

# Brian's Puzzle, version 4.0

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**By R. G. Sparber**

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Although the need for this approach is long gone, I still found it an interesting exercise. I got to use a few new tools and find a few new tricks. I think I also found a bug in Alibre<sup>®</sup> CAD.

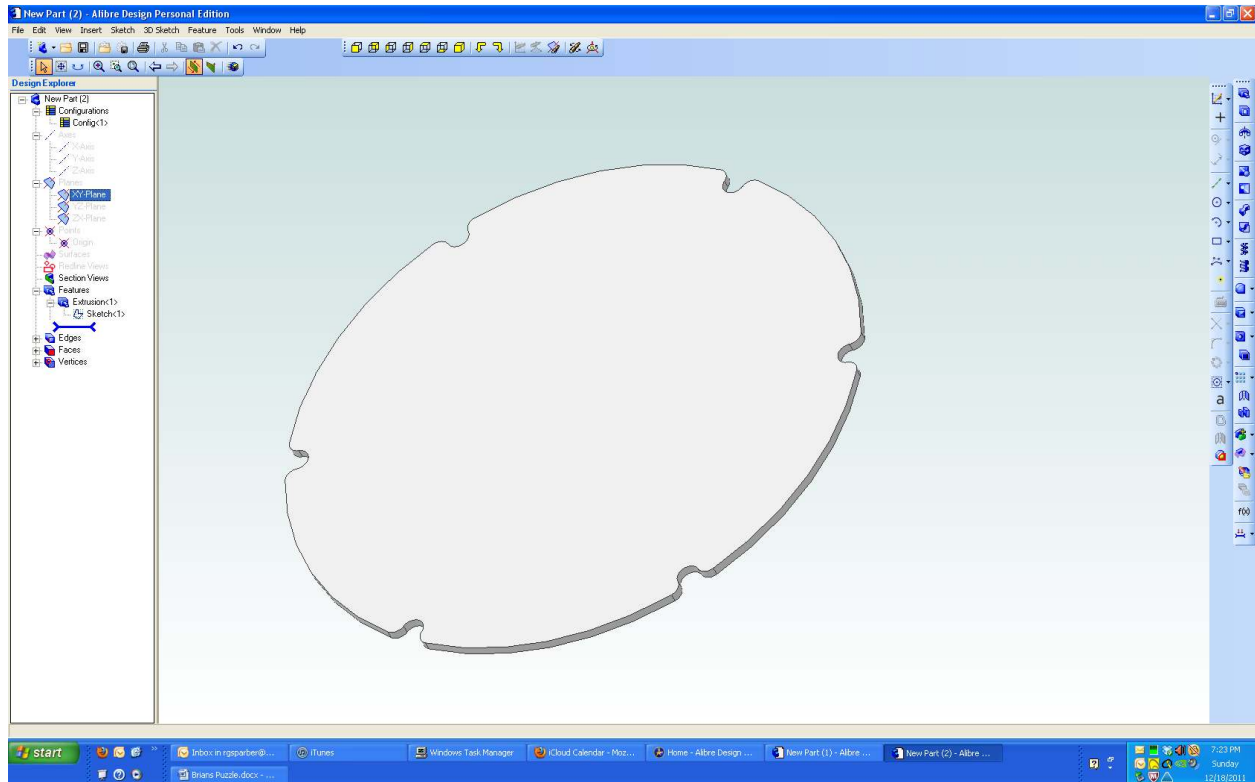
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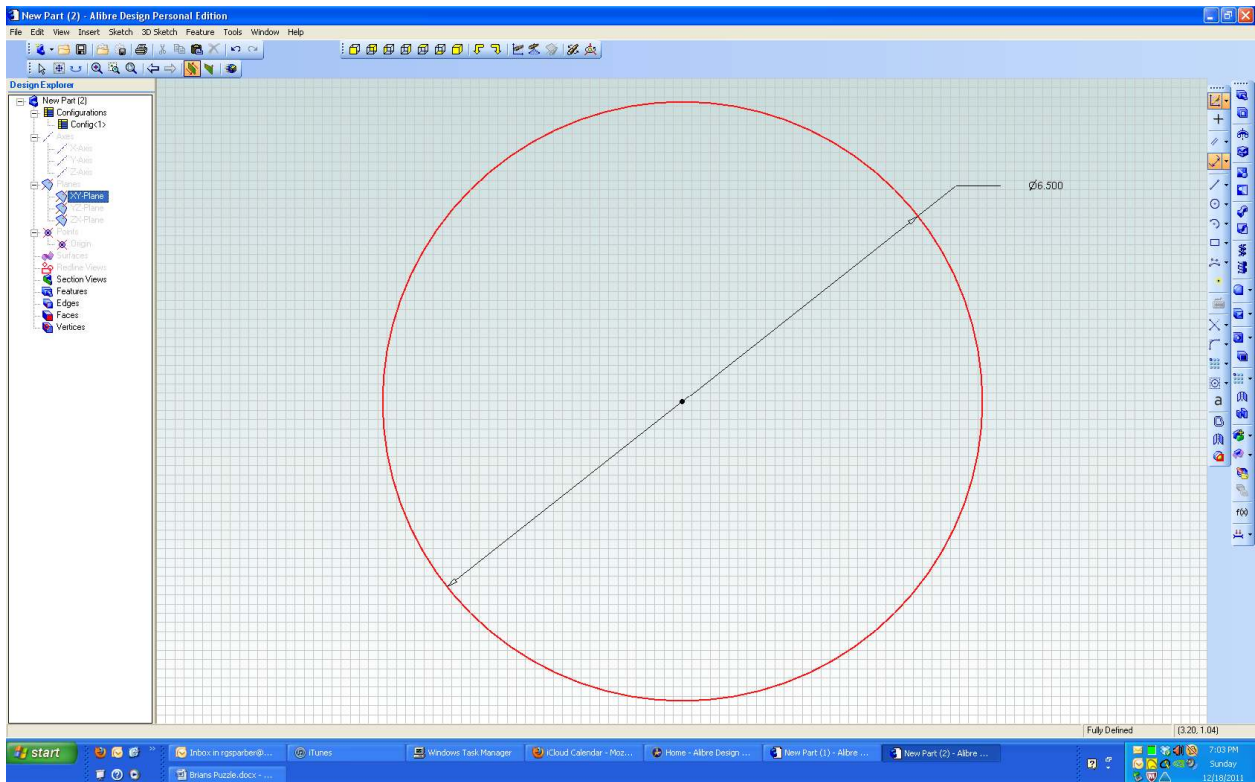
<sup>1</sup> You are free to copy and distribute this document but not change it.

# Flat Disk With Cut-outs

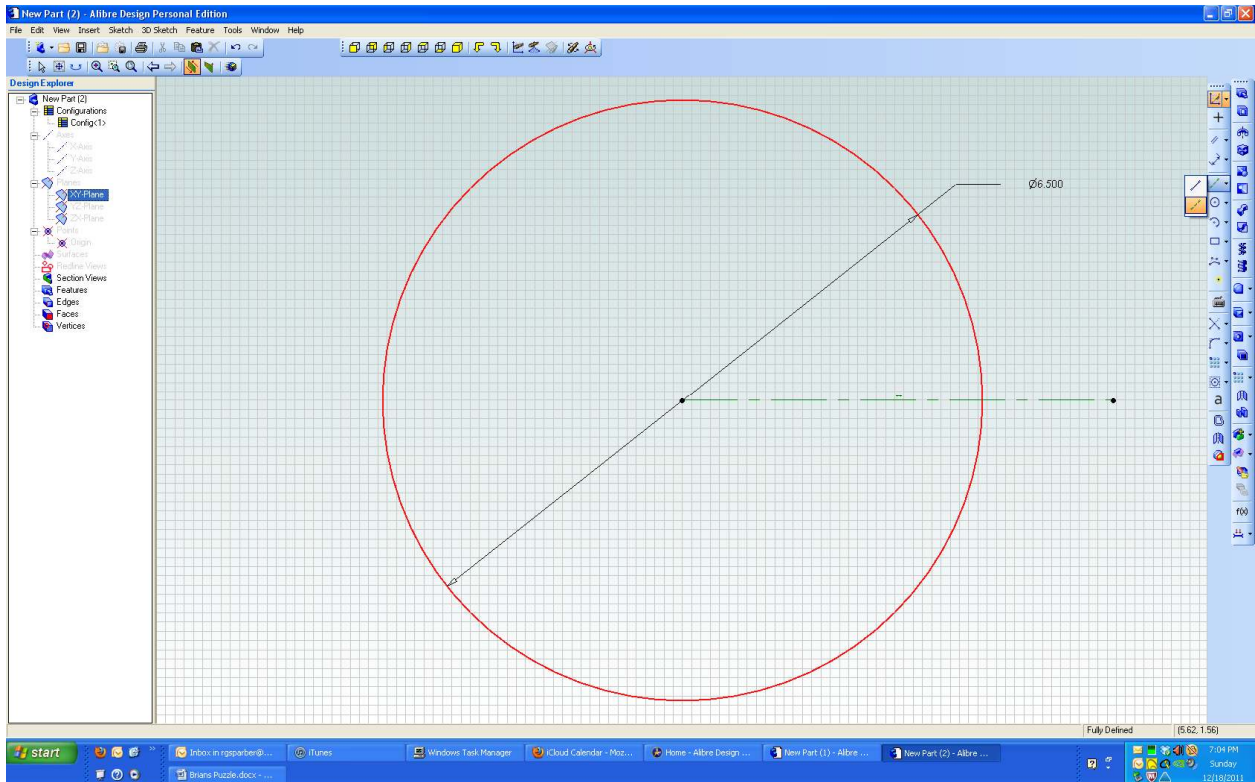
The first goal was to draw this:



Here is how I did it:

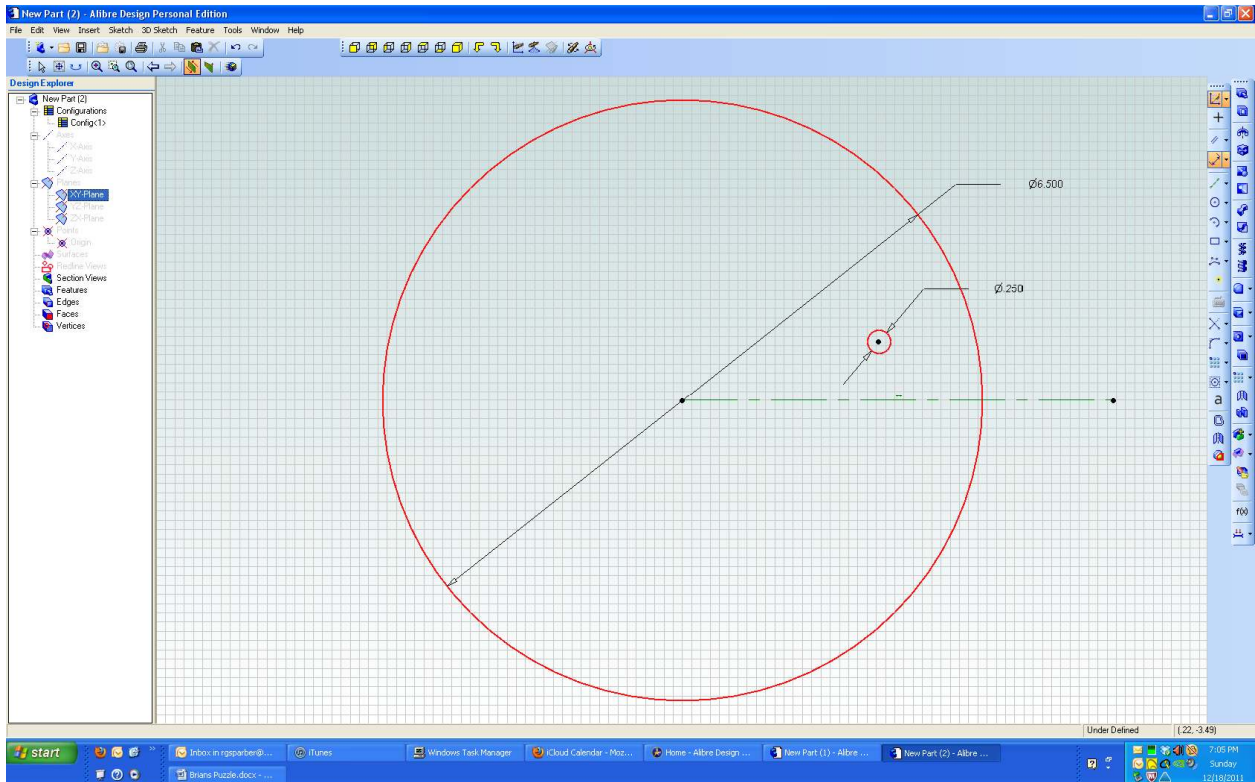


First I drew the major outline which is a 6.5" diameter circle.

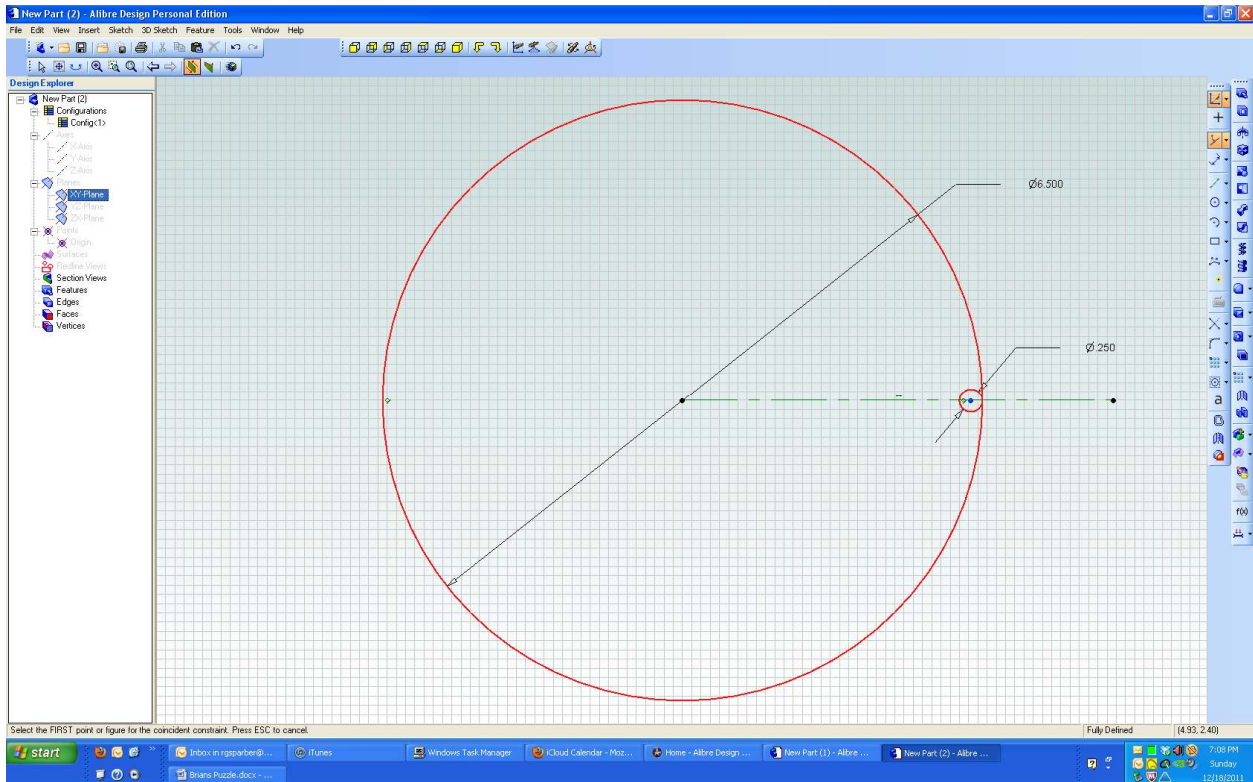


Then I drew a reference line from the center of the circle horizontally to beyond the perimeter.

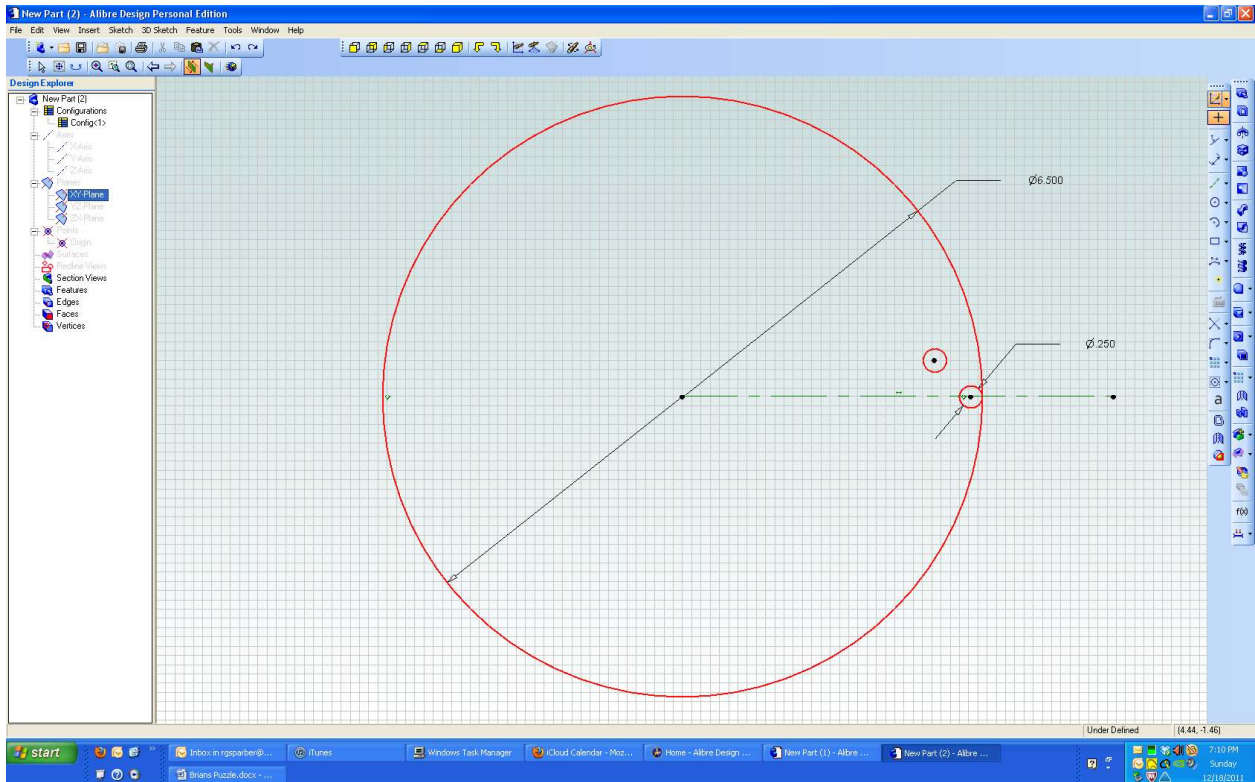




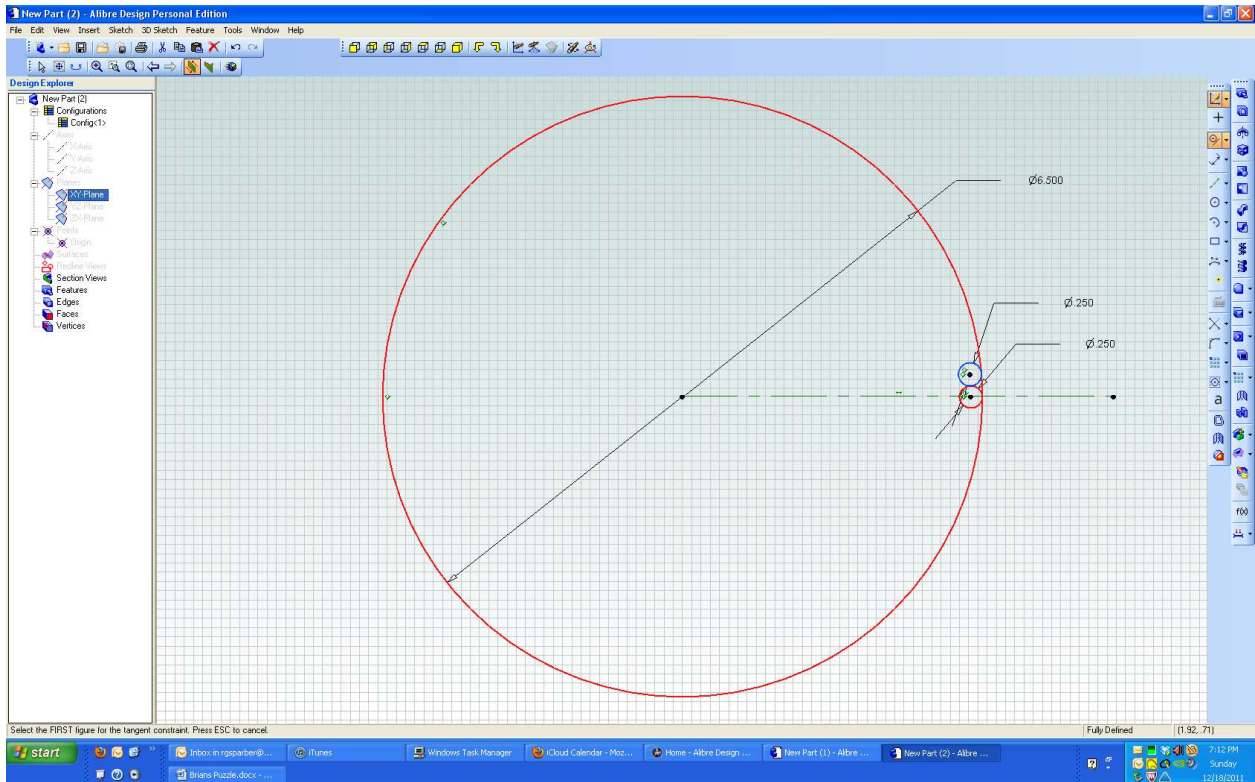
Next I drew a small circle and dimensioned it to be 0.25". This locks its size.



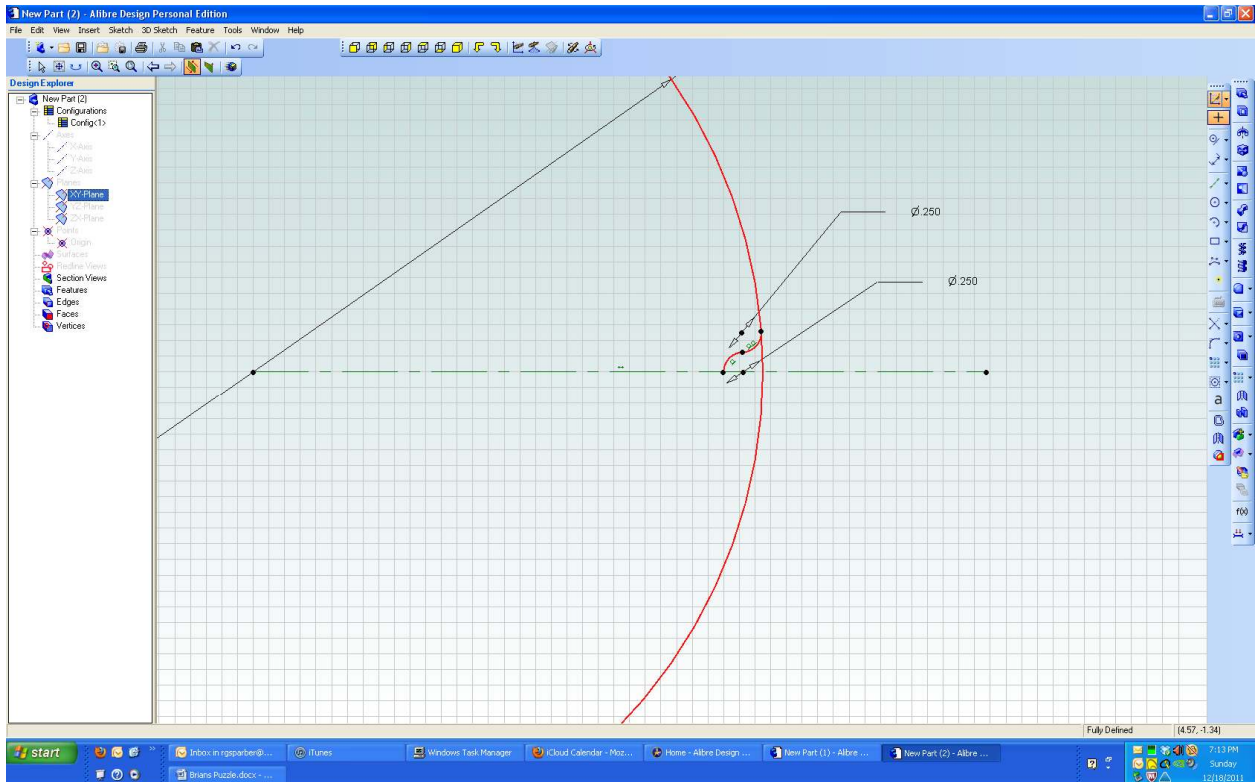
Using the tangent constraint, I locked the small circle to the large one. Then I used the coincident constraint to lock the small circle to the reference line. Since I wanted the small circle to move in each case, it was always the second object clicked.



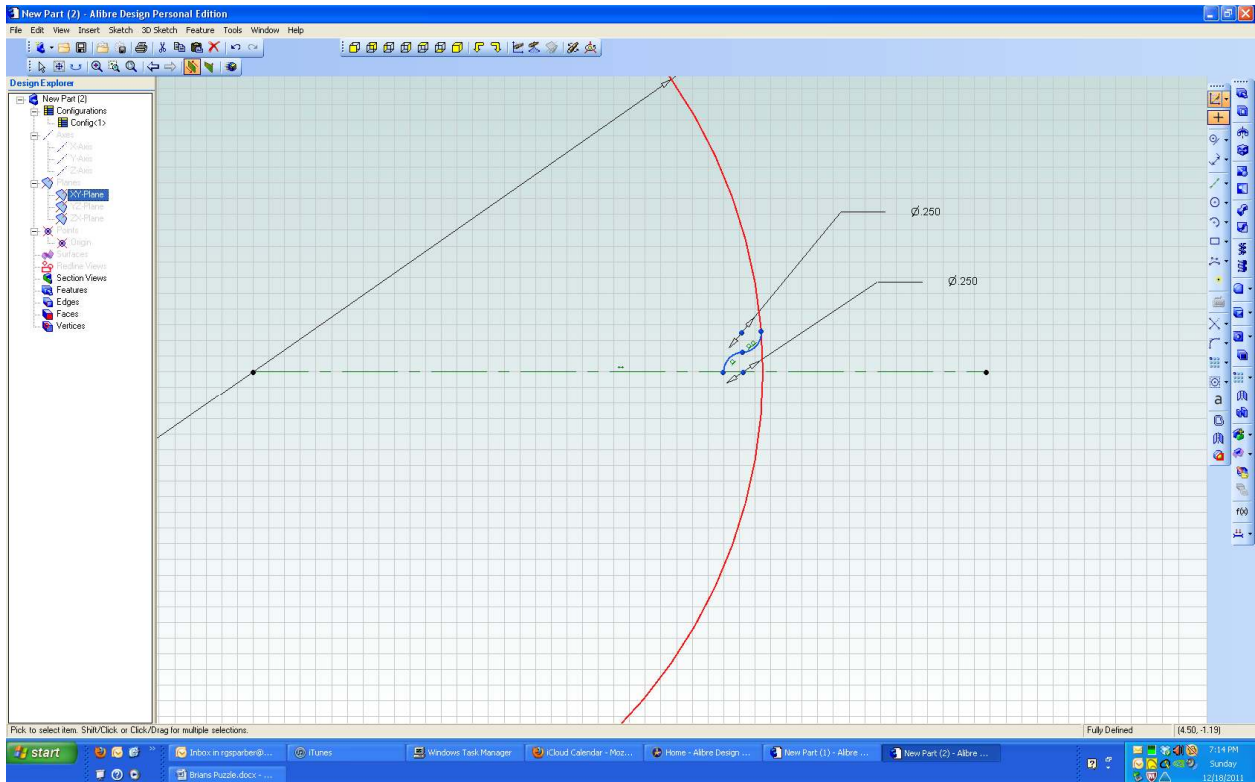
I made a copy of the 0.25" circle and must then dimension it to lock its size.



Using the tangent constraint, I locked this second circle to the larger circle and then to the first small circle.

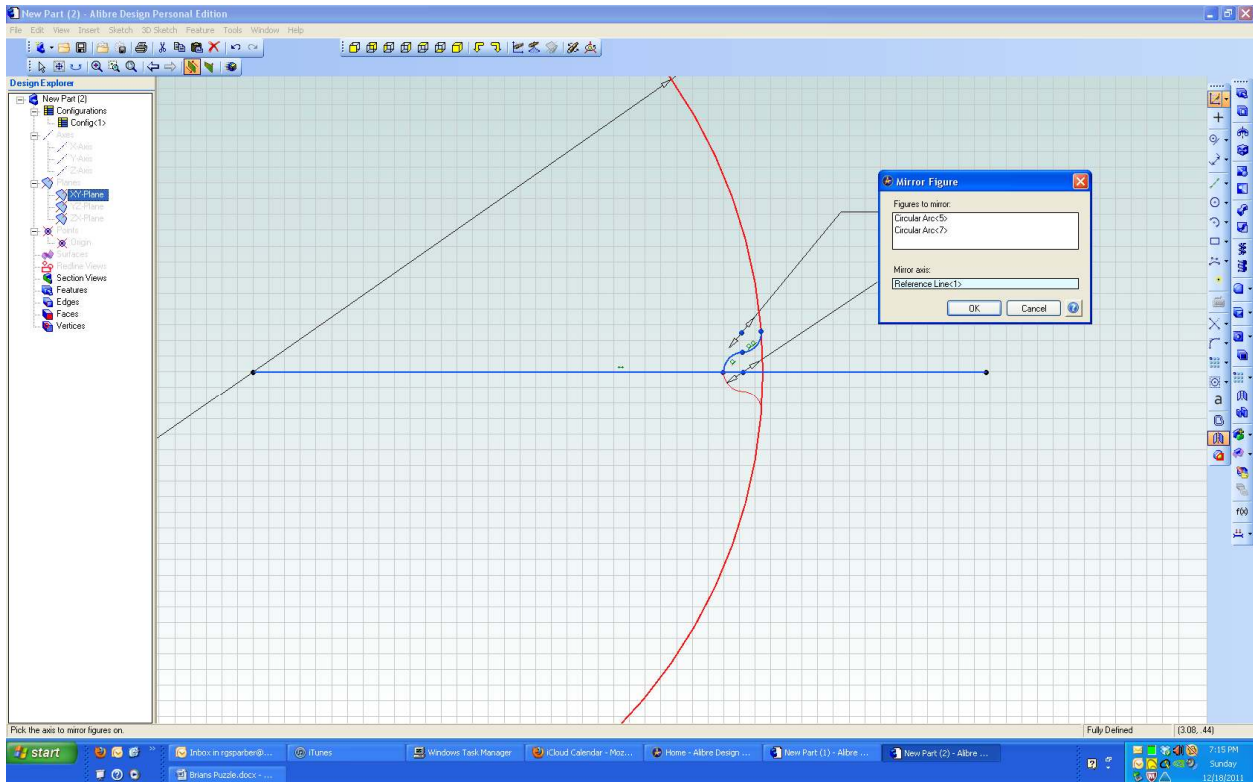


I have removed all but two line segments using the line cut tool.

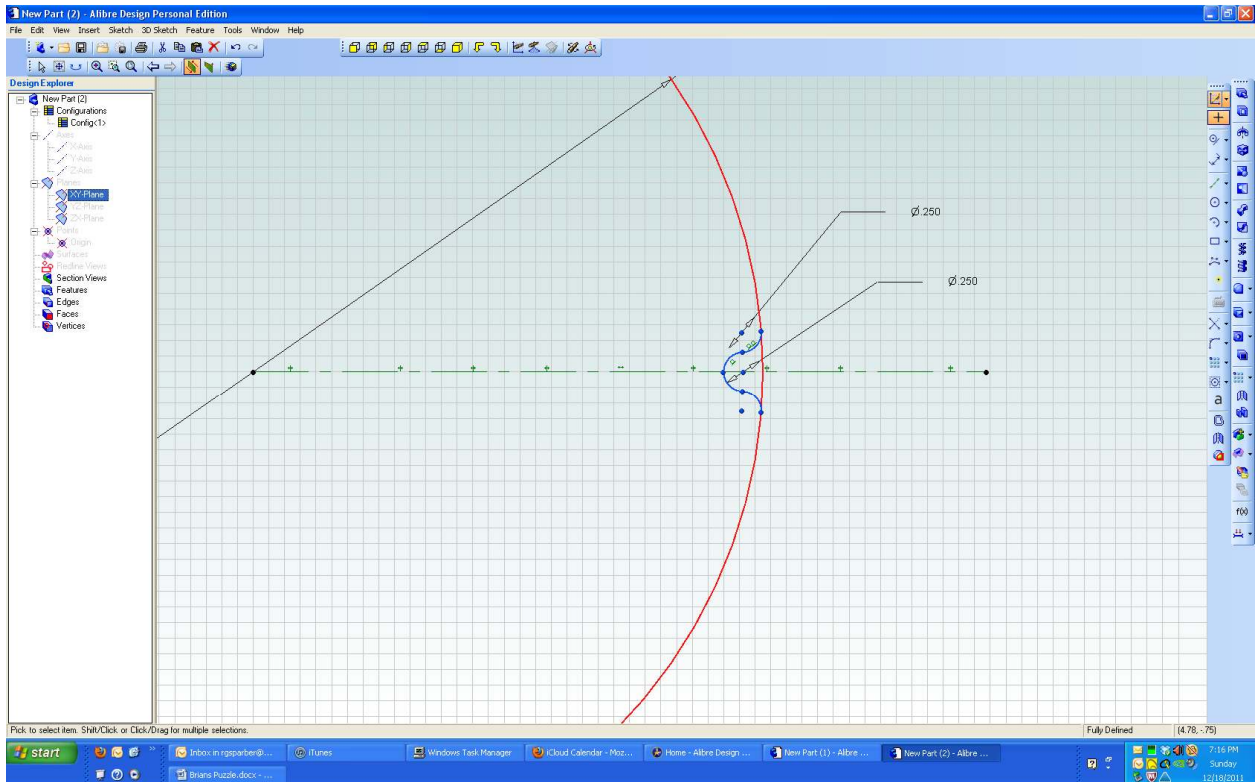


I next selected these two line segments. Note that they are blue while the larger circle is still red.



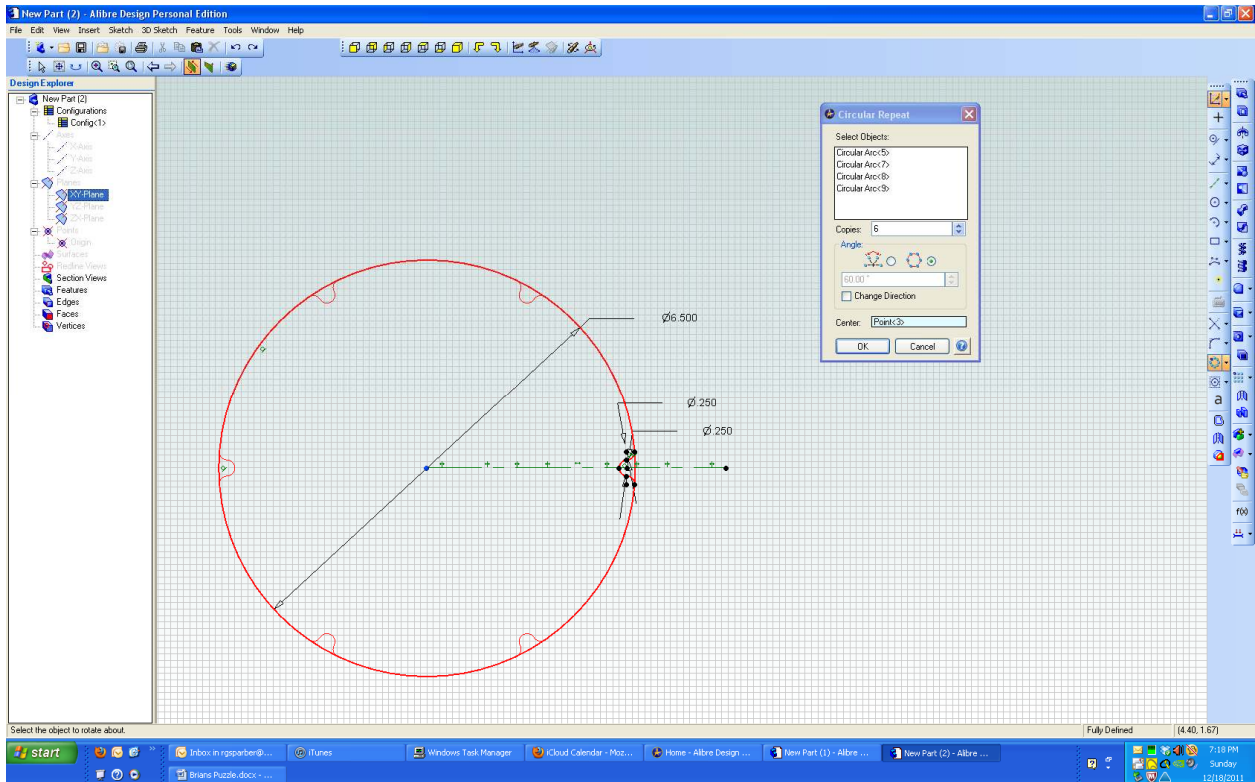


Using the mirror figure tool (thanks Brian), I formed the second half of the feature. That reference line that I drew in the beginning is now my mirror axis.

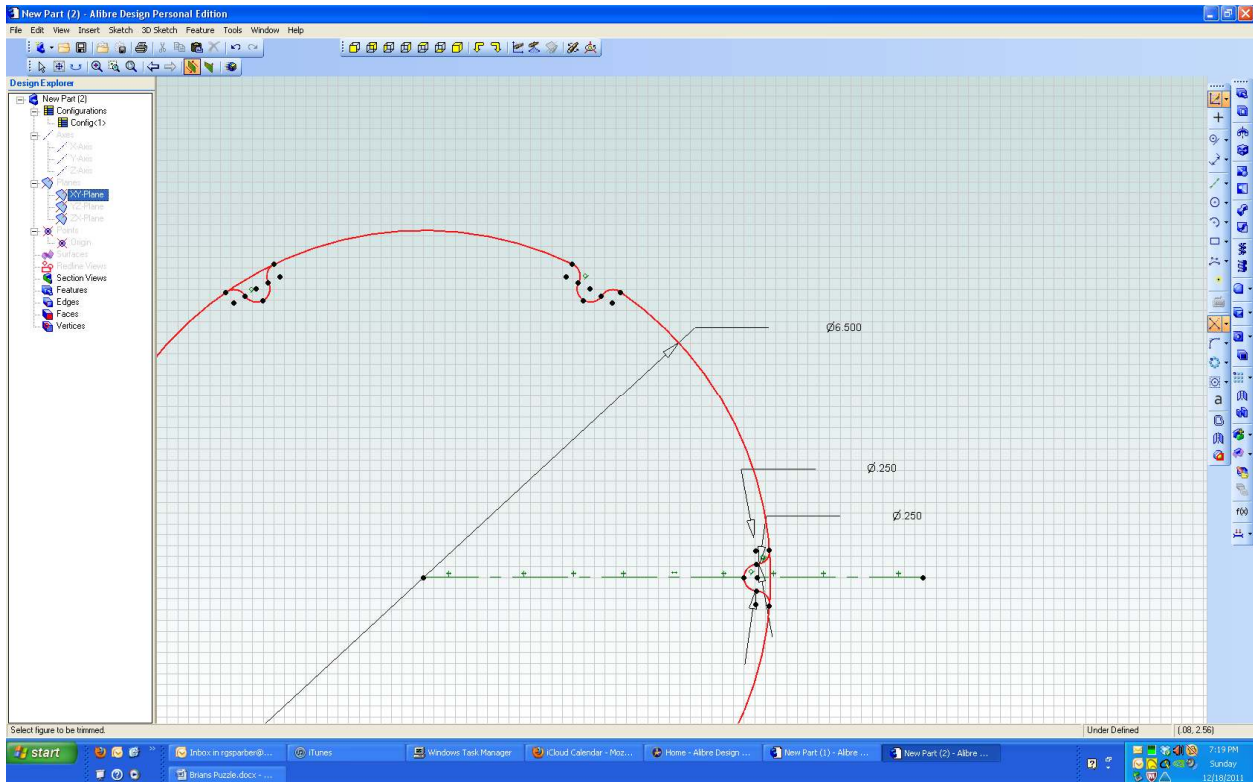


Then I selected the entire feature.



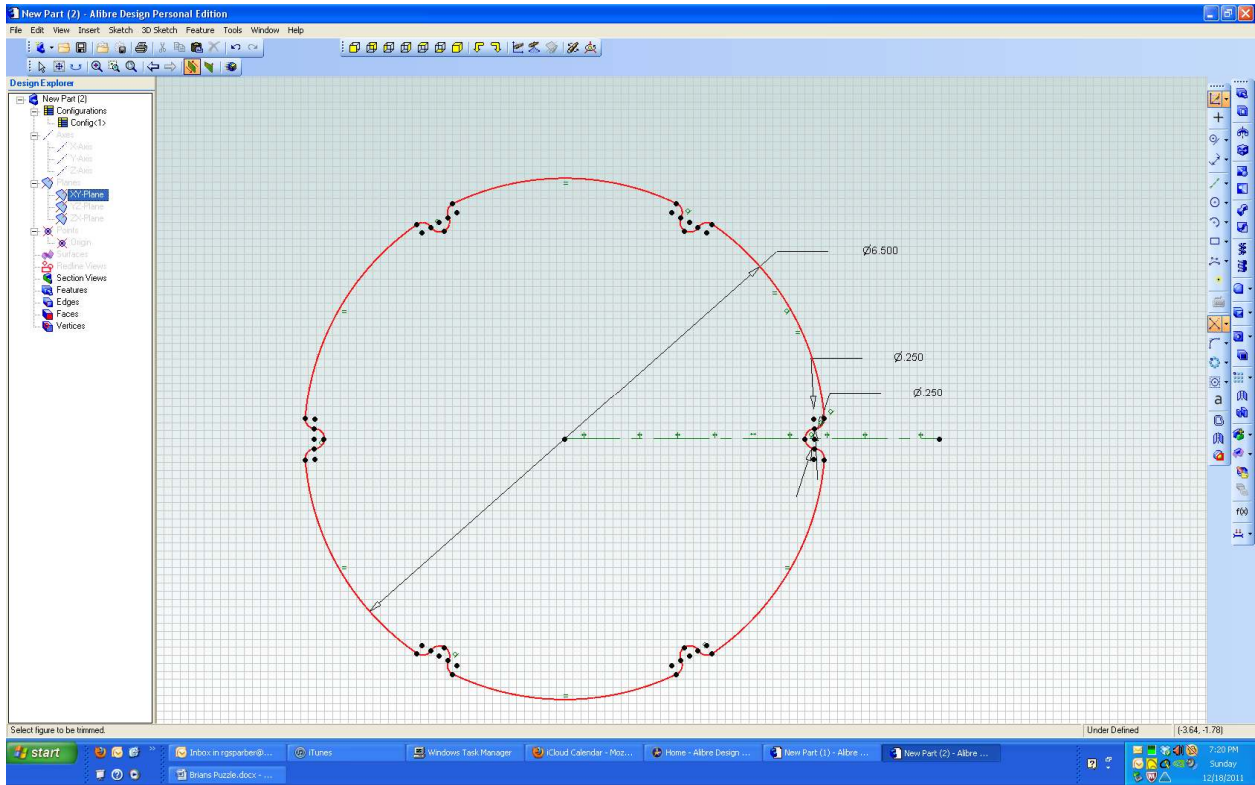


Using the circular repeat tool, I am ready to place 6 copies of this feature around the larger circle.

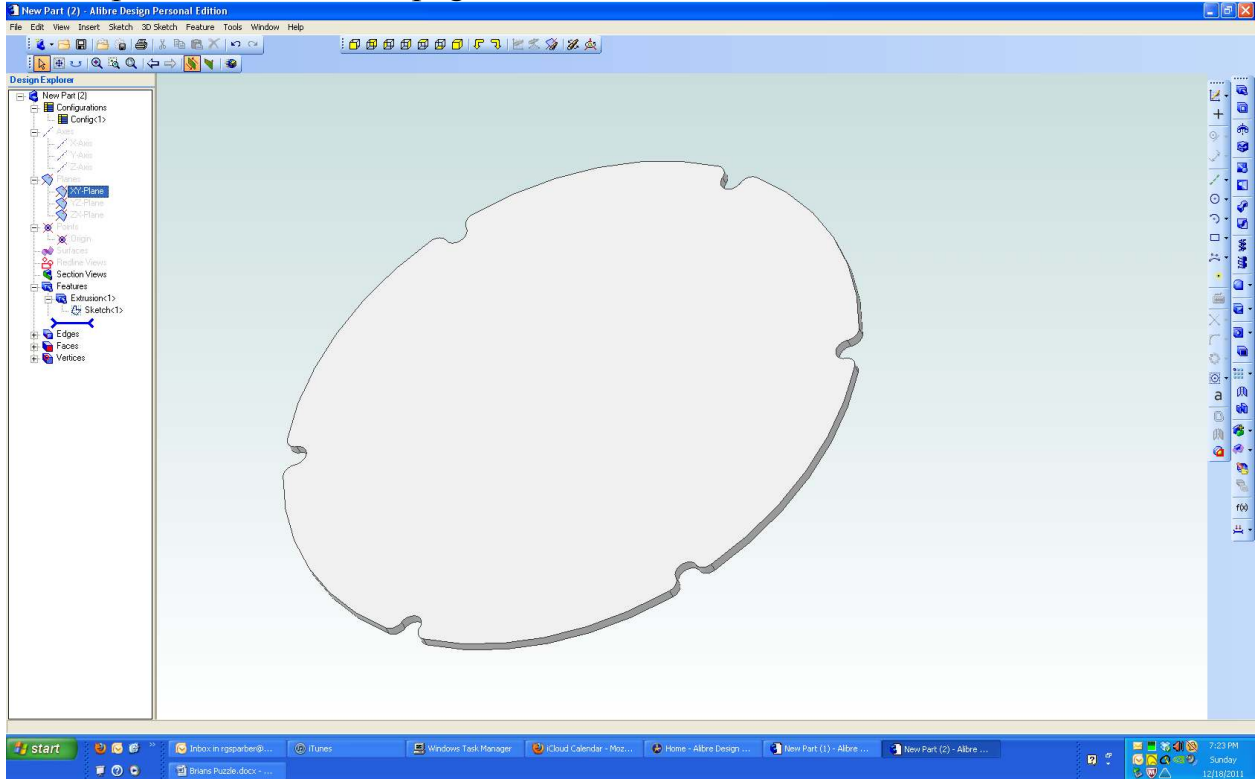


Using the line cut tool, I have removed one of the segments from the larger circle. Then I removed the rest of them.

Rolf Strand, of the atlas\_craftsman Yahoo group, suggested this approach: Another simpler method is to start with a 30 degree 6.5 radius arc at 0,0. Add a 180 degree 0.25 radius arc at 6.25 , 0 and then fillet with a 0.25 radius. Mirror all three arcs and then polar array all at 60 degrees and your done.

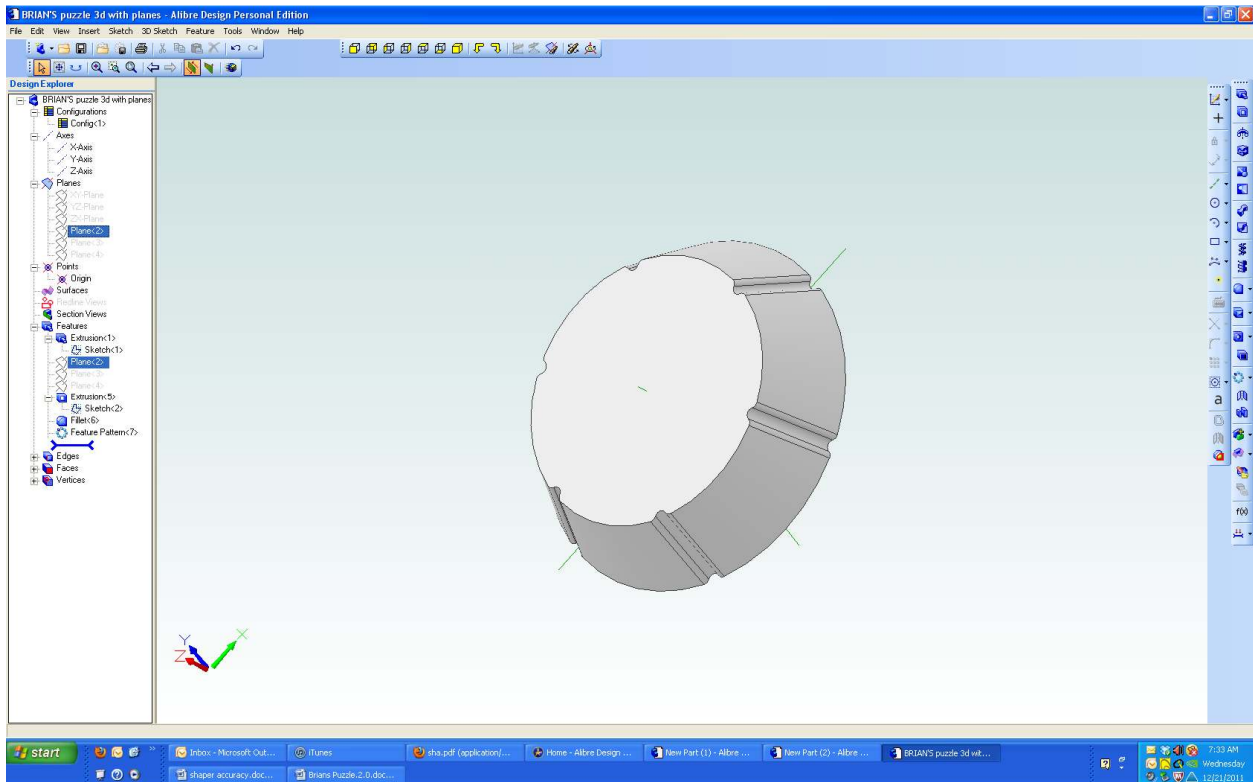


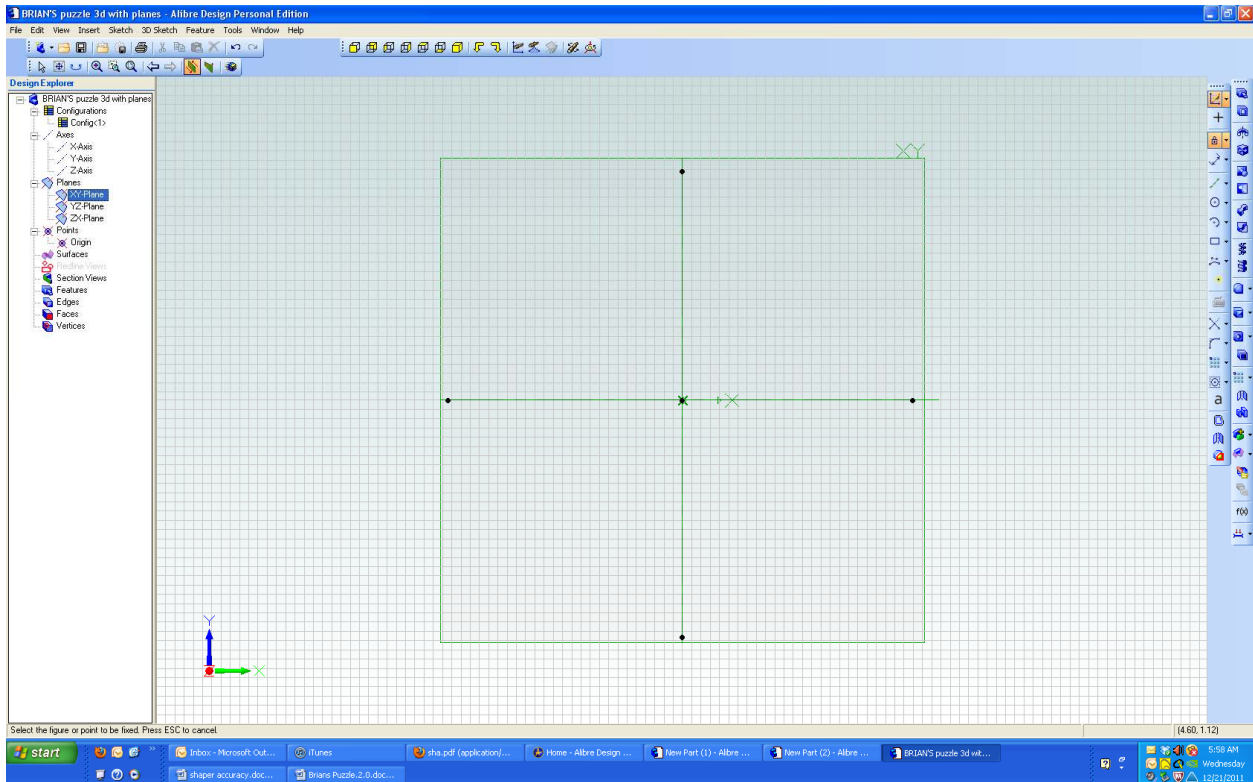
And here is the finished 2D sketch. All that is left is to use the extrude tool to form the 3D part shown back on page 1.



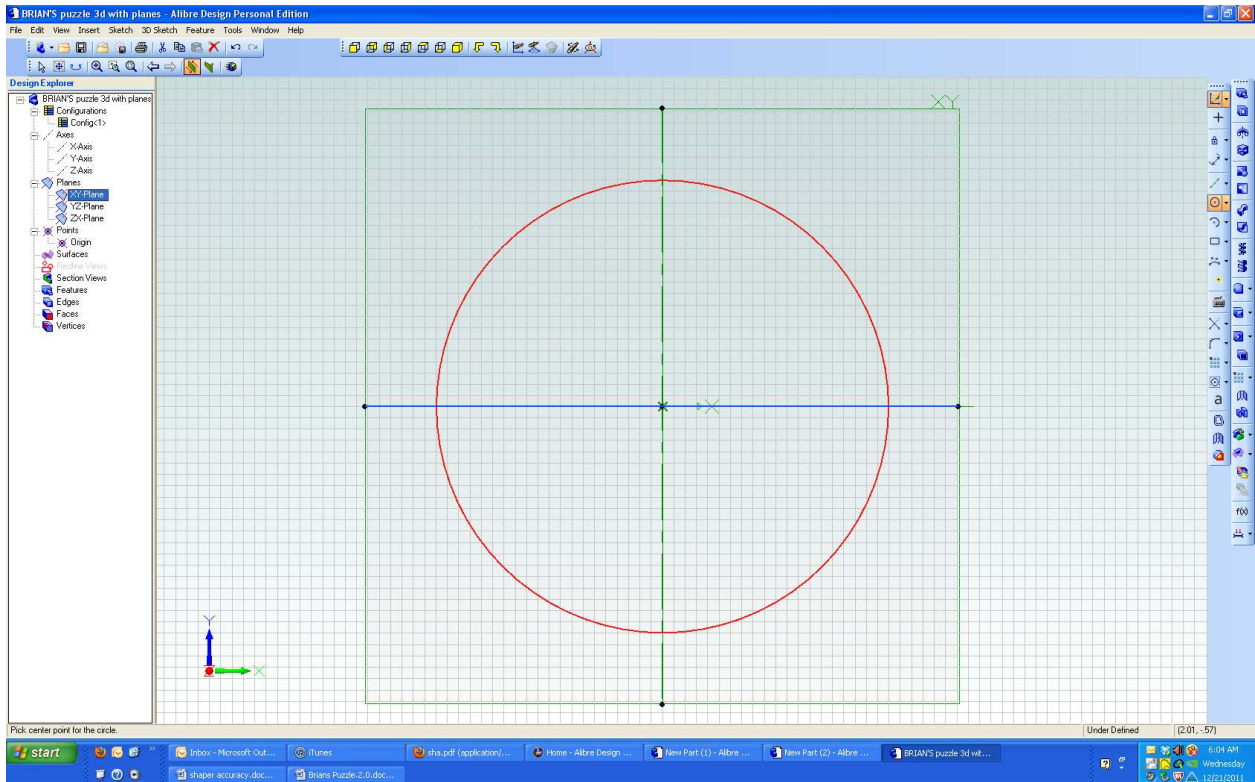
# Tapered Puck with Fixed Depth Cut-outs Using Tapered Extrusion and Planes

The second goal was to draw this:



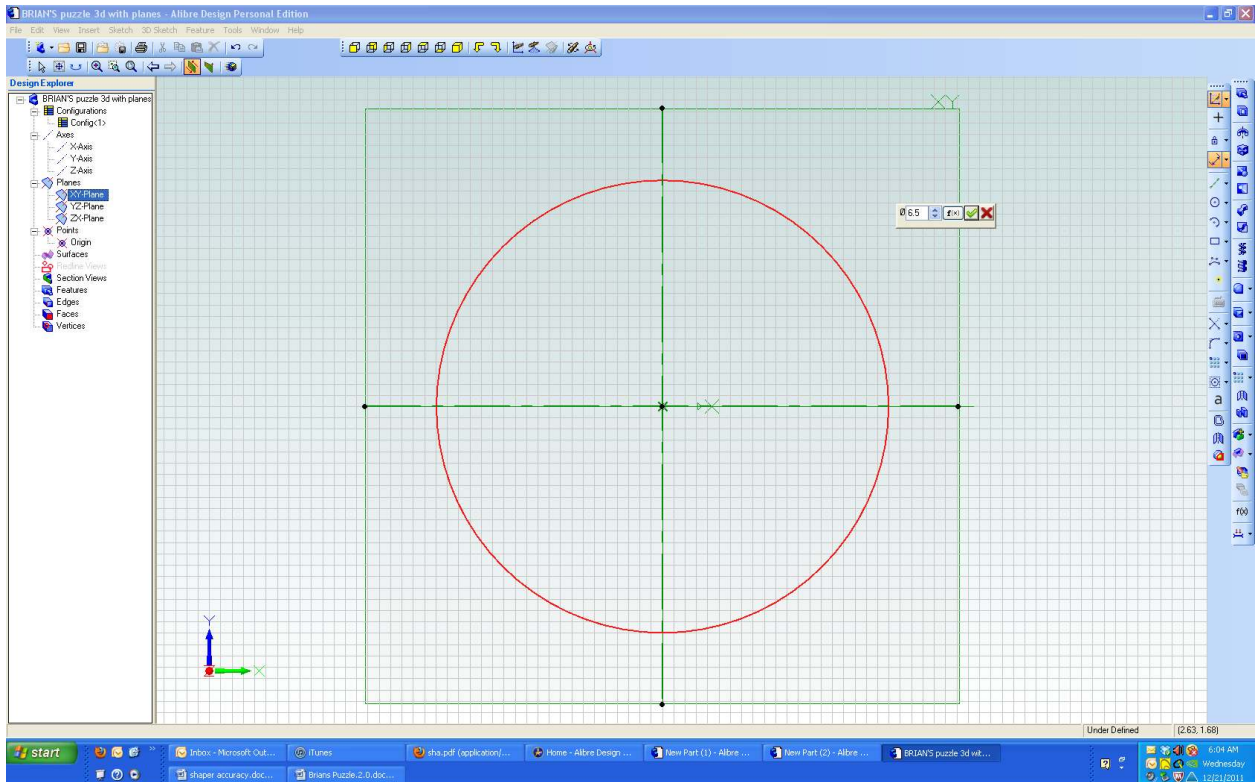


The first step was to draw two reference lines, use the symmetric tool to force the line centers to be at the origin, and lock them. This suggestion came from Lee Studley (thanks Lee!). Having these lines makes it easier to hold other features in place. I want to make the symmetric so when I move near the origin, I only see it. If one of the lines had a center point not at the origin, I might hit it instead.

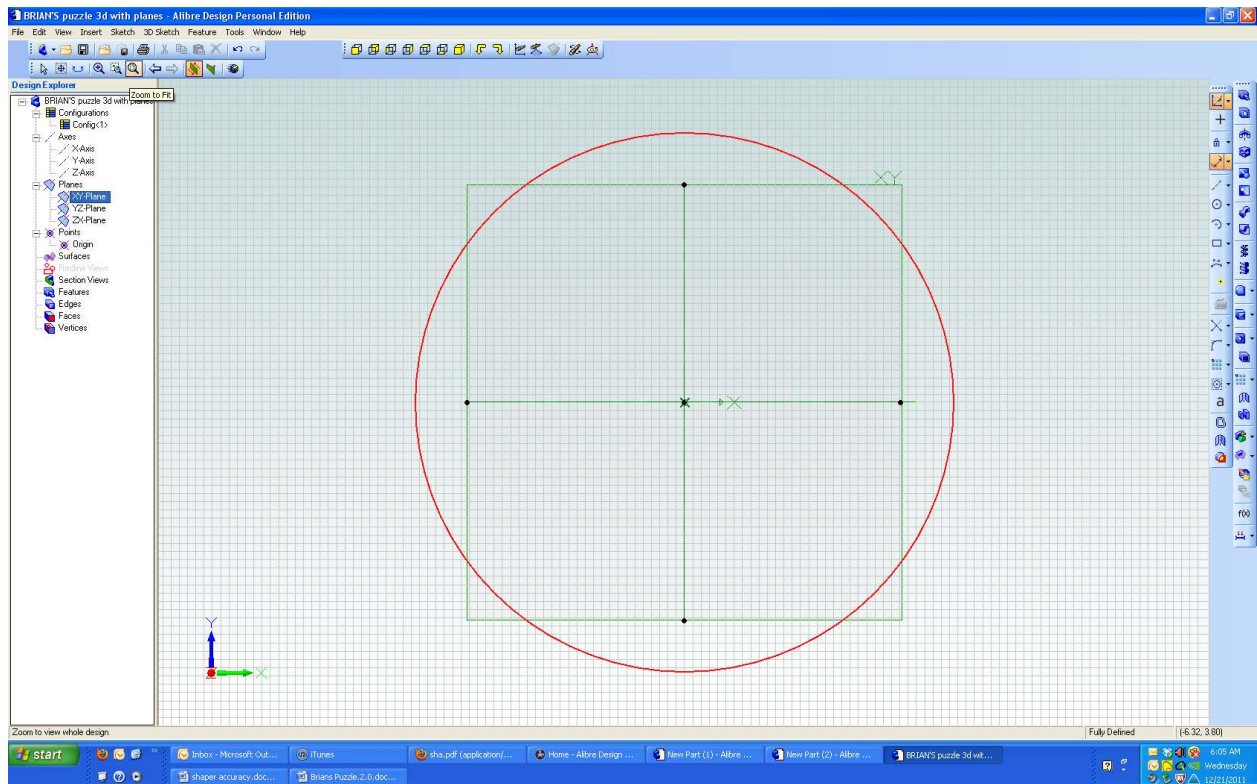


I have drawn a circle to an arbitrary diameter with its center at the origin.



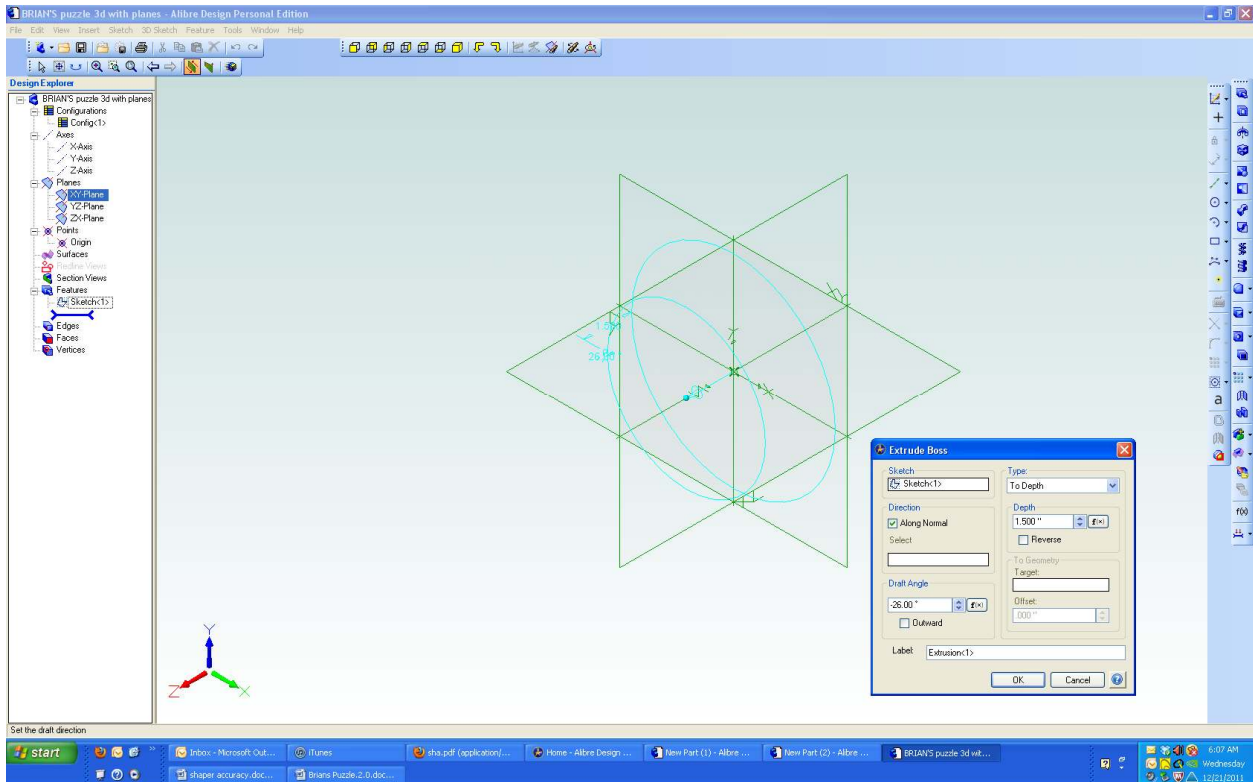


I used the dimension tool to set the circle to 6.5". Since it is now dimensioned, its diameter is locked.



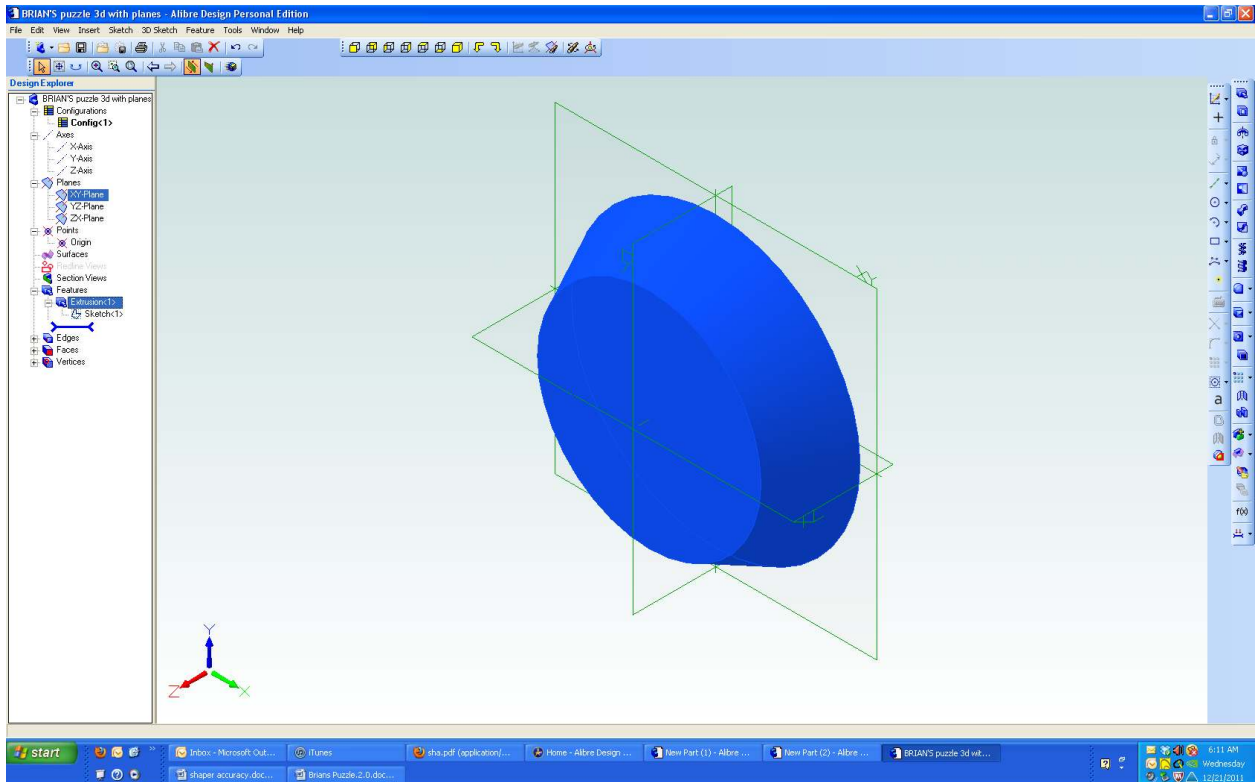
I clicked Zoom to fit to re-center the drawing and have it fill the screen.





I next used my extrusion tool. The thickness was set to 1.5", my draft angle was set at 26°, and I toggled the Outward box below the angle input window to see if I wanted a draft angle of 26° or -26°.

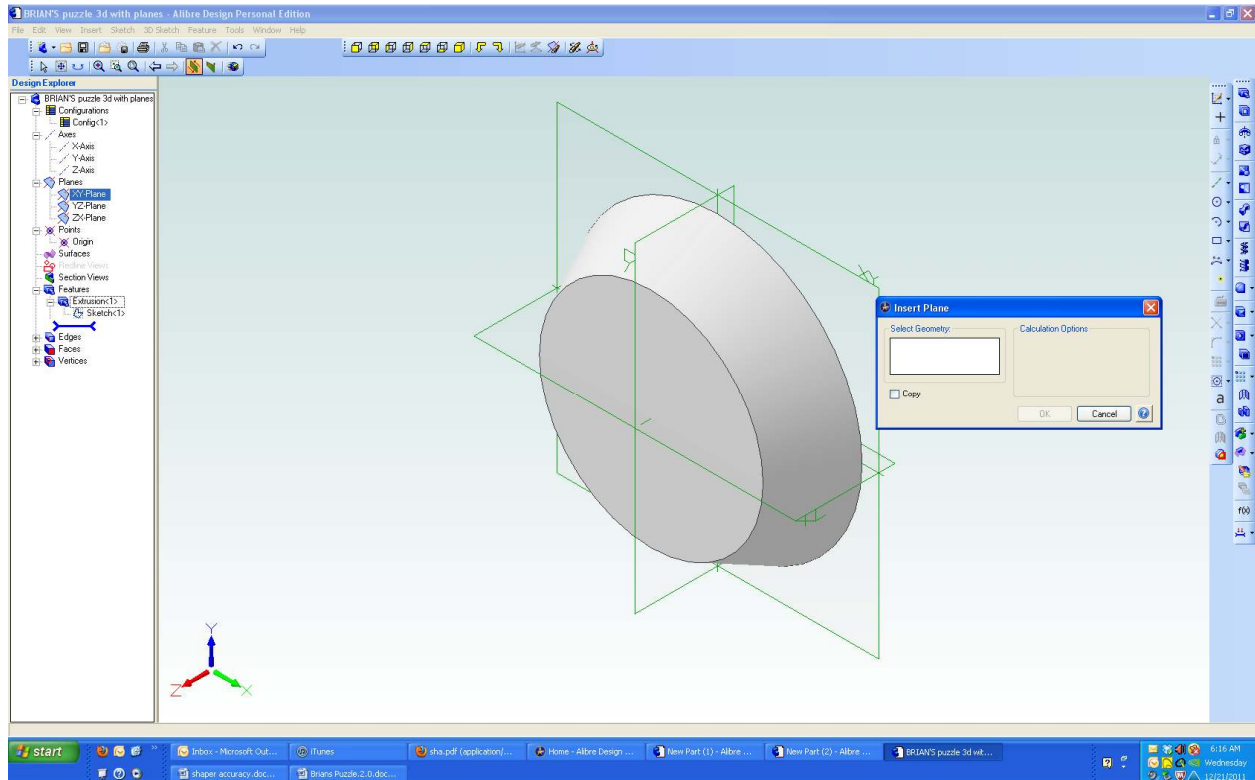
Minor note: 26° is not exactly what Brian wanted. To calculate the angle he wanted I needed to take the radius of the base and subtract the radius of the top. Divide this result by the thickness of the part. Then take the arctangent.



Here is the resulting tapered object.

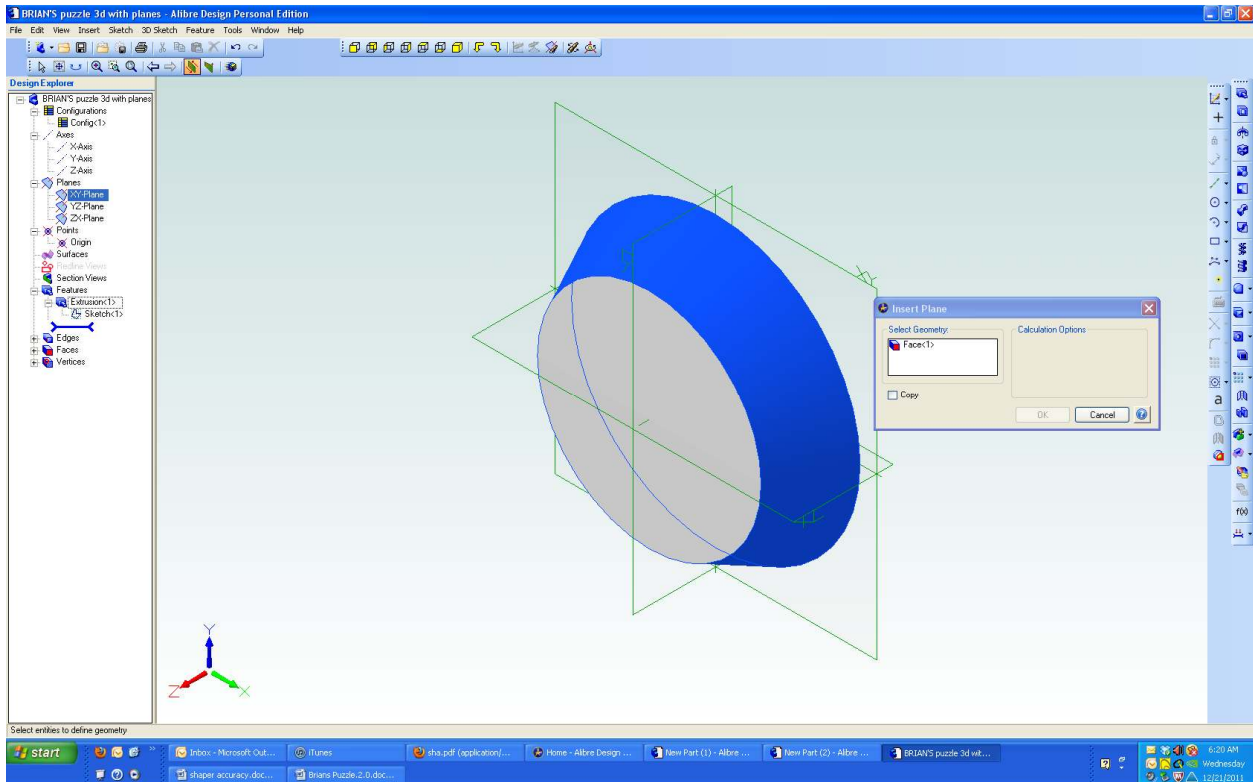
Lee used the Loft Boss tool to do this same thing. I have not figured out that tool yet.

Let's stop and think about how we got this object. I first selected a plane. Then I drew a 2D object on that plane, my circle. I then extruded it to 3D along a perpendicular axis. I could have selected any plane with its perpendicular plane for this task. In this next section I will define a new set of planes and repeat the same action of forming an object.



I have called up the Insert Plane tool. Nothing has been entered into the Select Geometry box and the OK button is not lighted. When more information is needed, Alibre tells you this by not lighting the OK button. It can be rather frustrating when you think it has all necessary information yet the OK button remains grayed out.

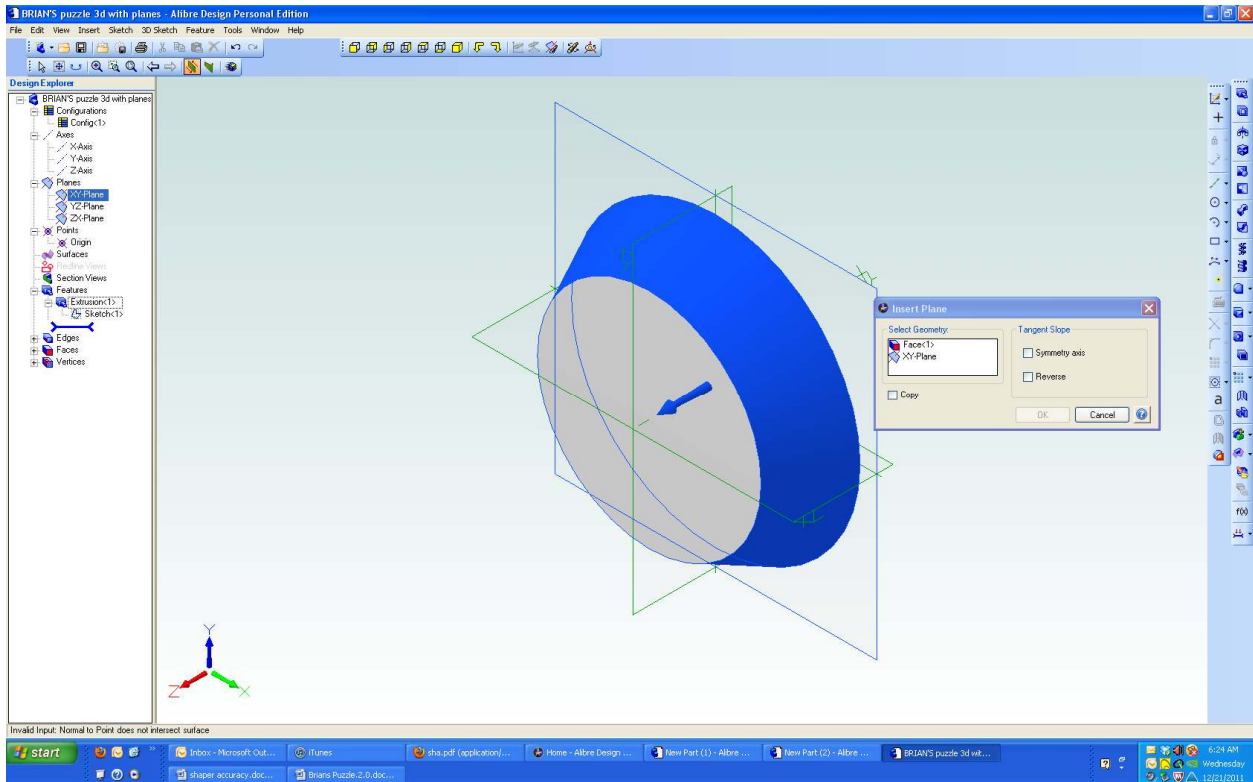
I need to cut a single groove in the tapered side of the object. If the object was not tapered, I could do the steps outlined in the first half of this article. But with the taper, my XY plane is not at the correct angle. I need to define a new plane that is aligned with the taper.



I click the taper and it turns blue. This is Face<1> and is put in my Select Geometry box. The OK box is gray.

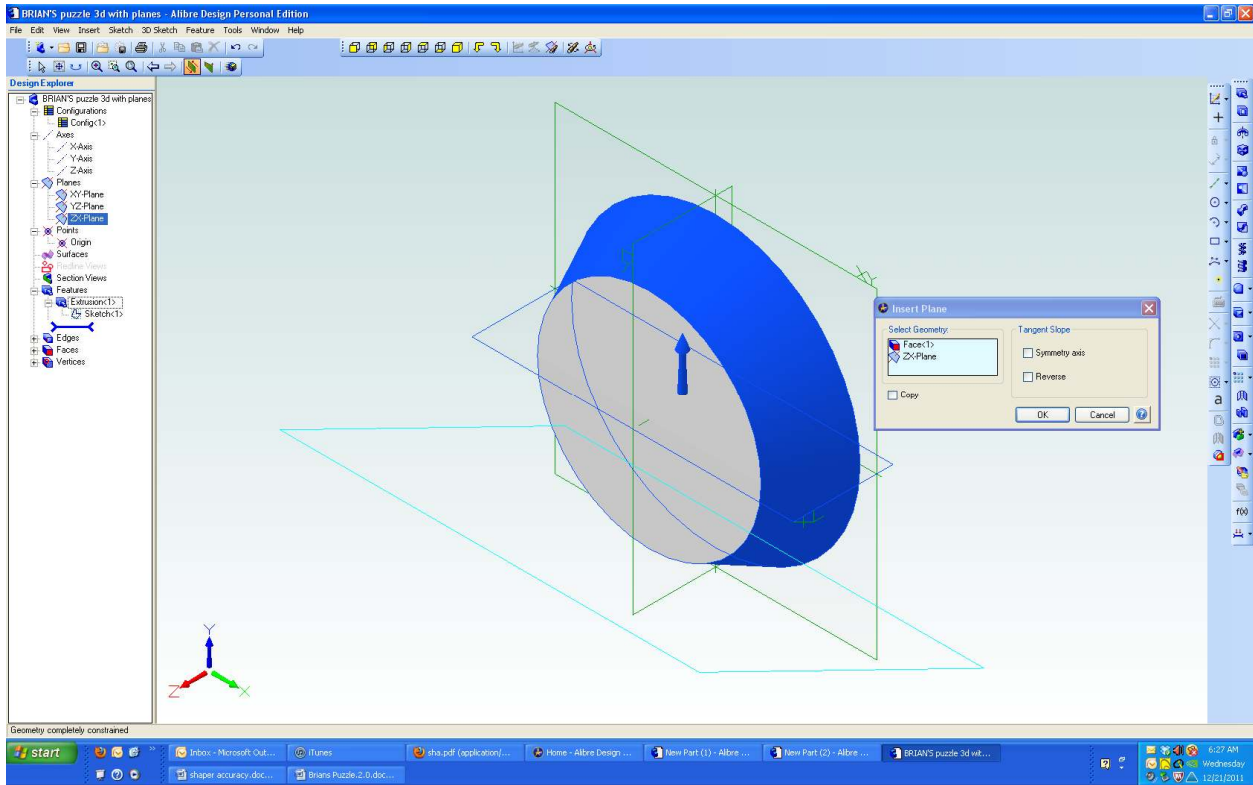
I have told the tool the angle of the new plane but it needs to know where on this curved surface to anchor it.

I have three choices of planes to use as anchors for my new plane. Say I were to select my XY plane which is the one supporting the base of the object.



I clicked on the XY plane and its name was entered into the Select Geometry box. But the OK button is still gray. Hmm, let's think about this a bit more. My XY plane cannot define where to put the new plane. In fact, it adds no new information at all. My Face<1> is already aligned with the XY plane.

What about the ZX plane?

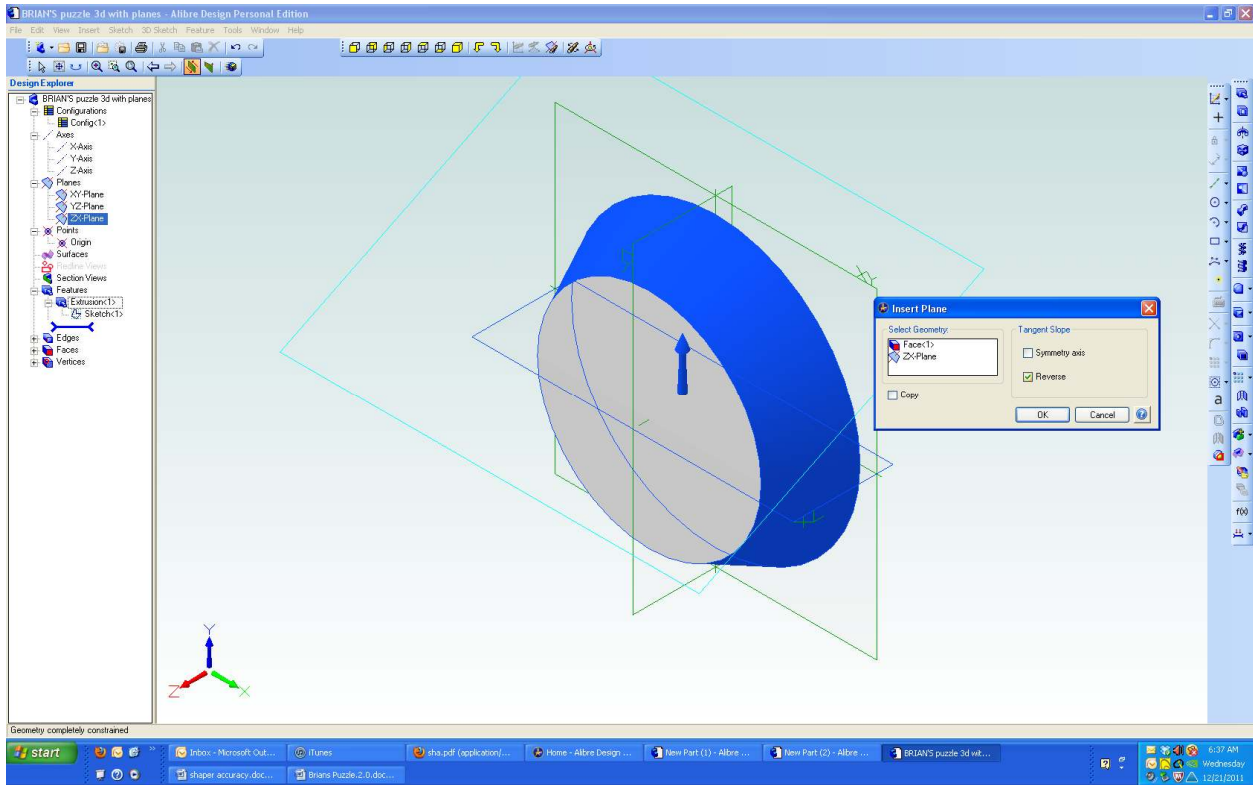


The ZX plane is perpendicular to the XY plane.

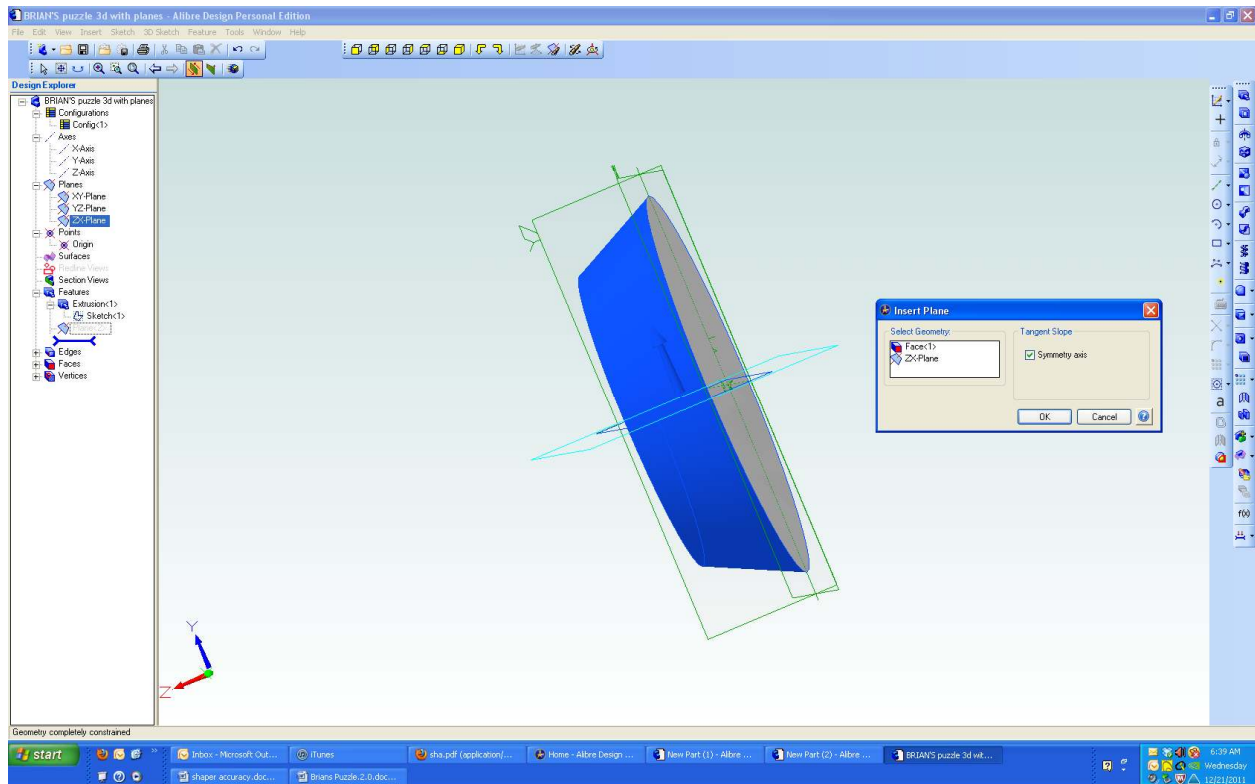
After clicking the XZ plane, the plane's name has been put in the Select Geometry box and to my relief; the OK button is now black. I also see my new plane which is angled to match the taper.

Note that I can draw a line on my new plane that is parallel with a line I could draw on my ZX plane. The tool sees this and therefore has enough information to define the location of the new plane.

What if I drew a line on my ZY plane that was parallel to my new plane? I could do it but I could also slide this XY bound line around on its plane and swing the new plane around. In other words, it would not be locked into position.

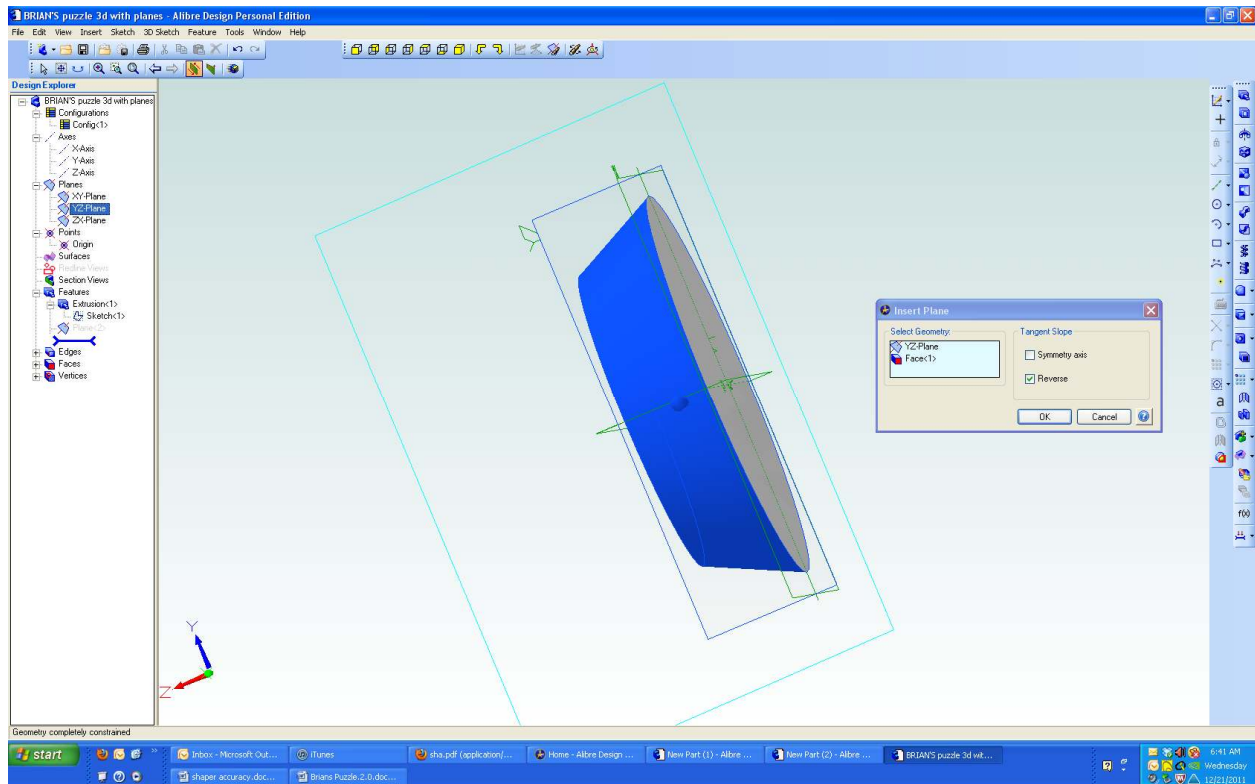


Before I hit OK, note that I can click the Reverse option and my new plane will align with the opposite side of the object.

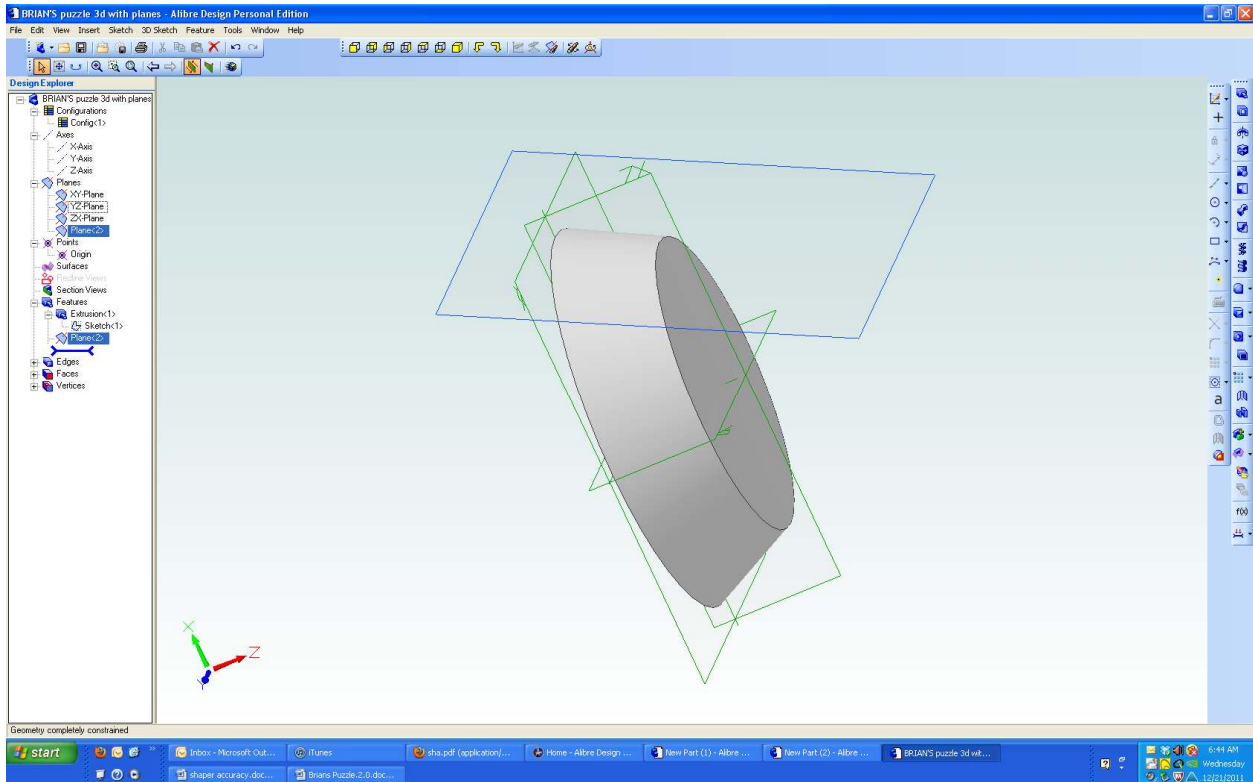


I can also click the Symmetric option and my new plane aligns in a position that is symmetric with the two tapered sides of my object. Since these two sides are already symmetric, I end up with my plane aligned with my ZX plane. Boring...



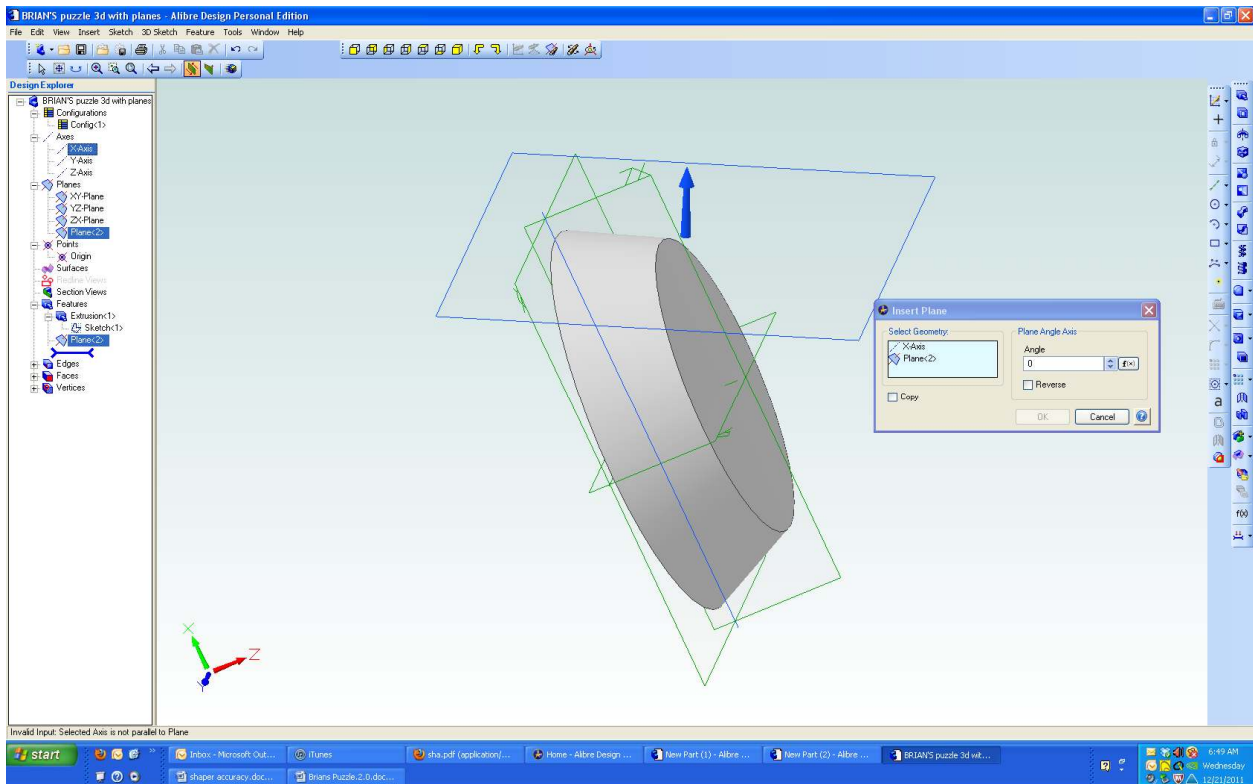


I tried my XY plane and the taper and found that it could not work to define my new plane. Then I tried my ZX plane and the taper and it did work. Here I have tried my ZY plane and the taper. It too works. The plane defined by using the ZY plane is 90° rotated from the one defined using the ZX plane but is otherwise identical. I'll keep this orientation.

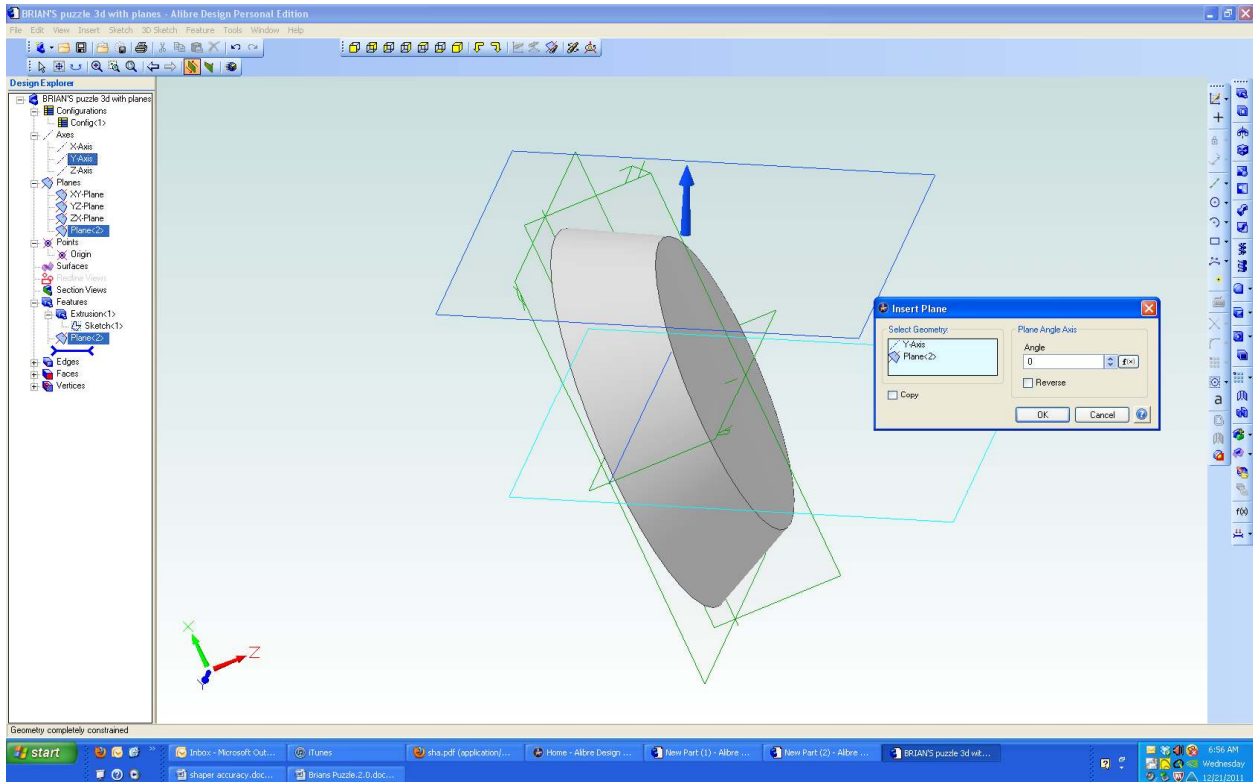


I clicked OK and now have my new plane. It is called Plane<2>. While I was playing around with generating various planes, I must have created Plane<1> and then deleted it.

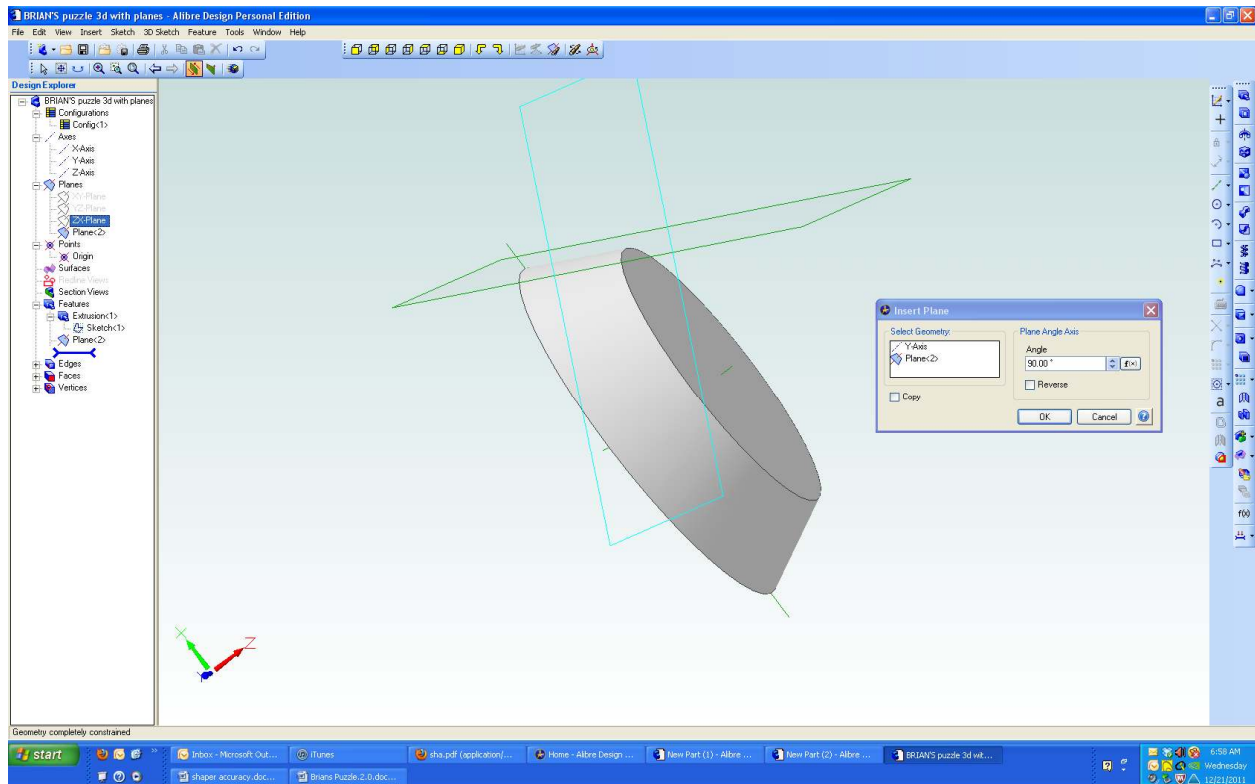
With a plane parallel to my taper, I can draw a 2D object and then Extrude cut into the tapered object. Unfortunately, that won't get me the shape that Brian wanted. I need to create an additional plane that is perpendicular to my new plane.



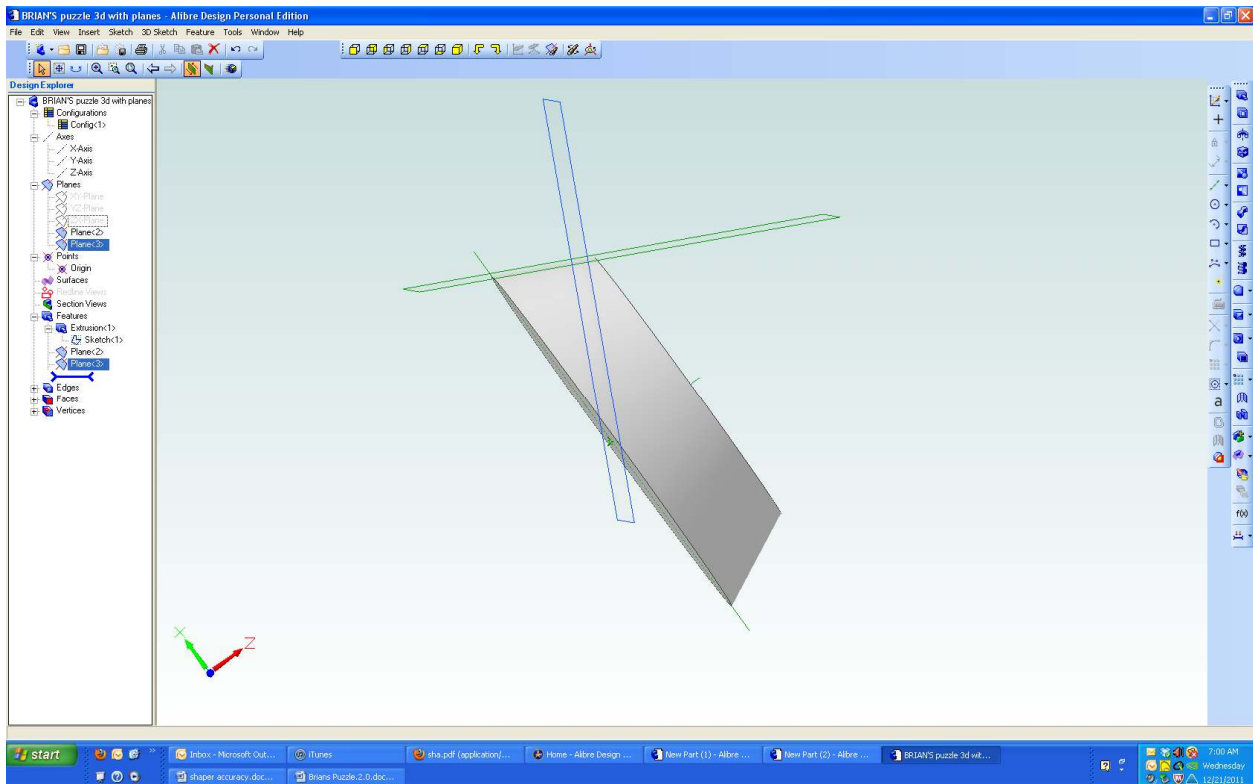
I again called up my Insert Plane tool. I've clicked on my new plane, Plane<2>, but we know that is not enough to define the perpendicular plane. I need a feature that will force this new plane to be aligned with an axis of Plane<2>. Well, Plane<2> was created by using the ZY plane. If I select my Y axis, that should do it.



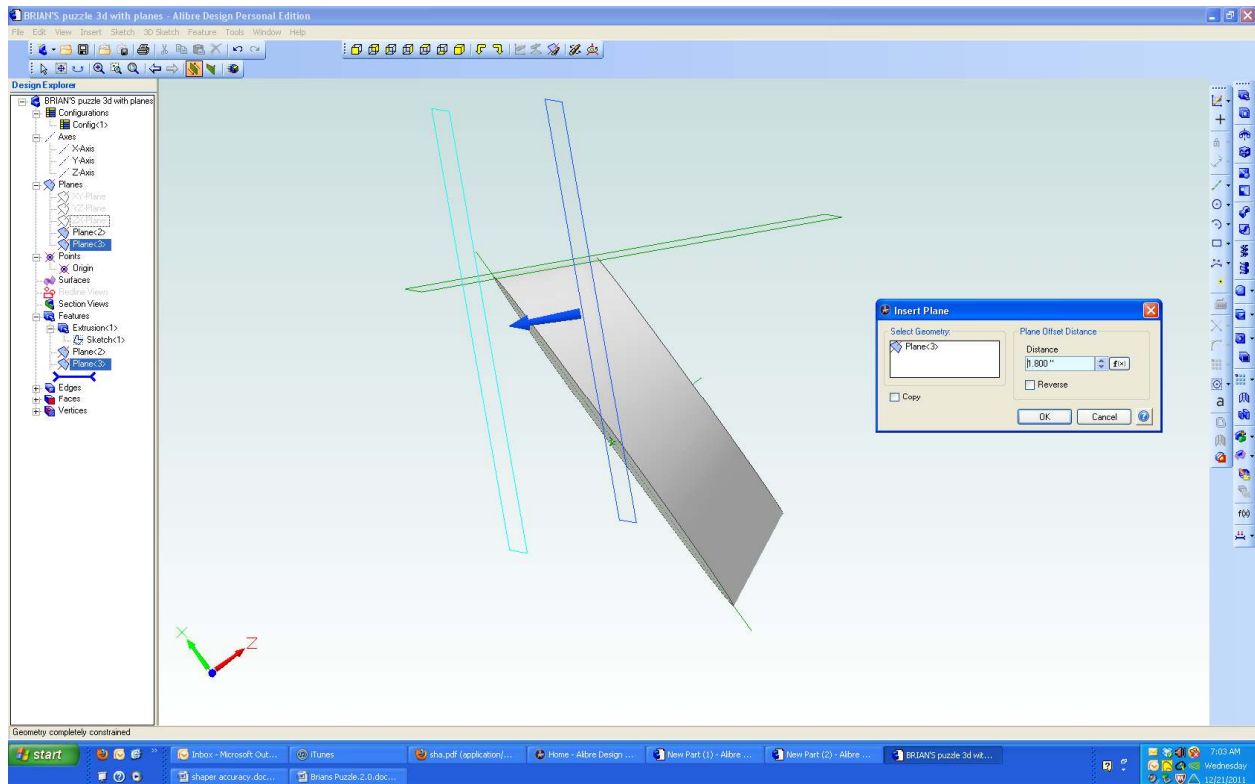
I have provided enough information for the tool so the OK button is black. But notice where the new plane is located. It is parallel to Plane<2>. However, also notice that a new option has appeared. I can specify the angle formed between Plane<2> and my new plane.



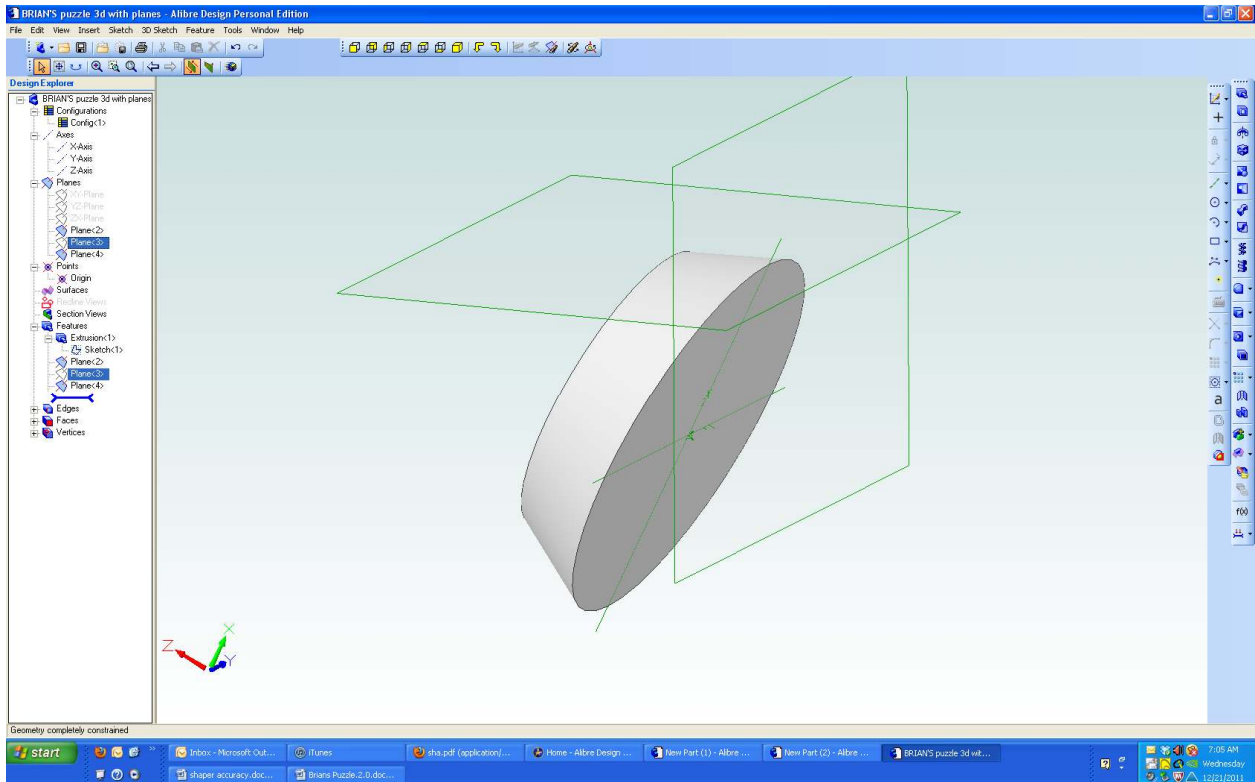
I have hidden all planes except Plane<2> and the new plane. Notice that my new plane passes through the X axis at the center and bottom of the tapered object plus is perpendicular to Plane<2>. Click OK.



I'm close to having what I want. My new plane, called Plane<3>, just needs to be moved over so it is not inside my tapered object. If I drew 2D shapes in this position, they would only cut from Plane<3> on out so would not be able to cut all the way through the tapered object.

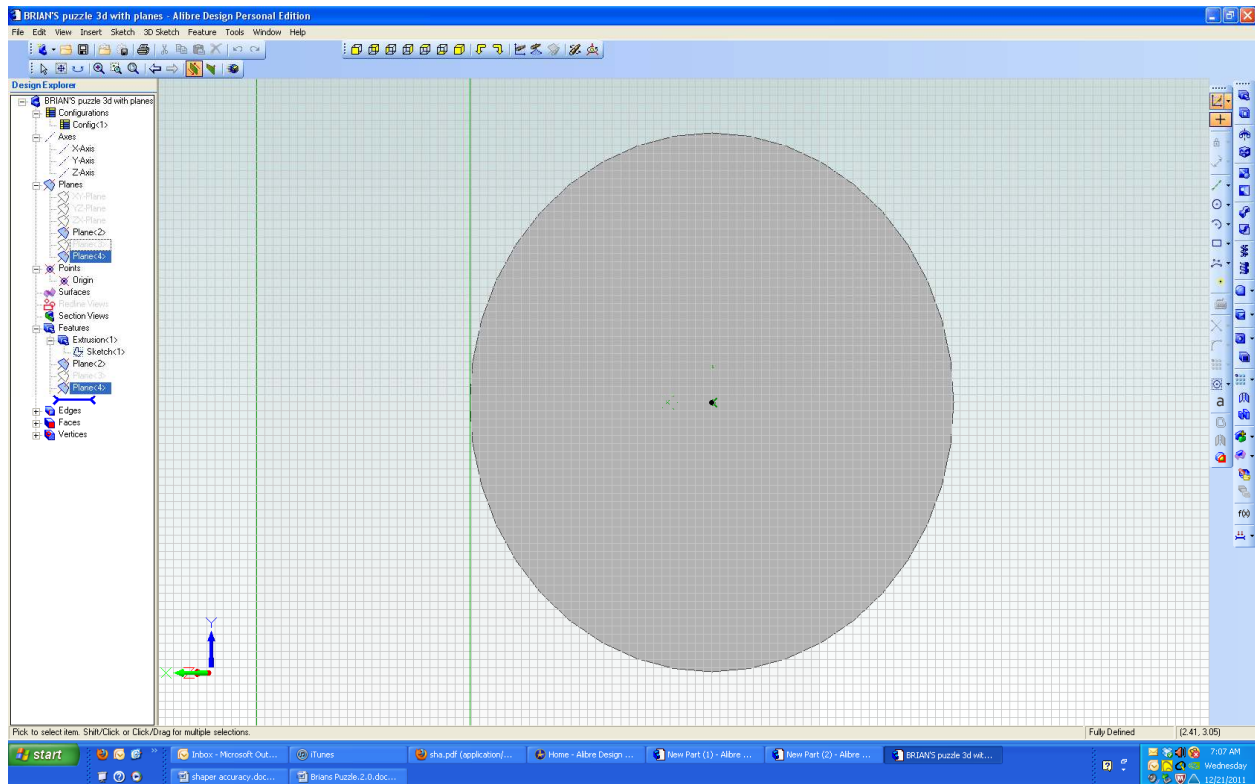


I have pulled up Insert Plane one last time in order to define a parallel plane that is a distance away. I held down the little up arrow in the Distance box until my new plane was off of the tapered part. Then I clicked OK. I will then hide Plane<3> since it is now just confusing.

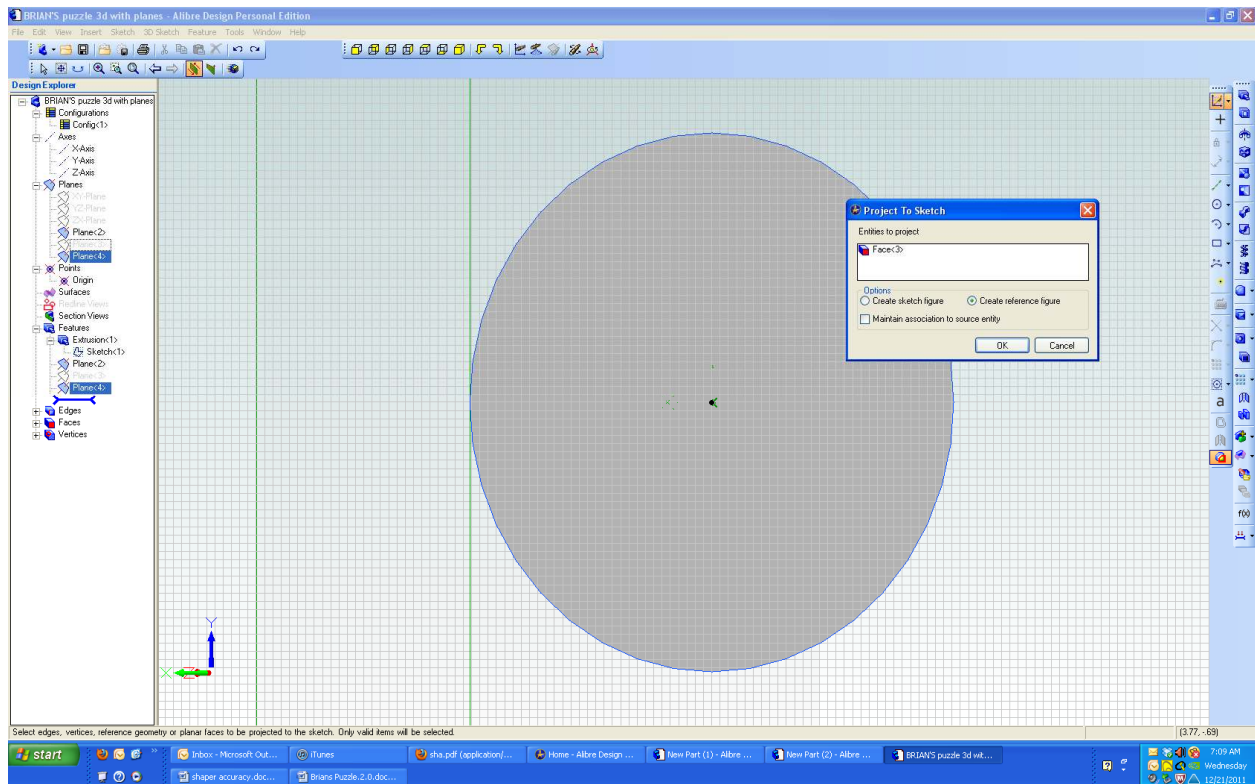


I now have two planes, Plane<2> and Plane<4>, that are perpendicular and aligned with the taper. The next few steps should look familiar.

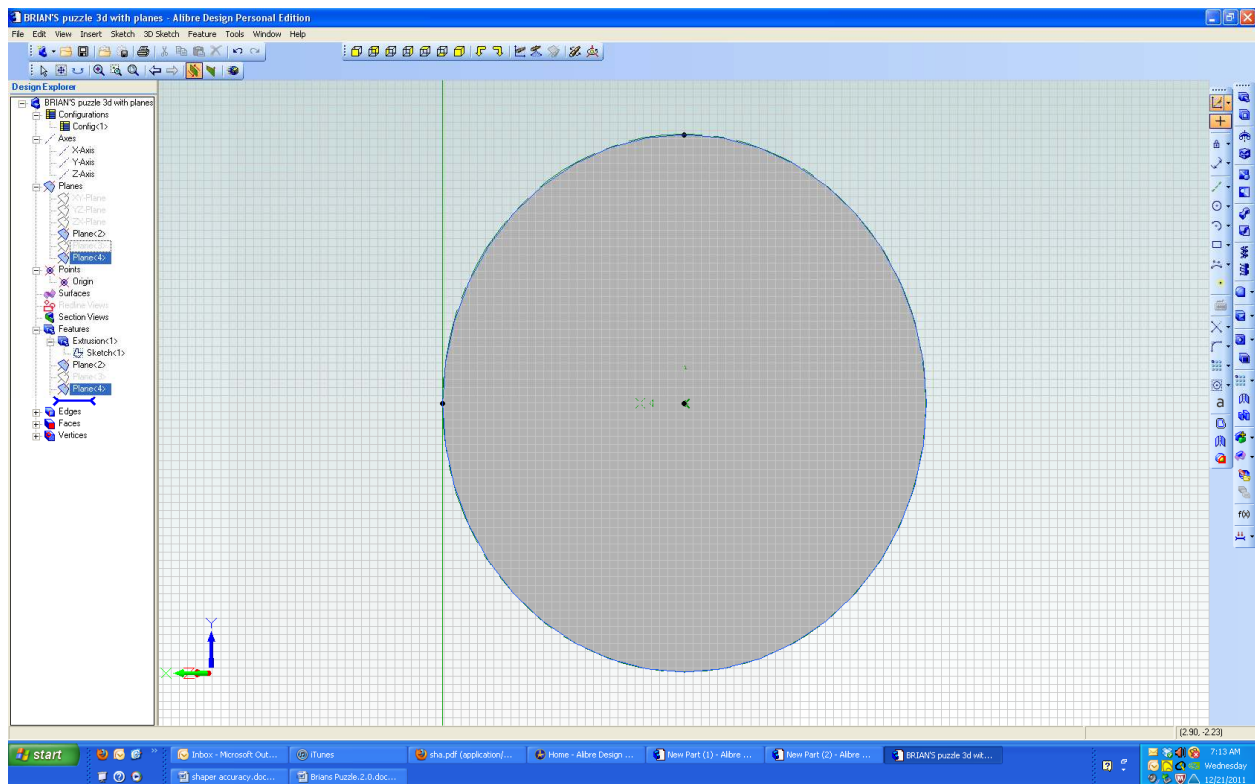




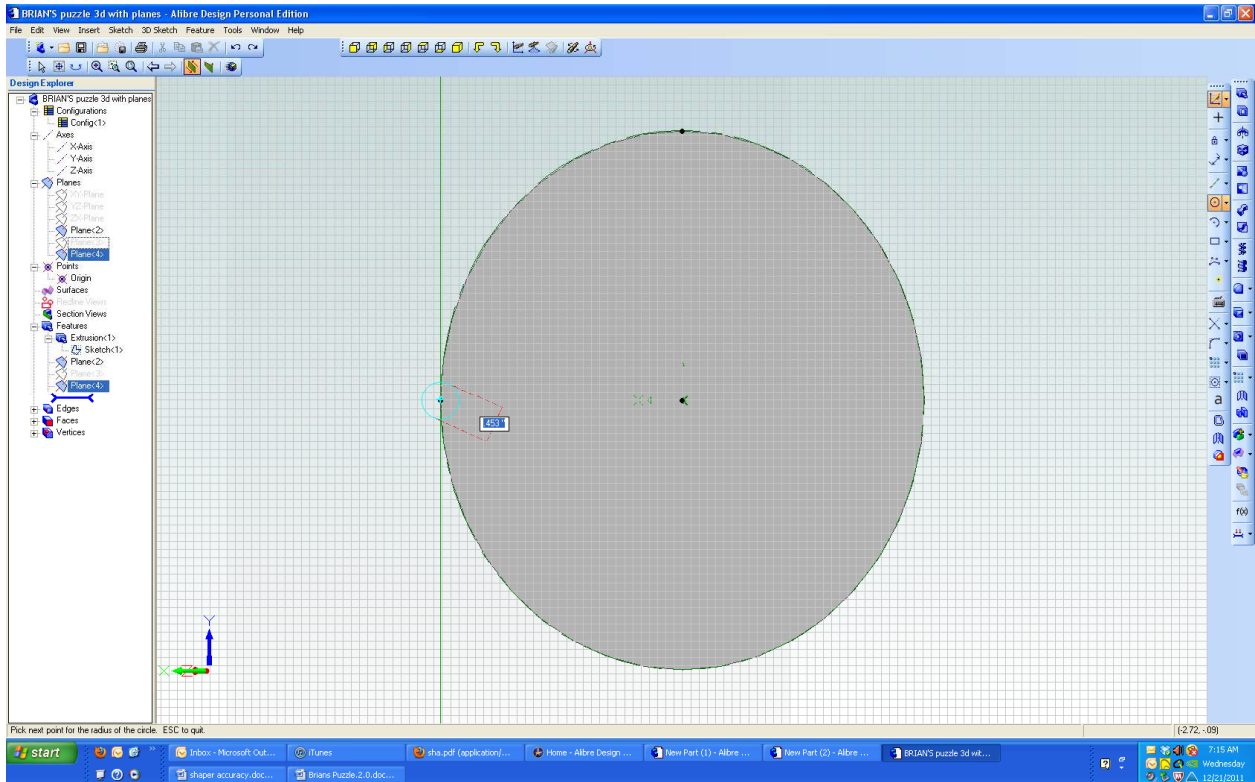
I select my 2D Sketch tool and then click on Plane<4>. That vertical green line that is tangent to the circle is the edge of Plane<2>. This circle is the bottom of my tapered object. If in doubt, rotate it a bit and see but then put it back.



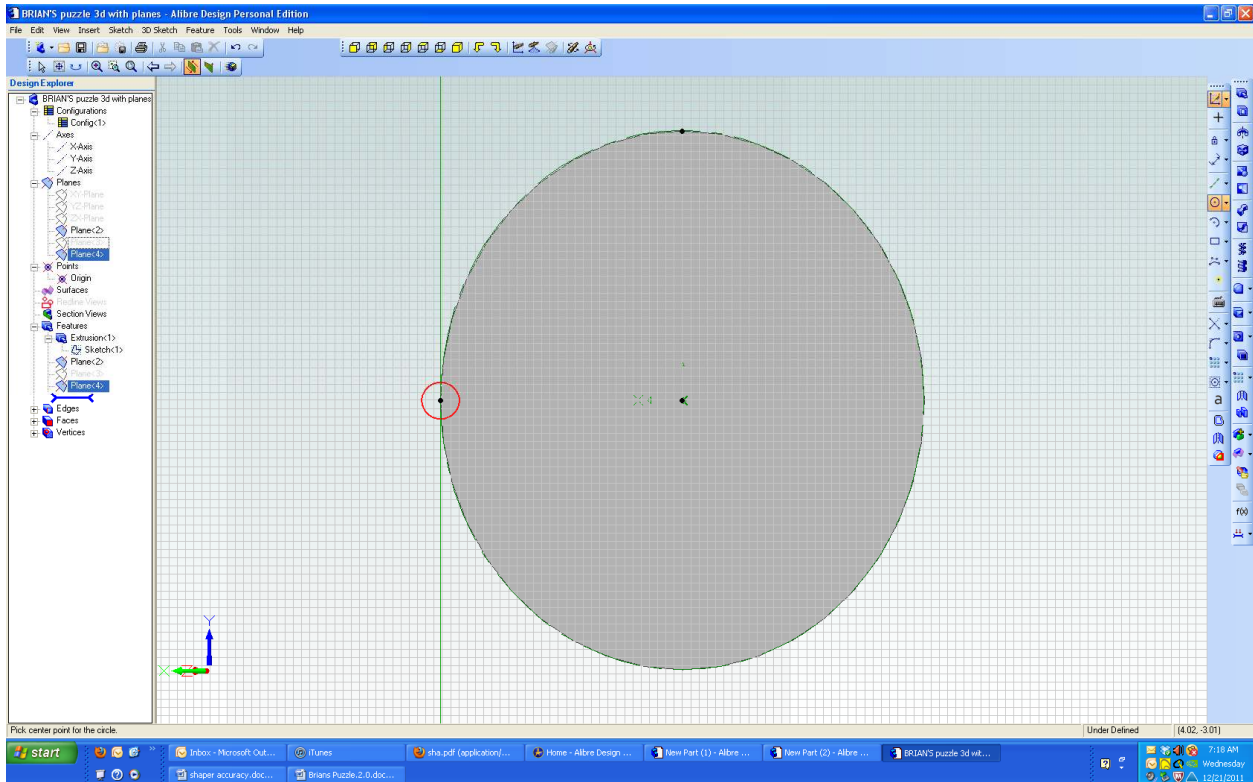
I want to draw a 2D object on the bottom of the tapered object. I start by projecting the bottom of the tapered object onto my new plane as a reference figure.



I now have a projection of the bottom of my tapered object on Plane<4>.

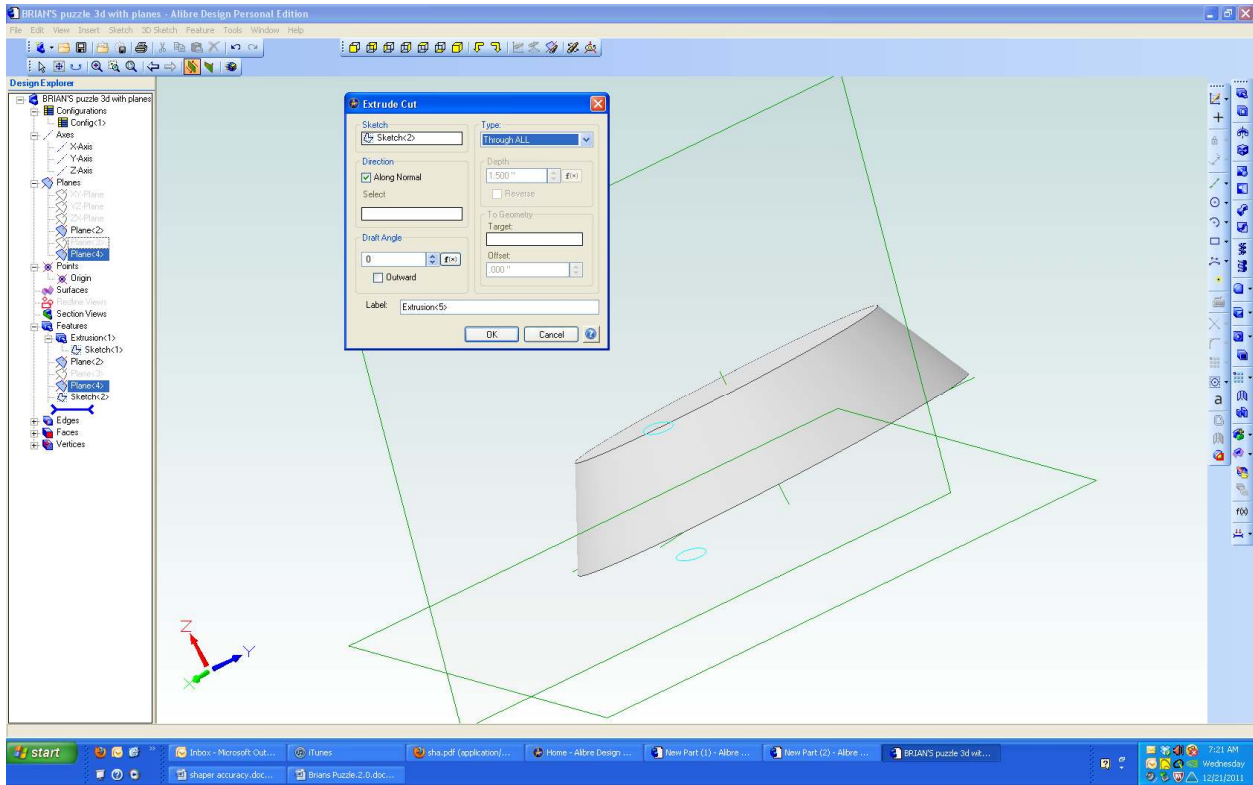


Using my circle tool, I have drawn a circle of arbitrary diameter at a rather special point. This is the point where Plane<2> is tangent to the taper. This is the only point where my two new planes will produce the desired cut in my tapered object.

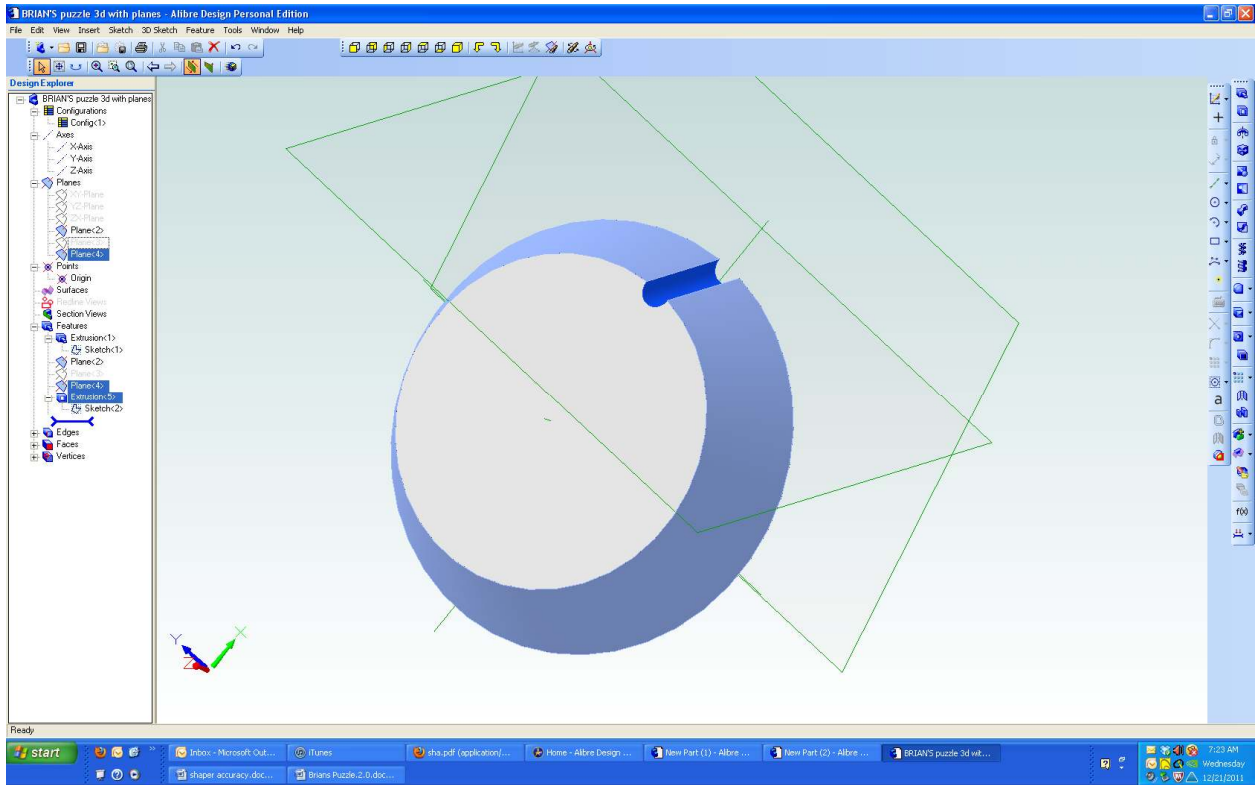


I have used my dimension tool to set the circle's diameter to 0.25".

If Brian wanted just a rounded groove in the tapered object, then I would just do an Extrude cut and be done with the step. But he wants fillets too. There are a few ways to do this. One was shown in the first half of this article. This time, I'll use my fillet tool.

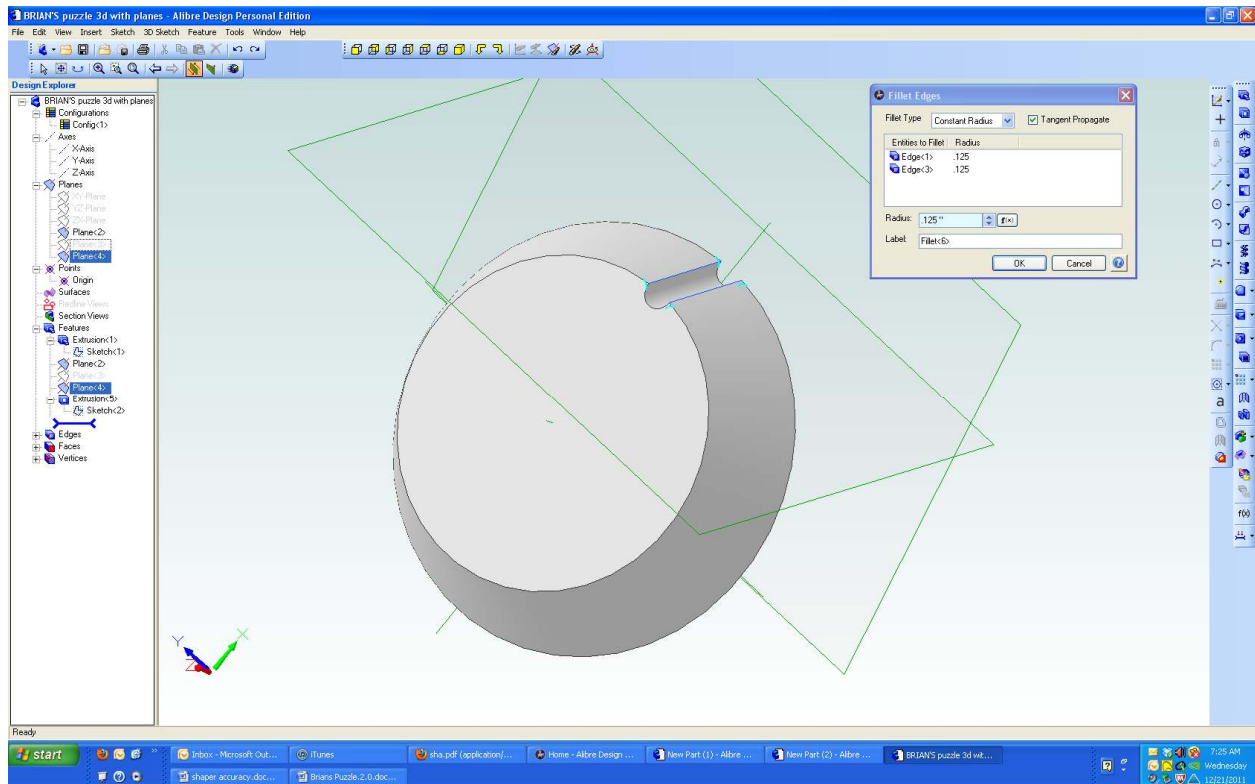


I have called up the Extrude Cut tool and set it to cut Through All. Note the two blue circles that define the ends of the cut. The bottom circle is on my plane and the top circle is aligned with the top of the tapered object.



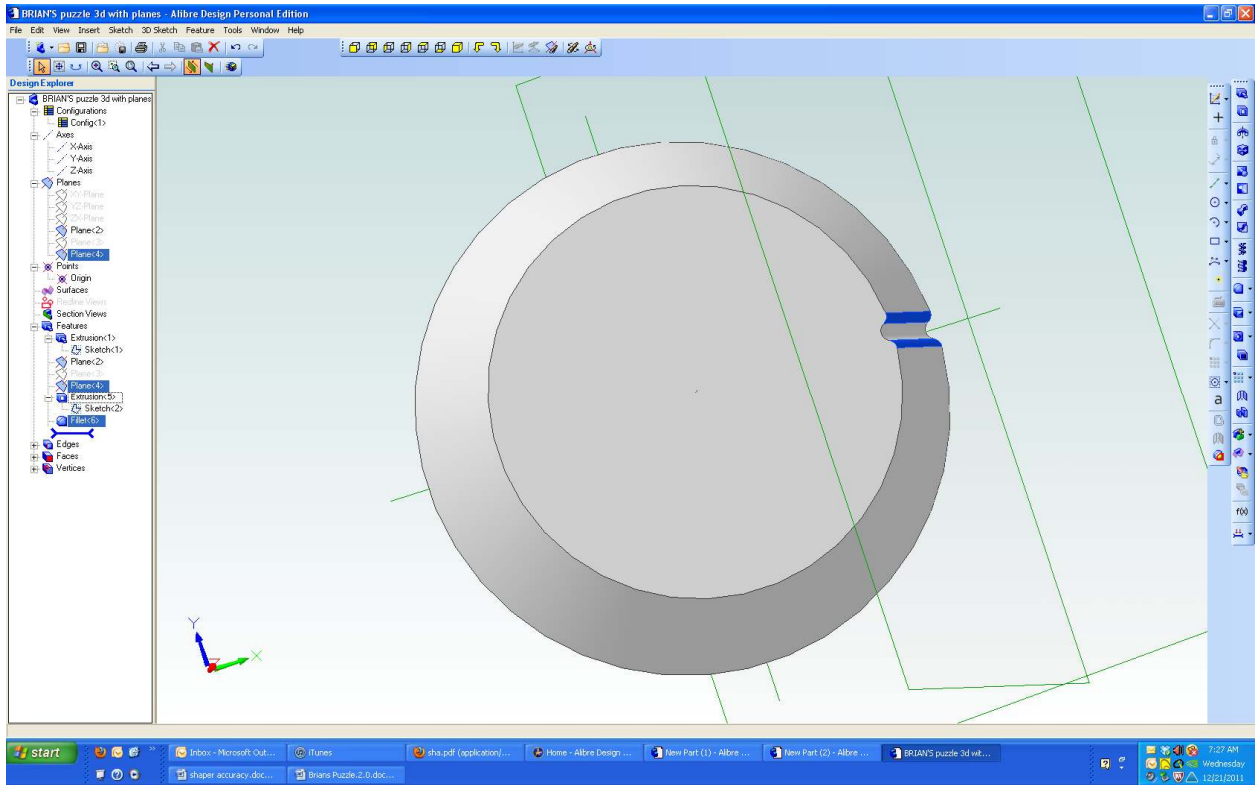
I now have my first rounded cut which is at a uniform depth with respect to the tapered surface.



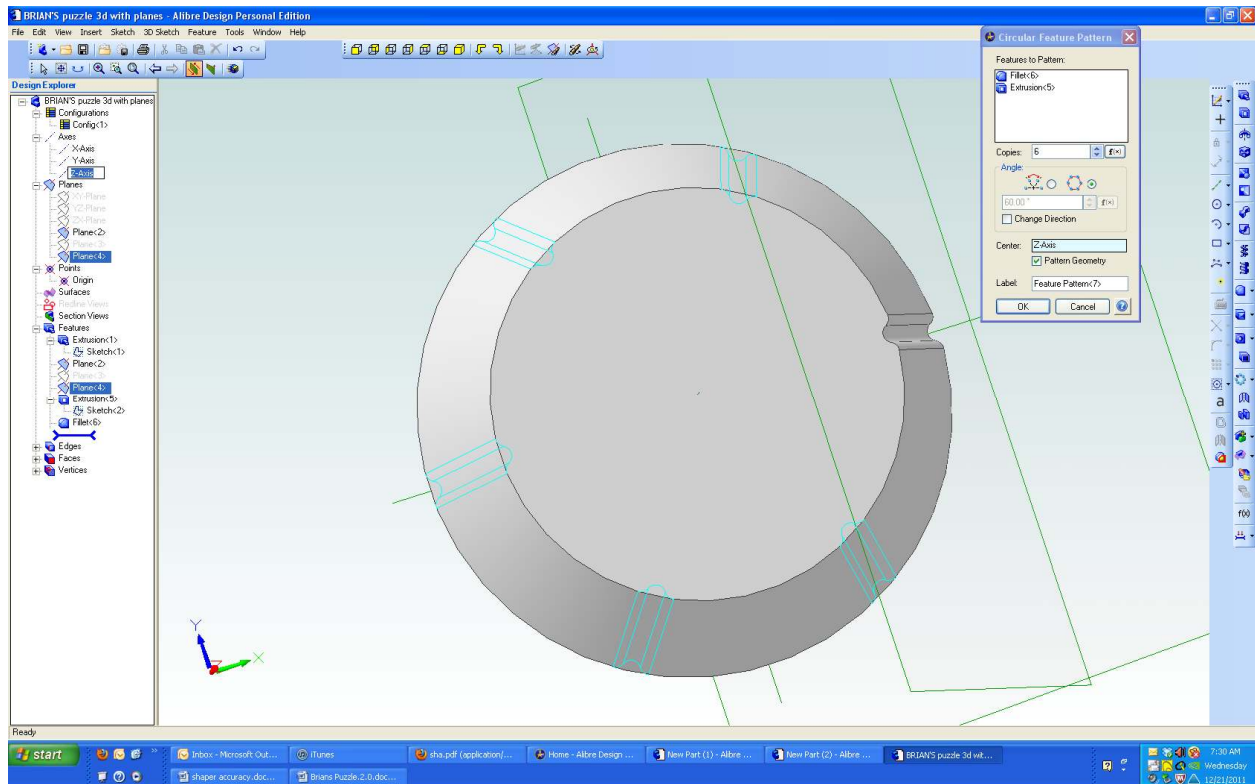


I have called up my 3D Fillet tool. By clicking on the edges of the cut I have told the tool where I want to put the fillets. I then enter the radius of the fillets, 0.125", and click OK.

Something does not look right. After I clicked OK, I went back to my 2D circle and discovered that my defined diameter did not take. No problem, I just did it again. The fillets adjust to the new circle diameter.

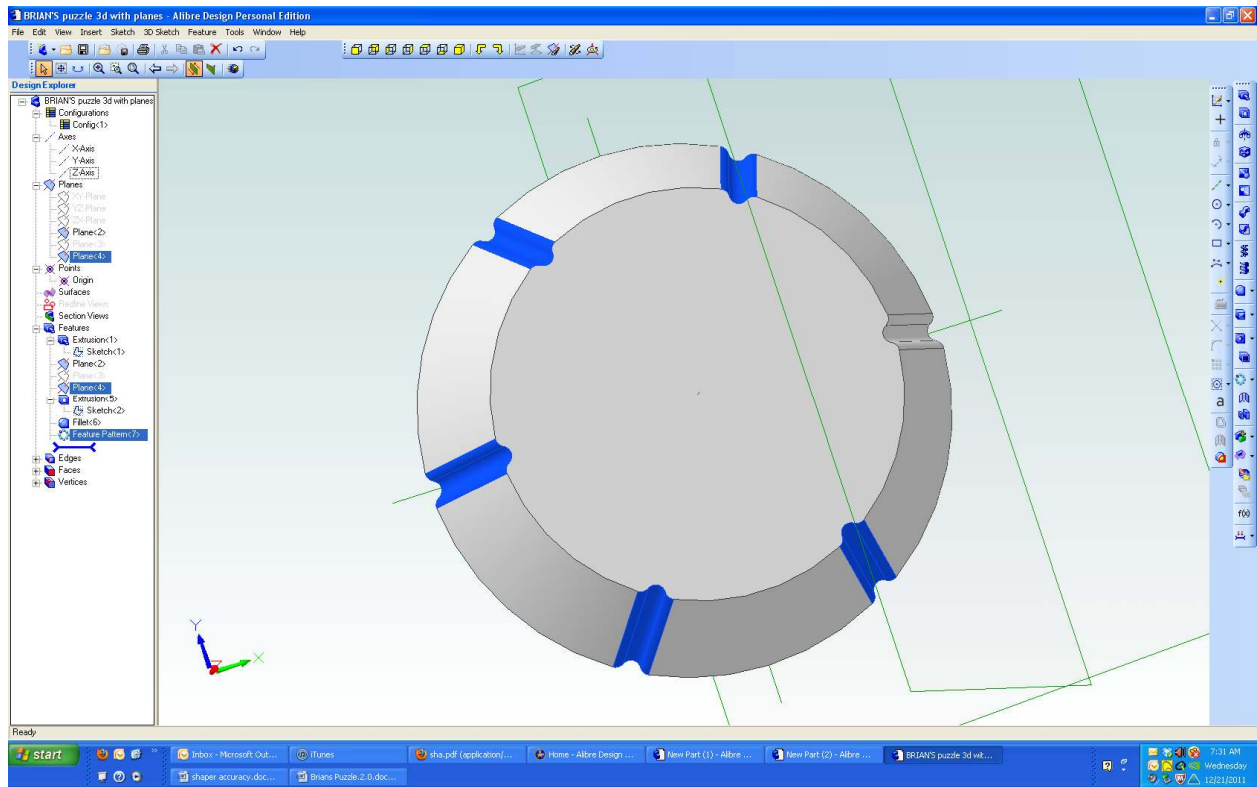


Here is my first filleted and rounded groove.

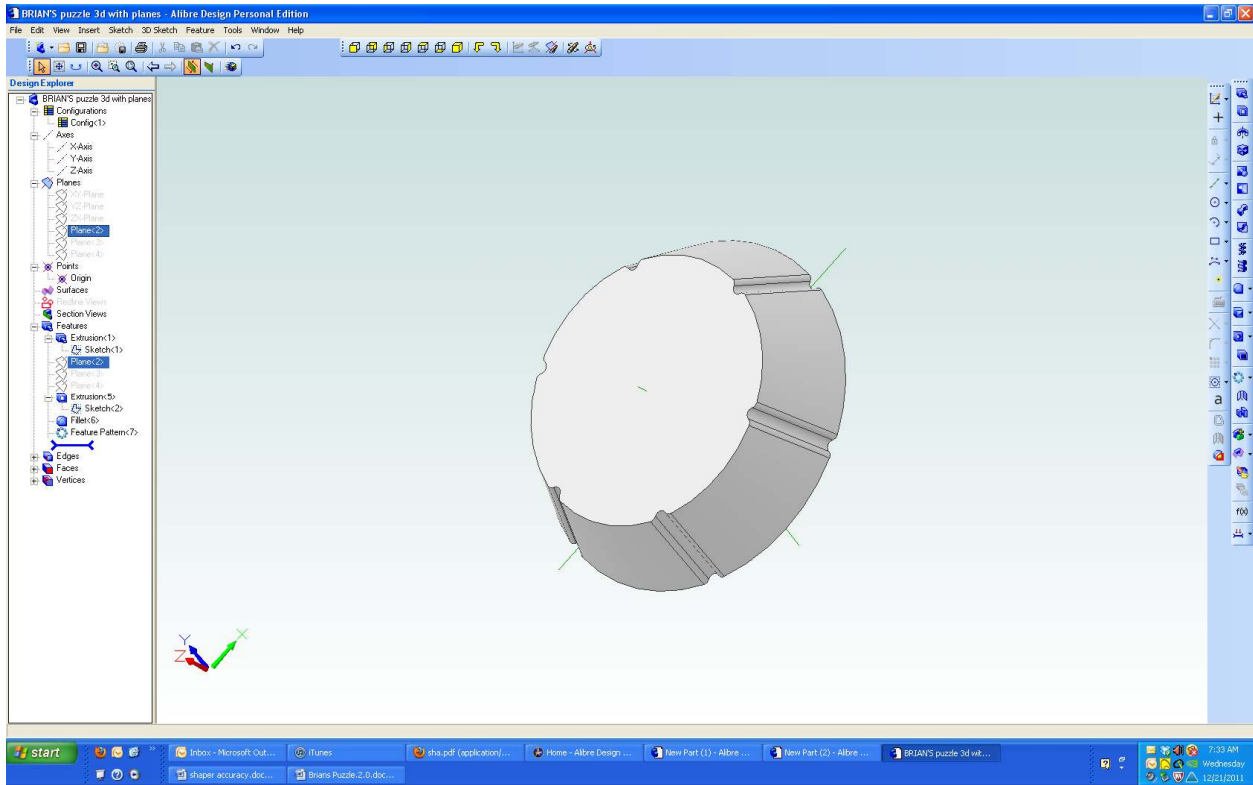


I have selected my fillets plus the rounded part of the groove as Features to pattern (thanks Lee for showing me how to use this tool).

I click on round pattern and tell it I want 6 copies (including the one I drew). I want them centered around the Z axis so click on Z axis in the Design Explorer.



And here are my 5 new cuts plus the original cut.

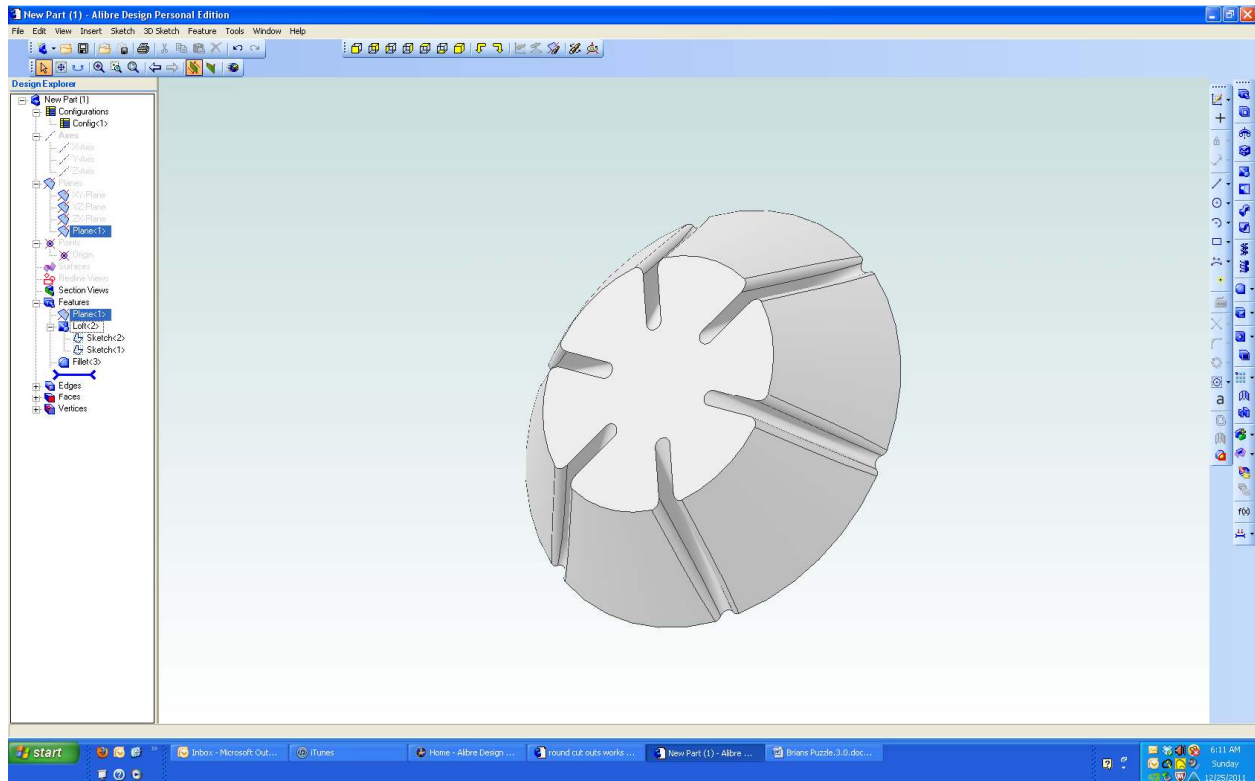


I have hidden all planes so you can better see the finished object.

In this approach I spent a lot of time defining my two planes. One plane is parallel to my taper, the other is perpendicular to this first plane plus aligned with an axis. That did take a bit of doing. But once I had my two planes, the rest of the work was routine and went fast.

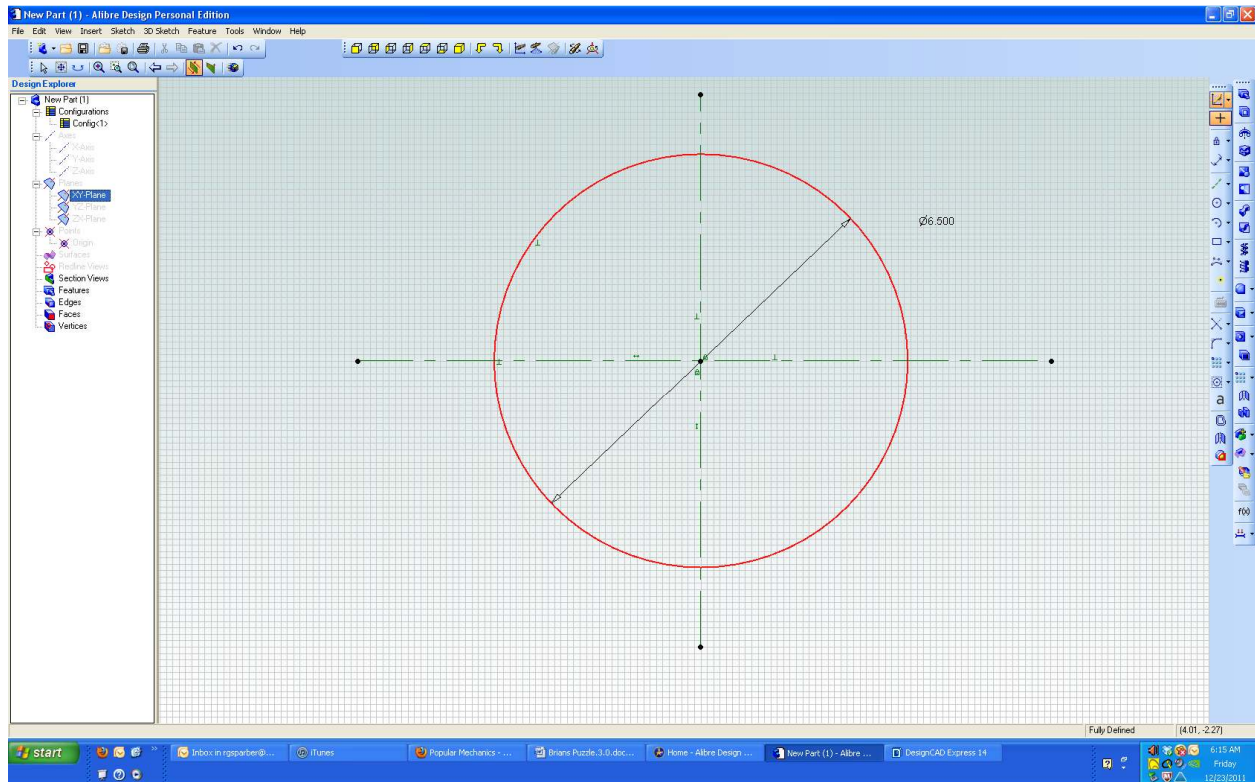
## Tapered Puck with Loft Boss Formed Shape

Well, Brian was not happy yet. I missed the fact that the cut-out is not at a uniform depth over the face of the taper. Fortunately, Lee did figure it out so I will present his approach next. Up to now the procedures have involved thinking mostly in 2D. Lee uses more 3D tools. We will end up with this beauty.



I will first present the procedure for creating this shape and in the next section show you another way that leads to distorted cut-outs. I believe this second way exposes a bug in Alibre.

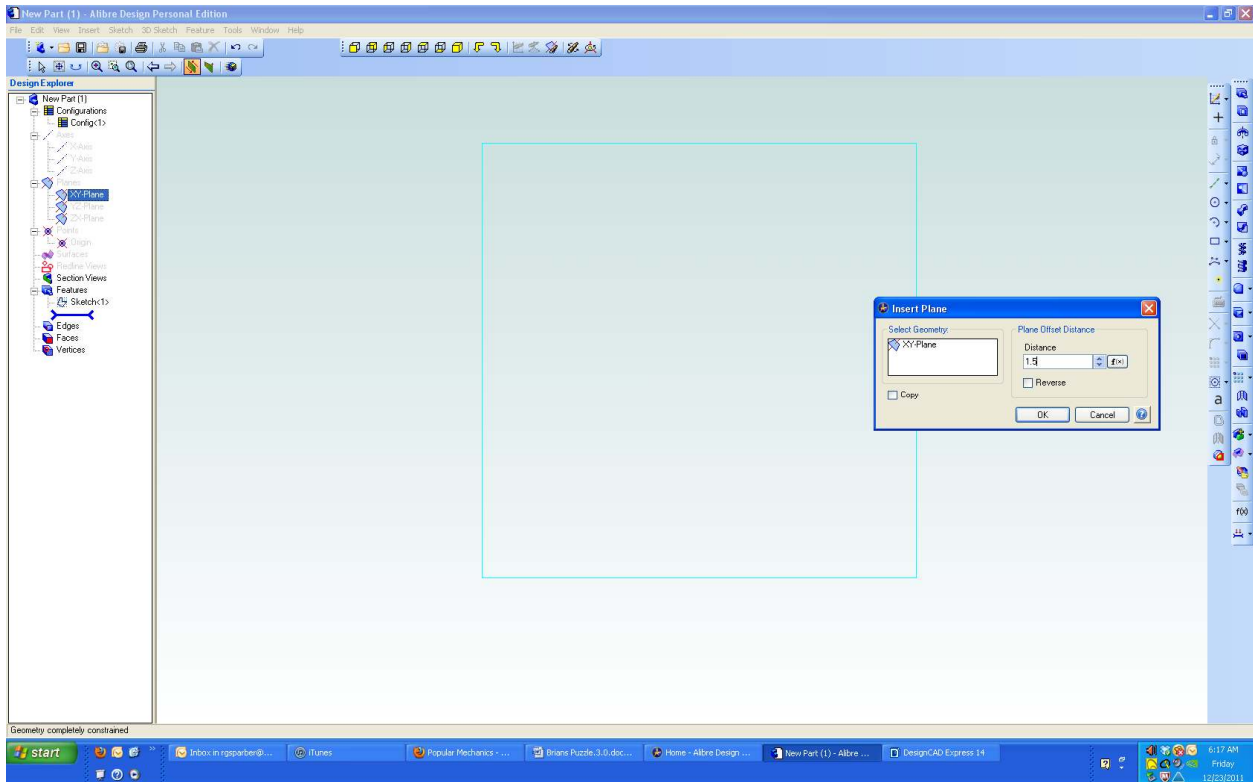
After starting up Alibre, I use my 2D Sketch tool to select the XY plane. Then I draw my X axis and Y axis reference lines and lock them in place with the lock constraint tool.



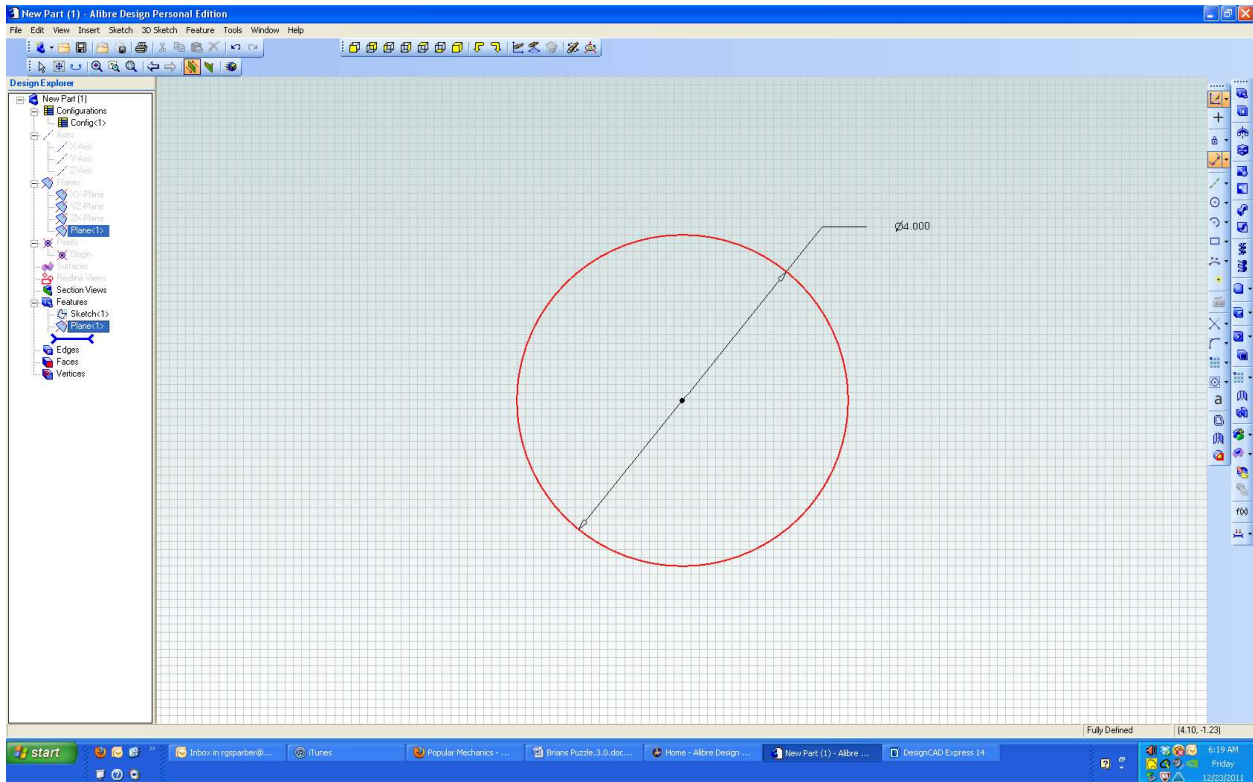
I then drew a circle that will be the base of my tapered object. The diameter is locked because I dimensioned it.

Note that this time I have gone to the menu View and selected Sketch display. From there I made visible constraint indicators, guide lines, and dimensions.





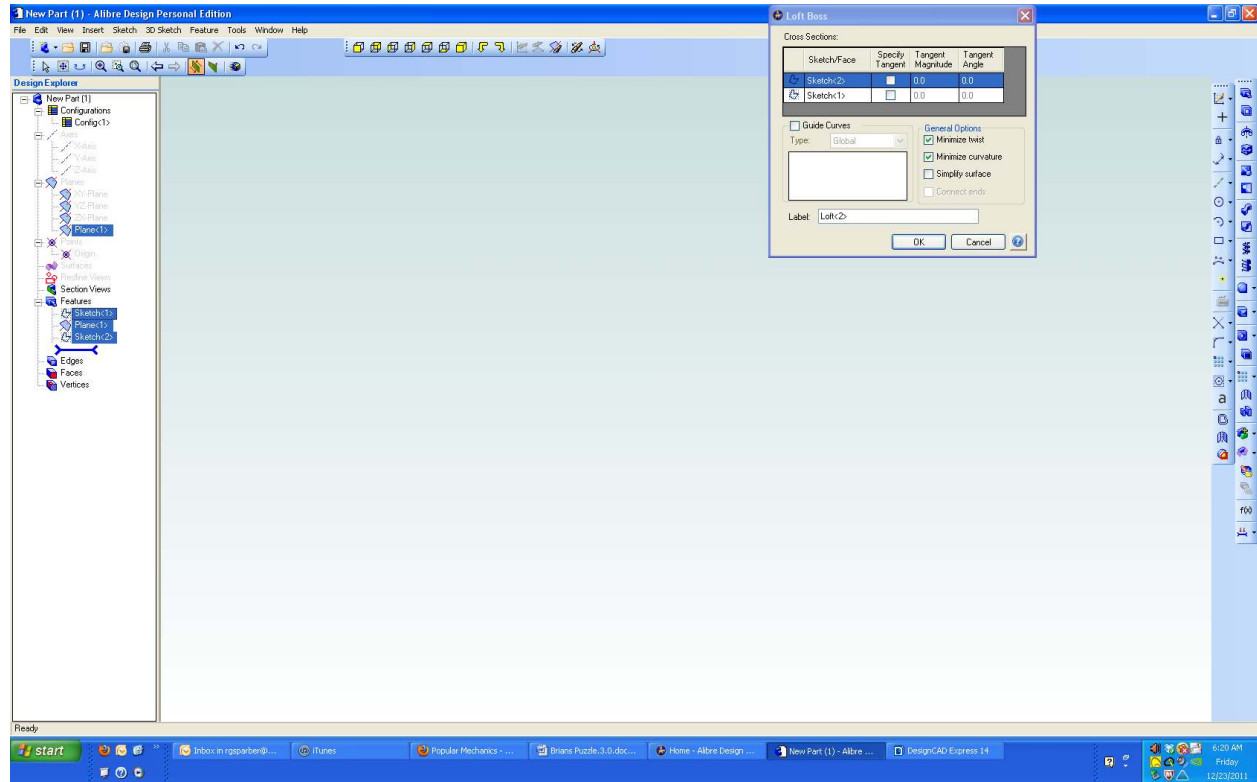
The top of the tapered object is 1.5" above the bottom. I brought up my Insert Plane tool and selected my XY plane as the selected geometry. Then I entered 1.5" into the offset window. This will create a new plane that is parallel to my XY plane but 1.5" above it. If I had entered -1.5", the new plane would have been below my XY plane.



The cycle repeats. I use my 2D Sketch tool but this time click on my new plane, Plane<2>, rather than my XY plane. I then draw a circle centered at the origin and dimension it to lock is diameter at 4”.

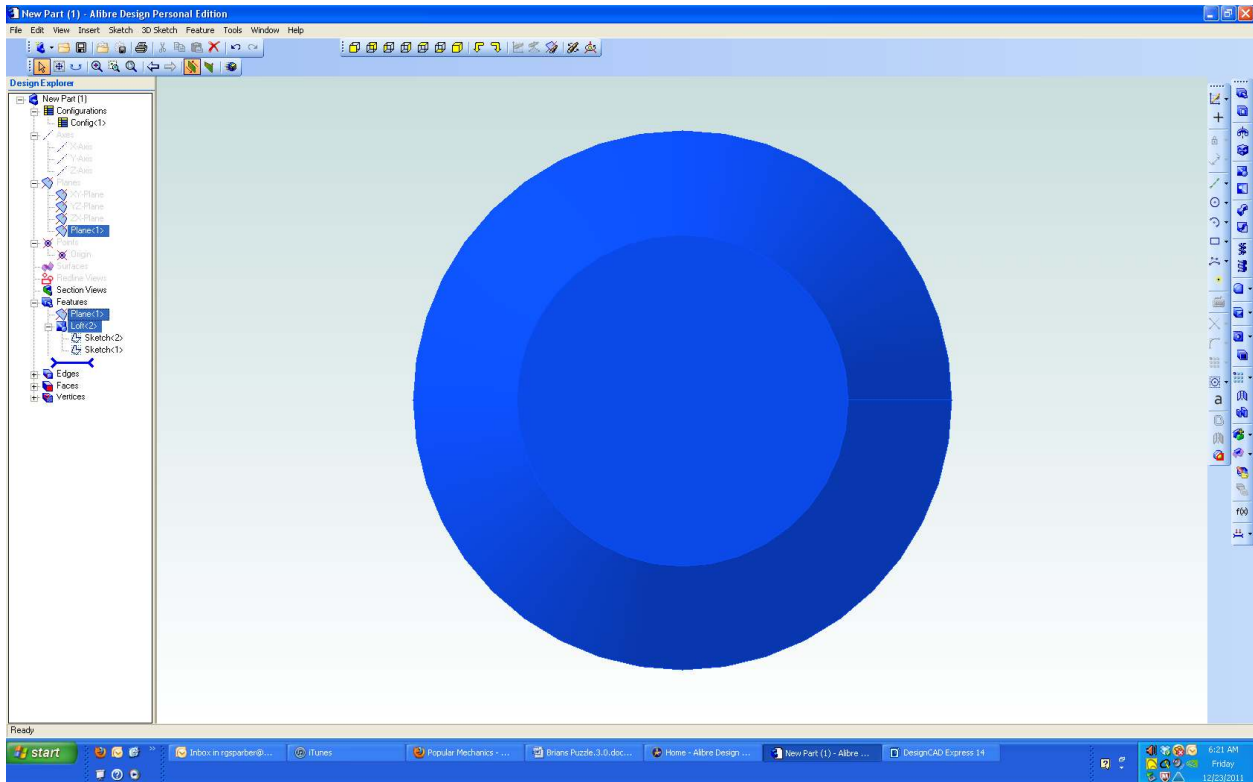
I now have my base circle on the XY plane and the top circle on Plane<2> which is 1.5” above it.

I exited my 2D Sketch editor and brought up my “Loft boss” tool from the 3D column.



It had already selected Sketch<2> as one end of the boss. I held down the Control key and clicked Sketch<1>.

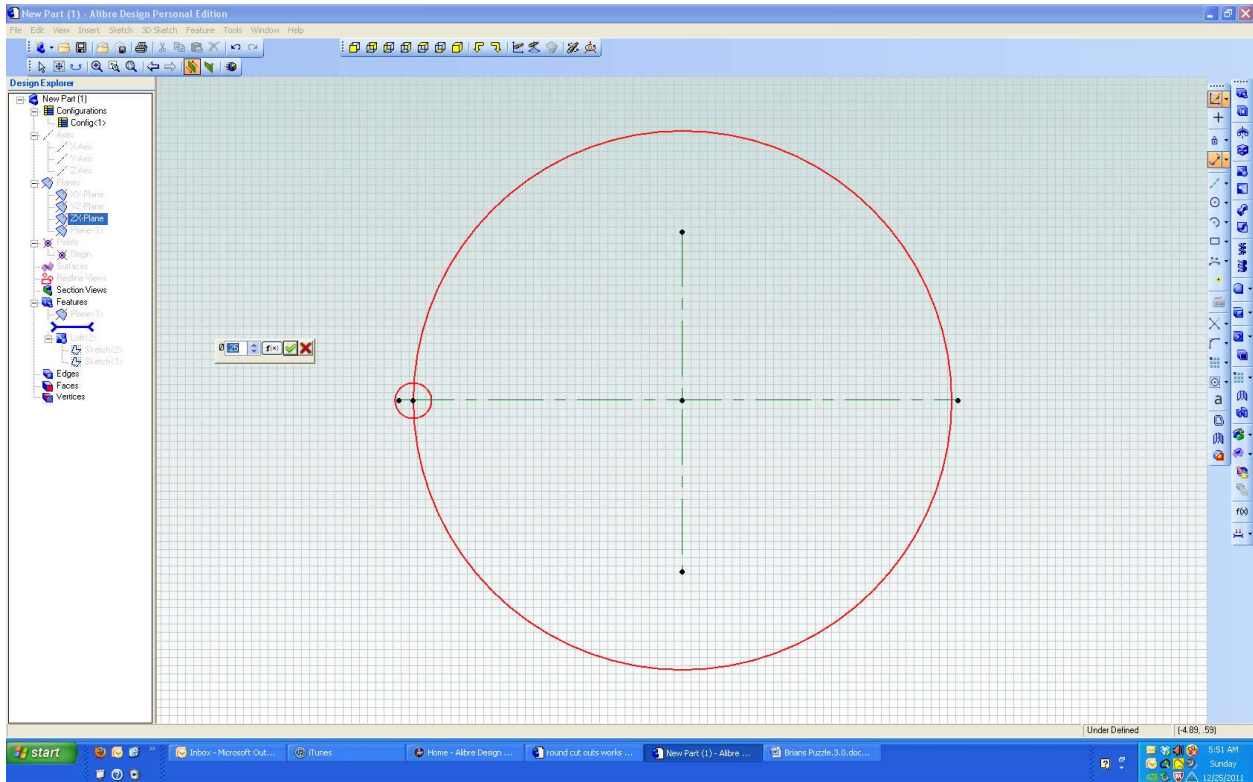
I readed that the order of the sketches matters but maybe because this is such a simple shape, it doesn't.



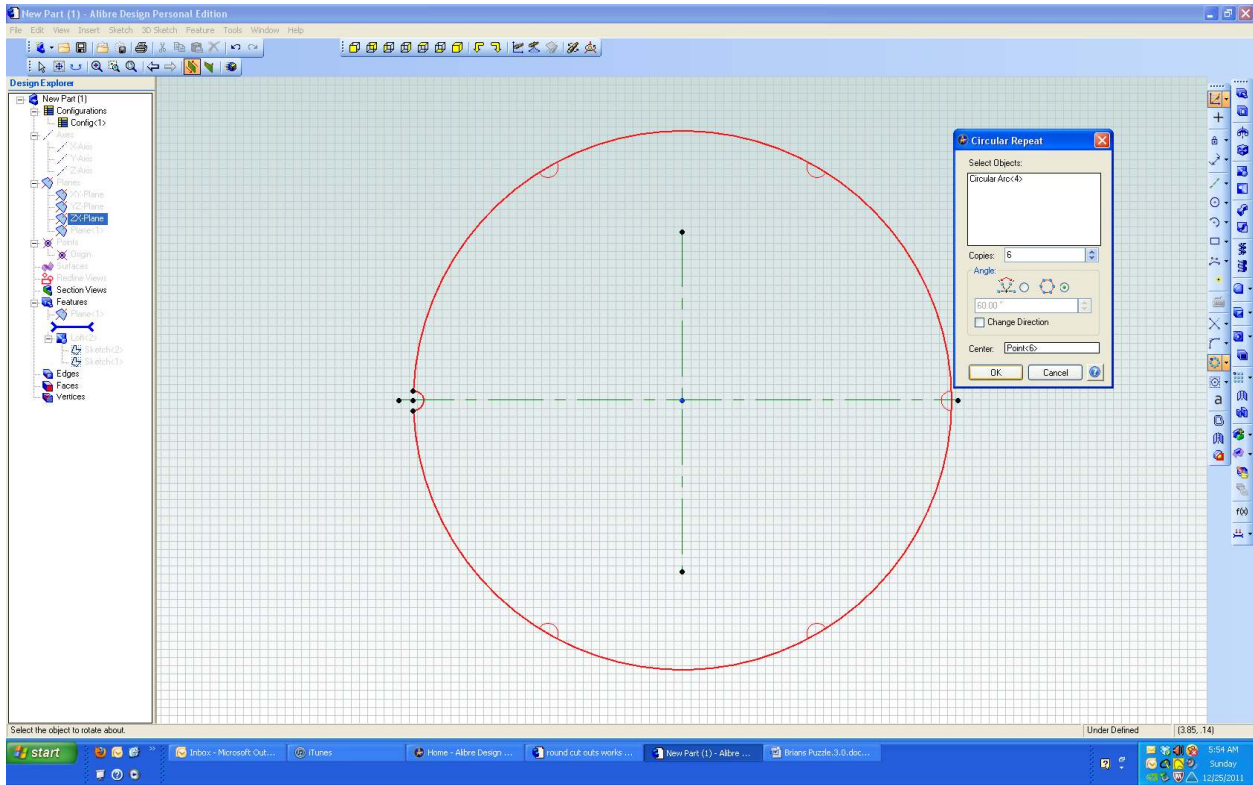
I clicked OK and now have my tapered cone. There are a few big advantages to creating the cone this way. The first is that I directly specify the top and bottom's diameter so do not have to calculate the taper angle.

The second advantage is that I can define the shape of the cut at the top and bottom and the tapered surface will automatically conform. Since the top and bottom of the cut-outs are independently specified, I have more control of the total shape than with previous methods.

With the last approach, the top and bottom shapes had to be the same. This time I will make the cut deeper at the top than at the bottom plus change the profile.

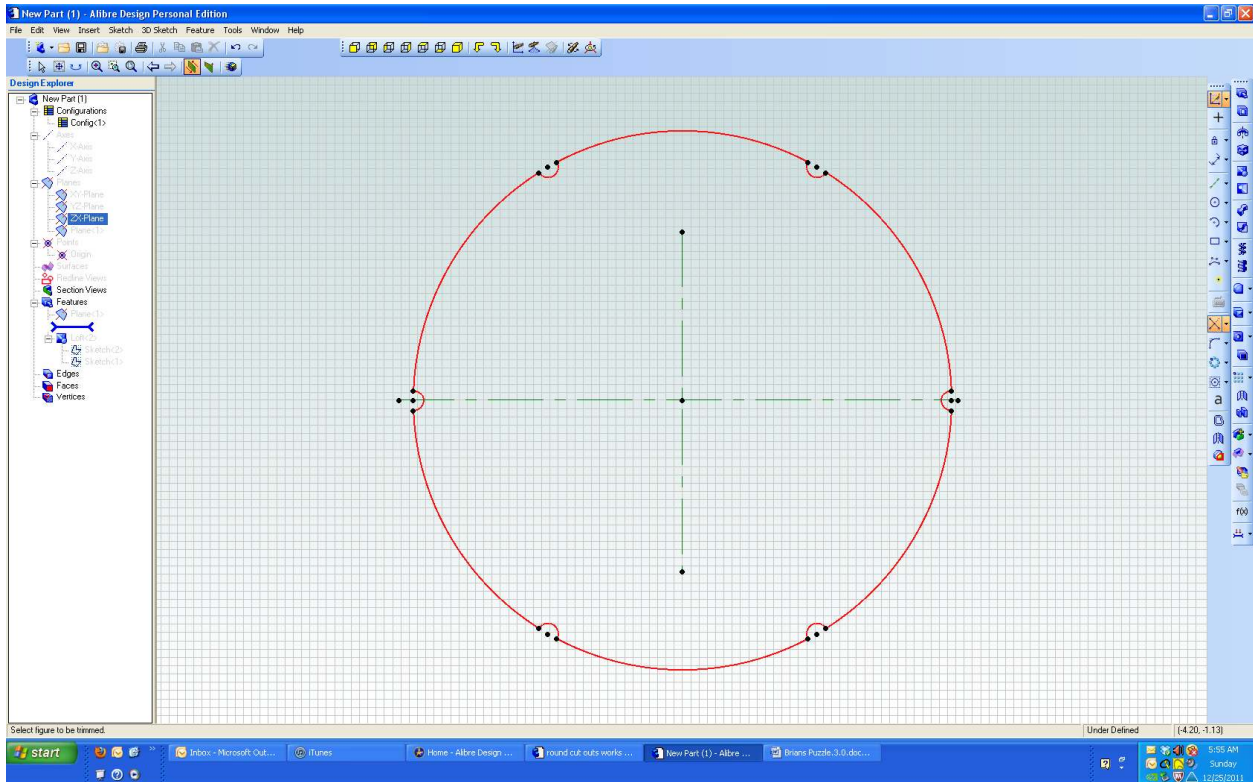


Returning to Sketch<1>, my bottom sketch, I drew a circle at the perimeter of my circle lined up with my horizontal reference line. Then I set its diameter to 0.25”.



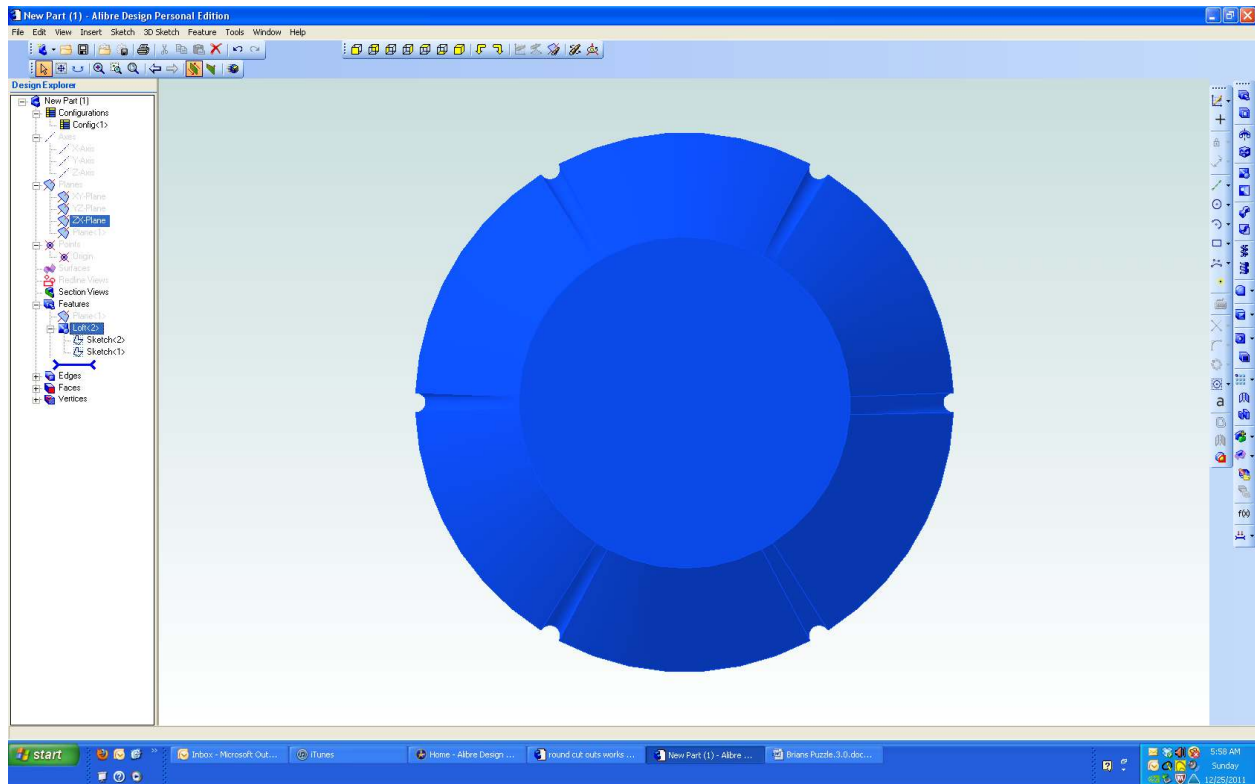
After using my line delete tool, I brought up my Circular repeat tool.



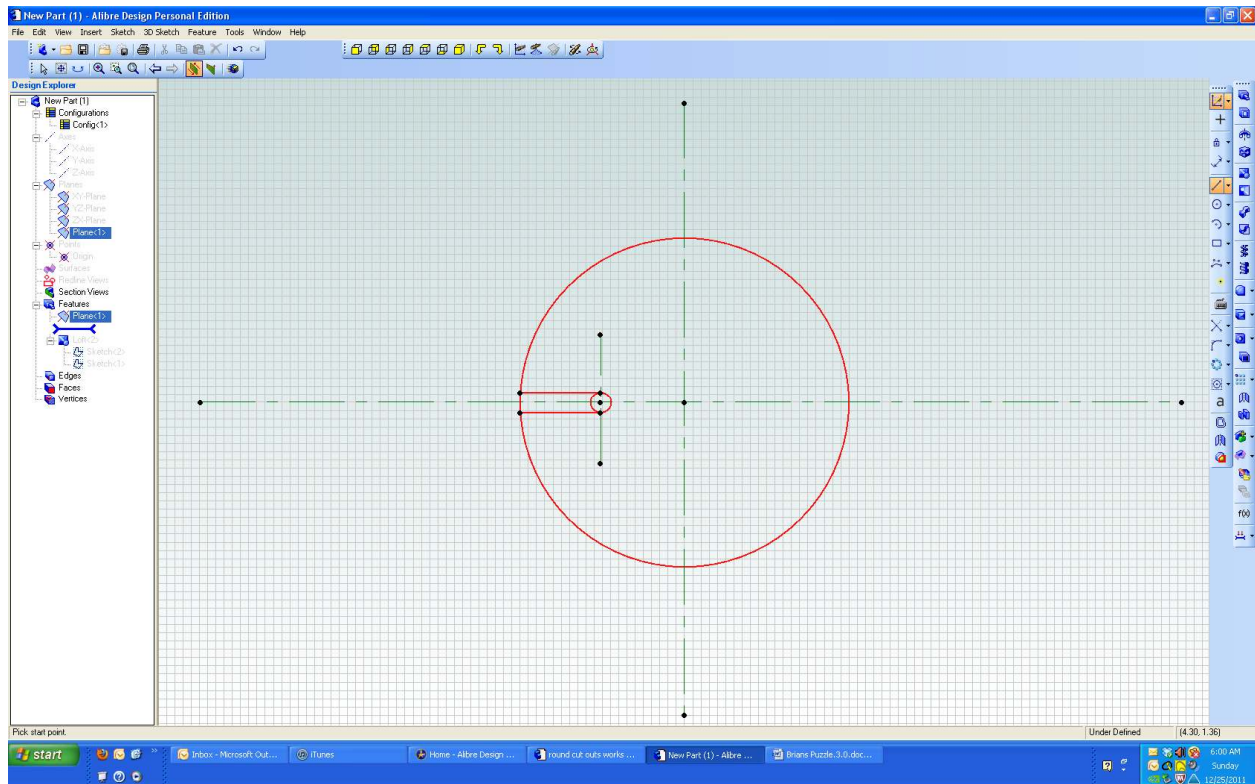


I then used line cut to remove the segments of the large circle that passed through the cut outs. Note that I did not add the fillet. Doing so, either via tangent circles or with the fillet tool causes the strange distortions of the cut-outs. You will see that in the next section.



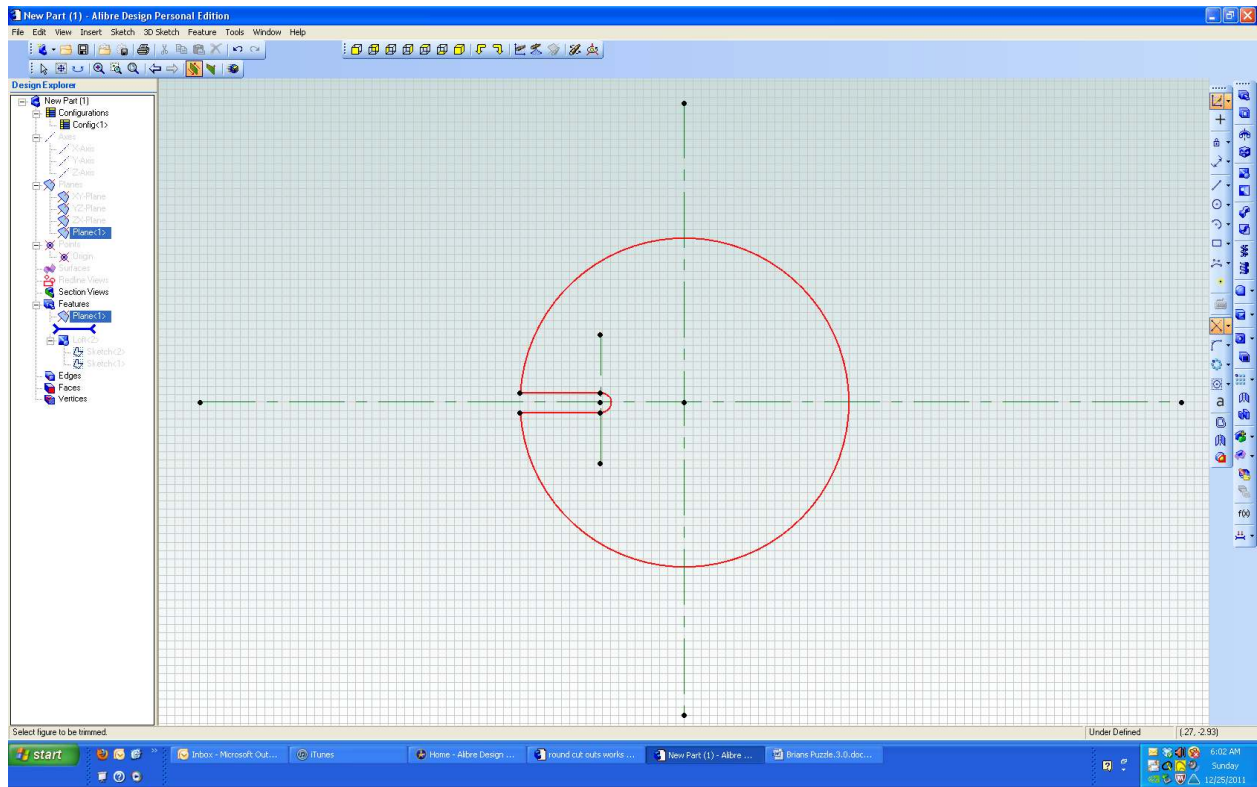


When I leave 2D edit I can see the cut-outs on the base that smoothly transition to no cut-outs on top. We will next add the top cut-outs but no fillets.

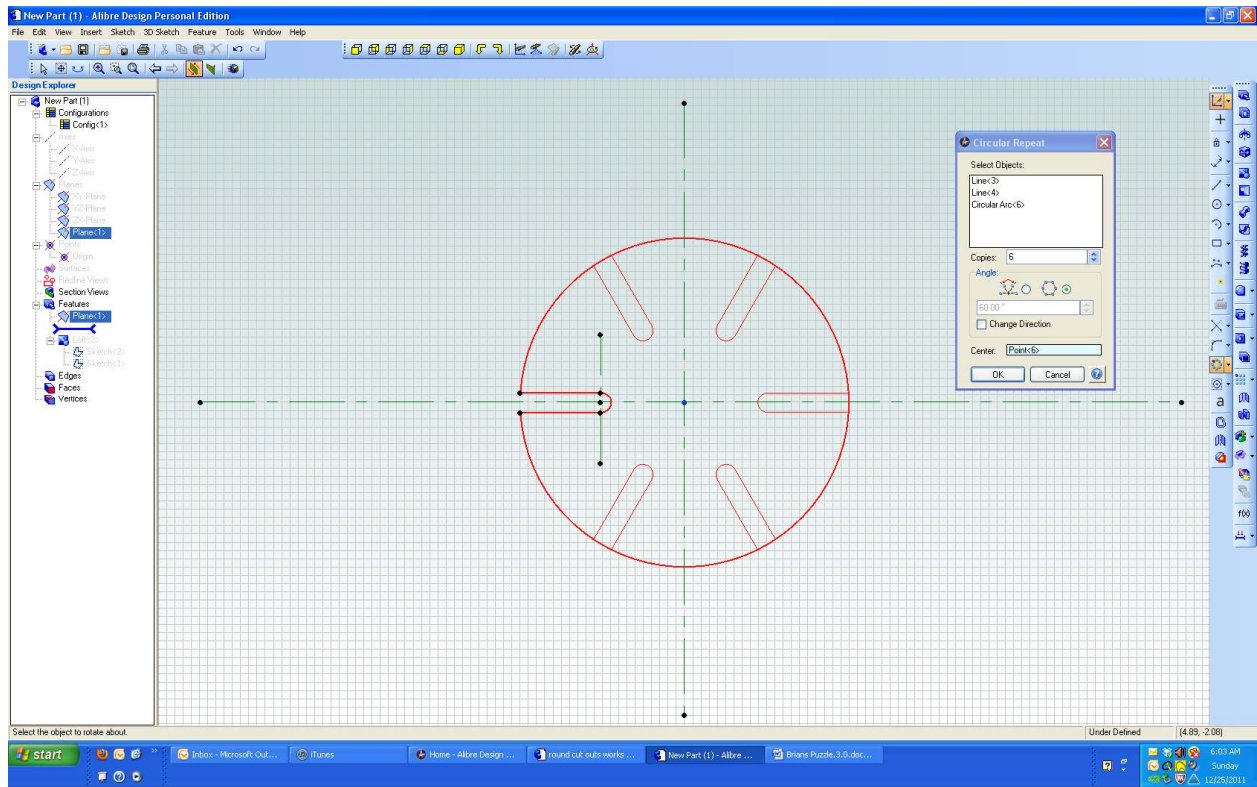


I previously drew the bottom cut-out along the horizontal reference line so must do the same for the top cut-out. Otherwise some of the cut-outs will not line up.

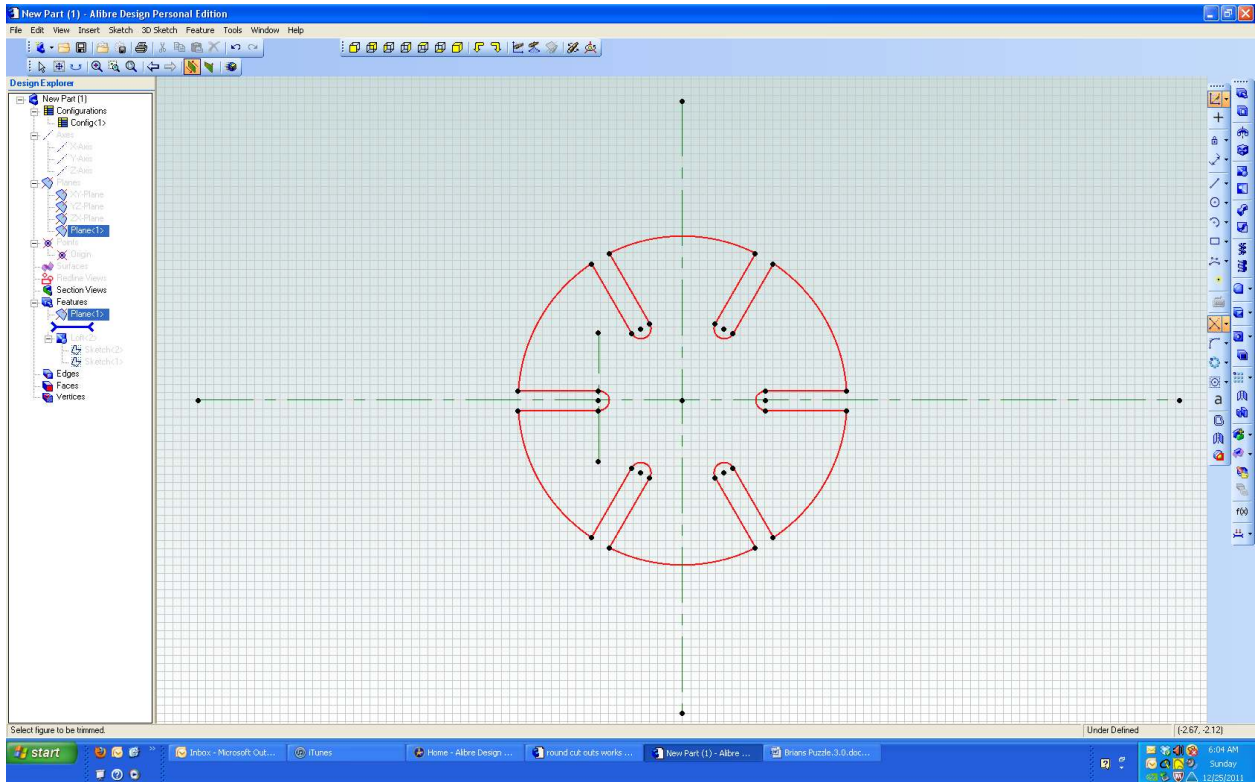
This time I chose to draw my small circle and then add lines. Note the reference line through the center of the small circle which enabled me to precisely locate the tangents.



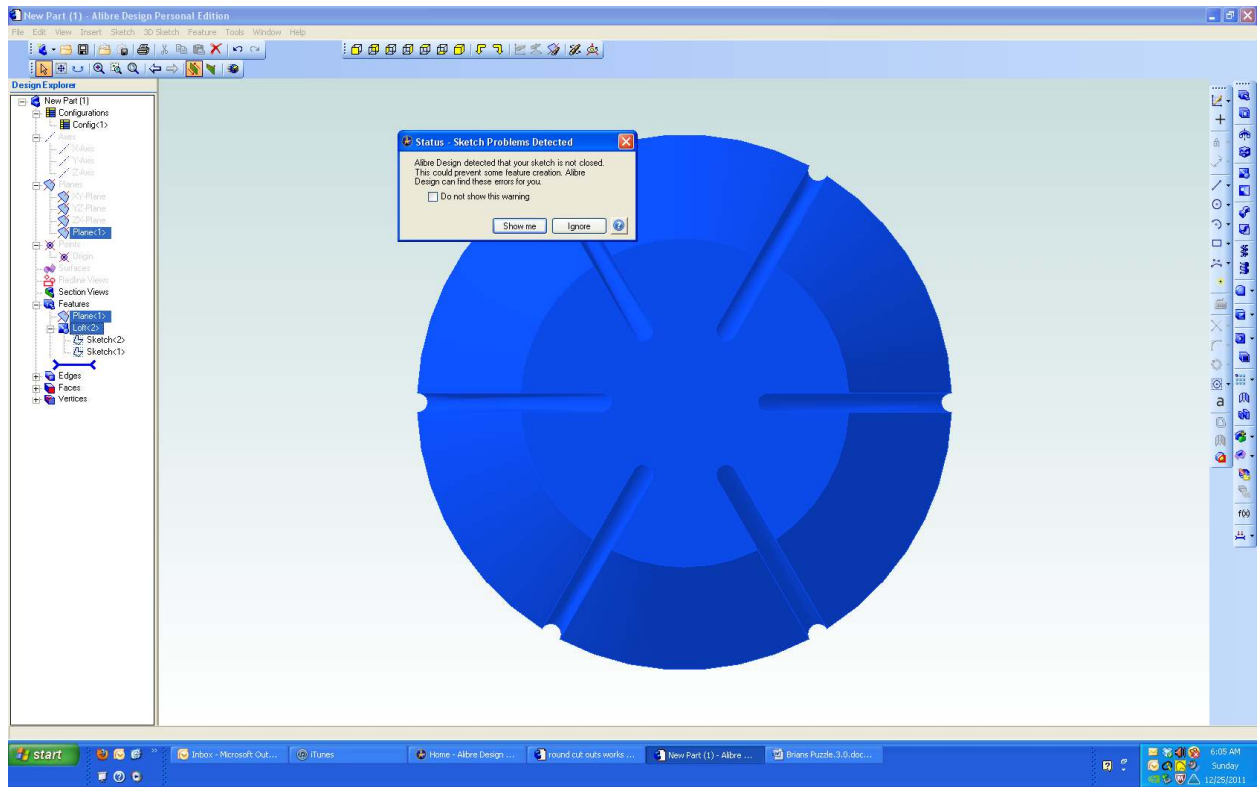
Line cut was used to remove the unwanted arcs.



Circular repeat was used to generate my 6 cut-out outlines.

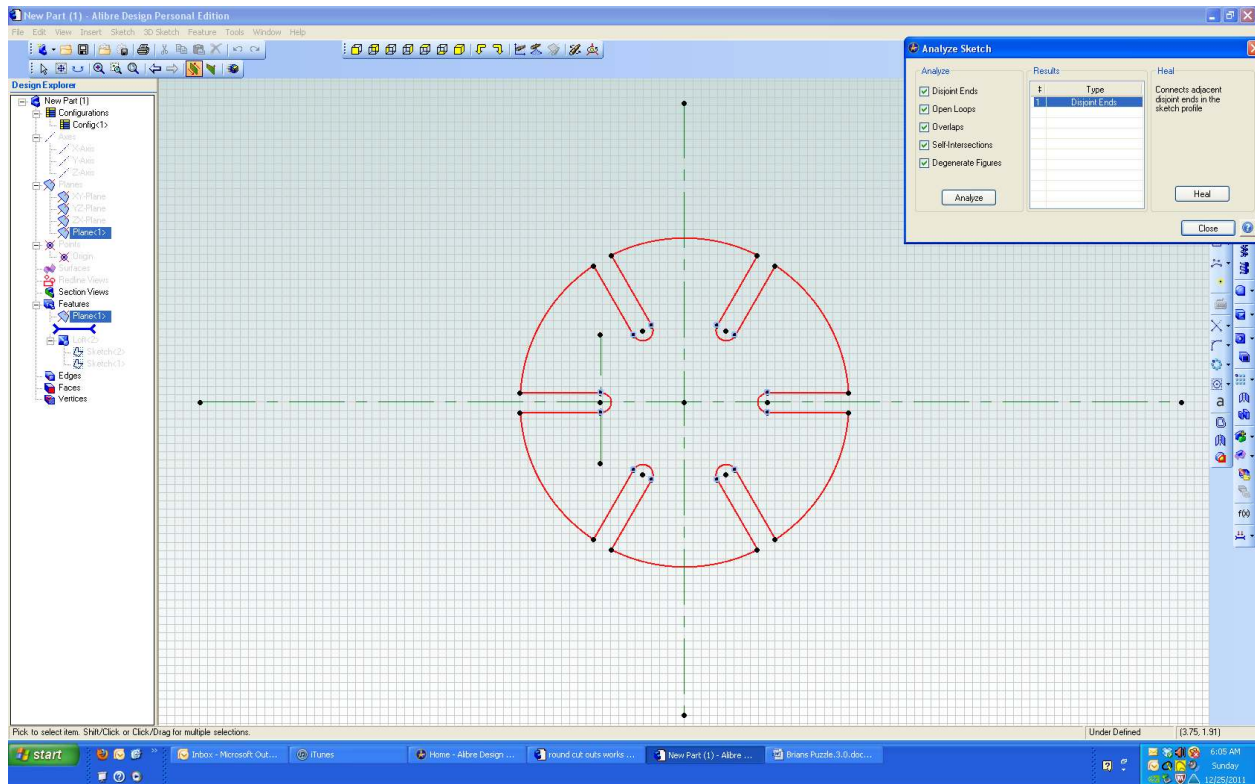


All 6 cut-outs are now formed. Note, again, that I have not added fillets between the cut-outs and the large circle.



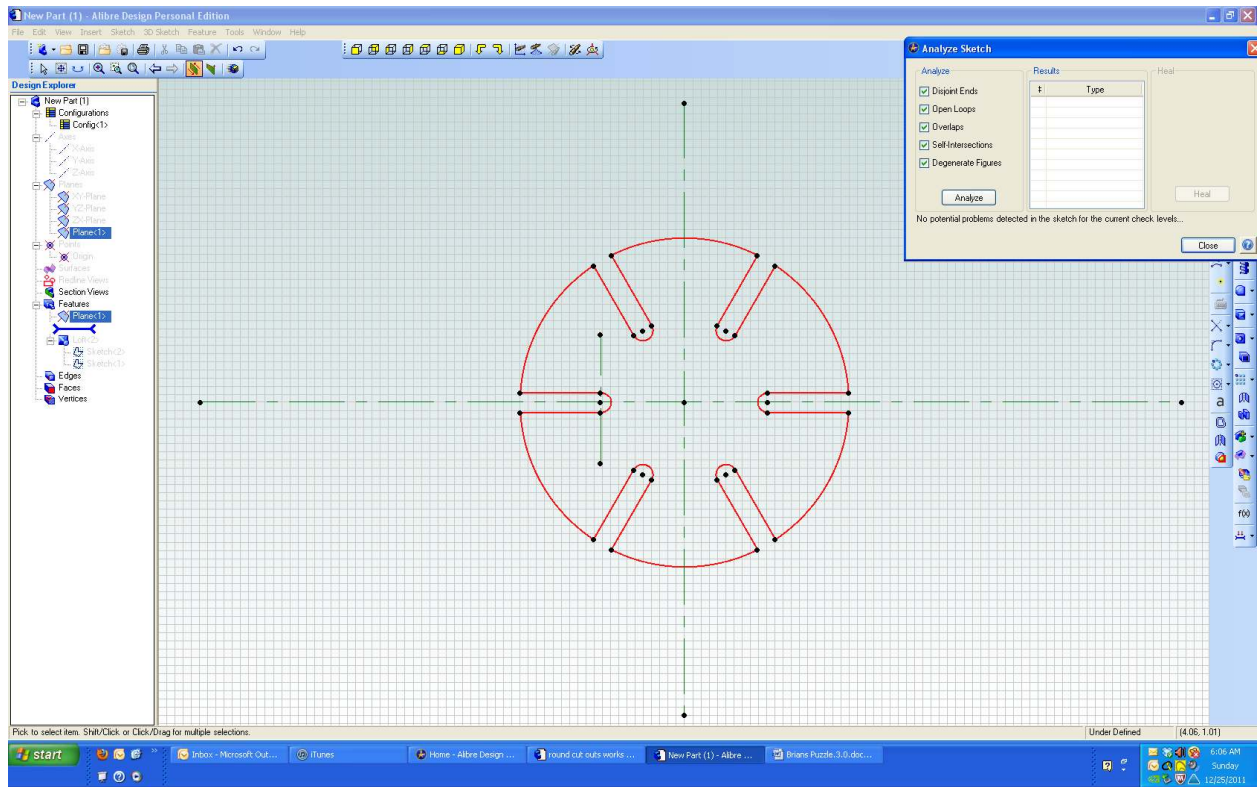
When I left 2D sketch, I got an error message.



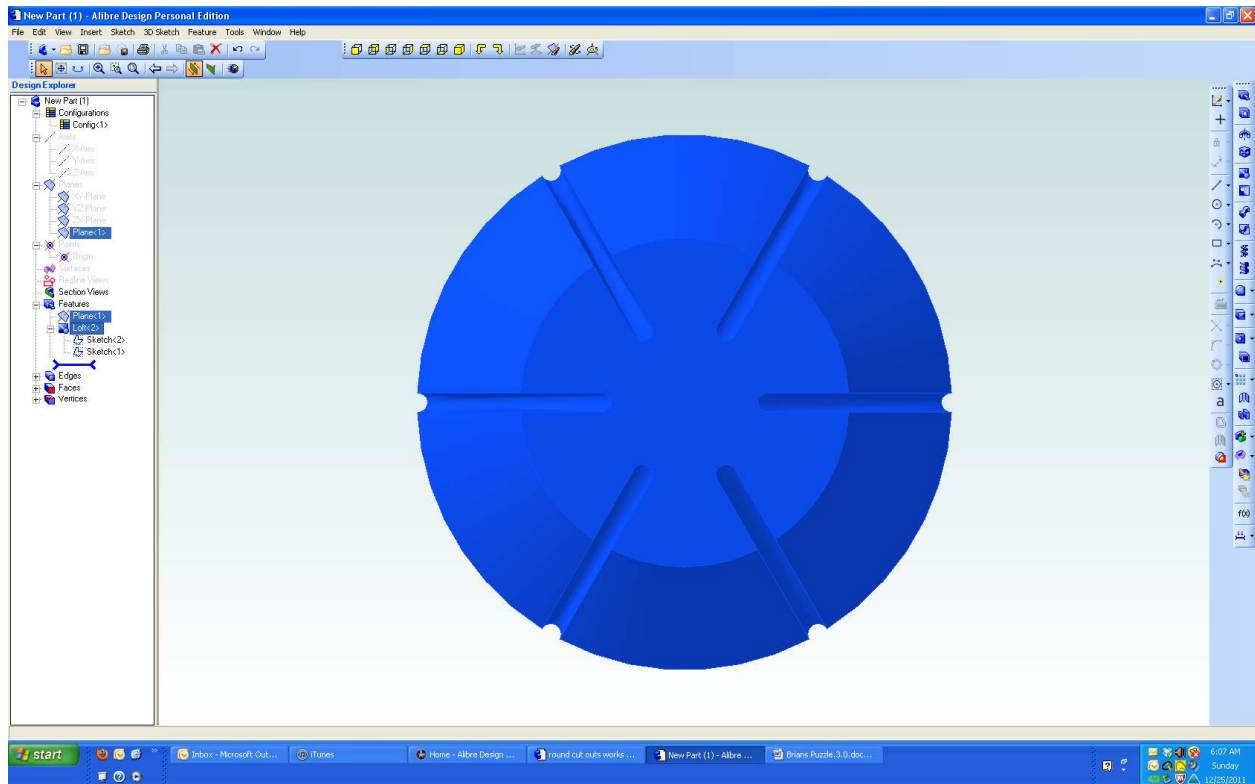


Alibre was not happy with how I attached my lines to my 0.25” circle. It must be minor because it is able to automatically “heal” it if I click the button.

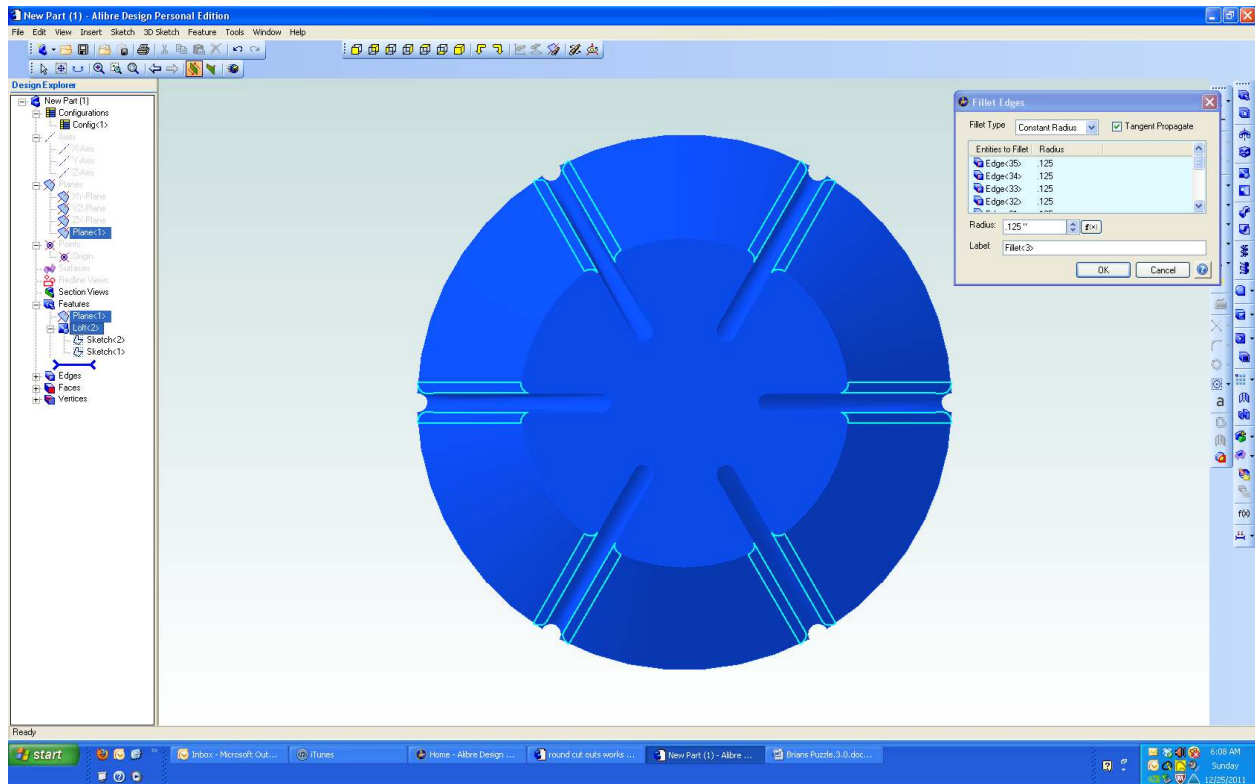




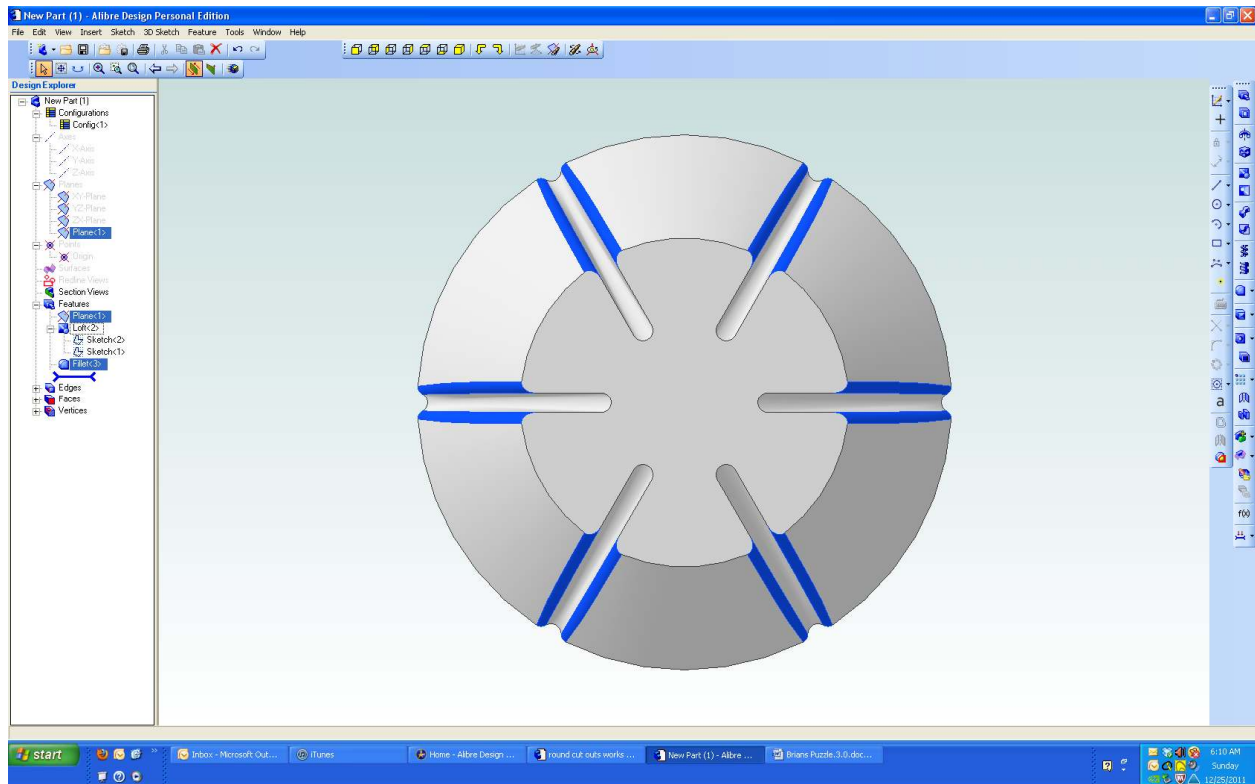
Now Alibre is happy so I will click Close.



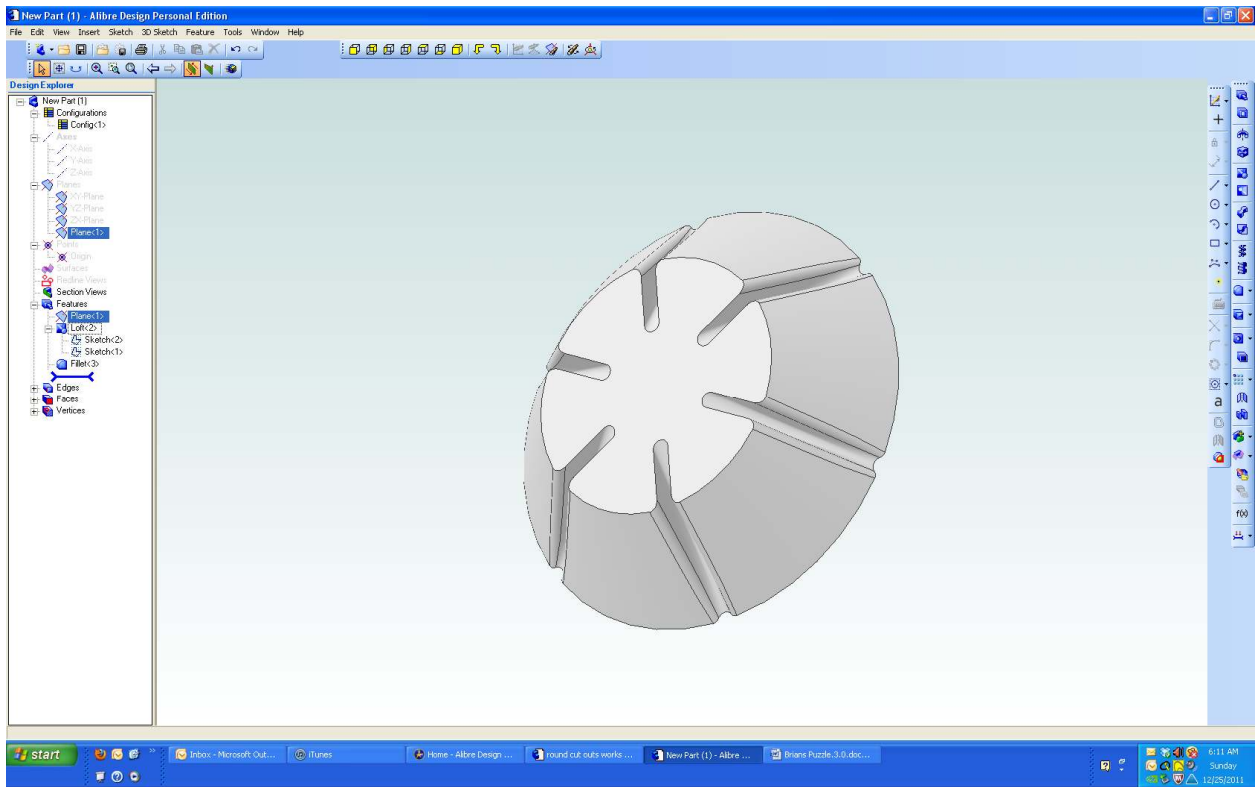
When I left 2D sketch of the top face, I got to see my tapered puck. Note that the cuts are uniform but not filleted.



I called up my 3D Fillet tool and selected each edge that I want to be rounded. Note that I selected the edges and not the adjoining surfaces.



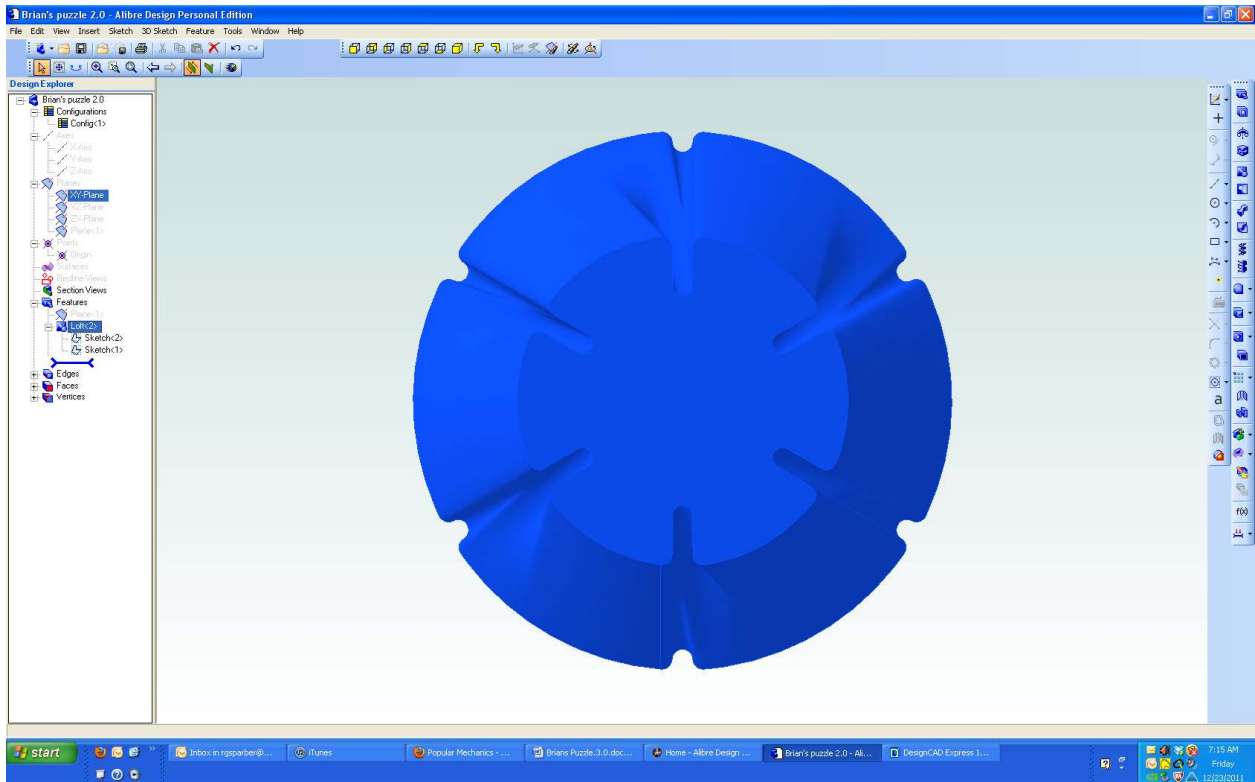
When I clicked OK, I was able to see the filleted cut-outs as they should be – no distortion of the sides.



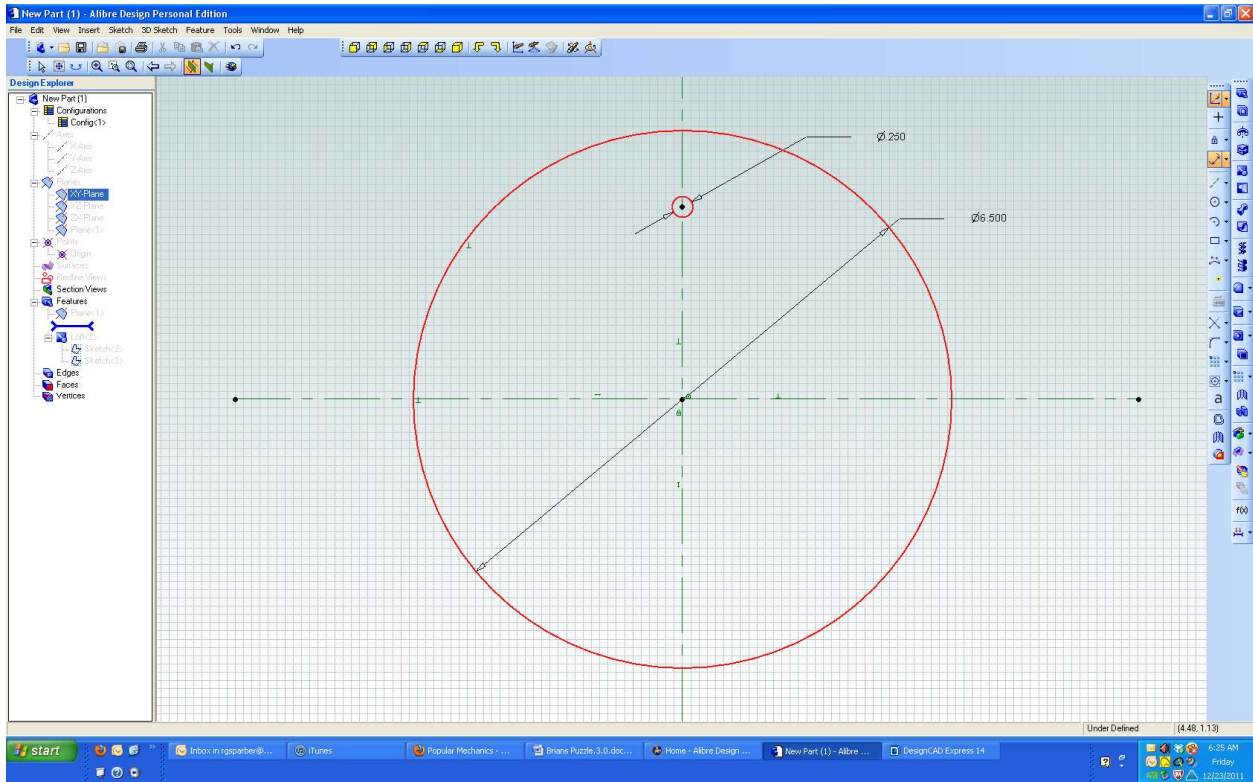
Here is the final part.

# Trying To Draw the Tapered Puck with Loft Boss and 2D fillets But Getting Distortion

This approach causes a strange distortion of the cut-outs. I think it is a bug.



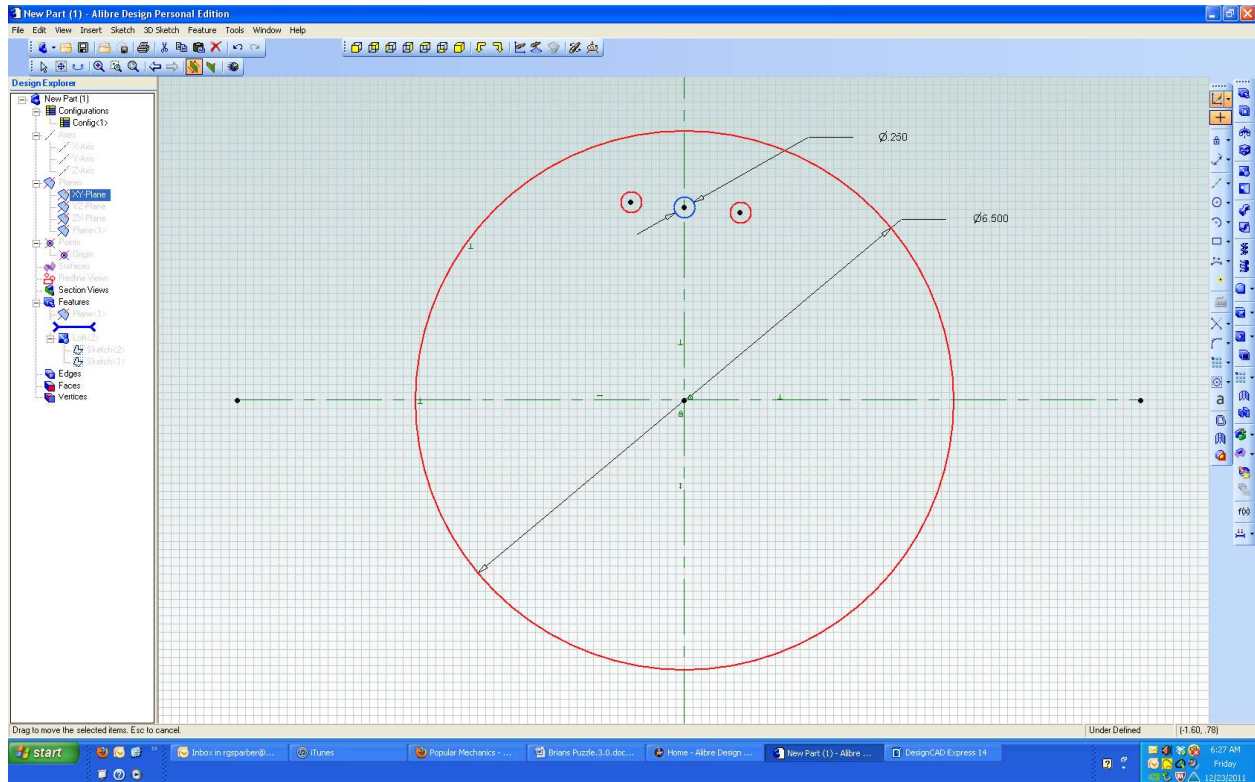
I had already drawn my top and bottom 2D sketches.



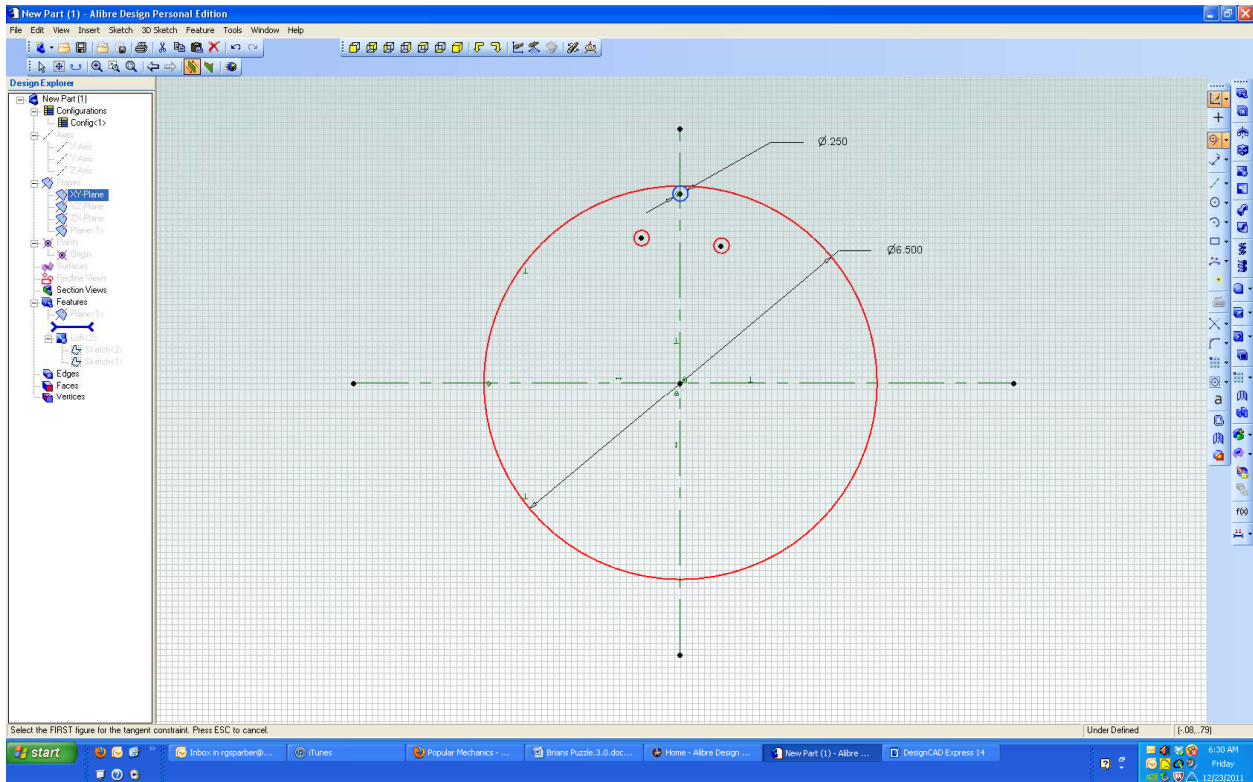
I'm back to 2D sketching on my base which is Sketch<1>.

First I drew a small circle and then defined its diameter to be 0.25" to lock it. I drew this circle on my vertical reference line because I plan to make my first cut out at the 12:00 position above it.



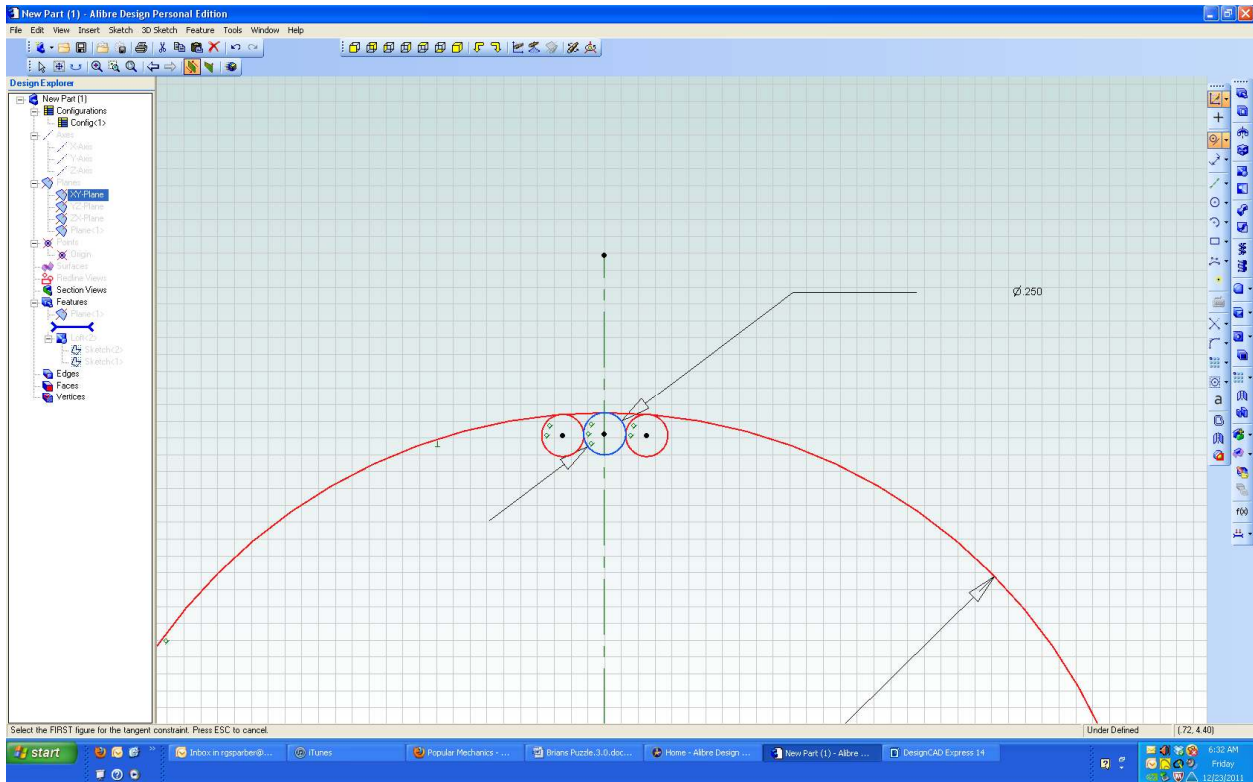


I used 3 equal sized circles to form my cut out. Here I made two copies of the original circle and put them on either side of the vertical line.

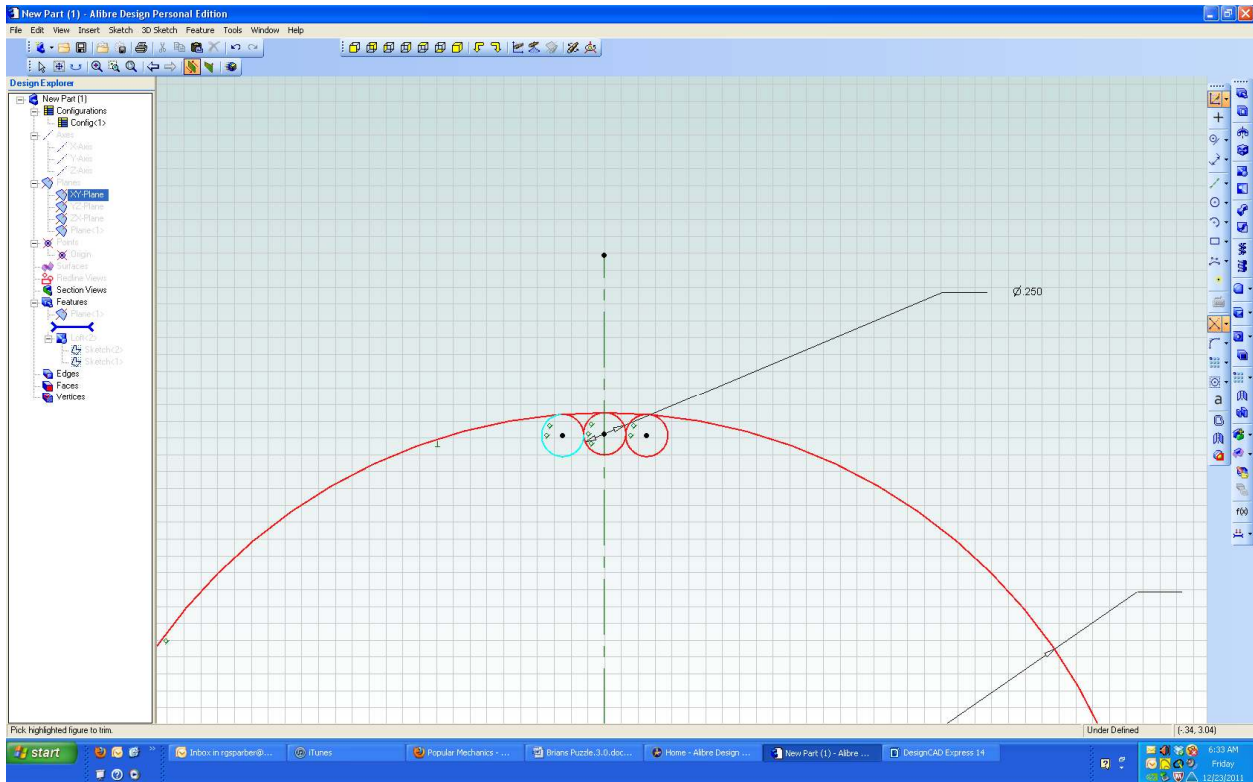


I picked up the tangent constraint tool next. I wanted my center circle to be tangent to the big circle so first clicked the big circle and then the small circle. This tells the tool to move the small circle to the big one.

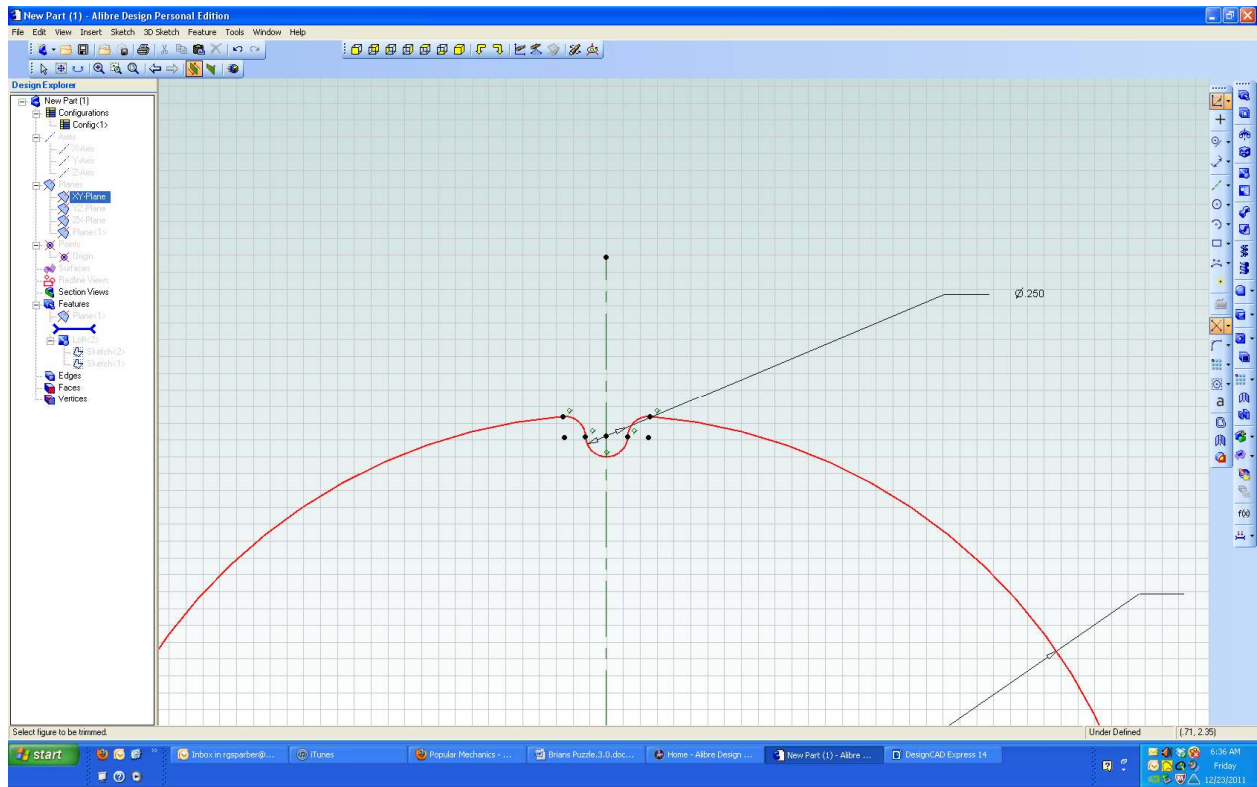
If I clicked the big circle and then the small one, the big circle would move to the small circle.



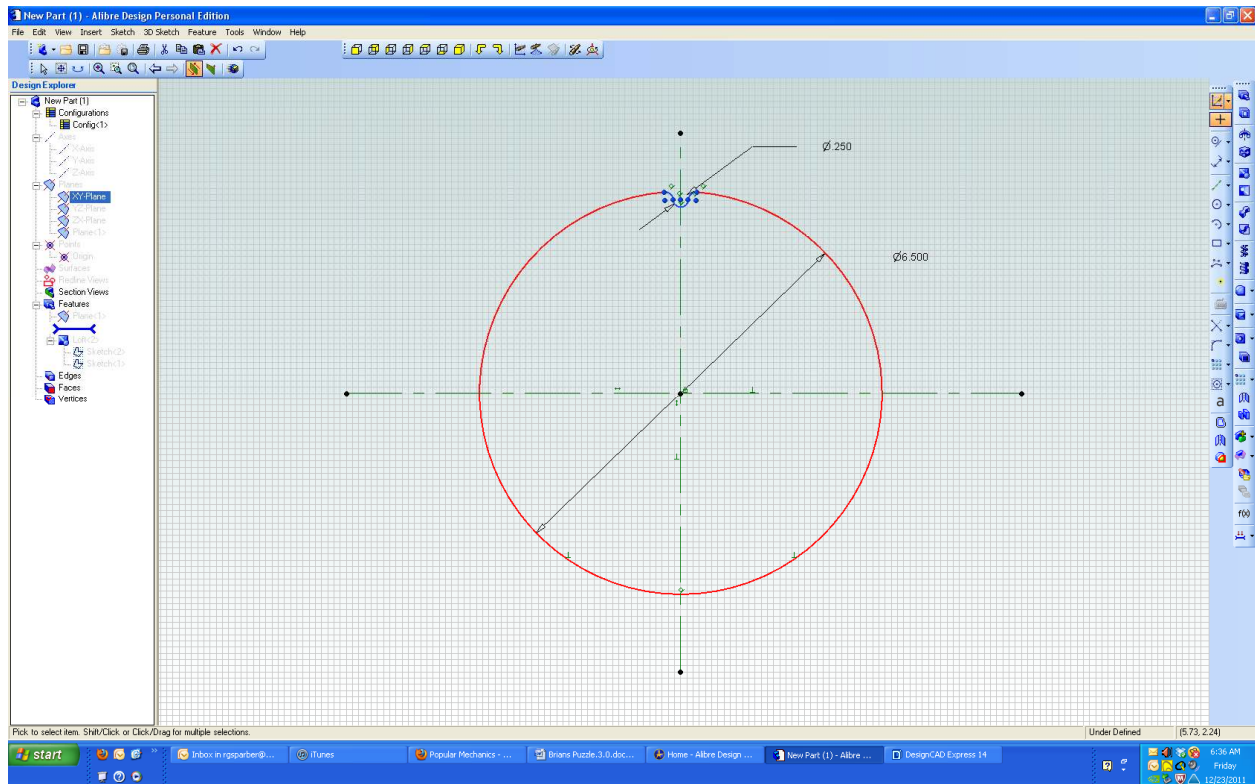
With repeated uses of the tangent constraint tool, I have managed to place the two side circles tangent to the center circle and also to the large circle.



I selected my line cut tool and moved the cursor over the left small circle at about the 5:00 point. Note that three quarters of it is now blue. That is the part I want to cut. When I click the mouse, the line segment is erased.

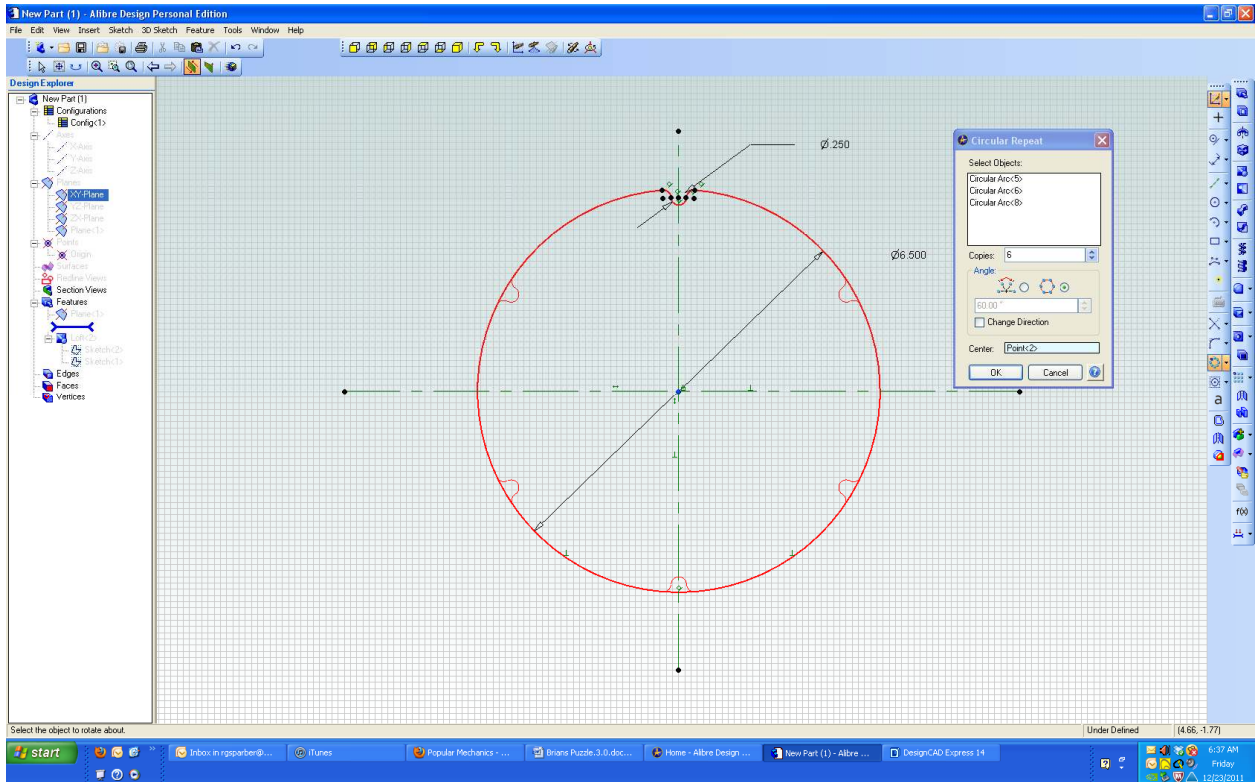


My first bottom feature is now done.



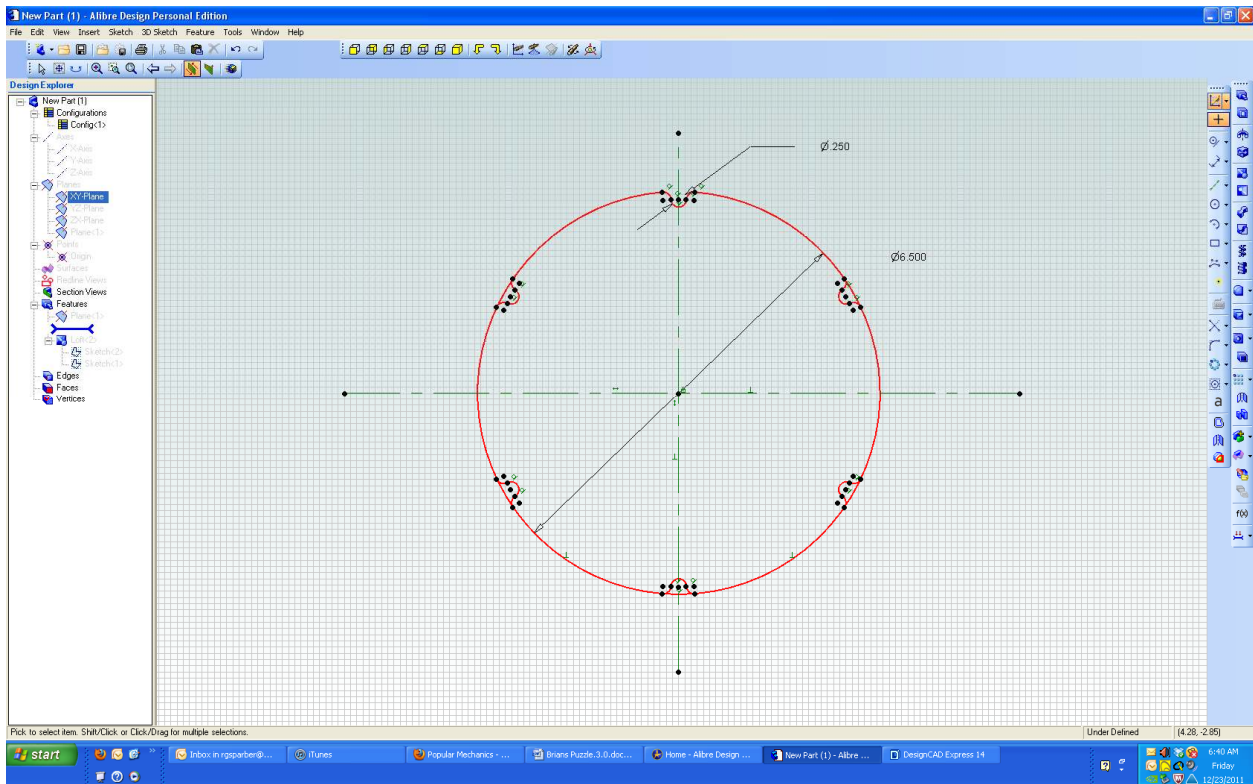
I changed to my selection tool and click-dragged across the cut out. This selected the three arcs that define my cut out.



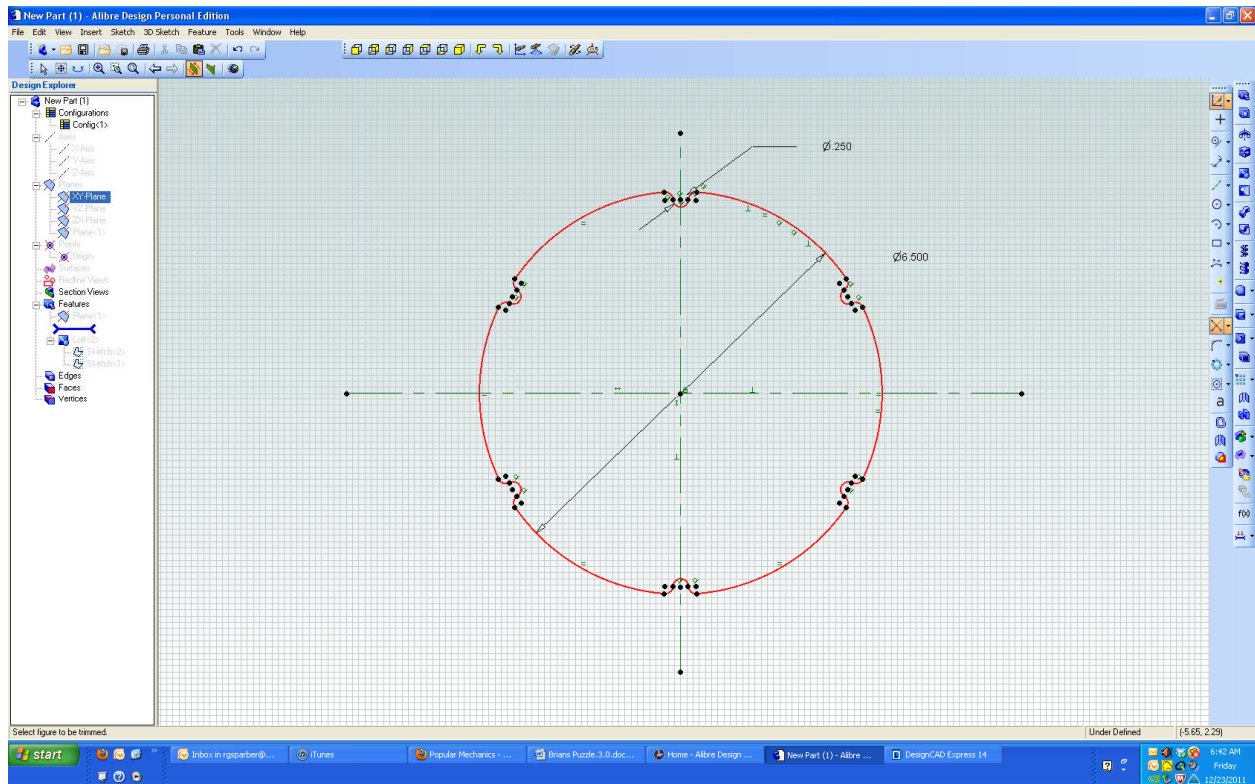


Next I enabled the Circular sketch repeat tool. Because my arcs were already selected, the tool puts them in the Select objects box. I then put 6 in the copies window, selected the radial pattern, and clicked on the center of my circle as my center.

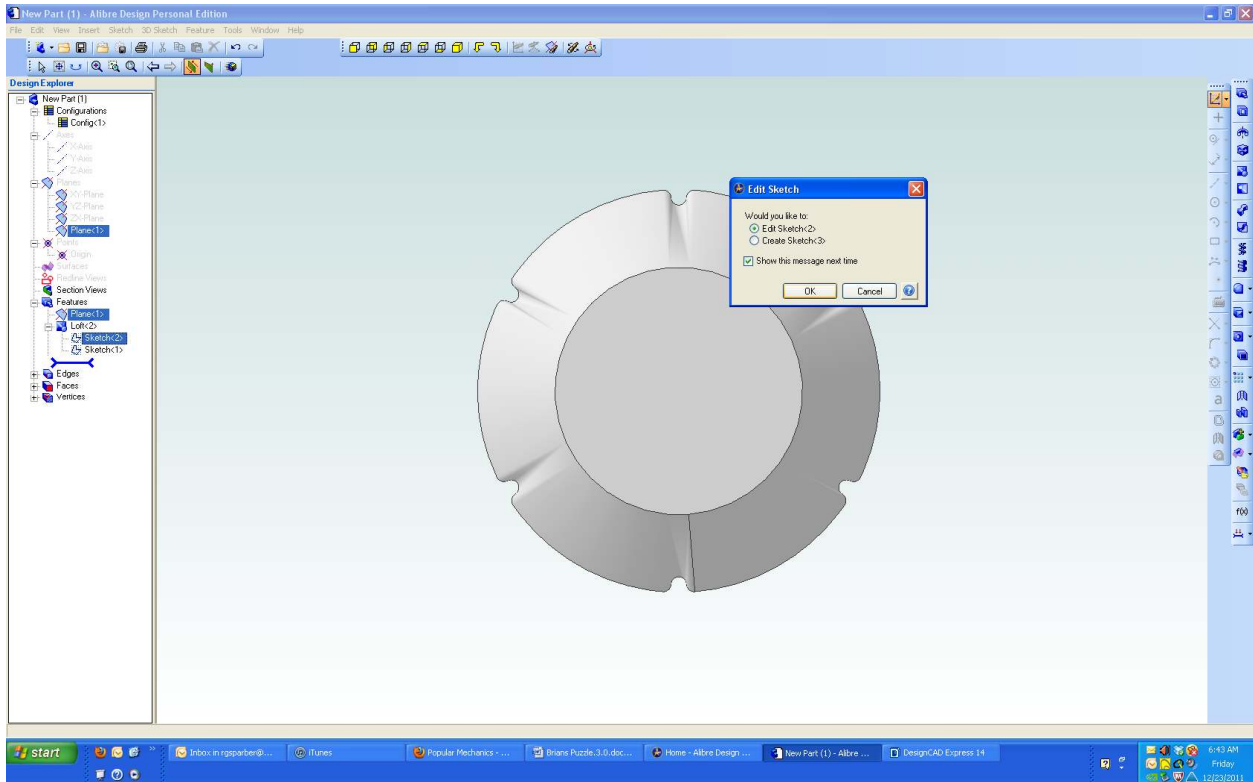




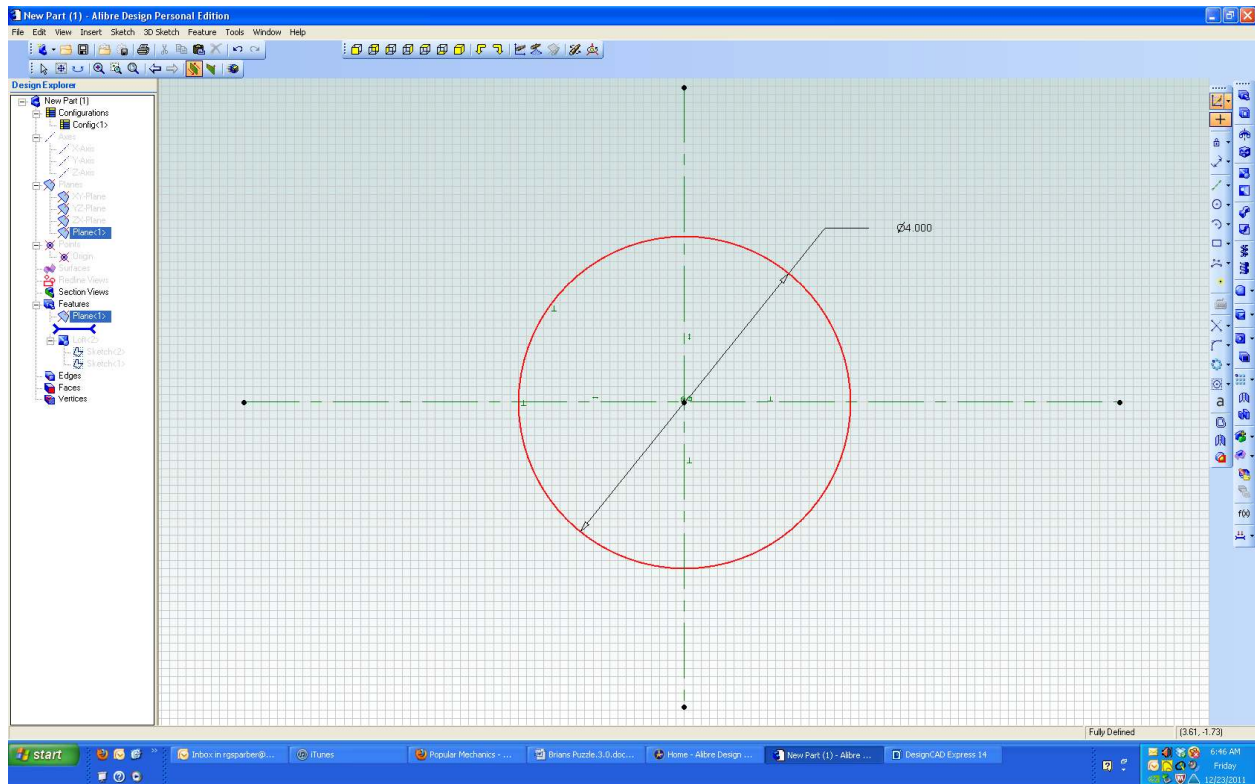
When I clicked OK, I got 5 copies of the cut out for a total of 6. I then needed to go to each cut out and remove the arc across the repeated feature's opening.



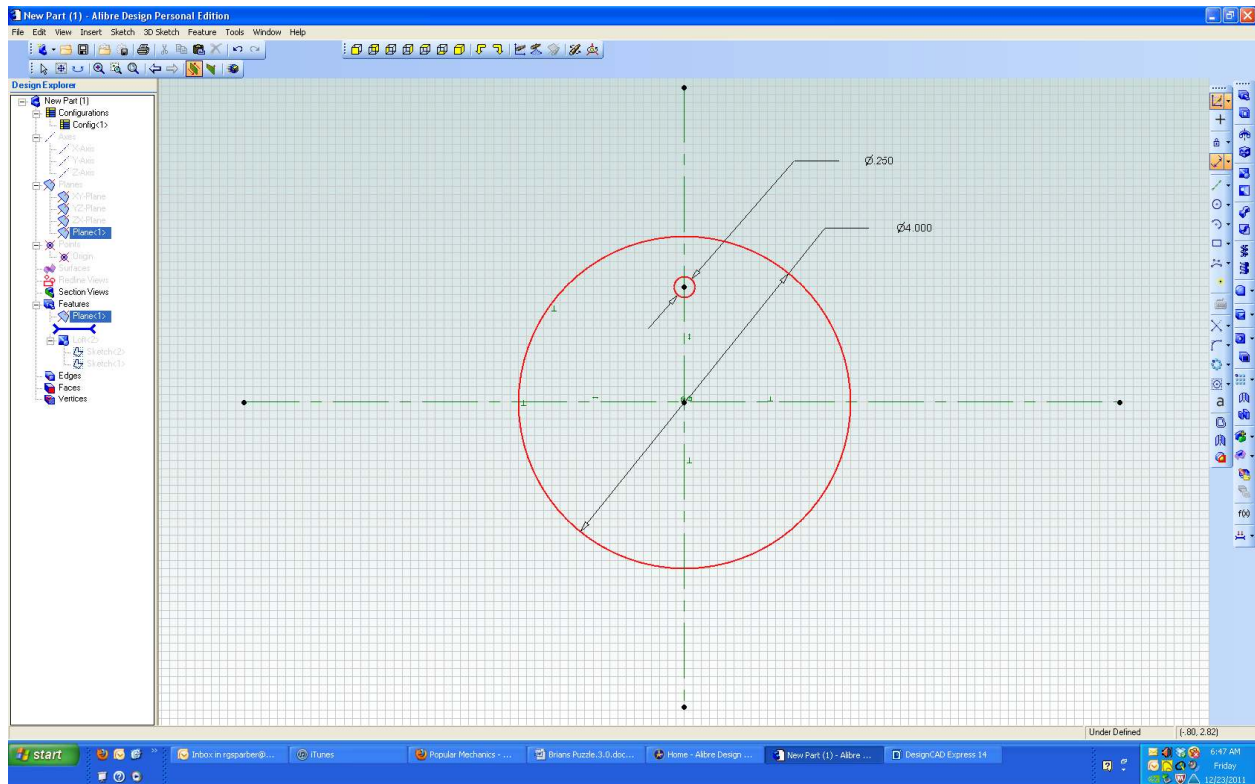
My base is now complete with its 6 cut outs. This is the same as previous examples.



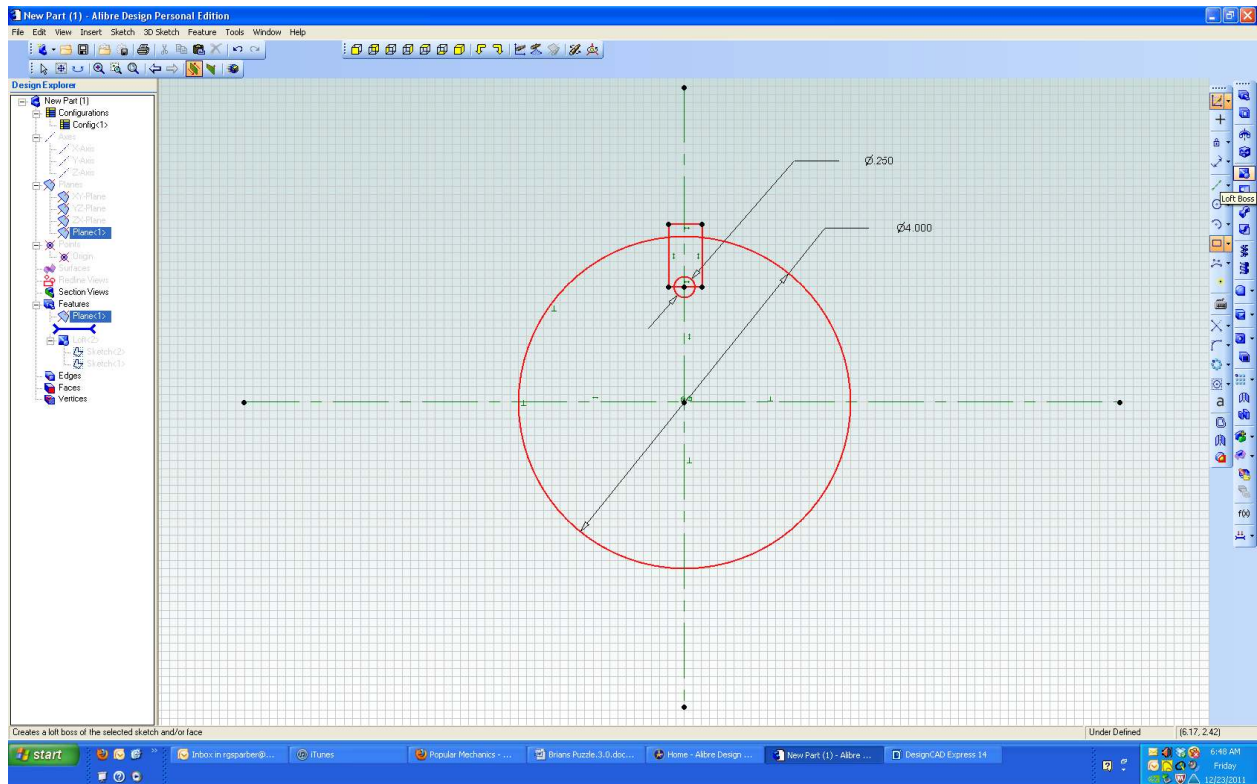
I deselected my 2D Sketch tool which brought me to the 3D view. I then wanted to go back to the sketch that defined the top of my object and put cut out cross sections on it. When I selected the top sketch for 2D editing, this dialog box asked me if I wanted to edit the existing sketch or create a new one on top of it. I want to edit the existing sketch.



Up popped the sketch that defined the top of my object. I added horizontal and vertical reference lines and locked them.

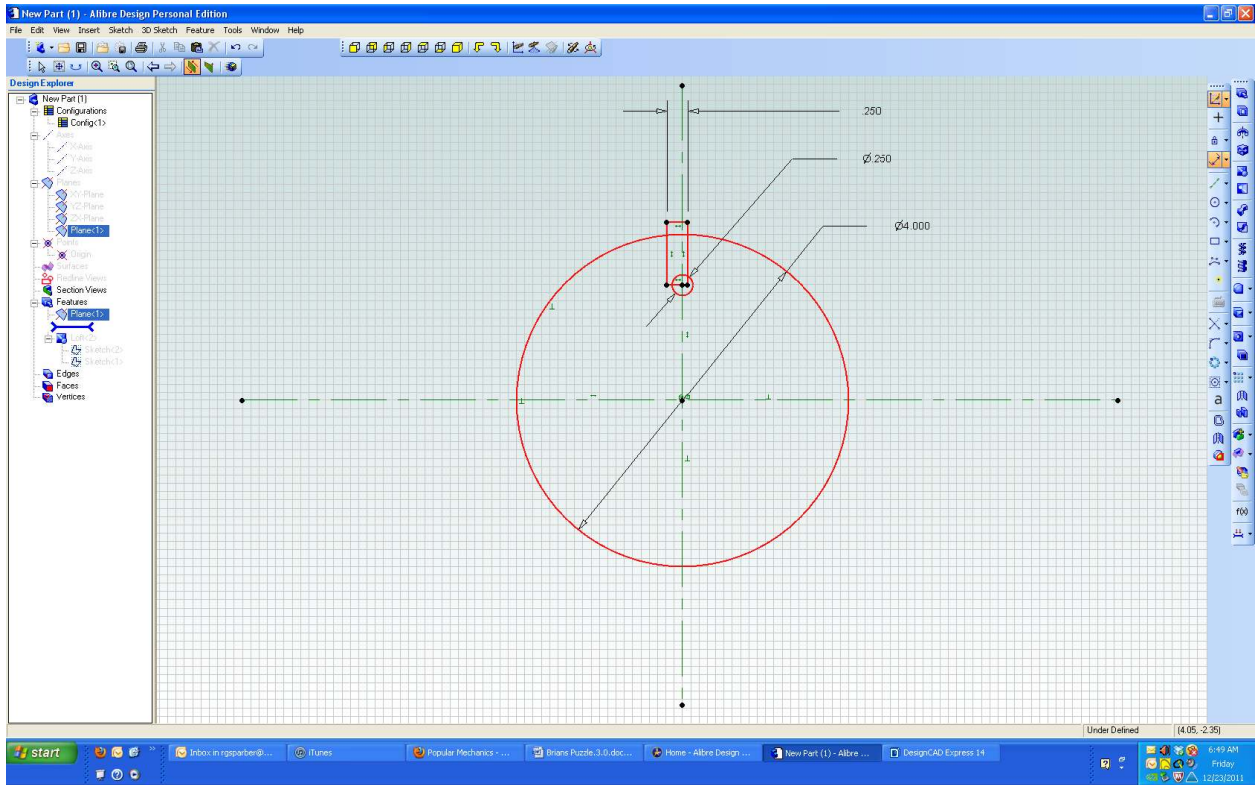


I had again placed a small circle on my vertical reference line and dimensioned it to be 0.25”.



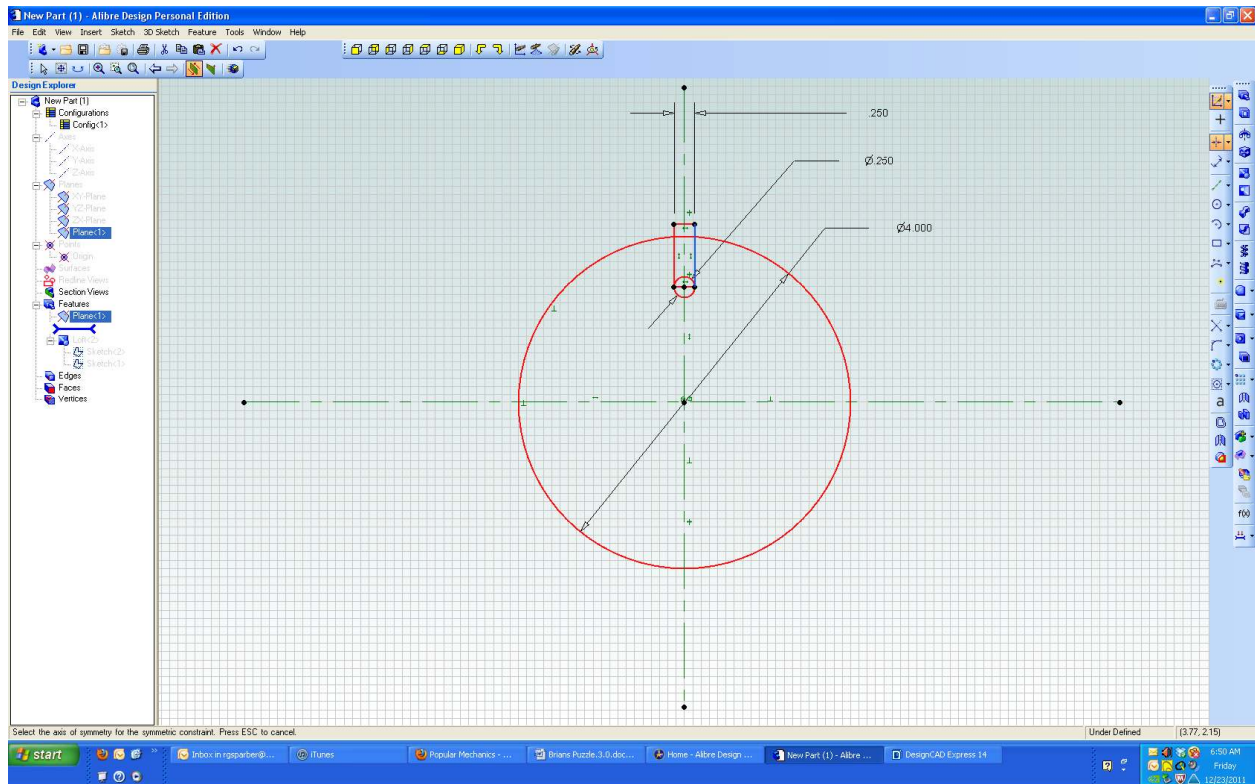
Next I drew a rectangle with the bottom aligned with the center of the small circle.



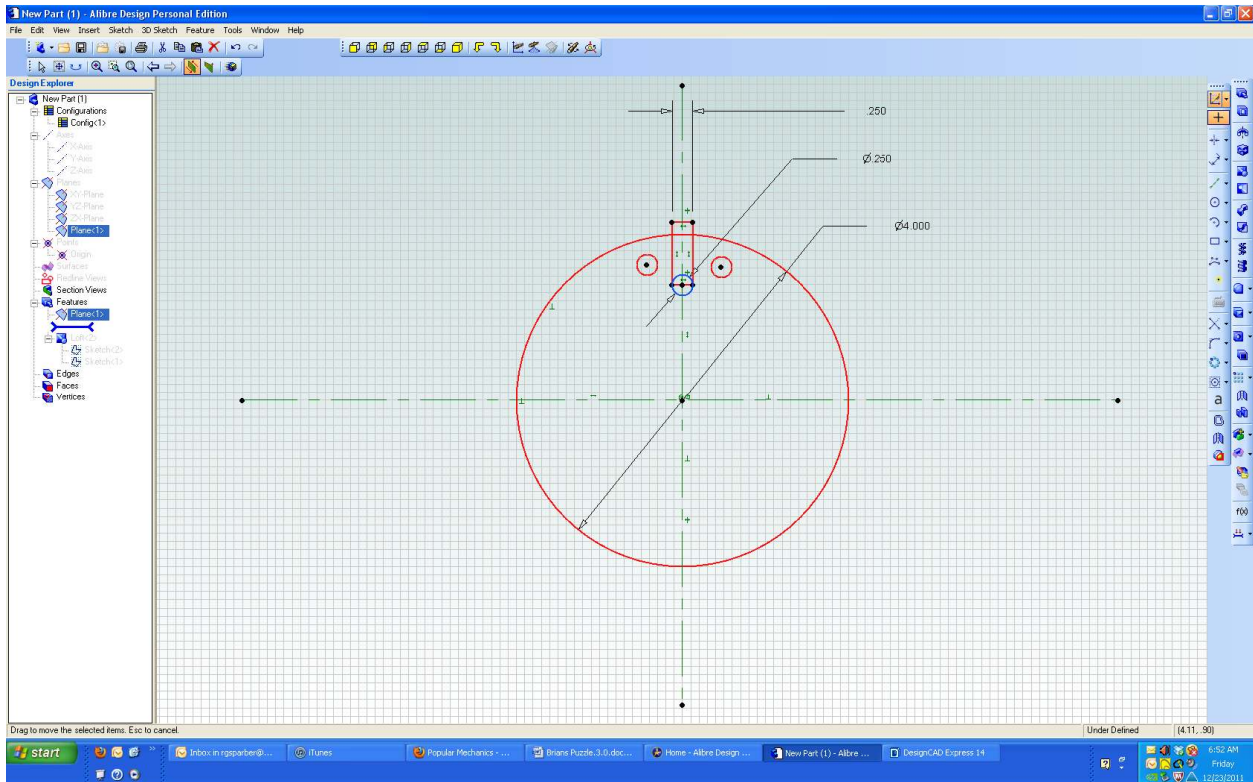


I set the width of the rectangle to be 0.25". Note that it is no longer symmetric with the vertical reference line.

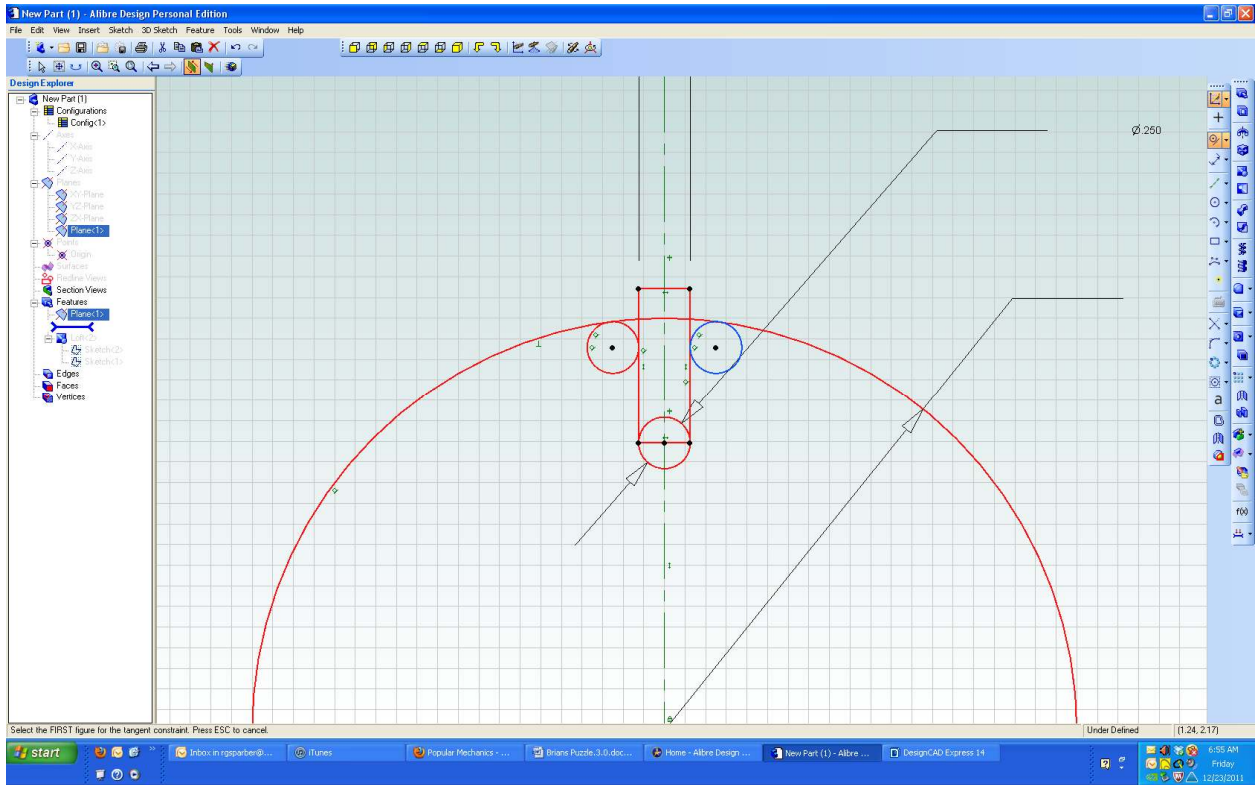




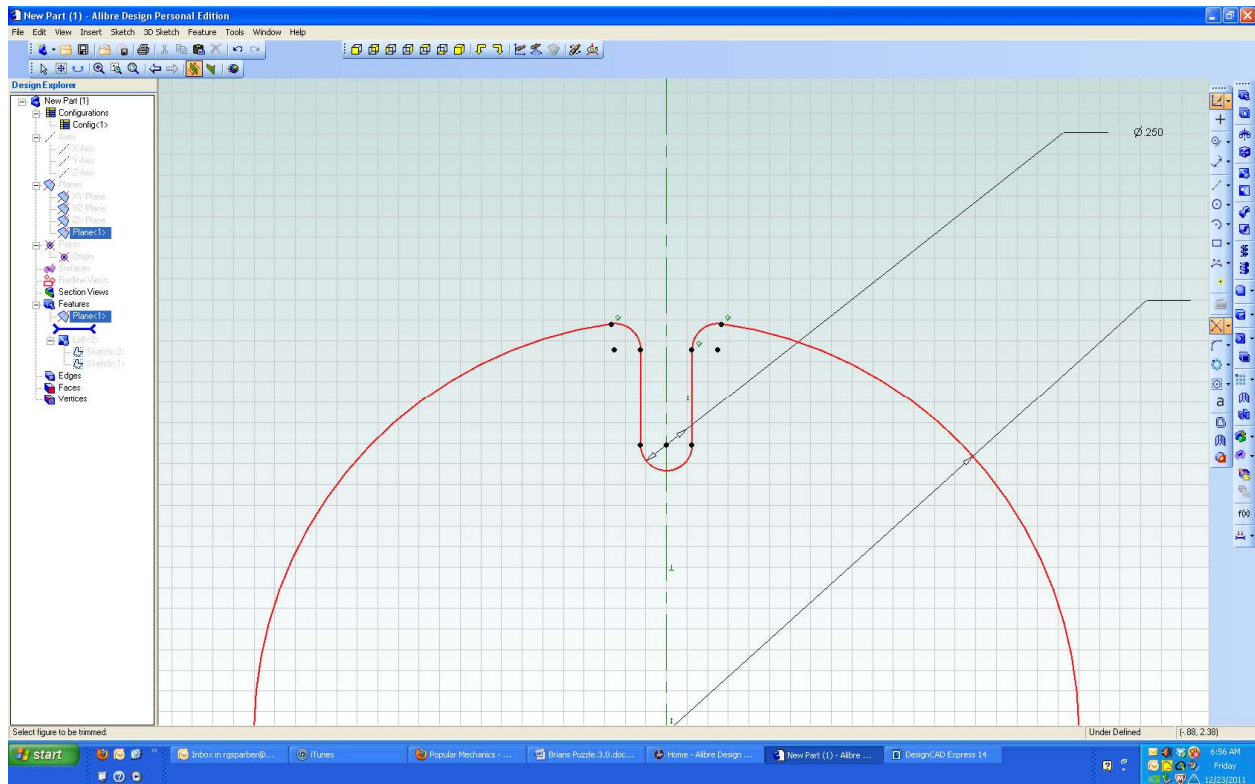
Using the Symmetric constraint tool, I first clicked the vertical constraint line and then the two vertical sides of my rectangle. That pulled the rectangle over so it is lined up with my small circle.



I again made two copies of my small circle and placed them on either side of the vertical reference line.



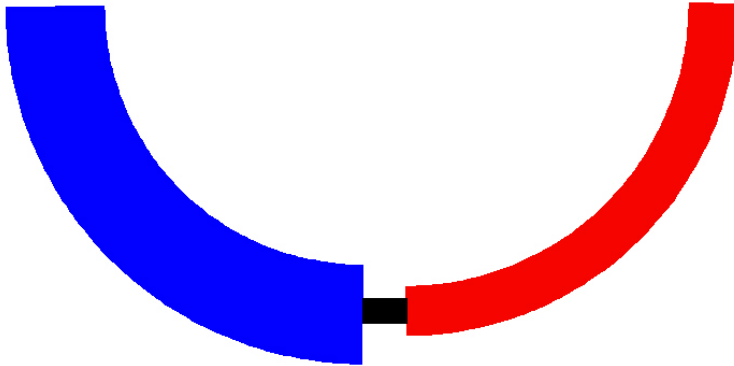
I used the tangent constraint tool to move the side circles into position.



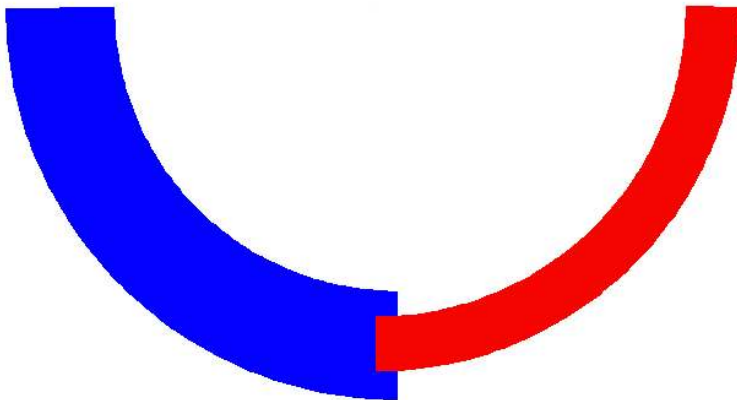
I then used the line cut tool to remove the unwanted segments.

One observation about the bottom of this cut out. I have previously tried to form this arc using my fillet tool on each corner. It generates an error message. Let's look at it closer.

I have exaggerated the line width of my two fillets and made each line a different thickness so the problem can be more easily seen.



Here the two fillets have been pulled apart which means that a short straight line segment exists between them.

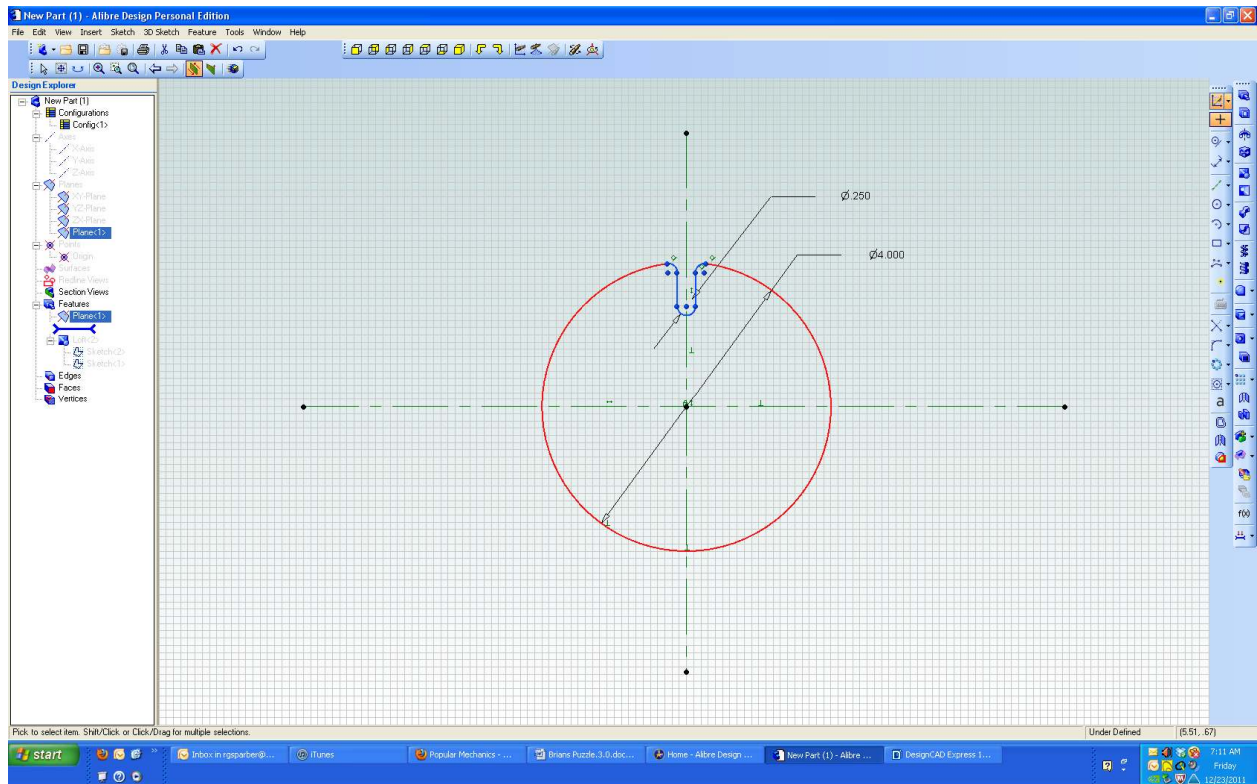


If each fillet has a radius of  $1/8''$  and I place them  $1/4''$  apart, then the ends of the fillets will occupy the same point. Alibre does not permit any overlap of lines.

When you leave the 2D sketch mode, an error message will come up warning you of this condition. If you let it, Alibre will modify the fillets so the single overlap point is removed.

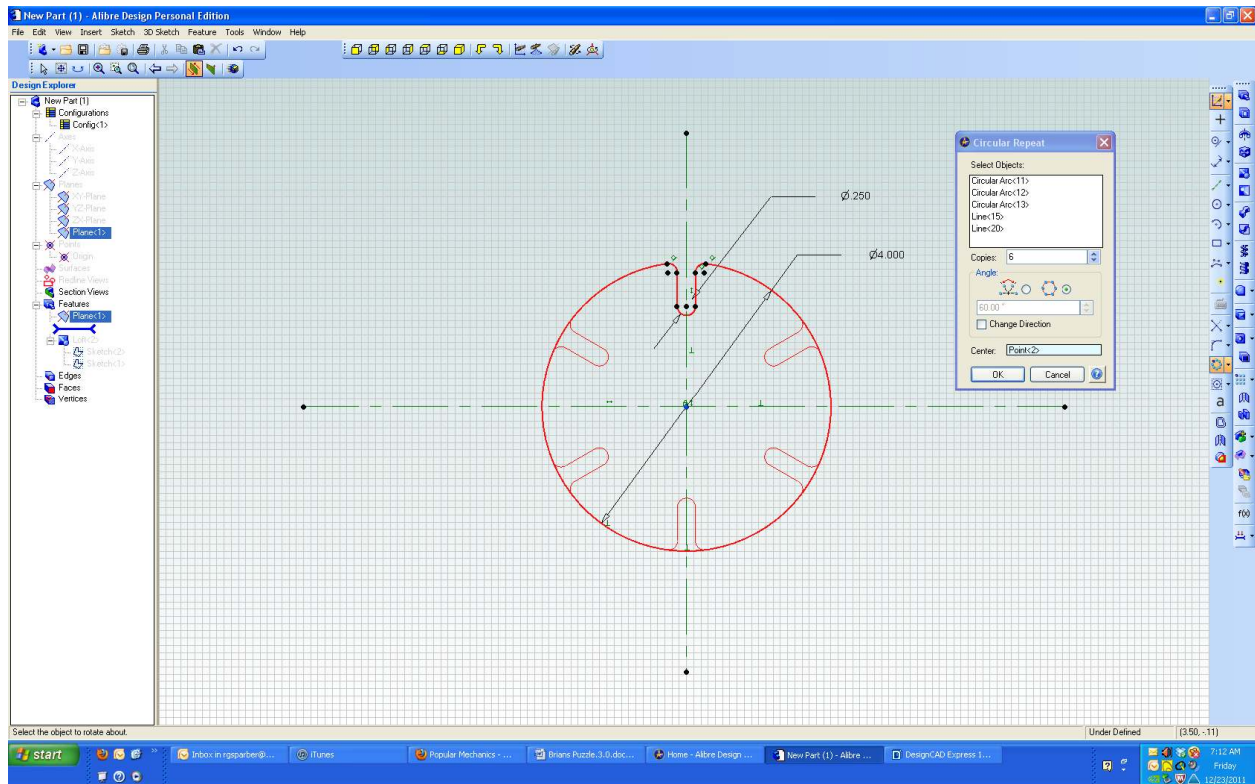
By just using an arc, this problem is avoided.

OK, back to drawing the cutout at the top of the object.



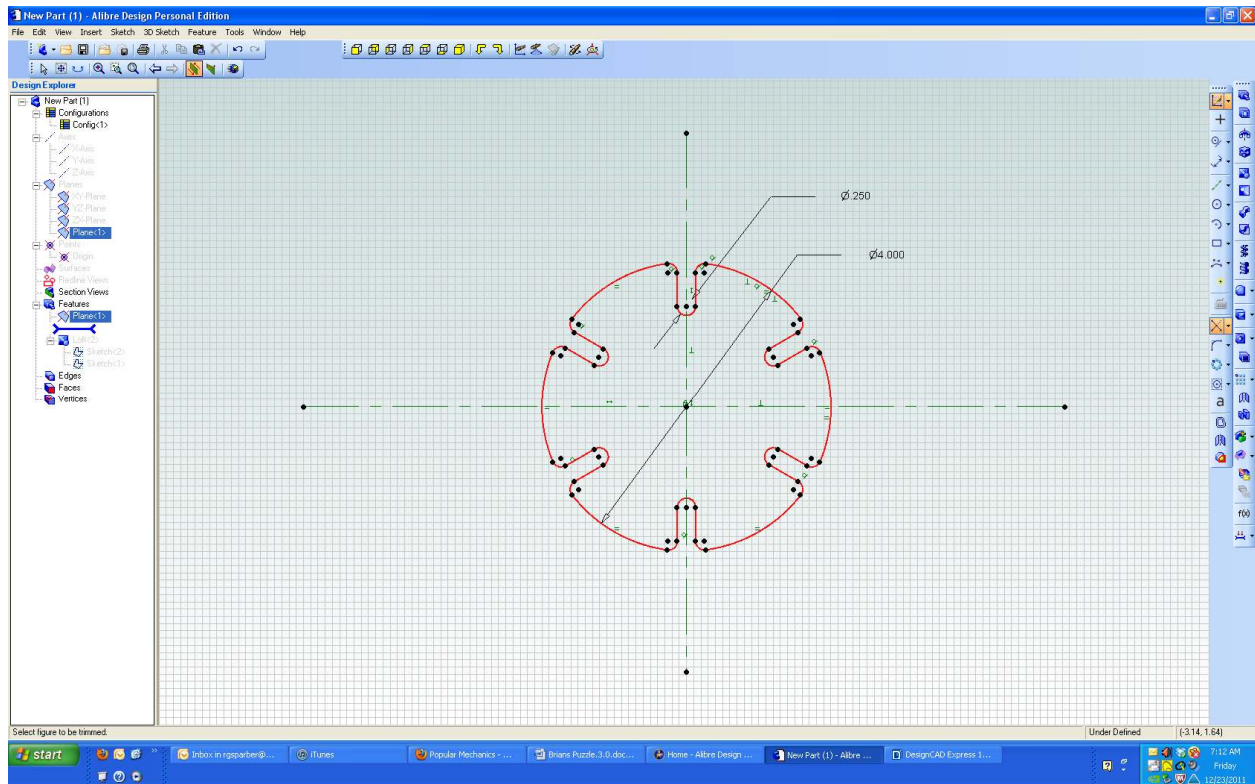
I used my selection tool and click-dragged across the cut out.



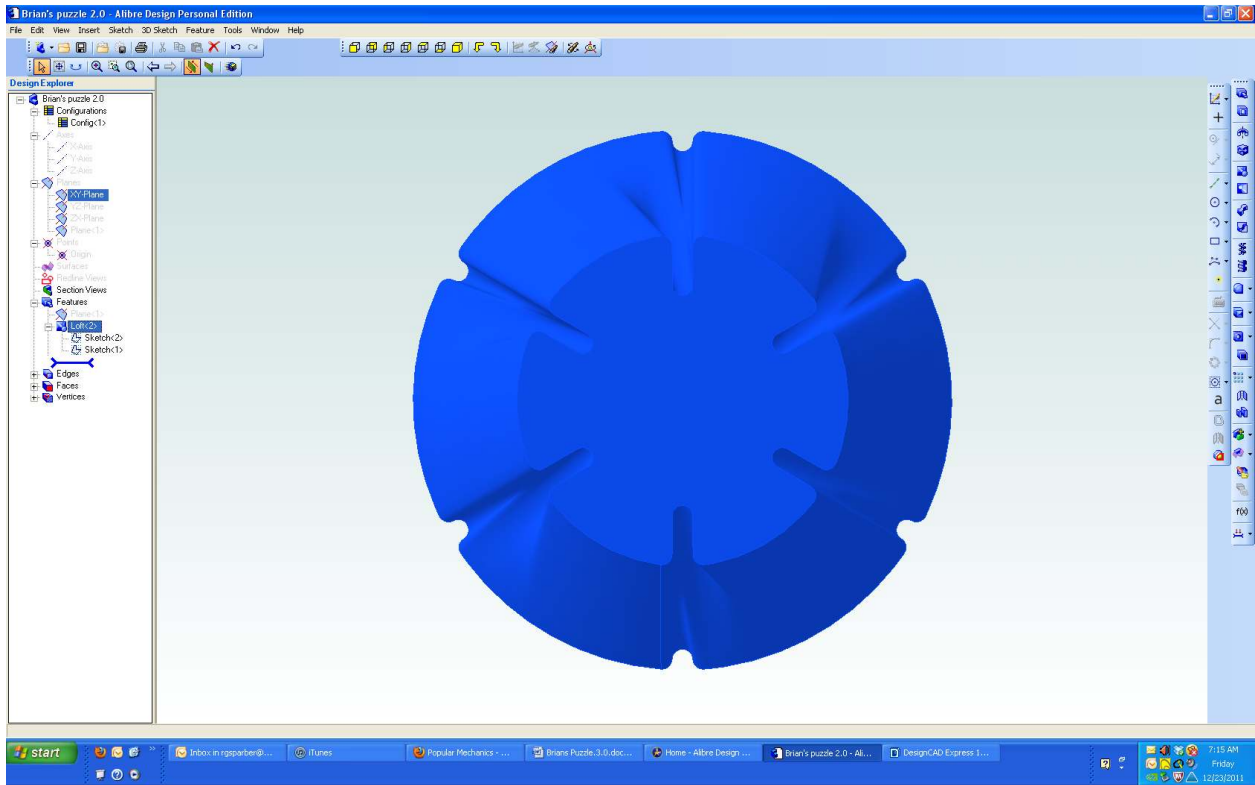


Then I used the Circular repeat tool to generate my 6 cuts.

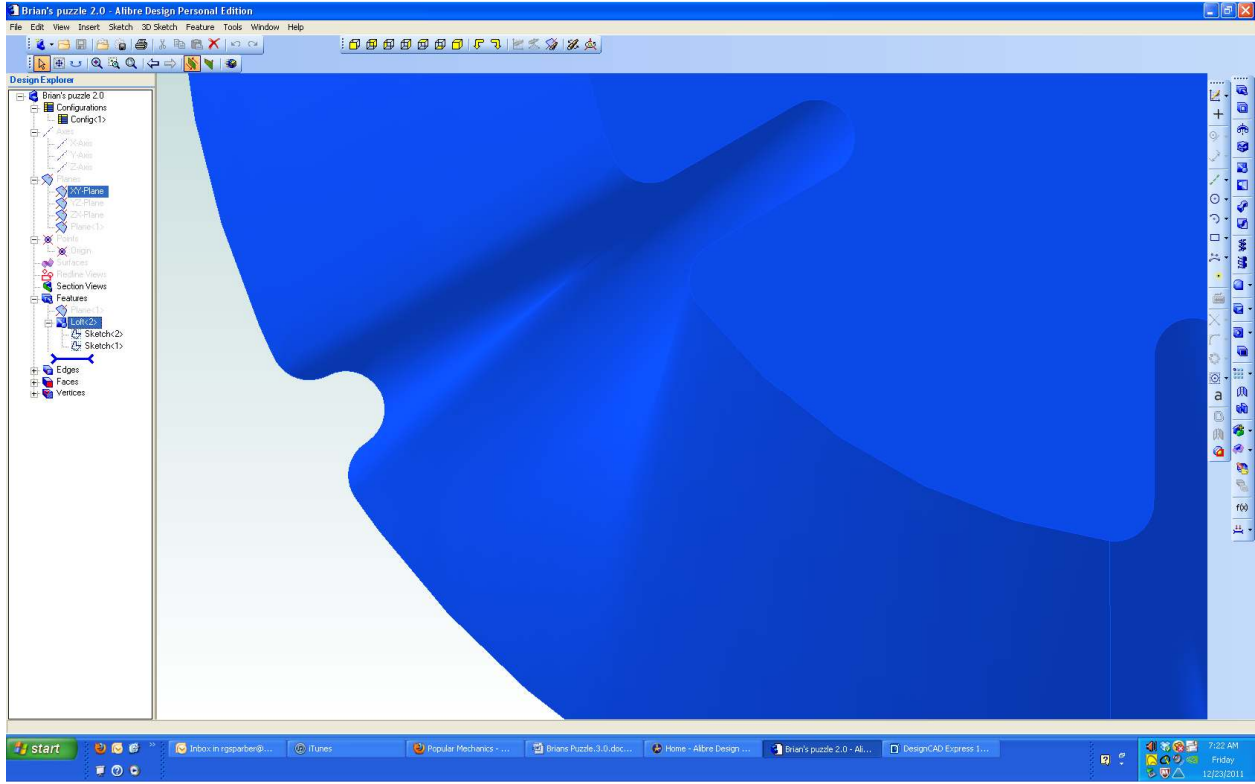




The top is now done. I did not bother to dimension the depth of these cuts cut that can be done at any time.



Gee, look at that distortion!



Hopefully someone will help me to see why this distortion exists.

I welcome your comments and questions.

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[Rick.Sparber.org](http://Rick.Sparber.org)

