Multi-Axis Lesson Plan for an Oval Tool Handle

Session 1

- Introduction, safety on the lathe, class room rules and requirements, multi-axis ground rules.

Introduction: In this four week class we will learn the unique style of turning spindle projects using multiple axes. The projects will be an oval tool handle, a candlestick holder turned on several axes and then a twisted spindle that we will fit onto a goblet cup and base.

Safety on the lathe: Please turn to the handout "Woodturning Safety Rules" as we will go over the eight safety rules listed.

Class room rules and requirements:
1. When entering the classroom please sign in and write out a name tag to be worn.
2. Do not operate any power equipment including grinders before the start of the class.
3. No open toed shoes will be allowed.
4. Long hair must be tied back and jewelry that can catch should be taken off.
5. Safety glasses with side shields must be worn at all times while operating any power equipment.
6. During the class we will stop from time to time to discuss our progress. When the instructor asks that all lathes be turned off, please adhere to the request immediately.

Additional introduction: I would like to take just a brief minute to go around the room so you can and introduce yourself and your turning experience, also what you expect to get from this class, what are your goals, and have you done any multi-axis turning.

Multi-axis ground rules:
1. Ensure the ends of the spindle are square.
2. Mark all points clearly with numbers.
3. Pre-mount the spindle on all axes to better seat the spur centers.
4. Use safe drive spur center where possible. A safe drive center is one that allows the spindle to stop spinning if you get a catch. This helps to avoid run back especially when using a skew. Some safe drives have a set to teeth but not very deep. If a catch occurs they will allow the spindle to stop. The One-way safe drive has no teeth; the Sorby has a multi-tooth ring and a spring loaded center point. A normal spur drive center has two or four sharp, deep teeth that dig into the end of the

spindle and will not lose their grip on the spindle. In this case if you get a catch you will get either a run back or you can split the spindle if it is thin enough.

5. Mark about 1" on each end as a "no turn zone".
6. Use a roughing gouge to round the spindle.
7. Use a bowl gouge or a larger fingernail grind spindle gouge to turn off center axis. The advantage of a bowl gouge or larger spindle gouge is the mass of the tool. Often times with offset turning the tool rest will be farther away than with normal turning which means the tool will be hanging over the tool rest much more. The thicker tools will have less vibration at these distances than the smaller tools and will be less likely to catch.
8. Keep lathe speeds at or just below 1200 rpms as these types of turnings will be off center and vibrate. Going too slow can increase the possibility of catches.

First Activity - Turning an oval tool handle

- Materials list, tools, settings etc.
- Discuss the layout, preparation – marking the blank, turning.

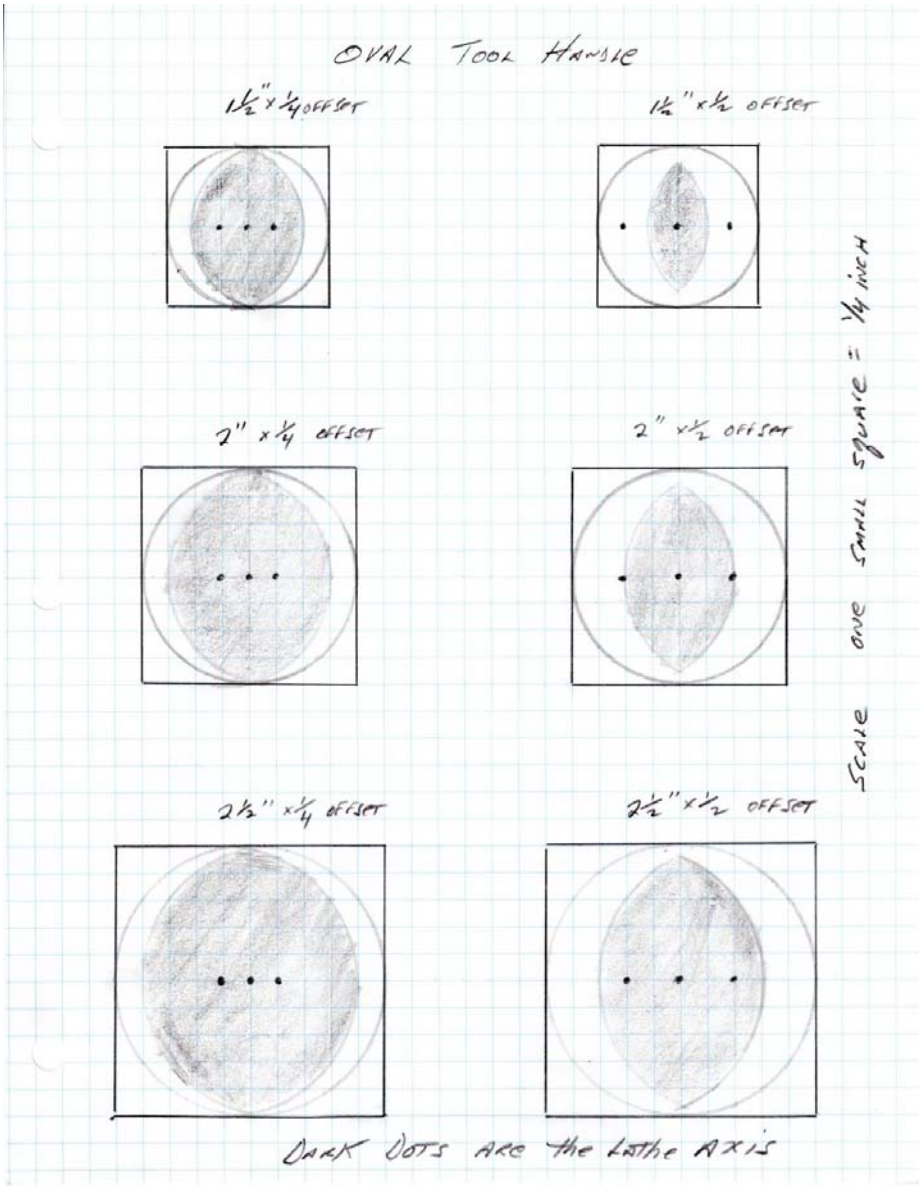
Materials list, tools, settings.

A dry wood spindle approximately 10” long and 2 inches in diameter, a roughing gouge, bowl gouge or large spindle gouge and parting tool, 500-800 rpm to rough, 1000 to 1200 rpm to turn.

Discussion of layout

Predicting the outcome of multi-axis turning is important, easy to do and necessary to ensure the outcome desired. An example of what we are talking about can be studied in the following graph paper example.

OVAL TOOL HANDLE LAYOUT



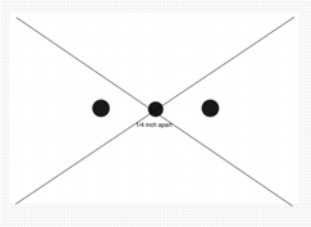
As you can see we have three different size spindles, 1 1/2 inch, 2 inch and 2 1/2 inch. In each size we move the axis over from 1/4 inch to 1/2 inch offset. In the first case of the 1 1/2 inch spindle, the width of the oval handle is reduced by half (from 1 inch to 1/2 inch). In the second example we start out with a 1 1/2 inch width, by moving the axis another 1/4 inch the new width of the handle is 1 inch. In the third example the width starts out at 2 inches and is reduced to 1 1/2 inch by moving the axis over an additional 1/4 inch.

Preparation and marking

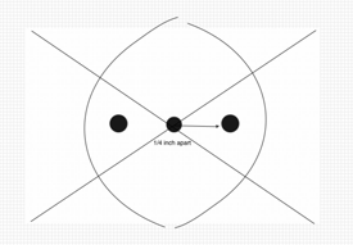
- For this project we will be making the 1 1/2 inch oval tool handle using a 1/4 inch offset from the center axis.

1. Choose a blank that is approximately 10 inches long and a minimum of 2 inches in diameter.

2. Mark the ends of the blank by drawing a line from corner to corner. Then from the center axis on each end make a mark 1/4 inch from the center on both sides of the center. Ensure that the marks on both ends of the blank are in the same plane.



3. With a compass set at a 3/4 inch radius draw an arc from each of the 1/4 inch offset marks. This will give you a general idea of what the shape of the handle will be and when to stop turning on that particular axis.



4. Preset by hammering with a dead blow or wooden hammer, all six axis points with the spur center. This will make your point easier to find once mounted on the lathe.
5. Mount the blank on the center axis and turn just round using a roughing gouge.
6. Re-mount the spindle using one of the offset axes. Ensure that both axes are in the same plane.
7. Carefully turn the spindle down to the corresponding mark on the ends of the spindle. You can continue to use the roughing gouge or switch to a bowl or spindle gouge.
8. Re-mount the spindle on the other offset axis and turn to the corresponding mark on the ends of the spindle. Ensure that the tops of the oval intersect the center line at the end of the spindle. This ensures that the oval is balanced.
9. If you intend to use a 3/4 brass bushing on one end to prevent splitting the handle, you can re-mount the spindle on the center axis again and just turn about a 3/4 inch round on one end to allow for the brass bushing.
10. Sand the handle to 220 grit.
11. **Finishing** - tool handles are best when finished with an oil type finish (Tung, walnut or boiled linseed oil) or an oil varnish blend such as a Maloof finish. If the wood is an oily exotic such as cocobolo, ebony, etc. then I suggest using a teak oil finish or no finish at all. Any film type finish (lacquer, varnish or shellac), would probably wear off with use. For this class we will use the wipe on Maloof Poly/Oil finish.

Oval Tool Handle

Candle Holder Multi-axis Lesson Plan

Session 2

Materials list, tools, settings etc.; introduction of project; set-up on lathe and marking; finishing.

Materials list, tools, settings etc:
Use a dry wood spindle approximately 12 inches long and 2 inches in diameter. We will use a roughing gouge, bowl gouge or large spindle gouge and parting tool. (Note: Use a bowl gouge or a larger fingernail grind spindle gouge to turn off center axis. The advantage of a bowl gouge or larger spindle gouge is the mass of the tool. Often times with offset turning the tool rest will be farther away than with normal turning which means the tool will be hanging over the tool rest much more. The thicker tools will have less vibration at these distances than the smaller tools and will be less likely to catch.) Speeds will be 500-800 for roughing and 1000 to 1200 rpm for turning.

Introduction: With this project we will be making a candle holder complete with a tapered mortise on the top to accept the standard 3/4" to 7/8" candle taper. Because of the size of the taper, we need to insure that the outside diameter of the top is a minimum of 1 1/2" to a maximum of 1 3/4" and a width of between 1 1/4" to 1 1/2". This will be part of our 'no turn zone'. We should also have about a 1" no turn zone on the bottom of the piece to be used as a base.

Set-up on the Lathe:
1. We will be using a blank that is 2" x 2" x 12". Find and mark the center of the spindle on the ends. With a compass set at a 1/2" radius draw a 1" circle on the center axis of the headstock end of the spindle. This will be the base of the candle holder. Divide that 1" circle into three equal parts using the compass around the circumference of the 1" circle (see attached instructions).
2. Before mounting the spindle in the lathe tap the center axis along with the three additional axes with the spur center to better seat the spur center once on the lathe. You could also use a spring-loaded center punch to make the indentations. If using the four spur drive center try to position the spurs so that they have equal coverage of the spindle and use these marks when re-seating the spindle.
3. Mount the spindle on the lathe, ensuring that the multi-axis end is at the head stock.
4. Using the center axis, true the blank round. Once true, mark the no turn zones, 1" at the headstock and 1 1/2" at the tail stock. Next to each no turn zone make a 1 inch bead. When making the bead complete that portion of the bead closest to the ends of the spindle. For the side of the bead furthest from the spindle ends complete the beads but attach a half **"V"** groove as a transition point for the next feature. Count on about 7" to 8" of turntable spindle for the multi-axis turning. This means we can have four 2 inch features on the spindle. At this time, using a pencil mark lines with

about 2 inch spacing. Our features will be a series of **"V"** grooves, beads and coves.

Important: Label each one of these sections from #1 to #4 starting with #1 at the tailstock.

5. Move the spur center to the marked **# 1 axis at the headstock**. Keeping within our first marked area, **make a "V" groove at the tailstock end of the spindle.**

   When making the **"V"** groove, ensure you cut through the 'air wood' but stop when you get to the all solid wood. Stop the lathe frequently to look at the transition on both sides of the feature. These transitions must have no flat spots.

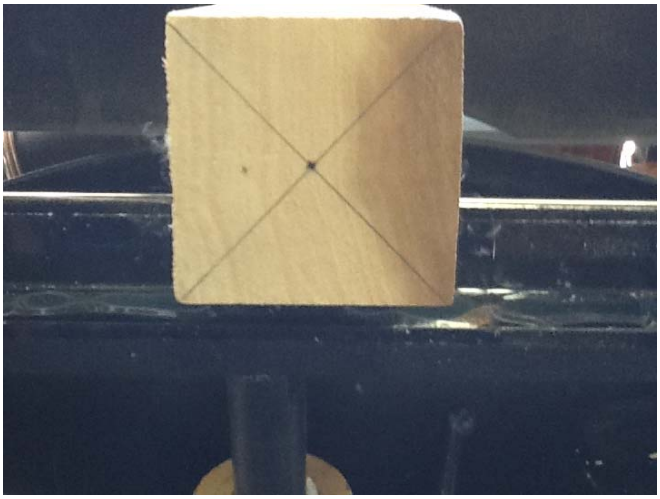
6. Now move the spur center to the marked **# 2 axis**. For this feature make a **bead** in the #2 marked section. Again work through the air wood to all solid wood, keeping the solid wood as thick as possible (for stability). Stop the lathe frequently to look at the transition on both sides of the feature.
7. Move the spur center to the marked **# 3 axis.** In the section marked #3 (third from the tailstock) make another **"V"** groove as we did in step 5 but giving it a broader sweep making it different from the first **"V"** groove, again working through the air wood to all solid wood and stopping frequently to check the transitions..
8. Move the spur center to the marked **# 1 axis.** In the section marked #4, make a long bead, again working through the air wood to all solid wood and watching the transitions.
9. Now we want to blend the ends. Move the spur center to the **center axis** and blend the base and top with their connected features. Carefully examine the transition from the feature to the connected top (or bottom). Gently take your gouge and make this transition as smooth as you can without changing the feature. Also finish the very top of the spindle with a gentle flowing line to match the taper that we will be drilling in the next step. With the tailstock still in place gently face off the end of the spindle as this is where the candle is placed. Make a gentle cove towards the center stopping just before the tailstock adapter. (small spindle gouge with a pull cut will work here). This is also a good time to finish shaping the base of the candle holder.
10. Now it's time to drill the tapered hole (mortise) in the top of the candle holder. We will put a tapered drill bit into a Jacobs chuck and put that into the spindle of the head

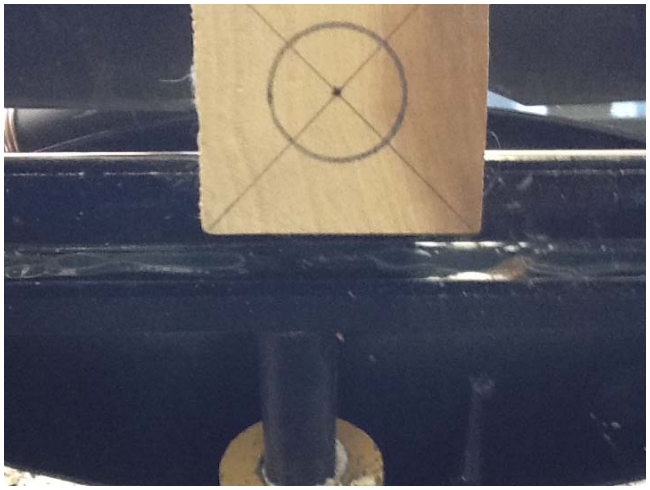
stock. Put the spur center into the tail stock and line up the center axis with the base at the tail stock end. Set the lathe to the slowest speed possible. The pressure on the drill bit should be minimal as to keep the spindle from spinning. Hold the spindle in one hand and crank the tail stock bringing the spindle into the drill bit, cutting the hole to the correct depth. **As we have only the one drill bit, this step will be done by one of the instructors.**

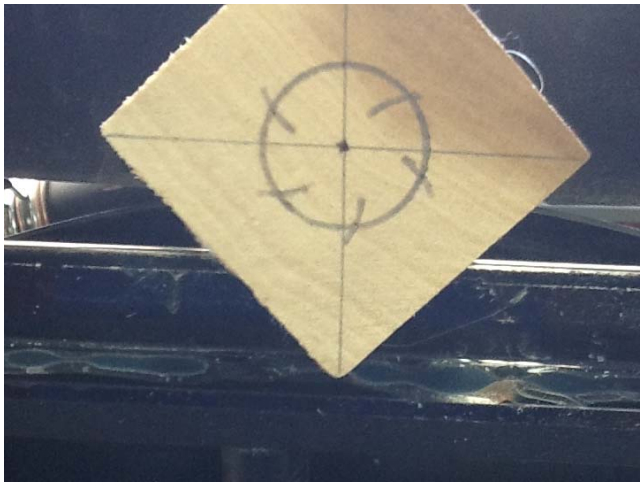
11. Remount the candle holder using a cone shaped live center in the newly created mortise in the tail stock, and remount the base back into the headstock using the spur center. Once you are satisfied with the end result, part off the spindle at the spur center. Be sure to make the very bottom of the base concave so it will sit flat.

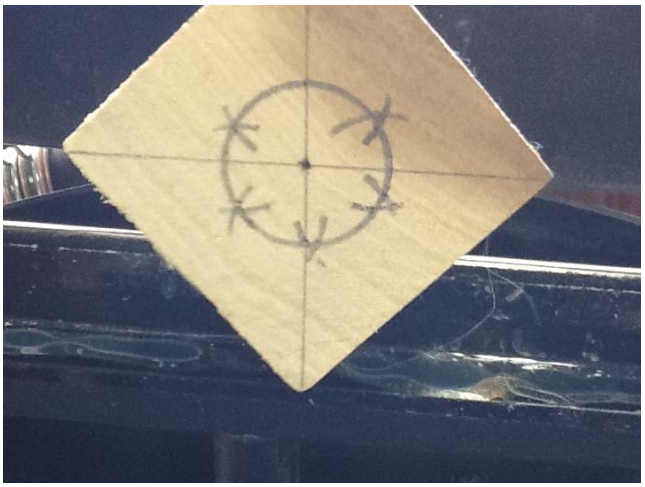
Candle Holder Examples

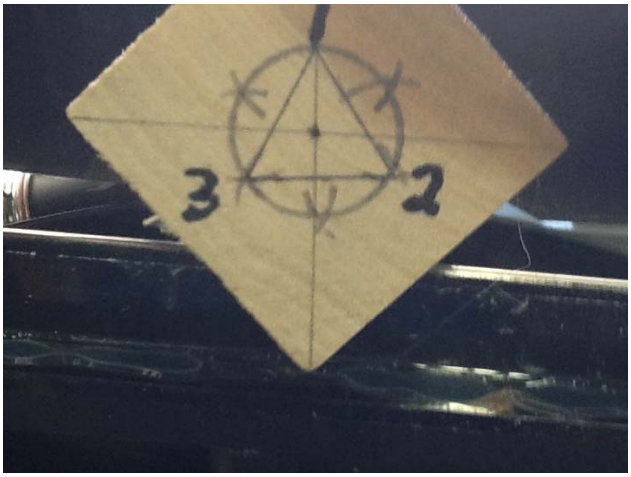
How to divide a circle into three parts

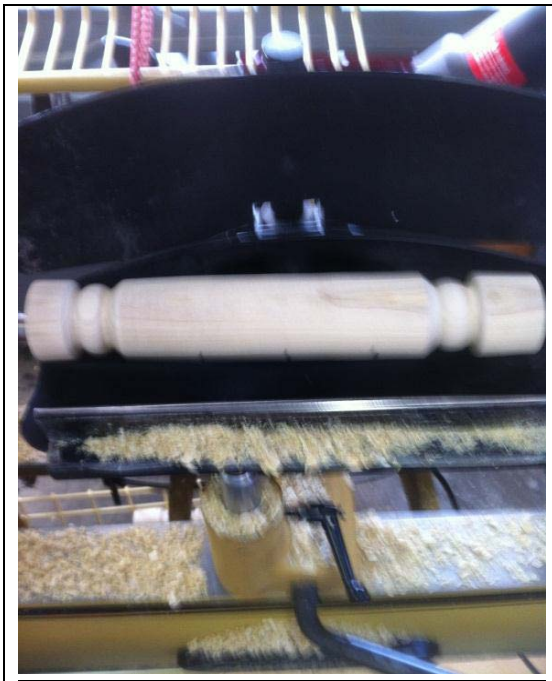


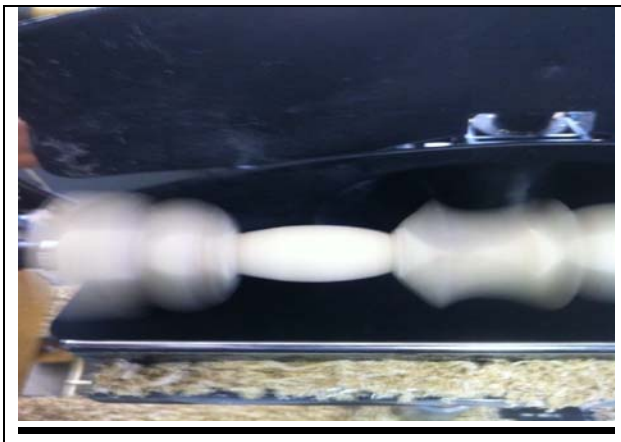










Twisted Spindle Goblet Lesson Plan for Spindle

Session 3

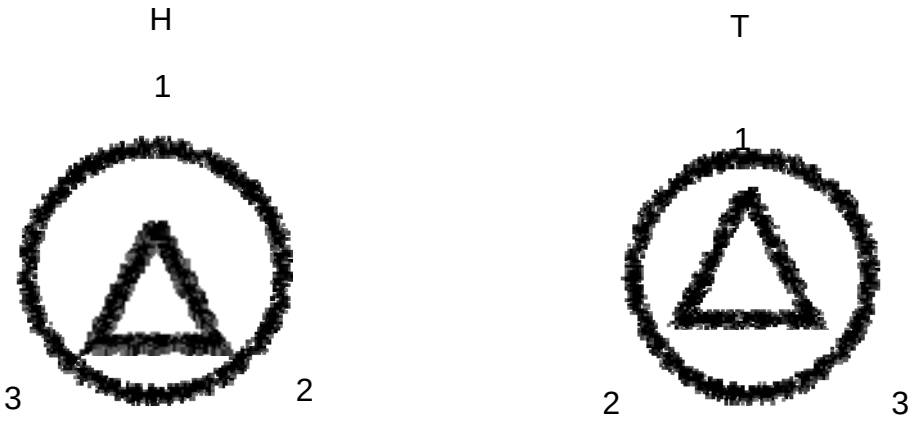
- Materials list, tools, settings etc., introduction of project, marking, set up on the lathe, turning the spindle, turning the tenon on each end of the spindle.

Materials list, tools, settings etc.:
Use a dry wood spindle approximately 8 inches long and 2 inches wide. We will use a roughing gouge, bowl gouge or large spindle gouge and parting tool (Note: Use a bowl gouge or a larger fingernail grind spindle gouge to turn off center axis. The advantage of a bowl gouge or larger spindle gouge is the mass of the tool. Often times with offset turning the tool rest will be farther away than with normal turning which means the tool will be hanging over the tool rest much more. The thicker tools will have less vibration at these distances than the smaller tools and will be less likely to catch.) Speeds will be 500-800 for roughing and 1000 to 1200 rpm for turning.

Introduction: In this session we will make a twisted spindle that will be one of three parts to complete a goblet (see attached photo). The other parts will be the cup and base of the goblet. The three parts will be attached via a tenon turned on both ends of the twisted spindle and a mortise drilled in the bottom of the cup and the top of the base. The cup and base will be turned in session 4.

Marking the ends:
1. The stem will be approximately 4 inches in length so let's start out with a 8 inch blank. Ensure that the ends are square, find and mark the center with a spring loaded center punch.
2. From the center draw a 1/2" circle at each end. Divide those circles in thirds as we did in session 2 - "How to divide a circle in three".
3. Label each third # 1, #2, #3. Ensure that the #1, #2 & #3 axes are each on the same plane (see photo)

Twisted Spindle Setup



Note: Ensure that the numbers are connected to the same number on each end. Do not cross the center axis when marking. In other words the number 1 on each end should be on the same plane (straight line to each). The number 2 on each end should be on the same plane (straight line to each). The number 3 should be on the same plane (straight line to each).

Set-up on the lathe:

1. Mount the spindle between centers to set the drive spur on the marks.
2. Now connect #1 on the headstock side to #2 on the tail stock. Drive the spur center until the marks are indented.
3. Now connect #2 on the headstock to #3 on the tail stock. Again drive the spur center until the marks are indented.
4. Now connect #3 on the headstock to #1 on the tail stock. Drive the spur center until the marks are indented.
5. Or, you can use the spring loaded center punch to mark all the axes.

Turning the spindle:

1. Remount the spindle onto the center axis and turn the spindle round. Mark the "no turn zone" on each end. Remember we want the spindle to be about 4 inches in length plus about a 1/4 inch tenon at each end.
2. Remount the spindle connecting #1 on the headstock to #2 on the tail stock. Turn a gentle cove the length of the turn zone. Without moving the tool rest determine the closest distance from the center of the cove to the tool rest. Mark this measurement on a story stick or use a ruler to record the exact distance.
3. Remount the spindle connecting #2 on the headstock to #3 on the tail stock. Turn a gentle cove the length of the turn zone. Without moving the tool rest measure the closest distance from the center of the cove to the tool rest. This distance should match the previous measurement of the #1- #2 combination.

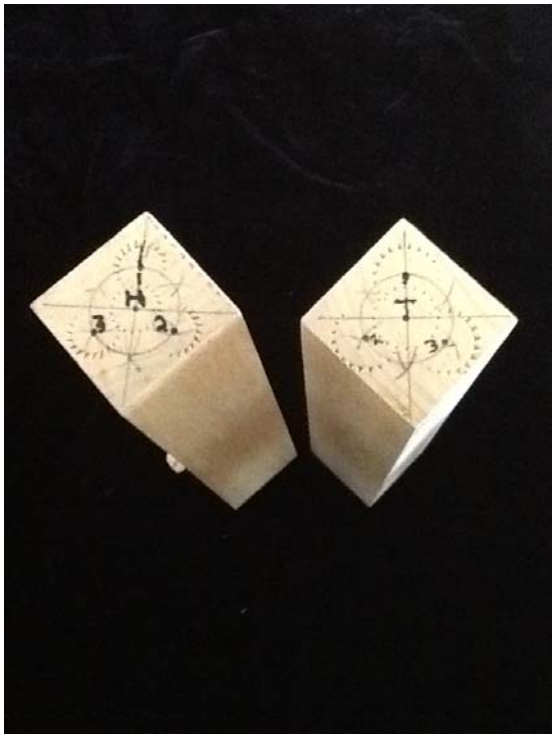
4. Remount the spindle connecting #3 on the headstock to #1 on the tail stock. Turn a gentle cove the length of the turn zone. Without moving the tool rest measure the closest distance from the center of the cove to the tool rest. This distance should match the previous measurement of the #2- #3 combination.
5. We want the average diameter of the spindle to be about 1/2 inch. Repeat the above steps until the 1/2 inch average diameter is achieved.

Turning a tenon on each end of the spindle:

1. The object is to create a 1/4 inch tenon at each end 1/4 inch long. The cup and base will have standard 1/4 inch holes (mortise) drilled in each piece to accept this twisted stem tenon.
2. Set calipers to 1/4 inch. This will be a critical measurement, so let's take our time and sneak up on the tenon using a 1/4 inch parting tool. We also need to have the spindle end of the tenons to be slightly concave. This will facilitate a better fit when we assemble the goblet. It's best to do this once we have achieved our critical 1/4 inch measurement.
3. Once the tenons are completed, stop the lathe and at the tenons just created, cut the twisted spindle using a hand saw. Ensure that you leave that 1/4inch tenon on each end.

Twisted Stem Goblet

Marking the ends of the spindle



Goblet design

Twisted Spindle Goblet Lesson Plan - Cup & Base

Session 4

- Materials list, tools, settings etc., introduction of project, set-up on lathe, turning and parting the cup, turning and parting the base, final assembly.

Materials list, tools, settings etc.:
Use a dry wood spindle approximately 6 inches long and 3 ¼ inches wide. We will use a roughing gouge, spindle gouge and parting tool. Rough out the blank at 500-800 rpm and turn the cup and base between 1000 and 1200 rpm.

Introduction: In this session, we will make the cup and base of our twisted spindle goblet. With each piece, we will drill a 1/4 inch mortise to accept the twisted spindle tenons. The three parts will be assembled using carpenters glue.

Setup on lathe: The cup dimensions are approximately 3 inches in diameter and 3 inches in length, keeping in mind that the bottom of the cup should be thick enough to accept the 1/4 inch tenon without being seen from the inside of the cup. The base will be approximately 2 3/4 inches in diameter and 1 1/4 inch tall. We can make both pieces from the same spindle. Given these dimensions, we should mount a spindle that is approximately 6 inches long by 3 1/4 inches wide.

Turning and parting the cup:
1. Find the center axis and mount the spindle.
2. Turn the spindle round and then turn a tenon on one end of the spindle to accept placement in a 4 jaw chuck (about 2 1/4 inches round).
3. Remount the spindle using the 4 jaw chuck and check to make sure the spindle is still true. If it is not, simply re-true the spindle.
4. Mark a line 3 inches from the tail stock. This will be the cup portion of the goblet.
5. Using a spindle gouge and a scraper, hollow out the inside of the cup leaving a thick bottom (suggest at least 1/2 inch). To start this process, first drill a 3/8 inch hole in the center of the cup close to your final depth of the cup. Using a spindle gouge with the flute turned at a 45 degree angle in the direction of the cut pivot from the center using your hand as a fulcrum and cut from the center to the edge. Only use the tip of the gouge to make this cut, not the side. Finish and fine tune the inside of the cup with a round nose scraper.
6. Now turn your attention to the outside of the cup. Making room at the base of the cup by removing unwanted stock from both sides of your line, gently roll your half bead to match the inside shape of the cup. Because our twisted spindle will be

approximately 1/2 inch diameter, the very bottom of the cup should also be at least 1/2 inch diameter, slightly concaved to better accept the tenon of the twisted spindle.

7. Carefully part off the cup.

Turning and parting the base:

1. Using the remainder of the spindle on the lathe, shape the base to be approximately 2 3/4 inches in diameter and 1 1/4 inch tall.
2. Ensure that the top of the base has the same 1/2 inch concave flat spot in the center to accept the tenon of the twisted spindle.
3. Carefully part off this base.

Final Assembly:

1. Carefully mark the center of the bottom of the cup and the top of the base.
2. Using the drill press, drill a 1/4 inch diameter hole 1/4 inch deep at the marked locations.
3. Test fit the base and cup with the twisted spindle, making any minor modifications to the spindle to ensure a seamless fit with the cup and base.
4. Once satisfied with the fit, glue the pieces together. Blend as desired using sandpaper.