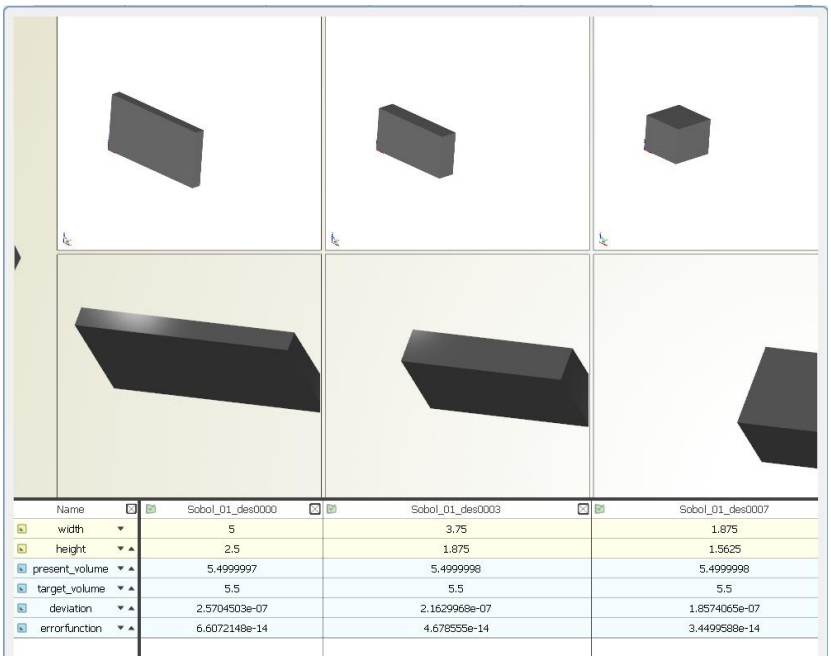
Fulfilling Geometry Constraints

The optimization engines of CAESES can also be used for generalized optimization tasks, such as finding the closest distance between objects, smoothing a curve, or keeping the volume of a geometry object constant while changing its shape. The latter will be shown in this tutorial.

We will create a cuboid which has 3 design variables “height”, “width” and “length” for its dimensions. Whenever we change the x- and z-dimension of the cuboid, the y-coordinate should be adjusted automatically so that a constant volume is kept.
This is a generic possibility in order to keep your geometry variants feasible with regard to given geometry constraints. Prominent examples for this are the shape optimization of a fuel injector where the volume is kept constant or ship hull optimization where a specific displacement needs to be kept and so on.

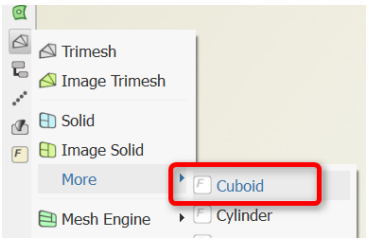


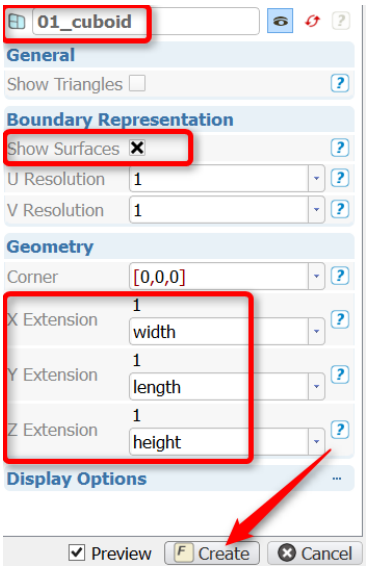
Name	Sobol_01_des0000	Sobol_01_des0003	Sobol_01_des0007
width	5	3.75	1.875
height	2.5	1.875	1.5625
present_volume	5.4999997	5.4999998	5.4999998
target_volume	5.5	5.5	5.5
deviation	2.5704503e-07	2.1629968e-07	1.8574065e-07
errorfunction	6.6072148e-14	4.678555e-14	3.4499588e-14

1 Create the Cuboid

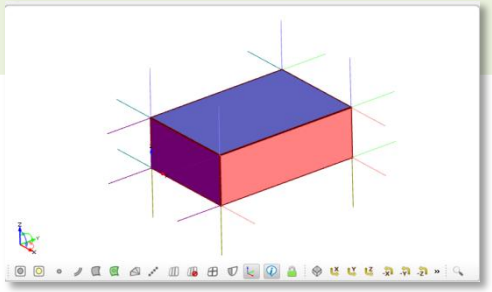
We create a cuboid and some design variables

- Save the project (CTRL + s).
- Create three design variables “width”, ”height” and “length”.
- Create a cuboid via *menu>CAD>solid>more>cuboid*.
- Change the name “f1” to “01_cuboid”
- Activate *Show Surfaces*.
- Set “width” for *X-Extension*.
- Set “length” for *Y-Extension*.
- Set “height” for *Z-Extension*.
- Create the feature (click on *Create*).





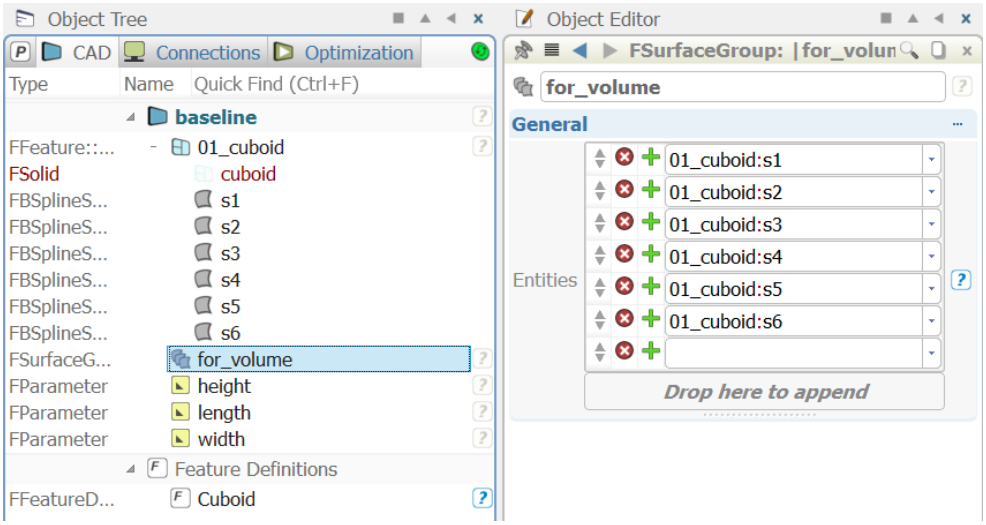
✓ Remember all surface normals need to point either inwards or outwards. The normals can be activated in the Display options of the surfaces.



2 Create a Surface Group

We need to group all surfaces in a surface group because a volume of surface can only be captured from this object.

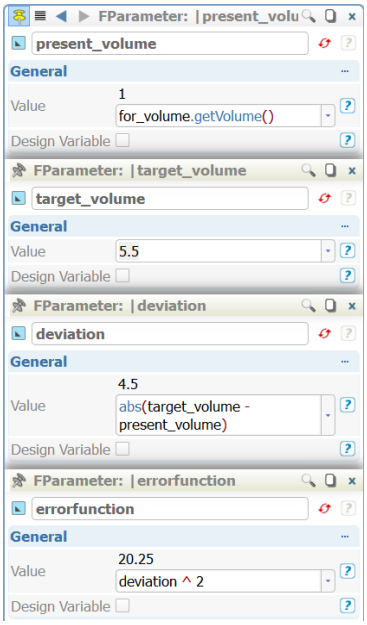
- Select the surfaces “s1-s6” of the feature “01_cuboid”.
- Create *surfacegroup* via *menu > CAD > Surfaces > Surfacegroup*.
- Change the name to “for_volume”.



✓ The trimesh, solid and brep also provide the command ”getvolume()”. It can be used in a parameter or in a feature definition.

3 Create Parameters

For the optimization task, we need to specify some required values and put them into parameters.



- Create a parameter “present_volume”.
- Drag and drop the surface group “for_volume” in “present_volume” and type “for_volume.getVolume()”.

Now it should display the volume of the cuboid, see the screenshots.

- Create a parameter for your “target_volume” and set the value to ”5.5”.
- Create another parameter “deviation” and set the value to “abs(target_volume - present_volume)”.

This ensures a positive value.

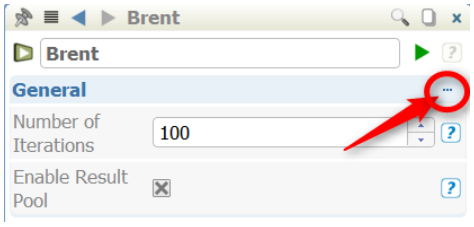
- Create a parameter.
- Change the name to “errorfunction”.
- Set the value to “deviation^2”.

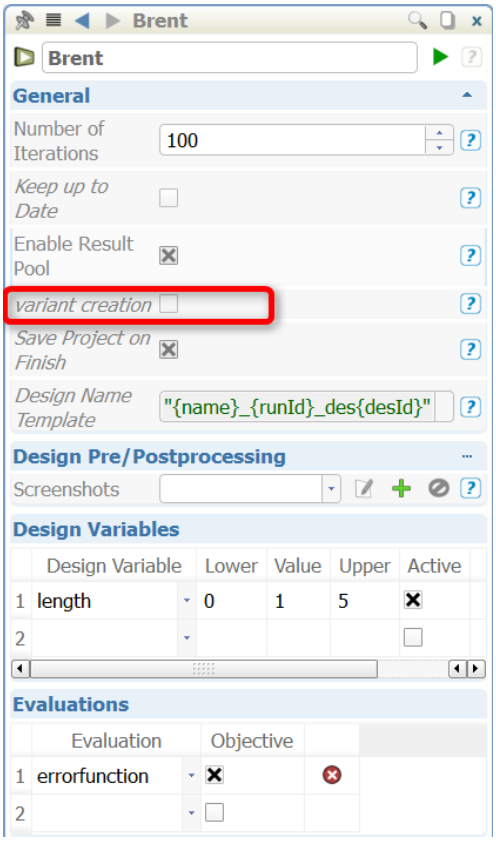
✓ Brep, trimesh and solid also provide the command ”getvolume()”. It can be used in a parameter or in a feature definition.

4 Setting up the Optimization

The length shall be adjusted automatically such that a specific volume is kept. In this step, we set up this optimization.

- Create a *Brent* design engine via *menu > optimization > brent*.
- Set "length" as design variable.
- Set the lower bound to "0" and the upper bound to "5".
- Set the parameter "errorfunction" as evaluation i.e. objective.
- Deactivate the creation of variants by unchecking this option, see below. Click on the three dots on the right side of *General* to show more options.





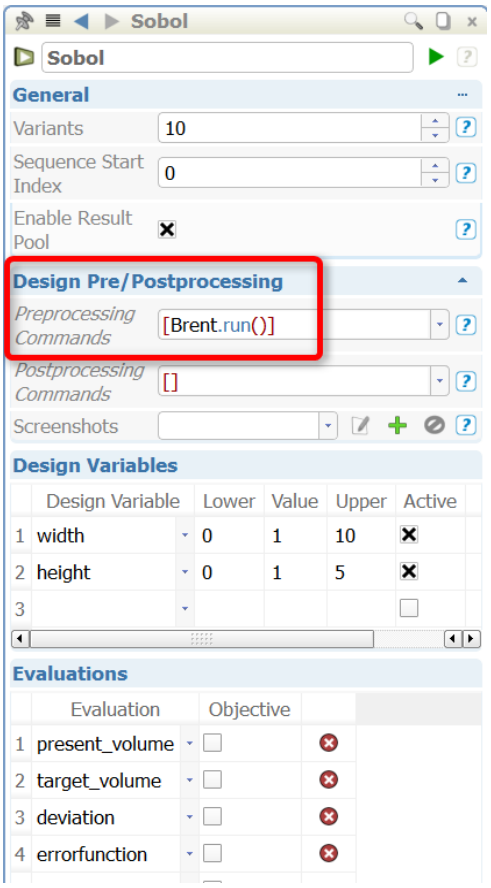
✓ Design engine *Brent*: It is a fast 1 dimensional optimization algorithm. It is the recommended design engine for this type of an optimization problem. For more information take a look at the documentation (simply select the brent in the object editor and press "F1" the type documentation will be opened in the *Documentation Browser* of CAESES).

5 Create a Design Engine for Shape Variation

Now we create another design engine that shall generate simple variants of the cuboid. The optimization engine from the last step is now linked to this variation as a pre-processing command.

- Create a *Sobol* design engine via *menu > optimization > sobol.*
- Set *Variants* to "10" (*CAESES Free* users: "4").
- Set "width" and "height" as design variables and their bounds corresponding to the screenshot below.
- Set "present_volume", "target_volume", "deviation" and "errorfunction" as evaluations.
- Since the brent design engine created in the previous step should be triggered for each variant of the sobol variation, simply set it as *Design Pre-Processing* command by entering "Brent.run()" (to show the italic printed attributes click on the three dots on the right side of *Design Pre/Postprocessing).*

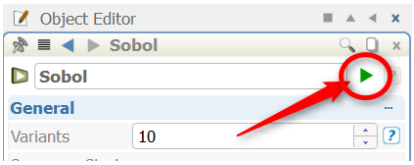
Now the brent engine will keep the volume constant for each variant according to our target_volume value.



6 Running a Variation

We will run the sobol variation, and create a screenshot collection in order to compare the designs in the *design viewer*.

- Run the sobol design engine.



In the design results table, you can see that the volume is kept constant at your "target_volume", while the shape gets varied.

To compare the shape we run a screenshot collection:

- Create a screenshot collection (1).
- Click on the design viewer button (2).

If you want to learn more about the design viewer, simply take a look at

documentation browser > tutorials > learn more > design viewer.