

## 5.3.1 Modeling - Curves - Introduction

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### Curves

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### Introduction



Bird logo made from Bezier curves.

Curves and *Surfaces* are particular types of Blender Objects. They are expressed by mathematical functions rather than a series of points.

Blender offers both Bezier Curves and Non-Uniform Rational B-Splines (NURBS). Both Bezier curves and NURBS curves and surfaces are defined in terms of a set of “control points” (or “control vertices”) which define a “control polygon”.

Both bezier and NURBS curves are named after their mathematical definitions, and choosing between them is often more a matter of how they are computed behind the scenes than how they appear from a modeler’s perspective. Bezier curves are generally more intuitive because they start and end at the control points that you set, but NURBS curves are more efficient for the computer to calculate when there are many twists and turns in a curve.

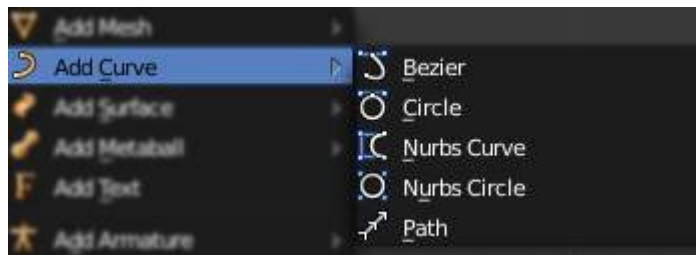
The main advantage to using curves instead of polygonal meshes is that curves are defined by less data and so can produce results using less memory and storage space at modeling time. However, this procedural approach to surfaces can increase demands at render time.

Certain modeling techniques, such as *extruding a profile along a path*, are possible only using curves. On the other hand, when using curves, vertex-level control is more difficult and if fine control is necessary, *mesh editing* may be a better modeling option.

Bezier curves are the most commonly used curves for designing letters or logos. They are also widely used in

animation, both as *paths* for objects to move along and as *F-curves* to change the properties of objects as a function of time.

## Curve Primitives



Add Curve menu.

In Object mode, the *Add Curve* menu, Blender provides five different curve primitives:

### Bezier Curve

Adds an open 2D Bezier curve with two control points.

### Bezier Circle

Adds a closed, circle-shaped 2D Bezier curve (made of four control points).

### NURBS Curve

Adds an open 2D NURBS curve, with four control points, with *Uniform* knots.

### NURBS Circle

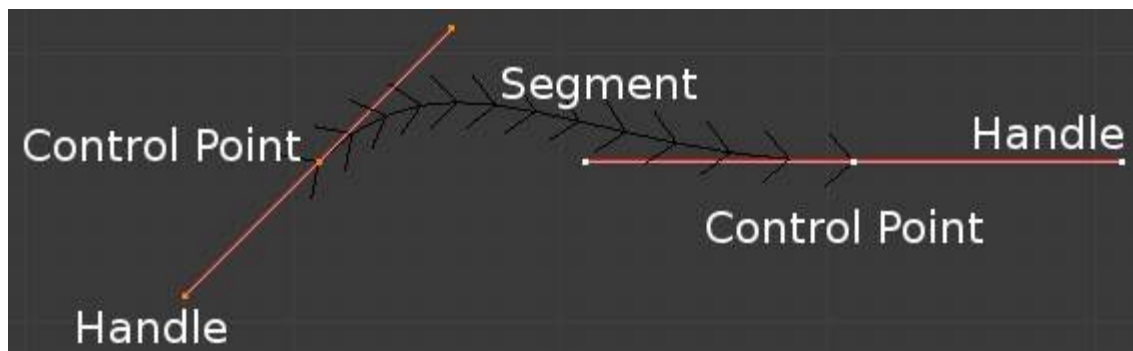
Adds a closed, circle-shaped 2D NURBS curve (made of eight control points).

### Path

Adds a NURBS open 3D curve made of five aligned control points, with *Endpoint* knots and the *CurvePath* setting enabled.

## Bezier Curves

The main elements used in editing Bezier Curves are the Control Points and Handles. A Segment (the actual Curve) is found between two Control Points. In the image below, the Control Points can be found in the middle of the pink line while the Handles comprise the extensions from the Control Point. By default the arrows on the Segment represents the direction and **relative** speed and direction of movement Objects will have when moving along the curve. This can be altered by defining a custom *Speed* Ipo.



Bezier Curve in Edit mode.

## Editing Bezier Curves

A Bezier curve can be edited by moving the locations of the Control Points and Handles.

- Add a Curve by **Shift - A** to bring up the *Add* menu, followed by Curve ▸ Bezier.
- Press **Tab** to enter *Edit mode*.
- Select one of the Control Points and move it around. Use **LMB** to confirm the new location of the Control Point, or use **RMB** to cancel.
- Now select one of the Handles and move it around. Notice how this changes the curvature of the curve.

To add more Control Points

- Select at least two adjacent Control Points.
- Press **W** and select *Subdivide*.
- Optionally, you can press **F6** immediately after the subdivision to modify the number of subdivisions.

Note that while in *Edit mode* you cannot directly select a Segment. To do so, select all of the Control Points that make up the Segment you want to move.

There are four Bezier curve handle types. They can be accessed by pressing **V** and selecting from the list that appears, or by pressing the appropriate hotkey combination. Handles can be rotated, moved, scaled and shrunk/fattened like any vertex in a mesh.

## Bezier Curve Handle Types

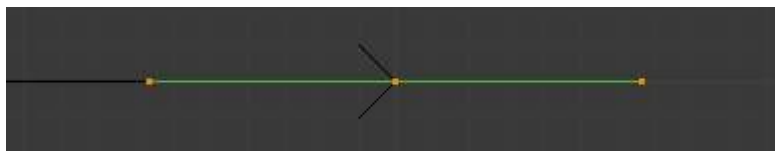
### Automatic V - A

This handle has a completely automatic length and direction which is set by Blender to ensure the smoothest result. These handles convert to *Aligned* handles when moved.



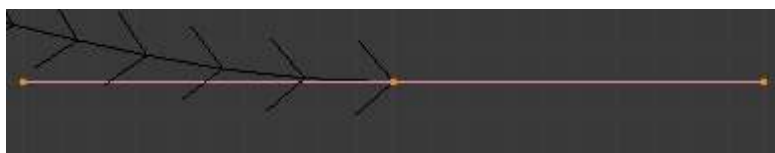
### Vector V - V

Both parts of a handle always point to the previous handle or the next handle which allows you to create curves or sections thereof made of straight lines or with sharp corners. Vector handles convert to *Free* handles when moved.



### Aligned V - L

These handles always lie in a straight line, and give a continuous curve without sharp angles.



### Free V - F

The handles are independent of each other.



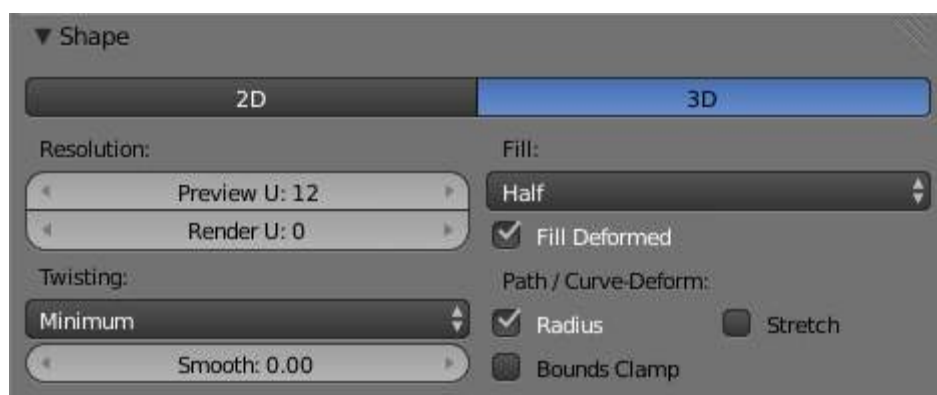
Additionally, the V - T shortcut can be used to toggle between Free and Aligned handle types.

## Curve Properties

Curve Properties can be set from the *Object Data* option in the *Properties Header* (shown below in blue).



### Shape



Curves Shape panel.

### 2D and 3D Curves

By default, new curves are set to be 3D, which means that Control Points can be placed anywhere in 3D space. Curves can also be set to 2D which constrain the Control Points to the Curve's local XY axis.

### Resolution

The *resolution* property defines the number of points that are computed between every pair of Control Points. Curves can be made more or less smooth by increasing and decreasing the resolution respectively. The *Preview U* setting determines the resolution in the 3D viewport while the *Render U* setting determines the Curve's render resolution. If *Render U* is set to zero (0), then the *Preview U* setting is used for both the 3D viewport and render resolution.



Curves with a resolution of 3 (left) and 12 (right).

### Twisting

A 3D Curve has Control Points that are not located on the Curve's local XY plane. This gives the Curve a twist which can affect the Curve normals. You can alter how the twist of the Curve is calculated by choosing from *Minimum*, *Tangent* and *Z-Up* options from the drop-down menu.



Curves with a twist of minimum (left) and tangent (right).

## Fill

Fill determines the way a Curve is displayed when it is Beveled (see below for details on Beveling). When set to *Half* (the default) the Curve is displayed as half a cylinder. The *Fill Deformed* option allows you to indicate whether the Curve should be filled before or after (default) applying any Shape Keys or Modifiers.



Curves with a fill of half (left) and full (right).

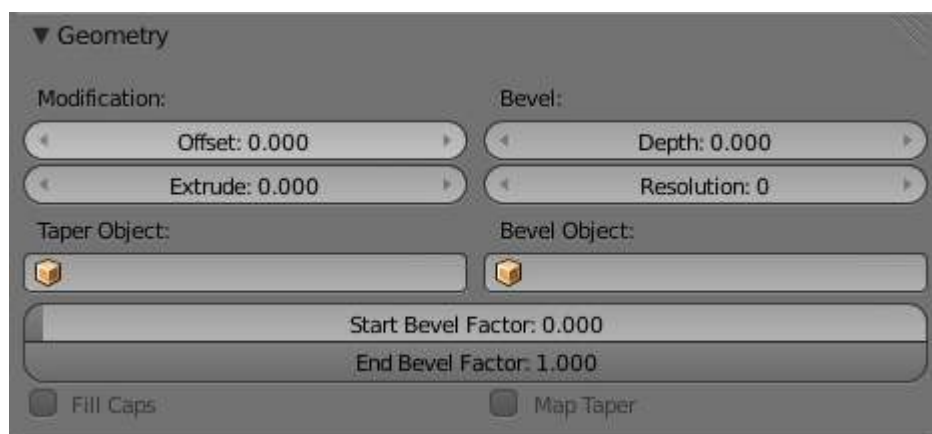
## Path/Curve-Deform

These options are primarily utilized when using a Curve as a Path or when using the Curve Deform property. The *Radius*, *Stretch* and *Bounds Clamp* options control how Objects use the Curve and are dealt with in more detail in the appropriate links below.

See also

- *Basic Curve Editing*
- *Animation Paths*

## Geometry



Curves Geometry panel.

## Modification

### Offset

By default, text Objects are treated as curves. The Offset option will alter the space between letters.

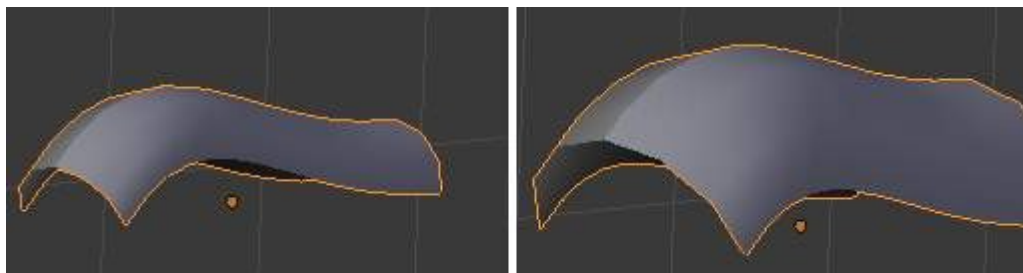
### Extrude

Will extrude the curve along both the positive and negative local Z axes.

## Bevel

### Depth

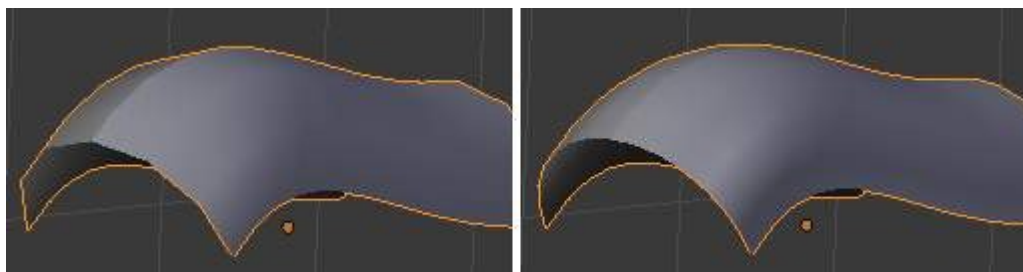
Changes the size of the bevel



A Curve with different Bevel depths applied.

### Resolution

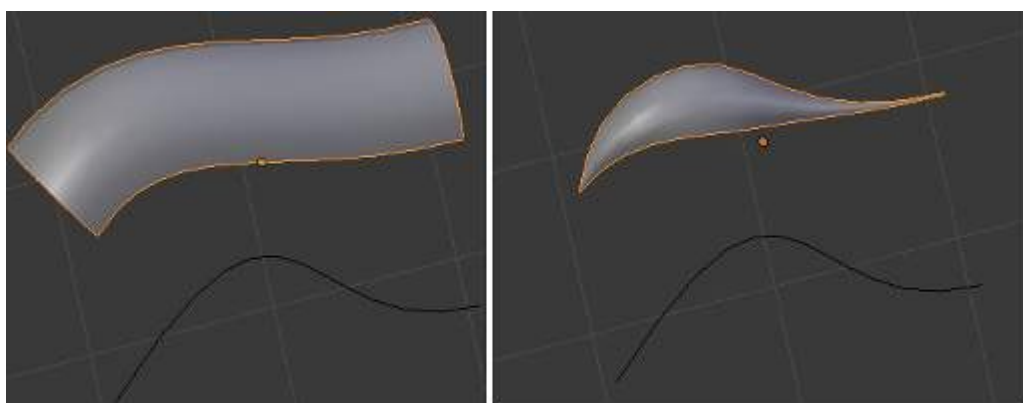
Alters the smoothness of the bevel



A Curve with different resolutions applied.

## Taper Object

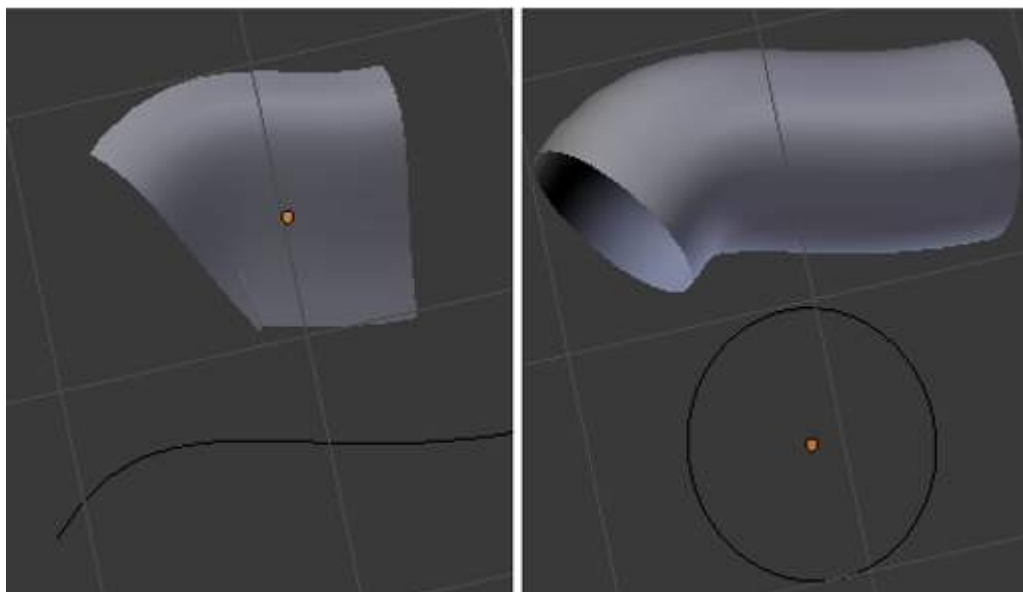
Tapering a Curve causes it to get thinner towards one end. You can also alter the proportions of the Taper throughout the tapered object by moving/scaling/rotating the Control Points of the Taper Object. The Taper Object can only be another Curve. Editing the Handles and Control Points of the Taper Object will cause the original Object to change shape.



A Curve before (left) and after (right) a Bezier Curve Taper Object was applied.

## Bevel Object

Beveling a Bezier Curve with a Bezier Curve as the Bevel Object generally gives it the appearance of a plane, while using a Bezier Circle as the Bevel Object will give it the appearance of a cylinder. The Bevel Object can only be another Curve. Editing the Handles and Control Points of the Bevel Object will cause the original Object to change shape. Given the options available, it is best to experiment and see the results of this operation.



A Curve with the Bevel Object as a Bezier Curve (left) and as a Bezier Circle (right).

### Fill Caps

Seals the ends of a beveled Curve.

### Map Taper

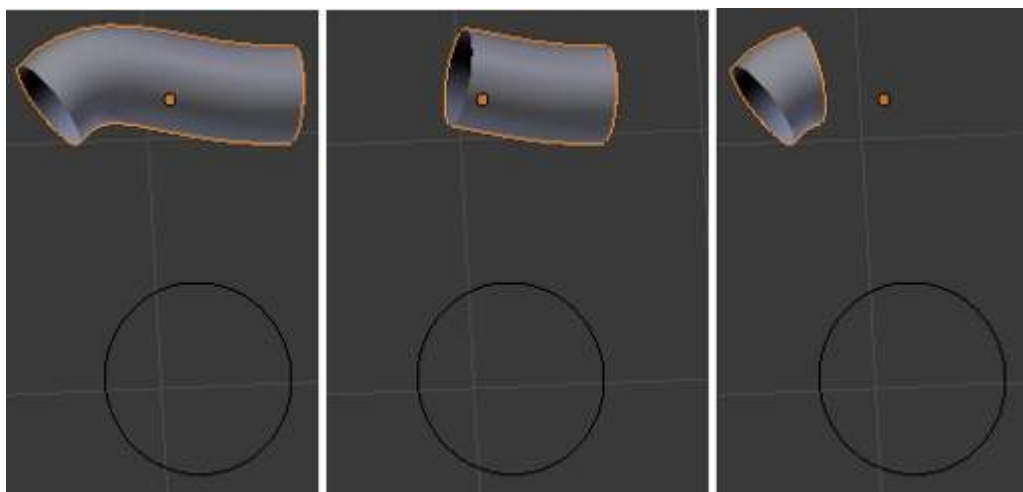
For Curves using a Taper Object and with modifications to the *Start/End Bevel Factor* the *Map Taper* option will apply the taper to the beveled part of the Curve (not the whole Curve).



A Curve without (left) and with (right) Map Taper applied.

### Start Bevel Factor and End Bevel Factor

These options determine where to start the Bevel operation on the Curve being beveled. Increasing the *Start Bevel Factor* to 0.5 will start beveling the Curve 50% of the distance from the start of the Curve (in effect shortening the Curve). Decreasing the *End Bevel Factor* by 0.25 will start beveling the Curve 25% of the distance from the end of the Curve (again, shortening the Curve).



A Curve with no Bevel factor applied (left), with a 50% Start Bevel Factor (middle) and with a 25% End Bevel Factor (right).

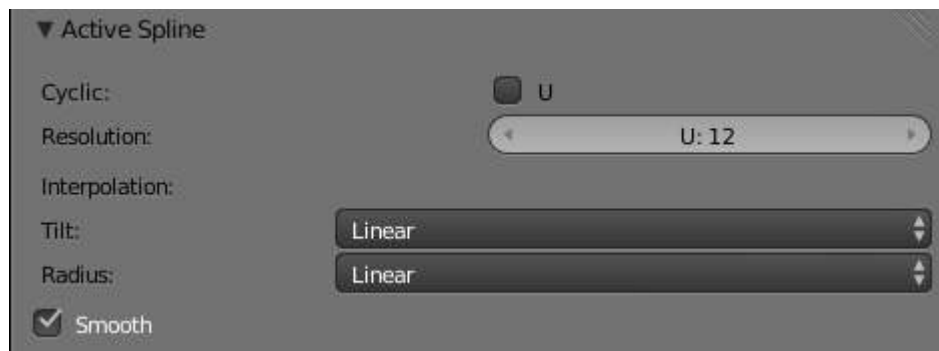


## Path Animation

The Path Animation settings can be used to determine how Objects move along a certain path. See the link below for further information.

*Read more about utilizing Curves for paths during animation*

## Active Spline



Curves Active Spline panel.

The *Active Spline* panel becomes available during *Edit mode*.

### Cyclic

Closes the Curve.

### Resolution

Alters the smoothness of each segment by changing the number of subdivisions.

### Interpolation

#### Tilt

Alters how the tilt of a segment is calculated.

#### Radius

Alters how the radius of a Beveled Curve is calculated. The effects are easier to see after Shrinking/Fattening a control point **Alt** - **S**.

#### Smooth

Smooths the normals of the Curve

## Non-Uniform Rational B-Splines (NURBS)

One of the major differences between Bezier Objects and NURBS Objects is that Bezier Curves are approximations. For example, a Bezier circle is an *approximation* of a circle, whereas a NURBS circle is an *exact* circle. NURBS theory can be a *very* complicated topic. For an introduction, please consult the Wikipedia page. In practice, many of the Bezier curve operations discussed above apply to NURBS curves in the same manner. The following text will concentrate only on those aspects that are unique to NURBS curves.

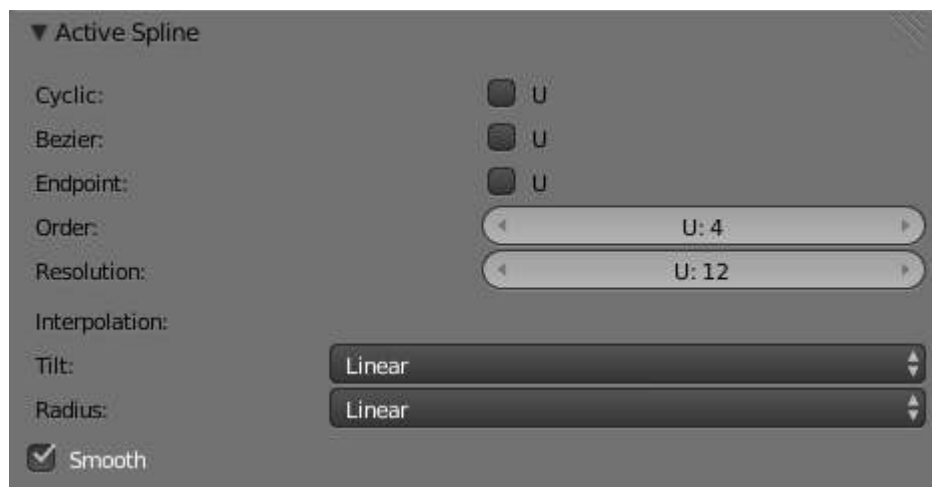
## Editing NURBS Curves

A NURBS Curve is edited by moving the location of the Control Points.

- Place a Curve by **Shift** - **A** to bring up the Add menu, followed by Curve ▸ NURBS curve.
- Press **Tab** to enter *Edit mode*.
- Select one of the Control Points and move it around. Use **LMB** to confirm the new location of the Control Point, or use **RMB** to cancel.

- If you want to add additional Control Points, select both of them, press **W** and select *Subdivide*. Press **F6** immediately after to determine how many subdivisions to make.

## Active Spline



NURBS Active Spline panel.

## Knots

One of the characteristics of a NURBS object is the *knot vector*. This is a sequence of numbers used to determine the influence of the control points on the curve. While you cannot edit the knot vectors directly, you can influence them through the *Endpoint* and *Bezier* options in the Active Spline panel. Note that the *Endpoint* and *Bezier* settings only apply to open NURBS curves.

### Cyclic

Makes the NURBS curve cyclic.



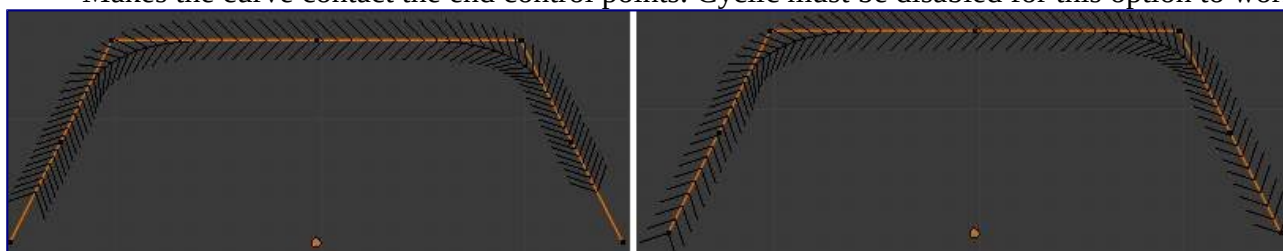
A NURBS curve with Cyclic applied.

### Bezier

Makes the NURBS curve act like a Bezier curve.

### Endpoint

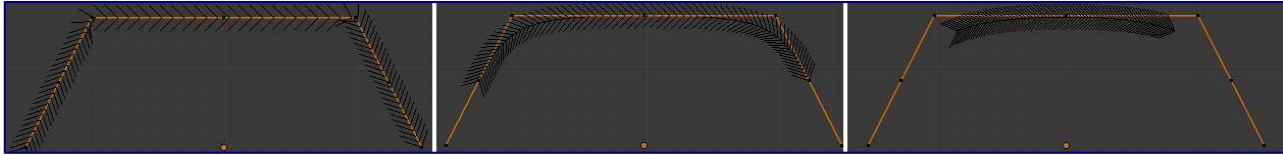
Makes the curve contact the end control points. Cyclic must be disabled for this option to work.



A NURBS curve with Endpoint enabled.

## Order

The order of the NURBS curve determines the area of influence of the control points over the curve. Higher order values means that a single control point has a greater influence over a greater relative proportion of the curve. The valid range of *Order* values is 2-6 depending on the number of control points present in the curve.



NURBS curves with orders of 2 (left), 4 (middle) and 6 (right).

## Weight

TODO.

## Path

As mentioned above, Curves are often used as *paths*. Any curve can be used as a Path if the *Path Animation* option is selected.

The Path option available from the *Add Curve* menu is identical to a 3D NURBS curve, except that you do not have access to the *Active Spline* panel.