INTRODUCTION: The Variable Eccentric Cup Chuck Chucks that I wrote about in the last issue of WTD are great for adding lines and arcs to the sides of a sphere. But if you want to hollow the sphere or add nearly circular or oval features, you need a chuck that can hold the sphere by one end. This is that chuck.

The Sliding Eccentric Sphere chuck is a jam chuck combined with either tape or vacuum to hold the sphere. It is by no means the first sphere chuck that I tried. I first used modified PVC pipe fittings held in a 4-jawed chuck, then with a double eccentric ring set up for variable eccentricity. I tried a solid PVC chuck that was mostly a larger version of the Variable Eccentric Cup Chuck. And several others I won't bore you with. Most of the worked, but they all shared a flaw, in that it was hard to tell the orientation of the maximum eccentricity, or apogee, and this is critical to getting the intended results. A crooked smile means something entirely other than a centered smile.

The pictures will follow making a sphere chuck out of Maple sized for 2-3/4 to a little over 3” spheres. This size will come in handy for the article in the next issue. Starting with a square maple block, rebates are cut on the base. The block is mounted between 2 jaws and a zero pin added. The chuck is hollowed, sealed with CA glue, and lined with foam. Then a flexible hose is added to bridge between the vacuum fitting on the headstock and the chuck. The chuck can be used with blue tape instead of or in supplement to vacuum.

PREPARING THE CHUCK BLANK: Begin by looking at Drawing A, which shows the cross-sectional dimensions of the chuck. If you wish to make a different size, you can probably get good results using a turning square about the size of the biggest sphere you want to hold. If you would rather plan more precisely, download www.DavidReedSmith.com/articles/SlidingEccentricSphereChuck/PlanAChuck.pdf from my website, which shows a sequence you can use to calculate the size required.

You can make the Sliding Eccentric Sphere Chuck out of any material you can turn (that is, or can be made airtight if you’re using vacuum). I have used solid PVC, maple, and glued up mdf, as shown in the lead photo. As with the cup chucks, there is a compromise between range and mounting security. The steeper the walls of the chuck, the smaller the range of spheres it will hold, but the more securely it will hold them. A cut on my left hand convinced me that 25 degrees is too wide—20 degrees seems to be about right. The chuck is lined with 2mm craft foam. The foam helps form an airtight seal between the chuck and the sphere even with minor irregularities.

If you don’t have a table saw you can cut the rebates on a bandsaw. A large blade is helpful for straight cuts. Cut up from the bottom and in from the sides to form the rebates as in Fig02. If you do have a table saw you can cut the rebates more accurately. I usually don’t bother to mount a dado set, but make multiple passes using a sled. Set the height of the blade to just under 1/2”, and set the stop block 3/4” from the left side of the blade. Make the defining cut with the blank against the stop block and then make a series of cuts until the rebate is completed as in Fig03. Figure04 shows blanks rebated on the bandsaw (left) and table saw (right).

Cut a chuck blank to 3x3x2.5”. You can use whatever grain orientation fits the stock you have, but spindle orientation is easier to turn. Layout the rebates at the base of the chuck. If you are making a different sized chuck you will have to allow for to your jaw size and the amount of eccentricity required. For big chucks consider switching to #3 tower jaws. For this chuck the rebates should be just under 1/2” deep to allow for maximum jaw contact without bottoming out in the jaws and 3/4” in from the sides as shown in Fig01.

Drawing A: The cross-sectional plan of the chuck.
Draw corner to corner lines to locate the center of the top of the chuck blank as in Fig05. Remove opposing jaws from your chuck and mount the chuck on the lathe as in Fig06. If your chuck has a pin on one jaw to limit jaw opening, leave that jaw mounted. Mount the blank between the two jaws, using your tailstock at the intersection of the diagonal lines to help center it as in Fig07.

Cut the head off of a 12D (or so) common nail and chuck it in a drill, then spin the nail into the rebate against the edge of a jaw as in Fig08 to serve as zero stop. Unchuck the nail from the drill, remove the blank from the chuck and trim the nail so it protrudes about 3/8" as in Fig09.

**TURNING THE CHUCK:** Remount the blank in your chuck being careful to have the zero stop against the side of a jaw. It's prudent to pick one jaw to use consistently and even write the jaw number on the blank. Begin by turning the blank round, except at the back, as in Fig10. If you're using wood in spindle orientation you can use a spindle roughing gouge. For other materials and face grain orientation, use a bowl gouge. Turn the face of the blank true and mark a diameter of 2-7/8" as in Fig11.
The recess should have walls at an angle of 20 degrees to the sides. Rather than trying to measure the angle it's easier to drill a hole to a calculated depth and turn to a line that joins the rims of the chuck and the hole. Mount a 1-3/4" drill in a tailstock mounted drill chuck and drill a hole 1.55" in depth as in Fig12. The result is shown in Fig13. Then turn the walls of the recess to form a straight line between the rims as in Fig14. Regardless of material, this is probably easiest with a small bowl gouge. You may wish to tweak the straightness of the recess walls with a side cutting scraper.

![Fig12: Drilling a 1-3/4" hole 1.55" deep.](image1)

![Fig13: After drilling a hole to mark the extent of the recess.](image2)

![Fig14: After turning the recess.](image3)

Now mount an O drill in your tailstock drill chuck and drill a hole for the vacuum line through the bottom of the blank as in Fig15.

![Fig15: Drilling a hole for the vacuum tubing.](image4)

**Fig15:** Drilling a hole for the vacuum tubing.

**SEALING AND LINING:** Unless you've turned the chuck out of PVC you'll have to seal the chuck—wood is not nearly as air tight as it looks. If you're going to use the chuck as a jam/tape chuck you can skip this step. Three (thick) coats of varnish will do, but usually one coat of medium CA glue will work, and is a lot quicker. Sure CA glue is relatively expensive, but when’s the last time you actually used all the CA glue in a bottle before it went bad? Put a nitrile glove on your dominant hand (you could put some blue tape around your index finger instead, or use a hand held square of waxed paper). Apply glue to a finger as in Fig16 and spread the glue on the chuck, prioritizing coverage rather than appearance. You may wish to turn your dust collector on to clear fumes. Turn the lathe spindle by hand and apply until the accessible parts of the chuck are well covered as in Fig17 and then allow the CA glue to cure.

![Fig16: Applying CA glue to seal the chuck.](image5)

![Fig17: After applying sealant.](image6)

After the CA cures on its own time, reverse the blank in the 4-jawed chuck and apply CA glue to the back of the blank to complete sealing the vacuum chuck.

![Fig18: After applying CA glue to seal the back of the sphere chuck.](image7)

**Fig18:** After applying CA glue to seal the back of the sphere chuck.

To help create a vacuum seal between the sphere chuck and a sphere, apply 2mm craft foam to the inside walls of the sphere chuck. Do this even if you don't intend to use vacuum. The foam allows even a slightly irregular sphere to jam into the sphere chuck and increases the friction between chuck and sphere to help hold it in place. The size foam required can be calculated from measurements of the maximum and minimum diameters of the recess and the length of the side walls. You can measure the maximum diameter and side wall directly with a dial or electronic caliper. It's easiest to measure the minimum diameter with a pair of inside calipers. Or, if your turning has been accurate to the rim of the drilled hole, you can use 1.75". Fig19 shows the set-up for measuring the recess.
Once you have the measurements you can calculate the foam size required. Call the maximum diameter $D_1$, the minimum diameter $D_2$, and the side length $S$ all in decimal inches. The formula yields the measurements for the foam pattern given as maximum radius $R_1$, the minimum radius $R_2$, and the angle $A$. The formula is $R_1 = \frac{(D_1 \times S)}{(D_1 - D_2)}$, $R_2 = R_1 - S$, and $A = \frac{180 \times D_1}{R_1}$. If you would rather not do the math yourself, you can download a spreadsheet from my web site: www.DavidReedSmith.com/Articles/SlidingEccentricSphereChuck/FoamCalc.xls.

Following DiagramB, construct a pattern for the foam on paper. I usually do this quickly with a CAD program but a compass, protractor and ruler will work perfectly well. After laying out the pattern, cut outside the lines and staple the pattern to a sheet of 2mm craft foam as in Fig20.

Cut out the foam piece along the lines of the pattern, extending one end by about 1/4" for overlap. The staples will keep the pattern from slipping but won't compromise the vacuum seal as they only lead to the sealed walls of the chuck. Remove the pattern after cutting out the foam and then apply spray adhesive to one side of the foam as shown in Fig21. After allowing the adhesive to dry following the instructions on the can, install the foam inside the chuck. If the foam is only pressed gently against the walls or itself you can reposition it. Form a loop by overlapping the ends and position the foam in the recess opposite the overlap. Then gradually gently press the foam into place. Fig22 shows the chuck after installing the foam.

To bridge the gap between the fitting and the chuck, where alignment changes when the chuck is eccentric, use a piece of 3/16" ID clear vinyl tubing. Cut a piece of tubing 4" long. As is the tubing won't fit in the fitting (the vacuum fitting on my lathe is based on the hollow 3/8" NF all-thread commonly use for lamps) but the tubing is heat formable. So head for the kitchen when the coast is clear and heat up a container with about 2" of water to boiling. Stick one end of the tubing in the water as in Fig23 and give it a minute or so to soften. Then turn on the cold water at the sink. Grab the cold end of the tube with one hand and the hot end of the tube with pliers and pull hard. The warm part of the tube will stretch out and narrow, leaving a tapered transition which will seal in the fitting nicely. Maintaining the pull, head for the sink and run cold water on the stretched part to set it. Fig24 showed the tubing after stretching. Measure the outside diameter of the stretched part to make sure it will fit in the fitting—if, say, you allow the boiling water to cool carrying it down to your photo light box, it may not stretch enough. If all is well, cut off the deformed area where the pliers gripped the tubing.
**USING THE SPHERE CHUCK:** When using the sphere chuck, first make sure the top sides of the dado are against the top surfaces of the two 4-jawed chuck jaws. If you want it to be axial, turn the lathe on before mounting a sphere to check and see if it's running true—the stop pin isn't fool-proof. Avoid mounting a sphere that is too big. It may hold briefly, but if the walls aren't tangential to the sphere it is much more likely to shift position or come off entirely. You can use any smaller size sphere that doesn't bottom out in the chuck, however you may not be able to access to as much of the sphere as you like.

To mount a sphere simply push it into the chuck and turn on the vacuum and check the gage to be sure you've got an adequate seal. You may need to encourage it to seat by smacking it with your hand.

If you do not have a vacuum set up you can substitute blue masking tape. Really. It's more secure than you think. As the chuck is a jam chuck, the tape is only helping keep the sphere jammed in—it's not providing the only holding power. In addition, as we remove tape a little at a time by peeling it off, we tend to underestimate the holding power of tape when multiplied by a large area. Simply push the ball into the chuck and wind some blue masking tape around the joint between the chuck and ball as in Fig27. Go around a couple times if you like. Then press the tape into the ball where it bridges between the chuck and ball as in Fig27. Go around a couple times if you like. Then press the tape into the ball where it bridges between the chuck and ball. This is also a good supplement to using vacuum if you have switch delexia and tend to sometimes turn off the vacuum before the lathe. The major drawback to using tape is that it takes more time to reposition the ball. If you were trying to turn dimples like a golf ball it would probably drive you crazy. But it's a good way to try the system out to see if you like it without buying a vacuum set up first.

To mount the chuck eccentrically, simply loose the lathe chuck jaws slightly and slide the zero pin the desired amount away from the jaw. You still want the tops of the dados firmly against the tops of the lathe chuck jaws. Fig30 shows the chuck mounted about 1/2" eccentrically on the left, as indicated by the arrow, and the resulting ghost image on the right. You can use this kind of mounting to turn tapered arcs, where the depth is shallow at the beginning and end and deeper in the middle such as the eyebrows in Fig31. You can also turn features that appear elliptical, such as the eyes in Fig31.
Fig31: An example of what can be done with eccentric mounting.

It is important to correctly orient the sphere with respect to the maximum eccentricity. For instance a face looks happy if the elliptical axis of the eyes angle up, and sad if they angle down. It would look strange if the orientations were random instead. This is one of the best features of using a sliding eccentric sphere chuck--the maximum eccentricity is easy to determine. When trying to lay out a feature, pencil in both the center of rotation and the axis of maximum eccentricity. You can then use your tailstock center to line up the center, and point the axis along the direction the sphere chuck was slid in the lathe chuck. For instance, going back to the eyes in Fig31, the tailstock pointed to where the cross was carved in the eyeball, and the maximum eccentricity was about 30 degrees down relative to the face. I suggest playing with some practice balls to get a feeling for what you can do and how to do it.

You can also use the sphere chuck to hollow a hemisphere, as in Fig32. Mount the sphere chuck axially in the lathe chuck. Taping over the hemisphere is good insurance if the wood is porous to avoid losing vacuum when you’re almost done. Mount the hemisphere in the chuck trying to get the rim evenly protruding past the rim of the chuck. You can use the tailstock ram, with the tailstock center removed, to aid in alignment if you like. Hollow the hemisphere with a bowl gouge. Compared to hollowing through a small hole this goes astonishingly quickly as you are cutting, not scraping, and you don’t have to constantly stop to remove chips. Then just glue the hemispheres back together and disguise the glue line. Fig33 shows a tree ornament (to be featured in the next issue of WTD) made of Baltic Birch plywood. Two pairs of three segments were glued together, flattened, and then the pairs assembled with a temporary joint and turned to a sphere. The temporary joint was split and both resulting hemispheres hollowed and then glued back together for sanding and finishing.

Fig32: After hollowing a hemisphere.

Fig33: A Christmas ornament hollowed as two hemispheres.

You can make the equivalent of eccentric cup chucks using the same sliding technique as for the sliding eccentric sphere chuck. Start by making the same rebate with a zero stop, mount it in the zero position with 2 jaws of the 4-jawed chuck and turn the size recess you desire. For the tailstock end, thread a wood block to fit the threads on a Oneway pattern tailstock center and turn it to a flat pad. Add a couple of layers of 2mm craft foam to the end of the flat.

**TOOLS:**
- Bandsaw or Table saw
- 4-jawed chuck with #2 jaws
- portable drill
- Drill chuck
- 1-3/4" drill bit
- O drill bit
- Calipers
- Utility knife
- Pliers
MATERIALS:
Maple block 3x3x2.5”
12D Common nail
Medium CA glue
Nitrile glove
2mm Craft Foam (look in the craft section at Wal*Mart or any craft store)
3M #77 spray adhesive
3/16” ID clear vinyl tubing (plumbing section any hardware store)
Original blue masking tape

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