Lesson 7: Understanding constraints

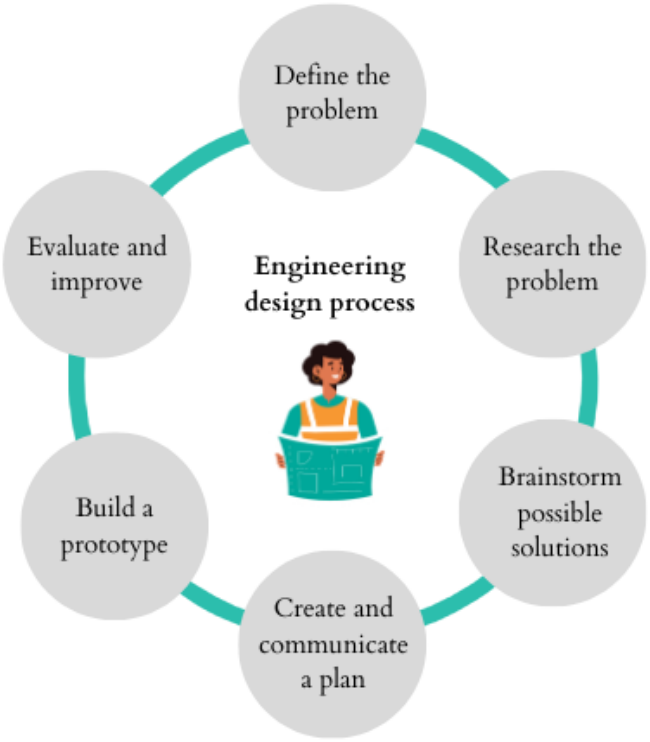
Objectives:

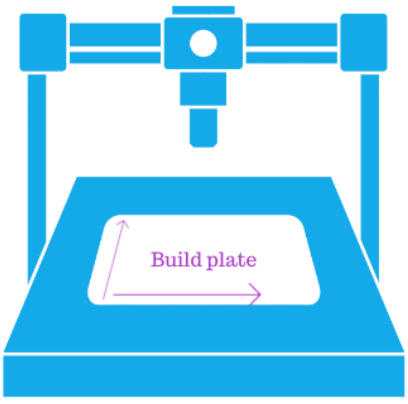
1. Explore constraints related to build plate dimensions.
2. Understand how draft angles play a key role in removing mycelium from its growth form.
3. Consider wall thickness of design and the impact on the strength of the mycelium.
4. Consider shrinkage in the X, Y and Z planes and the implications on the desired size of the mycelium form.

Introduction:

Recall that in the engineering design process, you have a specific problem in mind. As you learned in Lesson 2: Mycelium Design Challenge, your challenge is to create a growth form for a mycelium desktop organizer. You are almost ready to create!

In the engineering design process, the designer must consider key constraints during the phase "Create and communicate a plan". Constraints are limitations to the design process and serve as guidelines for when you are planning and prototyping. In engineering projects, constraints can vary from the resources available, to the capabilities of certain manufacturing processes, to perhaps the specifications that the client desires. It is critical to design with your constraints in mind, or you will end up having to redo a lot of your work. The activities below will walk you through the constraints to building the growth form for your mycelium desktop organizer.



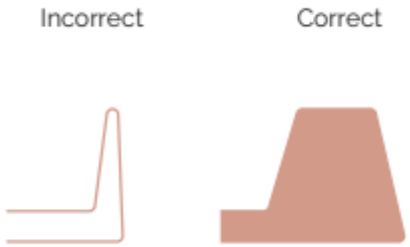


Constraint #1: What is the print area of your 3D printer?

The build plate is the part of the 3D printer that the design will be printed on. Usually it will be a glass rectangle at the bottom of the printer. Your designs are limited to the size of the build plate.

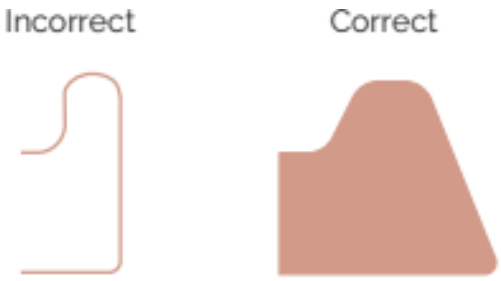
Constraint #2: Mycelium walls should grow at least 1 cm thick.

Consider wall thickness of design and the impact on the strength of the mycelium. Wall thickness where mycelium will grow must be at least 1 cm to be structurally sound. Avoid large thin walls, or intricate shapes.

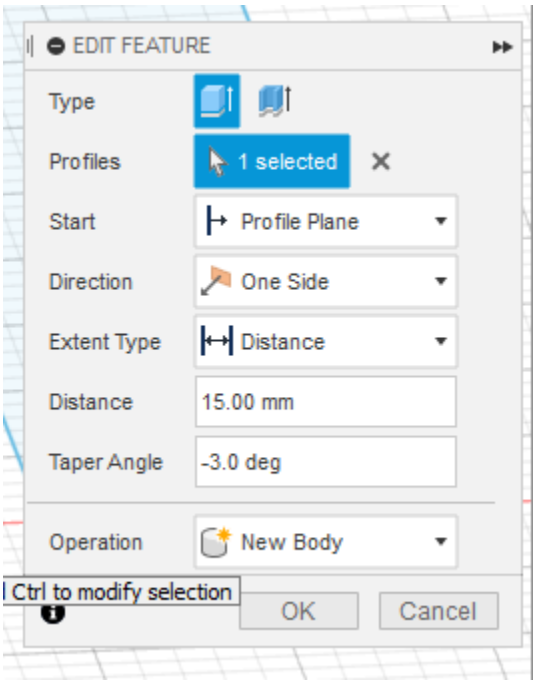


Constraint #3: There should be at least a 3° draft angle on all vertical walls.

When the mycelium grows to fill the form, it will then be dried in the oven and finally removed. To successfully remove the mycelium from the growth form, it helps if the walls are not perfectly vertical. You can use the extrude tool to create draft angles by changing the 'taper angle', as seen in Lesson 6: Fusion 360 skills.



When you are extruding a sketch, you will likely want to use a negative taper angle, which will slant the wall like the image above. The walls should be slanted so that as the mycelium fills the form, it will be gradually more narrow towards the end of where the mycelium is.



Constraint #4: Fillet all corners to create a smooth, rounded edge.

Creating fillets will allow the mycelium to be more structurally sound and pop out of the form more easily. Instead of harsh 90° angles, use fillets to lessen the angle the mycelium is growing and drying at.

Constraint #5: Plan the growth form to be slightly larger than the final mycelium product.

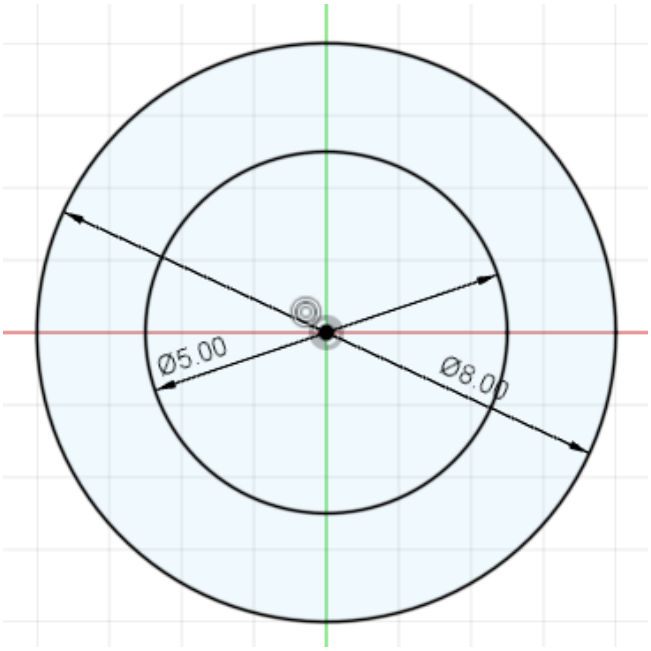
Consider shrinkage in the X, Y and Z planes and the implications on the desired size of the mycelium form.

The desk organizer will shrink a height of 7%, and a length and width of 4%.

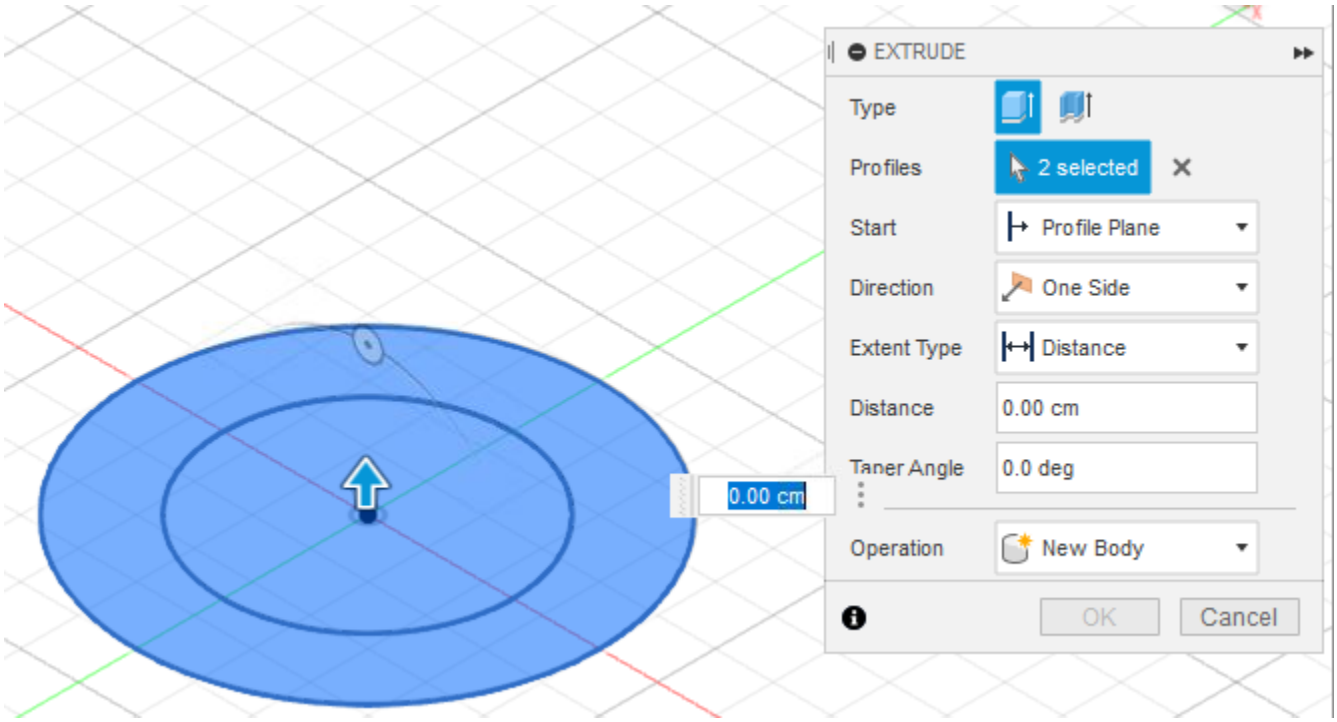
Practice:

1. Constraint #1
    a. Find the brand of the 3D printer you will be printing on, and then look up or measure the print area. Record this for your reference.

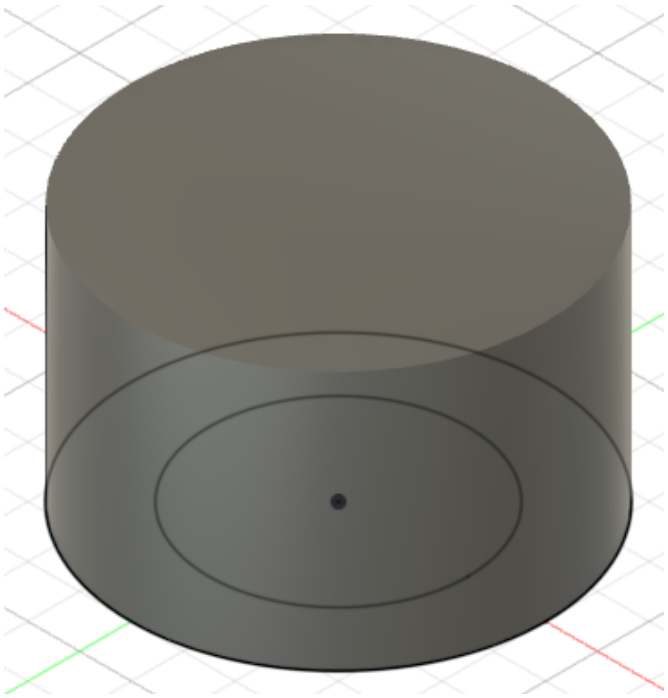
2. Constraint #2
    a. Practice making a simple mycelium form and adjusting the wall thickness.
    b. Start out by creating 2 sketches of concentric circles along the XY plane. **Hint:** the space between these two features will be where the mycelium grows. Make sure this space is at least 1 cm wide! More is even better to make it more structurally sound. The example below gives a space of 1.5 cm.



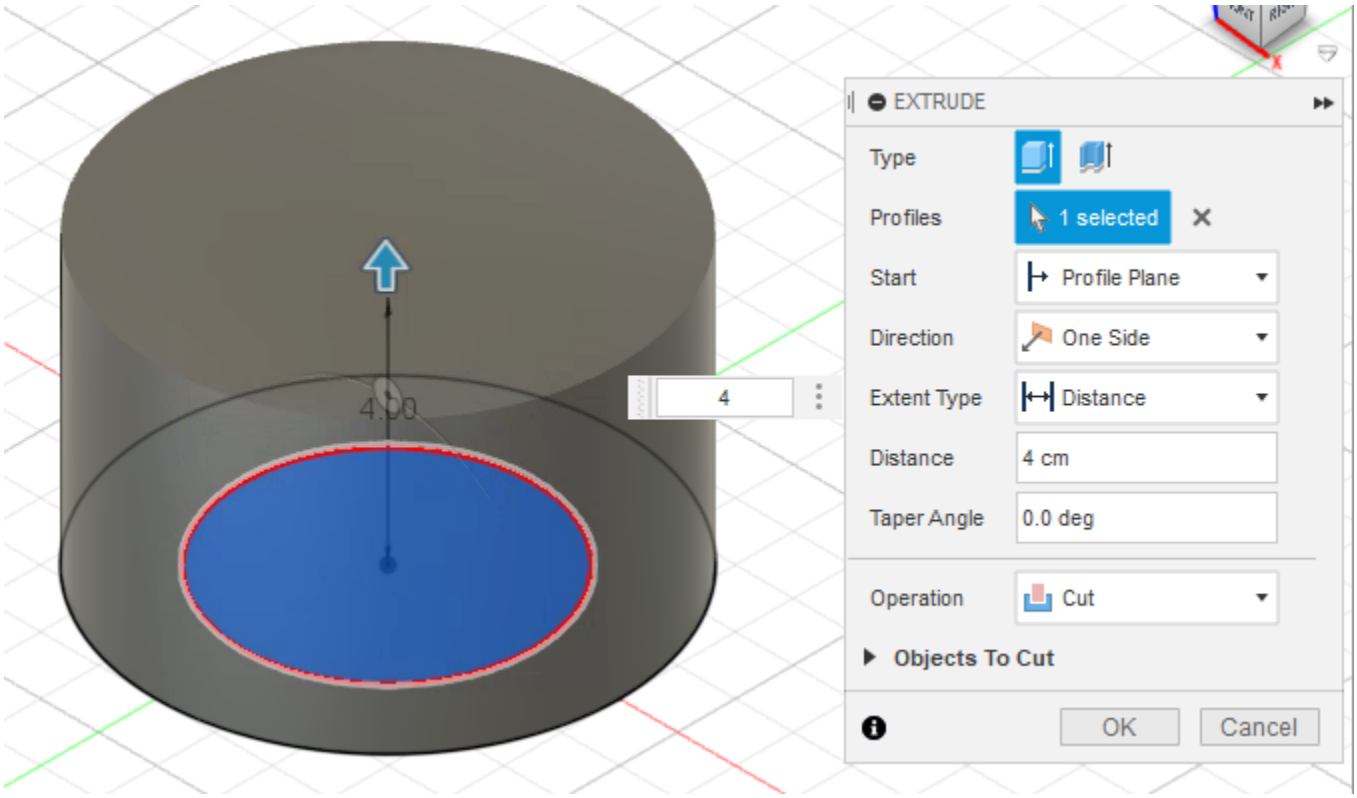
    c. Extrude the whole sketch to give it a height of 5 cm. You can do this by holding down “control” as you click on both the inner and outer sections of the sketch.



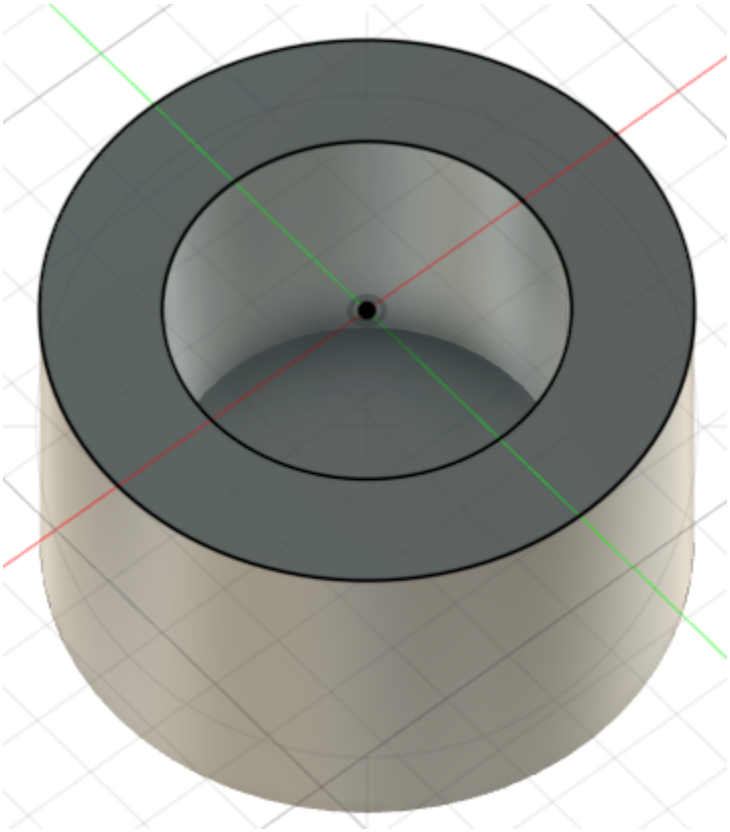
d. Extrude to 5 cm.



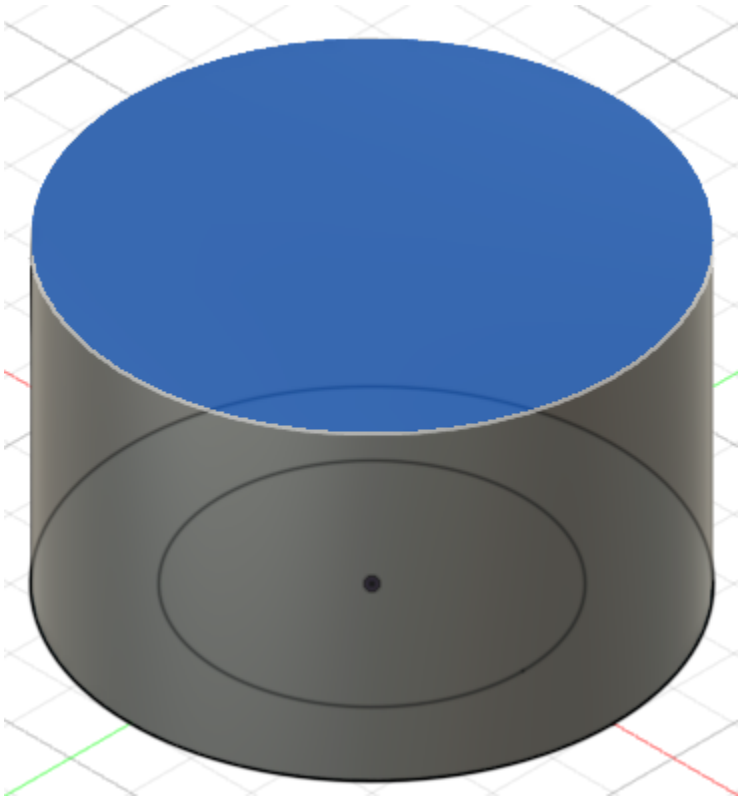
e. Then click on the inside circle to extrude it. Change the operation to “Cut” in the Extrude preferences. Extrude to 4 cm.



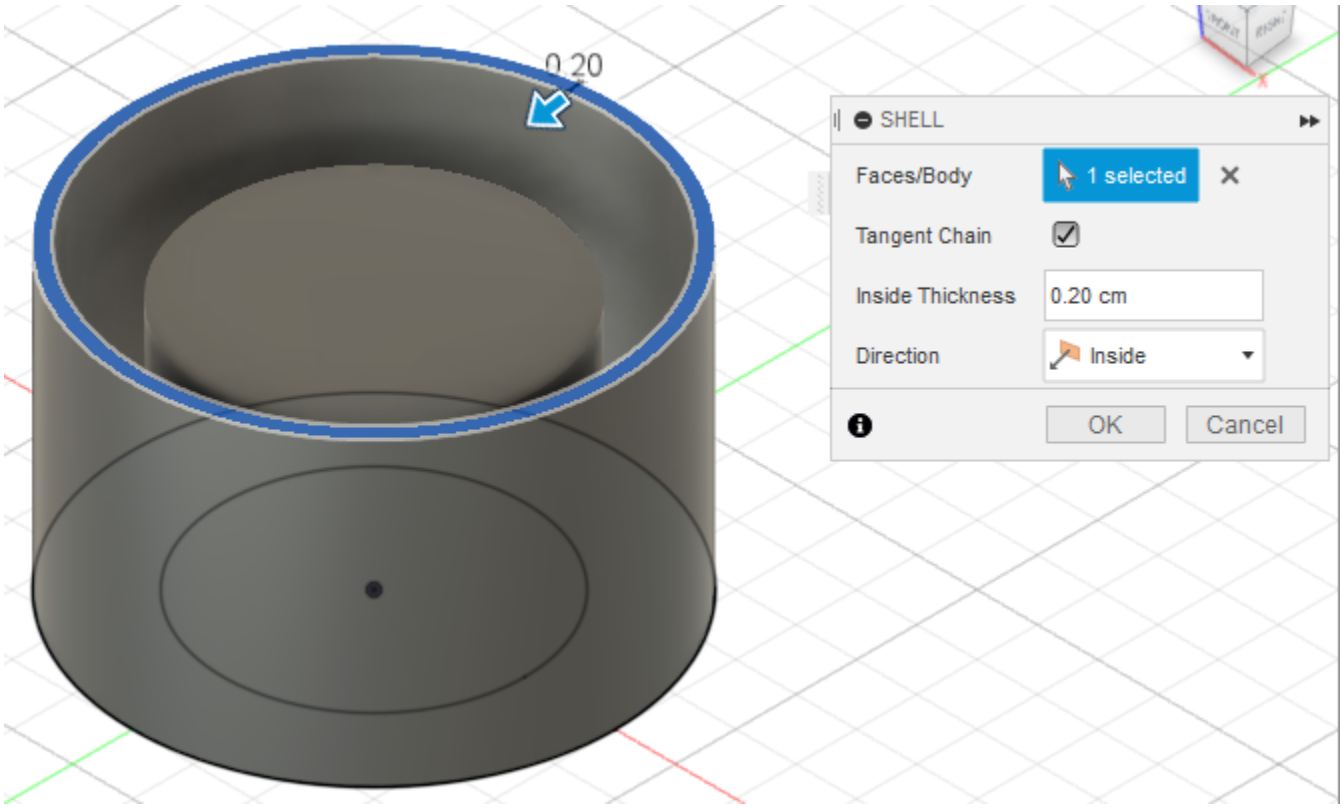
f. Use the orbit tool to rotate so you can see the hole in the center where you extruded.



g. Now go to “home” on the view cube so that you are viewing the bottom side once more.

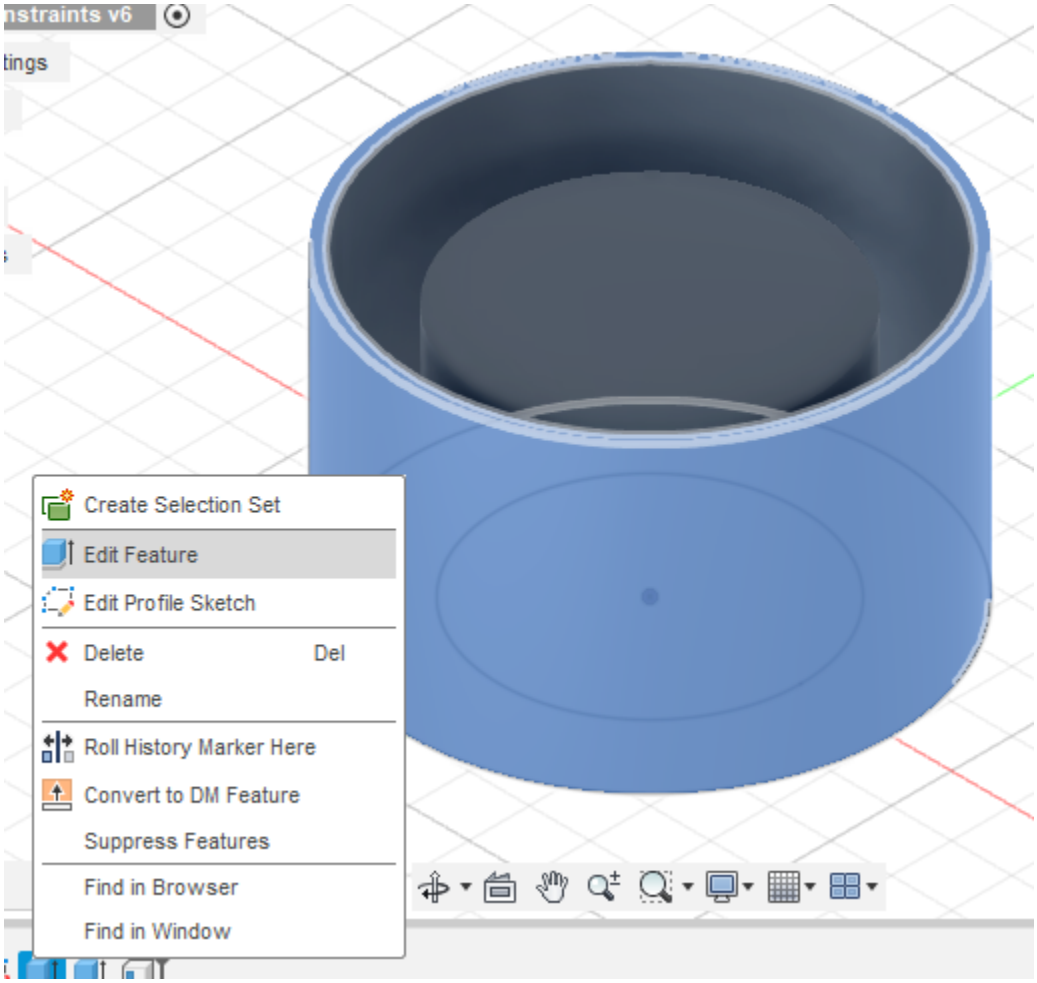


h. Shell out the bottom of the form to make it hollow. When you shell, you are creating the width of the walls that will be 3D printed. It's helpful if the 3D print is thin, around 0.2 cm. This will make the form flexible and will avoid wasting excess printing filament.

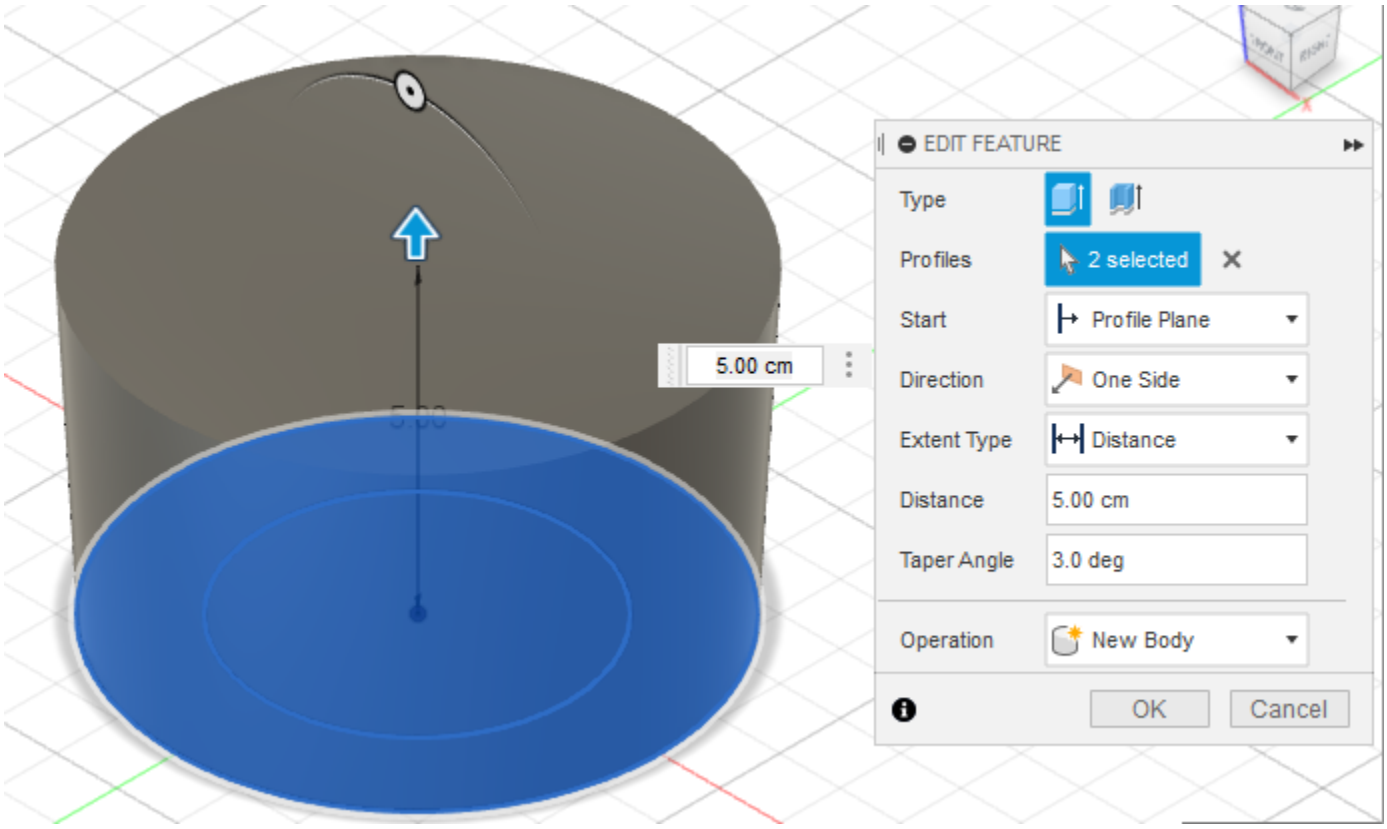


3. Constraint #3
    a. Notice in the form you have created so far that the walls are vertical. This will make it difficult to pop the mycelium out of the form after it is done growing. This is the importance of creating a draft angle.

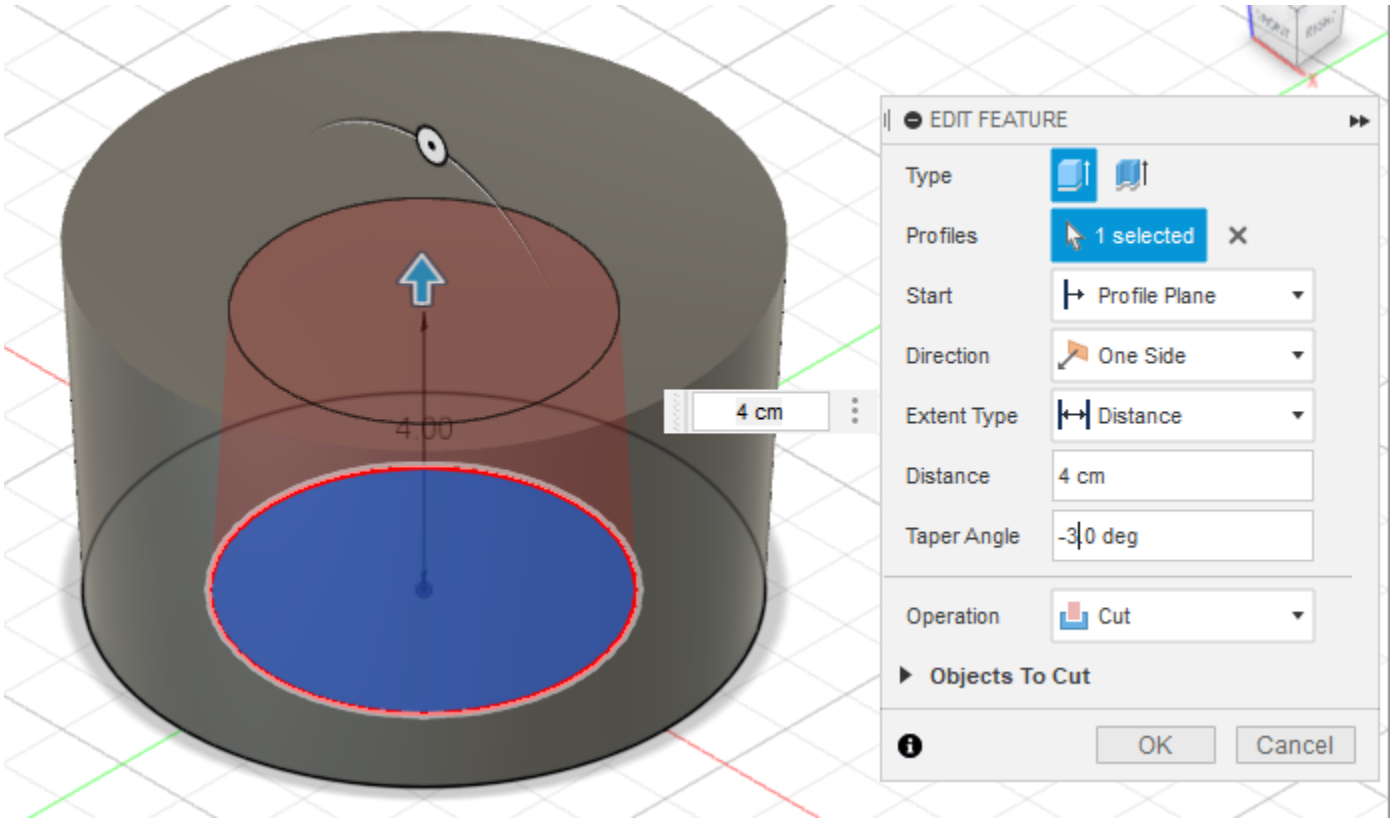
    b. Go to the bottom of the screen where the timeline is. Right click on the first extrude icon and click “edit feature”. This will allow you to edit the first extrusion.

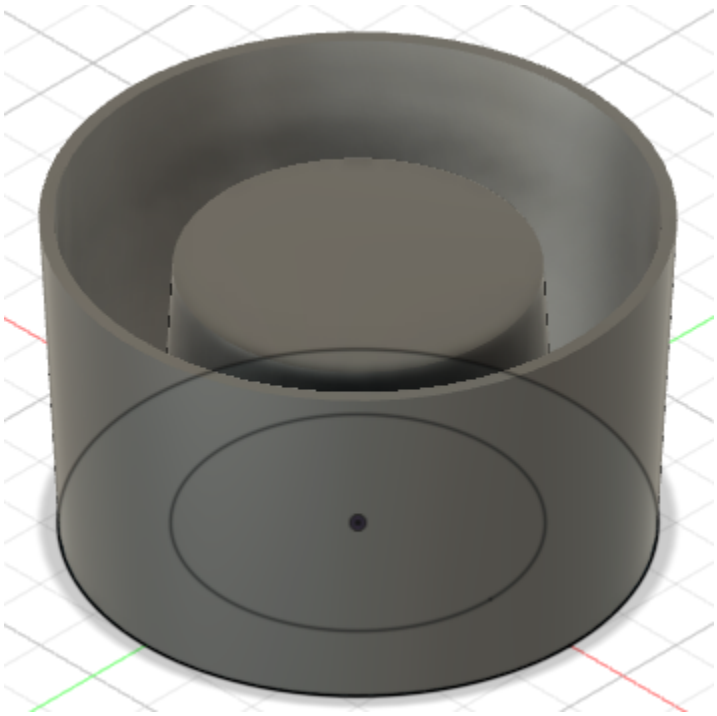


    c. Now change the taper angle to 3. Observe how the walls become wider at the top. This will make it smoother for the mycelium to pop out of the form.

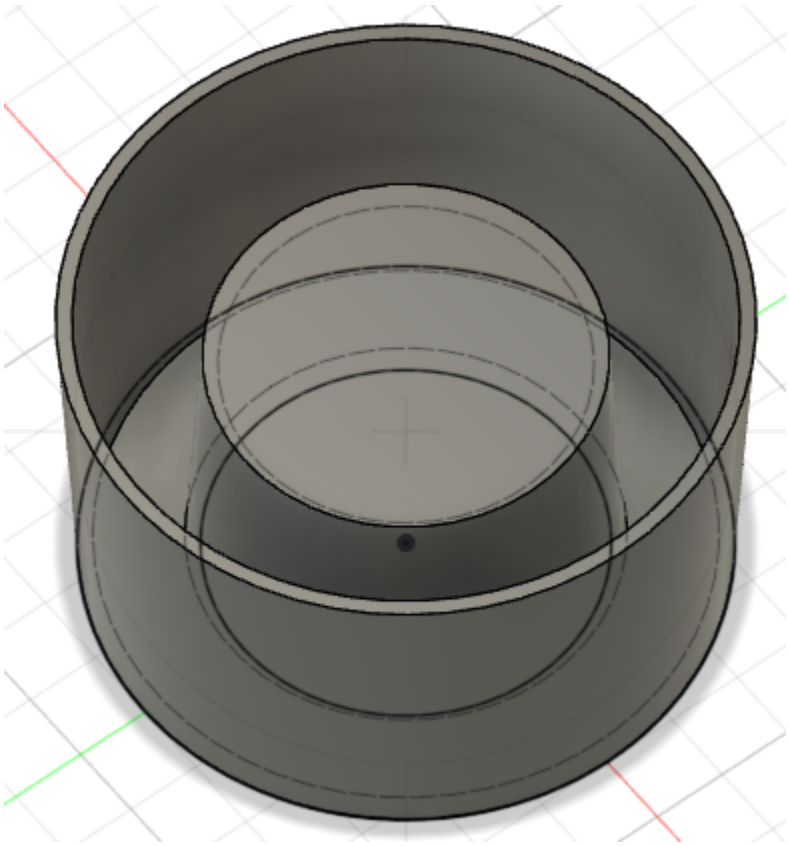


d. Now extrude the inside circle. This time give it a taper angle of -3. Notice how the inner walls get more narrow. This provides even more space for the mycelium to pop out.

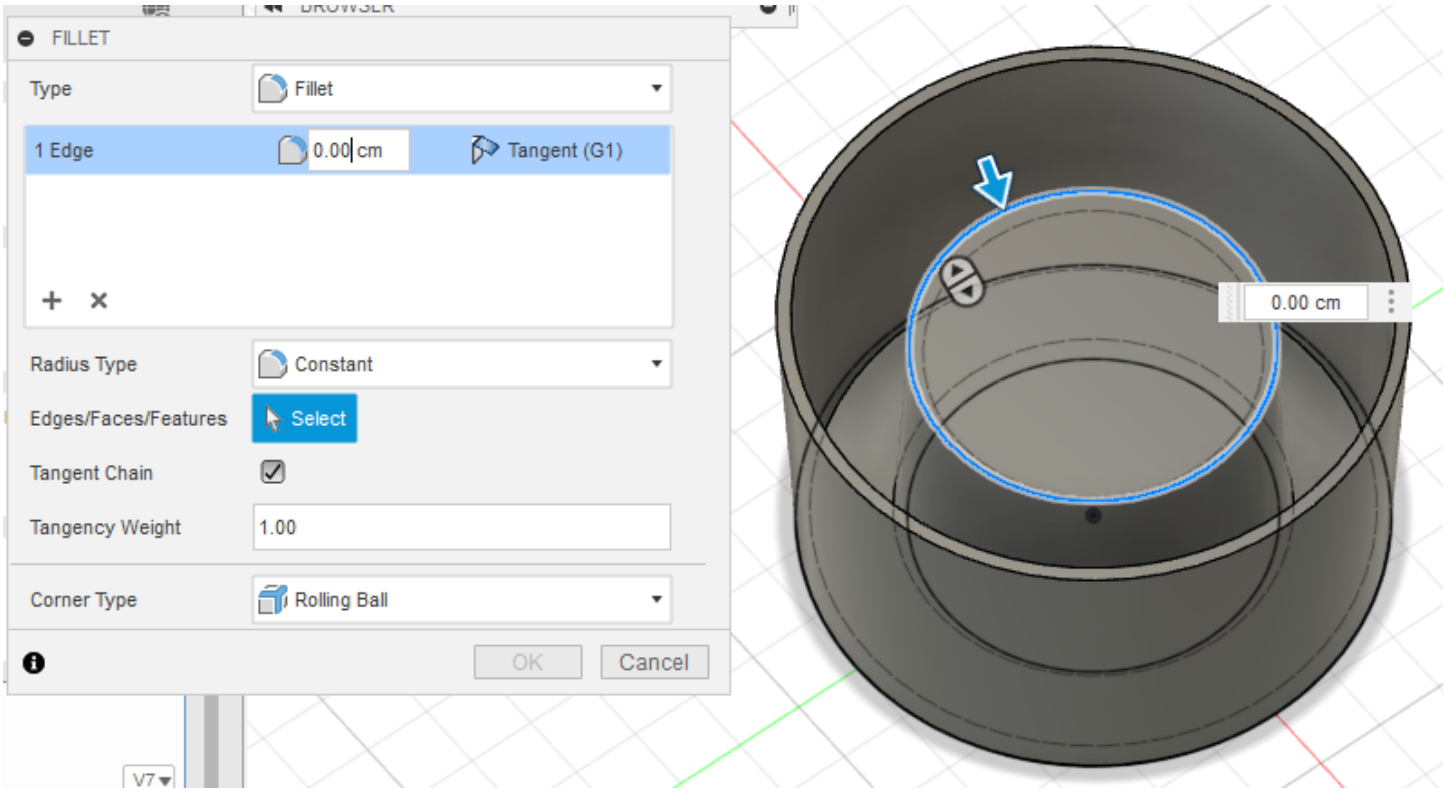




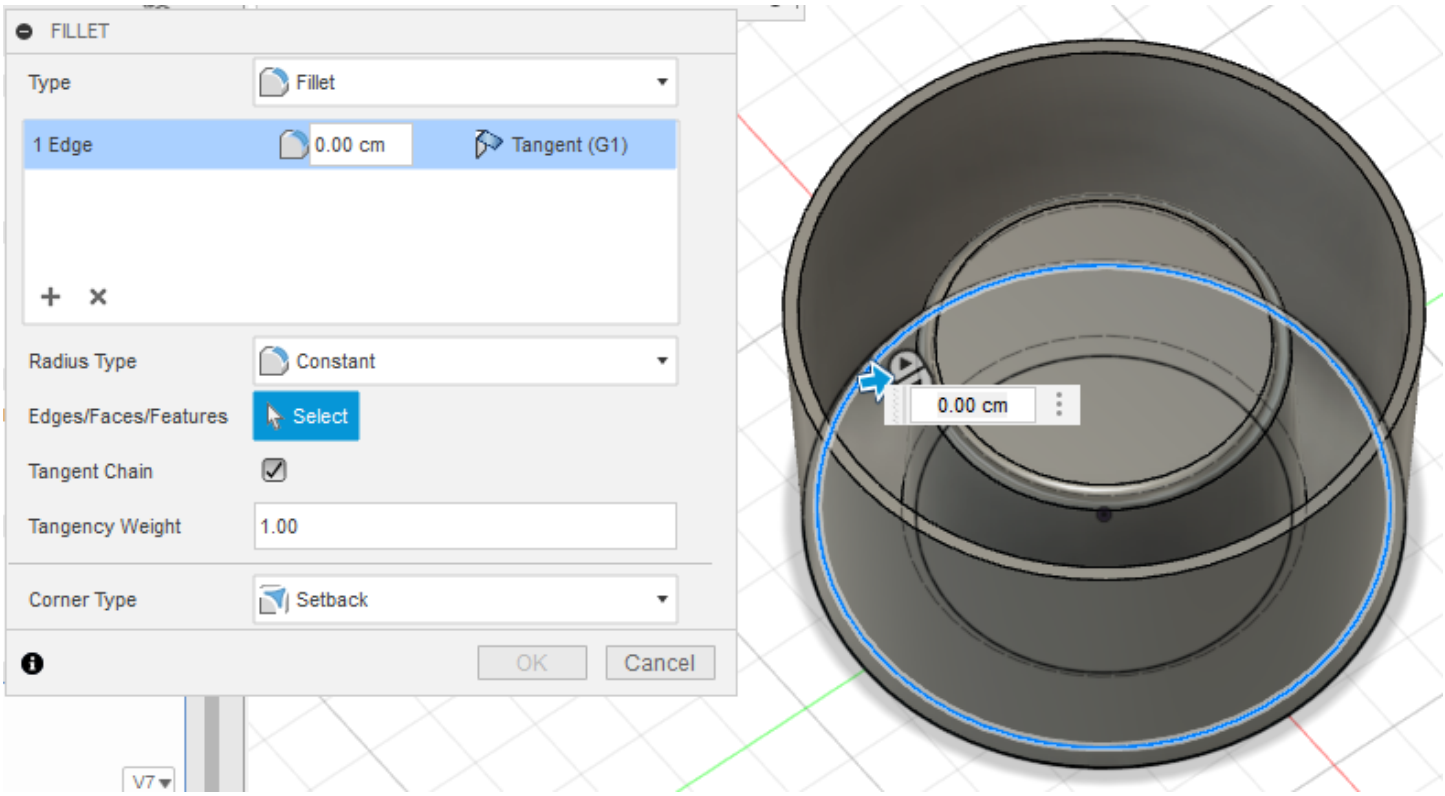
4. <u>Constraint #4</u>
    a. Now we want to get rid of any harsh 90° angles to make it easier for the mycelium to solidify. Notice all edges in the model below. The mycelium will fill the 1.5cm space inside of the form to create a bowl.



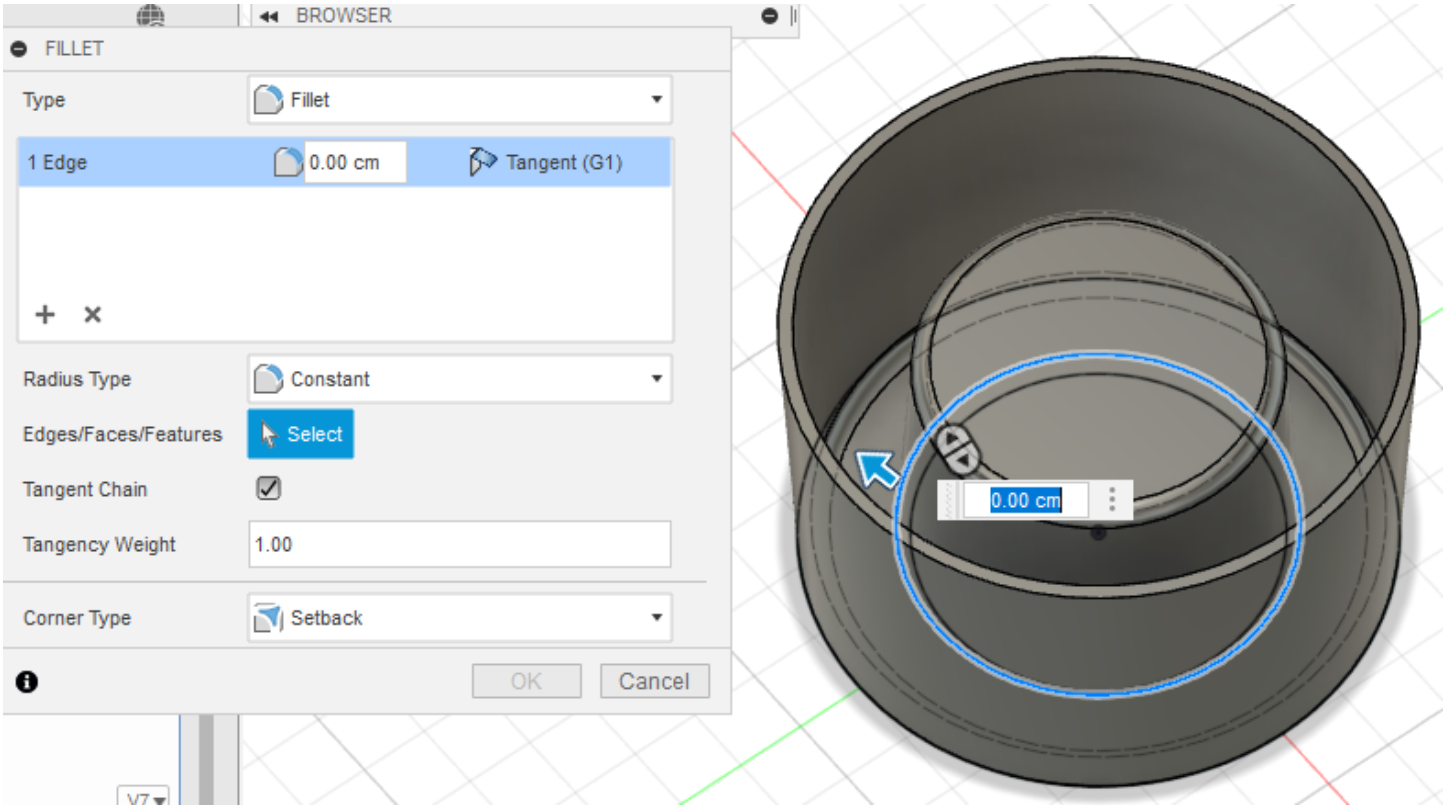
b. Click on the edge of the inner structure. Fillet with a corner type of “rolling ball” (which works well for exterior edges). Fillet at least 0.25 cm.



c. Click on the bottom wide edge inside of the form to fillet. Choose a corner type of "setback", which works well for interior angles. Fillet at least 0.25 cm.



d. Do the same for the inner angle. Use a corner type of “setback” with at least a 0.25 cm fillet.



e. At the bottom navigation panel, go to Display Settings. Click Visual Style and set it to “wireframe”. Here you can view the rounded fillets you have made, as well as the tapered angles.