TURNING GOOD APPROXIMATIONS TO SPHERES

By Ed Graham

During Chris Howarth's interesting March meeting demo on turning spheres he mentioned that his first attempts at eyeballing spheres did not give the results he wanted. Last year I wanted to turn a ball at the top of each of a couple of vertical posts that were to be part of a quilt rack. After a couple of somewhat imperfect attempts, I too concluded that I had a long way to go before I could turn good spheres just by eye.

I wanted an approach that gave an acceptable result quickly without the stop and go associated with using a template. Since the ball was part of a piece of furniture and did not have to roll anywhere, being absolutely spherical was not critical. If it looked spherical, that was good enough. My solution is based on simple geometry and trigonometry, but it is certainly not original. There was an article two or three of years ago in the AAW journal that described essentially the same approach.

To understand the approach, think of the cross sections involved. The cross section of a sphere is a circle; the cross section of the cylinder that you start with is a square. The basic idea is to cut off the corners of the square to make an octagon, and then cut off the corners of the octagon to make a 16-sided polygon. The key is that each of the cuts is a straight line in the cross section, and the center of each line is tangent to the final sphere. When you get enough sides to the polygon, it is easy to eyeball the cuts to round off the remaining corners and get to a good approximation of a sphere.

The calculations are just simple trigonometry using a one-inch radius circle. This makes it possible to scale up the results to any size sphere simply by multiplying the required radius and diameter by the ratios shown here. Note that the results are rounded off to two decimal places since that is 'good enough'. Also, because of symmetry the results for one quadrant are the same all the way around the circle.

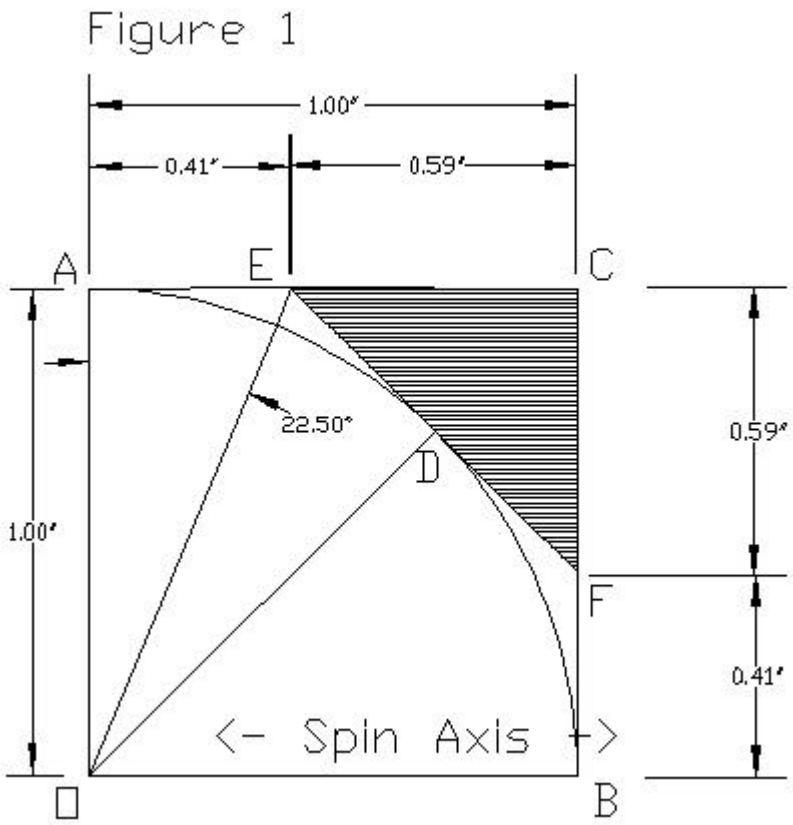
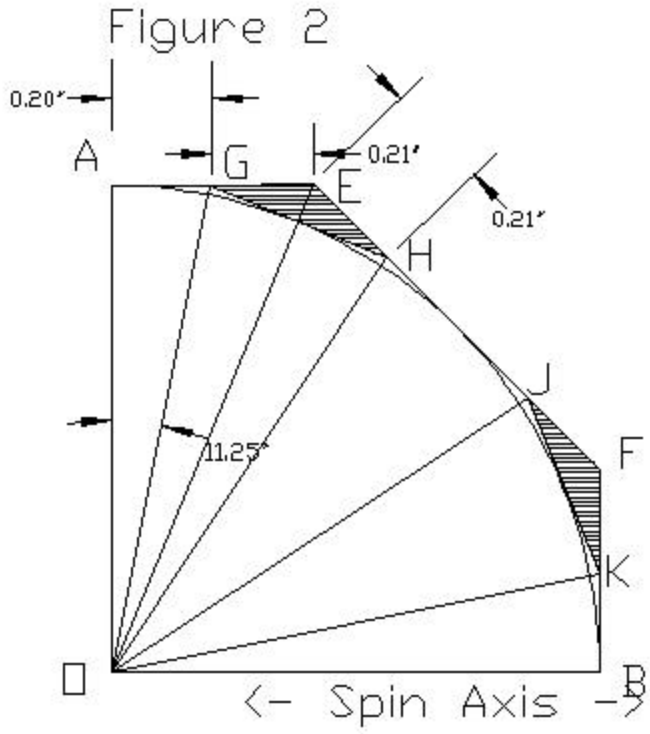


Figure 1 shows the layout for the first cut. The length of AE is tan(22.5) or 0.41". Because of symmetry, BF also is 0.41"

1. Turn a cylinder with the required diameter and a little longer than the diameter of the final sphere.
2. Turn a short spigot on the tailstock end of the cylinder with a diameter that is 0.41 times the diameter of the sphere. Be sure the end of the cylinder remains square to the spin axis.
3. Measure 0.59 times the radius from the end of the cylinder and mark a circle for the point E.
4. Before doing any cutting mark circles on the cylinder for the center and the left side of the sphere. Also mark a circle left of the sphere center for a point that corresponds to point E. (Call this circle E prime.) This circle can be measured either 0.59 times the radius from the far end of the cylinder or 0.41 times the radius from the center of the sphere.
5. Turn away stock on the left side of the cylinder to form a spigot that is 0.41 times the diameter of the sphere.
6. Turn away the corners of the cylinder from the circle at E down to the circle where the spigot and the right side intersect at F. This leaves a band that is tangent to the final sphere. Turn away the similar corner on the left side starting with the E prime circle.
7. Mark the circle at the center of these two bands. On the right side this is at point D. These lines will remain untouched until the final sanding of the completed sphere.



Next turn away the triangular sections GEH and JFK shown in Figure 2. Since the length of AE is 0.41" and AG = tan(11.25) = 0.20, the length of EG = AE–AG = 0.21".
Because of symmetry EG = EH = FJ = FK

8. Measure 0.21 times the radius on both sides of point E and one side of point F. Draw circles at G, H, and J. Do the same on the left side of the sphere.
9. Turn down the spigots to a diameter of 0.20 times the sphere diameter. This gives you point K and its mirror image on the left side.
10. On both sides of the center, turn away the material between the circles at G and H and between the circle at J and the spigot at K. Keep the surfaces as straight as possible. It is important that the widths of all the bands GH, HJ, AND JK are equal.
11. Draw circles half way between G and H and between J and K to mark the point of tangency with the sphere. Again, these circles remain untouched until final sanding.

For smaller spheres these approximations will be enough since further divisions become so close your eyeball won't need the help. Also, the small distances are a pain to measure. However, if you want to continue subdividing the surface, repeat the above process with circles 0.10 times the radius on either side of points G, H, J and one side of K. (The 0.10 is just tan(5.625)) Turn the spigot down to 0.10 times the diameter of the sphere. Turn away the sections between the circles and mark the centers. If you are working on a really big sphere and want to continue the process, the next measurements for the circles are 0.05 times the radius and the spigot is also 0.05 times the diameter. (The 0.05 comes from tan(2.812))

Once the tangent bands are complete, you should be able to trust your eye to complete the turning. Remove the bumps remaining on the roughed out sphere to connect the circles at the center of each band with a smooth flowing curve. Finally, sand to remove all the pencil line circles.

If the sphere is to be part of a piece of furniture as in my quilt rack posts, you will have to treat the left side of the turning a little differently. If the dimension of the wood that supports the ball is less

than 0.414 inches, you can turn the first spigot and cut off the 45-degree corner with no problem. In my design the ball sat on a 0.75-inch diameter disk, so I couldn't use a spigot for a reference. The solution was to draw a cross section of the ball and disk including a tangent line at 45 degrees. From this I could see where to cut to get a reference for the tangent plane. As long as you keep some reference mark for the left end of the cylinder, with a little experience you should be able to eyeball the 45 degree cut and get it close enough for an acceptable sphere. Remember that at the point of cutting this 45-degree corner you will also have the other 45-degree cut as a reference for a right angle.