent”. So the expression above is written as $y = x^3$.

We can write polynomials with exponents, such as:

$$y = ax^2 + bx + c$$

(You may recall from math class that this is a *quadratic* equation). The exponent (the 2) on the first occurrence of x means that the graph of this function is curved rather than straight.

Degree

The *degree* of a polynomial equation is the largest exponent in the equation. Recall that the largest exponent on the equation for a line was 1. (When a term has no visible exponent, that is the same as an exponent of 1.)

- The degree of a linear equation is 1.
- A quadratic equation, which has a term x^2 , is degree 2.
- A cubic equation, which has a term x^3 , is degree 3, and so on.

Parametric representations

There are two general ways to write an equation for a curve. The *implicit* representation combines every variable in one long, non-linear equation, such as:

$$ax^3 + by^2 + 2cxy + 2dx + 2ey + f = 0.$$

In this representation, to calculate the x and y values to plot them on a graph, we must solve the entire non-linear equation.

The parametric representation rewrites the equation into shorter, easily solved equations that translate one variable into values for the others:

$$x = a + bt + ct^2 + dt^3 + \dots$$

$$y = g + ht + jt^2 + kt^3 + \dots$$

Using this representation, the equations for x and y are simple. We just need a value for t , the point along the curve for which we want to calculate x and y .

You can visualize parametric curves as being drawn by a point moving through space. At any time t , we can calculate the x and y values of the moving point.

This is a very important point, because the concept of associating a parameter number with every point on the line is used by many tools. This corresponds to the *U dimension* of the curve.

Creating complex curves

The lower the degree of a curve equation, the simpler the curve described. What if we want to represent complex curves? The simple answer might be to increase the degree of the curve, but this is not very efficient. The higher the degree of the curve, the more computations are required. Also, curves with degree higher than 7 are subject to wide oscillations in their shape, which makes them impractical for interactive modeling.

The answer is to join relatively low-degree (1 to 7) curve equations together as segments of a larger, more complex composite curve. The points at which the curve segments, or *spans*, join together is called an *edit point*.

Higher degree curves should not be completely discounted, however. Degree 5 and 7 curves have certain advantages such as smoother curvature and more “tension”. They are often used in automotive design.

Smooth joins

The degree of the curve determines the smoothness of the joins between spans. Degree 1 (linear) curves give positional continuity at the join. Degree 2 (quadratic) curves give tangent continuity. Degree 3 (cubic) curves give curvature continuity.

NURBS

NURBS stands for *Non-Uniform Rational B-Splines*.

- *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 that have a parametric representation.

1 | Background

About > Degree

Related topics

- ❖ "Curves" on page 21
- ❖ "Surfaces" on page 25
- ❖ "Object properties" on page 14

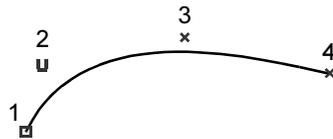
Object properties

Explains the properties common to NURBS objects.

Degree

Degree is a mathematical property of a curve or of a surface that controls how many CVs per span are available for modeling. Degree is the curve or surface's degree of freedom to bend. A degree 1 curve connects its edit points with straight lines. A degree 2 curve can have one bend between edit points, and so on.

The default degree in Maya is 3, which has four CVs for the first curve span. This is sufficient for almost any modeling task.



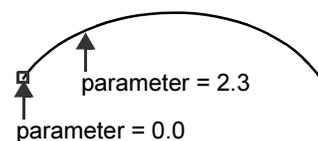
Surfaces can have different degrees across their width and length. For example, a surface could be degree 3 along its width, and degree 5 along its length.

The degree of your curves can affect data transfer to other software packages. Some other packages cannot accept curves with degree higher than 3.

Parameters and parameterization

What are parameters?

Parameters are the unique numeric values (like coordinates) of points on a curve or surface. Parameters let you refer to specific points along the length of a curve. The higher the parameter, the further is the point along the curve.



Just as points in space have three dimensions, called X, Y, and Z, the parameters of a point are measured along the one internal dimension (length) of the curve. We call this dimension U .

Since surfaces have two internal dimensions (length and width), we need another parameter (in addition to U) to specify a point on a surface. We call this parameter V .

Just as every point along the length of a curve has a U parameter, every point across a surface has U and V parameters.

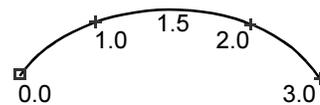
What is parameterization?

The method the application uses to number the points along a curve is called the curve's *parameterization*. There are two parameterization methods available: *uniform* and *chord-length*.

Each method has advantages and disadvantages depending on how the curve will be used. You can choose which parameterization method to use when you create a new curve, and you can rebuild existing curves to use a specific parameterization.

Different actions can create curves or surfaces with different parameterization methods, often as a user-configurable option. For example, the CV Curve Tool and EP Curve Tool use uniform knot spacing by default. The Pencil Tool uses chord length knot spacing.

Uniform



Uniform parameterization assigns integral parameter values to the edit points, and evenly distributes parameters along the spans between edit points. So the first edit point is always parameter 0.0, the second edit point is always 1.0, the third is always 2.0, and so on.

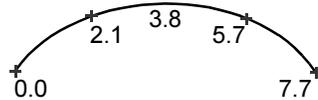
A bonus feature of uniform parameterization is that the parameter value of the last edit point is the also the number of spans in the curve. However, unlike chord-length parameterization, the parameters of a uniform curve have nothing to do with the actual length of the curve.

Though the default values for uniform parameterization range from 0 to the total number of spans, you can use Rebuild Curve/Rebuild Surface to change the range to 0 to 1. (The 0 to 1 scheme is common in other computer graphics packages. Some users may want to use it for the sake of familiarity.)

1 | Background

About > Parameters and parameterization

Chord-length



Chord-length parameterization assigns parameter 0.0 to the start of the curve, then increases the parameter value proportionally to the *chord length*, or the shortest linear distance, between the surrounding edit points.

Unlike uniform parameterization, the parameters of a chord-length curve are irregularly spaced between the edit points, and the edit points do not have integral parameters.

Comparison

Each parameterization method has advantages and disadvantages, depending on how you will use the curve or surface.

Type	Pros	Cons
Chord-length	<ul style="list-style-type: none">• Parameter value gives some indication of the point's relative position along the curve.• Distributes curvature better.• Minimizes stretching and squeezing of textures.	<ul style="list-style-type: none">• Parameters are not obvious.• Surfaces built from chord-length curves can be more complex because of cross-knot insertion.
Uniform	<ul style="list-style-type: none">• Easy to reckon parameters (for example, 1.5 is about half-way between edit points at 1.0 and 2.0).	<ul style="list-style-type: none">• In many cases, interpolation between edit points is not as good.• Can lead to unpredictable stretching of textures during rendering.

Just as with degree, surfaces can have different parameterization methods for their U and V dimensions. For example, the U isoparms of a surface can be degree 3 with uniform parameterization, while the V isoparms are degree 1 with chord-length parameterization.

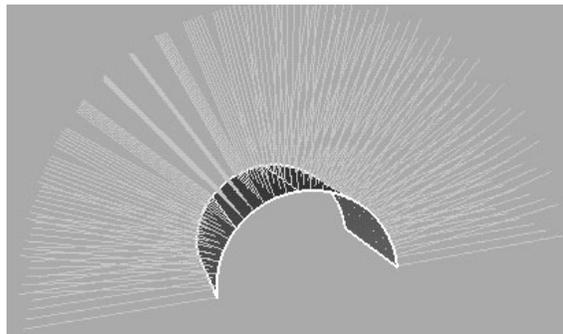
To avoid problems manipulating and texturing a joined surface, make sure the joined surfaces use the same parameterization (uniform or chord length). If both surfaces use uniform parameterization, make sure that both use the same parameter range (0 to 1 or 0 to total number of spans).

Viewing parameters

When you select a curve or surface point, the U and V (for surfaces) values are shown in the status line as you drag.

Normals

Normals are imaginary lines perpendicular to each point on a curve or surface.



The direction of U and V isoparms on a surface determines the direction of the surface's normals.

Normals are a mathematical side-effect of NURBS. They are often used as a way of specifying which side of a surface points "inside" or "outside" (for example, when creating *shells*).

Normals are also an indirect indicator of the shape of a curve or surface. Since they are always perpendicular to the curve or surface, the way normal lines point toward or away from each other can reveal subtle curvature.

Periodic, closed, and open

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

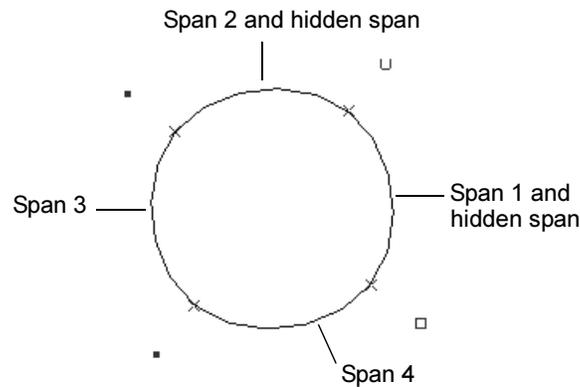
1 | Background

About > Periodic, closed, and open

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.

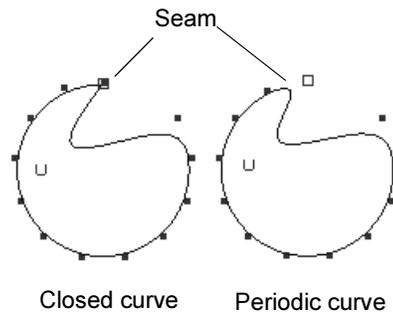


In contrast to a periodic curve, a closed curve can have a sharp corner at the seam because it lacks the extra spans.

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.

1 | Background

About > Periodic, closed, and open

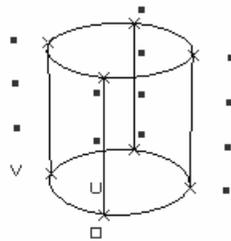


To see whether a curve is periodic, closed, or open, select the object, display the Attribute Editor, and examine the contents of the Form text box.

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).

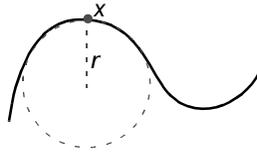
To see whether a surface is periodic, closed, or open, select the object, display the Attribute Editor, and examine the contents of the Form U and V text boxes. A surface is considered periodic whether it's periodic in U, V, or both.

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.

Modeling concepts

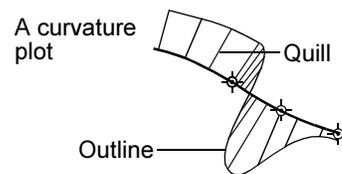
Curvature

Curvature is a measure of how much a curve curves.



Curvature is measured by fitting a circle into the curve, then taking the reciprocal of the circle's radius. In this figure, at point x the curve is best described by a circle with radius r . At this point, the curvature is $1/r$.

(We use the reciprocal, $1/r$, instead of just r because a flat line has an infinite radius. Taking the reciprocal gives us 0 instead of infinity.)



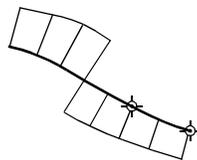
Continuity

Continuity is a measure of how well two curves or surfaces "flow" into each other where they meet.

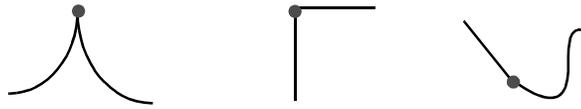
Types of continuity

Continuity is a mathematical indication of the smoothness of the flow between two curves or surfaces.

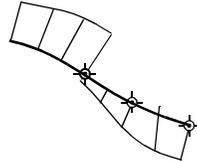
Positional (G0)



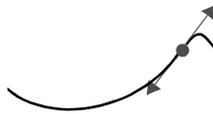
The endpoints of the two curves meet exactly. Note that two curves that meet at any angle can still have positional continuity.



Tangent (G1)

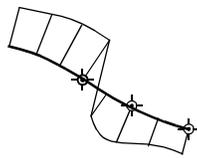


Same as positional continuity, plus the end tangents match at the common endpoint. The two curves will appear to be travelling in the same direction at the join, but they may still have very different apparent “speeds” (rate of change of the direction, also called *curvature*).



For example, in this figure, the two curves have the same tangent (the double-arrow line) at the join (the dot). But the curve to the left of the join has a slow (low) curvature at the join, while the curve to the right of the join has a fast (high) curvature at the join.

Curvature (G2)



Same as tangent continuity, plus the curvature of the two curves matches at the common endpoint. The two curves appear to have the same “speed” at the join.

Curves

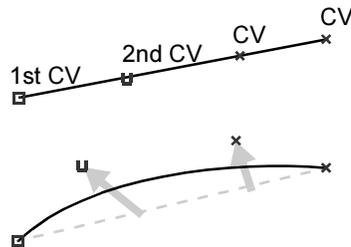
Curve components

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

1 | Background

About > Curve components

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*.

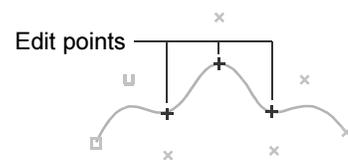
The number of CVs is equal to the degree of the curve plus one. So, for example, a degree 3 curve has four CVs per span. To increase the number of CVs to gain more control over curve shape, you can increase the number of spans by inserting edit points or increase the curve’s degree.

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



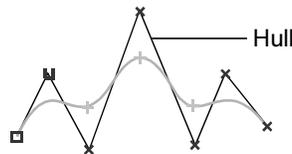
You can tell when a curve is made from multiple spans in several ways. One is to look for *edit points* on the curve. Edit points mark the connection point between two spans. Maya draws edit points as small Xs.

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.

Moving edit points vs. moving CVs

In theory, moving edit points would be an excellent way to edit a curve, since they lie on the curve itself. Unfortunately, it doesn't work out that way. This is because the shape of the curve determines the positions of edit points, not the other way around.

Maya *does* allow you to move edit points by "reverse engineering" the curve from the edit point. When you move an edit point, the Move tool tries to find a curve which passes through the new edit point location.

Because this process is time-consuming and has an infinite number of solutions, the tool must place constraints on how moving the edit point affects the curve. Because of these constraints, you usually cannot make major changes well by moving edit points. Moving edit points is best for small scale reshaping.

Even though it is slightly less intuitive, the only way to reshape the curve with complete power is by moving CVs.

1 | Background

About > Multi-knots and CV multiplicity

Multi-knots and CV multiplicity

A multi-knot is multiple edit points at the same location in space.

CV multiplicity is multiple CVs at the same location in space.

Multi-knots and CV Multiplicity achieve similar effects (sharper bends in curves), even though they are different mathematically.

Multi-knots are usually the result of curve or surface editing operations that require a sharp turn in a curve.

Multi-knots and CV multiplicity are generally undesirable. Some tools cannot work with them, they do not build very good surfaces or animate predictably, and some other software packages will not accept models with multi-knots.

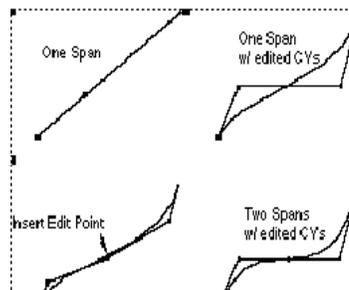
Constructing quality curves

To create quality surfaces you need quality curves. These guidelines will help you create good curves.

Simple curves

Use the simplest curves that can describe the shape you want. Simpler curves mean simple, faster rendering surfaces.

One effective method for achieving simple curves is:



- 1 Begin a curve by drawing a single span.
- 2 Move the CVs to achieve the shape you want.
- 3 If you can't achieve the shape, add an edit point to create more CVs.
- 4 Continue until you have the shape you need.

This iterative process ensures your curve only has as many spans as are absolutely necessary.

You can also use the **Rebuild curve** tool to simplify existing curves. The tool can simplify a curve while maintaining its shape within a tolerance you set.

Parameterization

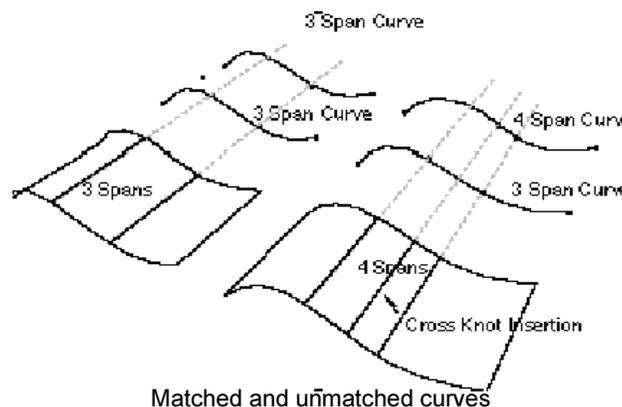
It is often best to build curves with uniform parameterization, because it makes inserting edit points and detaching curves at exact locations easier.

- When drawing Edit point curves with Uniform parameterization, the resulting CVs may be placed awkwardly. To fix this, move the CVs to prevent crossing hull lines.
- Try to consistently use either Uniform or Chord length parameterization when drawing curves. If you mix and match curve styles, it could result in cross knot insertion when the curves are used to build a surface.

Planning for surfaces

When creating curve, plan ahead to the surfaces that you want. Try to have the same number of spans in all the construction curves for building a surface. A simple way to achieve this is to start with one curve, then duplicate it to create more construction curves.

When you create a surface from curves with different numbers of spans, the new surface will have an extra isoparametric curve corresponding to every extra edit point. This is known as *cross knot insertion*. It makes the new surface more difficult to edit and more complex.



Surfaces

Describes how isoparametric curves, U and V coordinates, and possible trims combine to form a surface.

1 | Background

About > Surface components: CVs, isoparms, and patches

Surface components: CVs, isoparms, and patches

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

Isoparms

Isoparametric curves (or isoparms) are lines running along the surface in the U and V directions, showing the shape of the surface as defined by the CVs.

Patches

The area enclosed by four adjacent isoparms is called a *patch*.

CVs

Like curves, NURBS surfaces have CVs that control the shape of the surface. Each patch has a certain number of CVs, controlled by the degree of the curve. To increase the number of CVs you can insert extra isoparms or increase the degree of the surface.

2 Creating curves

How do I? Create and edit models

Create curves

Draw 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.

To draw a NURBS curve by placing edit points

Use this tool if you want the curve to pass through certain points. It calculates the positions of CVs based on where you want the 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.

2 | Creating curves

How do I? > Create a curve from a surface edge, isoparm, or curve-on-surface

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.

What if...?

I want the curve to form a closed loop?

- ❖ "Make a curve or surface open or closed" on page 119

Related topics

- ❖ "Create arcs" on page 29
- ❖ "Create > CV Curve Tool" on page 32
- ❖ "Create > EP Curve Tool" on page 33
- ❖ "Create > Pencil Curve Tool" on page 34

Create a curve from a surface edge, isoparm, or curve-on-surface

To create a new curve from a surface component curve

- 1 Select an edge, isoparm, or curve-on-surface.
- 2 Select Edit Curves > Duplicate Surface Curves.

When construction history is on, the curve remains linked to the original surface. Transformation is relative to the original surface, and changes to the component curve from which it was created change the duplicated curve.

Tip You can duplicate an isoparm and use it as a wire deformer for the surface.

Create arcs

To create a two-point arc

This tool allows you to create up to 180 degrees of arc by specifying two endpoints and then manipulating the center point/radius.

- 1 Select Create > Arc Tools > Two Point Arc Tool.
- 2 Click to place the first endpoint, an on-curve point, and the second endpoint of the arc.

Maya shows a manipulator for the new arc.

- 3 Do any of the following:
 - Drag any of the points to move them.
 - Press Enter to finish the arc.

To create a three-point arc

- 1 Select Create > Arc Tools > Three Point Arc Tool.
- 2 Click to place the three endpoints of the arc.

Maya shows a manipulator for the new arc.

- 3 Do any of the following:
 - Drag the endpoints or center point to move them.
 - Click the circle to switch the direction the arc travels between endpoints.
 - Press Enter to finish the arc.

Edit an arc after creation

- 1 In the channel box, select the CircularArc node associated with the arc you want to change.
- 2 In the toolbox, click the Show Manipulator tool.
The arc manipulator will appear.

Notes

- You cannot create a complete circle with the Arc Tools.
- Points in the arc cannot have the exact same position.

What if...?

I want to create a circle?

Use Create > NURBS Primitives > Circle.

2 | Creating curves

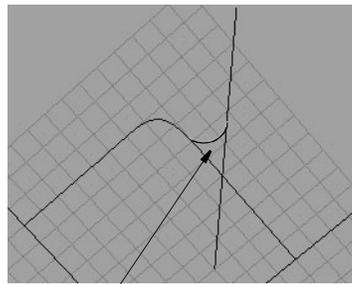
How do I? > Create a fillet curve between two existing curves

Related topics

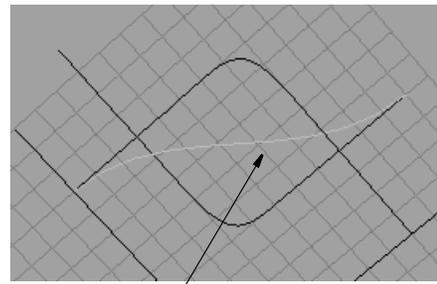
- ❖ "Create a fillet curve between two existing curves" on page 30
- ❖ "Create > Arc Tools > Three Point Circular Arc, Two Point Circular Arc" on page 34

Create a fillet curve between two existing curves

You can create a circular or freeform fillet. The freeform fillet offers more position and shape control.



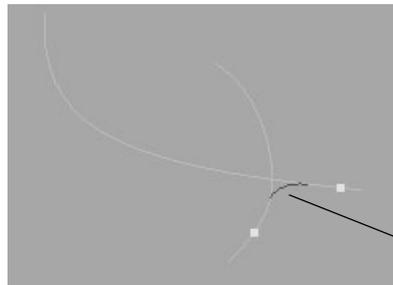
Circular curve fillet



Freeform curve fillet

To create a circular fillet curve between two curves

- 1 Select curve points on each curve about where you want the fillet to begin and end. (The radius you enter for the fillet will determine the actual start and end points.)



For a circular fillet, select curve points on this side of the intersection to place the fillet here.

- 2 Select Edit Curves > Curve Fillet > .
- 3 Click Circular and enter the Radius for the fillet.
- 4 To trim the curves back to the fillet end points, turn on Trim. When Trim is on, you can also turn on Join to join the curves together into one new curve.
- 5 Click Apply.

2 | Creating curves

How do I? > Create a degree 3 curve to match degree 1 (scan) data

To create a freeform fillet curve between two curves

- 1 Select a curve point on each curve to specify the start and end points of the fillet.
- 2 Select Edit Curves > Curve Fillet > .
- 3 Click Freeform.
- 4 To trim the curves back to the fillet end points, turn on Trim. When Trim is on, you can also turn on Join to join the curves together into one new curve.
- 5 Click Apply.

Note You cannot create a fillet using a curve-on-surface.

What if...?

Maya does not create a fillet curve?

- Maya may not create a curve if it's not possible to fillet the selected curve with the radius you entered. Try entering a different radius and click Apply again.
- Try reshaping the curves so they intersect.

Related topics

- ❖ "Create arcs" on page 29
- ❖ "Edit Curves > Curve Fillet" on page 35

Create a degree 3 curve to match degree 1 (scan) data

- 1 Select the degree 1 curve.
- 2 Choose Edit Curves > Fit B-Spline.

Related topics

- ❖ "Edit Curves > Fit B-spline" on page 37

2 | Creating curves

Reference > Create > CV Curve Tool

Reference Menus

Create

Create > CV Curve Tool

Lets you draw a NURBS curve by placing CVs.

Related topics

- ❖ "Curve components" on page 21
- ❖ "Draw curves" on page 27
- ❖ "Create > EP Curve Tool" on page 33
- ❖ "Create > Pencil Curve Tool" on page 34

Create > CV Curve Tool > □

Curve Degree

The higher the Curve Degree, the smoother the curve. The default setting (3 Cubic) works well for most curves. You must create at least one more CV than the Curve Degree number. For example, you need at least six CVs to complete a degree 5 curve:



See "Degree" on page 12 for more details.

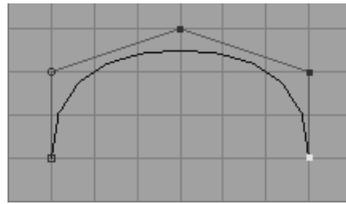
Knot Spacing

The type of knot spacing sets how Maya assigns U position values to edit point (knots). Chord length knot spacing distributes curvature better. If you use the curve to build a surface, the surface might display textures better.

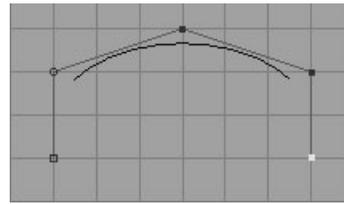
Uniform knot spacing creates curve U position values that are easier for you to predict. See "Parameters and parameterization" on page 14 for details.

Multiple End Knots

When turned on, the curve's end edit points (knots) are superimposed on the end CVs. Generally, this makes the curve's end region easier to control.



Multiple End Knots on



Multiple End Knots off

Notice how the curve does not go through the end CVs.

If you create a pair of curves with Multiple End Knots off, you can use Snap to Points to align the second CVs (next to the end CVs) of each curve to create tangent continuity between the two curves.

Note As with all tools in Maya, you can change the options after you create an object. Select the curve and open the Channel Box or the Attribute Editor.

Create > EP Curve Tool

Lets you draw a NURBS curve by placing edit points.

Related topics

- ❖ "Curve components" on page 21
- ❖ "Draw curves" on page 27
- ❖ "Create > CV Curve Tool" on page 32
- ❖ "Create > Pencil Curve Tool" on page 34

Create > EP Curve Tool > □

Curve Degree

The higher the Curve Degree, the smoother the curve. The default setting (3 Cubic) works well for most curves.

Knot spacing

The knot spacing specifies how Maya assigns U positioning values to knots. Chord length knot spacing distributes curvature better. If you use the resulting curve to build a surface, the surface might display texture mapping better.

Uniform knot spacing produces curve U positioning values that are easier for you to predict.

2 | Creating curves

Reference > Create > Pencil Curve Tool

Create > Pencil Curve Tool

Lets you draw a freehand NURBS curve.

Related topics

- ❖ "Curve components" on page 21
- ❖ "Draw curves" on page 27
- ❖ "Create > CV Curve Tool" on page 32
- ❖ "Create > EP Curve Tool" on page 33

Create > Pencil Curve Tool > □

Curve Degree

The 1 Linear option creates jagged curves known as polylines. The default setting (3) creates smooth curves.

Create > Arc Tools > Three Point Circular Arc, Two Point Circular Arc

Lets you create arcs by specifying points and then using a manipulator.

Related topics

- ❖ "Create arcs" on page 29

Create > Arc Tools > Two/Three Point Circular Arc > □

Circular Arc Degree

1 Linear creates jagged curves. The default setting (3) creates smooth curves.

Sections

Sets the number of curve segments of the arc.

Modeling menu set

Edit Curves

Edit Curves > Duplicate Surface Curves

Creates a new NURBS curve from the selected surface edge, isoparm, or curve-on-surface.

Related topics

- ❖ "Create a curve from a surface edge, isoparm, or curve-on-surface" on page 28
- ❖ "Edit Curves > Offset > Offset Curve, Offset Curve on Surface" on page 126

Edit Curves > Duplicate Surface Curves >

Group With Original

Creates the duplicated curve as a child of the surface from which it was created. This affects transformations applied to the curve (or surface).

For example, duplicate a cylinder isoparm, move the middle CV of the resulting curve in X, then rotate the cylinder 90 degrees about Z. If this option is turned on, the center CV of the curve is moved in X. If off, the center CV is moved in Y.

Visible Surface

Isoparms

Lets you duplicate all isoparms of an object in the U, V, or U and V directions. This option works only when the entire surface is selected.

U specifies all isoparms in the U direction.

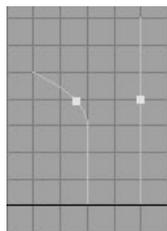
V specifies all isoparms in the V direction.

Both specifies both U and V directions (all isoparms).

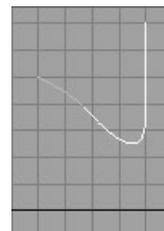
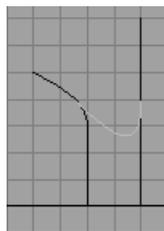
Edit Curves > Curve Fillet

Trim

Keeps only the parts of the original curves that flow toward the fillet curve ends. Other parts are deleted.



Freeform fillet with Trim turned off



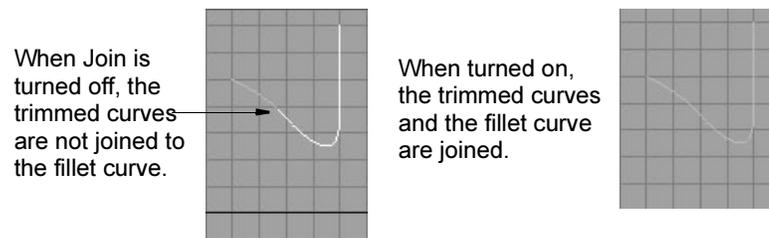
Same fillet with Trim turned on

2 | Creating curves

Reference > Edit Curves > Curve Fillet

Join

Joins the trimmed curves to the fillet curve, thereby creating a single curve. Available only when Trim is on.



Keep Original

Retains the original curves used to create the fillet. This allows you to create a curve fillet again for the curves but with different settings.

Construction

Circular creates a semicircular arc.

Freeform creates a curve that's determined by the curve points you selected before the Curve Fillet operation.

Radius

Sets how sharply a circular fillet arcs.

Freeform Type

Tangent puts the freeform fillet's apex near the intersection corner.

Blend puts the freeform fillet's apex near the midpoint between the curve points you selected before the Curve Fillet operation.

Blend Control

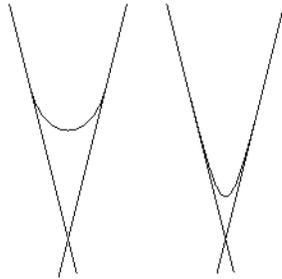
Adjusts the fillet shape curvature by enabling Depth and Bias. Note that if Blend Control is on for a circular fillet, the fillet will not be circular.

Depth

The higher the Depth, the deeper the fillet curve is positioned in the intersection corner.

2 | Creating curves

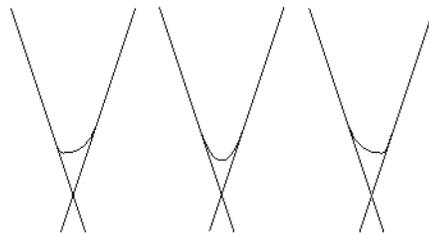
Reference > Edit Curves > Fit B-spline



Depth = 0.25 Depth = 0.75

Bias

Controls whether the fillet curve warps in the direction of one curve or the other. A value of 1 warps the fillet curve toward one curve, -1 toward the other curve. A value of 0 puts the fillet curve evenly between the two. (You can use a value below 0 in the Attribute Editor, not in the options window.)



Bias = -1 Bias = 0 Bias = 1

Input Curve

Gives you access to the history of the curves you used to create the fillet. Click the arrow buttons to select one of these curves if you want to edit it.

Curve Parameters

The Curve Parameter1 and Curve Parameter2 define the region between the two curves where the fillet curve is created.

Edit Curves > Fit B-spline

Fits a degree 3 (cubic) curve to a degree 1 (linear) curve. Typically you use Fit B-spline after you import curves, surfaces, and digitized data from other products in which the curves have curve degree 1.

Related topics

- ❖ "Create a degree 3 curve to match degree 1 (scan) data" on page 31

2 | Creating curves

Reference > Edit Curves > Fit B-spline

Edit Curves > Fit B-spline >

Use Tolerance

The tolerance sets how much accuracy is maintained between the original and fit of interpolated curves.

If set to Global, the fit is accurate to within 0.010 units, by default.

Local lets you change the tolerance value in the Positional Tolerance box.

Input Curve

The Input Curve information is read-only. You can click the arrow button to select the curve and edit it with the Attribute Editor.

Tolerance

See Use Tolerance above for details.

3 Creating NURBS surfaces

How do I? Create and edit models

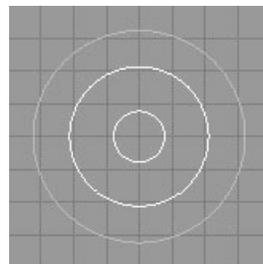
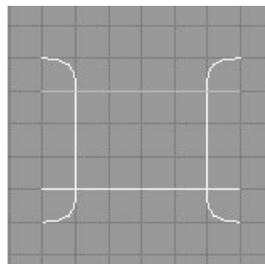
Create NURBS surfaces

Create a flat surface inside a curve

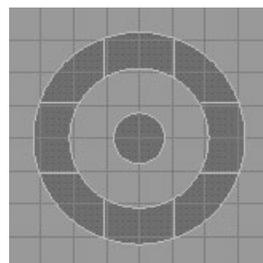
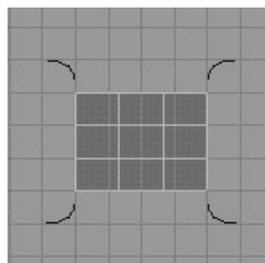
The Planar action creates a flat, trimmed NURBS surface inside a curve.

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

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



Original curves

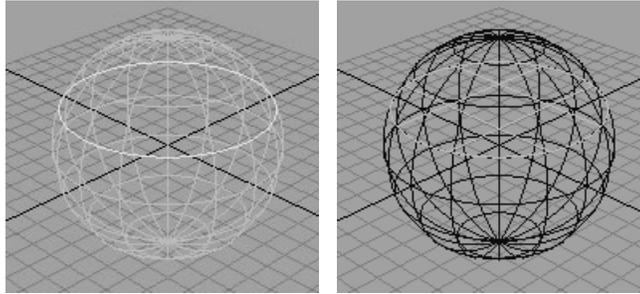


Planar Trimmed surface

- 2 Choose Surfaces > Planar.

3 | Creating NURBS surfaces

How do I? > Skin a surface across profile curves



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.

Related topics

- ❖ "Skin a surface across profile curves" on page 40
- ❖ "Create a surface within bounding curves" on page 44
- ❖ "Surfaces > Planar" on page 65

Skin a surface across profile curves

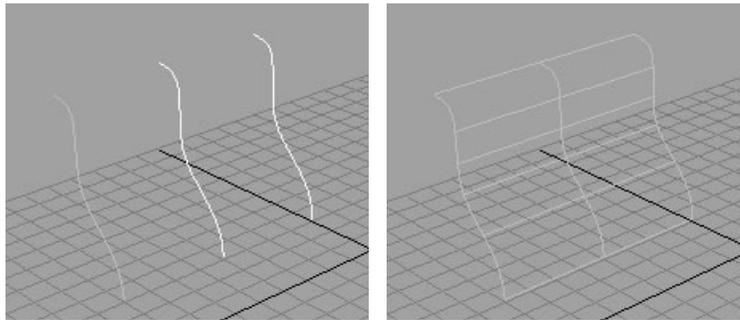
You can use the Loft action to create a surface between a series of cross-section or "profile" curves. The profile curves can be normal 3D curves, surface isoparms or edges, trim edges, or curves-on-surface.

To make a surface between profile curves

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

3 | Creating NURBS surfaces

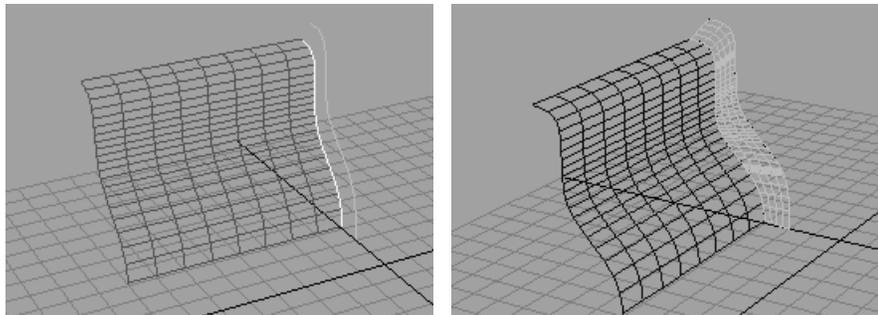
How do I? > Skin a surface across profile curves



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.



Related topics

- ❖ "Sweep a profile curve along a path curve" on page 42
- ❖ "Sweep one or more profile curves along two path curves (birail)" on page 43
- ❖ "Surfaces > Loft" on page 61

3 | Creating NURBS surfaces

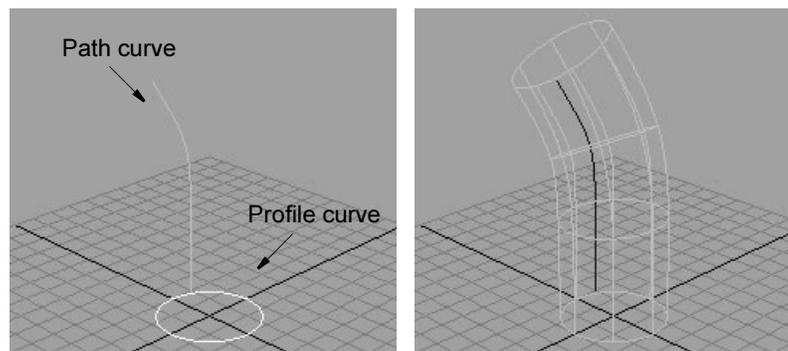
How do I? > Sweep a profile curve along a path curve

Sweep a profile curve along a path curve

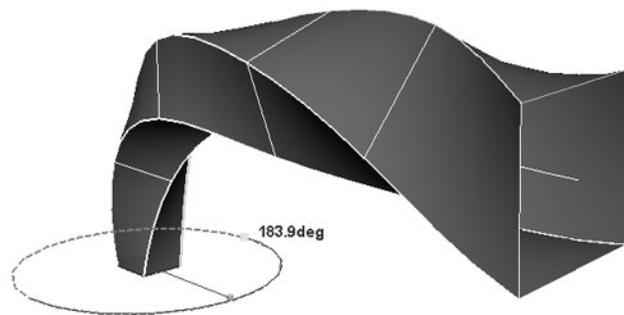
The Extrude action creates a surface by sweeping a cross-section (or “profile”) curve along a path curve. The curves can be normal 3D curves, surface isoparms or edges, trim edges, or curves-on-surface. The ends of the extruded surface are open; however, you can create caps at each end using Surfaces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



Tip If 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.

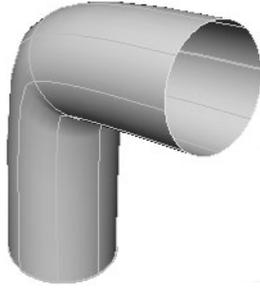
3 | Creating NURBS surfaces

How do I? > Sweep one or more profile curves along two path curves (birail)

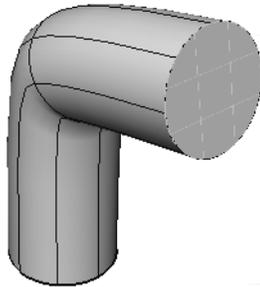
To cap the end of an extruded surface

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

To do this, press the right mouse button 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.



Related topics

- ❖ "Create a flat surface inside a curve" on page 39
- ❖ "Skin a surface across profile curves" on page 40
- ❖ "Sweep one or more profile curves along two path curves (birail)" on page 43
- ❖ "Surfaces > Extrude" on page 67
- ❖ "Surfaces > Planar" on page 65

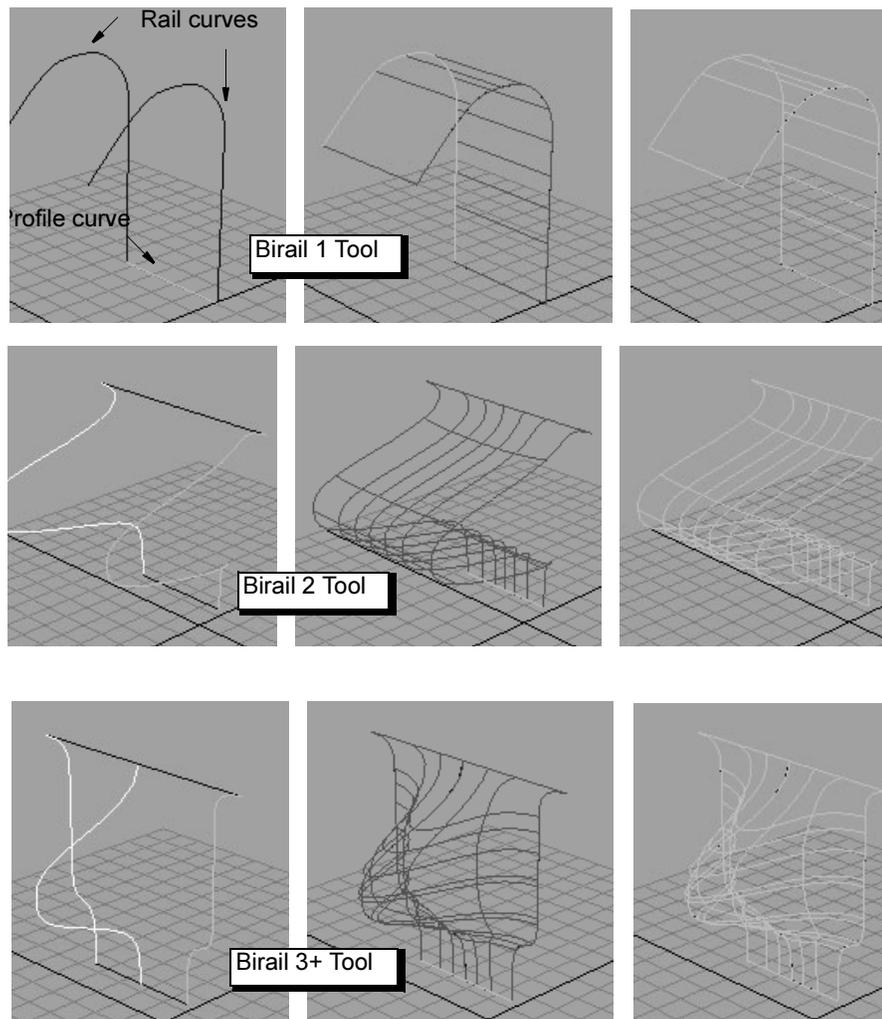
Sweep one or more profile curves along two path curves (birail)

- 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.

3 | Creating NURBS surfaces

How do I? > Create a surface within bounding curves



Related topics

- ❖ "Skin a surface across profile curves" on page 40
- ❖ "Sweep a profile curve along a path curve" on page 42
- ❖ "Surfaces > Birail > Birail 1 Tool, Birail 2 Tool, Birail 3+ Tool" on page 73

Create a surface within bounding curves

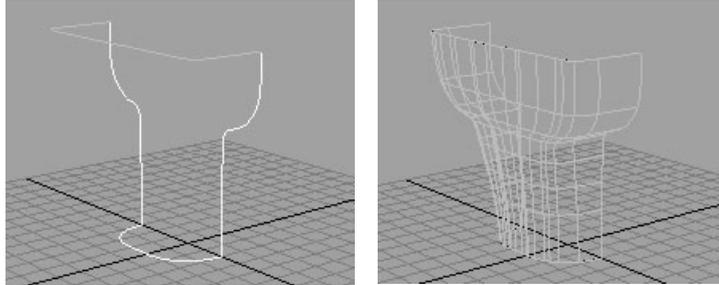
- 1 Select the boundary curves.

If you select only three curves, Maya will create a "three-sided" surface (see notes below).

3 | Creating NURBS surfaces

How do I? > Create a surface within bounding curves

2 Choose Surfaces > Boundary.



If you turn on the Partial option to use a subsection of the curves, you can control which part of each 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 curves to allow you to drag the values.

Notes

- The order you select the input curves does not matter to the shape of the surface. However, order can affect parameterization of the curves and the resulting surface.

Some of the curves may be reversed to make sure their start and end points match. The first curve you select is used for the surface U parameters.

If you select opposing pairs of curves in order (that is select the first curve, then select the curve on the opposite side, then the third curve, then the curve opposite it), you can determine which curves will control which parameters.

- A three-sided surface is actually a 4-sided surface with one side collapsed to a zero length multi-knot (sometimes called a degenerate surface). These kinds of surfaces can sometimes be problematic in rendering and data transfer.

If the end points of two side curves do not meet exactly, a short straight line segment will result instead of a zero length line.

- For a three-sided boundary surface, the zero-length side always appears where the first curve meets the second curve.

Related topics

- ❖ "Create a surface from four boundary curves that maintains continuity (square)" on page 46
- ❖ "Create a surface between two sets of boundary curves" on page 52
- ❖ "Surfaces > Boundary" on page 76

3 | Creating NURBS surfaces

How do I? > Create a surface from four boundary curves that maintains continuity (square)

Create a surface from four boundary curves that maintains continuity (square)

Square creates a three or four-sided surface that maintains continuity with adjacent surfaces (where you use an isoparm, edge, or curve-on-surface as an input curve).

- 1 Make sure the boundary curves intersect.
- 2 Select the curves in order (clockwise or counterclockwise).
The first curve you select sets the U direction for the surface and the second curve sets the V direction.
- 3 Select Surfaces > Square.
- 4 In the toolbox, click Show Manipulators to view the continuity indicators.
Click the indicator on a side to set the requested continuity, or open the channel box and set the square surface's continuityTypeN attribute (the numbers indicate the order you clicked the curves).

If even Maya cannot create the requested continuity, it will create a surface.

What if...?

I can't achieve the continuity I want?

- Make sure your curves intersect.
- You can't create a surface inside boundary curves with sharp corners, CV multiplicity, or multi-knots.
- Try selecting the curves in a different order.

Related topics

- ❖ "Create a surface within bounding curves" on page 44
- ❖ "Surfaces > Square" on page 78

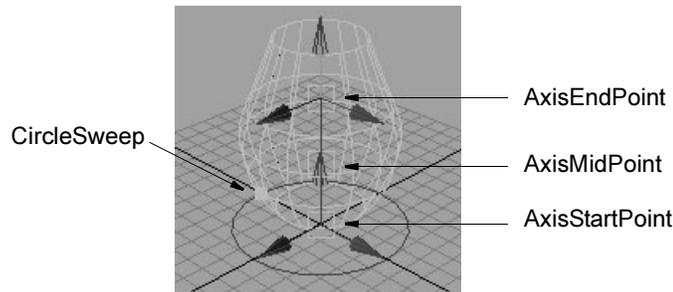
Sweep out a surface by rotating a curve around an axis

- 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.

3 | Creating NURBS surfaces

How do I? > Extrude and bevel a surface from a curve

- 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.

Related topics

- ❖ "Create a flat surface inside a curve" on page 39
- ❖ "Surfaces > Revolve" on page 57

Extrude and bevel a surface from a curve

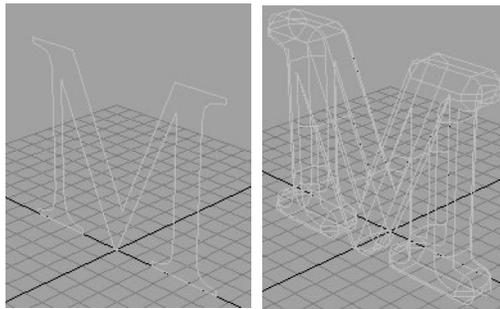
Use Surfaces > Bevel to create an extruded surface with a beveled edge from any curve, including text curves and trim edges. For example, to create a ledge on a building, or the rolled edges on an upholstered chair.

Create a simple extrude and bevel

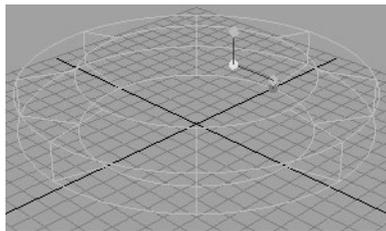
- 1 Select the curve.
You can create beveled surfaces from normal 3D curves, isoparms, and surface edges.
- 2 Choose Surfaces > Bevel.

3 | Creating NURBS surfaces

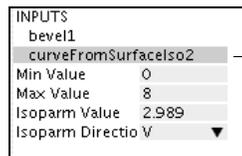
How do I? > Extrude and bevel a surface from a curve



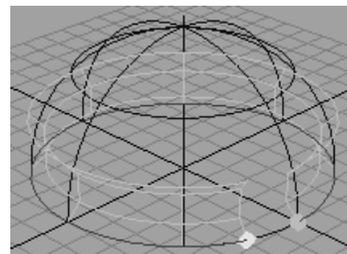
- 3** In the toolbox click the Show Manipulators tool to manipulate the beveled surface.



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



Click to display Start and End manipulators



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.

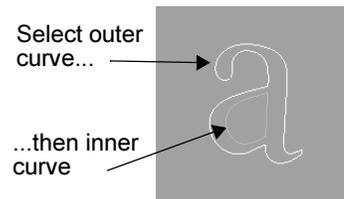
3 | Creating NURBS surfaces

How do I? > Create a new surface from patches of an existing surface



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.

Related topics

- ❖ "Sweep a profile curve along a path curve" on page 42
- ❖ "Round off the meeting point between two edges" on page 50
- ❖ "Create a fillet between two surfaces" on page 51
- ❖ "Surfaces > Bevel" on page 79
- ❖ "Surfaces > Bevel Plus" on page 82

Create a new surface from patches of an existing surface

To duplicate surface patches

- 1 Select patch or patches.
- 2 Select Edit NURBS > Duplicate NURBS Patches.

3 | Creating NURBS surfaces

How do I? > Round off the meeting point between two edges

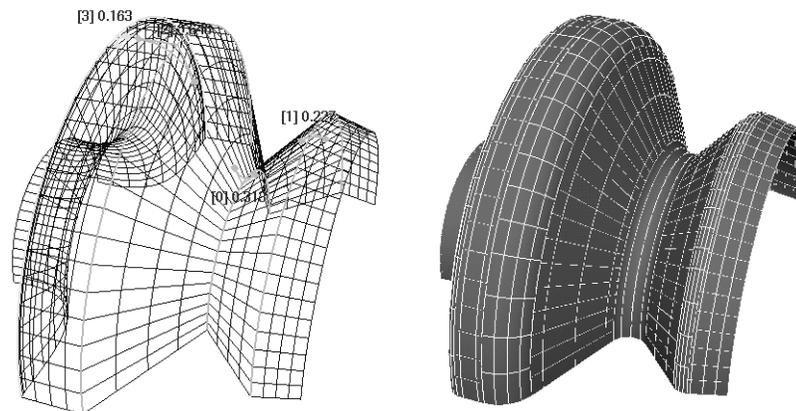
Create NURBS transition surfaces

Round off the meeting point between two edges

- 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.

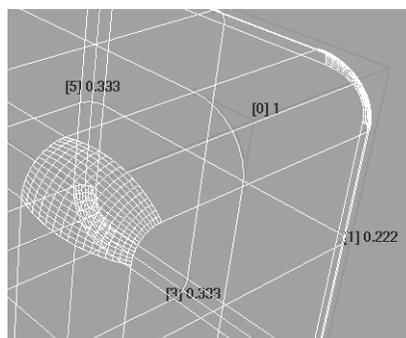
To deselect an edge, click the manipulator on the edge and press Delete.

- 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.



3 | Creating NURBS surfaces

How do I? > Create a fillet between two surfaces

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.

Related topics

- ❖ "Extrude and bevel a surface from a curve" on page 47
- ❖ "Create a fillet between two surfaces" on page 51
- ❖ "Edit NURBS > Round Tool" on page 88

Create a fillet between two surfaces

Create a circular fillet

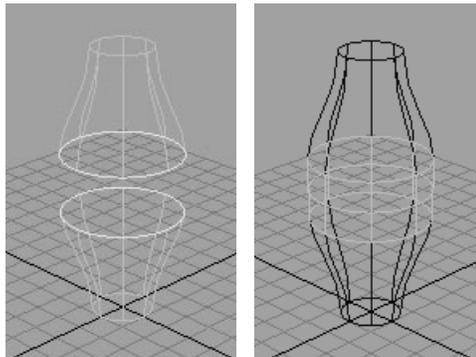
- 1 Select two intersecting surfaces.
- 2 Select Edit NURBS > Surface Fillet > Circular Fillet > .
- 3 Do any of the following:
 - Use the channel box, attribute editor, or Show Manipulator tool to change the radii.
 - Select one of the surfaces and choose Edit NURBS > Reverse Surface Direction to change 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 | Creating NURBS surfaces

How do I? > Create a surface between two sets of boundary curves



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.

Related topics

- ❖ "Round off the meeting point between two edges" on page 50
- ❖ "Create a surface between two sets of boundary curves" on page 52
- ❖ "Edit NURBS > Surface Fillet > Circular Fillet" on page 88
- ❖ "Edit NURBS > Surface Fillet > Freeform Fillet" on page 91

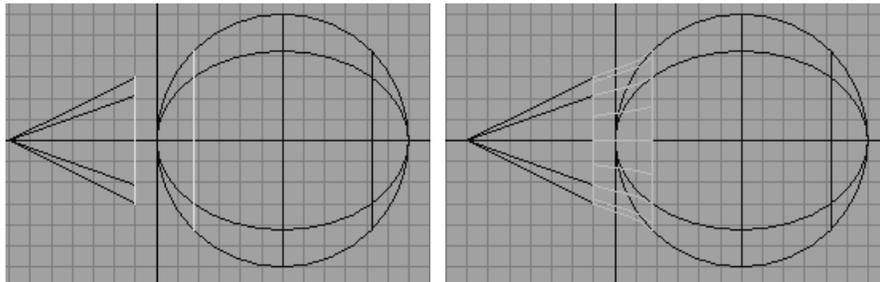
Create a surface between two sets of boundary curves

You can build a blend between two boundaries defined by sets of surface curves. For example, you can use this tool to create a surface that forms a smooth juncture between a creature's arm and torso.

- 1** Select Edit NURBS > Surface Fillet > Fillet Blend Tool.
- 2** Click the surface curves that form the first boundary, then press Enter. You can use isoparms, edges, or curves-on-surface.
- 3** Click the surface curves that form the second boundary, then press Enter.

3 | Creating NURBS surfaces

Reference > Create > NURBS Primitives



If you edit the surfaces that provided the input curves for the blend, the blend updates automatically.

Note If you use the manipulator handles to adjust a fillet blend between straight lines (such as the edges of two planes), twisting and unexpected results may occur.

What if...?

The blend surface is twisted?

- Reverse the direction of the surface curves at one end of the blend.
- If reversing the curves is undesirable, use the Reverse Direction Left/Right attribute to reverse the surface after it is created.

Related topics

- ❖ "Round off the meeting point between two edges" on page 50
- ❖ "Create a fillet between two surfaces" on page 51
- ❖ "Edit NURBS > Surface Fillet > Fillet Blend Tool" on page 91

Reference Menus

Create

Create > NURBS Primitives

Create various geometric primitive shapes using NURBS surfaces or curves. Most of the options are shared between primitive types.

3 | Creating NURBS surfaces

Reference > Create > NURBS Primitives

Create > NURBS Primitives > *Type* >

Sphere

You can create a sphere as the starting point for an assortment of rounded objects, for instance, eyeballs, planets, and human heads.

Pivot

By default, the Pivot is set to Object, and the primitive is created at the origin. Specifically, its rotate and scale pivots are at the origin.

If you set Pivot to User Defined, you can enter values in the Pivot Point X, Y, and Z boxes to position the pivots (and the primitive).

Axis

Select X, Y, or Z to specify a preset axis direction of the object.

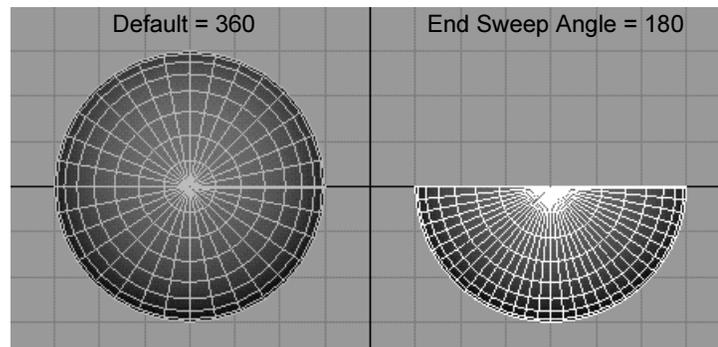
Select Free to enable the X, Y and Z Axis Definition boxes. Enter new values to select your own axis direction.

Select Active View to create the object perpendicular to the current orthographic view. The Active View option has no effect when the current modeling view is a camera or perspective view.

Start and End

Sweep Angles

These options let you create a partial sphere by specifying a degree of rotation. Degree values can range from 0 to 360 degrees. The following example shows the top view of a sphere with an End Sweep Angle of 180 degrees.



Radius

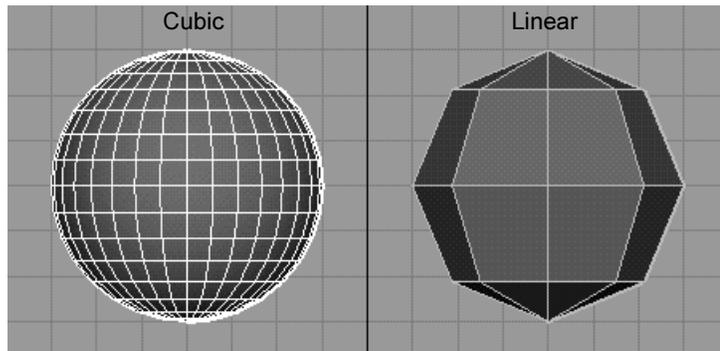
Sets the width and depth of the primitive.

Surface Degree

A Linear surface has a faceted appearance; a Cubic surface is rounded. For details on surface degree, see "Degree" on page 12.

3 | Creating NURBS surfaces

Reference > Create > NURBS Primitives



Use Tolerance

You can use this option to improve the precision of the primitive's shape. If set to Global tolerance, the Positional tolerance value in the Settings part of the Preferences window is used (Window > Settings/Preferences > Preferences). Lower values increase surface precision.

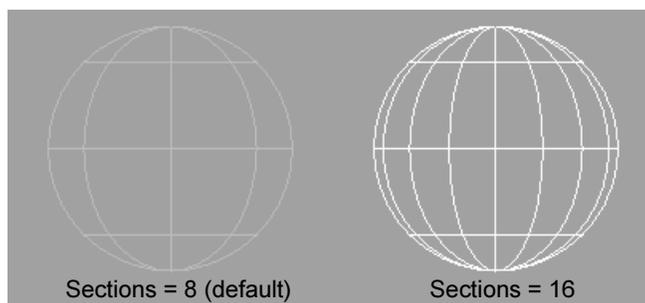
If set to Local, you can enter a value in the options window to override the Positional tolerance value in the Preferences window.

If set to None, tolerance is ignored and the sphere is created with the specified number of sections and spans (see below).

Number of Sections

Sets the number of surface curves created on the sphere in one direction. Surface curves, also called *isoparms*, show the outline of the surface shape. The more sections (and spans) a surface has, the more precisely it shows surface deformations.

The following figure shows two spheres, the left with 8 sections and the right with 16 sections. A value less than 4 gives a crude sphere.



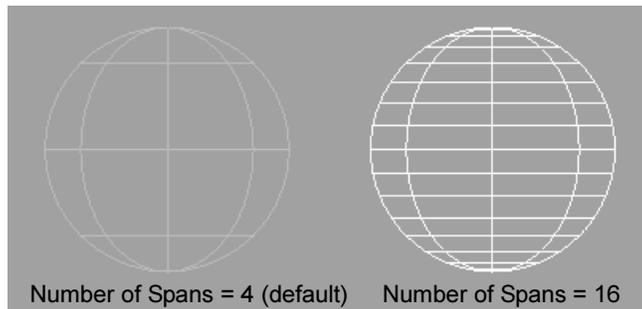
Subsequent chapters explain how to use isoparms to create new surfaces.

3 | Creating NURBS surfaces

Reference > Create > NURBS Primitives

Number of Spans

Sets the number of surface curves created on the sphere in the direction that crosses the Section direction. A value less than 4 gives a crude sphere.



Cube

A cube has six sides, each selectable. You can select a side of the cube in the view, or click its heading in the Outliner. For example, if you select leftnurbsCube in the Outliner, you select a single side of the cube. To select the whole cube, marquee-select the cube and press the keyboard's up arrow.

Options unique to cubes follow:

Width, Length, Height

Sets the cube dimensions.

U/V patches

Sets the number of U and V Patches between the edges that make up the cube. This value changes the number of spans and sections.

Cylinder

You can create a cylinder with or without end caps. The options unique to cylinders pertain to end caps. You can create caps for either, both, or no ends of the cylinder. You can also create caps as separate transform nodes so you can manipulate them independently of the cylinder.

Cone

You can create a cone with or without a cap on its base. Its other options are similar to those of other NURBS primitives.

Plane

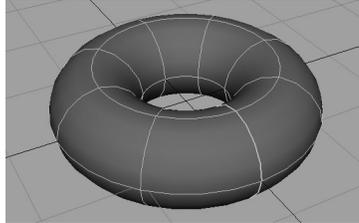
A plane is a flat surface made up of a specified number of patches. Its options are similar to other NURBS primitives.

3 | Creating NURBS surfaces

Reference > Surfaces > Revolve

Torus

A torus is a 3D ring. It has options similar to other NURBS primitives.



Circle

A circle is a curve, not a surface. Its options are similar to a sphere.

Square

A square is a group of four curves, not a surface. A square is useful in various modeling operations, for instance, trimming window shapes from buildings. Its options are similar to other NURBS primitives.

Modeling menu set

Surfaces

Surfaces > Revolve

Sweeps out a surface by revolving a profile curve around a pivot point.

Related topics

❖ "Sweep out a surface by rotating a curve around an axis" on page 46

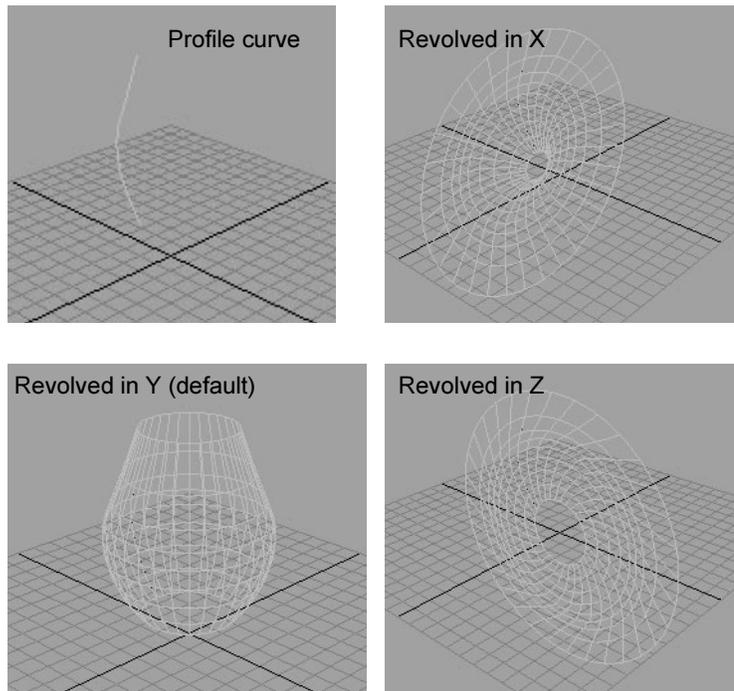
Surfaces > Revolve > □

Axis Preset

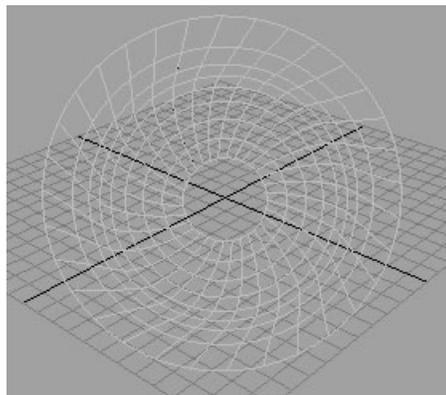
Specifies the revolution axis. The default is Y. In the following figure, a profile curve (drawn in the front view) is revolved using each revolution axis in the perspective view.

3 | Creating NURBS surfaces

Reference > Surfaces > Revolve



If you set the Axis Preset to Free, you can enter values in the Axis X, Y, or Z boxes to specify the axes about which the profile curve is revolved. The following figure shows a surface resulting from a value of 1 for Axis X, Y, and Z.



Pivot

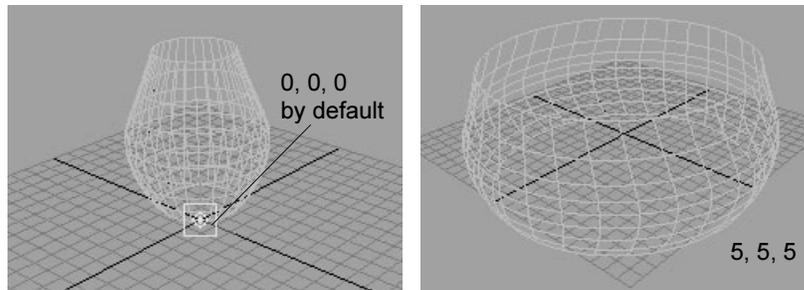
If you set Pivot to Object, the revolve is performed from the default pivot location (0,0, 0). This is the default.

If you select Preset, you can change the X, Y, or Z location of the pivot point by entering values in the Pivot Point boxes.

3 | Creating NURBS surfaces

Reference > Surfaces > Revolve

The following figure shows how a revolved surface is created with default pivot values and with values of 5 for X, Y, and Z.

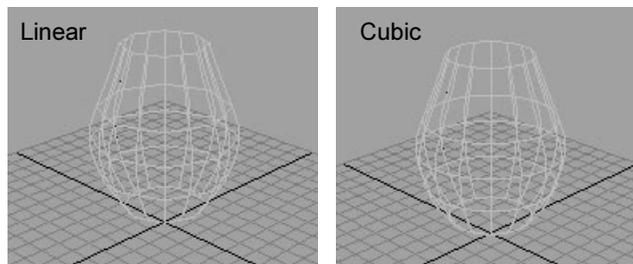


Surface Degree

The Surface Degree options determine whether the V parameter direction of the surface is created with linear (degree 1) or cubic (degree 3) geometry.

If you select Linear, the surface is constructed with flat facets all around.

If you select Cubic, the smooth profiles are defined by the original profile curve. This is the default.



Start and End Sweep Angle

Use the Start Sweep Angle and End Sweep Angle values to specify the angle of revolution in degrees. The default is 360, with a valid range of 0 to 360.

Use Tolerance

The Use Tolerance options control the accuracy of the resulting revolved surface. You can apply tolerance globally or locally.

If you select None you can change the segments value.

If you select Global tolerance, Maya uses the Positional and Tangential values in the Settings part of the Preferences window.

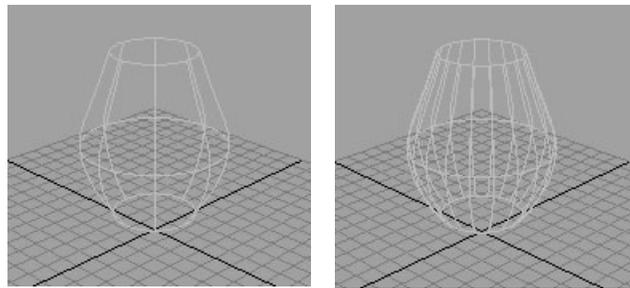
3 | Creating NURBS surfaces

Reference > Surfaces > Revolve

If you select Local tolerance, you can directly enter a new value that overrides the Positional tolerance of the Preferences window. This lets you create the revolved surface closer to the actual surface of revolution.

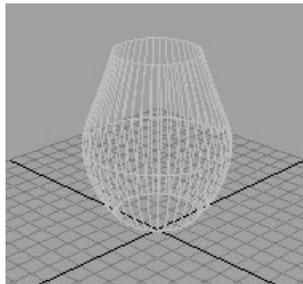
Segments

The Segments value determines how many sections are used to create the surface of revolution. With a sweep of 360 degrees, six or eight sections are usually sufficient. In the following figure, the left surface shows the revolve with eight segments. The right shows 20 segments.



If Use Tolerance is not set to None, the Segments value is automatically computed so that the result differs from the default revolved surface by less than the specified tolerance value.

If Local is set as the Use Tolerance option, the tolerance value of the revolved surface is closer to the actual surface of revolution.



Tip If animating the sweep angle, change the Segments value instead of the tolerance value to change the numbers of CVs of the surface.

Curve Range

Select Complete as the Curve Range to create the revolved surface along the entire profile curve. This is the default.

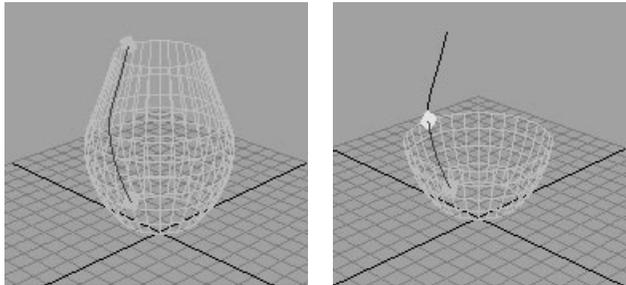
Select Partial if you want to use a segment of the curve for the revolve.

3 | Creating NURBS surfaces

Reference > Surfaces > Loft

If you set the Curve Range to Partial before you create the revolved surface, a subCurve is created. By lessening the length of the subCurve, you lessen the length of the revolved surface.

To edit the length of the subCurve, select the revolved surface, select the subCurve in the Channel Box, select the Show Manipulator Tool, then drag the curve segment manipulator or edit the Min and Max Value in the Channel Box.



For more details on editing subCurves, see "Editing the subCurve attributes" on page 61.

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 curve you used to create the revolved surface.

Editing the subCurve attributes

If you set the Curve Range to Partial in the options window when the revolve was created, you can edit the length of the curve. Select the revolved surface, then use the Show Manipulator tool or Channel Box to edit the subCurve attributes.

Surfaces > Loft

Skins a surface along a series of profile curves.

Related topics

- ❖ "Skin a surface across profile curves" on page 40

3 | Creating NURBS surfaces

Reference > Surfaces > Loft

Surfaces > Loft > □

Parameterization

This modifies the parameterization of the lofted surface (see "Parameters and parameterization" on page 14).

Uniform knot spacing makes the profile curves run parallel to the V direction. The parameter values of the resulting surface in the U direction are equally spaced. The first profile curve corresponds to the isoparm on the surface at $U[0]$, the second to $U[1]$, and so on.

Chord Length spacing causes the parameter values on the resulting surface in the U direction to be based on the distance between the start points of the profile curves.

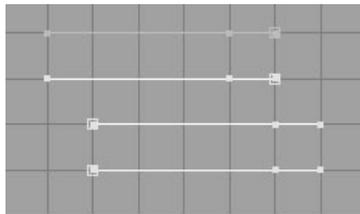
Tip If the curves have the same curve degree and number of edit points, the lofted surface will have the same number of spans in the U direction. The surface will be easier to manipulate and texture. A convenient way to accomplish this is to make copies of a single curve and transform CVs on the copies as necessary to get the desired profile curves.

If the parameterization of the curves differs, the lofted surface might have more spans than any of the profile curves. If you create the curves as Edit Point curves with Chord Length, the surface will be more complex and harder to work with.

Auto Reverse

If Auto Reverse is off, the curves are used as they are, which may result in a twisted surface. If on, the curves are automatically reversed.

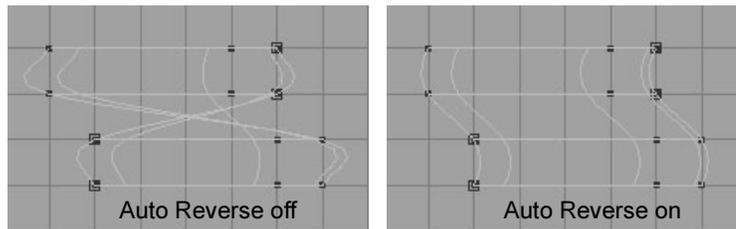
In the following example, the two top curves and the two bottom curves are going in different directions.



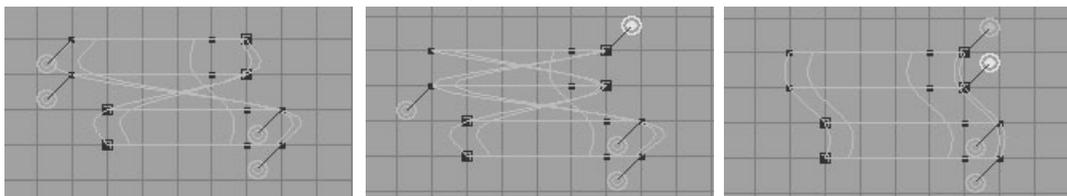
If Auto Reverse is off, the result is a twisted lofted surface. If on, the curves are automatically reversed.

3 | Creating NURBS surfaces

Reference > Surfaces > Loft



If Auto Reverse is off, you can use the Show Manipulator Tool to reverse the curve direction of the original profile curves as needed. Simply click the manipulator handle to reverse the curve direction.

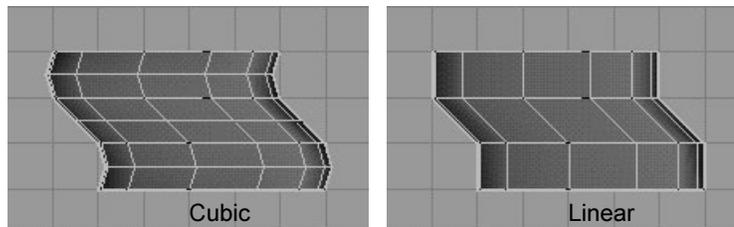


Close

The Close option sets whether the created surface is periodic in one dimension (U or V). Close is off by default. See "Periodic, closed, and open" on page 17.

Surface Degree

You can set the Surface Degree to either Linear or Cubic. This sets the lofted surface to linear or cubic in the U direction. Linear creates surfaces that appear faceted. Cubic creates smooth surfaces.



Section Spans

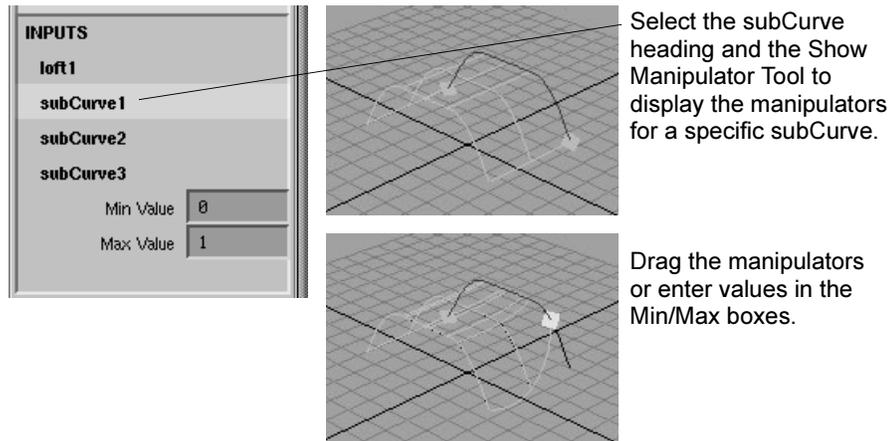
This option sets the number of spans between the lofted curves. Higher numbers give finer control of surface deformations at the expense of extra processing time.

Curve Range

If you select Partial, you can use the Show Manipulator Tool after the loft operation to change the length of the subCurves used to create the surface. This changes the length of the surface.

3 | Creating NURBS surfaces

Reference > Surfaces > Loft



Output Geometry

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

Input Curves

The options in the Loft History section of the Attribute Editor gives you access to the history of the lofted surface you constructed. This information is read-only. Click the arrow buttons to select the surface, isoparms, or curves, then open its section of the editor.

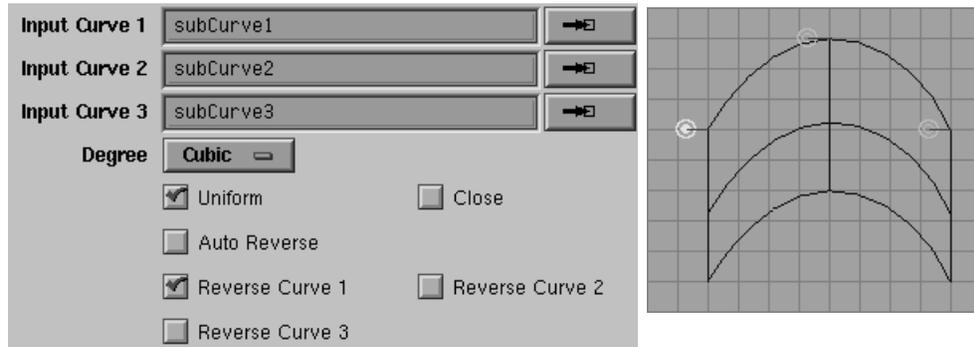
Reverse Curve

If you turned Auto Reverse off when you lofted the surface, a Reverse Curve option is displayed for each curve, primitive, or surface isoparm you used to create the lofted surface. Select the Show Manipulator Tool to display the reverse manipulators. Click the options to reverse the direction of the input curves, or click the manipulators.

In the following illustration, the first curve used to create the lofted surface is selected for reversal.

3 | Creating NURBS surfaces

Reference > Surfaces > Planar



Editing the subCurves in the Attribute Editor

If you set the Curve Range to Partial in the options window when the loft was created, you can use the Attribute Editor for the resulting subCurves.

Surfaces > Planar

Creates a planar (flat) surface within a boundary curve.

Related topics

- ❖ "Create a flat surface inside a curve" on page 39

Surfaces > Planar > □

Degree

Select either Linear (degree 1) or Cubic (degree 3) for the Degree if the output is a NURBS surface. Cubic is the default.

Curve Range

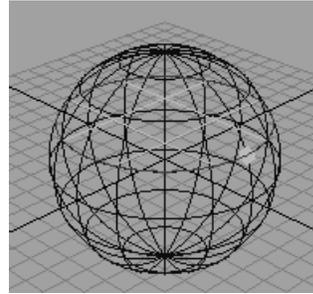
Complete creates the planar surface along the entire curve.

Partial lets you display manipulators on the planar surface with the Show Manipulator Tool and edit the resulting planar surface along part of the input curve. Click the input curve or isoparms's heading in the Channel Box to display the options.

3 | Creating NURBS surfaces

Reference > Surfaces > Planar

INPUTS	
planarTrimSurface2	
curveFromSurfaceso1	
Min Value	1
Max Value	0
Isoparm Value	2
Isoparm Directio	V ▼



Output Geometry

Specifies the type of geometry created.

Limitations Although the boundary of a planar surface can be manipulated to change the shape of the surface, the surface must remain planar at all times.

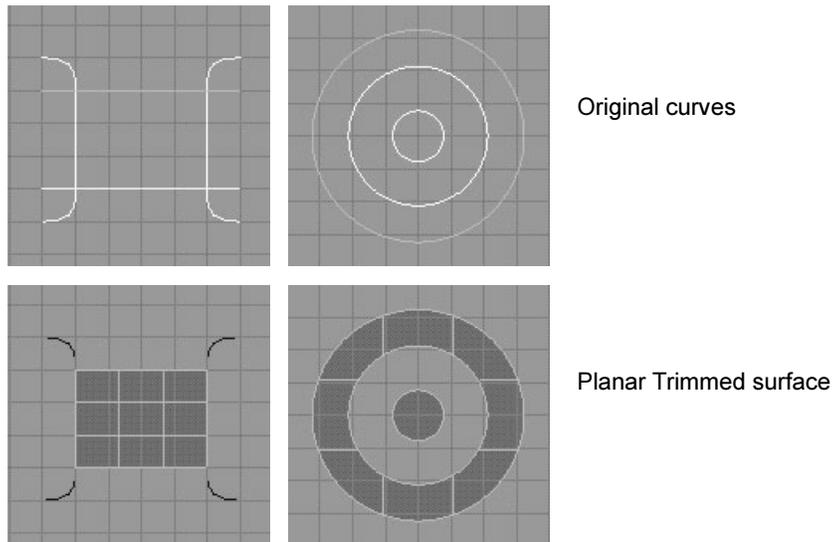
Although a planar surface can include cut-out areas or holes, the curves that define the holes must be co-planar with the main surface.

Creating trimmed surfaces from open curves

You do not necessarily need a single boundary curve to create a trimmed surface, however, you do need an enclosed region. This can be created by intersecting several curves. You can create trimmed surfaces using curves with overlapping boundaries. Select the curves and use Surfaces > Planar to create the trimmed surfaces.

3 | Creating NURBS surfaces

Reference > Surfaces > Extrude



Surfaces > Extrude

Creates a surface by sweeping a profile curve along a path curve.

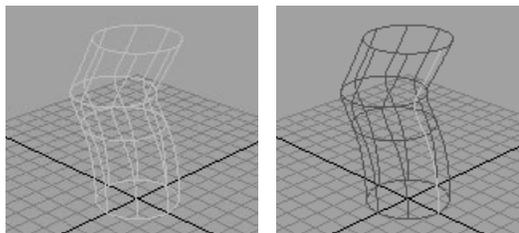
Related topics

❖ "Sweep a profile curve along a path curve" on page 42

Surfaces > Extrude > □

Style

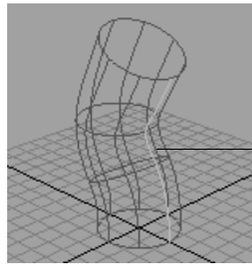
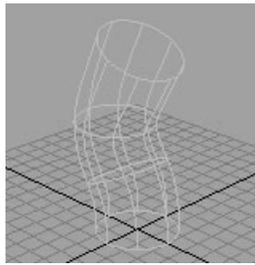
Flat maintains the orientation of the cross section as it moves along the extrusion path.



Tube sweeps the cross section along the path with the reference vector staying tangent to the path.

3 | Creating NURBS surfaces

Reference > Surfaces > Extrude

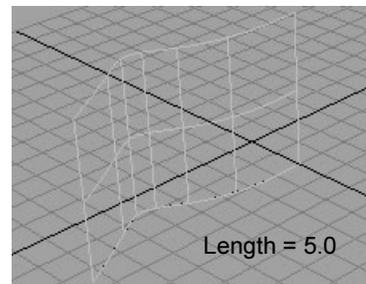
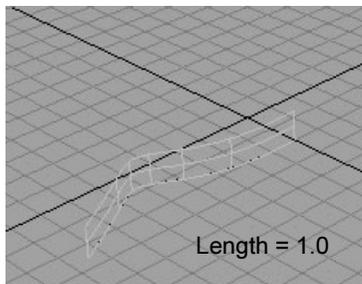


With Tube, the extrusion sweeps along the profile curve and pushes out as it follows the path.

Distance extrudes the profile in a straight line. Do not select a path curve when you turn on this option. When Distance is on, the options window provides extra options: Extrude Length, Direction, and Surface Degree.

Extrude Length

Specifies how far the extrusion goes.

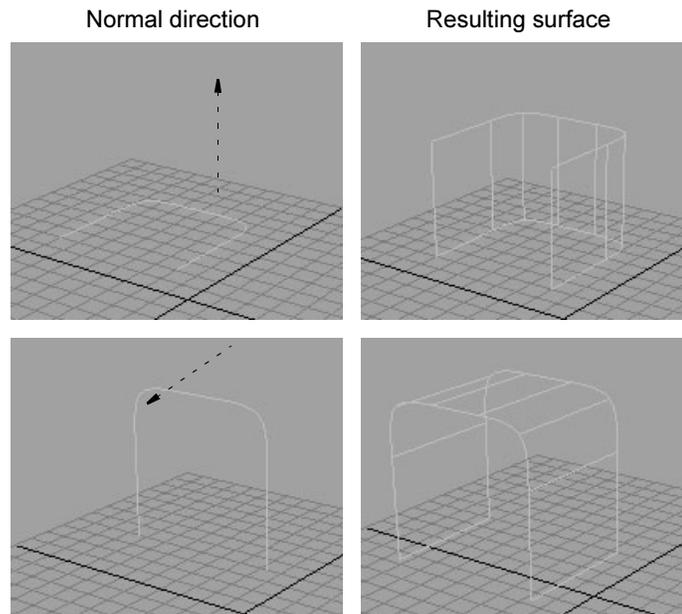


Direction

Profile Normal sets the direction of the path to the normal of the profile curve. If the profile curve is not planar, the average normal is used.

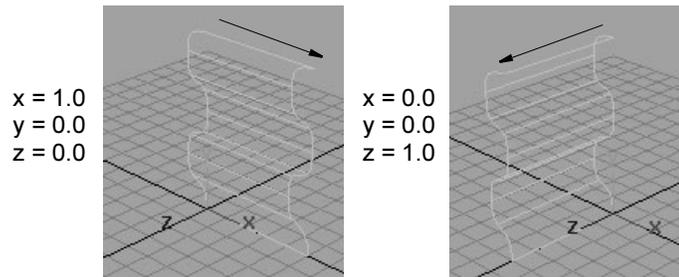
3 | Creating NURBS surfaces

Reference > Surfaces > Extrude



Specify lets you choose a Direction Vector for the extrusion: X Axis, Y Axis, Z Axis, or Free. For example, if you click the Z Axis button, the extrusion will be linear in the Z direction.

If you select Free, you can enter values in the X, Y, and Z boxes to specify a vector as the direction for the extrusion.



Surface Degree

Linear gives the surface sharp edges between isoparms. Cubic gives smooth edges.

Result Position

This option is available only if you set Style to Flat or Tube.

At Profile creates the extruded surface at the location of the profile curve.

At Path creates the extruded surface at the location of the path curve.

3 | Creating NURBS surfaces

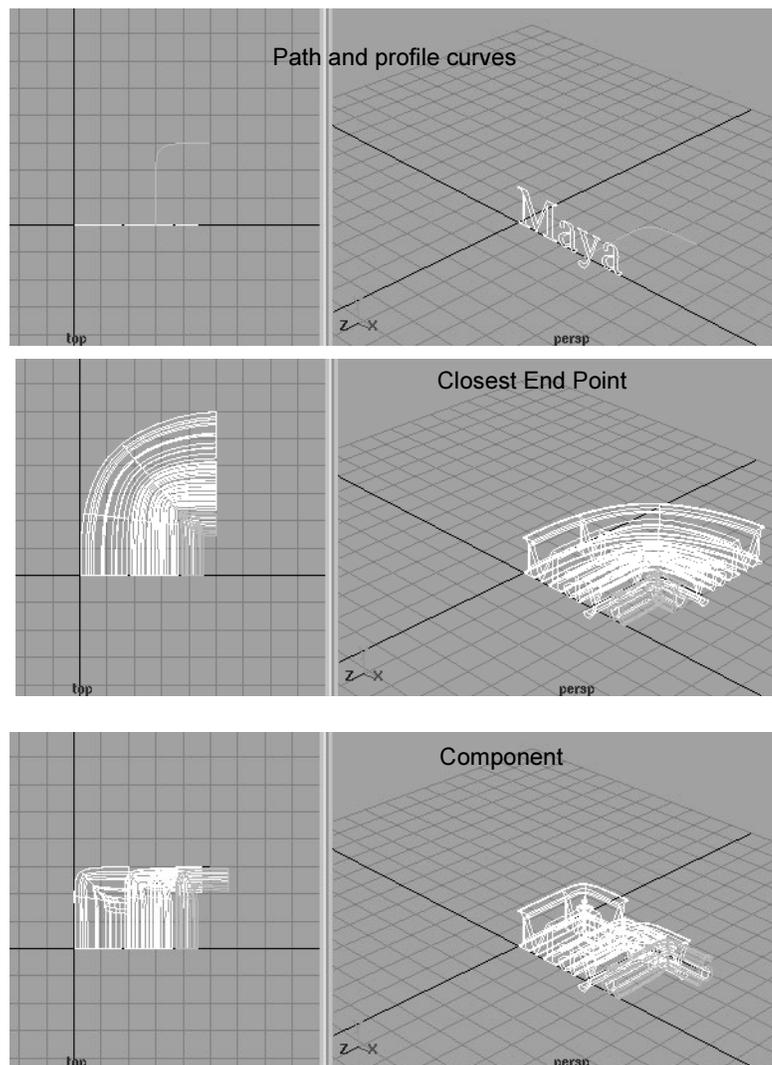
Reference > Surfaces > Extrude

Pivot

The Pivot options are available only if you set the Style to Tube. If you select At Path as the Result Position, you can choose the profile curve then position it at the pivot point on the extrusion path.

If you select Closest End Point, the path end point closest to the center of the bounding box of the profile curves is used. This end point is used as the pivot point for all the profile curves. If you are doing a multiple extrusion, the resulting surfaces are offset from the path.

If you select Component, the pivot point of each individual profile curve is used to extrude the profile curve. The extrusion occurs along the components of the profile curve.



3 | Creating NURBS surfaces

Reference > Surfaces > Extrude

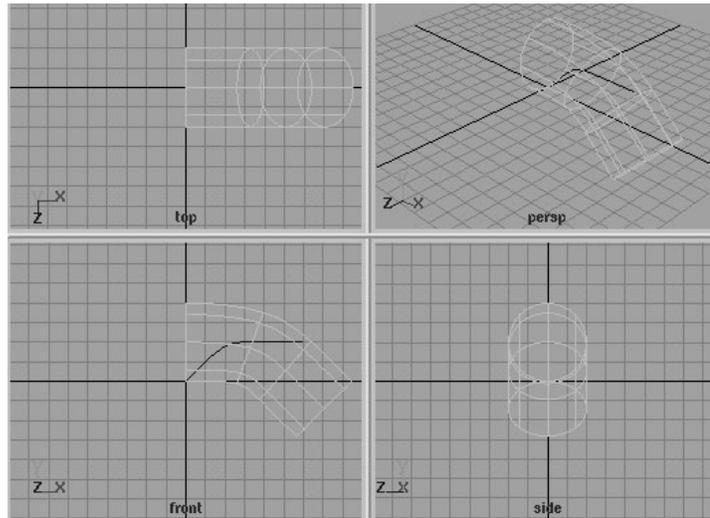
Orientation

The Orientation options are only available if Style is set to Tube.

If you choose Path Direction, the direction of the extrusion is set by the direction of the path curve. By default, the direction of the extrusion is set by the Profile Normal direction—the normal of the profile curve.

Orientation examples

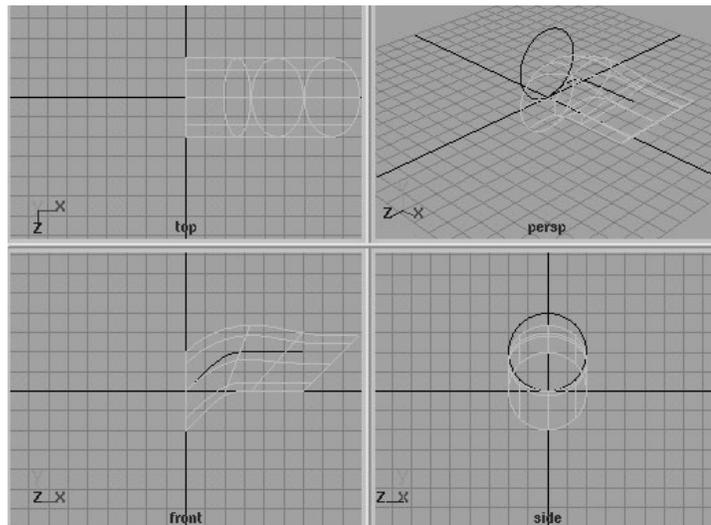
In the following example, Result Position is set to At Profile and Orientation is set to Profile Normal. The path curve is moved and rotated to match the profile curve. This is the default setting.



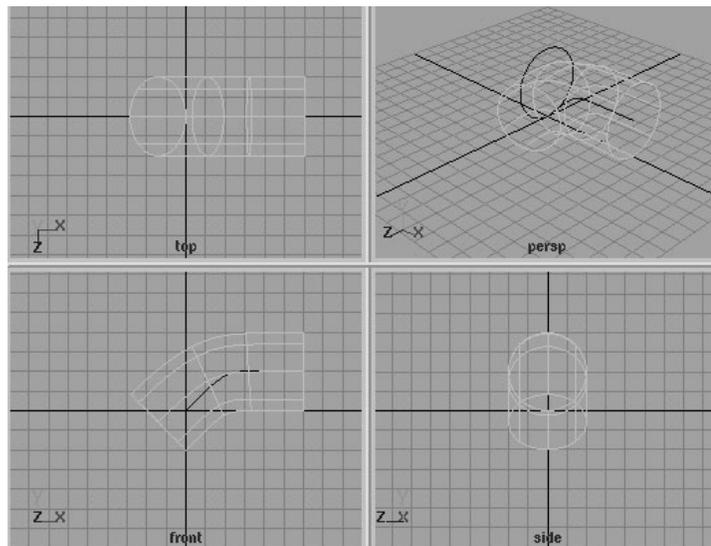
In this following example, Result Position is set to At Path and Orientation is set to Path Direction.

3 | Creating NURBS surfaces

Reference > Surfaces > Extrude



In the following example, Result Position is set to At Profile and Orientation is set to Profile Normal. The profile curve is moved and rotated to match the path curve.



Rotation

Rotates the profile curve as it is extruded along the path curve. Higher values cause the surface to stray from the path, especially with scaling.

3 | Creating NURBS surfaces

Reference > Surfaces > Birail > Birail 1 Tool, Birail 2 Tool, Birail 3+ Tool

Scale

Scales the profile curve as it is extruded along the path curve. Higher values cause the surface to stray from the path, especially with rotation.

Curve Range

Complete extrudes the entire profile along the entire path.

Partial extrudes only part of the profile along part of the path. If construction history is turned on, this creates a subCurve node that you can edit to change the extruded surface. See "Editing the extruded surface using manipulators" on page 73.

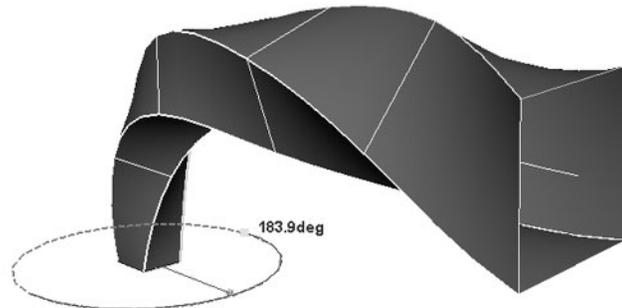
Output Geometry

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

Note that the Profile Curve and Path Curve boxes let you access the input curves as well as statistical information about these curves. Click the arrows beside the boxes to select the input curves. Click the tab to open the Attribute Editors for them.

Editing the extruded surface using manipulators

After you extrude the surface, select the surface, display the Channel Box, and select the Show Manipulator Tool. Click each of the subCurve nodes in the Channel Box to display the different manipulators available.



Experiment with the manipulators to see their effect on the surface. They let you change the length and sweep of the extrusion.

Surfaces > Birail > Birail 1 Tool, Birail 2 Tool, Birail 3+ Tool

Creates a surface by sweeping between a series of profile curves along two path curves. The resulting surface can maintain continuity with other surfaces.

3 | Creating NURBS surfaces

Reference > Surfaces > Birail > Birail 1 Tool, Birail 2 Tool, Birail 3+ Tool

Related topics

- ❖ "Sweep one or more profile curves along two path curves (birail)" on page 43

Surfaces > Birail > Birail 1/2/3+ Tool > □

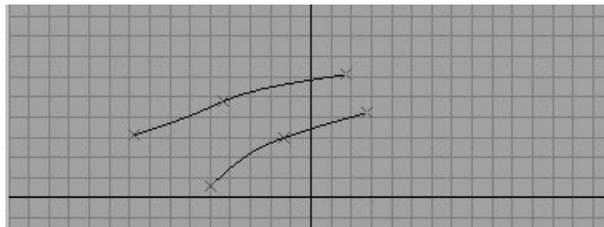
Transform Control

Select Proportional or Non Proportional to choose how to scale the profile curve sweep along the rails.

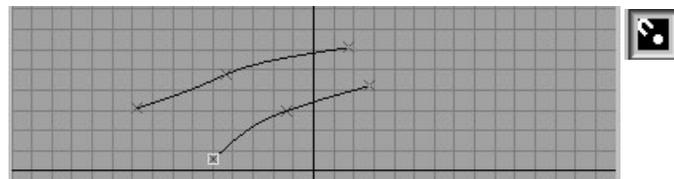
Example of using Transform Control

Construct rail curves in the XZ plane. Construct the profile curve so that the internal CVs are at some constant Y. By scaling nonproportionally, the internal CVs of the birail surface also preserve the constant Y as the profile.

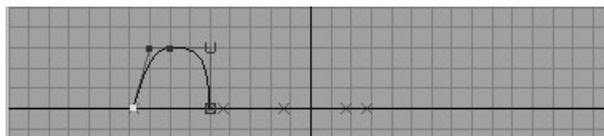
- 1** In the top view, create the two rail curves. Select Display > NURBS Components > Edit Points to display the edit points on the curves.



- 2** Click the Snap to points icon on the Status Line, place the first point of the profile curve, and click Snap to points again to turn snapping off.



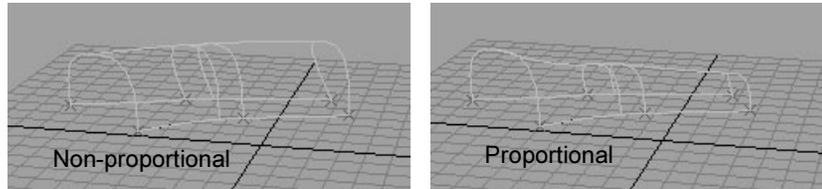
- 3** In the front view, continue to place the points to create the profile curve. Select the Snap to points icon to snap the last point to the last rail curve (remember to turn snapping off afterward).



3 | Creating NURBS surfaces

Reference > Surfaces > Birail > Birail 1 Tool, Birail 2 Tool, Birail 3+ Tool

- 4 Build the birail surface. While it is active, click the Transform Mode box of the Channel Box and select Non Proportional, then Proportional. The following figure shows the birail surface for each transform mode.



Profile Blend Value (Birail 2 only)

This option sets the influence the profile curves have on the intermediate profiles of the created surface. A value of 1.0 means the first selected profile curve has a greater influence than the second profile curve. A value of 0 has the opposite effect. By default, both selected profiles have an equal influence value of 0.5. This option is available only for a surface created with the Birail 2 Tool.

Continuity

This makes the resulting surface tangent continuous to the surface underlying the profile curve.

Because you use multiple profile curves for the Birail 2 and 3+ Tools, the Continuity option has Profile and Rail options for each curve you use.

Rebuild

Turn on one of the Rebuild options to rebuild the profile or rail curves before they are used to create the surface. Because you use multiple profile curves for the Birail 2 and 3+ Tools, the Rebuild option has Profile and Rail options for each curve you use.

Profile rebuilds the profile curve.

First Rail rebuilds the first rail curve you select when you build the surface. Second Rail refers to the second curve you select.

When you turn on any of the Rebuild options, Maya displays the Rebuild Curve options explained in "Edit Curves > Rebuild Curve" on page 136.

Output Geometry

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

3 | Creating NURBS surfaces

Reference > Surfaces > Boundary

Tool Behavior

Exit On Completion ends tool usage after you create the birail surface. If off, you can do another birail operation without having to select the tool again.

Auto Completion displays prompts at each step of the birail tool's usage. If off, you must pick the curves in the correct order then select the birail tool to complete the operation. Pick the profile curve first, then the two rail curves.

Input Profile & Input Rail

The Input Profile and Input Rail information boxes list the curves you used as profile and rail curves. Click the arrow buttons next to the curve names if you want to edit the curves.

Tangent Continuity Profile

The Tangent Continuity Profile options let you turn tangent continuity on or off for the input profile curve. This option is valid if the profile curve is a surface curve (isoparm, trimmed edge, curve-on-surface).

Surfaces > Boundary

Creates a surface by filling between boundary curves.

Related topics

❖ "Create a surface within bounding curves" on page 44

Surfaces > Boundary > □

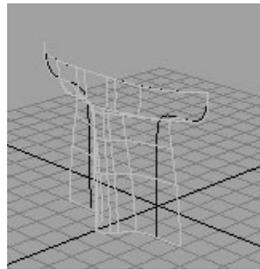
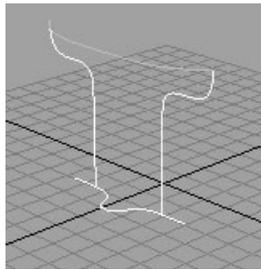
Curve Ordering

Automatic creates the boundary with an internal decision process. As Selected causes the curve selection order to determine the resulting surface.

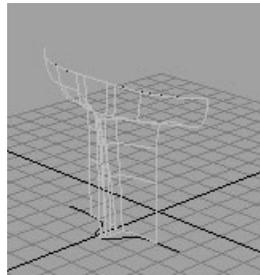
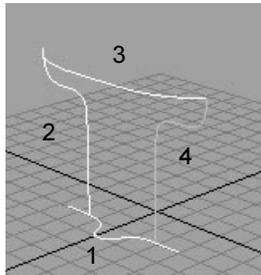
In the following figure, the first surface is created by selecting the curves while Automatic is selected. The second surface is created when As Selected is the option setting and you select the curves in a different order.

3 | Creating NURBS surfaces

Reference > Surfaces > Boundary



If Automatic is on and you select the curves, you get this result.



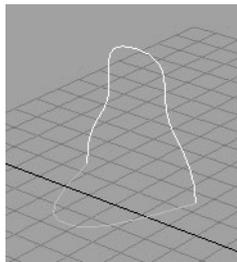
If As Selected is selected, pick the curves in a different order to get a different result.

Common End Points

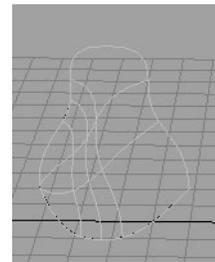
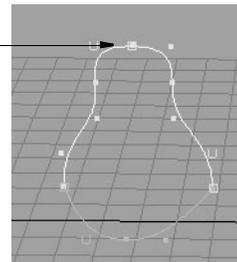
The Common End Points options let you decide whether the end points should match before the boundary surface is created.

If you select Optional, the surface is created even if the ends of the curves don't match. This is the default.

If you select Required, the boundary surface is only built if the end points of the curves match exactly.



Notice how the curve end points are matched.



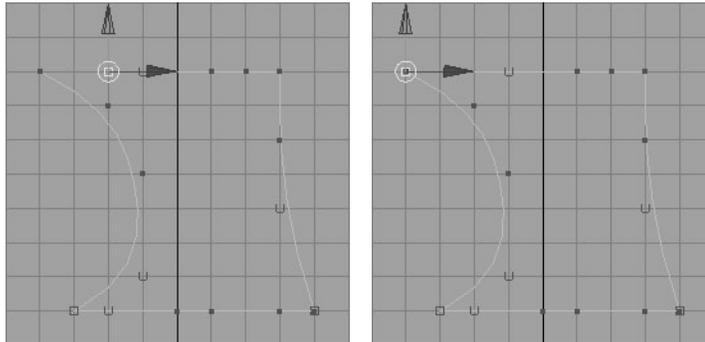
To make sure the end points match, remember to select a snap mode from the Status Line when drawing your curves.

To match the end points after you draw the curves:

- 1 Turn on a snap mode, for instance, as Snap to grids.
- 2 Select the edit point or CV you want to move.
- 3 Select the Move Tool and drag to snap to the same position.

3 | Creating NURBS surfaces

Reference > Surfaces > Square



End Point Tolerance

If you select Required as the Common End Point option, you can change the End Point Tolerance value of the end points to set how close they must be in order to be considered coincident.

Global tolerance causes Maya to use the Positional value in the Settings part of the Preferences window.

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

Surfaces > Square

Creates a surface by filling between four boundary curves. The resulting surface can maintain continuity with surrounding surfaces.

Related topics

- ❖ "Create a surface from four boundary curves that maintains continuity (square)" on page 46

Surfaces > Square >

Continuity Type

Sets the type of surface tangency created.

Fixed Boundary does not ensure continuity at the surface curves.

Tangent builds a smooth, continuous surface from the selected surface curves. When Tangent is on, the Curve Fit Checkpoints option becomes available. It specifies how accurately the Square surface will be built.

Implied Tangent creates a surface tangency based on the normal of the plane where the selected curve resides.

Curve Fit Checkpoints

Sets how many isoparms are used to achieve continuity across the surface curve. Larger values might create continuity with more precision, but the surfaces might be less useful. This is especially likely when the surface curves intersect acutely.

End Point Tolerance

Global tolerance means the Positional value you set in the Preferences window is used. Positional tolerance sets how close the end points need to be in order to be considered coincident.

Local tolerance lets can enter a new value to override the Positional tolerance value you set in Preferences.

Rebuild

Rebuild provides an option to rebuild the surface curves used to generate the Square surface. This can improve curve parameterization in some cases.

Output Geometry

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

Surfaces > Bevel

Creates beveled transition surfaces from a profile curve.

Related topics

- ❖ "Extrude and bevel a surface from a curve" on page 47
- ❖ "Surfaces > Bevel Plus" on page 82

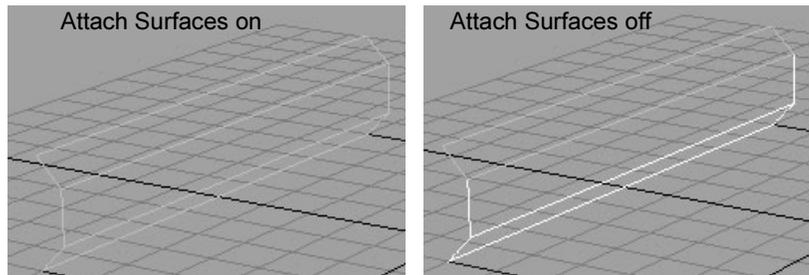
Surfaces > Bevel >

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.

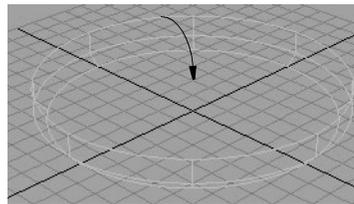
3 | Creating NURBS surfaces

Reference > Surfaces > Bevel



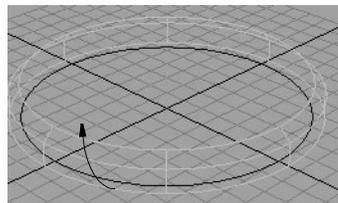
Bevel

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.



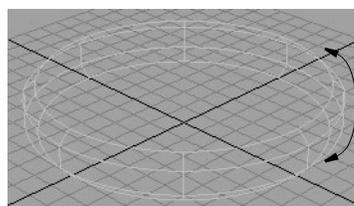
Top Side

The bevel is created from the top of the circle.



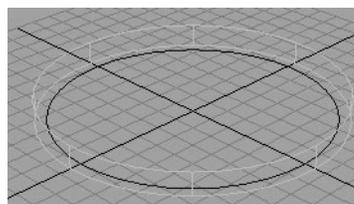
Bottom Side

The bevel is created from the bottom of the circle.



Both

The bevel is created from both the top and bottom of the circle. This is the default method.



Off

Only the extrude part of the bevel surface is created.

Note Selecting the Bevel Off option disables the bevel option controls (Width, Depth, Corners, and 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.

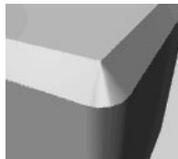
Bevel Corners

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.

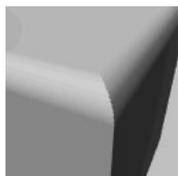


Circular Arcs

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.

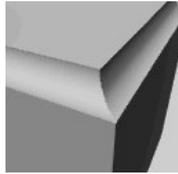


Convex

The bevel is created with a convex edge.

3 | Creating NURBS surfaces

Reference > Surfaces > Bevel Plus



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 causes Maya to use the Positional value in the Settings part of the Preferences window.

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 uses the entire curve for the bevel operation.

Partial 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.

Surfaces > Bevel Plus

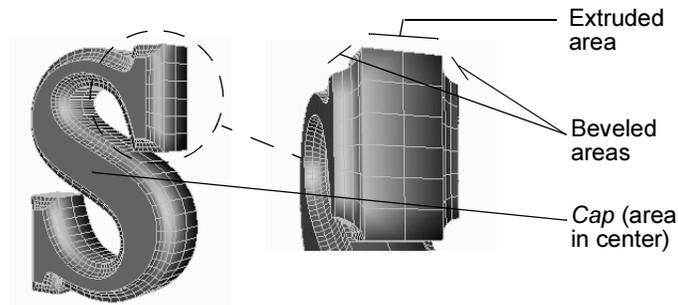
Lets you create beveled transition surfaces with a much higher degree of control than regular Bevel.

Related topics

- ❖ "Extrude and bevel a surface from a curve" on page 47
- ❖ "Surfaces > Bevel" on page 79

Surfaces > Bevel Plus > □

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.

3 | Creating NURBS surfaces

Reference > Surfaces > Bevel Plus

Create Cap: At Start, At End

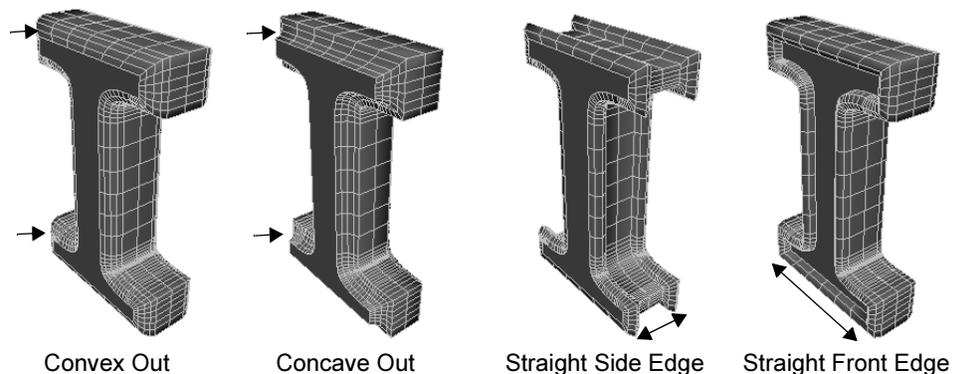
Turns on or off the creation of surfaces that cap the center area on either end of the beveled surface. At Start controls the portion closest to the curve and At End controls the portion furthest from the curve.

Outer Bevel Style, Inner Bevel Style

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.

You can switch between styles and compare the results by accessing the `outerStyleCurve` or `innerStyleCurve` attribute from the Attribute Editor or Channel Box.

The following figure illustrates some of the terms used in the bevel style names:



Same as Outer Style

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.

Use Tolerance

This option is enabled if you set the Output Geometry option to NURBS. Tolerance determines the degree of accuracy that is maintained between the original curve and the beveled surface. Choose from the following options:

3 | Creating NURBS surfaces

Reference > Surfaces > Bevel Plus

Global	Maya uses the Positional value in the Settings section of the Preferences window (Window > Settings/Preferences > Preferences > Settings).
Local	Lets you enter a new value to override the value set in the Preferences window.

Tolerance

If you choose Local, set the degree of accuracy between the original curve and the beveled surface. A low value creates a surface that closely follows the curve. A high value creates a surface that loosely follows the curve.

Output Options

Click the Output Options tab to specify the resulting geometry type and topology.

Output Geometry

Specifies whether to use NURBS or polygons for the resulting beveled surface.

Note If you choose NURBS, Maya creates trimmed surfaces for the cap areas of the beveled surface. Some external applications, such as game exporters, may not handle trimmed surfaces.

Tessellation Method

Controls the smoothness of the resulting beveled surface using two different methods. Count lets you specify the number of polygons; see "Count tessellation method" on page 85. Sampling lets you specify different degrees of tessellation in different areas of the beveled surface; see "Sampling Controls" on page 86.

Count tessellation method

By setting Tessellation Method to Count, you can specify the number of faces created in the resulting beveled surface.

Face Count

Enter a face count and Maya tessellates the surface to match or approximate the count. For optimum performance, set a value that gives enough smoothness while maintaining a low polygon count.

3 | Creating NURBS surfaces

Reference > Surfaces > Bevel Plus

Note The actual number of faces will be higher than the Face Count value, because number of faces created for the beveled areas and caps are not included.

Sampling Controls

If the Tessellation Method is set to Sampling (the default), the following options are available. Sampling lets you specify different degrees of tessellation in different areas of the beveled surface.

Along Extrusion

Use these settings to control the tessellation along the direction of the extrusion.

Section Use this option if you want the space between tessellated subdivisions to be different for the beveled areas versus the extruded area. With Section turned on, the tessellation occurs separately for each section of the beveled surface: the front beveled area, the back beveled area, and the non-beveled extruded area. Each section will have the same number of subdivisions, as specified in the Samples setting.

Complete Use this option if you want the tessellated subdivisions to be more evenly spaced across the surface. With Complete turned on, the tessellation occurs along the entire beveled surface, from one surface cap to the other.

Samples

The number of subdivisions in the resulting tessellation.

Along Curve

Use these settings to control the tessellation along the direction of the source curve.

Span Use this option if you want the space between tessellation subdivisions to be different for long spans versus short spans. (A span is the part of a curve between two edit points.) With Span turned on, the tessellation occurs between each span of the source curve. Each span will have the same number of subdivisions, as specified in the Samples setting.

3 | Creating NURBS surfaces

Reference > Edit NURBS > Duplicate NURBS Patches

Complete Use this option if you want the tessellation subdivisions to be evenly spaced across the surface. With Complete turned on, the tessellation occurs along the entire beveled surface, from the curve's start point to the end point.

Samples

The number of subdivisions in the resulting tessellation.

Secondary Controls

If the Tessellation Method is set to Sampling (the default), the following options are available.

These options are mainly useful for industrial designers concerned with the accuracy of a model in relation to a prototype model.

Use Chord Height, Chord Height

The smaller the Chord Height value, the better Maya's approximation of the beveled surface to the original curve. Chord height is the maximum distance from the original curve to the edge of the resulting polygon.

Note If you scale the beveled surface, avoid using the Chord Height setting, because the chord length will always be relative to the object, not to world space. Use Chord Height Ratio instead.

Use Chord Height Ratio, Chord Height Ratio

The Chord Height Ratio is calculated by dividing the chord height (maximum distance from the original curve to the edge of the resulting polygon) by the chord length (distance between two polygon vertices).

For example, the default value, 0.1, means that the chord height must be larger than 1/10 of the chord length before additional edit points are created.

Edit NURBS

Edit NURBS > Duplicate NURBS Patches

Creates new surfaces from the selected NURBS patches.

3 | Creating NURBS surfaces

Reference > Edit NURBS > Round Tool

Related topics

- ❖ "Create a new surface from patches of an existing surface" on page 49

Edit NURBS > Duplicate NURBS Patches >

Group With Original

If on, the duplicate surface is parented under the original object that contains the patches. If off, the resulting surface is independent of the original object.

Important Unlike polygonal facets, you cannot move, rotate, or scale a NURBS patch that is a component of an object. You *can* move, rotate, or scale a NURBS patch that is a new object created with Duplicate NURBS Patches.

Edit NURBS > Round Tool

Creates rounded transition surfaces along the edges between existing surfaces.

Related topics

- ❖ "Round off the meeting point between two edges" on page 50

Edit NURBS > Round Tool >

Radius

Specifies the fillet radius the tool uses when you select edge pairs.

Tolerance Value

Override tolerance means the Positional value you set in the Preferences window is used. Positional tolerance is used to determine how close the end points need to be to be considered coincident. The default is Override.

User Preferences tolerance lets you enter a new value to override the Positional tolerance value you set in Preferences.

Edit NURBS > Surface Fillet > Circular Fillet

Creates a circular fillet surface between two existing surfaces.

Related topics

- ❖ "Create a fillet between two surfaces" on page 51

3 | Creating NURBS surfaces

Reference > Edit NURBS > Surface Fillet > Circular Fillet

- ❖ "Edit NURBS > Surface Fillet > Freeform Fillet" on page 91
- ❖ "Edit NURBS > Surface Fillet > Fillet Blend Tool" on page 91

Edit NURBS > Surface Fillet > Circular Fillet >

Create Curve On Surface

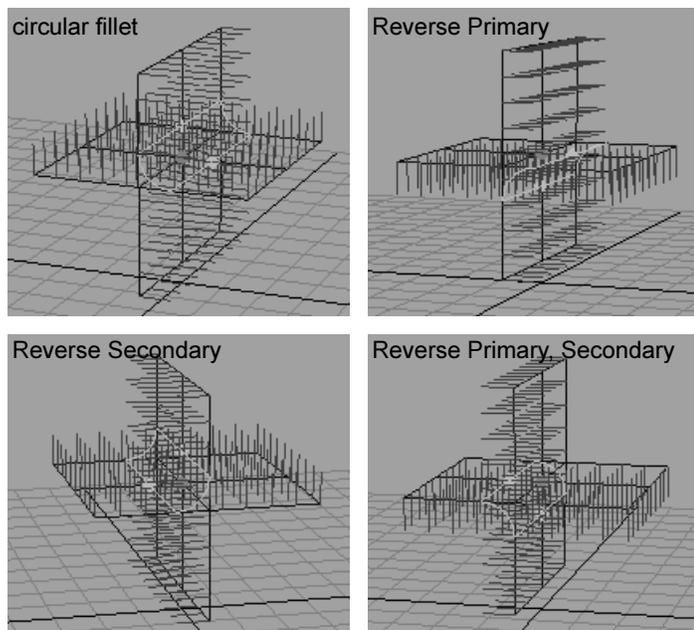
Turn on Create Curve On Surface to create curves-on-surface when the fillet is constructed. The curves are placed on the surface at the point where they intersect with the fillet.

When Create Curve On Surface is off, curves-on-surface are not constructed on the original surface. The default is off.

Reverse Surface Normals

During the fillet construction, the surfaces are offset in the direction of the normals by the Radius value you specify. By reversing the surface normals, you can construct the desired fillet. Click the Show Manipulator icon to see the surface normals.

Before you create the fillet, choose to reverse either the primary surface normal (the first selected surface), or the second surface normal (the second selected surface). The following examples show both primary and secondary reverse methods with a radius value of 0.75.



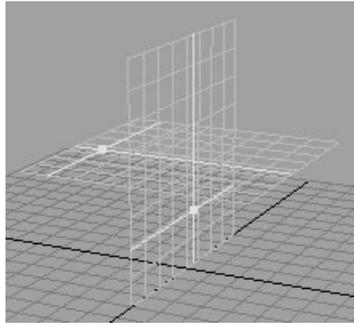
3 | Creating NURBS surfaces

Reference > Edit NURBS > Surface Fillet > Circular Fillet

To reverse surface normals by selecting surface points:

You can also reverse surface normals by selecting points on the surfaces and constructing the fillet. For example, the normals on the secondary surface are reversed if the point selected on the primary surface does not lie on the same side as its surface normal.

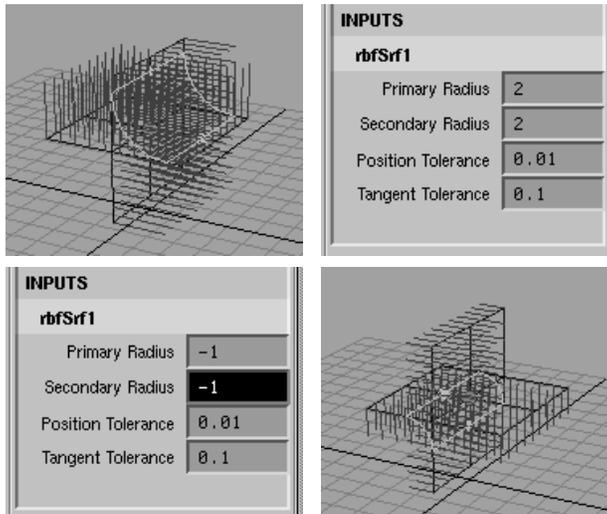
- 1 Select a point then Shift-select another point.



- 2 Select either Reverse Primary Surface Normal or Reverse Secondary Surface Normal, then click the Fillet button. Click the Show Manipulator icon to see the surface normals.

Editing the circular fillet normals using manipulators

- 1 To display the surface normals and radius manipulator after you create the fillet, select the fillet surface and display the Show Manipulator Tool.
- 2 Drag a radius manipulator handle.



3 | Creating NURBS surfaces

Reference > Edit NURBS > Surface Fillet > Freeform Fillet

Use Tolerance

The Use Tolerance options let you apply a circular fillet within a specified tolerance value. You can apply tolerance globally or locally.

Global tolerance causes Maya to use the Positional and Tangential values from the Settings part of the Preferences window.

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

Edit NURBS > Surface Fillet > Freeform Fillet

Creates a fillet surface with configurable bias between two existing surfaces.

Related topics

- ❖ "Create a fillet between two surfaces" on page 51
- ❖ "Edit NURBS > Surface Fillet > Circular Fillet" on page 88
- ❖ "Edit NURBS > Surface Fillet > Fillet Blend Tool" on page 91

Edit NURBS > Surface Fillet > Freeform Fillet > □

Bias

The Bias value scales the end tangents across the two surface curves.

Depth

The Depth value controls the curvature of the filleted surface.

Use Tolerance

The Use Tolerance options let you reapply a free-form fillet within a specified tolerance value.

Global tolerance causes Maya to use the Positional and Tangential values from the Settings part of the Preferences window.

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

Output Geometry

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

Edit NURBS > Surface Fillet > Fillet Blend Tool

Creates a fillet surface between two existing surfaces.

3 | Creating NURBS surfaces

Reference > Edit NURBS > Surface Fillet > Fillet Blend Tool

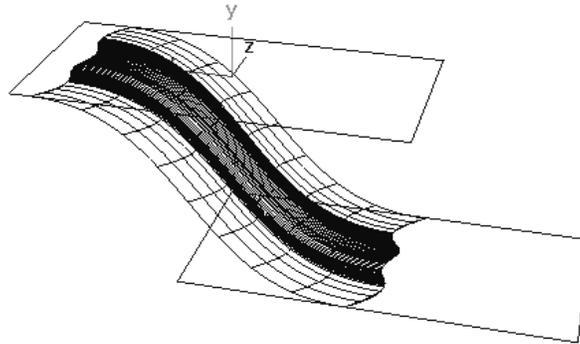
Related topics

- ❖ "Create a fillet between two surfaces" on page 51
- ❖ "Edit NURBS > Surface Fillet > Circular Fillet" on page 88
- ❖ "Edit NURBS > Surface Fillet > Freeform Fillet" on page 91

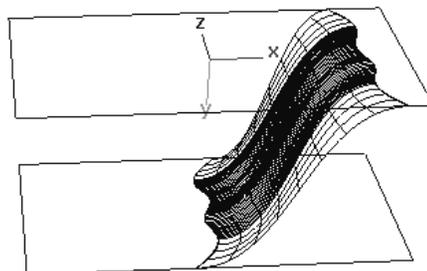
Edit NURBS > Surface Fillet > Circular Fillet >

Auto Normal Dir

Turns on automatic orientation of the blended surface's junctures with the original objects. If off, you must choose the surface orientation. For example, suppose you create the following fillet-blended surface (the middle object) from a pair of planes:



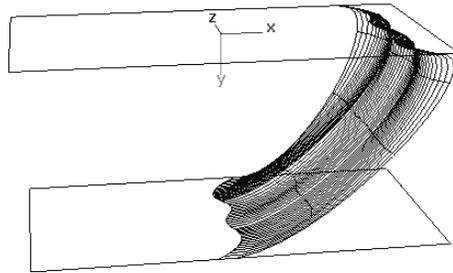
Where the blended surface meets the top plane, notice how the curvature curls towards the left-most part of the plane. If you rotate the top plane 180 degrees around its z-axis, the curvature still curls towards the same part of the plane.



If Auto Normal Dir is off, the curl of your surface may point in the opposite direction after the rotation. In the above example, the blended surface would curl toward the left end (former right end) of the top plane.

3 | Creating NURBS surfaces

Reference > Edit NURBS > Surface Fillet > Fillet Blend Tool



In most cases, turning on Auto Normal Dir creates the desired orientation automatically when you rotate the surfaces.

Auto Normal Dir is called Auto Normal in the Channel Box and Attribute Editor.

Multiple Knots

When on, Maya creates the blended surface with multiple knots at each knot position. This displays the surface with greater precision. Be aware that using multiple knots might break the tangency between the blended and original surfaces as you deform the surface. For example, you might see a sharp break in curvature on the surface as you deform it.

If you're uncertain how to set this option, leave it off. If you will not be deforming the blended surface, turn this option on to create a better fit with the surfaces. Also, if you select Bezier as the output geometry, you can leave this option on because the conversion creates multiple knots anyway.

Note that the number of multiple knots increases with a lower Positional Tolerance number. See "Use Tolerance" on page 96.

ImportantIf Multiple Knots is on, Auto Normal Dir is off regardless of its setting. If Multiple Knots is off, Auto Normal Dir is on regardless of its setting.

Reverse Normal Left/Right

If Auto Normal Dir is off, you can turn on Reverse Normal Left or Reverse Normal Right to correct a situation where the blended surface curls towards one of the original surfaces improperly. Reverse Normal Left reverses the curl towards the first surface you selected when you used the Fillet Blend tool. Reverse Normal Right reverses the curl towards the second surface.

3 | Creating NURBS surfaces

Reference > Edit NURBS > Surface Fillet > Fillet Blend Tool

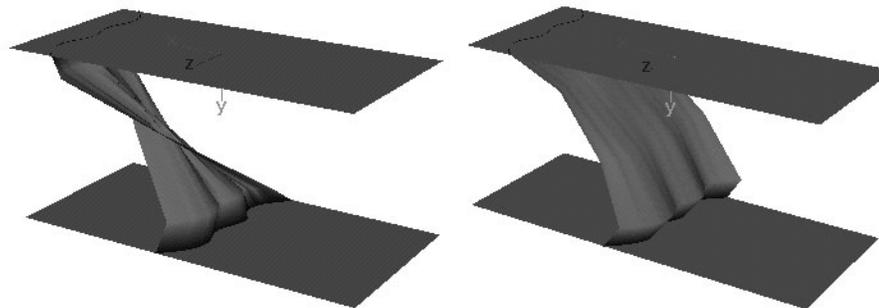
If you're uncertain about how to use these settings, use the Attribute Editor to experiment with different settings for Left or Right (or both) until you get the desired result.

Note Left means the first surface you selected. *Right* is the second surface. The two terms do not refer to spatial placement in the workspace.

The Reverse Normal Left/Right attributes are named Flip Left/Right Normal in the Channel Box and Attribute Editor.

Reverse Direction Left/Right

If Auto Normal Dir is off, you can use these options to correct a blended surface that has an undesired twist after creation. If you turn on either of these options, the blended surface responds as though you were reversing the direction of a curve that joins the blended shape to the surface. (The curves are not actually reversed.) By experimenting with these settings in the Attribute Editor, you can untwist the blended surface.



The Reverse Direction Left/Right attributes are named Reverse Left/Right in the Channel Box and Attribute Editor.

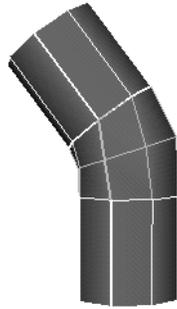
Auto Closed Rail Anchor

This option prevents a blended surface from twisting when you rotate the original surface. The Auto Closed Rail Anchor option is relevant mainly for working with a blended surface created from periodic curves.

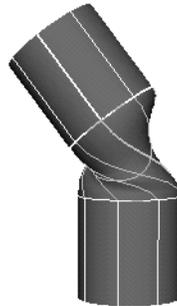
For instance, suppose you've created a blended surface from a pair of cylinders as shown in the following figure. The blended surface is the curving cylinder sandwiched between the top and bottom cylinders:

3 | Creating NURBS surfaces

Reference > Edit NURBS > Surface Fillet > Fillet Blend Tool



If Auto Closed Rail Anchor is off and you rotate the top or bottom cylinder around its Y-axis, the blended surface (middle cylinder) twists as if it's glued to the cylinders:



If Auto Closed Rail Anchor is on and you rotate the top or bottom cylinder, the middle cylinder slides along the bordering rings. No twisting occurs, so the middle cylinder retains its original shape. The middle cylinder will rotate if you rotate the top or bottom cylinders.

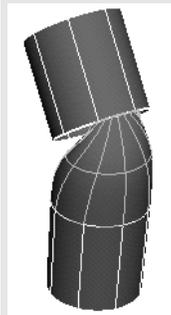
The Auto Closed Rail Anchor attribute is named Auto Anchor in the Channel Box and Attribute Editor.

3 | Creating NURBS surfaces

Reference > Edit NURBS > Surface Fillet > Fillet Blend Tool

Tip To set your own anchor point for the adjoining surfaces, turn off Auto Closed Rail Anchor when you use the Fillet Blend tool. Display the ffBlendSrf node in the Attribute Editor to edit the Left/Right Anchor, Left/Right Start, or Left/Right End.

Left/Right Anchor sets an anchor position (in U) for the curve from which the blended shape was created. This is used with the Left/Right Start or Left/Right End to specify a range of curve length along which the blended surface joins the adjacent surfaces. Note that you also can use the Show Manipulator Tool to adjust this option. Be aware that twisting will still occur when you rotate the adjoining surfaces.



Left Anchor = 0
Left Start = 0.6
Left End = 0.8

Use Tolerance

Global tolerance causes Maya to use the Positional and Tangential values from the Settings part of the Preferences window.

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

Positional tolerance sets how snugly the blended surface fits the original surfaces. Tangential tolerance sets how precisely the tangency at the edges of the blended surface merge with the tangency at the edges of the original surfaces.

For Positional and Tangential tolerance, lower values increase accuracy at the expense of longer rendering time.

Unless you're modeling for manufacturing output, it's probably unimportant to display the surfaces in the workspace with perfect fit. They'll still likely render well. To enhance the rendering quality, you can adjust the Tessellation options of the blended surface shape node.

Output Geometry

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

3 | Creating NURBS surfaces

Reference > Edit NURBS > Surface Fillet > Fillet Blend Tool

Tool Behavior

If you turn off Exit On Completion, Maya remains focused on the Fillet Blend tool after each usage. Turn off Exit On Completion if you want to use the tool repeatedly.

3 | Creating NURBS surfaces

Reference > Edit NURBS > Surface Fillet > Fillet Blend Tool

4 Editing NURBS

How do I? Create and edit models

Reshape NURBS curves and surfaces

Reshape a curve or surface manually

To move CVs on a curve or surface

- 1 Choose the Move tool.
- 2 Press the right mouse button on the curve or surface and choose Control Vertex.
- 3 Select the CVs you want to edit and use the manipulator to move them.

Tip With a CV selected you can press the up and down keys to select the next/previous CV in the row. On a surface, press the left and right keys to select the next/previous CV in the column.

Note Avoid tweaks (moving CVs) on objects with history. If you tweak an object with history, the tweak is applied to a specific component ID. Subsequent changes to the object's history can cause the component IDs to change, altering the effect of the tweak.

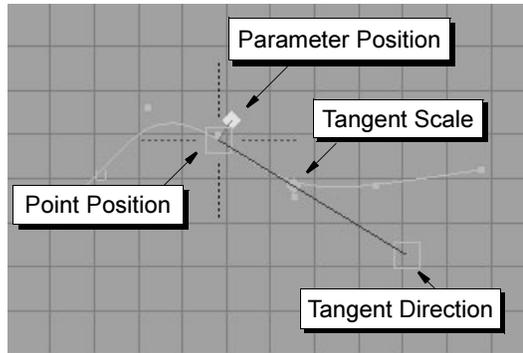
For example, if you revolve a curve to create a surface, then tweak CV number 3 on the surface, the tweak will always apply to CV number 3. If you later change the revolve node attributes to reduce the number of segments on the surface, the CV that you tweaked will now have a new number, and the tweak will no longer be applied to it. The tweak will be applied to the CV that is now number 3, which may be in a different location on the surface.

4 | Editing NURBS

How do I? > Reshape a curve or surface manually

To reshape a curve with the Curve Editing tool

- 1 Select Edit Curves > Curve Editing Tool.
- 2 Click the curve.



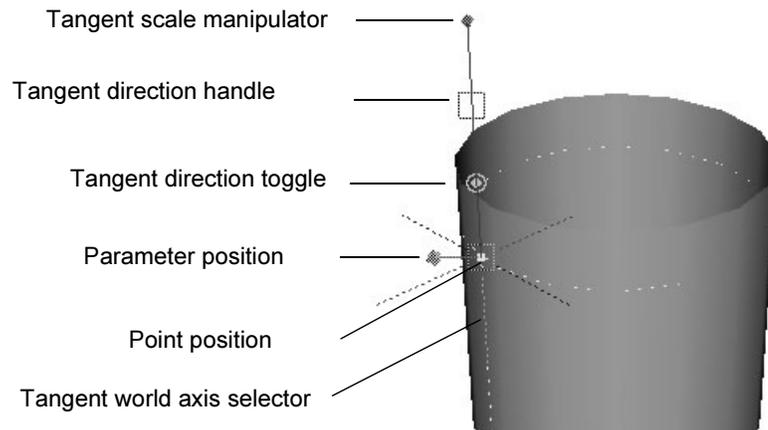
- 3 Do any of the following:
 - Drag the parameter position handle to move the manipulator along the curve.
 - Drag the point position handle to move this point. The curve will reshape so the curve passes through the point as you move it.
 - Drag the tangent direction handle to change the direction of the curve at this point.
 - Drag the tangent scale handle to change the “speed” of the curve at this point.
 - Click a dashed line to align the tangent at this point with one of the axes.

To reshape a surface with the Surface Editing tool

- 1 Select Edit NURBS > Surface Editing > Surface Editing Tool.
- 2 Click the surface.

4 | Editing NURBS

How do I? > Reshape a curve or surface manually



3 Do any of the following:

- Drag the parameter position handle to move the manipulator across the surface.
- Drag the point position handle to move this point. The surface will reshape so the surface touches the point as you move it.
- Click the tangent direction toggle (the double circle) to switch between editing the U, V, and Normal tangent.
- Drag the tangent direction handle (the box) to change the tangent of the surface at this point.
- Drag the tangent scale handle to change the “speed” of the tangent at this point.
- Click a dashed line to align the tangent at this point with one of the axes.

Tips The Surface Editing Tool deforms a region within two spans of the manipulator. Deformation decreases with distance from the tool position.

You can use Snap to curve to snap the manipulator to an isoparm, or Snap to grid to snap to a patch corner. The snapping occurs to the isoparms or patch corners that appear when you display the object with Display > NURBS Smoothness > Rough—not the isoparms or patch corners that appear only with finer Smoothness settings.

To reshape a curve or surface with the Soft Modification tool

See *Use the Soft Modification Tool* in the Character Setup book.

4 | Editing NURBS

How do I? > Align a curve with a curve or surface

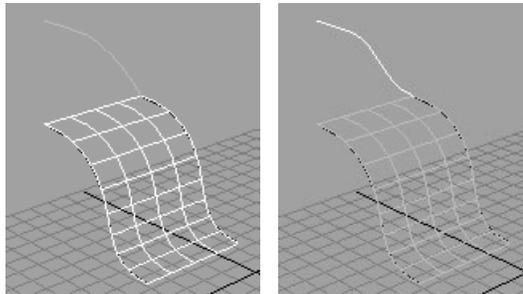
Related topics

- ❖ "Smooth a curve" on page 105
- ❖ "Extend a surface" on page 108
- ❖ "Push or pull a surface with the Sculpt Surfaces tool" on page 198
- ❖ *Use the Soft Modification Tool*
- ❖ "Display > NURBS Components > Custom" on page 121
- ❖ "Edit Curves > Curve Editing Tool" on page 140
- ❖ "Soft Modification tool" on page 120
- ❖ Deform > Soft Modification

Align a curve with a curve or surface

Make a curve tangent or curvature continuous with a surface

- 1 Select the surface and then the curve.
- 2 Select Edit Curves > Project Tangent > .
- 3 Set Construction to Tangent or Curvature.
- 4 Click Project.



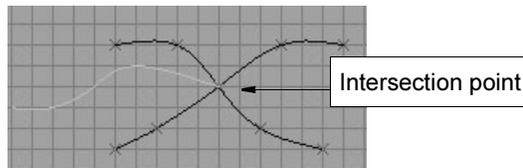
Select the project tangent node and click the Show Manipulator tool to manipulate curvature scale, tangent scale, or tangent rotation.

To make a curve tangent or curvature continuous with a curve intersection

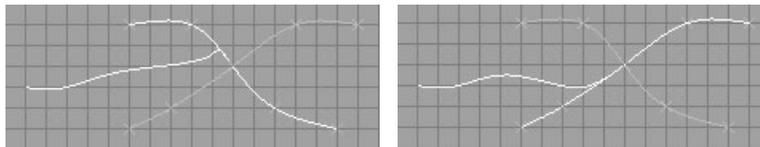
- 1 Choose Edit Curves > Project tangent > .
- 2 Click the curve or surface edge you want to modify, near the end which intersects the surface.
- 3 Click two intersecting curves that define a plane.

To make a curve tangent or curvature continuous with another curve

- 1 Make sure the endpoint of the curve you want to make tangent intersects the curves that define the plane.



- 2 Select the curve you want to reshape first, then select the other curves. The projected tangent is based on the key curve (the curve you select last, highlighted in green).
- 3 Select Edit Curves > Project Tangent > .
- 4 Set Construction to Tangent or Curvature.
- 5 Click Project.

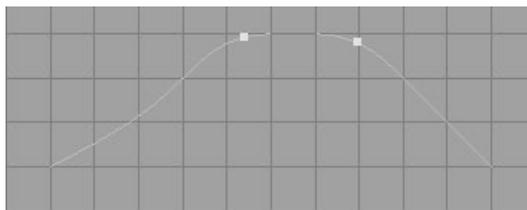


Edit a project tangent action

Select the project tangent node and click the Show Manipulator tool to manipulate curvature scale, tangent scale, or tangent rotation.

To align the ends of two curves

- 1 Select the points on the curves (or isoparms) where you want to align the curves.



- 2 Select Edit Curves > Align Curves.

Tip When construction history is on, you can select the align node and use the Show Manipulator tool to edit the tangent scale and curve points.

4 | Editing NURBS

How do I? > Align surface edges

What if...?

I can't project tangents at both ends of a curve?

The project tangent action "takes over" a few CVs at the end of the curve to maintain continuity. If there aren't enough interior CVs to avoid overlap, you can't use project tangent at both ends. Try inserting edit points to increase the number of CVs on the curve.

Related topics

- ❖ "Continuity" on page 20
- ❖ "Align surface edges" on page 104
- ❖ "Join two curves or surfaces together (attach)" on page 110
- ❖ "Edit Curves > Align Curves" on page 131
- ❖ "Edit Curves > Intersect Curves" on page 134
- ❖ "Edit Curves > Project Tangent" on page 141

Align surface edges

To align surfaces

- 1 Select an edge on the first surface.
- 2 Shift-select an isoparm on the other surface. You can align the edge of the first surface to any isoparm on the second surface.
- 3 Select Edit NURBS > Align Surfaces.

Limitations

- You cannot align edges that are closed or periodic.
- You cannot align a surface to itself.
- Exact tangency or curvature continuity cannot be guaranteed if surfaces are rational.
- You cannot align to a trimmed edge. Align Surfaces uses the original surface edge, not its trimmed shape.

Related topics

- ❖ "Align a curve with a curve or surface" on page 102
- ❖ "Join two curves or surfaces together (attach)" on page 110
- ❖ "Edit NURBS > Align Surfaces" on page 153

Smooth a curve

The Smooth Curve action smooths out sharp changes in direction in a curve. This can be especially useful for curves created with the Pencil Curve tool and curves created from scan or translated data.

You cannot smooth a closed curve, surface isoparm, or curve-on-surface. Smooth Curves doesn't change the number of CVs.

To smooth a curve or a selection of CVs

- 1 Select the curve, or select only the CVs you want to smooth.
- 2 Select Edit Curves > Smooth Curve.

To control the amount of smoothing, choose Edit Curves > Smooth Curve > and set the Smoothness option. Lower values do less smoothing. The default value is 10.

Related topics

- ❖ "Smooth a surface with the Sculpt Surfaces tool" on page 198
- ❖ "Display > NURBS Smoothness" on page 121
- ❖ "Straighten, smooth, curl or bend a curve" on page 106
- ❖ "Edit Curves > Smooth Curve" on page 139

Lock or unlock the length of a curve

You can lock the length of a curve so that it maintains a constant hull length, even when you edit the curve (for example, by moving a CV).

To lock/unlock the length of a curve

- 1 Select the curve (or CVs).
- 2 Press and hold down the l (lower case L) key.
- 3 Modify the curve, and it will maintain a constant hull length.
- 4 To unlock the length, release the l (lower case L) key.

Note You can also lock/unlock the length of a curve by selecting the curve (or CVs), and selecting Edit Curves > Modify Curves > Lock Length or Edit Curves > Modify Curves > Unlock Length, but be careful you don't forget to unlock the length. Using the hotkey is better, because you're not likely to forget to unlock the length.

4 | Editing NURBS

How do I? > Straighten, smooth, curl or bend a curve

Note When you first lock the length of a curve, a Lock Length attribute is added to the curveShape node. You can thereafter lock/unlock the length of the curve by turning on/off the Lock Length attribute.

Related topics

- ❖ "Edit Curves > Modify Curves > Lock Length" on page 142
- ❖ "Edit Curves > Modify Curves > Unlock Length" on page 143

Straighten, smooth, curl or bend a curve

To...	Do this
Straighten a curve.	Select the curve (or CVs) and choose Edit Curves > Modify Curves > Straighten.
Smooth a curve.	Select the curve (or CVs) and choose Edit Curves > Modify Curves > Smooth.
Curl a curve.	Select the curve (or CVs) and choose Edit Curves > Modify Curves > Curl.
Bend a curve.	Select the curve (or CVs) and choose Edit Curves > Modify Curves > Bend.
Reduce or exaggerate a curve's curvature.	Select the curve (or CVs) and choose Edit Curves > Modify Curves > Scale Curvature.

Tip Because Straighten, Smooth, Bend, and Scale Curvature are actions that you apply to curves, you cannot interactively adjust their effect as you would with a tool. However, you can set the scaling of the tool very low (for example, set Straightness to 0.1) and repeatedly apply the action until the curve has the desired shape.

Related topics

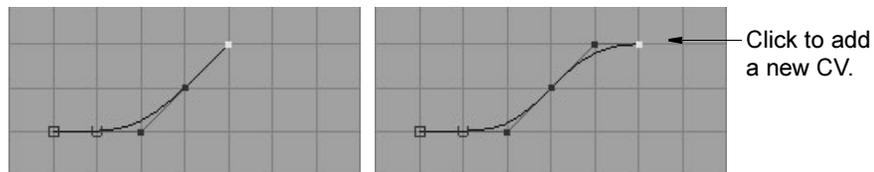
- ❖ "Edit Curves > Modify Curves > Straighten" on page 143

- ❖ "Edit Curves > Modify Curves > Smooth" on page 144
- ❖ "Edit Curves > Modify Curves > Curl" on page 145
- ❖ "Edit Curves > Modify Curves > Bend" on page 145
- ❖ "Edit Curves > Modify Curves > Scale Curvature" on page 146

Extend a curve

Add CVs or edit points to the end of a curve

- 1 Select the curve to add CVs, or select the last edit point to add edit points.
- 2 Select Edit Curves > Add Points Tool.
- 3 Click in the view to add new CVs or edit points.
- 4 Press.



Extend a curve or curve-on-surface a certain distance

- 1 Select the curve.
- 2 Choose Edit Curves > Extend > Extend Curve > or Edit Curves > Extend > Extend Curve On Surface > .
- 3 Click Distance (or Parametric Distance for a curve-on-surface) and enter the distance you want to extend the curve. You can interactively change the distance in the channel box or attribute editor after you extend.

For curves-on-surface the Parametric Distance sets a fraction of the surface length in the direction the curve runs. For instance, a value of 0.5 extends the curve length by roughly half the length of the surface in the direction the curve runs.

- 4 Do one of the following:
 - Click Linear to extend the curve in a straight line.
 - Click Circular to extend the curve in an arc.
 - Click Extrapolate to maintain tangent continuity with the current shape of the curve.
- 5 Set Extend Curve At to choose which end (or Both ends) to extend from.

4 | Editing NURBS

How do I? > Extend a surface

- 6 To make the extension part of the current curve, turn on Join to Original. Turn this option off to make the extension a new curve.
- 7 Click Extend.

Extend one end of a curve or curve-on-surface out to exact coordinates

- 1 Select the curve.
- 2 Choose Edit Curves > Extend > Extend Curve > or Edit Curves > Extend > Extend Curve On Surface > .
- 3 Click Point (or UV Point for a curve-on-surface).
- 4 Set Extend Curve At to choose which end to extend from.
- 5 To make the extension part of the current curve, turn on Join to Original. Turn this option off to make the extension a new curve.
- 6 Click Extend.

Tip When Keep Original is on in the Extend Curve option box, Maya will create an extend node on the curve. You can select the extend node in the channel box or attribute editor to tweak the extend operation, including distance, interactively.

Related topics

- ❖ "Extend a surface" on page 108
- ❖ "Edit Curves > Extend > Extend Curve" on page 123

Extend a surface

Extend a surface a certain distance

- 1 Select the surface.
- 2 Choose Edit Curves > Extend > Extend Surfaces > .
- 3 Enter the distance you want to extend the curve. You can change the distance interactively in the attribute editor after you extend.
- 4 Do one of the following:
 - Click Tangent to add new isoparms as you extend.
 - Click Extrapolate to extend the shape without adding isoparms.
- 5 Choose which edge(s) you want to extend from.
 - Set Extend Side to Start, End, or Both.
 - Set Extend Direction to U, V, or Both.

You can change the side controls interactively in the channel box or attribute editor after you extend.

- 6 Turn off Join to Original.
- 7 Click Extend.

Notes

- You cannot extend a trimmed surface.

Related topics

- ❖ "Extend a curve" on page 107
- ❖ "Edit NURBS > Extend Surfaces" on page 148

Select curve CVs: first, last or all

To...	Do this
Select all CVs on a curve.	Select the curve and choose Edit Curves > Selection > Select Curve CVs (or press Ctrl + the right mouse button and choose To CVs).
Select the first CV on a curve.	Select the curve and choose Edit Curves > Selection > Select First CV on Curve (or press Ctrl + the right mouse button and choose To First CV).
Select the last CV on a curve.	Select the curve and choose Edit Curves > Selection > Select Last CV on Curve (or press Ctrl + the right mouse button and choose To Last CV).

Related topics

- ❖ "Edit Curves > Selection > Select Curve CVs" on page 147
- ❖ "Edit Curves > Selection > Select First CV on Curve" on page 147
- ❖ "Edit Curves > Selection > Select Last CV on Curve" on page 147

4 | Editing NURBS

How do I? > Join two curves or surfaces together (attach)

Edit NURBS curves and surfaces

Join two curves or surfaces together (attach)

To...	Do this
Join two 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. <ul style="list-style-type: none">• 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.

Related topics

- ❖ "Align surface edges" on page 104
- ❖ "Split a curve or surface (detach)" on page 111
- ❖ "Edit Curves > Attach Curves" on page 128
- ❖ "Edit NURBS > Attach Surfaces" on page 150

Split a curve or surface (detach)

To...	Do this
Split a curve at some point.	<p>Select the curve point at which you want to split the curve and choose Edit Curves > Detach Curves.</p> <p>When construction history is on, you can select the detach node and use the Show Manipulator tool to edit the detach point.</p>
Split a surface at an isoparm.	<p>Select the isoparm at which you want to split the surface and choose Edit NURBS > Detach Surfaces.</p> <p>You can select multiple isoparms to split the surface into multiple parts.</p>
Split a curve wherever it crosses another curve in a view.	<p>Select the curves in the view where they overlap, then choose Edit Curves > Cut Curve.</p> <p>You cannot split a curve with an isoparm or curve-on-surface. Use Edit Curves > Duplicate Surface Curves to create a new curve from the isoparm or curve-on-surface you want to use.</p>

Related topics

- ❖ "Join two curves or surfaces together (attach)" on page 110
- ❖ "Edit Curves > Detach Curves" on page 130
- ❖ "Edit NURBS > Detach Surfaces" on page 151

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.

4 | Editing NURBS

How do I? > Create an offset copy of a curve or surface

To...	Do this
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.

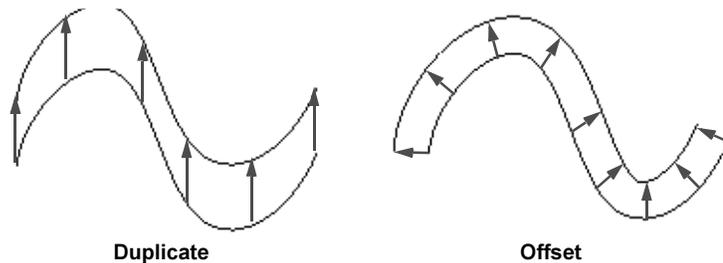
When the Keep Original option is on in the option box (Edit Curves > Insert Knot > or Edit NURBS > Insert Isoparms >) you can select the Show Manipulator tool to reposition the new edit point or isoparm after you insert it.

Related topics

- ❖ "Edit Curves > Insert Knot" on page 135
- ❖ "Edit NURBS > Insert Isoparms" on page 161

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).

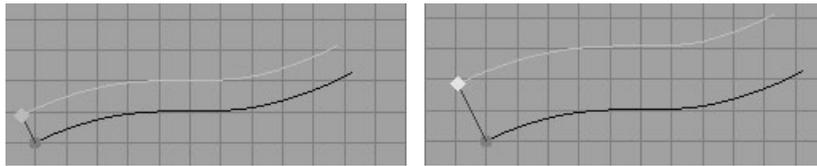


Create an offset copy of a curve

- 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.

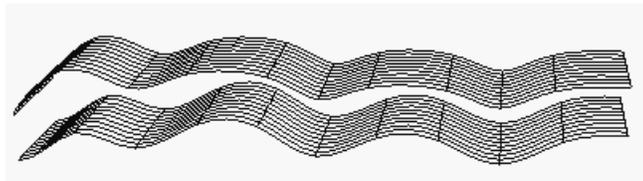
4 | Editing NURBS

How do I? > Reverse the direction of a curve or surface normals



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 Fix.
 - To preserve CV layout, set Method to CV Fix.
- 4 Enter a distance to offset. You can change the distance interactively in the channel box or attribute editor after you offset.
- 5 Click Extend.



Related topics

- ❖ "Edit Curves > Offset > Offset Curve, Offset Curve on Surface" on page 126
- ❖ "Edit NURBS > Offset Surfaces" on page 149

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 > <input type="checkbox"/> and choose the surface direction to reverse, or swap to swap U and V.

4 | Editing NURBS

How do I? > Reduce the complexity of a curve or surface

Related topics

- ❖ "Normals" on page 17
- ❖ "Curve components" on page 21
- ❖ "Edit Curves > Reverse Curve Direction" on page 136
- ❖ "Edit NURBS > Reverse Surface Direction" on page 163

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 curve.
- 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.

Related topics

- ❖ "Control multi-knots and CV hardness" on page 115
- ❖ "Automatically add spans to areas of a curve with high curvature" on page 117
- ❖ "Edit Curves > Rebuild Curve" on page 136
- ❖ "Edit NURBS > Rebuild Surfaces" on page 164

Control multi-knots and CV hardness

Multi-knots are multiple edit points at the same location that create a sharp bend or corner in a curve. For example, the Create > Text tool creates curves with multi-knots to represent letters with sharp corners.

To set the hardness of a CV

“Hardening” a CV creates multiknots that make the curve take a sharp turn at the CV.

1 Select the CVs.

You can only harden a CV if the previous and next CVs on the curve are not hardened.

2 Select Edit Curves > CV Hardness > .

3 Do one of the following:

- Click Full to make this a hard CV, resulting in a sharp bend in the curve.
- Click Off to make this a normal CV, resulting in a normal (softer) bend of the curve.

4 If you turn on Keep Original, Maya will create a new curve with the hardness applied to the CV. In the dependency graph, you can see a node that takes the original curve, hardens the CV, and outputs a new curve.



You can select this node and turn the hardness on or off using the Multiplicity slider in the attribute editor.

If you turn off Keep Original, the operation applies to the CV on the original curve and is not editable.

5 Click Harden.

To add or remove a tangent break at an isoparm

A tangent break inserts multi-knots along an isoparm to break tangent continuity. This lets you make a sharp bend in the surface along the isoparm. The shape of the surface doesn't immediately change.

To...	Do this
Break tangency along an isoparm.	Select the isoparm and choose Edit Surfaces > Surface Editing > Break Tangent.

4 | Editing NURBS

How do I? > Control multi-knots and CV hardness

To...	Do this
Break tangency along isoparms in both directions.	Select a surface point and choose Edit Surfaces > Surface Editing > Break Tangent.
Break an arbitrary tangent.	Use the Surface Editing tool to select the tangent direction, then choose Edit Surfaces > Surface Editing > Break Tangent. ❖ "Reshape a curve or surface manually" on page 99
Smooth a broken a tangent.	Select the isoparm and choose Edit Surfaces > Surface Editing > Smooth Tangent.

Note Edit Surfaces > Surface Editing > Break Tangent sometimes doesn't work for U direction isoparm of closed surface.
If this happens, use Edit NURBS > Move Seam first.

To remove multi-knots from a curve

- 1 Select the curve.
- 2 Choose Edit Curves > Rebuild Curve > .
- 3 Set Rebuild Type to No Multiple Knots.
- 4 Click Rebuild.

To remove multi-knots from a surface

- 1 Select the curve.
- 2 Choose Edit NURBS > Rebuild Curve > .
- 3 Set Rebuild Type to No Multiple Knots.
- 4 Click Rebuild.

Related topics

- ❖ "Edit Curves > CV Hardness" on page 139
- ❖ "Edit NURBS > Rebuild Surfaces" on page 164
- ❖ "Edit NURBS > Surface Editing > Surface Editing Tool, Break Tangent, Smooth Tangent" on page 168

How do I? > Automatically add spans to areas of a curve with high curvature

Automatically add spans to areas of a curve with high curvature

This action inserts more edit points/CVs in areas of high curvature. This gives you finer control for reshaping the curve.

- 1 Select the curve.
- 2 Choose Edit Curves > Rebuild Curve > .
- 3 Set Rebuild Type to Curvature.
- 4 Click Rebuild.

Related topics

- ❖ "Edit Curves > Rebuild Curve" on page 136

Convert a curve or surface to uniform parameterization

Convert a curve to uniform parameterization

- 1 Select the curve.
- 2 Choose Edit Curves > Rebuild Curve > .
- 3 Set Rebuild Type to Uniform.
- 4 Click Rebuild.

Convert a surface to uniform parameterization

- 1 Select the surface.
- 2 Choose Edit NURBS > Rebuild Surfaces > .
- 3 Set Rebuild Type to Uniform.
- 4 Click Rebuild.

Related topics

- ❖ "Parameters and parameterization" on page 14
- ❖ "Edit Curves > Rebuild Curve" on page 136
- ❖ "Edit NURBS > Rebuild Surfaces" on page 164

Convert a surface to non-rational geometry

Convert a surface to non-rational geometry

- 1 Select the surface.
- 2 Choose Edit NURBS > Rebuild Surfaces > .

4 | Editing NURBS

How do I? > Change a curve or surface's degree or number of spans/patches

- 3 Set Rebuild Type to Non-Rational.
- 4 Click Rebuild.

Related topics

- ❖ "Edit Curves > Rebuild Curve" on page 136
- ❖ "Edit NURBS > Rebuild Surfaces" on page 164

Change a curve or surface's degree or number of spans/patches

Change a curve's degree or overall number of spans

- 1 Select the surface.
- 2 Choose Edit NURBS > Rebuild Curve > .
- 3 Set Rebuild Type to Uniform.
- 4 Set the Number of Spans and Degree options.

Change a surface's degree or overall number of patches

- 1 Select the surface.
- 2 Choose Edit NURBS > Rebuild Surfaces > .
- 3 Set Rebuild Type to Uniform.
- 4 Set the Number of Spans U, Number of Spans V, Degree U, and Degree V options.

Divide surface patches by inserting isoparms

- ❖ "Insert additional edit points/isoparms in a curve or surface to add more CVs" on page 111

Related topics

- ❖ "Degree" on page 14
- ❖ "Curve components" on page 21
- ❖ "Surface components: CVs, isoparms, and patches" on page 26
- ❖ "Edit Curves > Rebuild Curve" on page 136
- ❖ "Edit NURBS > Rebuild Surfaces" on page 164

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 the start CV (the CV that looks like a hollow box) and choose Edit Curves > Detach Curves.
Separate the ends of a periodic (closed) curve.	Select a closed curve and choose Edit Curves > Open/Close Curves. Maya opens the curve and reshapes it so its endpoints are separated.
Join edges of a surface to make a periodic (closed) surface.	Select an open surface and choose Edit NURBS > Open/Close Surfaces > <input type="checkbox"/> . 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 > <input type="checkbox"/> . Click U, V, or Both to choose which edges are periodic.

Related topics

- ❖ "Periodic, closed, and open" on page 17
- ❖ "Edit Curves > Detach Curves" on page 130
- ❖ "Edit Curves > Open/Close Curves" on page 132
- ❖ "Edit Curves > Move Seam" on page 133

4 | Editing NURBS

Reference > Match the topology of one curve to another

- ❖ "Edit NURBS > Detach Surfaces" on page 151
- ❖ "Edit NURBS > Open/Close Surfaces" on page 159
- ❖ "Edit NURBS > Move Seam" on page 161

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.

Related topics

"Edit Curves > Rebuild Curve" on page 136

Reference Tools

Toolbox

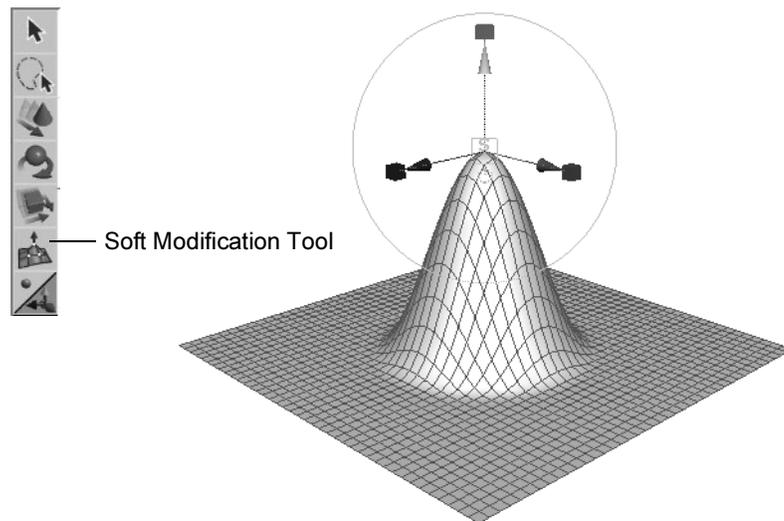
Soft Modification tool

The Soft Modification tool lets you push and pull geometry as a sculptor would push and pull on a piece of clay.

By default, the amount of deformation is greatest at the center of the push/pull, and gradually falls off further away from the centre. However, you can control the falloff of the deformation to create various types of effects.

4 | Editing NURBS

Reference > Display > NURBS Components > Custom



The Soft Modification tool is located in the Toolbox. The corresponding action is Deform > Soft Modification.

You can use the Soft Modification tool on NURBS surfaces, polygonal surfaces, subdivision surfaces, curves, particles or any object with components.

Related topics

- ❖ Deform > Soft Modification
- ❖ *Use the Soft Modification Tool*

Menus

Display

Display > NURBS Components > Custom

You can specify the scope of which NURBS objects display their components using the Scope pull-down menu. The scope can be active objects, all objects, new curves, or new surfaces.

Display > NURBS Smoothness

Hull

Shows hulls only.

4 | Editing NURBS

Reference > Display > NURBS Smoothness

Rough, Medium, Fine

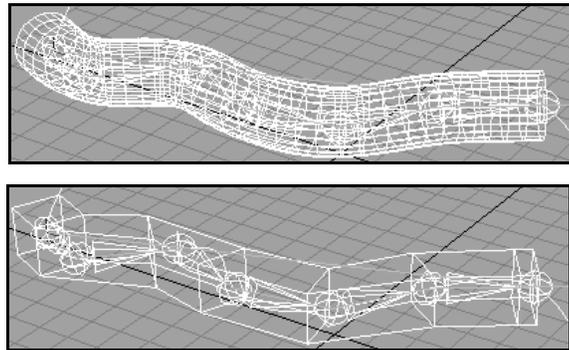
Displays objects at preset levels of quality. Selecting Medium or Fine slows the display and interactivity, but improves image precision.

Tip The hotkeys for these settings are: 1 (Rough), 2 (Medium), and 3 (Fine).

Custom

Lets you customize the display quality.

In the following figure, an object's smoothness is changed from a default medium level of quality to a custom hull quality level.



Setting custom NURBS smoothness options

Select Display > NURBS Smoothness > Custom > .

Geometry

To display all geometry, select Full. To display hulls only, select Hull.

Surface Div per Span U

Surface Div per Span V

Together, these settings subdivide the NURBS patches for display purposes to give it the appearance of a finer mesh. The range is from 0 to 32.

Curve Div per Span

Specifies the number of curve divisions per span to give the curves a rougher or smoother appearance. The range is from 1 to 128.

Display Render Tessellation Geometry

Turn on to see the pattern of tessellation that the renderer will use for the surface. You must be in shade mode to see this pattern.

Surface Div per Span

Specifies the number of surface divisions per span in shaded mode. The range is from 0 to 32.

Hull Simplification U

Hull Simplification V

If you have the Geometry set to Hull, you can use these settings to control the number of hull divisions displayed.

Modeling menu set

Edit Curves

Edit Curves > Extend > Extend Curve

Related topics

- ❖ "Extend a curve" on page 107
- ❖ "Edit Curves > Add Points Tool" on page 126

Edit Curves > Extend > Extend Curve >

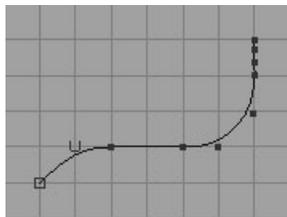
Extend Method

Distance lets you enter a value for the length of the Extension Type.

Point extends to a world space position you specify in Point To Extend To.

Extension Type

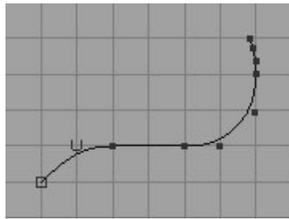
Linear extends the curve in a straight line:



Circular extends the curve as an arc:

4 | Editing NURBS

Reference > Edit Curves > Extend > Extend Curve



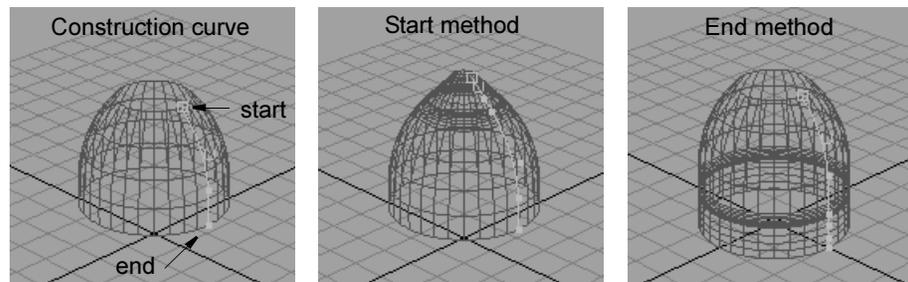
Extrapolate maintains the tangent of the selected curve.

Extend Curve At

Start extends the curve from its start point.

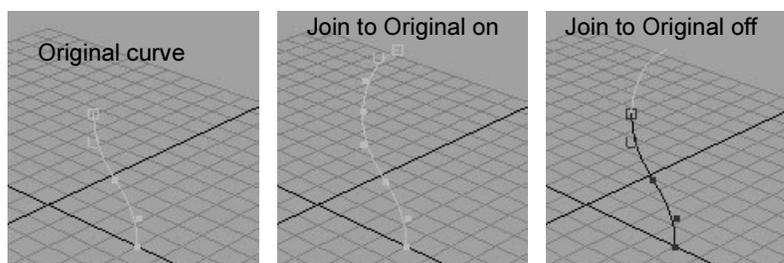
End extends the curve from its end point.

Both extends the curve at both ends.



Join to Original

Attaches the curve extension to the original curve. If off, the input curve and the curve extension are independent objects. You can transform the extension separately.



Remove Multiple Knots

Removes the multiple knots that Maya creates when Join To Original is turned on.

Keep Original

Keeps the original curve after the extension is created. If both Keep Original and Join to Original are off, the extension curve replaces the original curve.

Input Curve

Input Curve information is read-only. It gives you access to the input curve you extended. Click the arrow button to select the curve and open that section of the Attribute Editor.

Input Point

This is the same as Point To Extend To in the options window.

Edit Curves > Extend > Extend Curve on Surface

Related topics

- ❖ "Extend a curve" on page 107
- ❖ "Edit Curves > Extend > Extend Curve" on page 123

Extend Method

Specifies how to extend the curve in the surface's UV space:

Parametric Distance

Linear extends the curve in a straight line.

Circular extends the curve in an arc direction.

Extrapolate extends the curve by deducing the direction and tangency of the curve.

The Parametric Distance value specifies the length of the extension. The value specifies a percentage of the surface length in the direction the curve runs. For instance, a value of 0.5 extends the curve length by roughly half the length of the surface in the direction the curve runs.

UV Point

Lets you specify an extend position in the UV Point To Extend To entry box. To use actual UV values rather than estimates, select Create > Measure Tools > Parameter Tool, drag on the surface, and release the mouse button to display the UV coordinates at the pointer.

4 | Editing NURBS

Reference > Edit Curves > Add Points Tool

Edit Curves > Add Points Tool

Lets you add points to the end of the selected curve.

Related topics

- ❖ "Extend a curve" on page 107
- ❖ "Edit Curves > Extend > Extend Curve" on page 123

Edit Curves > Offset > Offset Curve, Offset Curve on Surface

Creates an copy of the selection, offset from the original by a certain distance.

Related topics

- ❖ "Create an offset copy of a curve or surface" on page 112

Edit Curves > Offset > Offset Curve/Curve on Surface >

Normal Direction

The Geometry Average and Active View options select the method Maya uses to position the offset. It's easiest to learn how each works by simply creating the offset and adjusting its positioning with the Show Manipulator Tool.

Geometry Average is the more intuitive method. For a planar curve, imagine you are standing at the start point of the curve looking in the direction of the initial curve direction. Geometry Average puts the offset curve to the left of the curve. It scales down the curve where it arcs left, and scales up the curve where it arcs right.

For a 3D curve, Geometry Average takes into account the normals of the average plane in which the points of the curve are located.

For both planar and 3D curves, Active View takes into account the camera viewing direction.

Offset Distance

Specifies the distance between the original curve and the offset curve.

Connect Breaks

If you create an offset curve from a curve that has multiple knots or CVs with multiplicity greater than 1, Maya might create the offset curve with sharp corners or it might break the curve into multiple discontinuous curves.

Circular creates a continuous curve by inserting circular arcs at the break points.

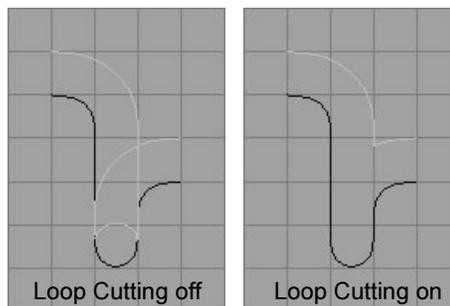
Linear creates a continuous curve by connecting the break points with a straight line.

Off leaves the offset curve broken into multiple discontinuous curves.

If you select Circular or Linear, Maya inserts multiple knots on the curve to preserve the curve shape. If you adjust the curve near the multiple knot locations, tangent breaks might occur on the curve.

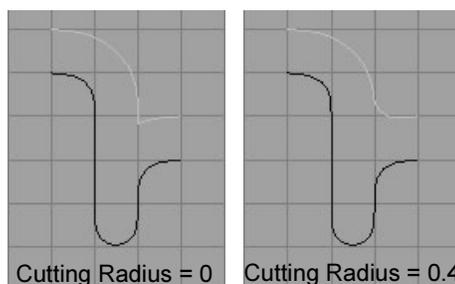
Loop Cutting

Sets whether any loops in a planar curve are trimmed. Looping occurs if the distance from the original curve exceeds the minimum bend radius (curvature) of the curve being offset. For example, if a curve has a 20 cm radius and you try to offset more than 20 cm inward, the offset curve crosses over itself and creates a loop. Use Circular to insert arcs at trimmed loops.



Cutting Radius

When Loop Cutting is on, the Cutting Radius value is used. If the Cutting Radius value is greater than 0, instead of getting a sharp corner at the point where the loop has been cut, you get an arc of the specified radius.



4 | Editing NURBS

Reference > Edit Curves > Attach Curves

Max Subdivision Density

Specifies the maximum number of times the offset geometry may be subdivided within the current tolerance. The default is 5, which means any single span on the curve may be subdivided up to 5 times.

Use Tolerance

If you select Global tolerance, Maya uses the Positional value you set in the Settings part of the Preferences window.

If you select Local tolerance, you can directly enter a new value that overrides the Positional tolerance value of the Preferences window.

Tolerance

Specifies the accuracy in which the offset curve is placed at a specified distance. The default is accurate to within 0.05 units. The default unit is in centimeters. Offsetting is an iterative process that continues until the current offset comes within the tolerance value or the maximum subdivision limit.

Curve Range

Complete creates the offset curve for the entire original curve.

Partial lets you create an offset curve for only part of the original curve. It creates a subCurve node you can edit to alter the offset distance after creation.

Input Curve

Lists the history node of the offset curve or isoparm. Click the arrow button next to the Input Curve name to edit the length of the curve.

Edit Curves > Attach Curves

Joins curves together at their endpoints to form a new curve.

Related topics

- ❖ "Join two curves or surfaces together (attach)" on page 110

Edit Curves > Attach Curves > □

Attach Method

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 point. This lets you break the curvature continuity at the join point.

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

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 point.

Insert Knot creates two extra knots near the join point. 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.

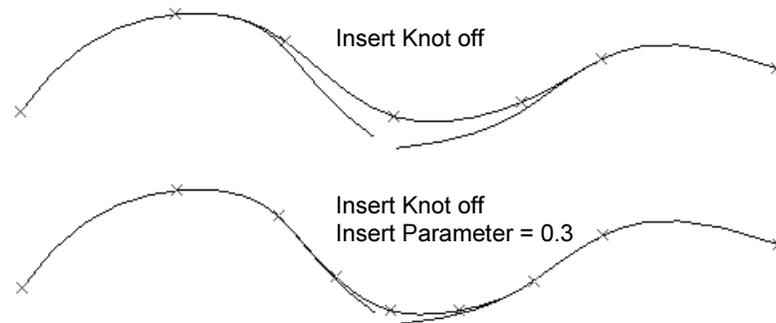
Insert Parameter

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.

4 | Editing NURBS

Reference > Edit Curves > Detach 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:

Reverse1 & 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 Curves > Detach Curves

Splits a curve into two new curves.

Related topics

❖ "Split a curve or surface (detach)" on page 111

Edit Curves > Detach Curves >

Keep Original

Retains the original curve when you detach part of it.

Edit Curves > Align Curves

Aligns the endpoints of curves.

Related topics

❖ "Align a curve with a curve or surface" on page 102

Edit Curves > Align Curves >

Attach

Joins the curves. If you turn this option on, turn Construction History off or the curve might deform oddly when you transform it.

Multiple Knots

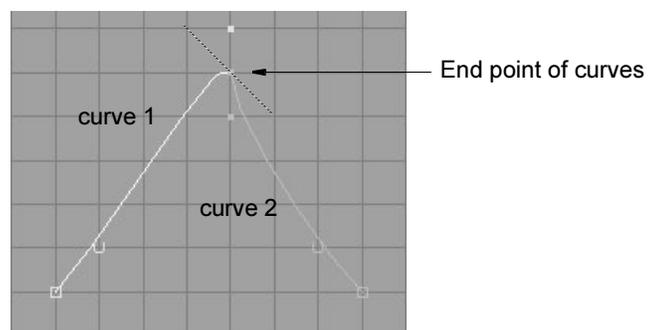
Keep creates multiple knots at the attached region, which lets you break the curvature continuity there.

Remove deletes as many knots as possible without changing the shape of the attached region.

Continuity

Position causes the two points to meet exactly.

Tangent causes the tangency at the two points to match.



Curvature causes the two points to meet with the same arch in curvature. When this option is selected, the curvature scale sliders are available.

4 | Editing NURBS

Reference > Edit Curves > Open/Close Curves

Modify Position

First moves the entire first curve to the second curve.

Second moves the entire second curve to the first curve.

Both moves both curves halfway.

Modify Boundary

First moves the selected point of the first curve to the second curve.

Second moves the selected point of the second curve to the first curve.

Both moves the selected points of both curves halfway.

Modify Tangent

First adjusts the tangent of the first curve selected.

Second adjusts the tangent of the second curve selected.

Tangent Scale

First and Second

First increases or decreases the tangent magnitude of the first curve selected.

Second increases or decreases the tangent magnitude of the second curve selected.

Curvature Scale

First and Second

First increases or decreases the curvature of the first curve selected.

Second increases or decreases the curvature of the second curve selected.

Keep Original

Retains the original curves and aligns copies of the curves.

Edit Curves > Open/Close Curves

Converts a curve between open and closed/periodic.

Related topics

- ❖ "Periodic, closed, and open" on page 17
- ❖ "Make a curve or surface open or closed" on page 119

Edit Curves > Open/Close Curves > □**Shape**

Ignore does not preserve the shape of the original curve.

Preserve adds or deletes control vertices as necessary to preserve the shape of the original curve. This is the default setting.

Blend tries to create continuity on the resulting curve. It uses the Blend Bias for the amount of smoothing.

Blend Bias

Alters the amount of continuity for the resulting curve. Large values might distort the tangency of the original curve.

Insert Knot

Inserts a knot at the join point and lets you set a value for the Insert Parameter. This option is available only if you select Blend.

Insert Parameter

Sets the amount of influence the inserted knot has on the curve shape.

Keep Original

Retains the original curve after opening or closing the curve.

Edit Curves > Move Seam

Moves the join point of a closed/periodic curve to the selected edit point.

Related topics

- ❖ "Make a curve or surface open or closed" on page 119

Edit Curves > Cut Curve

Splits curves wherever they cross a cutting curve in the view.

Related topics

- ❖ "Split a curve or surface (detach)" on page 111

Edit Curves > Cut Curve > □**Cut**

At All Intersections cuts curves at all intersecting points of selected curves.

Using Last Curve cuts only the last curve selected.

4 | Editing NURBS

Reference > Edit Curves > Intersect Curves

Keep

Longest Segments deletes all but the longest piece of each cut curve.

All Curve Segments keeps all curves after the cut.

Segments with Curve Points keeps all curve segments that have curve points selected on them. If no curve points are selected for a curve, no segments are discarded.

Keep Original

Keeps the original curves and creates new curves from the cut.

Edit Curves > Intersect Curves

Use Edit Curves > Intersect Curves to create curve point locators where two or more independent curves touch or cross one another in a view or direction. Intersect Curves is commonly used with Cut Curve, Detach Curve, and Snap to Point.

Related topics

❖ "Align a curve with a curve or surface" on page 102

Edit Curves > Intersect Curves > □

Find Intersections

In 2D and 3D creates intersection points where the curves cross one another in the active view.

In 3D Only creates intersections only where curves actually touch one another.

Use Direction

Specifies which axis or view to use to create intersection points.

X, Y, and Z create intersections along the direction of the axis chosen.

Active View create intersections in the active camera view.

Free lets you specify the axis of intersection in the Direction boxes.

Intersect

All Curves creates intersections for all selected curves.

With Last Curve Only creates intersections for only the last curve selected. Turn this on to create intersections where several curves overlap one curve.

Use Tolerance

Global uses the Positional Tolerance value in the Settings part of the Preferences window.

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

Note Several NURBS menu items provide Use Tolerance as way to increase how precisely Maya creates a curve or surface. For example, you can create a revolved surface with a preset number of sections or you can enter a low Tolerance value to create more surface sections.

Edit Curves > Insert Knot

Inserts an edit point at the selected curve point.

Related topics

- ❖ "Insert additional edit points/isoparms in a curve or surface to add more CVs" on page 111

Edit Curves > Insert Knot >

Insert Location

At Selection inserts the knot exactly at the selected curve point.

Between Selections inserts the knot halfway between a pair of selected curve points.

Multiplicity

Set to inserts an absolute number of knots according to the Multiplicity value. For example, if Multiplicity is 3 and At Selection is on, three knots will be inserted at the point whether or not it has an existing knot. Multiple knots at any position lets you create a sharp corner there.

Increase by adds extra knots to the point according to the Multiplicity value.

If you turn on Between Selections and set Multiplicity higher than 1, Maya creates multiple knots at each knot, with even spacing between the positions.

4 | Editing NURBS

Reference > Edit Curves > Reverse Curve Direction

Keep Original

Keeps the original curve in addition to creating the curve with new knots.

Tip You can drag a manipulator to reposition a new knot after you insert it. Select the Show Manipulator Tool and turn on Keep Original before using Insert Knot.

Edit Curves > Reverse Curve Direction

Reverses the direction of the selected curve(s).

Related topics

❖ "Reverse the direction of a curve or surface normals" on page 113

Edit Curves > Reverse Curve Direction >

Keep Original

Retains the original curve after the Reverse Curve operation. If you turn on Keep Original (and construction history is on), you can use the Show Manipulator Tool to click a manipulator to reverse the curve direction.

Edit Curves > Rebuild Curve

Performs various operations to transform the selected curve.

Related topics

- ❖ "Reduce the complexity of a curve or surface" on page 114
- ❖ "Control multi-knots and CV hardness" on page 115
- ❖ "Automatically add spans to areas of a curve with high curvature" on page 117
- ❖ "Convert a curve or surface to uniform parameterization" on page 117
- ❖ "Convert a surface to non-rational geometry" on page 117
- ❖ "Change a curve or surface's degree or number of spans/patches" on page 118
- ❖ "Match the topology of one curve to another" on page 120

Edit Curves > Rebuild Curve >

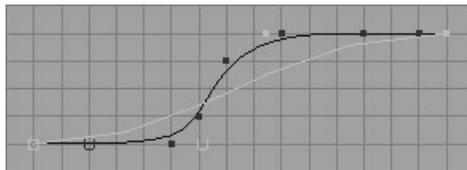
Rebuild Type

Uniform rebuilds a curve with uniform parameterization. With this option, you can change the Number of Spans and Degree of the curve.

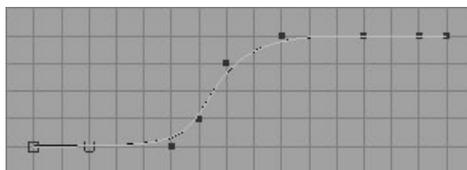
Reduce removes knots if their removal does not cause any remaining knots to move by a distance greater than the tolerance setting. A higher tolerance setting removes more knots.

Match Knots rebuilds a curve by matching the curve degree, knot values, and number of spans of another curve. Before you rebuild the curve, select the curve to be rebuilt first and Shift-select the curve to be matched. The Keep options become available when you select Match Knots.

No Multiple Knots removes any extra knots created during the rebuild operation. The curve has the same curve degree as the original. The Keep options are not available when you select this option.



Curvature inserts more knots in the areas of higher curvature. The curve is the same degree as the original. The Keep options are not available when you select this option, however, the Use Tolerance options are displayed.



End Conditions rebuilds the positioning of the curve's end CVs and knots. If you select End Conditions, two extra options appear for the End Conditions: No Multiple knots and Multiple knots.

With No Multiple Knots turned on, the rebuilt curve doesn't pass through the end CVs. This makes the curve harder to control in some cases, but makes other operations easier. For example, it's easier to create smooth joins between adjacent curves. (If you rebuild both curves with No Multiple knots, you can snap CVs together to get exact tangency across the boundary.)

4 | Editing NURBS

Reference > Edit Curves > Rebuild Curve

If you turn on Multiple Knots, the curve touches the end CVs, making it easier to control the curve boundaries and related tangency.

A curve rebuilt with End Conditions has the same degree as the original.

Parameter Range

0 to 1 sets the resulting curve's parameter range from 0 to 1.

Keep matches the rebuilt curve's parameter range to the original curve.

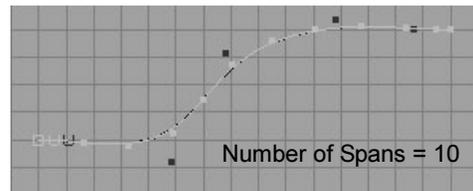
0 to # spans creates integer knot values that make numerical input easier. If you are using the Uniform Rebuild Type, 0 to # spans *always* creates integer knot values. This is useful if you'll be entering knot parameter values with curve options. For example, if you enter a knot value for the Detach Surfaces operation, it's easier to type the number 2 than a number like 0.362.

Keep

Turn on Ends, Tangents, CVs, or NumSpans if you want the rebuilt curve to have the original's end points, tangents, CVs, or number of spans. NumSpans is available only with the Uniform option.

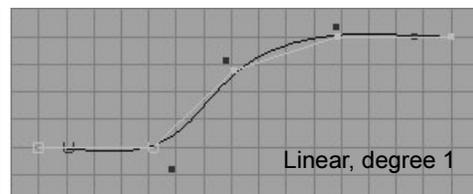
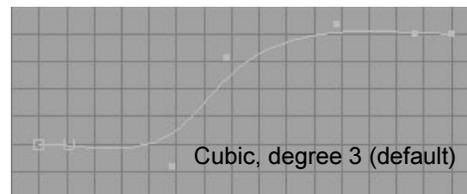
Number of Spans

Specifies the number of spans in the resulting curve.



Degree

The higher the Degree, the smoother the curve. The default setting (3 Cubic) works well for most curves.



Keep Original

Keeps the original curve and creates a new curve as the rebuilt curve. This is useful for comparing various curves with different options.

Use Tolerance

If the Rebuild Type is Reduce or Curvature, the Use Tolerance options appear in the options window. These options let you rebuild the curve within a specified tolerance of the original curve. Global uses the tolerance setting from the Maya's Preferences window. Local lets you enter a tolerance directly in the options window.

Input Curve

The Input Curve information is read-only. It gives you access to the history of the original curve you rebuilt. Click the arrow button to select the curve and open its section of the editor.

Match Curve

The Match Curve read-only information is available only if there is more than one curve and Match Knots was selected in the options window.

Edit Curves > Smooth Curve

Smooths out kinks in the selected curve(s). Select the command again to smooth more.

Related topics

- ❖ "Smooth a curve" on page 105

Edit Curves > CV Hardness

Sets the multiplicity of the selected CVs.

Related topics

- ❖ "Control multi-knots and CV hardness" on page 115

Edit Curves > CV Hardness >

Multiplicity

By default, when you create a cubic curve, the end knots have a multiplicity factor of 3 and the arcs in between have a multiplicity factor of 1.

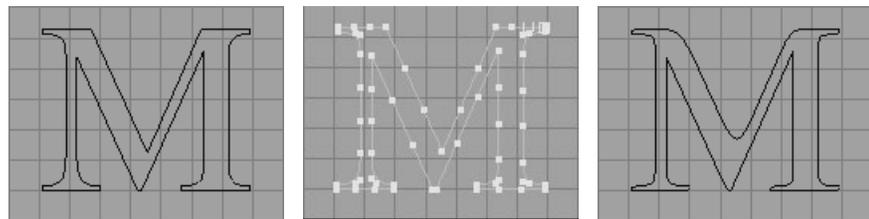
4 | Editing NURBS

Reference > Edit Curves > Curve Editing Tool

Full changes the multiplicity of the interior CVs from 1 to 3. To change a multiplicity factor from 1 to 3, there must be at least two CVs on each side of the CV being modified that have a multiplicity factor of 1.

Off changes the multiplicity of the interior CVs from 3 to 1.

The following figure shows a text object before and after using CV Hardness > with Multiplicity turned off. The text loses its hard edges.



Keep Original

Keeps the original curve after you change the multiplicity setting.

hardenPointCurve node

If you turned on Keep Original when you adjusted CV hardness, you can use the Attribute Editor to edit the CV hardness any time later. See also `hardenPointCurve`.

Input Curve

The Input Curve information is read-only. It gives you access to the history of the curve you changed. Click the arrow button to select the curve and open its section of the editor.

Multiplicity

Enter a value in the Multiplicity box, or use the slider, to specify the number of knots you want to insert when adjusting the CVs.

Edit Curves > Curve Editing Tool

Shows a manipulator on the curve you click that lets you change the position and direction at arbitrary points along the curve.

Related topics

- ❖ “Reshape a curve or surface manually” on page 99

Edit Curves > Project Tangent

Makes the end of a curve tangent or curvature continuous with another curve or surface.

Related topics

- ❖ "Align a curve with a curve or surface" on page 102

Edit Curves > Project Tangent > □

Tangent modifies the curve by projecting its tangent vector where it intersects the surface onto the tangent plane of the surface. This means that only necessary modifications are made to the start or end of the curve where it intersects the surface.

Curvature makes the curve tangent and the curvature continuous with the surface in the direction of the tangent vector. An extra manipulator is displayed on the curve to let you adjust the Curvature Scale value. (The Curvature Scale slider is also displayed in the options window when this option is selected).

Tangent Align Direction

The Tangent Align Direction options provide a convenient way to either:

- Reverse the direction of the curve's tangent vector.
- Aligns the tangent vector with the U or V parameter directions of the intersecting surface or two curves.

U and V pick the tangent you want to use for the adjustment. U is the U direction of the surface, or it's the second selected curve. V is the V direction of the surface, or it's the third selected curve.

Normal is the normal vector of the tangent plane. Select the Normal option to make a curve normal to or perpendicular to a surface or two curves. When selected, the curve is no longer tangent to the surface since it is perpendicular to the surface.

When you select Normal, it becomes the mode you are working in for the current curve modification. To return to the general project tangent operation, select either the U or V tangent align direction.

Reverse Direction

Turn Reverse Direction on or off to change the direction of the tangent vector so that it points in the opposite direction. Reverse Direction simply multiplies the current tangent scale factor by -1.0.

4 | Editing NURBS

Reference > Edit Curves > Modify Curves > Lock Length

Tangent Scale

The Tangent Scale slider displays the current tangent scale factor. Scaling the tangent adjusts the length of the tangent vector without changing its direction. A negative scale factor reverses the direction of the tangent vector.

Tangent Rotation

The Tangent Rotation slider displays the current tangent rotation angle. Adjusting the rotation rotates the tangent vector on the tangent plane defined by the surface intersection.

Tangent rotation is not available when the Tangent Align Direction is Normal. If you change the Tangent Rotation value, the curve is no longer tangent to the surface or two other curves.

Curvature Scale

Project tangent works by selecting a curve to modify then by selecting a surface or two other curves that intersect with either of its end points. The curve is modified by projecting its tangent vector where it intersects the surface onto the tangent plane of the surface.

If Curvature is selected as the construction type, the curve is made tangent and the curvature is made continuous with the surface or curves in the direction in which the tangent vector is going.

Adjusting the Curvature Scale value modifies the curve in such a way that the tangent or curvature doesn't change at the curve or surface intersection point. For example, if you modify a curve at its end point, the curvature slider moves the third CV from the end of the curve along a line that joins the end two CVs of the curve (for instance, along the tangent vector line). Such a modification doesn't change the curvature at the end of the curve, it just adjusts the tangent vector.

Keep Original

Keeps the original curve after the projection is performed.

Edit Curves > Modify Curves > Lock Length

When you select Edit Curves > Modify Curves > Lock Length, the selected curve (or selected CVs) will maintain a constant hull length. If you then modify the curve, for example, by moving a CV, the shape of the curve will adjust so that it maintains a constant hull length (that is, CVs other than the one you move will also move).

When you select Edit Curves > Modify Curves > Lock Length, a Lock Length attribute is added to the curveShape node.

Notes

- You can use the l (lower-case L) key as a momentary hotkey. Press and hold down the l key to lock the length of the selected curve. Release the l key to unlock the length of the curve.
- Lock Length is useful for modeling purposes. Because modifying a curve with Lock Length turned on behaves similar to a dynamic simulation, animating a curve in this way (with keyframes) may produce unexpected results.
- If you turn on Lock Length, move a CV and then select Undo, only the CV you moved will return to its original position.
- If you turn on Lock Length and modify the curve, the curve's first CV will not move (unless you explicitly move the first CV). For example, if you move the curve's first CV, the curve will respond differently than if you move the curve's last CV.

Related topics

- ❖ "Lock or unlock the length of a curve" on page 105
- ❖ "Edit Curves > Modify Curves > Unlock Length" on page 143

Edit Curves > Modify Curves > Unlock Length

When you select Edit Curves > Modify Curves > Unlock Length, the selected curve (or selected CVs) will no longer maintain a constant hull length. If you then modify the curve, for example, by moving a CV, the curve's hull length will not remain constant (and only the CV you move will actually move).

When you select Edit Curves > Modify Curves > Unlock Length, the curveShape's Lock Length attribute is turned off.

Related topics

- ❖ "Lock or unlock the length of a curve" on page 105
- ❖ "Edit Curves > Modify Curves > Lock Length" on page 142

Edit Curves > Modify Curves > Straighten

Makes the selected curves (or selected CVs) straighter (in the direction of the curve's first segment). The curve's first CV will maintain its original position.

Related topics

- ❖ "Straighten, smooth, curl or bend a curve" on page 106

4 | Editing NURBS

Reference > Edit Curves > Modify Curves > Smooth

Edit Curves > Modify Curves > Straighten > □

Straightness

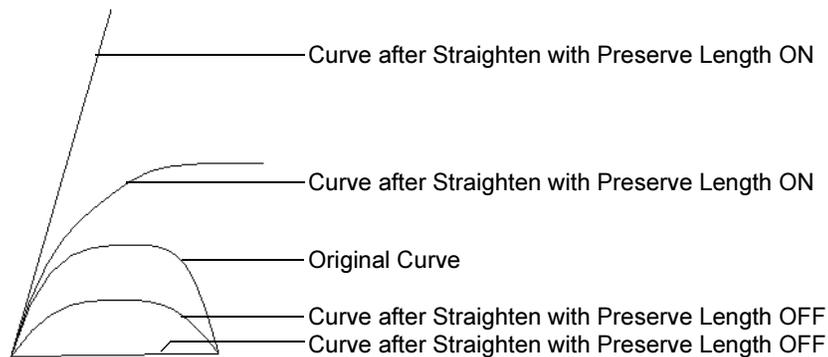
Determines how much each segment of the selected curves will be straightened. The higher the Straightness, the greater the effect. The effect will be greater on a curve with many CVs than on a curve with few CVs because the Straightness affects each segment.

When Straightness is 0, selected curves will not be straightened at all.
When Straightness is 1, selected curves will become entirely straight.
When Straightness is 2, selected curves will be flipped so they have the opposite curvature.

Preserve Length

The selected curve will remain the same length after straightening. The curve's first CV will maintain its original position, but its last CV will change position. (If you are applying Straighten to selected CVs with Preserve Length on, then some non-selected CVs may also be affected.)

If preserve Length is off, the curve's first and last CVs will both maintain their original positions.



Edit Curves > Modify Curves > Smooth

Makes the selected curves (or selected CVs) smoother. The curve's first and last CVs will maintain their original positions.

Related topics

- ❖ "Straighten, smooth, curl or bend a curve" on page 106

Edit Curves > Modify Curves > Smooth > □**Smooth Factor**

Determines how much each segment of the selected curves will be smoothed. The higher the Smooth Factor, the greater the effect. The effect will be greater on a curve with many CVs, than on a curve with few CVs, because the Smooth Factor affects each segment.

Edit Curves > Modify Curves > Curl

Makes the selected curves (or selected CVs) curly so they resemble a helix. The curve's first CV will maintain its original position.

Tip Do not apply Curl to a curve twice. The second Curl will produce poor results because it is trying to curl a curve that is already curly.

Related topics

- ❖ "Straighten, smooth, curl or bend a curve" on page 106

Edit Curves > Modify Curves > Curl > □**Curl Amount**

Determines how much each segment of the selected curves will be curled. The higher the Curl Amount, the greater the effect. The effect will be greater on a curve with many CVs than on a curve with few CVs because the Curl Amount affects each segment.

Curl Frequency

Determines how many curls the selected curves will be curled into.

Edit Curves > Modify Curves > Bend

Makes the selected curves (or selected CVs) bend in one direction. The curve's first CV will maintain its original position.

Related topics

- ❖ "Straighten, smooth, curl or bend a curve" on page 106

4 | Editing NURBS

Reference > Edit Curves > Modify Curves > Scale Curvature

Edit Curves > Modify Curves > Bend >

Bend Amount

Determines how much each segment of the selected curves will be bent. The higher the Bend Amount, the more the curve will be bent. A curve with many CVs will be bent more than a curve with few CVs because the Bend Amount affects each segment.

Twist

Controls the direction in which the selected curves will be bent.

Edit Curves > Modify Curves > Scale Curvature

Makes the selected curves (or selected CVs) straighter or exaggerates their existing curvature, depending upon the Scale Factor and Max Curvature values.

Related topics

❖ "Straighten, smooth, curl or bend a curve" on page 106

Edit Curves > Modify Curves > Scale Curvature >

Scale Factor

Determines how much each segment of the selected curves will be straightened or have their existing curvature exaggerated. The higher the Scale Factor, the greater the effect. The effect will be greater on a curve with many CVs than on a curve with few CVs because the Scale Factor affects each segment.

If Scale Factor is less than 1, the selected curves will become straighter.

If Scale Factor is greater than 1, the selected curves will have their existing curvature exaggerated (by exaggerating the curvature of each segment in the same direction as its existing curvature).

Max Curvature

Controls the maximum angle allowed between adjacent segments.

If Max Curvature is 1, then the maximum angle allowed between adjacent segments is 180 degrees. If Max Curvature is 0.5, then the maximum angle allowed between adjacent segments is 90 degrees.

Note If the selected curve already has adjacent segments with an angle greater than that allowed by the Max Curvature value, and you apply Scale Curvature with a Scale Factor greater than 1 (that is, to exaggerate the curvature of the curve), the curve may actually become straighter. This is because the Max Curvature value is reducing the angle between adjacent segments.

Edit Curves > Selection > Select Curve CVs

Selects all CVs on the selected curves.

Tip You can also access this command by pressing Ctrl + the right mouse button and choosing To CVs.

Related topics

❖ "Select curve CVs: first, last or all" on page 109

Edit Curves > Selection > Select First CV on Curve

Selects the first CV on the selected curve.

Tip You can also access this command by pressing Ctrl + the right mouse button and choosing To First CV.

Related topics

❖ "Select curve CVs: first, last or all" on page 109

Edit Curves > Selection > Select Last CV on Curve

Selects the last CV on the selected curve.

Tip You can also access this command by pressing Ctrl + the right mouse button and choosing To Last CV.

4 | Editing NURBS

Reference > Edit Curves > Selection > Cluster Curve

Related topics

- ❖ "Select curve CVs: first, last or all" on page 109

Edit Curves > Selection > Cluster Curve

Creates a cluster for each CV on the curve, for example, when building a character's back with spline IK.

Tip You can also access this command by pressing Ctrl + the right mouse button and choosing Cluster.

Related topics

- ❖ *Pose joints with spline IK curves* in the Animation book

Edit NURBS

Edit NURBS > Extend Surfaces

Extends an edge of a surface.

Related topics

- ❖ "Extend a surface" on page 108

Edit NURBS > Extend Surfaces > □

Extension Type

Tangent adds new isoparms to the extended surface.

Extrapolate rebuilds the surface according to the direction and distance specified, but without adding new isoparms.

Distance

Sets the length of extension.

Extend Side

Specifies the sides that will be extended; the start is the U0 and V0 location on the surface. This option is available in the Channel Box after you extend the surface. Select the `extendSurface` node to display the option.

Extend Direction

Specifies the U, V, or U and V directions for the extension to be built. This option is available in the Channel Box after you extend the surface. Select the `extendSurface` node to display the option.

Join to Original

You can turn off this option only when the Extend Side and Extend Direction options are not set to Both. Maya disables the selection of Both for Extend Side and Direction, and causes Extend Surfaces to create an unattached and separate surface.

Keep Original

This option causes Extend Surfaces to keep the original surface when it builds the new one. Turn this off if you prefer to discard the original surface.

Edit NURBS > Offset Surfaces

Creates a copy of the selected surface, offset a certain distance.

Related topics

- ❖ “Create an offset copy of a curve or surface” on page 112

Edit NURBS > Offset Surfaces >

Method

Surface Fit creates an offset surface that preserves the surface curvature.

CV Fit will create an offset surface that represents the offset of the CV positions along their normals.

Offset Distance

This is the distance that the new surface will be offset. Concave surfaces might produce overlapping and intersecting areas.

Edit NURBS > Selection > Select Surface Border

Selects CVs along the surface borders. The borders are defined by U and V values. By default, this operation selects CVs along all borders. In the options window for this operation, you can choose which border CVs you want to select: First U, Last U, First V, or Last V.

4 | Editing NURBS

Reference > Edit NURBS > Attach Surfaces

Edit NURBS > Attach Surfaces

Joins two surfaces together into a single surface.

Related topics

❖ "Join two curves or surfaces together (attach)" on page 110

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 Knots 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.

Edit NURBS > Attach Without Moving

Attaches the selected curves or surfaces by reshaping their ends, rather than moving the objects.

Related topics

- ❖ "Join two curves or surfaces together (attach)" on page 110
- ❖ "Edit NURBS > Attach Surfaces" on page 150

Edit NURBS > Detach Surfaces

Splits a surface into multiple surfaces at the selected isoparms.

Related topics

- ❖ "Split a curve or surface (detach)" on page 111

4 | Editing NURBS

Reference > Edit NURBS > Detach Surfaces

Edit NURBS > Detach Surfaces > □

Keep Original

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

Input Surface

The Input Surface information is read-only. It gives you access to the history of the surface you detached. Click the arrow button to select the surface and open its section of the editor.

Direction

Use the Direction pop-up menu items to specify the direction of the detachment.

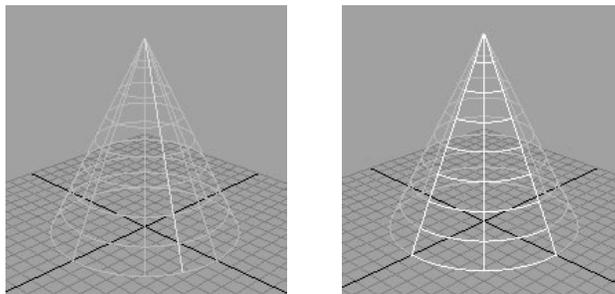
Keeping the geometry in U or V

The Keep section lets you specify whether original geometry is kept in U or V when you perform the detachment.

Changing the detach direction and position

You can change the direction of the detachment by selecting U or V from the Direction pop-up menu in the Channel Box or Attribute Editor. You can also enter a parameter value to change where the detachment occurs.

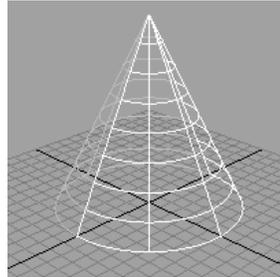
In the following figure, a V isoparm is selected, moved, then detached twice. The first detachment moves the seam of the cone, which is periodic in V.



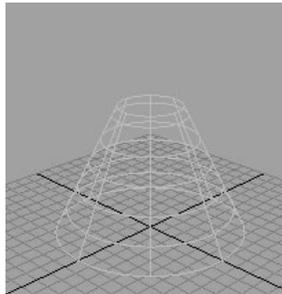
If you change the parameter value, the detachment area is increased or decreased. In the following example, the parameter value is increased to 1.5.

4 | Editing NURBS

Reference > Edit NURBS > Align Surfaces



To change the detach direction, select U from the Direction pop-up menu to detach the isoparm from a parameter value of 1.5 in the U direction.



Note that 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.

Edit NURBS > Align Surfaces

Makes the edges of surfaces tangent or curvature continuous.

Related topics

❖ "Align surface edges" on page 104

Edit NURBS > Align Surfaces > □

Attach

Select Attach if you want to attach the surfaces as well as align.

Multiple Knots

When objects are joined, Multiple Knots are created at the Join Parameter. Select Keep to retain these knots.

Select Remove to remove as many knots as possible without changing the shape of the object when the attach is performed.

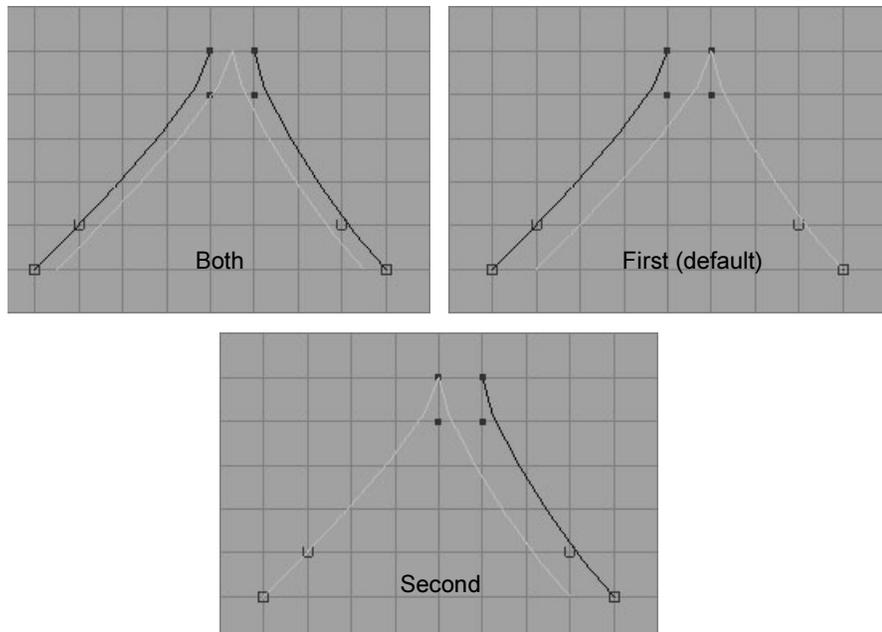
4 | Editing NURBS

Reference > Edit NURBS > Align Surfaces

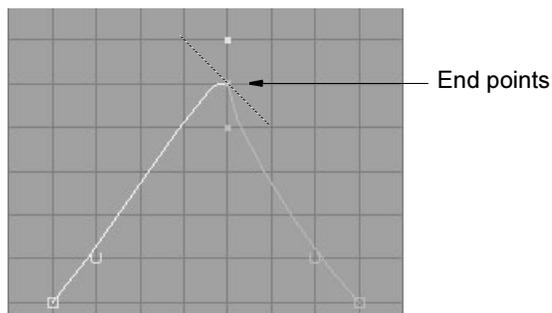
Continuity

Continuity means that two surfaces share a boundary. Continuity options let you specify how to achieve continuity for the two surfaces.

Positional continuity means that the ends of two surfaces meet exactly. The following figure shows a side view of how surfaces are aligned with each Modify Position option (First, Second, and Both). The alignment occurs depending on which surface is selected first (white) and last (green).



Tangent continuity exists when two surfaces are placed end to end, and the tangents at the endpoints also match. An example side view of aligned surfaces follows:



Curvature continuity exists when two surfaces that meet with tangent continuity also have the same curvature at the joint. When this option is selected, the curvature scale sliders are enabled.

Modify Position, Modify Boundary, Modify Tangent

You can choose the order you want the surface modified. The following tables show what is modified with the different Modify options.

Modify Position	Surfaces
<p>First Only the shape of the first surface you select is modified.</p>	<p>The entire first surface moves so its end boundary coincides with the start boundary of the second surface. Some adjustments are made to the first surface end boundary CVs.</p>
<p>Second Only the shape of the second surface you select is modified.</p>	<p>The entire second surface moves so its start boundary coincides with the end boundary of the first surface. Some adjustments are made to the second surface start boundary CVs.</p>
<p>Both The shapes of both the first and second surfaces you select are modified.</p>	<p>The entire first and second surfaces move so that the end boundary of the first surface and the start boundary of the second surface coincide. The adjacent boundary CVs move halfway along the line of minimum distance.</p>

Modify Boundary	Surfaces
<p>First Only the shape of the first surface you select is modified.</p>	<p>All the end boundary CVs of the first surface move to coincide with the adjacent start boundary CVs of the second surface.</p>
<p>Second Only the shape of the second surface you select is modified.</p>	<p>All the start boundary CVs of the second surface move to coincide with the adjacent end boundary CVs of the first surface.</p>

4 | Editing NURBS

Reference > Edit NURBS > Align Surfaces

Modify Boundary	Surfaces
<p>Both The shapes of both the first and second surfaces you select are modified.</p>	<p>All the end boundary CVs of the first surface and the start boundary CVs of the second surface move to coincide with each other. The adjacent CVs move halfway along the line of minimum distance.</p>

Modify Tangent	Surfaces
<p>First Only the shape of the first surface you select is modified.</p>	<p>The tangents at the end boundary of the first surface adjust to coincide with the tangents at the start boundary of the second surface.</p>
<p>Second Only the shape of the second surface you select is modified.</p>	<p>The tangents at the start boundary of the second surface adjust to coincide with the tangents at the end boundary of the first surface.</p>

Note Curvature continuity is applied to the surface that is modified for tangent continuity (see the table above).

Tangent Scale, Curvature Scale

The values in the Tangent Scale and Curvature Scale boxes increase or decrease the tangent magnitude or curvature at the end of the surface. You can enter a value in the box or drag the slider bar. The following table shows what happens when the tangent and curvature is scaled.

Tangent Scale	Surfaces
<p>First Only the shape of the first surface you select is scaled.</p>	<p>The tangent magnitude at the end boundary of the first surface adjusts.</p>
<p>Second Only the shape of the second surface you select is scaled.</p>	<p>The tangent magnitude at the start boundary of the second surface adjusts.</p>

Curvature Scale	Surfaces
<p>First Only the shape of the first surface you select is scaled.</p>	<p>The curvature at the end boundary of the first surface adjusts.</p>
<p>Second Only the shape of the second surface you select is scaled.</p>	<p>The curvature at the start boundary of the second surface adjusts.</p>

Keep Originals

If Keep Originals is off, the original surfaces are replaced with the aligned surfaces. If on, two new surfaces are created and the originals are retained.

Input Surface

The Input Surface information is read-only. It gives you access to the history of the surfaces you aligned. Click the arrow buttons to select an input surface and open its section of the editor.

Join Parameter

The Join Parameter slider becomes available depending on the Positional Continuity Type you select. Use Join Parameter to define the parameter on the first/second surface at which the alignment is performed.

Reverse/Swap

The Reverse and Swap options for surfaces define whether the surfaces have to be reversed and or swapped before performing the alignment (remember, align uses the end of the first surface and the start of the second). The reverse is done in the direction defined by Direction U (on or off) in the Channel Box.

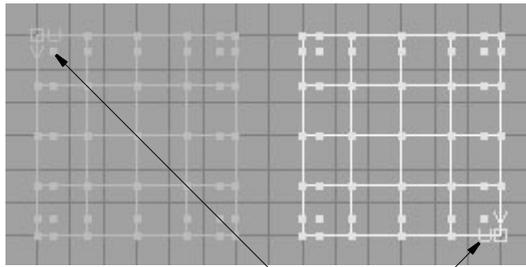
Twist

If Twist is turned on, the second surface is also reversed in the opposite direction of Direction U. Turn this on if your aligned surface is twisted.

For example, if you align the surfaces and the surface boundaries are going in different directions, the following results.

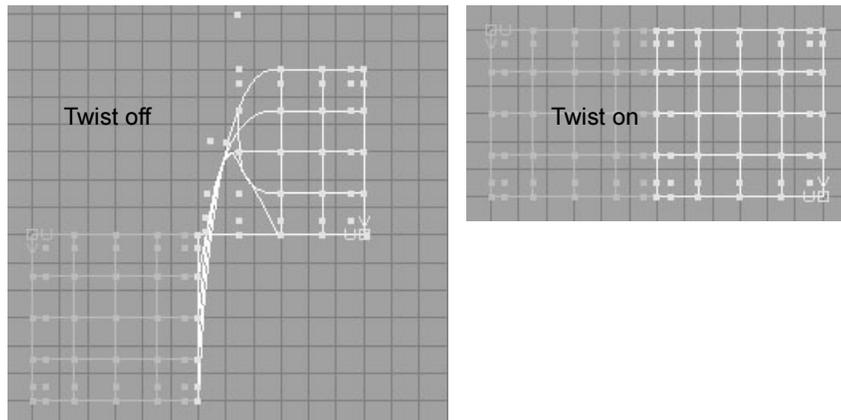
4 | Editing NURBS

Reference > Edit NURBS > Align Surfaces



Surface boundaries are not going in the same direction.

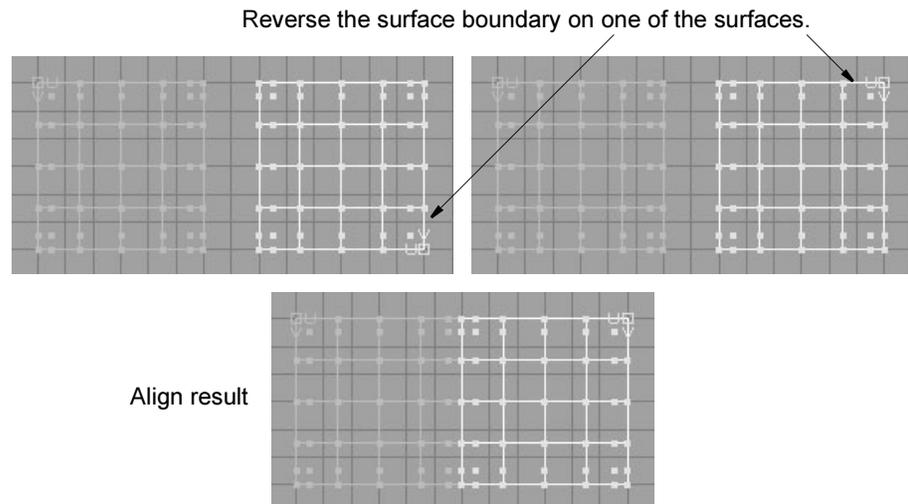
When you select the surfaces, the align result is twisted. Turn Twist on either from the Attribute Editor or in the Channel Box to correct the problem.



The other alternative is to check the surface U/V direction *before* you align the surfaces. Use Edit NURBS > Reverse Surfaces to reverse the surface directions if necessary.

4 | Editing NURBS

Reference > Edit NURBS > Open/Close Surfaces



Note Align Surfaces computes the twist values for edges, so you do not need to align surfaces then turn on the twist attribute to get a clean join.

Interior Blending

The Interior Blending sections are the same as the Tangent Scale options in the options window. The sliders become available depending on which type of continuity you select.

Edit NURBS > Open/Close Surfaces

Converts a surface between open and closed/periodic.

Related topics

❖ "Make a curve or surface open or closed" on page 119

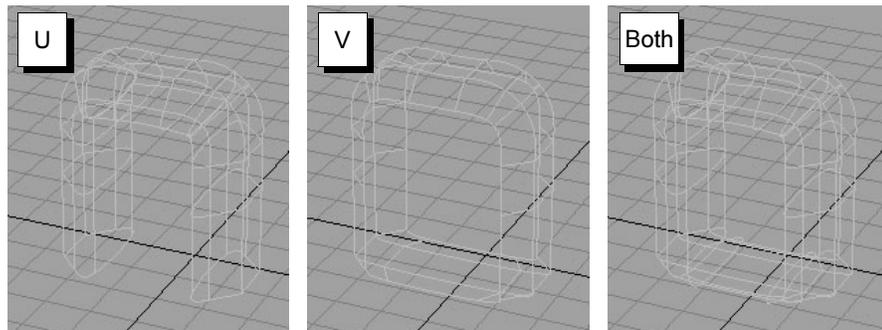
Edit NURBS > Open/Close Surfaces > □

Surface Direction

The Surface Direction options, U, V, and Both, let you choose the direction in which a surface is open or periodic. The following figure shows how these options are used to close a beveled curve.

4 | Editing NURBS

Reference > Edit NURBS > Open/Close Surfaces



Shape

Ignore does not preserve the shape of the original selection.

Preserve adds or deletes control points as necessary to preserve the shape of the original surface. This option is the default setting.

Blend tries to impose continuity on the input surfaces, using the Blend Bias setting to determine the amount of smoothing that will take place.

Note If the ends are touching and you close them with the Preserve setting on, you might get CVs that cross over each other and cause a loop in the surface when you move the CVs. In these situations, turn on the Blend setting instead.

Blend Bias

Alters the amount of continuity for the new surface; higher values may result in increased distortion of the tangency of the original surfaces.

Insert Knot

This option is available only when you select the Blend option for Shape. It inserts a knot along the join seam and lets you set a value for the Insert Parameter.

Insert Parameter

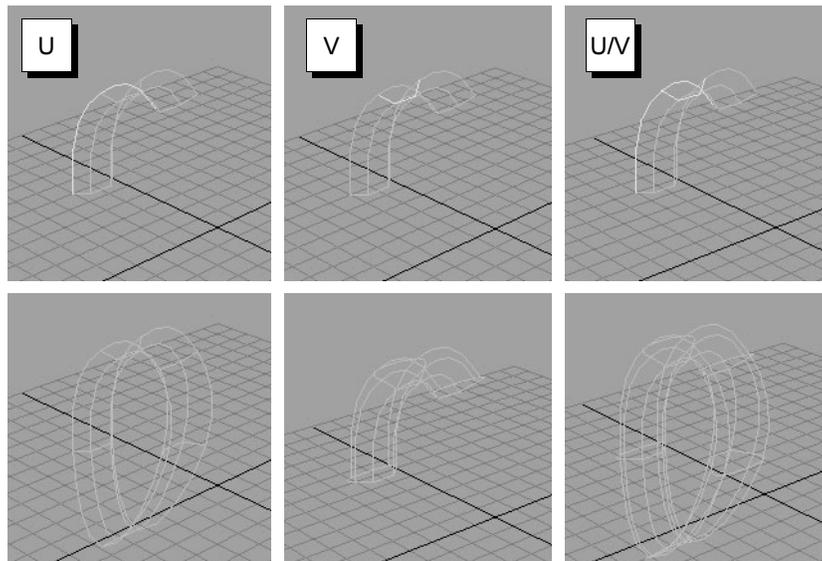
Controls the amount of influence the inserted knot has on the blended shape.

Keep Original

Sets whether the original curves or surfaces are retained after Open/Close.

Selecting an isoparm to change the periodic direction

You can select the direction in which you want the surface to be periodic from the options window, or you can click to select isoparms on the surface. When you do this, you override the Surface Direction setting in the options window.



Edit NURBS > Move Seam

Moves the seam of a closed/periodic surface to the selected isoparm.

Related topics

- ❖ "Make a curve or surface open or closed" on page 119

Edit NURBS > Insert Isoparms

Adds an edit point isoparm at the selected isoparm.

Related topics

- ❖ "Insert additional edit points/isoparms in a curve or surface to add more CVs" on page 111

4 | Editing NURBS

Reference > Edit NURBS > Insert Isoparms

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.

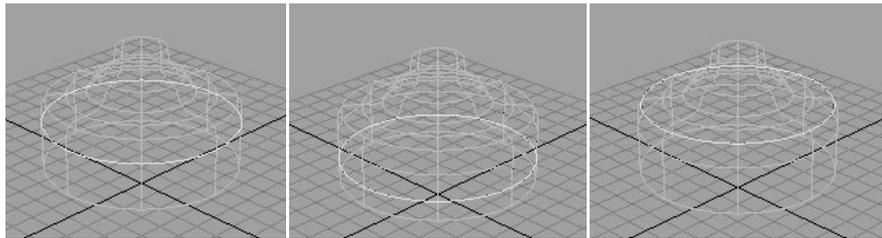
The Set to option lets you insert an absolute number of isoparms according to the Multiplicity value. For example, if Multiplicity is 3 and At Selection is turned on, three isoparms will be inserted at the position regardless of whether it already has an isoparm.

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

Keep Original

Turn on Keep Original if you want to keep the original surface in addition to the surface with new isoparms.

Tip To use a manipulator to reposition the new isoparm(s) after you insert it, turn on Keep Original. Click the Insert button in the Insert Isoparms options window, then select the Show Manipulator Tool and reposition the large yellow square. When you finish positioning the isoparm, deselect the curve.



Input Surface

This information is read-only. It shows the surface for which you inserted the isoparm. The Insert Between and Add Knots attributes affect the location of inserted knots.

Direction

This positions the isoparm in U or V.

Parameter

This sets a value that repositions the isoparm on the surface.

Number of Knots

This specifies how many isoparms you want to insert. This is the same as the Multiplicity option in the options window.

Edit NURBS > Reverse Surface Direction

Reverses or swaps the U and V directions of the selected surface.

Related topics

- ❖ "Reverse the direction of a curve or surface normals" on page 113

Edit NURBS > Reverse Surface Direction >

Surface Direction

Select U to reverse the CVs along the U parametric direction. U is the default surface direction.

Select V to reverse the CVs along the V parametric direction.

Select Swap to exchange U and V parameterization. Selecting an item a second time using the same direction restores the original CV sequence. Reversing the sequence of CVs for a surface reverses the surface normals.

Select Both to reverse the CVs and normals along both U and V parametric directions.

4 | Editing NURBS

Reference > Edit NURBS > Rebuild Surfaces

Keep Original

Turn Keep Original on to keep the original curves after reversing the surface.

Edit NURBS > Rebuild Surfaces

Performs various operations on the selected surface.

Related topics

- ❖ "Reduce the complexity of a curve or surface" on page 114
- ❖ "Control multi-knots and CV hardness" on page 115
- ❖ "Convert a curve or surface to uniform parameterization" on page 117
- ❖ "Convert a surface to non-rational geometry" on page 117
- ❖ "Change a curve or surface's degree or number of spans/patches" on page 118

Edit NURBS > Rebuild Surfaces >

Rebuild Type

The Rebuild Surface options window displays different options depending on the Rebuild Type option you select:

Uniform

Use the Uniform option to rebuild the surface with uniform parameterization. With this option, you can change the Number of Spans and Degree of the surface.

Reduce

If you select the Reduce option, Maya removes knots if their removal does not cause any remaining knots to move by a distance greater than the Tolerance setting. A higher Tolerance setting removes more knots.

Match Knots

Rebuilds a surface by matching the curve degree, knot values, and number of spans and sections of another surface. Before you rebuild the surface, select the surface to be rebuilt first and Shift-select the surface to be matched. The Keep options become available when you select Match Knots.

Setting Rebuild Method to Match can produce better quality surfaces.

No Multiple Knots

Removes any extra knots created during the rebuild operation. The resulting surface has the same curve degree as the original. The Keep options are not available when you select this option.

Non-Rational

Select Non-Rational to rebuild a rational surface into a nonrational surface. The CVs of a rational surface have weights that are not all equal to 1. The CVs of a nonrational surface all have weights equal to 1. The resulting surface has the same degree as the original surface. The Keep options are not available when you select this option.

Maya creates surfaces with all CVs weighted at 1 by default. Other software packages, especially design packages, might create surfaces with CVs not weighted at 1. The Non-Rational option is useful if you import surfaces from such packages.

The reason some design packages use weights not equal to 1 is because they allow finer surface precision. As Maya is used mainly for entertainment, extreme precision is typically not essential. If you rebuild an imported surface to have equal weighting, Maya processes your subsequent work on the surface faster, while still providing accurate precision.

End Conditions

Rebuilds the positioning of the surface's end CVs and knots. If you select End Conditions, two extra options appear for the End Conditions: No Multiple knots and Multiple knots.

With No Multiple Knots turned on, the rebuilt surface doesn't pass through the end CVs. This makes the surface harder to control in some cases, but makes other operations easier. For example, it's easier to create smooth joins between adjacent surfaces. (If you rebuild both surfaces with No Multiple knots, you can snap CVs together to get exact tangency across the boundary.)

If you turn on Multiple Knots, the surface touches the end CVs, making it easier to control the surface boundaries and related tangency.

A surface rebuilt with End Conditions has the same degree as the original.

Trim Convert

Rebuilds a single-region trimmed surface (with four boundary curves) into a non-trim surface.

4 | Editing NURBS

Reference > Edit NURBS > Rebuild Surfaces

Bezier

Rebuilds the surface as a Bezier surface. If you prefer working with Bezier surfaces rather than NURBS surfaces, consider using this option to convert the surface.

Parameter Range

The three Parameter Range options are used to specify how U and V parameters are affected during the rebuild.

Select 0 to 1 if you want the resulting surface's U and V parameters to run from 0 to 1.

Select Keep if you want the rebuilt surface's U and V parameter ranges to match those of the original surface.

Select 0 to #Spans if you want the resulting surface's spans to give you integer knot values. These values make it easier for numerical input. If using the Uniform rebuild type, this option *always* gives you integer knot values. For example, if you want to use Detach and you prefer to type a value, it is easier to enter the number 2 than something like 0.362.

Direction

The Direction options, U, V, U and V, are used to determine the parametric direction of the surface for which knots will be removed. For example, if U is selected and the rebuild type is No Multiple Knots, only the multiple knots in the U direction are removed when the surface is rebuilt. U and V is the default.

Note Performing uniform surface rebuild on a periodic surface will always rebuild the surface to uniform in both direction, regardless of the setting for the surface direction.

Keep

Rebuilding a surface may change the surface in 3D. Use the Keep options to ensure the rebuilt surface conforms to the input (or original) surface.

Turn Corners on to ensure that the corners of the new surface are at the same 3D point as the original corners. Turn on CVs to specify whether or not you want to keep the CVs of the original surface.

NumSpans gives the rebuilt surface the same number of spans as the original.

Rebuild Method

Setting Rebuild Method to Match can produce better quality surfaces, especially if the rebuild or reference surface is periodic or if either surface does not have multiple knots at the ends.

Setting Rebuild Method to Classic produces the same results as in Maya 5.0 and earlier.

Number of Spans U/V

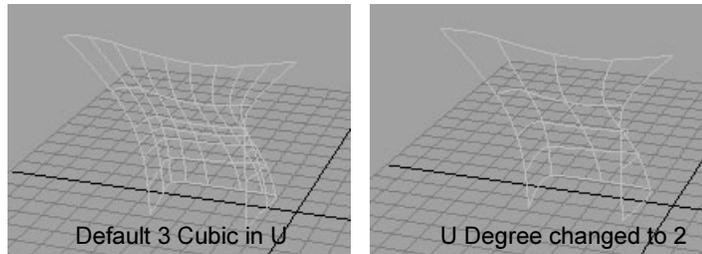
If Uniform is the rebuild type, the number of spans in the resulting surface can be set by the value you enter in the Number of Spans U/V boxes.

Degree U/V

The degree of the resulting surface is determined by the Degree U or Degree V you select.

If you turn on Original, the U/V degree of the rebuilt surface is the same as the original surface.

Note that you can turn on Degree U/V Original and Keep NumSpans to create a uniform rebuild for several surfaces that have a different number of spans.



Keep Original

Retains the original surface after it is rebuilt. If Keep Original is on, you can see the deviation of the resulting surface from the original surface.

Use Tolerance

This option is available only when you turn on Non-Rational or Reduce. It sets the longest distance between any point on the original and rebuilt surfaces. The smaller the tolerance, the more the rebuilt surface resembles the original. A small tolerance might create many patches, which slows processing time as you work with the surface.

Global uses the Positional value in the Preferences window. Local lets you enter the tolerance directly in the window.

4 | Editing NURBS

Reference > Edit NURBS > Surface Editing > Surface Editing Tool, Break Tangent, Smooth Tangent

Output Geometry

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

Input Surface

The Input Surface information is read-only. It gives you access to the history of the surfaces you rebuilt. Click the arrow buttons to select the surface, then open the appropriate section of the Attribute Editor.

Match Surface

If there is more than one surface and Match Knots was turned on when you rebuilt the surface, you can also access the Match Surface rebuilt surface.

Edit NURBS > Surface Editing > Surface Editing Tool, Break Tangent, Smooth Tangent

Attaches a manipulator to the surface you click that lets you set the position and shape at arbitrary points on the surface.

Related topics

❖ “Reshape a curve or surface manually” on page 99

Edit NURBS > Surface Editing > Surface Editing Tool >

Tangent Manip. Size

Controls the length of the tangent direction handle on the manipulator.

Edit NURBS > Selection

Grow CV Selection

Expands your CV selection in all directions around the surface.

Shrink CV Selection

Subtracts from your CV selection in all directions around the surface.

Select CV Selection Boundary

Keeps the outer CVs you have selected and deselect the inner CVs.

Select Surface Border

Selects CVs along the surface borders. The borders are defined by U and V values. By default, this operation selects CVs along all borders. In the options window for this operation, you can choose which border CVs you want to select: First U, Last U, First V, or Last V.

4 | Editing NURBS

Reference > Edit NURBS > Selection

5 Trimming

About

NURBS

Curves-on-surface

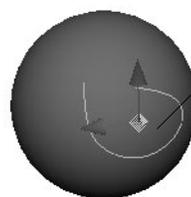
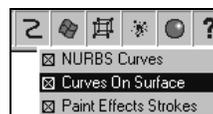
Curves-on-surface are special curves that are drawn in the UV space of a surface, rather than in the XYZ space of the scene.

You can create curves-on-surface by:

- Drawing directly on the surface. Click the magnet icon on the toolbar to make a surface “live”, then use the curve creation tools to draw a curve-on-surface directly on the surface.
- *Projecting* existing curves onto a surface.
- *Intersecting* existing geometry with a surface.

Curves-on-surface are usually used to trim surfaces, or to form an edge of new surfaces.

Curves on surface (along with their edit points) have a special Move manipulator. When you move a curve on surface, the manipulator constrains the curve on surface to the surface and allows movement across the surface in U and V.



Move curve on surface manipulator

Related topics

- ❖ “Create a curve-on-surface” on page 172
- ❖ “Trim or untrim a NURBS surface” on page 174

5 | Trimming

How do I? > Trimming

Trimming

Since NURBS surfaces are intrinsically four-sided and do not allow holes, you need a way to visually simulate irregular shapes and holes when using NURBS. The answer is *trimming*.

Trimming lets you visually cut or divide a surface along a curve-on-surface so it appears to have holes or missing pieces. The trimmed surface, however, is not actually cut. It exists in a hidden form that does not render or affect modeling. You can recover the trimmed part of a surface using the **Untrim** tool.

Creating curves-on-surface and then trimming is the most common way to combine NURBS surfaces in industrial design.

Related topics

- ❖ "Create a curve-on-surface" on page 172
- ❖ "Trim or untrim a NURBS surface" on page 174

How do I? **Create and edit models**

Trim a NURBS surface

Create a curve-on-surface

Draw a curve-on-surface directly

- 1 Select the surface on which you want to draw a curve-on-surface.
- 2 In the toolbar, 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.

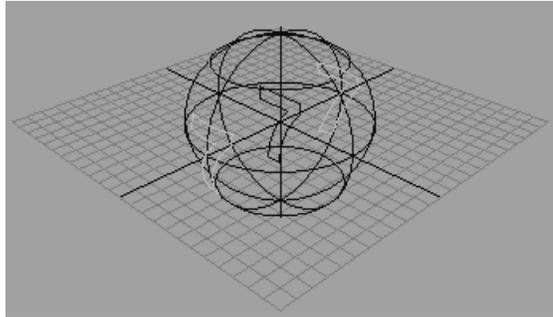
Project a curve onto a surface along the view direction

- 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.

5 | Trimming

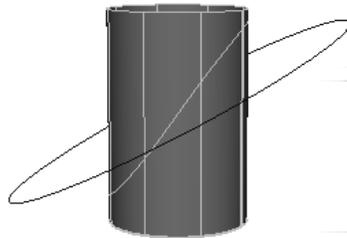
How do I? > Create a curve-on-surface

- 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.



Create curves on surface where two surfaces intersect

- 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.

Related topics

- ❖ "Trim or untrim a NURBS surface" on page 174
- ❖ "Edit NURBS > Project Curve on Surface" on page 177
- ❖ "Edit NURBS > Intersect Surfaces" on page 179

5 | Trimming

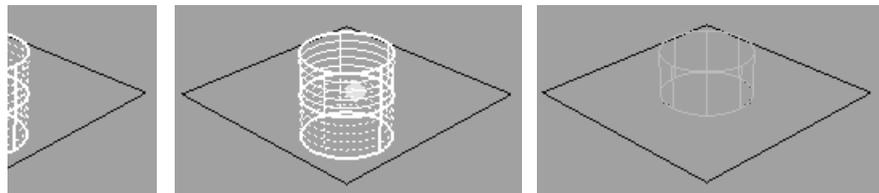
How do I? > Trim or untrim a NURBS surface

Trim or untrim a NURBS surface

Trimming removes (actually hides) any part of a surface bounded by curves-on-surface. This 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 untrim.
- 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.

Related topics

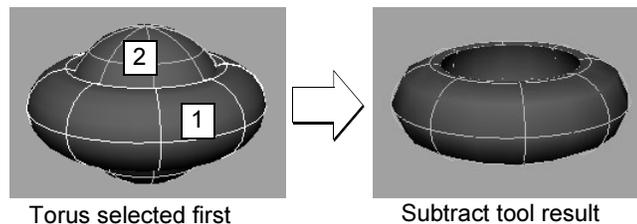
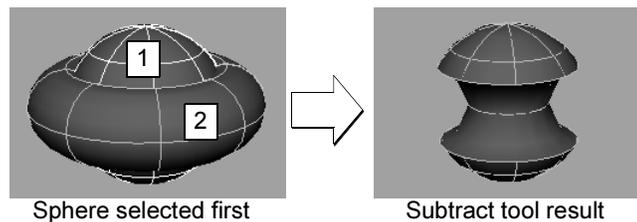
- ❖ "Trimming" on page 172
- ❖ "Create a curve-on-surface" on page 172
- ❖ "Perform boolean operations on surfaces" on page 175
- ❖ "Edit NURBS > Trim Tool" on page 180
- ❖ "Edit NURBS > Untrim Surfaces" on page 181

Perform boolean operations on surfaces

These actions trim surfaces to create the appearance of the union, intersection, or subtraction of two objects.

To perform boolean operations on surfaces

- 1 Choose an action from the Edit NURBS > Booleans submenu.
 - Union trims the surfaces so they appear to be merged.
 - Subtract trims the surfaces so that the volume of the second surface appears to be subtracted from the first.
 - Intersect 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 Subtract tool. Maya subtracts the second surface you click from the first.



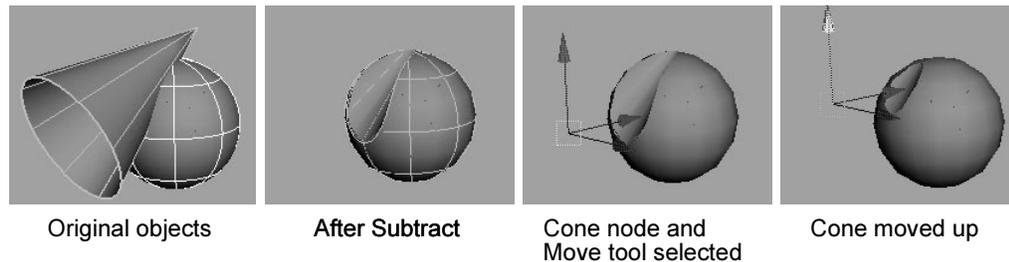
Maya groups the combined surfaces.

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

5 | Trimming

How do I? > Perform boolean operations on surfaces

- To change the Boolean operation, such as changing Subtract to Intersect, 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.



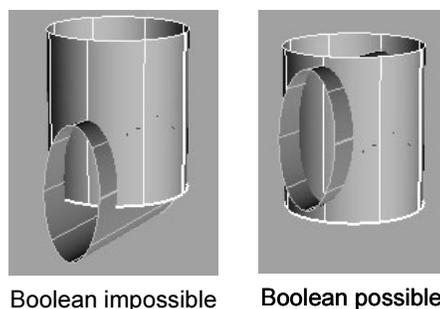
Note The only way to retrieve the original objects after a Boolean operation is to use Undo.

What if...?

I get a “node a valid NURBS shell” error?

This 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.



Related topics

- ❖ “Trim or untrim a NURBS surface” on page 174
- ❖ “Edit NURBS > Booleans > Union Tool, Subtract Tool, Intersect Tool” on page 181

Reference Menus

Modeling menu set

Edit NURBS

Edit NURBS > Project Curve on Surface

Creates curves-on-surface by projecting a 3D curve onto a surface.

Related topics

❖ "Create a curve-on-surface" on page 172

Edit NURBS > Project Curve on Surface >

Project Along

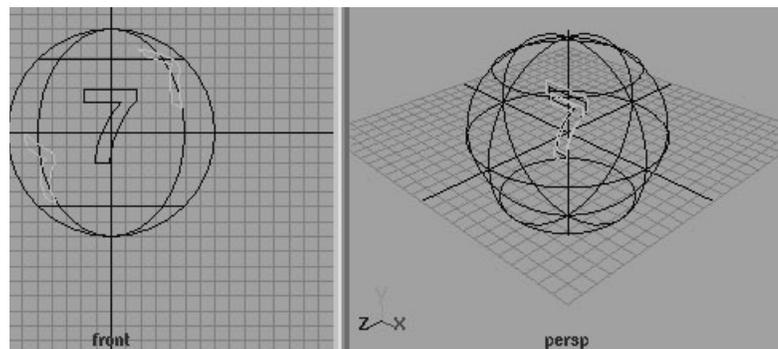
Specifies whether the projection will be normal to the active view or to the surface normal direction.

Active View, the default, means that the projection occurs in the direction of the normals in the active view. For example, if the front view is active, the curve is projected along the Z axis (the axis normal to the front view).

Making sure the projection works in the active view

If you project curves using the Active View option, you have to decide which view you want active *before* you use Project Curve On Surface. It is important to make sure the selected curve (or set of curves) is projected along the perpendicular (normal) axis of the current view.

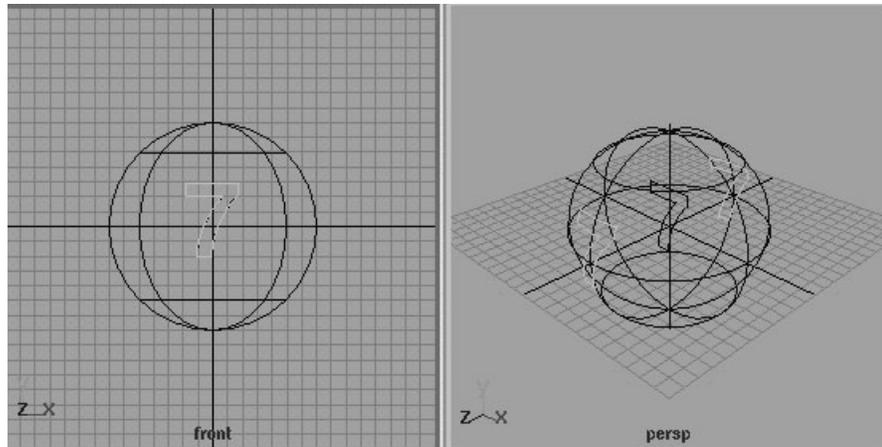
In the following figure, the projection was attempted while the perspective view was active. As you can see, the curve is not projected correctly.



5 | Trimming

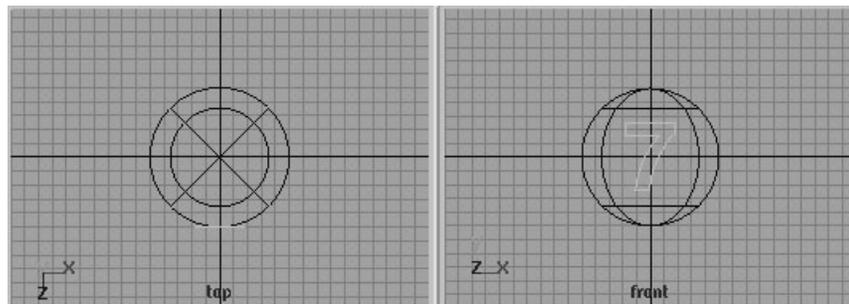
Reference > Edit NURBS > Project Curve on Surface

Projecting while the front view is active works because the perpendicular direction of the projection is relative to the surface normals of the front view.



Surface Normal lets you project a curve onto the selected surface in one view and then use the same curve to project onto additional surfaces in any other view. The active view is not important if you project while this option is selected.

If you select Surface Normal, make sure you move the curve to the outside of the surface.



The curve lies on the axis of revolution inside the surface. If the curve is inside the surface, the projection will either take a long time to complete or it will fail.

Use Tolerance

The Use Tolerance options let you project the curve within a specified tolerance of the original curve. You can apply tolerance globally or locally.

Global tolerance causes Maya to use the Positional value in the Settings part of the Preferences window.

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

Curve Range

Complete projects the entire curve onto the surface.

Partial lets you project only part of the curve onto the surface. This creates a subCurve (initially the whole curve) that can then be edited using the Show Manipulator Tool.

Editing projected curves in the Channel Box

Click the projectCurve heading in the INPUTS section of the Channel Box to display the projected curve's attributes.

Enter values in the boxes to change the X, Y, Z direction of the projection, or adjust the local tolerance value. You can type *on* to set the projection along the surface normals instead of in the active view. These options are also available in the options window and the Attribute Editor.

Note If the Project Along mode is set to Surface Normal, the Direction values in the Channel Box have no effect.

Input Surface & Input Curve

The Input Surface and Input Curve information is read-only. It gives you access to the history of the surfaces and curves you used to project the curve. Click the arrow buttons to select the surface or curve then click the tab to open its section of the editor.

Use Normal

Turn on Use Normal if you choose to project the curve along the surface normals.

Edit NURBS > Intersect Surfaces

Creates curves on surface wherever two surfaces intersect.

Related topics

❖ "Create a curve-on-surface" on page 172

Edit NURBS > Intersect Surfaces >

Create Curves for

First Surface causes only the first surface selected (the target surface) to receive a curve-on-surface.

5 | Trimming

Reference > Edit NURBS > Trim Tool

Both Surfaces causes the target surface and the surface selected as the intersecting surface to both receive curves-on-surface. This is the default.

Note If you select many surfaces, the last selected is the target surface. For example, if you select 10 surfaces, the first nine are intersected with the tenth.

Curve Type

Curve On Surface creates a curve-on-surface as the intersection curve. This is the default.

3D World creates a NURBS curve in 3D world space. The curve is not a curve-on-surface and cannot be used to trim the surface later on.

Note Text cannot be intersected with a target surface because text is a collection of curves. You cannot intersect a surface and curve. To intersect text, you must create the text as trim surfaces.

Use Tolerance

The Use Tolerance options let you intersect within a specified tolerance of the default intersection. You can apply tolerance globally or locally.

Global tolerance causes Maya to use the Positional value in the Settings part of the Preferences window.

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

Edit NURBS > Trim Tool

Hides parts of the surface defined by curves-on-surface.

Related topics

❖ "Trim or untrim a NURBS surface" on page 174

Edit NURBS > Trim Tool >

Selected State

If you want to keep the region you trimmed away, select Keep. To discard the region you trimmed away, select Discard. The default is Keep.

Shrink Surface

Causes the underlying surface to shrink to just cover the retained regions. This permanently changes the surface geometry and cannot be restored by untrimming, but Undo will still work.

Fitting Tolerance

Specifies how precisely the Trim Tool uses the shape of the curve-on-surface when it trims the surface. The default value works well in most cases, but you can use a smaller value to increase precision.

Keep Original

The original surface is retained after the trim is performed. If the surface and the curve-on-surface were created with construction history turned on, you must keep the original geometry.

Edit NURBS > Untrim Surfaces

Undoes the last trim or all trims to a surface.

Related topics

- ❖ "Trim or untrim a NURBS surface" on page 174

Edit NURBS > Untrim Surfaces > **Keep Original**

If you set Keep Original to On, the untrimmed surface is created and the original trimmed surface is retained. If you select Off, the untrimmed surface replaces the trimmed surface.

Untrim

Select All to remove all trimming information from the surface. All curves-on-surface are also redisplayed. All is the default.

Select Last to cancel the last trim operation. For example, if a surface had been trimmed three times, this option shows the result as if it had only been trimmed the first two times.

Edit NURBS > Booleans > Union Tool, Subtract Tool, Intersect Tool

Trims two surfaces to create the appearance of boolean operations.

Related topics

- ❖ "Perform boolean operations on surfaces" on page 175

5 | Trimming

Reference > Edit NURBS > Booleans > Union Tool, Subtract Tool, Intersect Tool

Edit NURBS > Booleans > Union/Subtract/Intersect Tool >

Delete Inputs

Maya can keep a construction history input from the original surfaces so you can transform them to change the resulting boolean surface. If you do not want to keep this history input, turn on Delete Inputs. Also, construction history must be turned off in the scene. If construction history is on, Maya keeps the history inputs, regardless of this option.

Tool Behavior

Exit On Completion, when turned on, takes you out of the Boolean tool after the Boolean operation is calculated. If turned off, the boolean tool remains the current tool so you can continue to perform other Boolean operations.

The Hierarchy Selection option ensures that you can successfully perform a Boolean on the result from a prior Boolean operation. When on, Maya selects and performs the Boolean operation on the root of any given hierarchy. You must turn off Hierarchy Selection if you want to perform a Boolean operation on objects that are within the same group.

6 **Stitching**

How do I? Create and edit models

Lock points or edges on NURBS surfaces together (stitching)

Automatically stitch multiple surfaces together

The global stitch action automatically stitches any of the selected surfaces together wherever their edges touch.

You can use Global Stitch to close gaps in adjacent surfaces or to prevent adjacent surfaces from splitting when deformation pulls the edges apart.

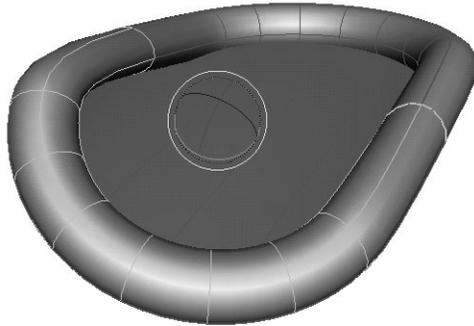
For example, if you create a human face from multiple surfaces, then use clusters and lattices to deform facial characteristics. You can prevent the surfaces from splitting apart as you deform the face with Global Stitch.

To stitch surfaces together

- 1** Model your surfaces to surface edges and corners are touching. Avoid overlapping corners with other surfaces. If necessary, you can have the surface normals face opposite directions.
- 2** Select the surfaces.
- 3** Select Edit NURBS > Stitch > Global Stitch > .
- 4** Set the options.
- 5** Click Global Stitch.

6 | Stitching

How do I? > Automatically stitch multiple surfaces together



Notes

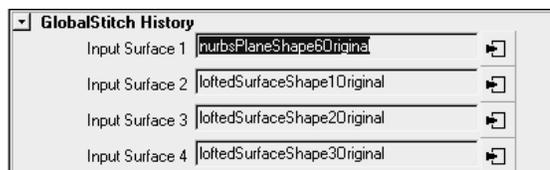
- If the surfaces to be joined have position gaps or dissimilar tangency, the stitched surface might be wavy in the stitch region.
- If the parameter range on surfaces is small, there may be problems when applying a global stitch to such surfaces.

Rebuild the surfaces to have a parameter range running from 0 to the number of spans.

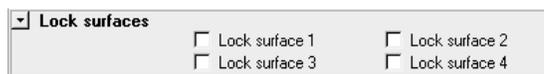
Lock a stitched surface to its original shape

You can “lock” certain surfaces so they won’t deform (the surfaces stitched to them will deform more to maintain stitching).

- 1 Make note of the name of the surface you want to lock.
- 2 Select the stitch node.
- 3 In the attribute editor, find the “input surface” number that corresponds to the surface you want to lock.



- 4 In the Lock Surfaces section, click the checkbox for the surface number you want to lock.



Related topics

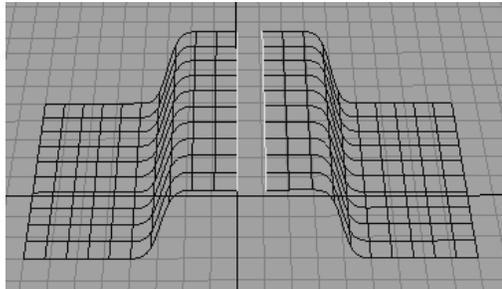
- ❖ “Manually stitch surface edges together” on page 185
- ❖ “Manually stitch surface points together” on page 186

❖ "Edit NURBS > Stitch > Global Stitch" on page 191

Manually stitch surface edges together

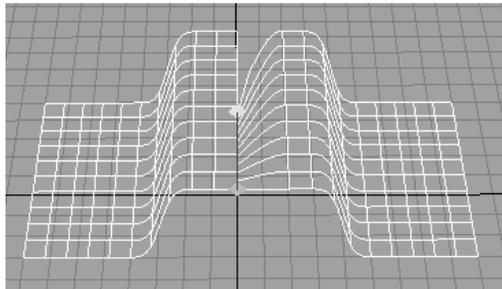
To stitch surface edges

- 1 Select Edit NURBS > Stitch > Stitch Edges Tool.
- 2 Select the edge isoparms on each surface you want to stitch together.

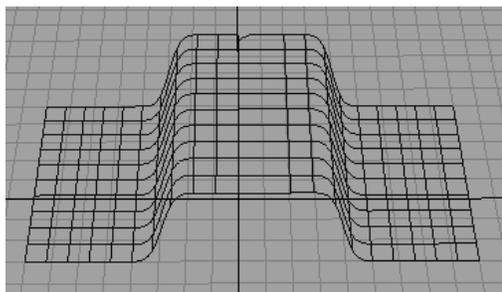


A temporary stitch surface is created.

- 3 You can drag the manipulators to edit the extent of the stitching.



- 4 Press to finish the stitch.



Related topics

❖ "Automatically stitch multiple surfaces together" on page 183

6 | Stitching

Reference > Manually stitch surface points together

- ❖ “Manually stitch surface points together” on page 186
- ❖ “Edit NURBS > Stitch > Stitch Edges Tool” on page 188

Manually stitch surface points together

To stitch surfaces together at individual points

- 1 Select the points on the first surface.
- 2 Select the points on the second surface.
- 3 Select Edit NURBS > Stitch > Stitch Surface Points.

You can control how much each surface pulls toward the stitched point on the other surface. Select the `stitchSrf` node attached to the surface you want to control. Edit the `bias` attribute to control how much the surface is pulled to the other surface. Higher values pull toward the meeting point with the other surface more. A value of 1 touch the other surface. A value of 0 means the stitching doesn't affect the surface at all.

Related topics

- ❖ “Automatically stitch multiple surfaces together” on page 183
- ❖ “Manually stitch surface edges together” on page 185
- ❖ “Edit NURBS > Stitch > Stitch Surface Points” on page 186

Reference Menus

Modeling menu set

Edit NURBS

Edit NURBS > Stitch > Stitch Surface Points

Related topics

- ❖ “Manually stitch surface points together” on page 186

Edit NURBS > Stitch > Stitch Surface Points > □**Keep Original**

If Keep Original is on, the stitch surface is created on top of the original input surfaces. This lets you move the resulting surface if you are not satisfied with the result. You can restitch a new surface with different option settings.

Assign Equal Weights

If Assign Equal Weights is on, a weighted average of the selected points is performed both in position and normal using an average NurbsSurfacePoint node.

If turned on, all the points are assigned a weight of 0.5. When turned off, the first selected point is assigned a weight of 1.0 and the rest 0. The default is on.

Cascade Stitch Node

If Cascade Stitch Node is on, the stitch operation ignores any prior stitch operations on the surface. If turned off and the surface has had a stitch operation performed on it, the stitch node from the previous operation is used. The default is on.

Input Surface

The Input Surface is a read-only attribute that lists the original object that was stitched.

Bias

Use the Bias value to blend the CVs between the input surface to the stitch node and the result from the stitch operation. A value of 0 has no effect.

Fix Boundary

You can use the Fix Boundary option only if the Cascade Stitch Nodes option and tangent continuity were on during the stitch operation.

While Maya creates tangent continuity across all four edges, the position of eight CVs might be modified (two boundary CVs next to each of the four surface corners). This might cause position discontinuity.

To prevent this, turn on Fix Boundary to ensure the eight CVs stay unmodified.

6 | Stitching

Reference > Edit NURBS > Stitch > Stitch Edges Tool

Note Other attributes displayed in the Attribute Editor depend on the type of surface points you stitched. Information on the possible attributes follows.

Setting point constraint options for stitched edit points

If you stitched edit points together, the Point Constraints options are available.

Parameter U/V

Enter values in the Parameter U and Parameter V boxes to adjust the U or V parameters of the edit points you used to stitch the surface.

Position/Normal

The Position and Normal information is read-only. These values indicate in which XYZ direction the edit points and surface normals are located.

Setting CV positions for stitched CVs

If CVs are stitched together, the Override CV Position options are available.

CV Index boxes

The CV Index boxes in the Override CV position section let you override the default position of the CVs you used to stitch a surface together.

CV Position

The CV Position values indicate in which XYZ direction the CVs are located.

Edit NURBS > Stitch > Stitch Edges Tool

Related topics

❖ “Manually stitch surface edges together” on page 185

Edit NURBS > Stitch > Stitch Edges Tool > □

Blending

Position stitches the surfaces with position continuity.

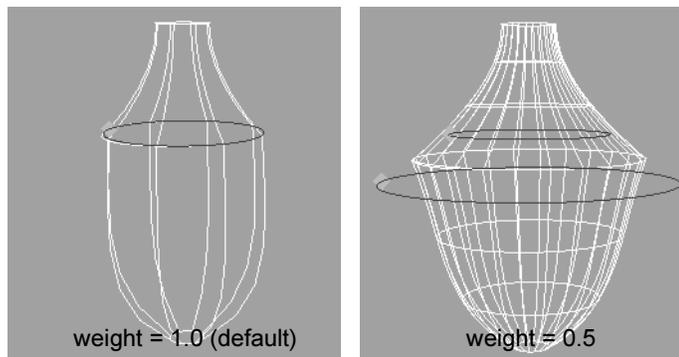
Tangent stitches the surfaces with tangent continuity.

Note The Stitch Tool does not change the number of CVs or the UV parameterization. It modifies the CV positions to have as much position and tangent continuity as possible.

Weighting on Edge

Before stitching the edges, the two selected isoparms are averaged in a weighted mode. The two surfaces are modified to meet along this averaged isoparm with tangent continuity. You can assign weights to the selected isoparms.

By default, weights of 1.0 and 0.0 are assigned to the first and second selected isoparms. In effect, this modifies the CVs on the second surface so the surface has tangent continuity with the first surface. If you assign a nonzero weight to the two selected isoparms, the CVs on both surfaces are modified to achieve tangent continuity.



You can modify the weights after creating the stitch with construction history turned on. Select the avgCurve node created during stitching, then display the Attribute Editor.

You can drag the manipulators to selectively alter the portions along the isoparms to be weighted together. These are the portions on the two surfaces that will be stitched together.

Tip To see the curve computed by the average node, select the Show Manipulator Tool on the average node. This manipulator provides a visual clue only and cannot be edited.

6 | Stitching

Reference > Edit NURBS > Stitch > Stitch Edges Tool

Samples Along Edge

The CVs for the stitched surface are determined by sampling the edge along the surface that needs to be modified for tangent continuity.

You can explicitly set Samples Along Edge to close any position gaps on the stitched surface. The higher the count, the slower the performance. This is the same as Step Count for the stitchSrf node in the Channel Box and Attribute Editor.

Cascade Stitch Node

If Cascade Stitch Node is on, the stitch operation ignores any prior stitch operations on the surface. If turned off and the surface has had a stitch operation performed on it, the stitch node from the previous operation is used. The default is on.

Keep Original

If Keep Original is on, the stitch surface is created on top of the original input surfaces. This way, you can move the resulting surface if you are not satisfied with the result and restitch a new surface with different option settings.

If off, the stitch operation replaces the surface being stitched.

Continuity

Type on or *off* in the Continuity boxes to set position or tangent continuity for the stitch surface.

Step Count

Step Count is the same as Samples Along Edge in the options window.

Bias

Use the Bias value to blend the CVs between the input surface to the stitch node and the result from the stitch operation. A value of 0 has no effect.

Fix Boundary

You can use the Fix Boundary option only if the Cascade Stitch Nodes option and tangent continuity were on during the stitch operation. While Maya creates tangent continuity across all four edges, the position of eight CVs might be modified (two boundary CVs next to each of the four surface corners). This might cause position discontinuity. To avert this, turn on Fix Boundary to ensure the eight CVs stay unmodified.

Tolerance Controls

If Toggle Tolerance is off (the default setting), the Step Count (Samples Along Edge) is used as the tolerance value. If on, you can set a specific tolerance value.

Edit NURBS > Stitch > Global Stitch

Related topics

- ❖ "Automatically stitch multiple surfaces together" on page 183

Edit NURBS > Stitch > Global Stitch > □

Stitch Corners

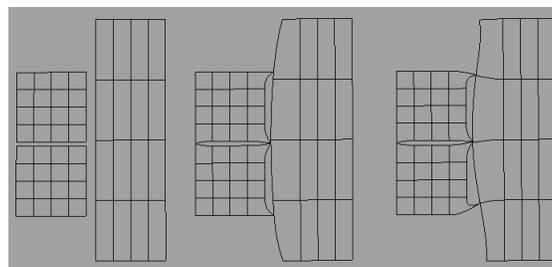
The Stitch Corners options specify where a surface corner is stitched to an adjacent corner or surface edge. Regardless of which option you choose, stitching occurs only if the points are within the Max Separation distance.

Stitching occurs at a point between two corners or between a corner and a point on the surface edge. Where a corner would stitch to a point on an edge rather than a corner, the following options are available.

Closest Point stitches a corner to the closest point on the edge.

Closest Knot stitches a corner to the closest knot on the edge.

Off does no explicit corner stitching.



Surfaces before
Global Stitch

Closest Point

Closest Knot

Stitch Edges

The Stitch Edges options specify where adjacent edges are stitched together. Regardless of which option you choose, stitching occurs only if the edges are within the Max Separation distance. Stitching occurs along an imaginary line midway between the edges.

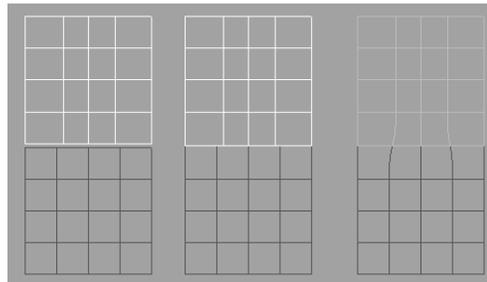
6 | Stitching

Reference > Edit NURBS > Stitch > Global Stitch

Closest Point stitches the closest points on the edges while ignoring parameterization differences between the edges. Because the number of patches may differ, an exact join might not occur.

Equal Params stitches points on the surface edges that have equivalent UV increments along each edge. The number of spans is ignored. To achieve the best possible fit with this type of stitching, make sure the two edges have the same UV values, the same number of spans, and lined-up knots.

Off does no explicit edge stitching. If you turn on one of the Stitch Corners options (other than Off) and set Stitch Edges to Off, the corners will be stitched together, but not the edges.



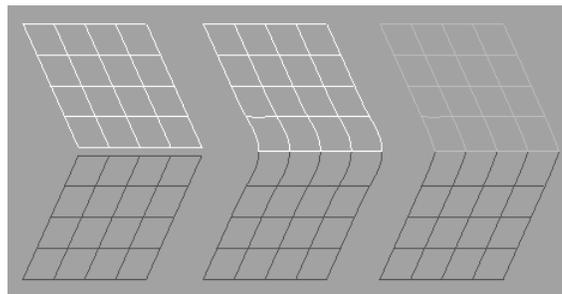
Surfaces before Global Stitch Closest Point Equal Params

Stitch Smoothness

Tangents bends isoparms so they are perpendicular where they meet the stitched edge. This yields the best continuity between the surfaces.

Normals does not require the isoparms to be perpendicular, though the surfaces still join smoothly.

Off turns off smoothing and doesn't ensure tangency of the edge regions.

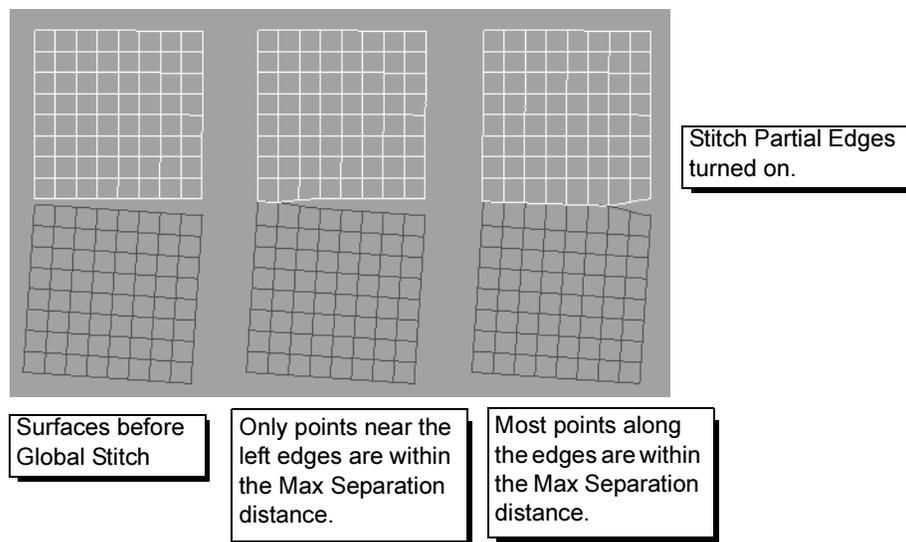


Surfaces before Global Stitch Tangents Normals

Note You can use Stitch Corners, Stitch Edges, and Stitch Smoothness in any combination to create a variety of stitching results. If Stitch Smoothness is Off but one of the Stitch Edges options is on, the edges will touch, but the stitched region between the edges might not be smooth.

Stitch Partial Edges

If this option is on, Maya joins any parts of an edge pair that are within the Max Separation distance. The same pair of edges may therefore join and separate a number of times along their length. If this option is off, no part of the edge pair will be stitched if any points along the edges exceed the Max Separation distance.



Do not turn on Stitch Partial Edges when unnecessary. This option takes extra processing time.

Max Separation

Specifies how close surface edges and corners must be for them to be stitched. High values might stitch more points than you want. Low values might cause the stitch operation to fail.

6 | Stitching

Reference > Edit NURBS > Stitch > Global Stitch

Modification Resistance

Specifies how much the surface CVs hold their positions when you stitch the surfaces. Increase this value to smooth waviness in the stitched surface. Don't increase the value too much or the surface joins might not be smooth.

Sampling Density

Sets how many points along each edge Maya samples during the stitch operation. Increasing the Sampling Density might improve the fit, but it slows the stitch operation. Start with the lowest value (1) and increase it only if the fit is poor. Values over 5 are typically unnecessary.

Lock surface *n*

The Lock Surfaces section of the Attribute Editor displays two or more attributes named Lock surface *n*. Each represents one of the surfaces stitched.

If you turn on this option for any of the surfaces, that surface doesn't change shape in the resulting stitched surface. Instead, the surface stitched to this surface is altered.

If you turn on this option for two adjacent stitched surfaces, they might appear unstitched. They're still part of the globalStitch*n* node, so you can turn off Lock surface for either surface and the stitching is displayed again.

Note After you stitch surfaces, you can move the original surfaces outside the Max Separation range without breaking the stitch. Loss of continuity and distortion might occur if you separate the surfaces too much.

If the original surfaces are far apart and you edit attributes on the globalStitch*n* node, the stitch will be recomputed based on the new positions of the surfaces. Edges formerly stitched may fail to produce results. Return surfaces to their original positions before editing attributes that specify how the surfaces are stitched.

7 The Sculpt Surfaces tool

About

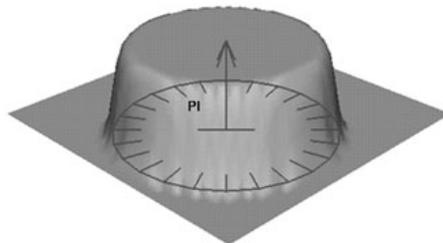
NURBS

The Sculpt Surfaces tool

Using the Sculpt Surfaces Tool, you can move CVs quickly with the stroke of a brush. You simply paint the surface with the Sculpt Surfaces Tool to push and pull CVs to achieve the shape you want.

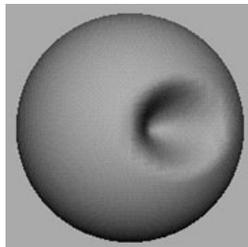
You can perform four different operations using the Sculpt Surfaces Tool: push, pull, smooth, and erase.

Push/pull

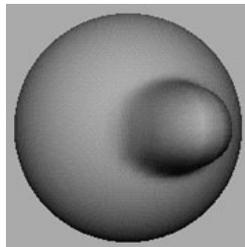


Transforming vertices using the Sculpt Surfaces Tool.

You can push or pull a surface in a configurable direction in the shape of the tool.



Push



Pull

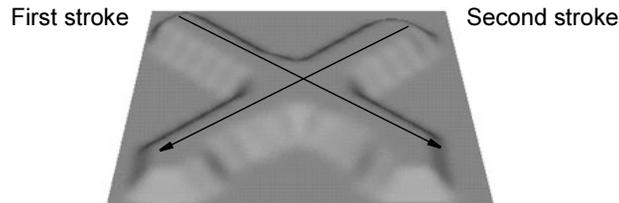
7 | The Sculpt Surfaces tool

About > The Sculpt Surfaces tool

Reference surface

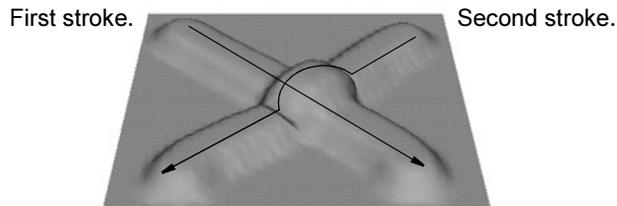
All sculpting you do pushes or pulls CVs from their initial positions on the *reference surface*. The Maximum Displacement options controls how far CVs can get from the reference surface.

In this example, the two strokes both raise the surface to the maximum displacement distance, but not beyond it.



If you update the reference surface, the current state becomes the reference, and further sculpting will displace CVs from it.

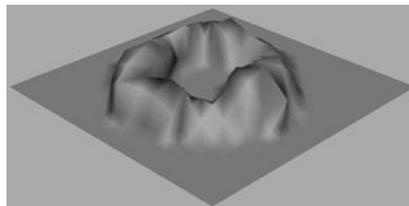
In this example, after the first stroke, the user updates the reference surface. The second stroke then applies the maximum displacement to it, going over the first stroke, which is now “baked onto” the reference surface.



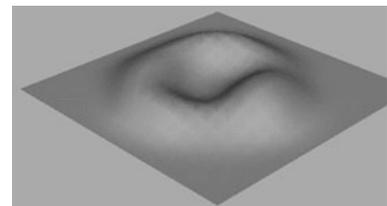
You can update the reference surface manually, or set the Update on Each Stroke option to bake each stroke onto the reference as you finish the stroke.

Smoothing

You can paint over bumps to smooth them out.



Before smoothing



After smoothing

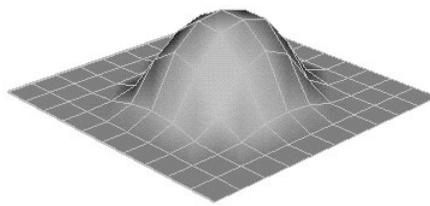
Erasing

You can save the state of a surface and then later “erase” changes to the surface back to the saved state.

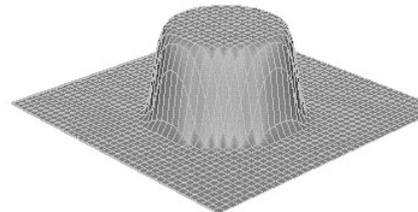
You can also turn on an option to save erase state after every stroke, which allows you to erase only the last stroke you made.

Surface density

Generally you should try to minimize the number of isoparms in your surfaces. However, when using the Sculpt tool, the more isoparms a surface has, the more precisely it deforms to the shape of the sculpting brush.



Low isoparm density



High isoparm density

Sculpting and construction history

- When you sculpt surfaces that have construction history, Maya’s performance can slow down.
- Editing the history of a surface that has been sculpted can give unexpected results.

If you don’t need to keep the history of the surface, consider deleting the history (select the surface and choose Edit > Delete by Type > History).

The Sculpt Surfaces Tool does not create construction history of its own.

Sculpting across seams and surface edges

In Maya, you can stitch two surfaces so they maintain their common edges. You can then sculpt across the surfaces and Maya will keep the seam together.

❖ “Sculpt across seams and surface edges” on page 200

7 | The Sculpt Surfaces tool

How do I? > Push or pull a surface with the Sculpt Surfaces tool

How do I? Create and edit models

Reshape NURBS surfaces with the Sculpt Surfaces tool

Push or pull a surface with the Sculpt Surfaces tool

To sculpt surfaces by pushing and pulling CVs with a brush

- 1 Select the surface, surfaces or CVs you want to sculpt.
- 2 Choose Edit NURBS > Sculpt Surfaces Tool > .
- 3 Under Operation, click Push or Pull.
- 4 Use the options under Sculpt Parameters to control how brushing pushes or pulls the surface.
- 5 Do any of the following:
 - Brush across the surface to push or pull CVs.
 - Hold b and drag left or right to change the brush radius.
 - Hold m and drag left or right to change how far the tool moves the surface.

To apply a push/pull action to the entire surface at once

- 1 In the Sculpt Surfaces option panel, set the options you want to apply to the entire surface.
- 2 Under Sculpt Parameters, click the Flood button.

Tips

- To retain control while sculpting, keep the Opacity and Max Displacement low and build up sculpting gradually.

Smooth a surface with the Sculpt Surfaces tool

To smooth surfaces with a brush

- 1 Select the surface, surfaces or CVs you want to sculpt.
- 2 Choose Edit NURBS > Sculpt Surfaces Tool > .
- 3 Under Operation, click Smooth.
- 4 Use the options under Sculpt Parameters to control how brushing smooths the surface.

7 | The Sculpt Surfaces tool

How do I? > Selectively erase back to a previous state with the Sculpt Surfaces tool

5 Do any of the following:

- Brush across the surface to push or pull CVs.
- Hold b and drag left or right to change the brush radius.
- Hold m and drag left or right to change how much the tool moves the surface as it smooths.

To apply a smooth action to the entire surface at once

- 1** In the Sculpt Surfaces option panel, set the options you want to apply to the entire surface.
- 2** Under Sculpt Parameters, click the Flood button.

Tips

- To progressively smooth a model, use the Flood button with Smooth as the selected operation, and set the opacity low.

Selectively erase back to a previous state with the Sculpt Surfaces tool

To save a state and then erase back to it

- 1** Make sure the Update on Each Stroke option next to Erase Surface (at the bottom of the Sculpt Parameters section) is off.
- 2** When you want to save the current state of a sculpted surface, click the Update button next to Erase Surface.
- 3** When you want to paint back to the saved state, set Operation to Erase.

To be able to paint out only the effects of your last stroke

- 1** Turn on the Update on Each Stroke option next to Erase Surface (at the bottom of the Sculpt Parameters section).
- 2** When you want to paint out part of the last stroke, set Operation to Erase.

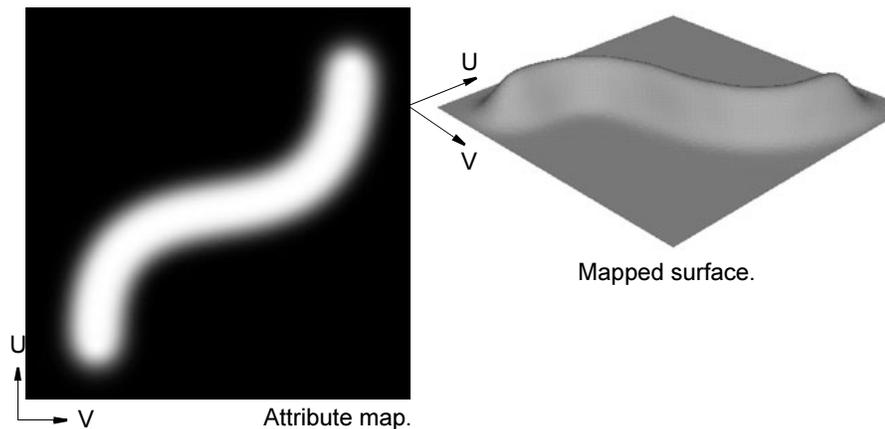
Sculpt according to an attribute map

When you import an attribute map to a surface using the Sculpt Surfaces tool, Maya applies the tool settings to the CVs, mapping the greyscale values to the Opacity value set for the tool.

In the following example, the Sculpt Surfaces Tool is set to Pull with a stroke displacement of 2.

7 | The Sculpt Surfaces tool

How do I? > Sculpt across seams and surface edges



Sculpt across seams and surface edges

Maya can keep the seam of a closed surface and common edges of adjacent surfaces (that have been stitched with Edit NURBS > Stitch > Global Stitch) together as you sculpt across them.

Keyframe sculpting changes

- 1 Select the CVs you want to keyframe.
- 2 Rewind to the first frame of the animation.
- 3 In the Preferences window (Window > Settings/Preferences > Preferences), click the Keys category and turn on Auto Key.
- 4 Set a key.
- 5 Move to the end frame of the sculpting animation.
- 6 Select the surface and choose Edit NURBS > Sculpt Surfaces Tool. Sculpt the surface into the shape you want.

The Auto Key option will set keyframes for the CVs the Sculpt Surfaces tool moves.

You can repeat this process at other frames to morph from one sculpted state to another.

Reference **Menus**

Modeling menu set

Edit NURBS

Edit NURBS > Sculpt Surfaces Tool

Use this tool to sculpt NURBS surfaces. See “How Artisan brush tools work” in the Paint Effects, Artisan, and 3D Paint guide.

Related topics

- ❖ “The Sculpt Surfaces tool” on page 195
- ❖ “Push or pull a surface with the Sculpt Surfaces tool” on page 198
- ❖ “Smooth a surface with the Sculpt Surfaces tool” on page 198
- ❖ “Selectively erase back to a previous state with the Sculpt Surfaces tool” on page 199
- ❖ “Sculpt according to an attribute map” on page 199
- ❖ “Sculpt across seams and surface edges” on page 200

Polygons > Sculpt Surfaces Tool >

Lets you specify the settings for the Sculpt Surfaces Tool in the Tool Settings editor. There are attributes unique to the Sculpt Surfaces Tool in the Sculpt Parameters sections. These unique attributes are described below. For descriptions of all other attributes in all other sections, see “Common Artisan Brush Tool Settings” in the Paint Effects, Artisan, and 3D Paint guide.

Sculpt Parameters

These are descriptions of the attributes in the Sculpt Parameters section.

Operation

Select Push, Pull, Smooth, or Erase. A letter appears within the brush stamp to reflect the operation: Ps (Push), Pl (Pull), Sm (Smooth) or E (Erase).

To remove the letters from the brush stamp, open the Sculpt Surface Tool Settings window, click the Display section, and turn off Draw Brush Feedback.

7 | The Sculpt Surfaces tool

Reference > Edit NURBS > Sculpt Surfaces Tool

Tip To select a brush operation from a marking menu, press your keyboard's u key while dragging the mouse.

Auto Smooth

If you selected Push or Pull as the brush operation, turn Auto Smooth on to smooth the surface automatically after every brush stroke.

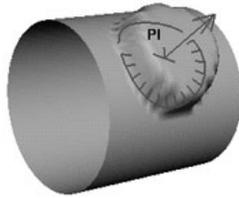
Auto Smooth Strength

Sets the number of times the Sculpt Surface Tool smooths the surface for each push, pull, or smooth stroke. Higher numbers speed the smoothing.

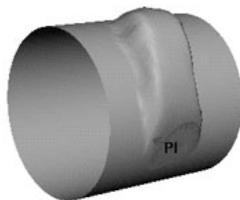
Reference Vector

The reference vector controls the direction the CVs move when you push or pull. The brush arrow represents the reference vector.

Normal moves CVs in the direction of the surface normal.



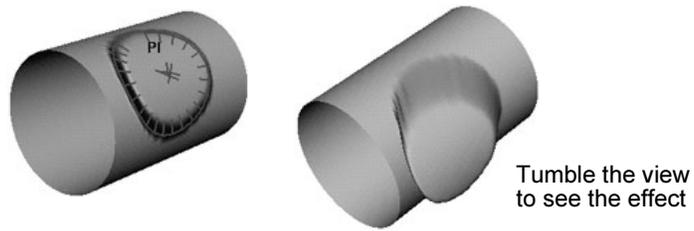
First Normal moves CVs in the surface normal direction at the beginning of the stroke.



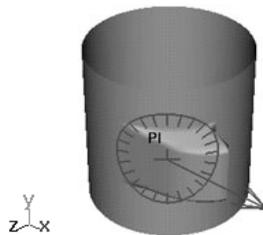
View moves CVs parallel to the camera view direction.

7 | The Sculpt Surfaces tool

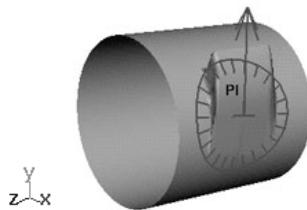
Reference > Edit NURBS > Sculpt Surfaces Tool



X Axis moves CVs in the direction of the X axis only, not the Y or Z axis.



Y Axis moves CVs in the direction of the Y axis only, not the X or Z axis.



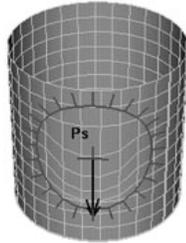
Z Axis moves CVs in the direction of the Z axis only, not the X or Y axis.



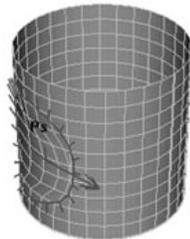
U moves CVs in the direction of the U isoparm.

7 | The Sculpt Surfaces tool

Reference > Edit NURBS > Sculpt Surfaces Tool



V moves CVs in the direction of the V isoparm.



Tip To avoid overlapping isoparms when you sculpt along the U or V isoparms, use a softer brush shape and keep the displacement small.

Max Displacement

Sets the maximum possible depth or height of the brush stroke. (The actual displacement of the brush stroke is based on how hard you press with the stylus and on the Opacity value.)

Seam/Pole Tolerance

Set how close the vertices must be along an edge, and how close the edges on the same surface must be to each other before they are detected as common. This is most commonly used to detect poles on surfaces like spheres.

Flood

Applies the Operation to all selected vertices.

When Operation is Push or Pull, Flood applies the maximum displacement to all selected vertices.

When Operation is Smooth, Flood smooths all selected vertices.

When Operation is Erase, selected vertices are restored to their last saved state.

7 | The Sculpt Surfaces tool

Reference > Edit NURBS > Sculpt Surfaces Tool

Reference Surface

Update on each stroke bakes or updates the surface automatically on each stroke. For a description of reference surfaces, see "Reference surface" on page 196. To update the reference surface manually, click Update.

Erase Surface

Update on each stroke updates the erase surface automatically on each stroke. To update the erase surface manually, click Update.

7 | The Sculpt Surfaces tool

Reference > Edit NURBS > Sculpt Surfaces Tool

8 Customization

How do I? Customize Maya

Switch NURBS operations between actions and tools

Almost all items under the Edit Curves, Surfaces, and Edit NURBS menus can be converted from actions to tools (or vice versa). You can distinguish tools from actions by the names of menu items. Tools have *Tool* in the menu entry title. Actions do not. For example, the Curve Editing Tool is a tool, but the Attach Curves menu item is an action.

If you change an action to a tool, Maya adds *Tool* to its name in the main menu and option window. If you change the tool back to an action, *Tool* is removed from the name. Regardless of whether a feature is a tool or action, the order in which you select objects or components stays the same.

You can change actions to tools throughout Maya or individually. To change the preference throughout Maya, choose Window > Settings/Preferences > Preferences. In the Categories list of the Preferences window, click Modeling, then turn on Everything is a Tool.

Afterwards, you'll notice more NURBS menu items have *Tool* in their names. To return to action-based behavior, turn on Everything is an Action in the same Preferences window.

If you turn on Mixed, a setting within each option box specifies whether the menu item is a tool or action.

To convert a single menu item from action to tool, open its options window and select Edit > As Tool. To return to action-based behavior, select Edit > As Action. If the options window doesn't have an Edit menu or the As Tool and As Action items are dim, the action (or tool) can't be converted.

The setting in the Options window takes precedence over the Preferences window. Changing from actions to tools or vice versa works immediately.

When you use an action converted to a tool, Maya sets an object and component selection mask appropriate for the tool. Maya returns to the prior selection mask after you finish using the tool.

8 | Customization

How do I? > Switch NURBS operations between actions and tools

Tool options

If you change an action to a tool, the options window for that tool displays two extra options:

- Exit Upon Completion

If this option is off, Maya's focus remains on the tool after you finish using it. You can use the tool repeatedly without selecting it again.

If this option is on, Maya exits the tool. The following menu items, when used as tools, have Exit Upon Completion as the default option.

- Edit Curves > Cut Curve Tool
- Edit Curves > Intersect Curves Tool
- Edit NURBS > Stitch > Global Stitch Tool

All other tools, including actions converted to tools, use Auto Completion as the default.

- Auto Completion

If this option is on, you don't have to press to finish a modeling task. The tool completes its task as soon as you select enough objects or components.

Numerics

- 0 to # spans
 - Rebuild Surfaces option 166
- 0 to 1 spans
 - Rebuild Surfaces option 166
- 3D text 48
- 3D World
 - Intersect Surfaces option 180

A

- actions
 - changing to tools 207
- Active View
 - Offset Curve option 126
 - Project Curve On Surface option 177
- Add Points Tool (Edit Curves menu) 126
- Align Curves (Edit Curves menu) 131
- align surfaces 104
- Align Surfaces (Edit NURBS menu) 153
- align the ends of two curves 103
- All Curves
 - Intersect Curves option 134
- Along Curve
 - Bevel Plus option 86
- Along Extrusion
 - Bevel Plus options 86
- animating
 - sculpting changes 200
- arc
 - edit 29
 - three-point, create 29
 - two-point, create 29
- Arc Tools (Create menu) 34
- As Selected
 - Boundary option 76
- As Tool
 - NURBS action or tool option 207
- Assign Equal Weights
 - Stitch Surface Points option 187
- At All Intersections
 - Cut Curve option 133
- At End
 - Bevel Plus option 83
- At Path
 - Extrude option 69
- At Profile
 - Extrude option 69
- At Start
 - Bevel Plus option 83
- Attach
 - Align Curves option 131
 - Align Surfaces option 153
- Attach Curves (Edit Curves menu) 128
- attach curves or surfaces together 110
- Attach Method
 - Attach Curves option 128
 - Attach Surfaces option 150
- Attach Surfaces
 - Bevel option 79
 - Bevel Plus option 83
- Attach Surfaces (Edit NURBS menu) 150
- Attach Without Moving (Edit NURBS menu) 151
- Attribute Editor
 - viewing loft history 64
- attribute map
 - sculpt according to 199
- Auto Anchor
 - Fillet Blend attribute 95
- Auto Closed Rail Anchor
 - Fillet Blend Tool option 94
- Auto Completion
 - Birail option 76
 - tool option 208
- Auto Normal
 - Fillet Blend Tool option 93
- Auto Normal Dir
 - Fillet Blend Tool option 92
- Auto Reverse
 - Loft option 62
- Auto Smooth
 - Sculpt Surfaces Tool 202
- Auto Smooth Strength
 - Sculpt Surfaces Tool 202
- Automatic
 - Boundary option 76

Index

- Axis
 - Extrude option 69
- axis
 - primitive, change direction of 54
 - rotate curve around to create a surface 46
- Axis Preset
 - Revolve option 57
- B**
- Bend (Modify Curves tool) 145
- Bend Amount 146
- Bevel (Surfaces menu) 79
- bevel a surface from a curve 47
- Bevel Cap
 - Bevel options 81
- Bevel Corners
 - Bevel options 81
- Bevel Depth
 - Bevel option 81
 - Bevel Plus option 83
- Bevel Plus
 - about 48
- Bevel Plus (Surfaces menu) 82
- Bevel Style
 - Bevel Plus options 84
- Bevel Width
 - Bevel option 81
 - Bevel Plus option 83
- Bezier
 - Rebuild Surfaces option 166
- Bias
 - Curve Fillet option 37
 - Freeform Fillet option 91
 - Stitch Edges Tool option 187, 190
- Birail (Surfaces menu) 73
- Birail action 43
- Blend
 - Attach Curves option 128
 - Attach Surfaces option 150
 - Curve Fillet option 36
 - Open/Close Surfaces option 160
- Blend Bias
 - Attach Curves option 129
 - Attach Surfaces option 150
 - Open/Close Curve option 133
 - Open/Close Surfaces option 160
- Blend Control
 - Curve Fillet option 36
- Blend Shape
 - Open/Close Curve option 133
- Boolean operations
 - perform on surfaces 175
- Booleans (Edit NURBS menu) 181
- Both
 - Bevel option 80
 - Reverse Surface Direction option 163
- Both Surfaces
 - Intersect Surfaces option 180
- Bottom Side
 - Bevel option 80
- Boundary (Surfaces menu) 76
- boundary curves
 - create surface from 46
 - create surface within 44
 - fillet between 52
- Break Tangent 115, 116
- brush
 - sculpt surfaces with 198
 - smooth surfaces with 198
- brush stamps
 - selecting 201
- brushes
 - stamps 201
- B-splines
 - about 11
 - fitting 37
- C**
- cap, extruded surface 43
- caps
 - bevels 81
 - for cones 56
 - for cylinders 56

Cascade Stitch Node	
Stitch Edges Tool option.....	190
Stitch Surface Points option.....	187
Chord Height	
Bevel Plus option.....	87
Chord Length	
knot spacing for Loft option.....	62
knots for CV curves.....	32
knots for edit point curves.....	33
parameterization, about.....	15
circle	
create.....	57
Circular	
Curve Fillet option.....	36
Extend Curve on Surface option.....	125
Extend Curve option.....	123
Offset Curve option.....	127
Circular Arcs	
Bevel corner option.....	81
circular fillet	
create.....	51
curve, create.....	30
Circular Fillet (Edit NURBS > Surface Fillet).....	88
Close	
Loft option.....	63
closed curves	
about.....	18
creating.....	119
closed surfaces	
about.....	19
creating.....	119
Closest End Point	
Extrude pivot option.....	70
Closest Knot (Corners)	
Global Stitch option.....	191
Closest Point (Corners)	
Global Stitch option.....	191
Closest Point (Edges)	
Global Stitch option.....	192
Cluster Curve.....	148
Common End Points	
Boundary options.....	77
Complete curve range	
Bevel.....	82
Extrude option.....	73
Offset Curve option.....	128
Planar option.....	65
Project Curve On Surface.....	179
Revolve option.....	60
complex curves.....	13
complexity, reduce for a curve or surface.....	114
Component	
Extrude pivot option.....	70
components	
curves.....	21
of surfaces.....	26
Concave	
Bevel cap option.....	81
cones	
creating.....	56
Connect	
Attach Curves option.....	128
Attach Surface option.....	150
Connect Breaks	
Offset Curve options.....	126
Construction	
Curve Fillet options.....	36
construction history	
and sculpting.....	197
Continuity	
Align Curves option.....	131
Align Surfaces options.....	154
Birail option.....	75
Stitch Edges Tool option.....	190
continuity	
about.....	20
curvature.....	13
maintain for Square operation.....	46
positional, change for stitch.....	188
tangent, change for stitch.....	188
Continuity Type	
Square options.....	78
control hull.....	22
control vertices (CVs).....	22
Convex	
Bevel cap option.....	81

Index

- copy and offset a curve or surface 112
- Corners
 - Rebuild Surfaces option, keep 166
- Create Bevel
 - Bevel Plus option 83
- Create Cap
 - Bevel Plus options 84
- Create Curve On Surface
 - Circular Fillet option 89
- Create Curves for
 - Intersect Surfaces option 179
- Create menu
 - Arc Tools 34
 - CV Curve Tool 32
 - EP Curve Tool 33
 - NURBS Primitives 53
 - Pencil Curve Tool 34
- cross knot insertion 25
- cubes
 - creating 56
- Cubic
 - Planar option 65
 - primitive sphere option 54
 - Revolve option 59
 - surface degree Extrude option 69
- cubic curves 13
- Cubic surface degree
 - Loft option 63
- Curl (Modify Curves tool) 145
- Curl Amount 145
- Curl Frequency 145
- Curvature
 - about 20
 - Align Curves option 131
 - Align Surfaces option 155
 - Project Tangent option 141
 - Rebuild Curve option 137
- curvature (G2) continuity 20
- curvature continuity 13
 - align curves with 131
 - align surfaces with 155
- curvature continuous
 - make a curve with a curve intersection 102
 - make a curve with a surface 102
 - make a curve with another curve 103
- Curvature Scale
 - Align Curves option 132
 - Align Surfaces option 156
 - Project Tangent option 142
- Curve Div per Span option 122
- Curve Editing tool
 - options 140
 - reshape curve with 100
- Curve Fillet (Edit Curves menu) 35
- Curve Fit Checkpoints
 - Square options 79
- Curve Parameters
 - Curve Fillet option 37
- Curve Range
 - Bevel options 82
 - Extrude options 73
 - Loft option 63
 - Offset Curve options 128
 - Planar options 65
 - Project Curve On Surface options 179
 - Revolve option 60
- curve segments
 - change for Arc Tools 34
- curve-on-surface
 - creating 172
 - creating with intersection 179
 - definition 171
 - extend a certain distance 107
 - extend to exact coordinates 108
 - use to create a curve 28

curves	
add spans	117
add to a lofted surface.	41
align ends	103
align with a curve or surface	102
attach	110
bounding, create surface from.	44
change degree, for edit point.	33
change degree, number of spans/patches.	118
circles.	57
closed.	18
complex.	13
convert to uniform parameterization	117
create from a surface component curve	28
create from Degree 1 curve	31
create on intersection of surfaces	173
creating trimmed surfaces	66
cubic.	13
detach	111
divisions per span	122
draw by placing CVs.	27
draw by placing edit points	27
draw freehand	28
extend a certain distance	107
extend to exact coordinates	108
extend with move CVs	107
extrude and bevel a surface from	47
fillets, create from two curves	30
fillets, trim.	35
intersecting	134
linear	13
make open or closed	119
match end points.	77
match topology	120
mathematical representations	12
multiple end knots.	32
of components	21
offset copy.	112
open	18
periodic.	18
planning for surfaces.	25
profile, used to make surfaces	40
project on surface along surface normals.	173
projecting on surface.	172
quadratic.	13
quality	24
reduce complexity	114
reshape	99
resulting, editing attributes	130
reverse normals	113
rotate around an axis to create a surface	46
seam.	18
simplest.	24
smoothing.	105
square	57
trimming.	134
uniform knot spacing	32
Curves On Surface	
Intersect Surfaces option	180
Custom	
NURBS Smoothness option	122
customizing menus to tools	207
Cut Curve	111
Cut Curve (Edit Curves menu)	133
Cutting Radius	
Offset Curve option.	127
CV Curve Tool (Create menu)	32
CV Hardness (Edit Curves menu).	139
CV Index	
Stitch Surface Points option.	188
CV Position	
Stitch Surface Points option.	188
CVs	
about	22
add more by inserting edit points/isoparms	111
add to end of curve	107
control multiplicity	115
manipulate to sculpt surfaces	198
move on a curve or surface	99
multiplicity	24
Rebuild Curve, Keep option	138
Rebuild Surfaces option, keep	166
surface component	26
use to draw a curve.	27
versus edit points	23
cylinders	
create	56

Index

D

- Degree
 - Planar option 65
 - Rebuild Curve option 138
- degree
 - about 14
 - change for Arc Tools 34
 - change for curves. 32
 - change for curves, surfaces 118
 - change for edit point curve 33
 - change for pencil curve. 34
 - of a polynomial equation 12
- Degree 1 (linear) curves 13
- Degree 2 (quadratic) curves 13
- Degree 3 (cubic) curves 13
- Degree 3 curve
 - create to match scan data 31
- degree type
 - geometry, changing. 54
- Degree U/V
 - Rebuild Surfaces option 167
- Delete Inputs
 - Booleans option 182
- density of isoparms, changing. 197
- Depth
 - Curve Fillet option. 36
 - Freeform Fillet option. 91
- Detach Curves (Edit Curves menu) 130
- detach curves or surfaces 111
- Detach Surfaces (Edit NURBS menu) 151
- Direction
 - Detach Surfaces option 152
 - Extrude option 68
 - Insert Isoparms option 163
 - Rebuild Surfaces options 166
- Direction Vector
 - Extrude option 69
- Discard
 - Trim Tool option 180
- Display menu
 - NURBS Smoothness 121
- display quality, customize 122
- Display Render Tessellation Geometry
 - NURBS Smoothness option 123
- Distance
 - Extend Curve option. 123
 - Extend Surfaces 148
 - Extrude option. 68
- divisions per span, curve 122
- drawing curves. 27
- Duplicate NURBS Patches (Edit NURBS menu) . . 87
- Duplicate Surface Curves (Edit Curves menu) . . 34

E

- edges
 - lock on surfaces (stitch) 183
 - round off meeting point between 50
 - sculpt across 200
 - use to create a curve 28
- Edit Curves menu
 - Add Points Tool 126
 - Align Curves 131
 - Attach Curves 128
 - Curve Editing Tool 140
 - Curve Fillet 35
 - customizing tools. 207
 - Cut Curve 133
 - CV Hardness 139
 - Detach Curves 130
 - Duplicate Surface Curves 34
 - Extend 123
 - Fit B-spline 37
 - Insert Knot 135
 - Intersect Curves 134
 - Move Seam 133
 - Offset 126
 - Open/Close Curves 132
 - Project Tangent 141
 - Rebuild Curve 136
 - Reverse Curve Direction 136
 - Smooth Curve 139

Edit NURBS menu	
Align Surfaces	153
Attach Surfaces	150
Attach Without Moving	151
Booleans	181
customizing tools	207
Detach Surfaces	151
Duplicate NURBS Patches	87
Extend Surfaces	148
Insert Isoparms	161
Intersect Surfaces	179
Move Seam	161
Offset Surfaces	149
Open/Close Surfaces	159
Project Curve on Surface	177
Rebuild Surfaces	164
Reverse Surface Direction	163
Round Tool	88
Sculpt Surfaces Tool	201
Selection	168
Stitch	186
Surface Editing	168
Surface Fillet > Circular Fillet	88
Surface Fillet > Fillet Blend Tool	91
Surface Fillet > Freeform Fillet	91
Trim Tool	180
Untrim Surfaces	181
edit points	
about	22
add to a curve	111
add to end of curve	107
moving	23
use to draw a curve	27
editors	
Curve Editing Tool	140
Curve Editing tool	100
Surface Editing tool	100
End Conditions	
Rebuild Curve type	137
Rebuild Surfaces option	165
End Point Tolerance	
Boundary option	78
Square options	79
end points	
match for Boundary surfaces	77
End Sweep Angle	
Revolve option	59
Ends	
Rebuild Curve, Keep option	138
EP Curve Tool (Create menu)	33
Equal Params	
Global Stitch option	192
equation for a curve	12
erase	
back to previous state	199
brush stamp	201
erase surface	
Sculpt Surfaces Tool	197
Erase Surface update	
Sculpt Surfaces Tool	205
Exit On Completion	
Birail option	76
Exit Upon Completion	
Tool option	208
extend	
curves with more CVs	107
surfaces	108
Extend Curve (Edit Curves > Extend)	123
Extend Curve At	
Extend Curve options	124
Extend Curve on Surface (Edit Curves > Extend)	125
Extend Direction	
Extend Surfaces option	149
Extend Method	
Extend Curve on Surface option	125
Extend Curve option	123
Extend Side	
Extend Surfaces option	148
Extend Surfaces	
Edit NURBS menu	148
Extension Type	
Extend Curve option	123
Extend Surfaces option	148
Extrapolate	
Extend Curve on Surface option	125
Extend Curve option	124
Extrude (Surfaces menu)	67
extrude a surface from a curve	47
Extrude action	42

Index

- Extrude Distance
 - Bevel Plus option 83
- Extrude Height
 - Bevel option 81
- Extrude Length
 - Extrude option 68
- F**
- Face Count
 - Bevel Plus option 85
- faceted surfaces 63
- fillet
 - between two surfaces 51
 - blend 52
 - circular 51
 - curve, create from two curves 30
 - for curves 35
 - freeform 51
- Fillet Blend Tool (Edit NURBS > Surface Fillet) . . 91
- Find Intersections
 - Intersect Curves option 134
- Fine display
 - NURBS Smoothness option 122
- First Normal
 - Sculpt Surfaces Tool 202
- First Rail
 - Birail Rebuild option 75
- First Surface
 - Intersect Surfaces option 179
- Fit B-spline (Edit Curves menu) 37
- Fitting tolerance
 - Trim Tool 181
- Fix Boundary
 - Stitch Edges Tool option 187, 190
- Flat
 - Extrude style option 67
- flat surfaces, create 39
- Flip Left/Right Normal
 - Fillet Blend Tool option 94
- flying logos
 - creating 48
- Free
 - change axis definition 54
 - Extrude option 69
 - Revolve option 58
- freeform
 - Curve Fillet option 36
 - drawing of a curve 28
 - fillet curve, create 31
 - fillet, create 51
- Freeform Fillet (Edit NURBS > Surface Fillet) . . . 91
- Freeform Type
 - Curve Fillet options 36
- G**
- G0, G1, G2 continuity 20
- Geometry
 - NURBS Smoothness option 122
- geometry
 - non-rational, convert to 117
- Geometry Average
 - Offset Curve option 126
- Global Stitch
 - change options 183
- Global Stitch (Edit NURBS > Stitch) 191
- Global tolerance
 - Bevel option 82
 - boundary option 78
 - Circular Fillet option 91
 - Fillet Blend option 96
 - Fit B-spline option 38
 - Freeform Fillet option 91
 - Intersect Surfaces option 180
 - Project Curve On Surface option 178
 - Revolve option 59
 - Square option 79
- Group With Original
 - Duplicate NURBS Patches option 88
 - Duplicate Surface Curves option 35
- Grow CV Selection
 - NURBS selection option 168

H

Height
 cube option 56

holes
 create by trimming 172

Hull Simplification
 NURBS Smoothness options 123
 options 123

hulls
 about 23
 control 22

I

Ignore
 Open/Close Surfaces option 160

Ignore Shape
 Open/Close Curve option 133

implicit representation 12

In 2D and 3D
 Intersect Curves option 134

In 3D Only
 Intersect Curves option 134

Increase by
 Insert Isoparms option 162
 Insert Knots option 135

Inner Bevel Style
 Bevel Plus option 84

Input Curve
 Bevel option 82
 Curve Fillet option 37
 CV Hardness option 140
 Extend Curve option 125
 Fit B-spline option 38
 Offset Curve option 128
 Rebuild Curve option 139
 Revolve option 61

Input Curves
 Loft History options 64

Input Point
 Extend Curve option 125

Input Profile/Input Rail
 Birail option 76

Input Surface
 Align Surfaces option 157
 Detach Surfaces option 152
 Insert Isoparms option 163
 Rebuild Surfaces option 168
 Stitch Surface Points option 187

Input Surface/Input Curve
 Project Curve On Surface option 179

Insert Isoparms (Edit NURBS menu) 161

Insert Knot
 Attach Curves option 129
 Attach Surfaces option 150
 Open/Close Curve option 133
 Open/Close Surfaces option 160

Insert Knot (Edit Curves menu) 135

Insert Location
 Insert Isoparms option 162
 Insert Knot options 135

Insert Parameter
 Attach Curves option 129
 Attach Surfaces option 151
 Open/Close Curve option 133
 Open/Close Surfaces option 160

Interior Blending
 Align Surfaces option 159

interpolated curves, fit 38

Intersect Curves (Edit Curves menu) 134

Intersect Surfaces (Edit NURBS menu) 179

intersection of objects 175

irregular shapes, create with trimming 172

isoparms
 add to a surface 111
 changing number 197
 definition 55
 insert 161
 surface component 26
 use to create a curve 28

J

Join
 Curve Fillet option 36

join
 curves or surfaces together 110
 smooth 13

Index

- Join Parameter
 - Align Surfaces option 157
- Join to Original
 - Extend Curve option 124
 - Extend Surfaces option 149
- K**
- Keep
 - Align Curves multiple knots option 131
 - Align Surfaces multiple knots option 153
 - Attach Curves option 129
 - Attach Surfaces multiple knots option 150
 - Cut Curve options 134
 - Rebuild Curve option 138
 - Rebuild Surfaces option 166
 - Trim Tool option 180
- Keep Original
 - Align Curves option 132
 - Align Surfaces option 157
 - Attach Curves option 130
 - Attach Surfaces option 151
 - Cut Curve options 134
 - CV Hardness option 140
 - Detach Curves option 131
 - Detach Surfaces option 152
 - Extend Curve option 125
 - Extend Surfaces option 149
 - Fillet Curve option 36
 - Insert Isoparms option 162
 - Insert Knot option 136
 - Open/Close Curve option 133
 - Open/Close Surfaces option 160
 - Project Tangent option 142
 - Rebuild Curve option 139
 - Rebuild Surfaces option 167
 - Reverse Curve Direction option 136
 - Reverse Surface Direction option 164
 - Stitch Edges Tool option 190
 - Stitch Surface Points option 187
 - Trim Tool option 181
 - Untrim Surfaces option 181
- keyframe
 - sculpting changes 200
- knot spacing
 - chord length 32
 - uniform 32
- knot values
 - integer values, Rebuild Surface 166
 - match, with Rebuild Surfaces 164
- knots
 - about 11
 - cross insertion 25
 - in fillet blends 93
 - remove in specific direction 166
- L**
- Last
 - Untrim Surfaces option 181
- Length
 - cube option 56
- Linear
 - Extend Curve on Surface option 125
 - Extend Curve option 123
 - Offset Curve option 127
 - Planar option 65
 - primitive sphere option 54
 - Revolve option 59
 - surface degree Extrude option 69
- linear curves 13
- Linear surface degree
 - Loft option 63
- Local tolerance
 - Bevel option 82
 - Boundary option 78
 - Circular Fillet option 91
 - Fillet Blend option 96
 - Fit B-spline option 38
 - Freeform Fillet option 91
 - Intersect Surfaces option 180
 - Project Curve On Surface option 179
 - Revolve option 60
 - Square option 79
- Lock Length 142
- lock points or edges on NURBS surfaces 183
- Lock surface
 - Global Stitch option 194
- Loft (Surfaces menu) 61

Loft action 40

Loop Cutting
 Offset Curve option. 127

M

Match Curve
 Rebuild Curve option 139

match end points
 for Boundary surfaces. 77

Match Knots
 Rebuild Curve option 137
 Rebuild Surfaces option 164

Match Surface
 Rebuild Surfaces option 168

Max Curvature
 Scale Curvature tool 146

Max Separation
 Global Stitch option. 193

Max Subdivision Density
 Offset Curve option. 128

Maximum Displacement
 options, about. 196
 Sculpt Surfaces Tool 204

Maya
 customizing 207

Medium display
 NURBS Smoothness option 122

menus
 creating tools from. 207

Method
 Offset Surfaces option. 149

Modification Resistance
 Global Stitch option. 194

Modify Boundary
 Align Curves option 132

Modify Position
 Align Curves option 132
 Align Surfaces option 154

Modify Tangent
 Align Curves option 132

Move Seam (Edit Curves menu) 133

Move Seam (Edit NURBS menu). 161

Multiple Knots
 about 24
 Align Curves option 131
 Align Surfaces option 153
 Attach Curves option 129
 Attach Surfaces option 150
 control 115
 CV curves option. 32
 Fillet Blend Tool option 93
 remove, with Rebuild Surface 165
 multiple spans 22

Multiplicity
 about 24
 control 115
 CV Hardness option 139
 Insert Isoparms option 162
 Insert Knot options 135

N

No Multiple Knots
 Rebuild Curve type. 137
 Rebuild Curves option 137
 Rebuild Surfaces option 165

Non Proportional
 Birail transform option. 74

Non-Rational
 Rebuild Surfaces option 165

non-rational geometry, convert to. 117

Non-Uniform Rational B-Splines
 see NURBS 13

Normal
 Global Stitch option. 192
 Project Tangent option 141
 Sculpt Surfaces Tool 202
 Stitch Surface Points option. 188

Normal Direction
 Offset Curve options. 126

normals
 about 17
 reverse direction for curves or surfaces 113
 reverse, with Circular Fillet 89
 surface, project curve along. 173

Number of Knots
 Insert Isoparms option 163

Index

- Number of Sections
 - primitive sphere option 55
 - Number of Spans
 - Rebuild Curve option 138
 - Rebuild Surfaces option 167
 - sphere primitive option 56
 - NumSpans
 - Rebuild Surfaces options 166
 - NURBS
 - about 13
 - introduction to splines 11
 - NURBS Primitives (Create menu) 53
 - NURBS Smoothness (Display menu) 121
 - NURBS Smoothness Custom Options 122
 - NURBS surface
 - see surface 39
- O**
- Object
 - pivot point option, primitives 54
 - Revolve option 58
 - Off
 - Bevel type 80
 - Offset Curve, no connection 127
 - Offset (Edit Curves menu) 126
 - offset copy of a curve or surface 112
 - Offset Curve/Curve on Surface (Edit Curves > Offset) 126
 - Offset Distance
 - Offset Curve option 126
 - Offset Surfaces option 149
 - Offset Surfaces (Edit NURBS menu) 149
 - open curves
 - about 18
 - creating trimmed surfaces from 66
 - making 119
 - open surfaces
 - making 119
 - Open/Close Curves (Edit Curves menu) 132
 - Open/Close Surfaces (Edit NURBS menu) 159
 - Operation
 - Sculpt Surfaces Tool 201
- Optional
 - Boundary option 77
 - Orientation
 - examples 71
 - Extrude options 71
 - Outer Bevel Style
 - Bevel Plus option 84
 - Output Geometry
 - Bevel option 82
 - Birail option 75
 - Extrude option 73
 - Fillet Blend Tool option 96
 - Freeform Fillet option 91
 - Loft option 64
 - Planar option 66
 - Rebuild Surfaces option 168
 - Revolve option 61
 - Square option 79
 - Output Options
 - for Bevel Plus 85
 - Override CV Position
 - Stitch Surface Points option 188
 - Override tolerance value
 - Round Tool option 88
- P**
- painting
 - out the effects of your last stroke 199
 - Parameter
 - Insert Isoparms option 163
 - Parameter Range
 - Rebuild Curve options 138
 - Rebuild Surfaces options 166
 - Parameter U/V
 - Stitch Surface Points option 188
 - parameterization
 - about 15, 25
 - convert to uniform 117
 - Loft options 62
 - uniform, for rebuild curve 137
 - parameters
 - about 14
 - Parametric Distance
 - Extend Curve on Surface option 125

parametric representations	12	positional (G0) continuity	20
Partial curve range		positional continuity	
Bevel	82	align curves with	131
Extrude option	73	align surfaces with	154
Loft options	63	change for stitch	188
Offset Curve option	128	Positional tolerance	
Planar option	65	Fillet Blend option	96
Project Curve On Surface	179	Preserve Length	144
Revolve option	60	Preserve Shape	
patches		Open/Close Curve option	133
divide by inserting isoparms	118	Open/Close Surfaces option	160
surface component	26	Preset	
use to create a surface	49	Revolve option	58
Path Direction		primitives	
Extrude orientation option	71	circle curves	57
Pencil Curve Tool (Create menu)	34	cones	56
periodic curves	18	cubes	56
periodic surfaces	19	cylinders	56
Pivot		plane	56
Extrude options	70	planes	56
Revolve option	58	spheres	54
pivot point		square curves	57
primitive	54	torus	57
Planar (Surfaces menu)	65	Profile	
Planar action	39	Birail Rebuild option	75
planes		Profile Blend Value	
create	56	Birail 2 Tool option	75
NURBS	56	profile curves	
planning for surfaces	25	skin a surface across	40
Point		sweep along a path curve	42
Extend Curve option	123	sweep along two path curves	43
Point Constraints		Profile Normal	
Stitch Surface Points option	188	Extrude option	68
points		Extrude orientation option	71
individual, stitch surfaces at	186	Project Along	
lock on surfaces (stitch)	183	Project Curve on Surface options	177
polynomial equations	12	Project Curve On Surface	
polynomial splines	11	change in Channel Box	179
Position		Project Curve on Surface (Edit NURBS menu)	177
Align Curves option	131	project tangent	
Align Surfaces option	154	edit	103
Stitch Edges Tool option	188	Project Tangent (Edit Curves menu)	141
Position/Normal		Proportional	
Stitch Surface Points	188	Birail transform option	74

Index

Pull brush stamp 201
push and pull a surface..... 195
Push brush stamp 201

Q

quadratic curves..... 13
quality curves 24

R

Radius
 Curve Fillet option..... 36
 primitive sphere option 54
 Round Tool manipulator 51
 Round Tool option 88
Rebuild
 Birail option 75
 curve tool, about 25
 Square option 79
Rebuild Curve (Edit Curves menu)..... 136
Rebuild Method 167
Rebuild Surfaces (Edit NURBS menu) 164
Rebuild Type
 Rebuild Curve option..... 137
 Rebuild Surfaces options 164
Reduce
 Rebuild Curve option..... 137
 Rebuild Surfaces option 164
Reference Srf update option..... 205
reference surface 196
 updating on each stroke 205
Remove
 Align Curves Multiple Knots option 131
 Align Surfaces Multiple Knots option 153
 Attach Curves Multiple Knots option 129
 Attach Surfaces Multiple Knots option 150
 Extend Curve Multiple Knots option 124
Required
 Boundary option 77
reshape curves or surfaces 99
Result Position
 Extrude options 69

Reverse
 Align Surfaces option 157
Reverse 1 & 2
 Attach Curves option 130
Reverse Curve
 Loft option 64
Reverse Curve Direction (Edit Curves menu).... 136
Reverse Direction
 Fillet Blend Tool option 94
 Project Tangent option 141
Reverse Normal Left/Right
 Fillet Blend Tool option 93
reverse normals for a curve or surface 113
Reverse Surface Direction (Edit NURBS menu) . 163
Reverse Surface Normals
 Circular Fillet option..... 89
revolution axis
 specify 57
Revolve (Surfaces menu) 57
ring, 3D 57
Rotation
 Extrude option..... 72
Rough Display
 NURBS Smoothness option 122
Round Tool
 Edit NURBS menu..... 88
 using 50

S

Same as Outer Style
 Bevel style option 84
Samples Along Edge
 Stitch Edges Tool option..... 190
Sampling Controls
 Bevel Plus option..... 86
Sampling Density
 Global Stitch option..... 194
Scale
 Extrude option..... 73
Scale Curvature 146
Scale Factor
 Scale Curvature tool 146

Sculpt Surfaces Tool	
about	195
erase surface	205
maximum displacement	204
options	201
sculpting	
across seams and surface edges	200
and construction history	197
and stitched surfaces	197
keyframing	200
with attribute map	199
seams	
curve	18
move	161
sculpt across	200
Second Rail	
Birail Rebuild option	75
Section Spans	
Loft option	63
Sections	
option for Arc Tools	34
Segments Revolve option	60
Segments	
Revolve option	60
Select Curve Cvs	147
Select CV Selection Boundary	
NURBS selection option	168
Select First CV on Curve	147
Select Last CV on Curve	147
Select Surface Border	
NURBS selection option	169
Select Surface Border (Edit NURBS > Selection)	149
Selected State	
Trim Tool options	180
Selection (Edit NURBS menu)	168
Set to	
Insert Isoparms option	162
Insert Knots option	135
Shape	
irregular, create with trimming	172
Open/Close Curve options	133
Open/Close Surfaces option	160
Shrink CV Selection	
NURBS selection option	168
Shrink Surface	
Trim Tool option	181
simplification, hull	123
skin a surface	40
Smooth	
Modify Curves tool	144
Smooth brush stamp	201
Smooth Curve (Edit Curves menu)	139
Smooth Factor	145
smooth joins	13
smoothing	
curves	105
Sculpt Surfaces Tool	196
spans	
add to areas of a curve	117
change number for primitives	56
change number of spans/patches	118
multiple	22
NURBS Smoothness options	122
Specify	
Extrude option	69
splines	
about	11
split curves or surfaces	111
Square (Surfaces menu)	78
Square action	46
square, create	57
Start and End Sweep Angles	
primitive sphere option	54
Start Sweep Angle	
Revolve option	59
Step Count	
Stitch Edges Tool option	190
Stitch Corners	
Global Stitch option	191
Stitch Edges	
Global Stitch	191
Stitch Edges Tool (Edit NURBS > Stitch)	188
Stitch Partial Edges	
Global Stitch option	193
Stitch Smoothness	
Global Stitch option	192
Stitch Surface Points (Edit NURBS > Stitch)	186

Index

- stitching
 - automatic 183
 - manual. 185
 - surfaces, Sculpt Surfaces Tool 197
- Straight
 - Bevel cap option. 81
 - Bevel corner option 81
- Straighten 143
- Straightness. 144
- Style
 - Extrude option 67
- subtraction of objects. 175
- Surface Degree
 - change, with Rebuild Surfaces. 167
 - Extrude options 69
 - Loft options. 63
 - primitive sphere option 54
 - Revolve options 59
- Surface Direction
 - Open/Close Surfaces option 159
 - Reverse Surface Direction option 163
- Surface Div per Span
 - NURBS Smoothness option 123
 - NURBS Smoothness options 122
- Surface Div per Span options. 122
- Surface Editing (Edit NURBS menu) 168
- Surface Editing tool 100
- Surface Normal
 - Project Curve On Surface option. 178
- surface normals
 - reversing, with Circular Fillet 89
- surface patches
 - duplicate 49
- surfaces
 - align 104
 - attach. 110
 - Boolean operations on 175
 - change degree, number of spans/patches. . . 118
 - change density 197
 - combine with trimming 172
 - components 26
 - convert to non-rational geometry 117
 - convert to uniform parameterization. 117
 - create by rotating a curve. 46
 - create flat, inside a curve 39
 - create from four boundary curves 46
 - create from patches 49
 - create within bounding curves 44
 - detach 111
 - erase with Sculpt Surfaces Tool. 197
 - extend a certain distance 108
 - extrude and bevel from a curve 47
 - faceted 63
 - fillet between intersecting 51
 - fillet between two sets of boundary curves. . . 52
 - flat plane 56
 - intersecting, create curves at 173
 - make open or closed 119
 - offset copy. 112
 - periodic and closed 19
 - planning for 25
 - push and pull the entire 198
 - push or pull parts 195
 - reduce complexity 114
 - reference 196
 - reshape 99
 - reverse normals 113
 - sculpt with a brush 198
 - skin across profile curves. 40
 - smoothing with Sculpt Surfaces Tool. 196
 - stitch and sculpt. 197
 - stitch together. 183
 - trim 174

Surfaces menu	
Bevel	79
Bevel Plus	82
Birail	73
Boundary	76
customizing tools.	207
Extrude	67
Loft.	61
Planar.	65
Revolve	57
Square	78
Swap	
Align Surfaces option	157
Reverse Surface Direction option	163
sweep	
angle, set	59
change start and end sweep angle, primitives option.	54
profile curve along a path curve	42
profile curves along two path curves	43
T	
Tangent	
Align Curves option	131
Align Surfaces option	154
Curve Fillet option.	36
Project Tangent option	141
Stitch Edges Tool options.	188
tangent	
break at an isoparm, add or remove.	115
breaking	115, 116
continuity, align curves with	131
continuity, align surfaces with	154
edit projected	103
make a curve with a curve intersection	102
make a curve with a surface.	102
make a curve with another curve	103
tangent (G1) continuity.	20
Tangent Align Direction	
Project Tangent option	141
Tangent Continuity Profile	
Birail option	76
Tangent Manip. Size	
surface editing option.	168
Tangent Rotation	
Project Tangent option	142
Tangent Scale	
Align Curves options	132
Align Surfaces options	156
Project Tangent option	142
Tangents	
Global Stitch option.	192
Rebuild Curve, Keep option	138
tessellation	
NURBS Smoothness options	123
Tessellation Method	
Bevel Plus option.	85
Three Point Circular Arc (Create > Arc Tools)	34
Tolerance	
Bevel Plus option.	84
Fit B-spline option.	38
Offset Curve option.	128
primitive sphere option	55
Revolve option.	59
Tolerance Controls	
Stitch Edges Tool.	191
Tolerance Value	
Round Tool options.	88
Tool Behavior	
Birail option	76
Booleans option	182
Fillet Blend Tool option	97
tools	
about	207
changing to actions	207
creating from menus	207
Top Side	
Bevel option	80
topology	
match from one curve to another	120
torus	
create	57
Transform Control	
Birail option	74
transition surfaces	
Fillet Blend tool	52
fillet tool	51
higher control with Bevel Plus	82
Round tool	50

Index

- Trim
 - Curve Fillets option 35
 - trim
 - curves 134
 - definition 172
 - surfaces 174
 - surfaces from open curves 66
 - Trim Convert
 - Rebuild Surfaces option 165
 - Trim Tool (Edit NURBS menu) 180
 - Tube
 - Extrude style option 67
 - Twist
 - Align Surfaces option 157
 - Twist attribute
 - Bend tool 146
 - twisted blend surface 53
 - Two Point Circular Arc (Create > Arc Tools) 34
- ## U
- U dimension of a curve 13
 - U/V
 - direction, Sculpt Surfaces Tool 203
 - patches, cube option 56
 - Project Tangent option 141
 - Reverse Surface Direction option 163
 - Uniform
 - knot spacing, Loft option 62
 - knots for CV curves 32
 - Rebuild Curve option 137
 - Rebuild Surfaces option 164
 - uniform knots
 - for edit point curves 33
 - uniform parameterization
 - about 15
 - convert to 117
 - union of objects 175
 - Unlock Length 143
 - Untrim
 - Untrim Surfaces options 181
 - untrim surfaces
 - about 174
 - cancel last trim 181
 - Untrim Surfaces (Edit NURBS menu) 181
 - Use all Surface Isoparms
 - Insert Isoparms option 162
 - Use Chord Height
 - Bevel Plus option 87
 - Use Direction
 - Intersect Curves options 134
 - Use Normal
 - Project Curve On Surface option 179
 - Use Preferences tolerance value
 - Round Tool option 88
 - Use Tolerance
 - Bevel options 82
 - Bevel Plus option 84
 - Circular Fillet option 91
 - Fillet Blend option 96
 - Fit B-Spline option 38
 - Freeform Fillet options 91
 - Intersect Surfaces option 180
 - Intersecting Curves option 135
 - Offset Curve option 128
 - Project Curve On Surface option 178
 - Rebuild Curve option 139
 - Rebuild Surfaces option 167
 - Revolve option 59
 - User Defined
 - pivot point, reposition 54
 - Using Last Curve
 - Cut Curve option 133
 - UV Point
 - Extend Curve on Surface option 125
- ## V
- View
 - Sculpt Surfaces Tool 202
 - Visible Surface Isoparms
 - Duplicate Surface Curves option 35
- ## W
- Weighting on Edge
 - Stitch Edges Tool option 189
 - Width
 - cube option 56

With Last Curve Only
Intersect Curves option. 134

X

XYZ Axis
Sculpt Surfaces Tool 203

Index

NURBS Modeling
228