Precision Angle Measurement

Tutorial Version 1.0.0

There are times such as when building segment cutting sleds when accurate angle measurement is critical. This paper provides an inexpensive approach that can provide angles to within a few hundredth of a degree.

Part of

The SegMaster Series

The SegMaster Series is a set of short articles provided for woodworkers interested in Segmented Wood Turning. They are short, concise, and filled with tips and techniques that readers may or may not have thought of themselves. They maximize photos and illustrations and can be skimmed quickly or read slowly and studied. They can be printed, taken to the shop, and used as tutorials. Please enjoy them and let me know how they can be improved.

Written By

The SegMaster

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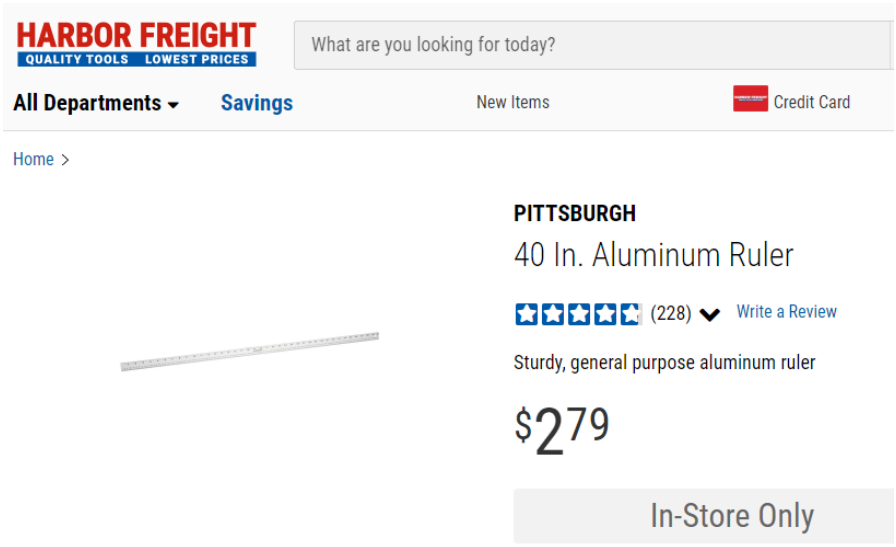
Sometimes woodworkers need accurate angles. The most common situation is when setting an angle for cutting pieces for a segmented bowl. Surprisingly, this was a significant topic of discussion at the Boston Segmenters Symposium a few years ago. This problem did not seem to be under control.

When I started segmenting, I purchased a Digital Protractor guaranteed to be accurate to 0.3 °. Multiply that by the 24 cuts needed for a 12-segment bowl and you have an error of more than 7 Degrees. For kicks, I just measured a 15° angle that I had verified to be perfect by building a ring from it where the 12 pieces fit perfectly. The digital protractor indicated that it was 14.6°. Bad! In fact, even 0.1 degrees is not accurate enough.

Since then, I have figured out two ways to do this. The most practical for most of us to make a triangle from yardsticks – well, actually, meter sticks. We really need those decimal markings. Another method is to use a 3D printer to print out an accurate angle guide. Since most readers will not have a 3D printer, I will focus on the meterstick method.The key to this is using three yardsticks – or more accurately stated, “meter sticks”. These are available from Harbor Freight for less than $3 each. Unfortunately, as of this writing, these are available “in store only” from Harbor Freight. Amazon has them for $9 each. Whatever. You need them for this method. You will also need a couple of squeeze clamps and a 5/16 nut and bolt or wingnut.



Having a centimeter scale on your ruler is most required. It is much easier to pick out a precise measurement on a decimal scale.

Notice that the rulers have a 5/16” hole in the 100 CM end.

It is a good idea to round this end. Do NOT round the “zero” end.

Place a 5/16” bolt through the holes and snug it.

We will use these meter sticks to make a triangle. Two legs of the triangle each be a meter long. I will call these the *Angle Legs*.

The third meter stick will be the *Measurement Leg.* Obtain the length of the measurement leg from the chart.

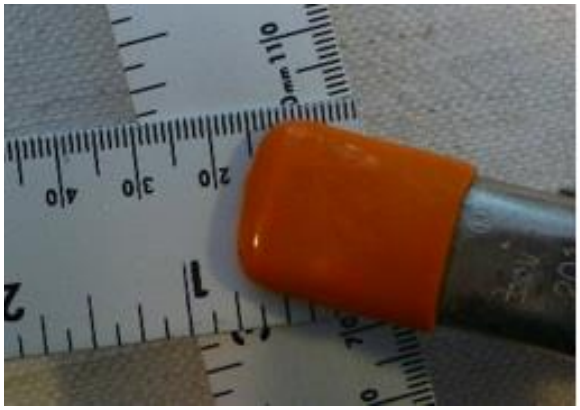
One corner of the triangle is set with the 5/16” bolt. Use the meter stock for the other two corners.

For a 12-segment ring, we need an angle of 15°. The length of the measurement leg will therefore be 26.11 cm. You will find it easiest not to use the “zero” point on the measurement meter stick; there is not enough space there for the spring clamp. Instead, clamp to the 10 cm position.

Clamp the other end to a point 26.11 cm beyond the 10 cm position – that is the 36.11 position. See the photos below.

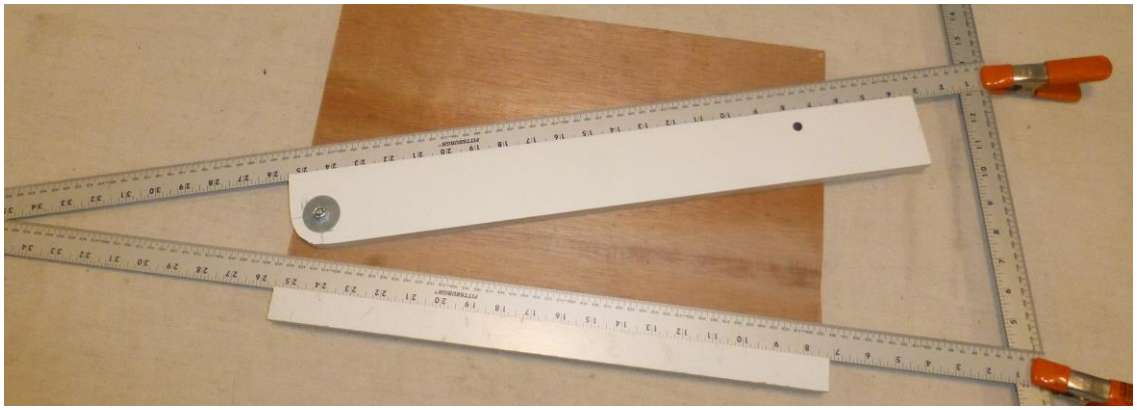
Chart for measurements:

Segments	Angle	Length
5	36	61.81
6	30	51.77
7	25.71	44.50
8	22.5	39.02
9	20	34.73
10	18	31.29
12	15	26.11
15	12	20.91
16	11.25	19.61
18	10	17.43



You might want to consider cutting the third meter stick in half. Use the upper half for your measurements, clamping at the 60 cm and 86.11 cm positions. This leaves you with a nice 18” ruler that you can use for other purposes.

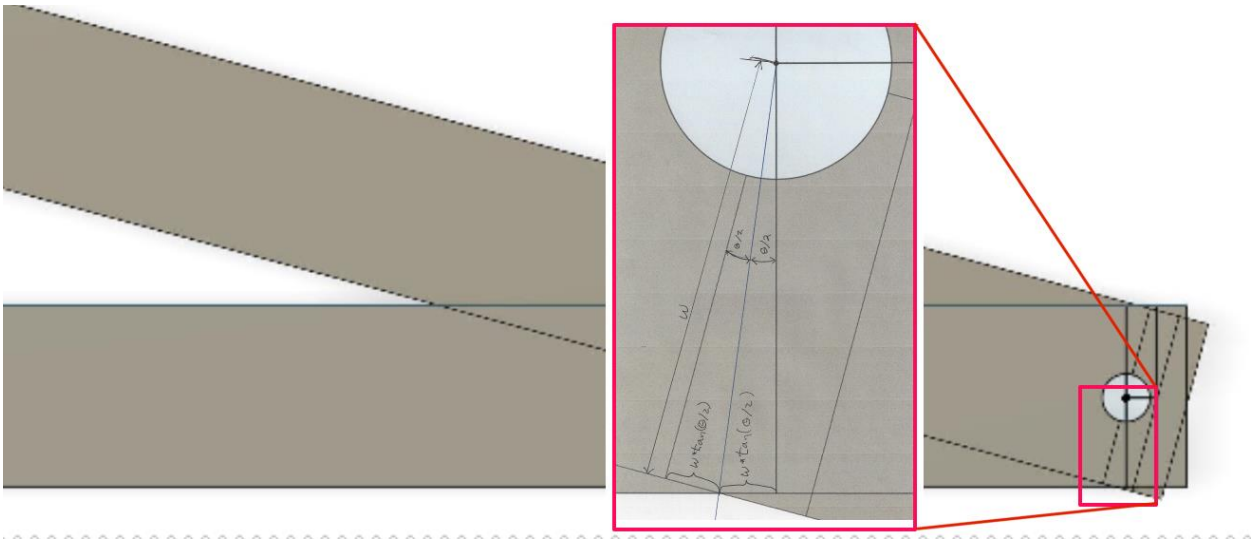
The following image shows how to use the angle to perfectly set a segment cutting sled. .

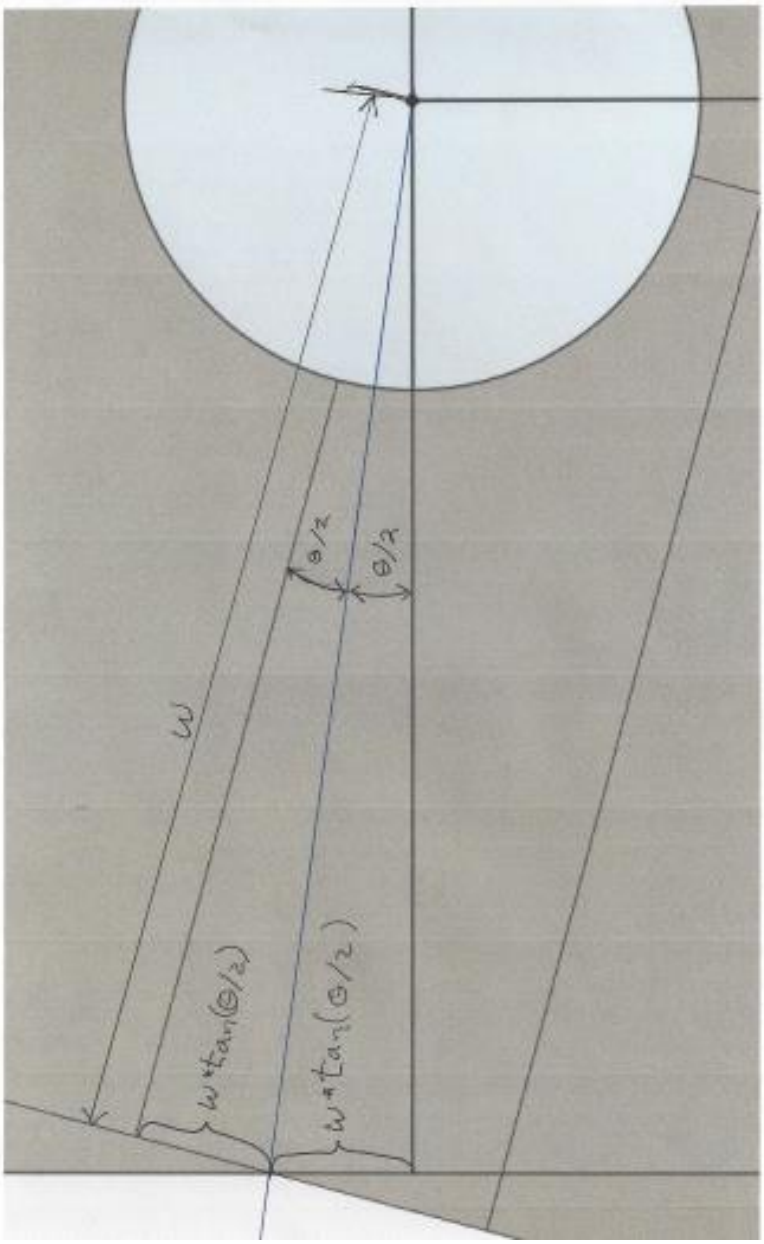


Understanding the Math

You do NOT need to read or understand this section to create perfect angles. I am putting it here if you enjoy these things.

You might think that you can use a simple Pythagorean formula with two one-meter legs. You would be almost right. The error arises with the angle rotation point being offset from the edges. Separating the legs changes the effective length of the two angle legs. The following drawing illustrates this:





When you adjust the angle legs, this has the effect of shortening the lower leg and extending the upper leg. The amount of lengthening or shortening is the amount of offset of the hole from the edge of the meterstick times the Tangent of half the angle. This is shown to the left. (Sounds simple, right?)

For my metersticks, the hole is 0.0147 meter from the edge. The Tangent of (15 ° / 2) is 0.1317. The shortening or lengthening is .0019 meters. So, one of our legs is 1.001948 and the other is .998052.

As you may (or may not) recall, the length of the third leg of a triangle is

SQRT(A^2+ B^2 - 2 * A * B * Cos(Θ))

Which for 15 ° gives us 26.11 cm.

Feel free to run the calculation for any angle you want. Or, pick the length of the Measurement Leg from the chart I provided.

Scaling

This paper tells us how to use metersticks to measure angles. There is nothing to stop you from using shorter (or longer) measuring sticks, but you will have to redo the math.

I tried making a triangle from 50 cm yardsticks thinking that it would be less cumbersome. The problem was that the squeeze clamps got in the way.

Note that you could NOT simply cut the distances in half, though it is close.

I will post a copy of the Excel spreadsheet onto the SegMaster web site: http://www.TheSegMaster.com. load this and play around all you want.

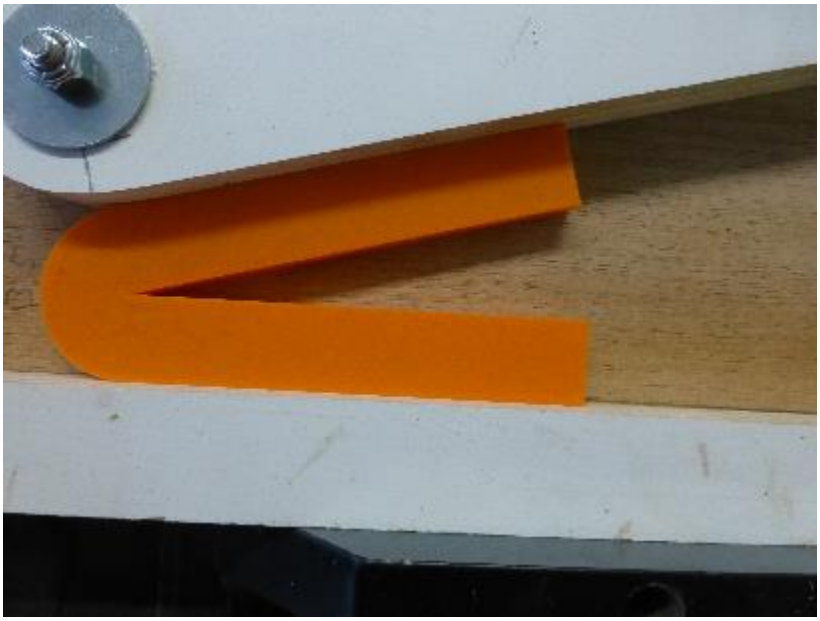
I have also found that it makes sense to shorten the *Measurement Bar*. It only takes about 40 cm to make an 8-segment ring. Cutting this to 50 cm will provide plenty of length without having a half meter of yardstick flopping around unnecessarily.

Angles With a 3D Printer.

I have a 3D printer. Recently, I got the idea of making a fixed angle gauge of exactly 15°.

I printed one with 4" legs and fit it into the sled I had made using meter sticks I had previously verified this sled by cutting 12 segments and having them fit exactly.

I was not surprised that the angle gauge fit perfectly in the sled.



Thus, it appears that if you have a 3D printer – or know someone else who does, you can make angle gauges. The design I have for this in Fusion 360 allows you to set any angle, any arm length and any arm width. I will post this online, possibly with some STL files for some common angles. http://www.TheSegMaster.com

It seems that this might be easier than using the meter stick method, but obviously it requires a 3D Printer.