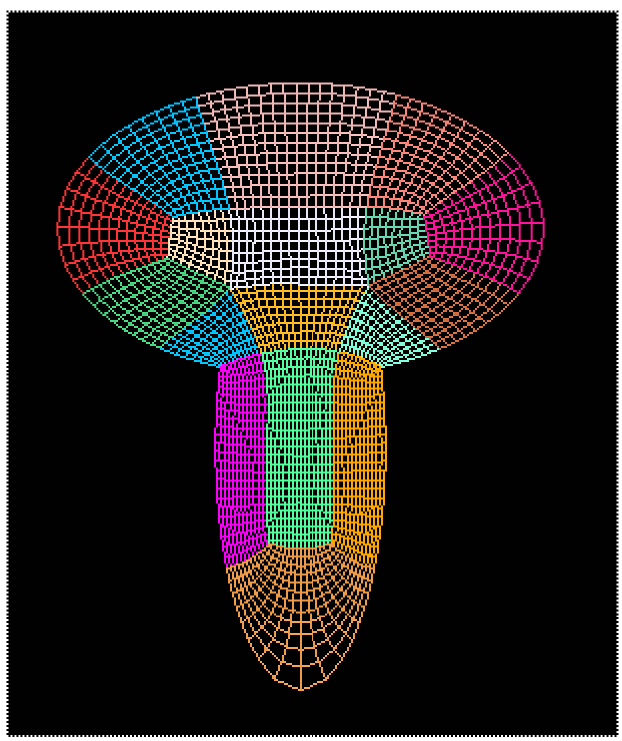
Tutorial 4.1: Gridding Two Intersecting Ellipsoids

Many cases involving grid generation require the user to create an internal surface that defines the grid angles between two intersecting tubes or joints. Examples include tubing used for cooling, flow distribution, piping inside of an automobile or aircraft, or blood vessels attached to a heart. In this tutorial we learn how to mesh such geometry that often includes sharp angles or convex corners. In Tutorial_**4.1** we will learn the basic concepts of how to mesh an idealized geometry (a mushroom shaped region formed by two intersecting ellipsoids) and will use the same principles in Tutorial_**4.2** where we will create the mesh in 3D. In Tutorial 5 we will apply what we have learned in Tutorial 4 to create a grid on an example that is more likely to appear in practice.

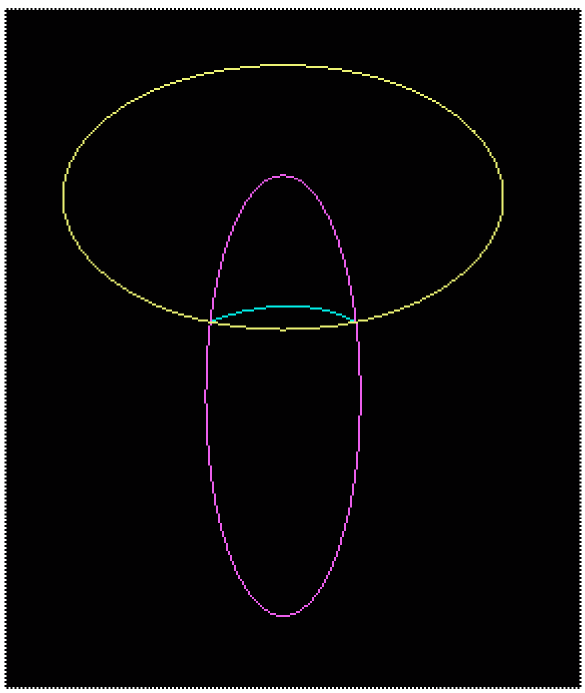
What You Will Create



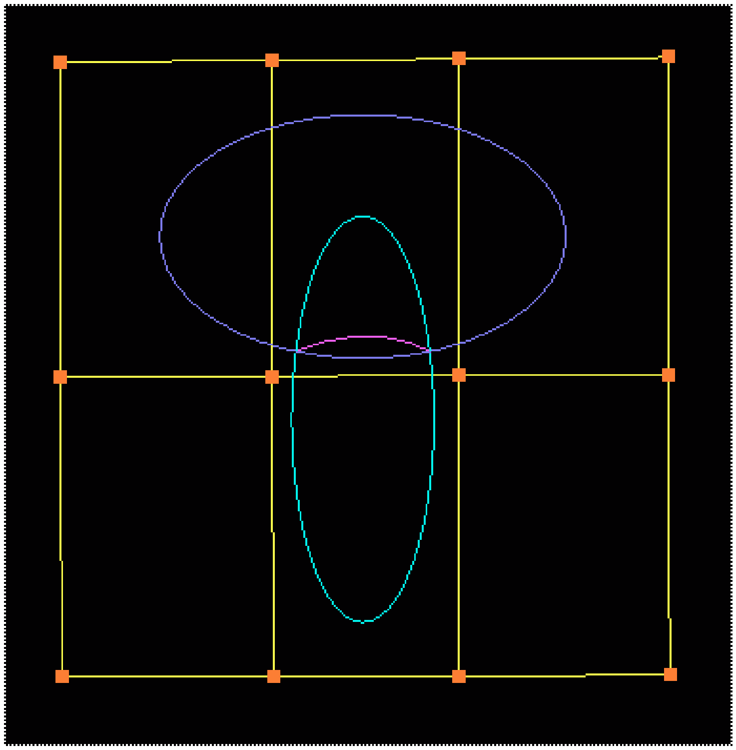
What You Will Learn	• Using an internal surface to create a grid around a convex corner • About triple surface assignments • Introducing singularities

Step 1 Creating the Topology

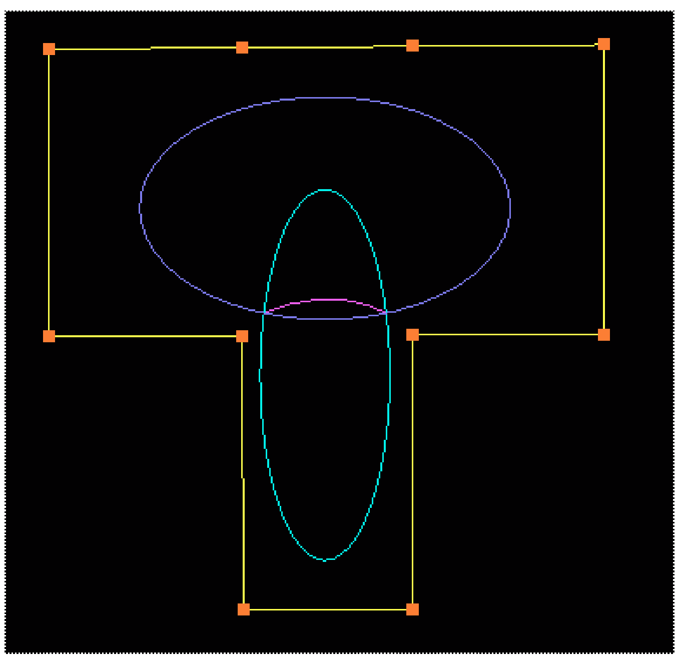
Load up the **Tutorial_4.1.fra** file and turn off the **Cut-Plane** and the **Global Axis**.



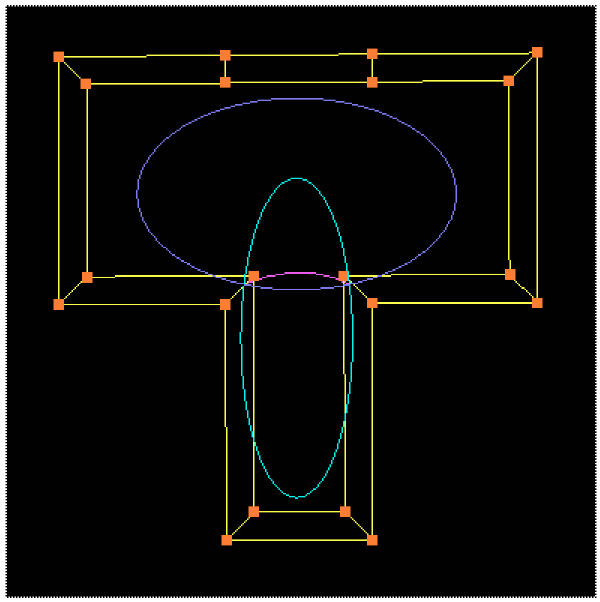
In **GridPro,** it is required to use an internal surface to mesh a convex corner around a sharp edge above 180 degrees. In this case, the internal surface has been provided and is colored in light blue as can be seen in the above picture. We need to create the topology for the full mushroom which includes the cap and stem. However, let's first answer the question as to why we need an internal surface by inspecting the quality when we grid the stem and cap without it. Create a large rectangular box around both surfaces and then slice it by inserting topology sheets around the stem and intersection as in the picture below.



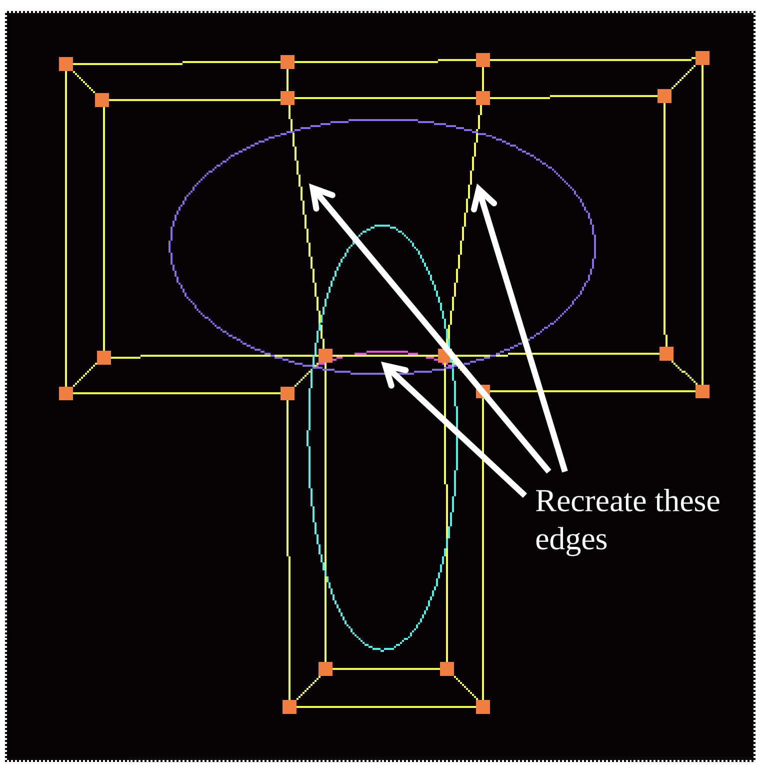
Remove the lower right and lower left corners, and the inner edges of the topology.



Now we are ready to create the wrap. Add the remaining topology to **Group 2** and wrap it 10% smaller as in the picture below.

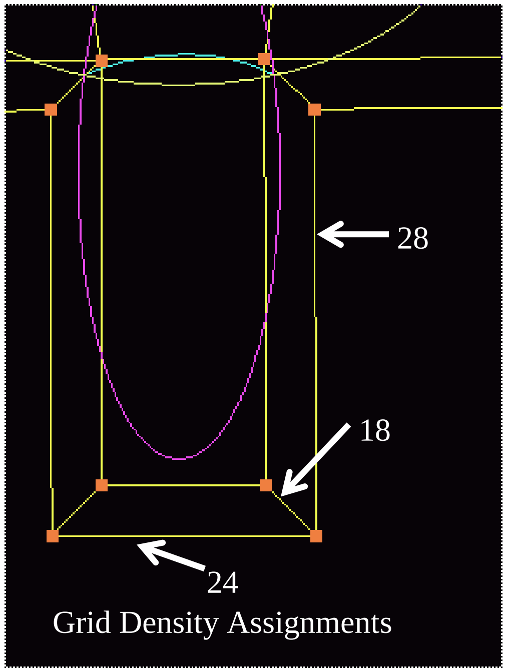


Since we want to create an internal mesh, we need to add internal edges to the wrap so that **GridPro** knows to create an area mesh inside the surfaces (2D mesh areas are defined by loops of four corners, otherwise there is no defined area).



Step 2 Grid Density

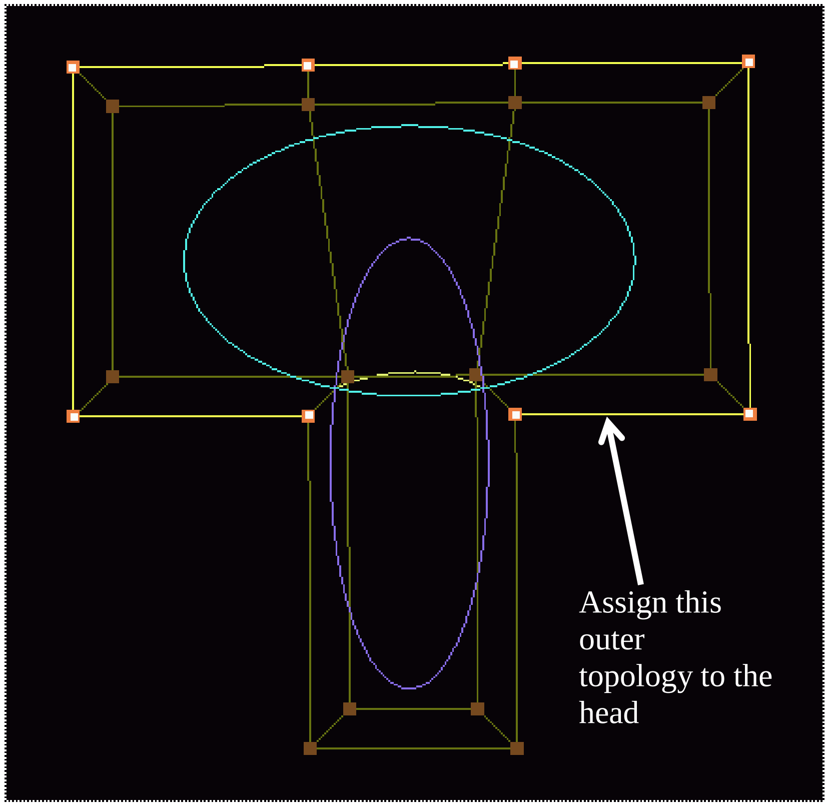
Assign the mushroom stem the same density numbers as in **Tutorial 3**; leave all of the other surfaces at their default values. See the picture below.

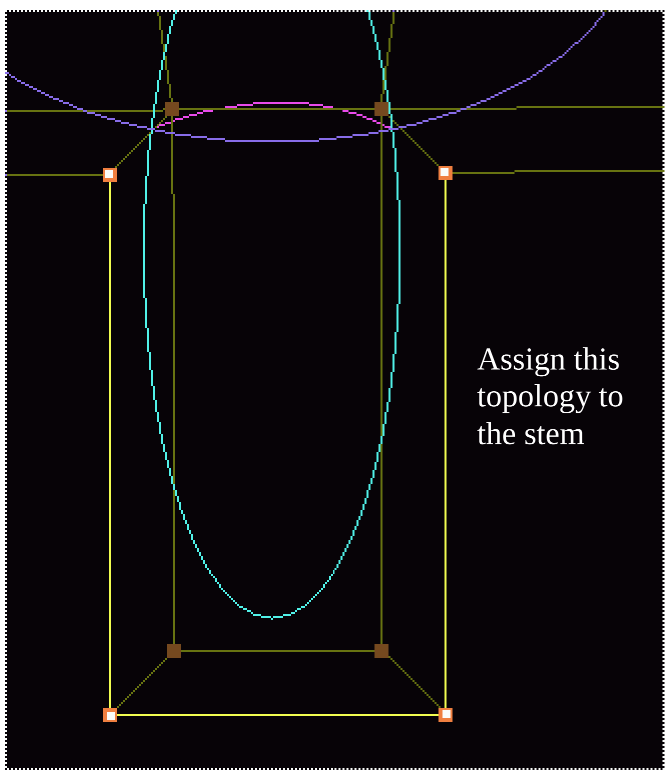


Grid Density Assignments

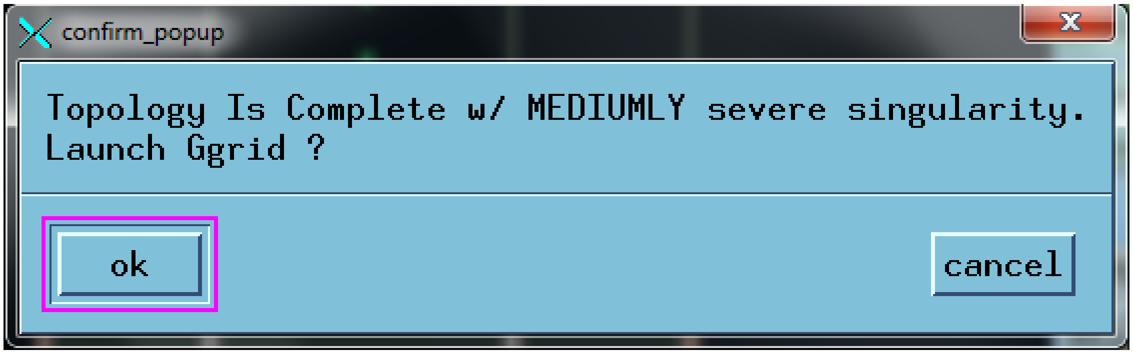
Step 3 Surface Assignments

Now that the topology is created, let’s assign the corners to the surfaces. Since we want to ignore the curved intersecting surface, it will not receive any surface assignments. As for the mushroom stem and cap, according to previous tutorials, our intuition tells us to assign the topology to their respective surfaces with a double assignment at the intersection. Let’s proceed with this method and see what we get. Remember, only the outer topology should be assigned to the surfaces while the wrap remains unassigned so it can converge to equilibrium inside the area.

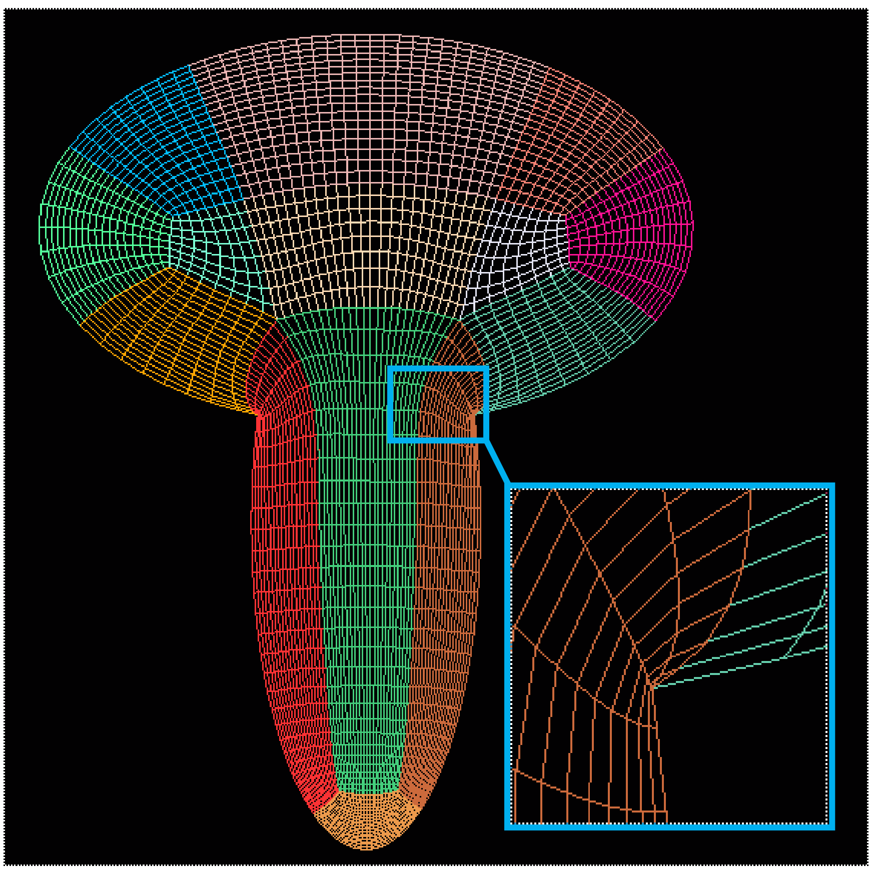

Assign this
outer
topology to the
head


Assign this
topology to
the stem

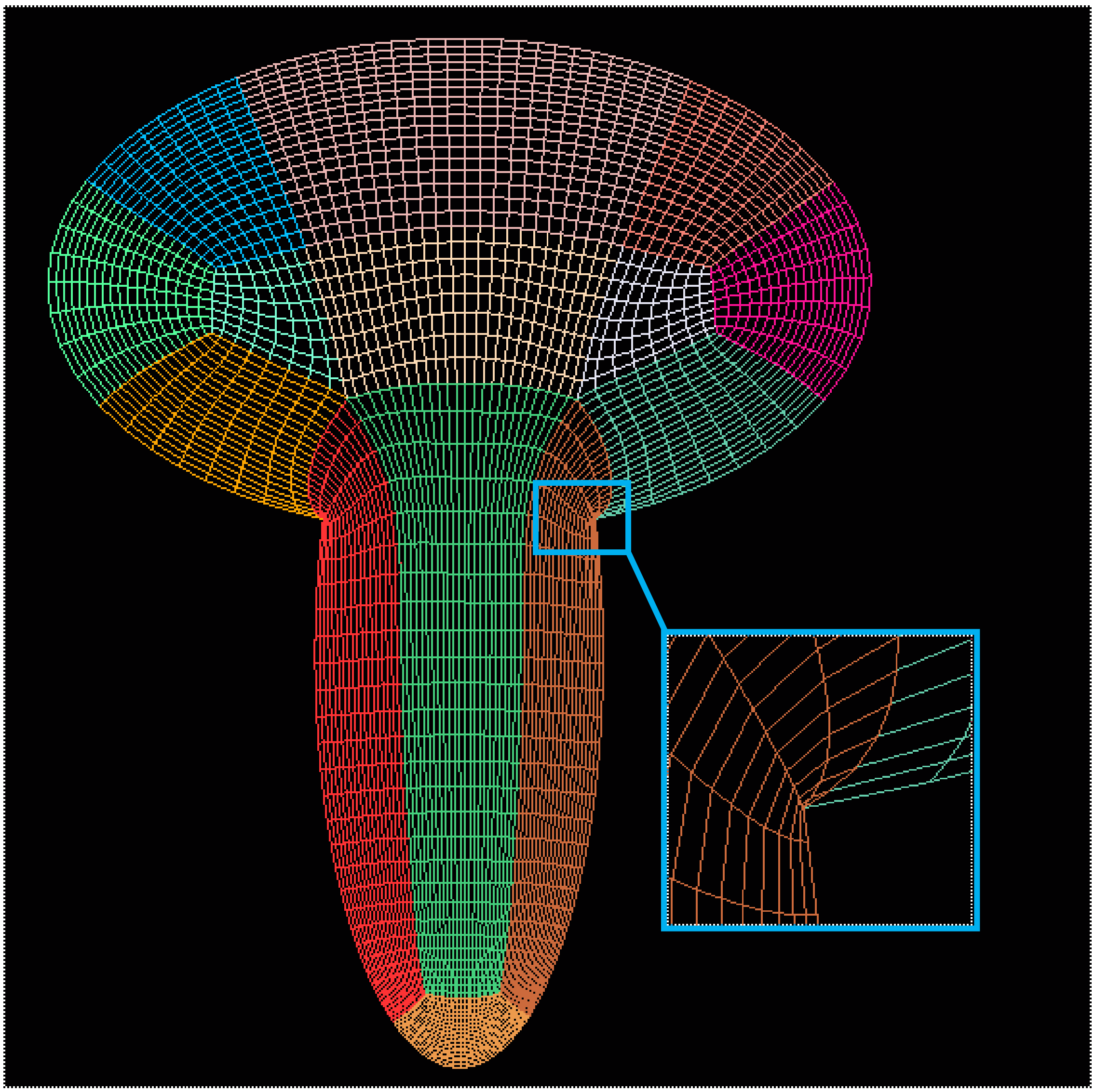
Now start the gridding process and see what happens. A pop-up menu with a singularity warning will appear.



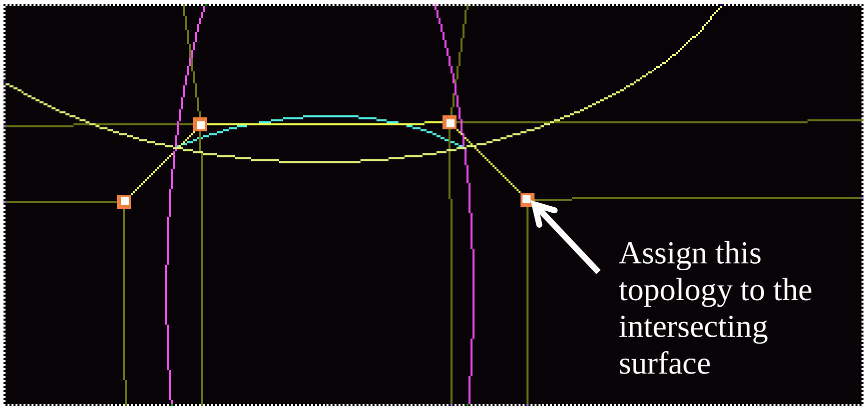
At this point, let’s ignore this error by clicking on **ok**. Wait a minute and then load up and view the mesh.



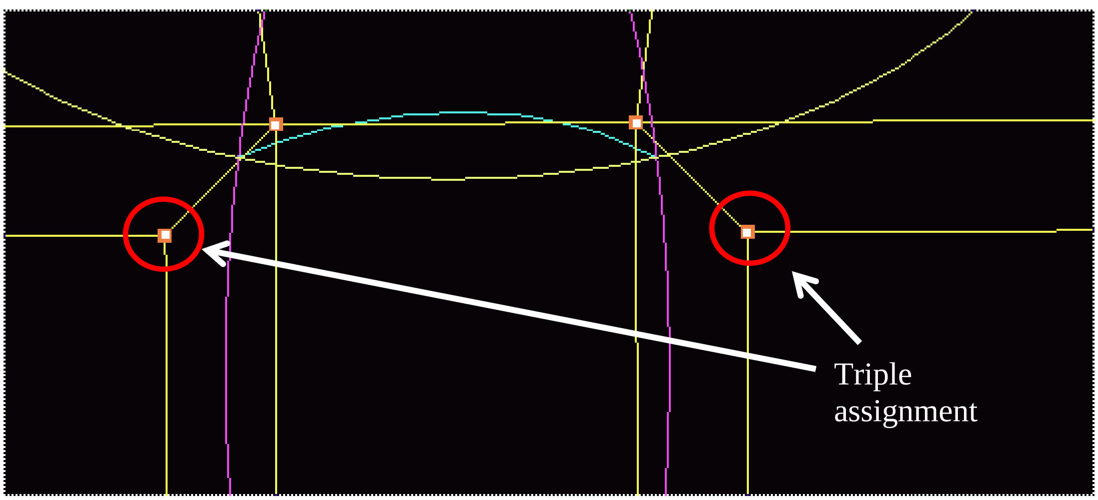
As can be seen from the above picture, the mesh is highly distorted particularly at the intersection. The mesh at the top of the stem is floating up into the mushroom cap; while the two double assigned corners remain fixed at the intersection causing the mesh to fold at that point. One way to make the problem less severe would be to reduce the mesh density which will result in a reduction of *pressure* on the fold at the fixed pints. Reduce the number of points along the length of the stem from 24 to 14 and let's run the grid again and look at the results



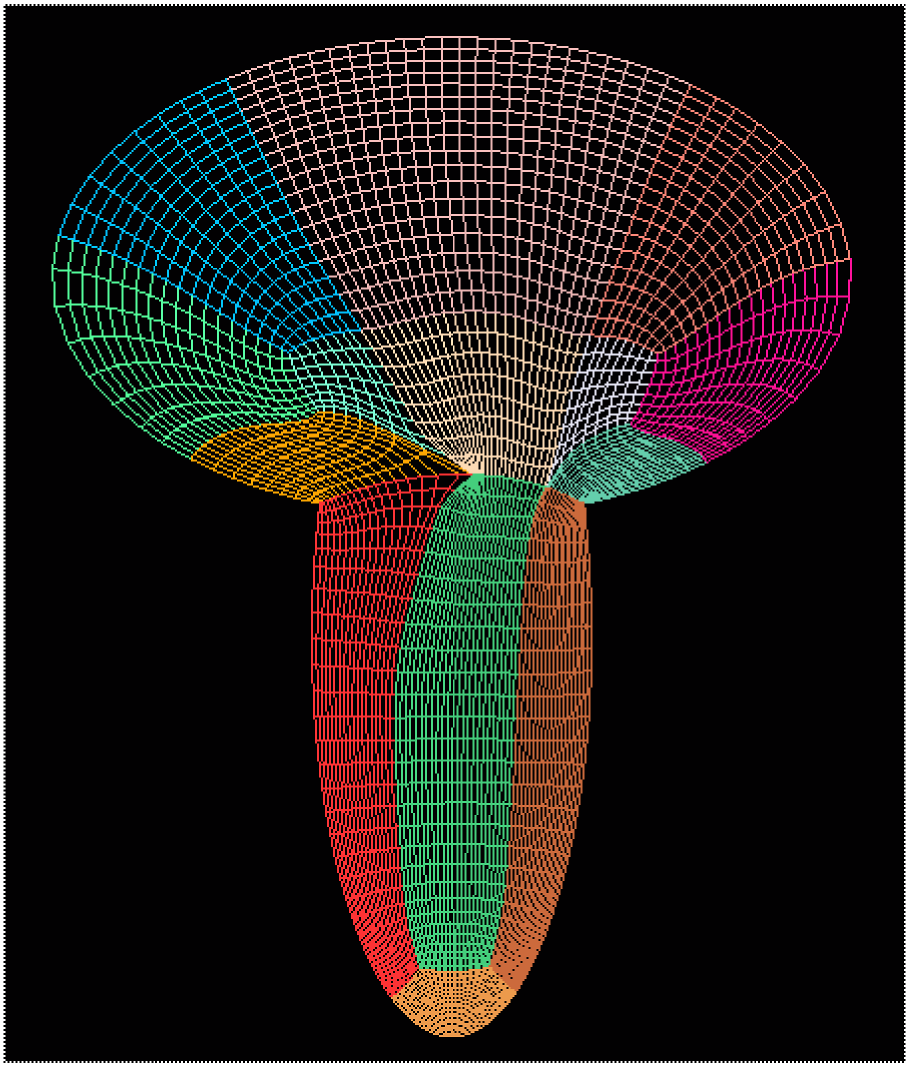
The grid is better, but the fold still exists at the intersection. We can continue to reduce the density to improve the results, in fact we may be able to eliminate the fold, but this method is unreliable. How shall we proceed? A more exact way to avoid this problem is to fix the grid at each intersection point by using an internal surface that bisects the angle over each convex corner. We want the internal surface to be a mesh surface so it is then necessary to assign the topology to the intersecting surface. Let's make these assignments and analyze the results.



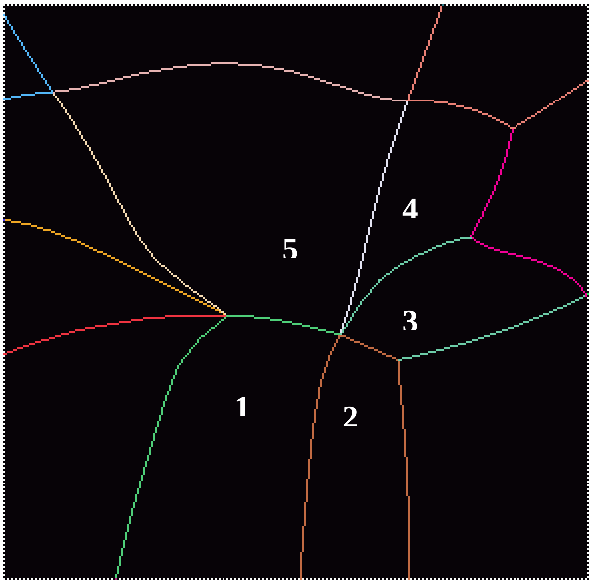
Two points at the intersection will be triple assigned to the mushroom cap, stem and the internal surface. See the picture below.

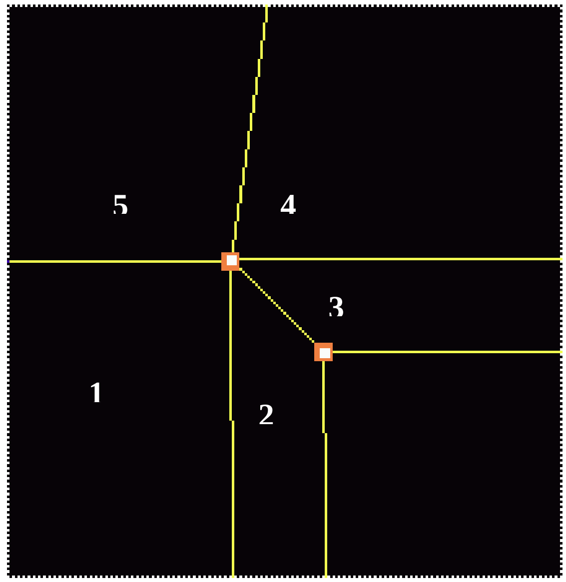


Start the gridding process. Again, a pop-up menu with a singularity warning will appear. Let's run the grid anyway and analyze the results. Load the mesh into the grid viewer. It should look like the picture below.



As can be seen, the mesh is highly distorted, and if the code is allowed to run for a few more minutes, it will probably diverge and eventually stop. Let’s look at the block pattern and topology at the point of intersection on the right (deletes the mesh in the **CUR** sub-command panel and make sure the blocks are turned on).

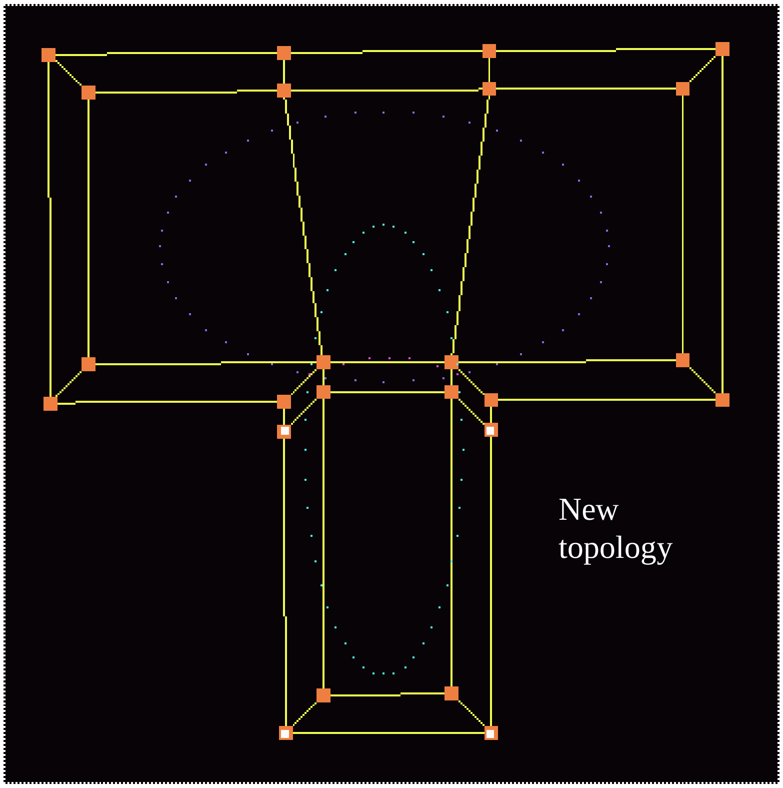


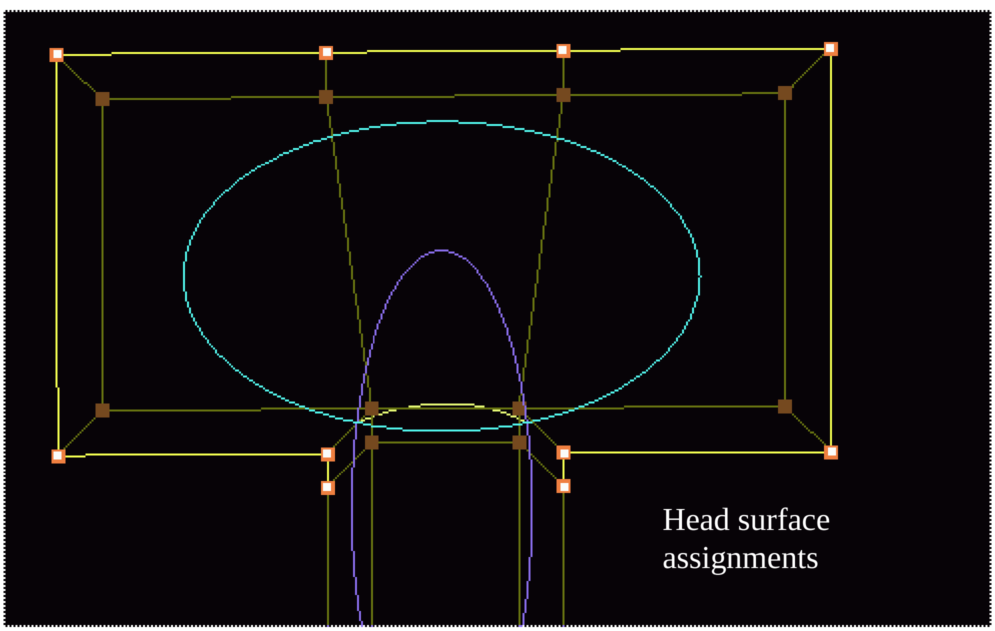


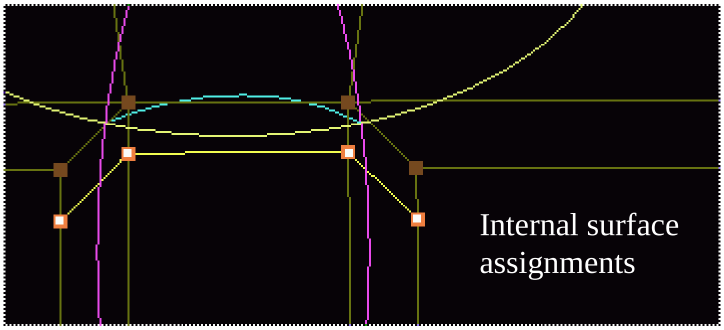
From the above picture we can clearly see the problem. On the right side, the topology was designed with a singularity of five blocks sharing a corner as opposed to four. Unfortunately, this singularity along with a similar one was assigned to lie on the internal surface. How can we avoid such a problem? To do so, we need to push the singularities away from the internal surface. One way is to create a second layer of topology close to the intersection and reassign the surfaces as in the pictures below.

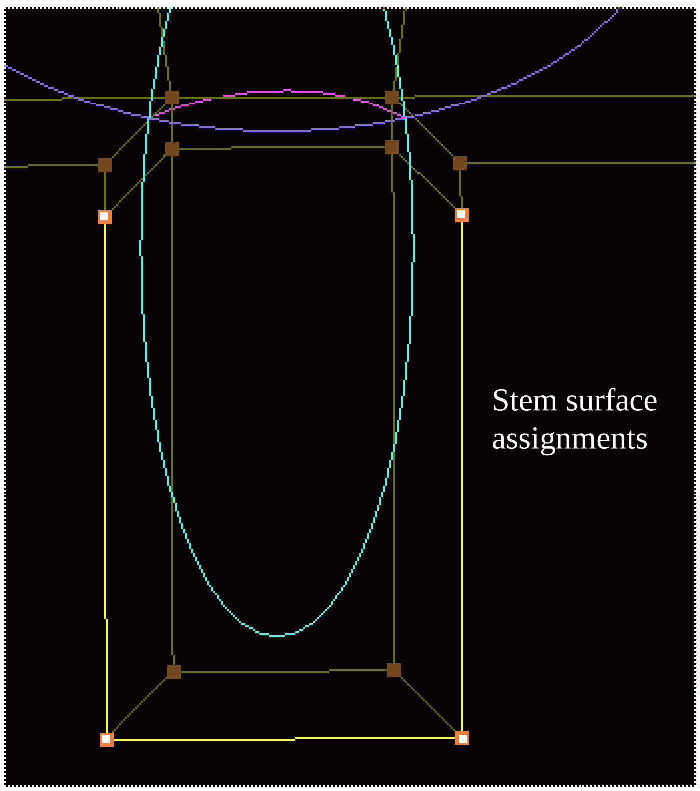
Introducing Singularities

Singularities are very important in understanding gridding in **GridPro** and will become more important downstream when the user creates grids of increasing complexity. A problematic singularity occurs when a block corner is assigned to a surface where certain local block patterns occur. The patterns are problematic when the block count is not equal to 2 on bounding surfaces, and not equal to 4 on internal surfaces. In this case, the singular pattern is composed of 5 blocks that are placed upon an internal surface (which should have two blocks on each side). To avoid this problem, we will create another layer of topology that will push the singularity away from the surface into the mushroom cap area. Singularities and their impact on the girding process will be covered in more detail in a later tutorial.

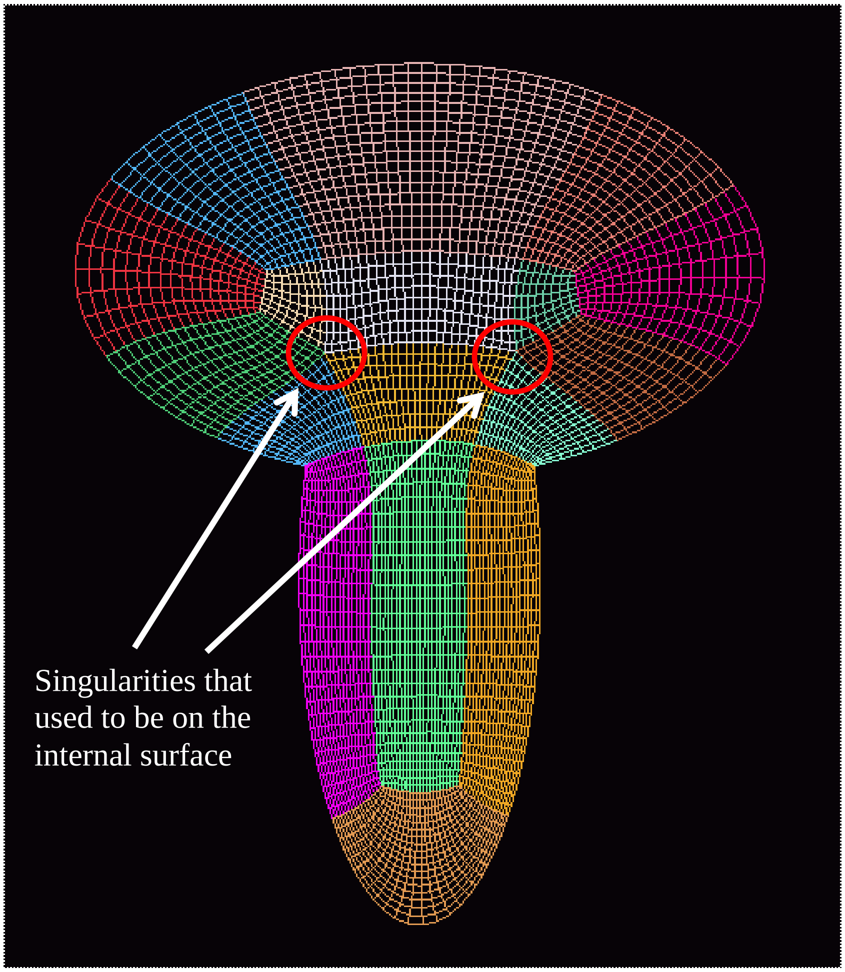

New
topology


Head surface
assignments





Now let's run the mesh and look at the results.



Notice that the singularity is pushed away from the internal surface and is allowed to converge to equilibrium within the mushroom cap. Also, notice how the internal surface defines a grid line that bisects the convex angle between the mushroom stem and cap.