MEASURING X-Y ORTHOGONALITY USING A MicroRule OR LINEAR SCALE

To simply and accurately measure Orthogonality of an X-Y stage, we recommend a MicroRule (6" - 40"), or some other accurate, stable linear scale. You must be able to read two points on the MicroRule and be confident in the Positional Accuracy of your point readings. The MicroRule is Certified Accurate with N.I.S.T. Traceability.

The steps include:
1. Set-up and calibration of the X-Y independent X- and Y-axes readouts.
2. Check for Orthogonality of the X-Y stage readouts using the MicroRule.

PROCEDURE

1.0 Set-up and Axis Readouts Calibration

1.1 To independently check both the X and Y readouts for correctness, we will measure each for "0" values of the opposite direction. We want to assure that the X and Y readouts correspond to the dimensions and measurements read from the MicroRule.

1.2 Position the MicroRule scale parallel to the X-axis and temporarily affix it to the stage surface. Measure the distance from 0.000 on the MicroRule to at least a second point at some distance.

For example, we will be using a 10" x 6" travel X-Y Stage and 12" MicroRule (P/N 300MLA0027-010, Overall Accuracy ±0.00025").
For True Orthogonality

$$C = \sqrt{A^2 + B^2}$$

$$Cos\ c = \frac{A}{C}$$

We suggest confirmation at 8.000" and 10.000".

1.3 Rotate the MicroRule so that the scale is positioned parallel to the Y-axis and again temporarily affix it to the stage surface. Measure the distance from 0.000 on the MicroRule to a second point at least a second point at some distance.
For our example, we suggest confirmation at 4.000" and 6.000".

1.4 For both the X-axis and Y-axis readings, the stage readouts should equal the suggested distances within ±0.00025" [0.006mm]. You may need to calibrate the stage readouts or make corrections.

2.0 Checking for Orthogonality of the X-Y Stage

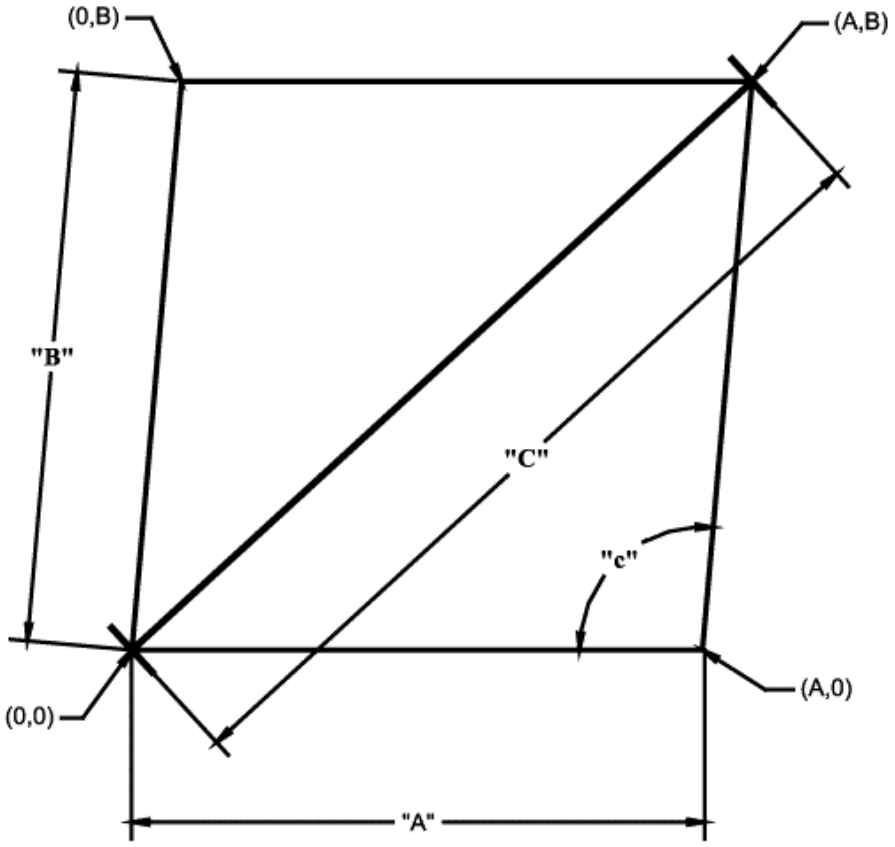
2.1 Position the MicroRule on the stage such that its scale is at approximately 45° above the X-axis, space permitting. Any angle is sufficient. However, at 45° this procedure will give the greatest precision to your answer.

For our Example, we position the MicroRule so that the stage origin (0,0) is near the 0.000 on the MicroRule. We rotate the MicroRule such that 10.000" on its scale is near X=8.5" and Y=5.3".

Tape or otherwise temporarily fix the MicroRule onto the stage. "Zero" the stage, i.e., set the stage origin (0,0) at the 0.000 on the MicroRule.

2.2 With the stage zeroed at MicroRule 0.000, measure the X- and Y- values at a distance along the Microrule. In effect, these values are the coordinates read.

For our example, we measure,
X-value = 8.4890" *("A")* ***"C" is 10.000" on the MicroRule scale.***
Y-value = 5.2930" *("B").*



2.3 Since we know the calibrated length along the MicroRule, i.e., the distance from (0,0) to coordinates read, we know the three sides of a triangle and can use the law of cosines to find

the angle. When compared to a True Right Angle (90°), we have the measure of Orthogonality. (See below)

$$\angle c = \arccos\left[\frac{(A^2 + B^2 - C^2)}{(2 \bullet A \bullet B)}\right]$$

$$\angle c = \arccos\left[\frac{(8.4890)^2 + (5.2930)^2 - (10.000)^2}{(2 \bullet 8.4890 \bullet 5.2930)}\right]$$

$$\Lambda = \arccos\left[\frac{(72.06312 + 28.01585 - 100.00000)}{89.86455}\right]$$

$$\mathrm{K} = ar\cos\left[\frac{.07897}{89.86455}\right]$$

$$\mathrm{K} = \arccos(.00088)$$

$$\mathrm{K} = .0503°$$

$$or \mathrm{K}\ 181.3 arc\sec \mathrm{K}\ or \mathrm{K}\ 3.02 arc\min.$$