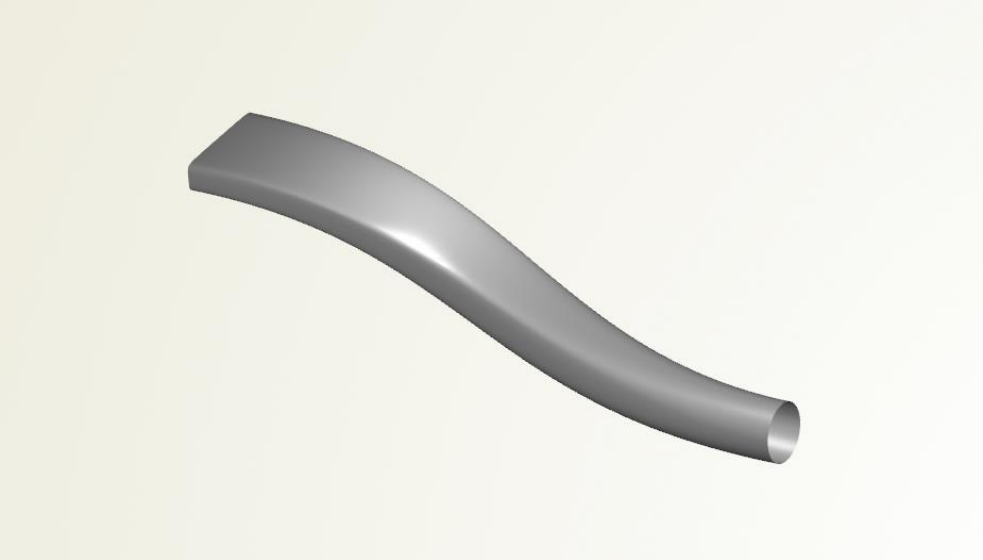
Sweep Transformation

The *sweep transformation* is an advanced way of creating sweep surfaces in CAESES. Generally, a 2D contour curve is defined first by a set of curve parameters (e.g. height, width, radius, area, …). These parameters are then controlled and changed by functions while sweeping the contour along the path.



Note: CAESES also provides a basic *sweep surface* (see *CAD > surfaces > sweep surface*). With this surface type, one or two contours are simply swept along the path. However, contours cannot be controlled and systematically varied between the starting and terminating location.

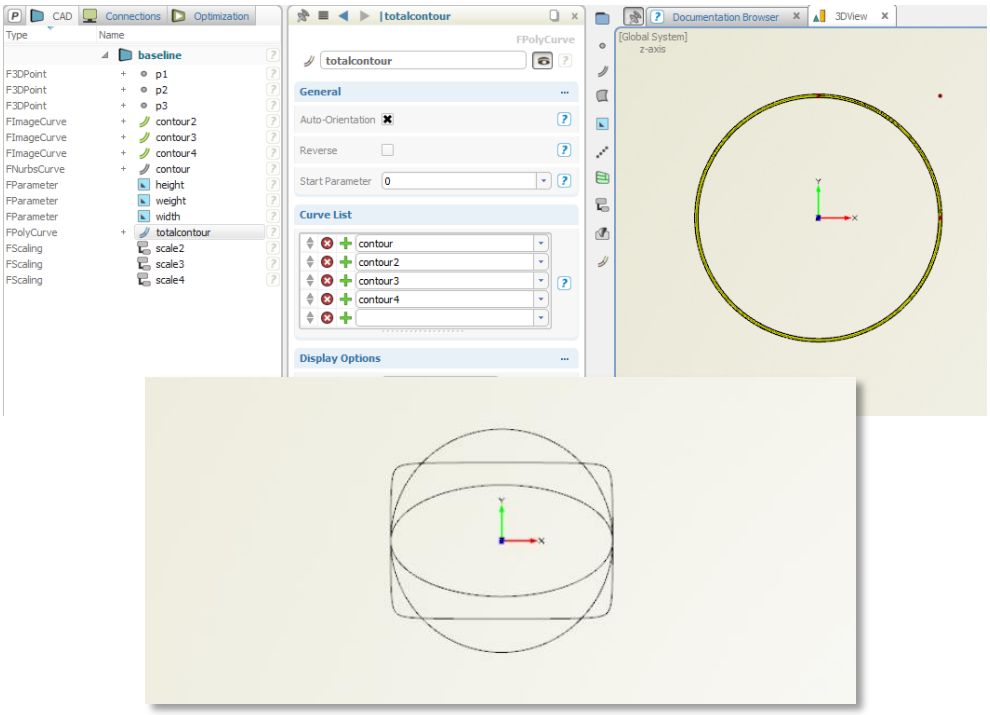
CAESES Project

The resulting model can be found in the section *samples > tutorials* of the documentation browser.

1 Contour Curve

We will use the contour curve from a previous tutorial. It generates 2D shapes starting from a circle, and ending as rectangular shape.

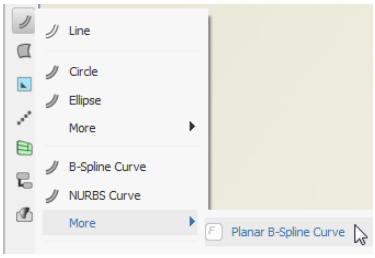
- Choose *file > open sample > tutorials > 11_Parametric_Contour.fdb*.
- Choose *file > save project as* and save the project with a new name.

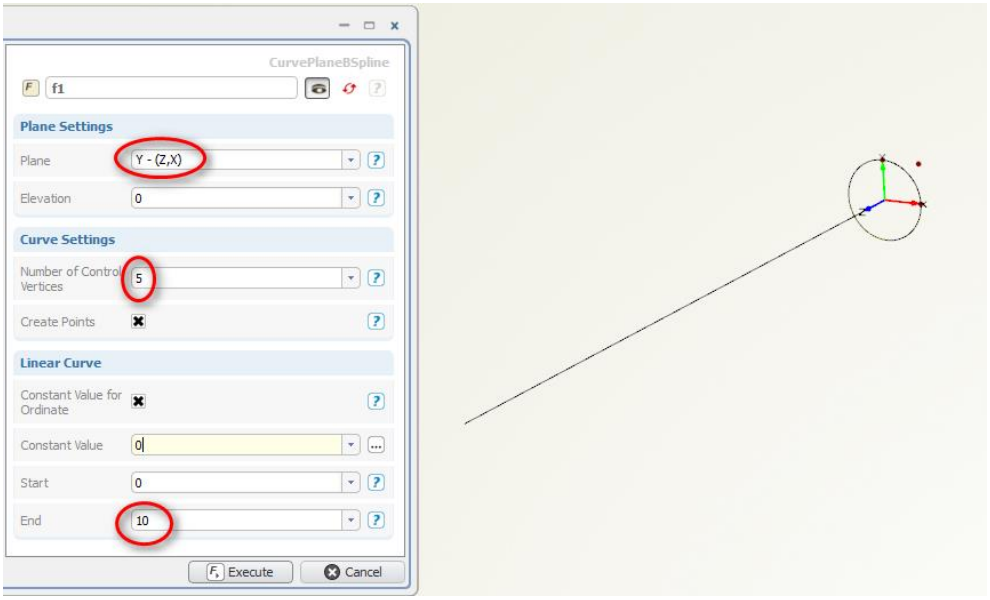


2 Sweep Path

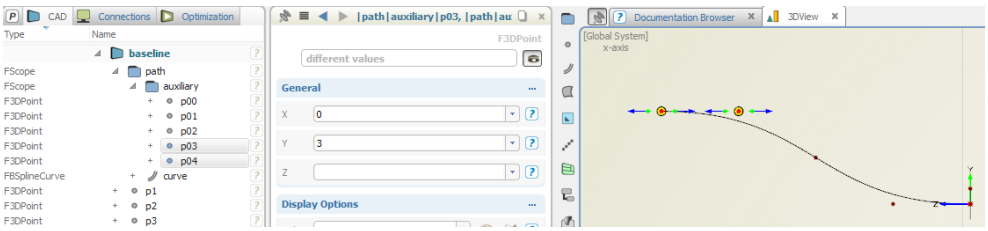
In this step, the 3D path (also called “trajectory”) is created, along which the contour curve will be swept. Note that any curve type can be used for such a path curve. For simplicity, we will create a *b-spline* curve.

- Choose *CAD > curves > more* of the b-spline curve menu and select *planar b-spline curve*.
- Set “Y – (Z,X)” for the *plane* attribute.
- Set *number of control vertices* to “5”.
- Set *end* position to “10”.
- Press *execute*.





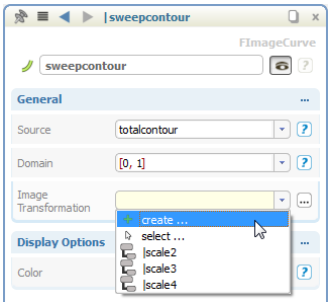
- Rename the new scope “f1” to “path”.
- In the scope path|auxiliary, set the y-coordinate of “p02” to “1.5”.
- Select “p03” as well as “p04” and set the y-coordinates to “3”.



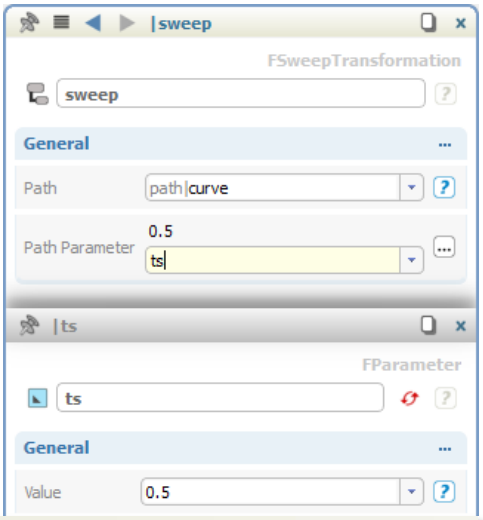
3 Sweep Transformation

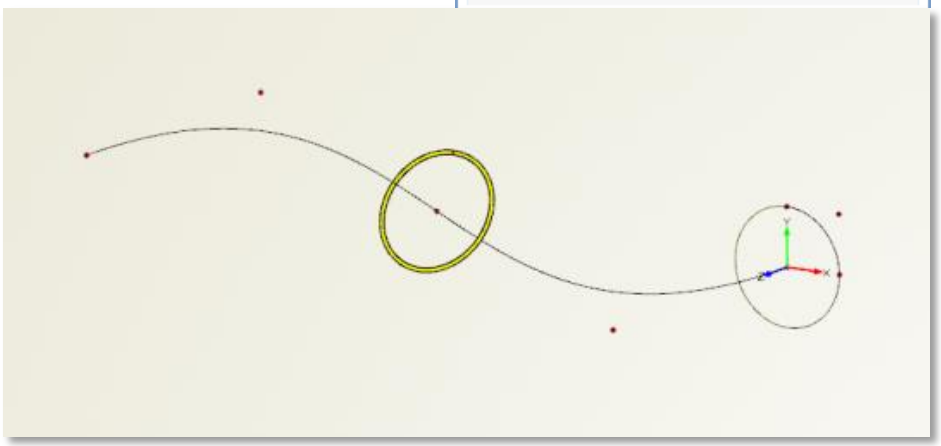
Let's create an image curve that utilizes the sweep transformation in order to sweep along the path:

- Select "totalcontour".
- Choose *CAD > curves > image curve* and set the name of the new image to "sweepcontour".



- From pull-down menu of the attribute *image transformation*, choose "create…" and create a *sweep* transformation.
- Set the name of the transformation to "sweep".
- For the path of "sweep", choose our curve from step 2 (i.e. "path|curve").
- Create a parameter "ts" from the context menu of the field *path parameter*.
- Try out different values for "ts" in the range [0,1], such as "0.25" and "0.5".

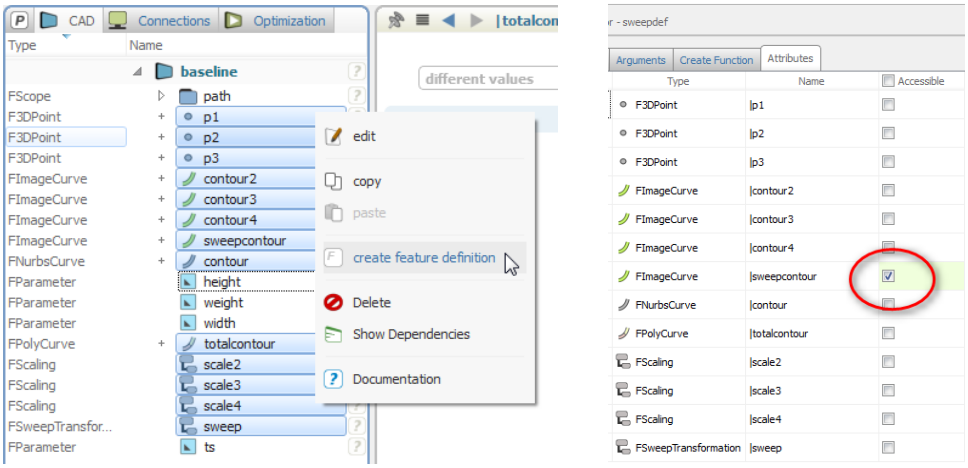




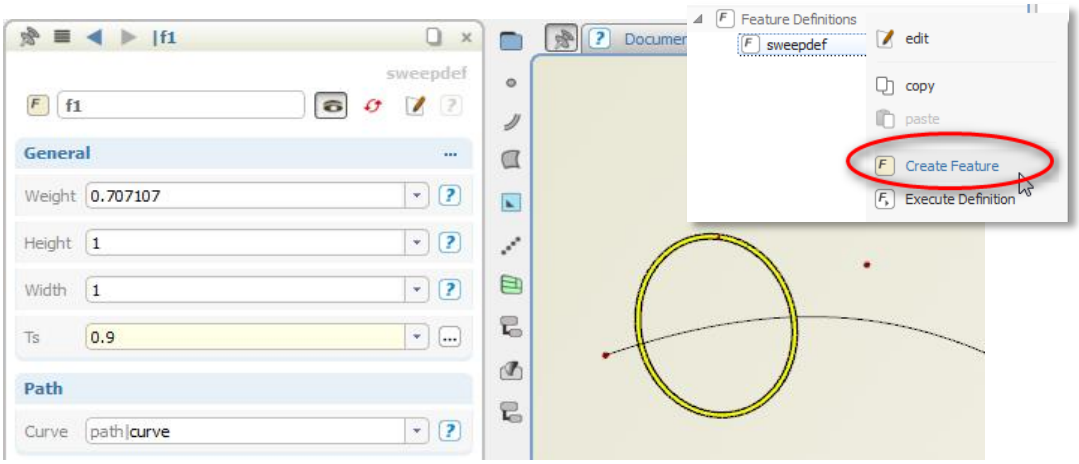
4 Feature Definition

Remember: The parameters “height”, “width” and “weight” as well as “ts” are variable values of our contour. In this step, we encapsulate the curve in a feature definition so that it can be used for *meta surfaces*.

- Select all objects in the CAD tree – apart from the parameters and the scope “path”!
- Choose *create feature definition* from the context menu.



- Set the type name to “sweepdef” (*general* tab of the new definition).
- In the *attributes* tab, make only “sweepcontour” accessible (we do not need the other geometries for surface creation).
- Press *apply* and close the dialog.
- Create a *feature* of “sweepdef”, set the path curve and test it by changing its input:



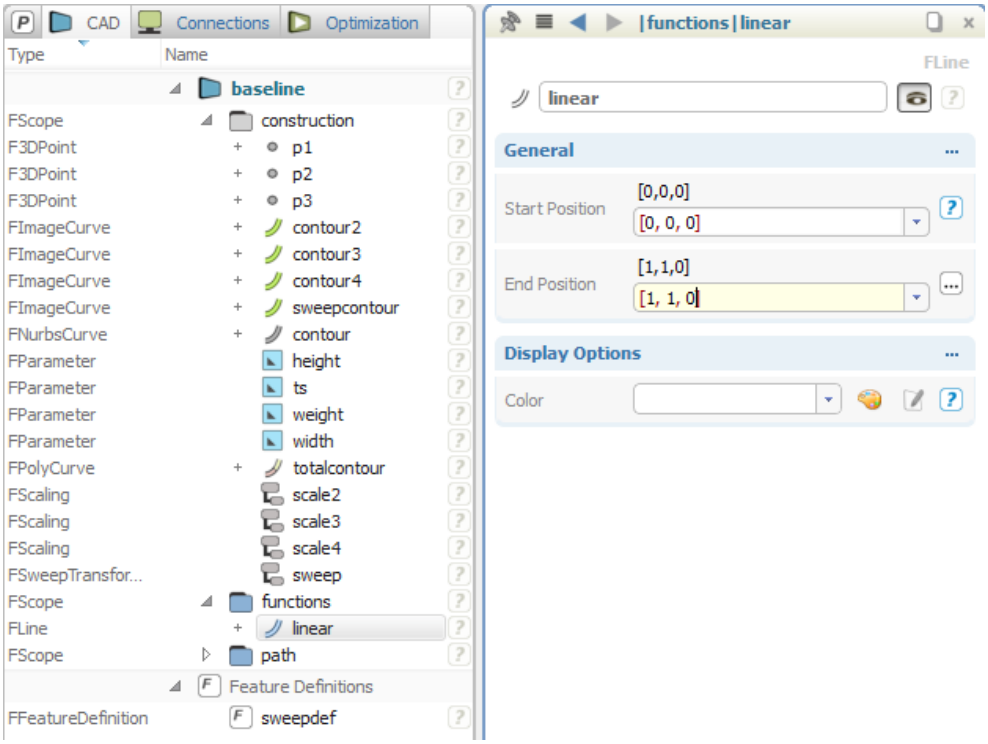
5 Preparing Surface Creation

In this step, the tree is slightly reorganized and a function for the path parameter "ts" is created. Within the surface creation process, this parameter runs from "0" to "1", i.e. along the path curve in a linear manner.

- Select all objects apart from the scope "path" and create a new scope via *CAD > scope.*
- Set the name of the new scope to "construction".
- Make it invisible by clicking on its scope icon in the tree.

Next we'll create the linear function:

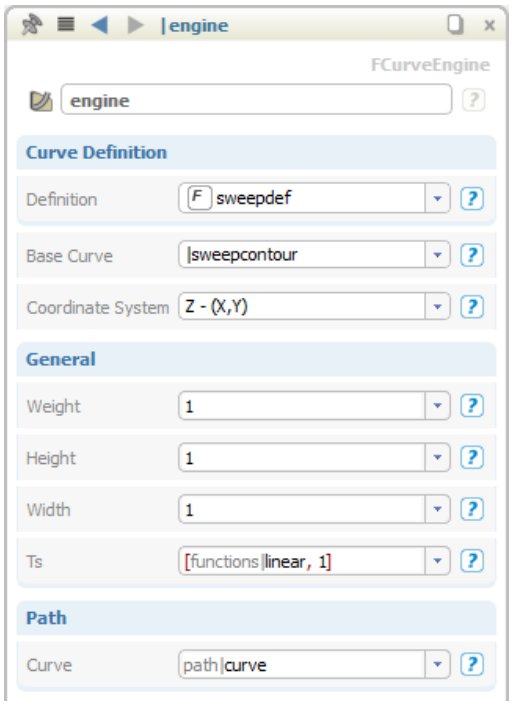
- Create a line via *CAD > curves > line* and name it "linear".
- Set the start position to "[0,0,0]".
- Set the end position to "[1,1,0]".
- While "linear" is still selected, choose *CAD > scope* again and rename the new scope to "functions" (our curve "linear" is now automatically in this scope).



6 Curve Engine

This is the final step before surface creation. We have to create a *curve engine* that connects the 2D sweeping curve definition with the directional information of how the surface is controlled along the path.

- Select the feature definition “sweepdef”.
- Choose *CAD > curves > curve engine* and set its name to “engine”.
- Set an initial value of “1” for *weight*, *height* and *width*.
- Set the function “linear” as input for the path parameter *ts*.
- Choose the path curve as final input for the curve engine.

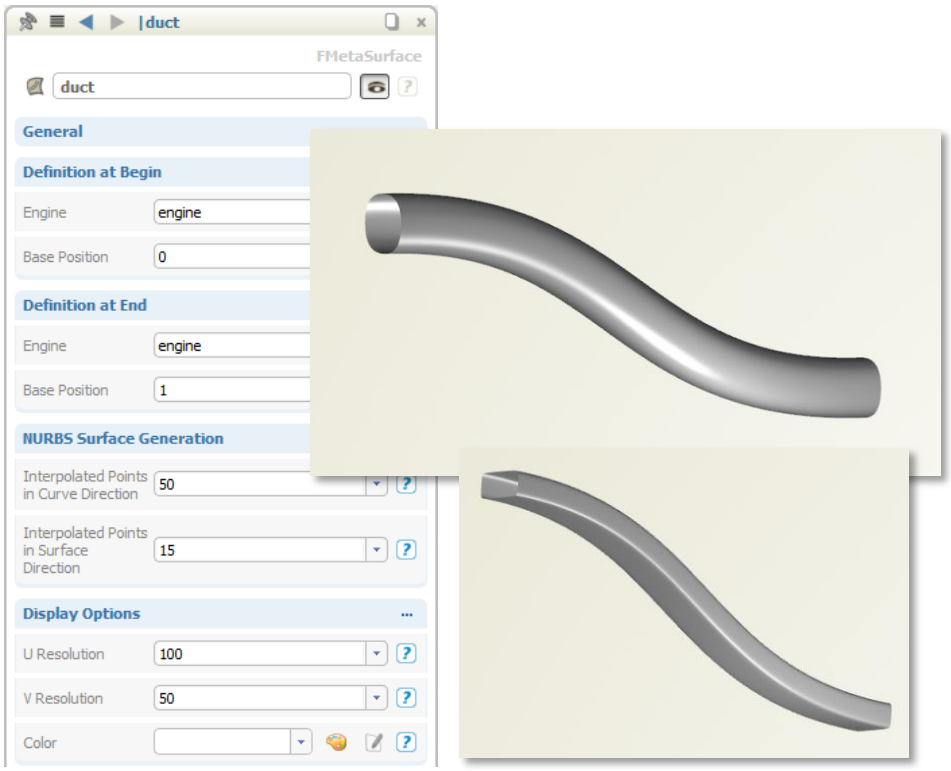


✓ Curve engines allow setting functions such as the linear function from above. The editor of the path parameter *Ts* shows “[functions|linear, 1]” which can be interpreted as [function, factor]. The function values get multiplied by the factor. In our case the factor is simply “1” (no changes to the function values). This is helpful for normalized functions that are given in the ordinate range of [0,1] but need to be scaled (e.g. angle values, absolute values of lengths or widths etc).

7 Meta Surface

Since the path parameter needs to run from “0” to “1”, which is done by the function “linear”, we can now create an initial surface:

- While “engine” is still selected, choose *CAD > surfaces > meta surface*.
- Set the name of the new surface to “duct”.
- Set the *U-* and *V-Resolution* in the display options of “duct” to “100” and “50”, respectively, in order to have a smoother visualization.



- Try out different values for *weight*, *height* and *width* in the curve engine from step 6.

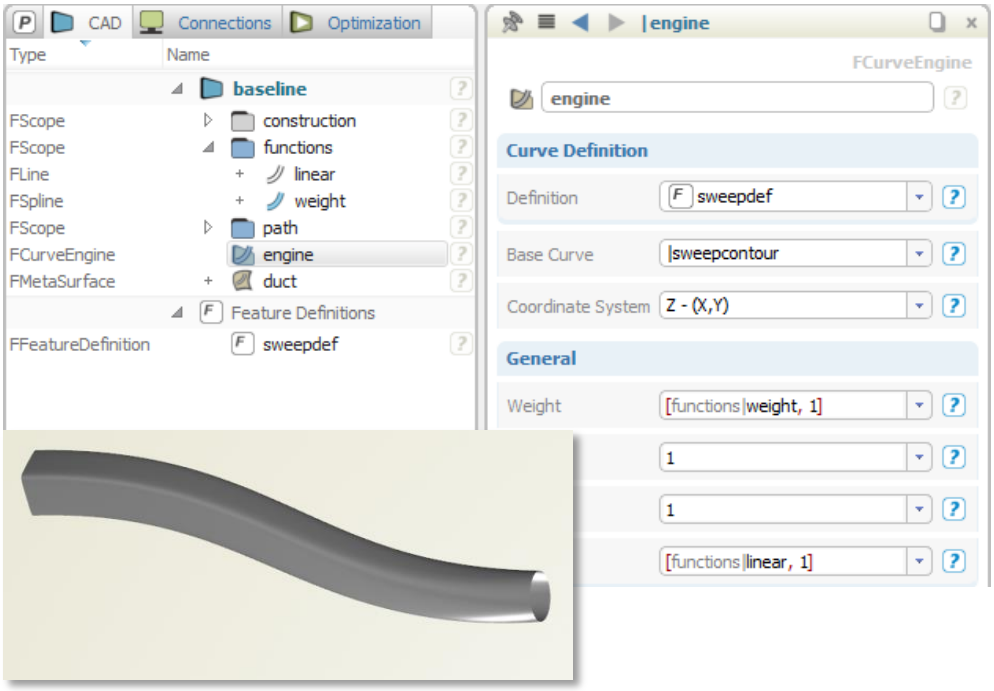
8 Weight Function

This is the moment where things get interesting. So far, the parameters *weight*, *height* and *width* can be changed, but they are constant while sweeping along the path. Why not create functions for them? Again, remember that the curve engine has an attribute *coordinate system* for the functions, which is currently the xy-system (this is the default). Therefore, the functions need to be given in this system (our curve "linear" is also in the xy-system). Here is one example for a weight-function:

- Choose *CAD > curves > f-spline curve* and rename the new curve to "weight" (if you cannot see the curve due to the surface in front, use the surface/curve filters of the 3D view).
- Set the start position to "[0,1/sqrt(2),0]" in order to have a circle at the beginning.
- Set the start tangent to "0" degree.
- Set the end position to "[1,5,0]".
- Set the end tangent to "0" degree.
- Drag & drop "weight" into the scope "functions".

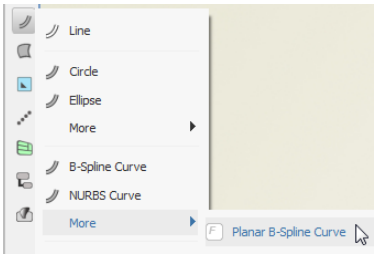
> ✓ By default, *the f-spline curve* is defined in the xy-system; see its attribute *principal plane*.

- Select "engine" and drag & drop (or choose from the pull-down menu) "functions|weight" into the corresponding *weight* attribute field.



9 Additional Functions

For the remaining variables *height* and *width* we can also introduce functions:

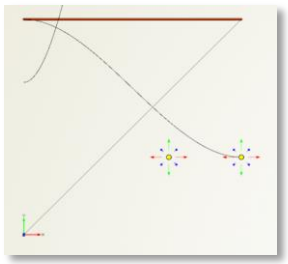


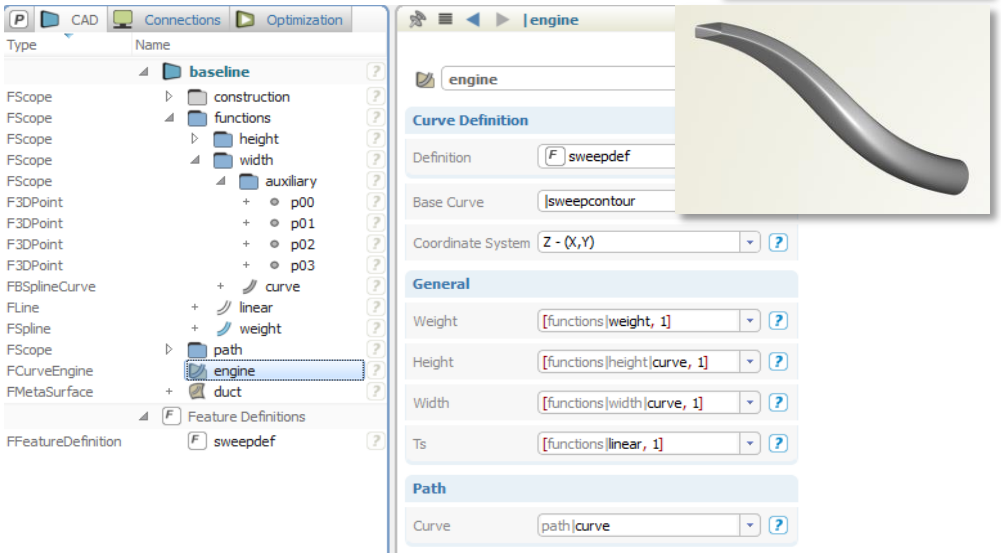
- Choose *CAD > curves > more > planar b-spline curve* from the *b-spline* menu.
- Set *number of control vertices* to "4".
- Set a *constant value* of "1".
- Press *execute*.
- Rename the new scope "f1" to "height".
- Drag & drop "height" into the scope "functions".
- Select "engine" and drag & drop the curve in "height" into the *height* attribute field.

Now the final function:

- Copy & paste the scope "height" and rename the new scope to "width".
- Select "engine" and drag & drop the curve in "width" into the *width* attribute field.

Select some points of the new functions (e.g. "p02" and "p03" of "height") and drag them in the y-direction in order to increase/decrease the height at the end of the surface. Make the scope "width" invisible (click on scope icon in the tree) if the function curves are coincident in order to easier access the points of "height".





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Conclusions

Any kind of curve type can be used to design the path, the contour, or the function curves along with the individual parameters. In this example, the control vertices of the path curve and the vertices of the functions are natural design variables in design studies and optimizations.

Typically, designers prefer to minimize the number of free variables ("design variables"), to those which are likely to have the biggest influence on performance (e.g. with regard to fluid dynamics), and thus reduce the computational time and resources required for optimization studies. Therefore, it is important to consider the modeling method and definition of functional parameters.

Note that the generated surface is a single NURBS surface for which the settings can be controlled in the meta surface "duct" (see category *NURBS Surface Generation* of "duct"). The final surface should not be fully rectangular, having sharp corners at the end. Whenever sharp corners are to be matched, a different or combined approach is required because a *single* meta surface is not able to reproduce sharp corners exactly.