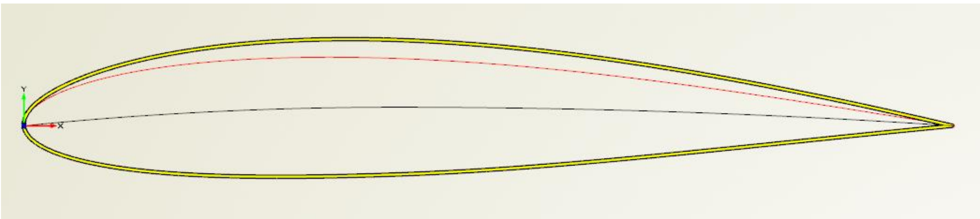
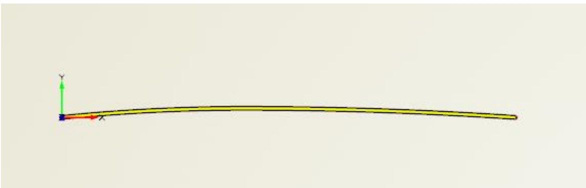
Profile Design

In CAESES, profiles can be defined in various ways. Basically, any curve type of CAESES can be used to set up a blade profile description. Typically, mathematical descriptions are used, for instance *NACA* formulas etc. This tutorial gives you an example of a parametric profile design where such a mathematical definition is involved.

See also the sample section where you can also find an axial blade design which is based on an offset curve, using a mean camber definition plus a thickness distribution.

Finally, if you want to design axial blades for compressors with rather complex i.e. curved meridional contours, then see the corresponding tutorial and samples for these types of turbomachinery.





$$y_c = \begin{cases} m\,\dfrac{x}{p^2}\left(2p - \dfrac{x}{c}\right), & 0 \le x \le pc \\ m\,\dfrac{c-x}{(1-p)^2}\left(1 + \dfrac{x}{c} - 2p\right), & pc \le x \le c \end{cases}$$

For demonstration purposes and to keep it simple, a mean line camber of a *NACA 4-digit* airfoil is defined in this tutorial. This will give you the basic idea of how to create your own mathematical definitions. Prerequisites for this example are the feature tutorials.

CAESES Project

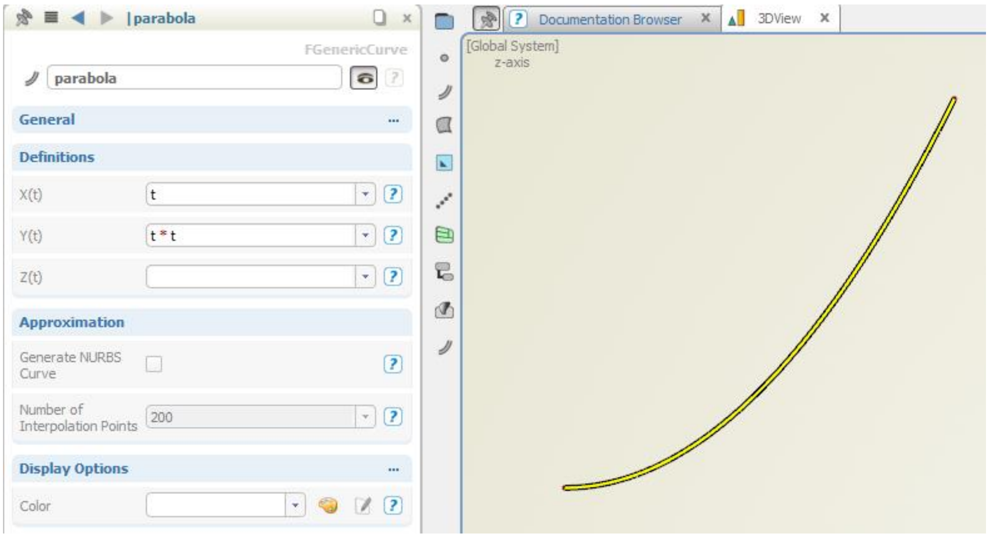
The resulting model can be found in the section *samples* > *tutorials* of the documentation browser.

1

Generic Curve

The *generic curve* allows you to define a parametric curve. The reserved parameter of this curve type is called "t": It internally runs from "0" to "1" so that a curve can be generated. In this step we'll have a quick look at the generic curve in order to understand the parameter "t".

- Choose *CAD > curves > generic curve*.
- Enter "t" into the attribute *x(t)*.
- Enter "t*t" into the attribute *y(t)*.



- Try out other expressions for *y(t)* such "sin(t*360)" – see the *global commands* section in the documentation browser for more mathematical commands.
- Delete the curve – we do not need it anymore for the next steps.

2

New Feature Definition

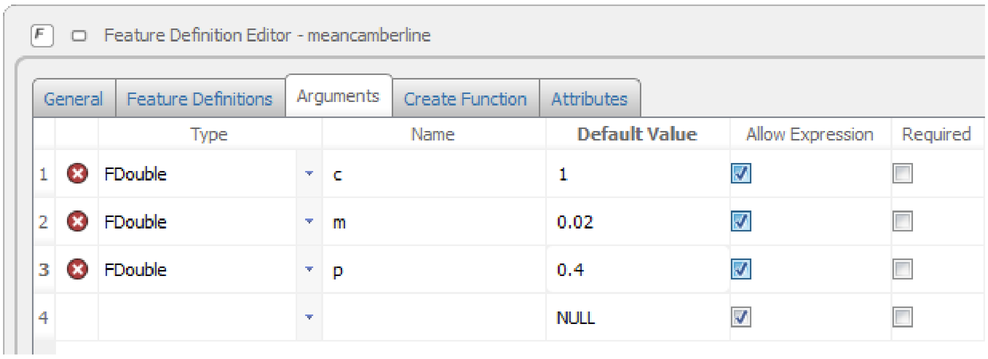
The mean camber line will be defined within a feature definition. This will give you a first idea of how to define your own formulas. In this step, the arguments are configured:

- Choose *features > new definition*.
- Enter “meancamberline” in the *type name* attribute (general tab).

The NACA mean camber line requires 3 input values: chord (“c”), maximum camber (“m”) and the location of maximum camber (“p”). Here is the definition:

$$y_c = \begin{cases} m\,\dfrac{x}{p^2}\left(2\,p - \dfrac{x}{c}\right), & 0 \le x \le pc \\[2ex] m\,\dfrac{c-x}{(1-p)^2}\left(1 + \dfrac{x}{c} - 2\,p\right), & pc \le x \le c \end{cases}$$

- Go to the *arguments* tab and add the 3 input arguments (*FDouble)*.
- Set default values according to the screenshot.



3 Formula

The formula for the mean camber line is now put into a generic curve. Note that the curve parameter "t" corresponds to "x" in the formula and "t" runs from "0" to "1". Therefore, we have to multiply "t" with the chord length. Once again, here is the formula for direct comparison:

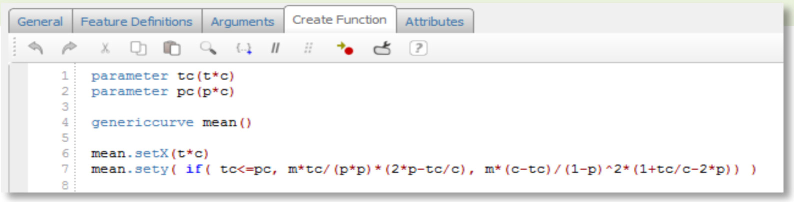
$$y_c = \begin{cases} m\,\dfrac{x}{p^2}\left(2p - \dfrac{x}{c}\right), & 0 \le x \le pc \\[2ex] m\,\dfrac{c-x}{(1-p)^2}\left(1 + \dfrac{x}{c} - 2p\right), & pc \le x \le c \end{cases}$$

▶ Paste this sequence into the *create function* editor, press *apply* and close the dialog:

```
parameter tc(t*c)
parameter pc(p*c)

genericcurve mean()
mean.setX(tc)
mean.sety( \
        if( tc<=pc, \
        m*tc/(p*p)*(2*p-tc/c), \
        m*(c-tc)/(1-p)^2*(1+tc/c-2*p)) \
)
```

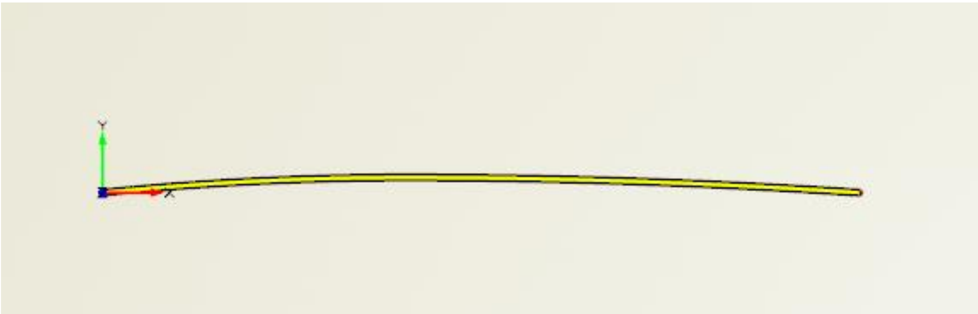
✓ Long expressions can be separated by using the "\" character. You can also write it in one line:



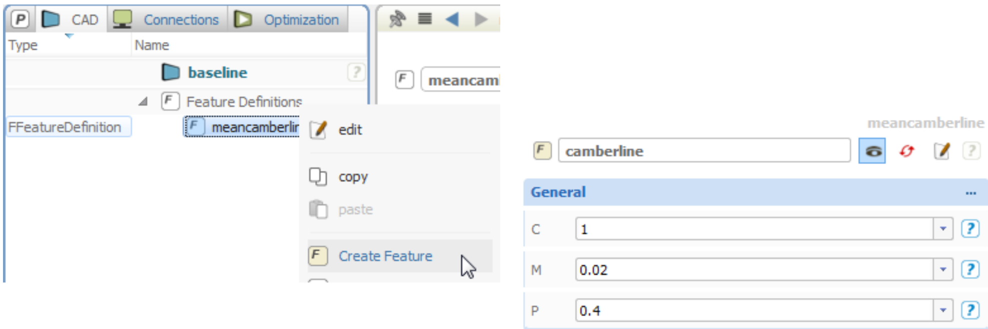
✓ Note that the if-statement in this expression is also a global command, see the *documentation browser > global commands* for more information.

4 Testing and Export

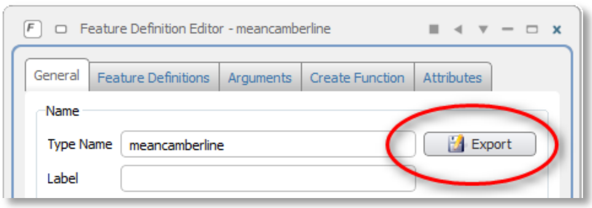
Let's create a feature from our new definition to check whether everything works correctly.



- Create a *feature* via the context menu of the definition in the tree (see screenshot below).
- Rename the new feature "f1" to "camberline".
- Change the input values "C", "M" and "P" to check the curve in the 3D view.
- Set the chord ("C") value to "1" – we won't change it in this tutorial.

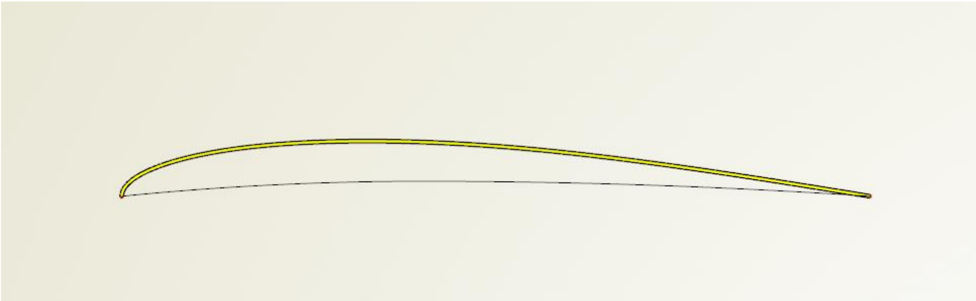


Optional: Export the definition so that you can access it again from other projects via the menu *features > in user directory* (helpful for recurring usage of the same definitions).

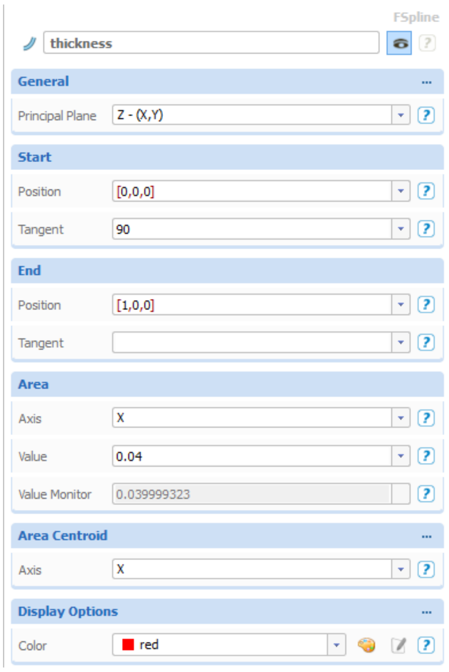


5 Profile Modeling: Thickness Distribution

In order to create a profile that is based on our mean camber line, we first need a simple thickness distribution.



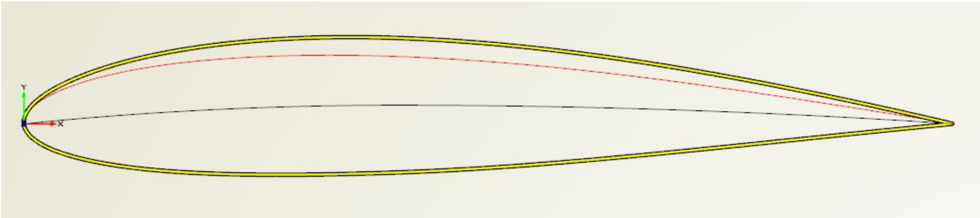
- Choose *CAD > curves > f-spline curve* and name the new curve "thickness".
- Set *start position* to "[0,0,0]".
- Set *start tangent* to "90".
- Set *end position* to "[1,0,0]".
- Set the *area value* to "0.04".
- Set the curve's color to "red" (*display options*).



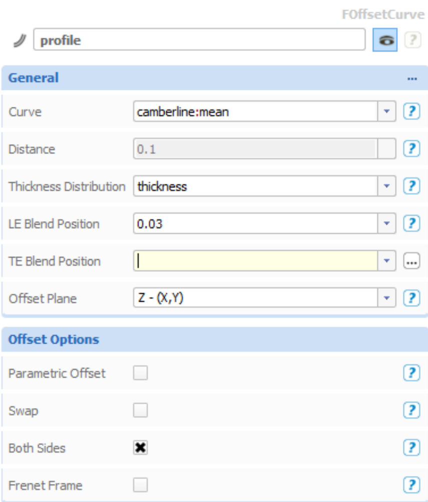
✓ We need a normalized thickness distribution in the x-interval [0,1] for the next step 6.

6 Profile Modeling: Offset Curve

So far, a camber mean line and a thickness distribution are given. The profile curve is now created by means of an *offset curve*.



- Choose *CAD > curves > offset curve* and name the new curve “profile”.
- For the *curve* attribute, set “mean” from the feature “camberline”.
- Set the curve “thickness” for the attribute *thickness distribution*.
- Set the LE (leading edge) blend position to “0.03”.
- Activate *both sides*.



✓ Important: When you specify a leading edge (LE) blend position, the offset curve can consider this information during the curve generation process. This results in better 2D and 3D shapes of the profiles.

Check out the sample section where you can find an axial blade whose profile is based on the presented design approach.