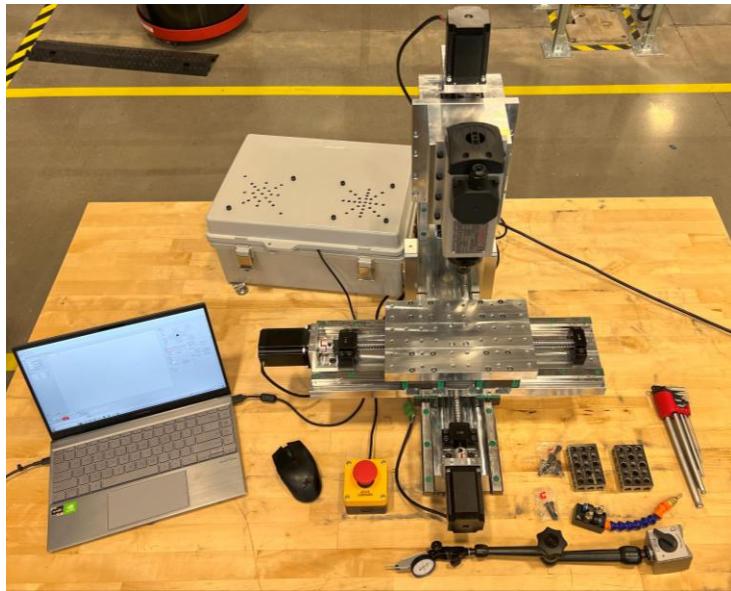


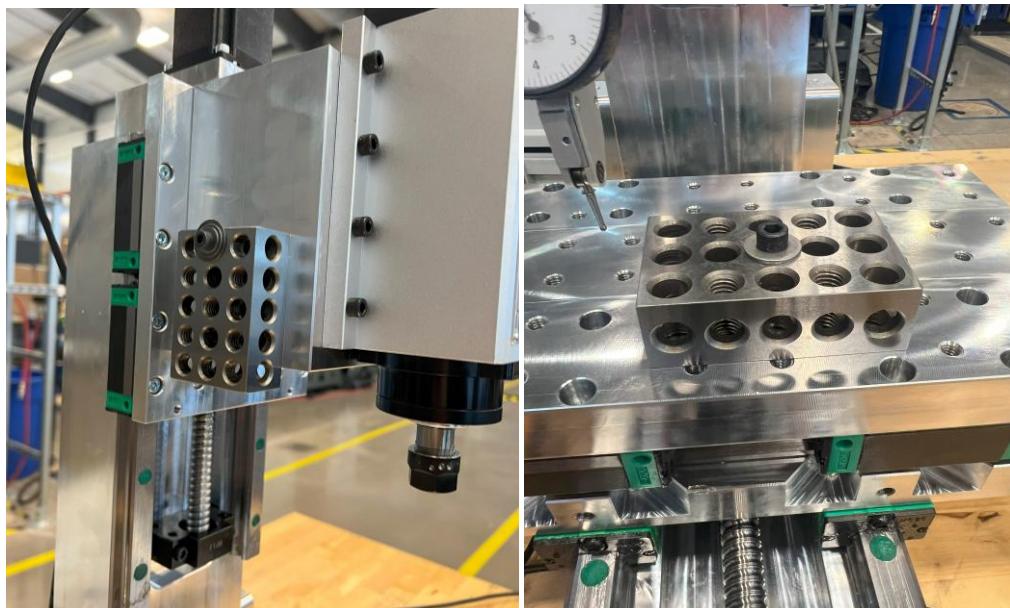
## **Desktop CNC milling machine assembly instructions (SQUARING)**

1. Gather the items below to begin the squaring process: 3, 16, 29, 30, 34, shim stock, gauge pin, assembled machine, assembled electrical box, and laptop. Do not begin the squaring process until electrical and software instructions are fully completed.

Be sure that the laptop connects consistently to the electrical box with ioSender but DO NOT plug in the spindle cable. Do not plug a cable into the door switch connector.



2. Using an M5 bolt and washers, attach a 1-2-3 block to the side of the Z-head by its largest face. Then, attach the remaining 1-2-3 block to a threaded hole on the X-carriage in the same way. Position the 1-2-3 block to be as square as possible by hand. The bolt should be tight enough to keep the block from pivoting easily, but not fully tight. Align the block to the X-carriage using calipers for a closer setup.



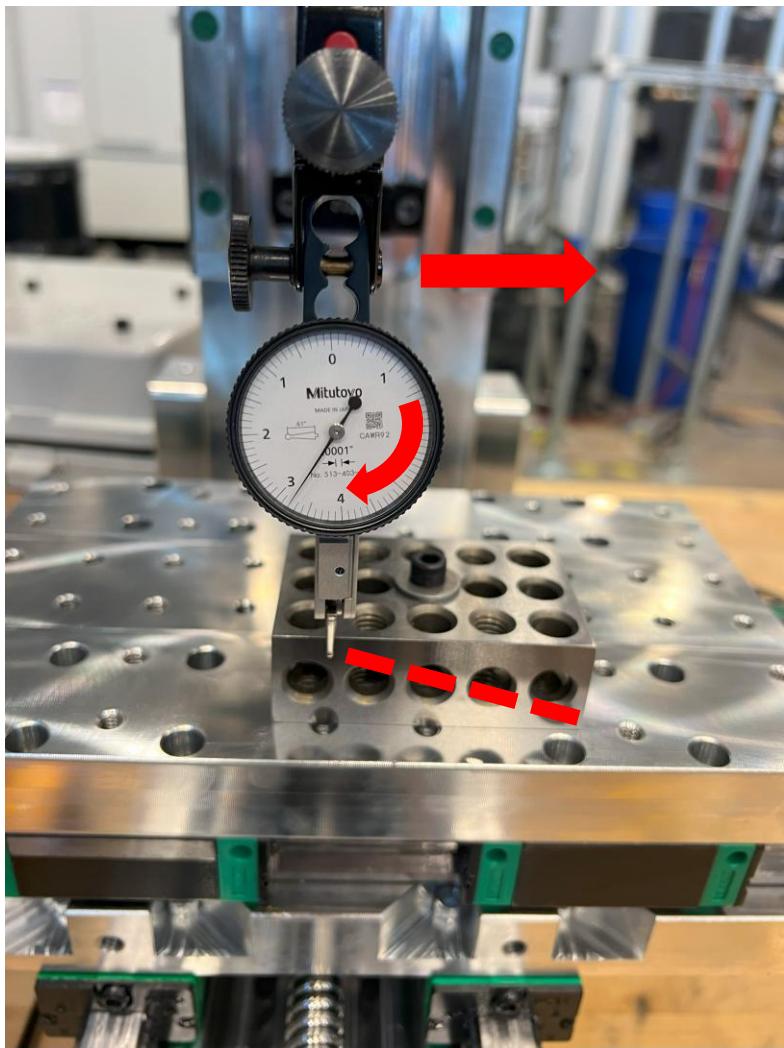
3. Jog the machine so that the X- and Y-axes are roughly centered. You now have a surface for mounting the dial indicator on the Noga arm's magnetic base (29) on the Z-head. Do so by turning the knob on the base to “-”, positioning, then flipping to “+” to attach.



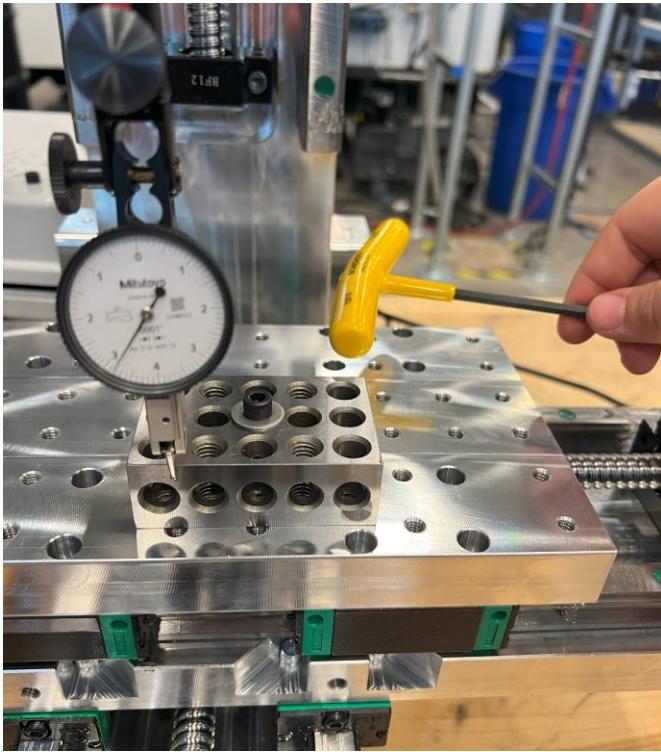
4. Loosen the arm and position it so that the indicator is upright, and the tip is close to the front upper surface of the 2<sup>nd</sup> 1-2-3 setup block. Position the indicator as seen below in one corner of the block's front face (jog axes as necessary). **NOTE:** During the entire squaring process, be sure that no axes will exceed their travel limits during measurement. Have the emergency stop button within reach to stop the machine before or if it reaches its motion limits.



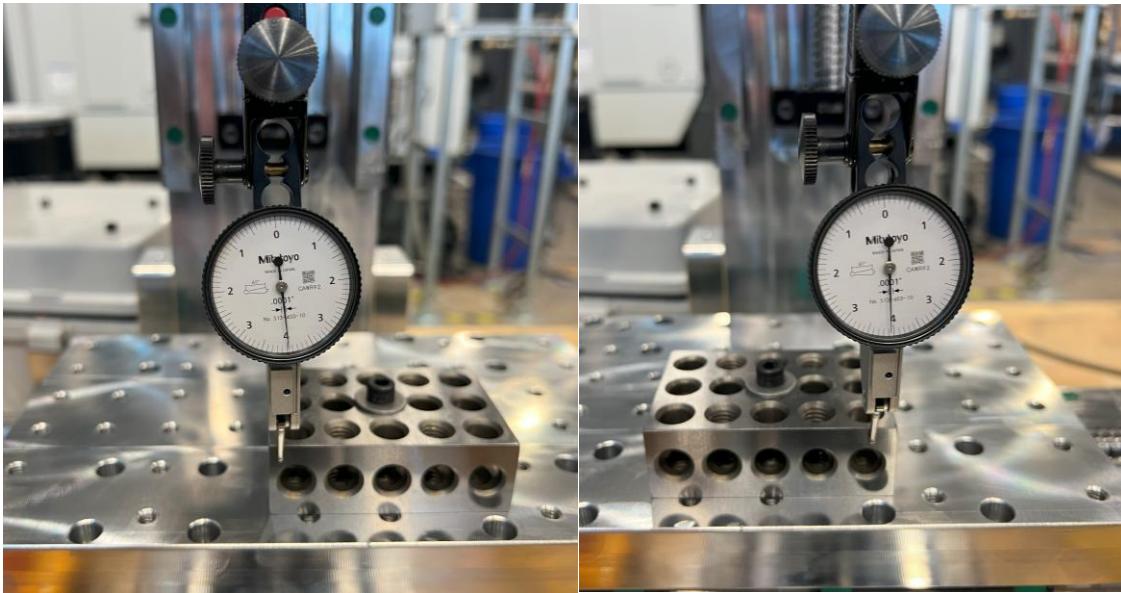
5. Lightly turn the small knob over the indicator dial until the tip touches the 1-2-3 block. Move until the dial moves past a half rotation and leave needle on a clear marking (“4” is used in the pictures and is a good recommendation for a reference marking).  
**NOTE:** This dial indicator precisely shows small changes and is thus very sensitive. It takes very light movements to turn the needle. Be sure that, when making fine or final measurements, the needle is not close to “maxing out” or losing contact with the measured surface.
6. Slowly jog the X-axis so that the indicator moves towards the opposite corner of the 1-2-3 block. Watch the needle on the dial indicator. This will tell you in what direction the 1-2-3 block must be moved. See example below: as the dial indicator moves right, the dial’s needle moves clockwise (an increase). Thus, the block must be turned slightly counterclockwise about the bolt to be square in X.



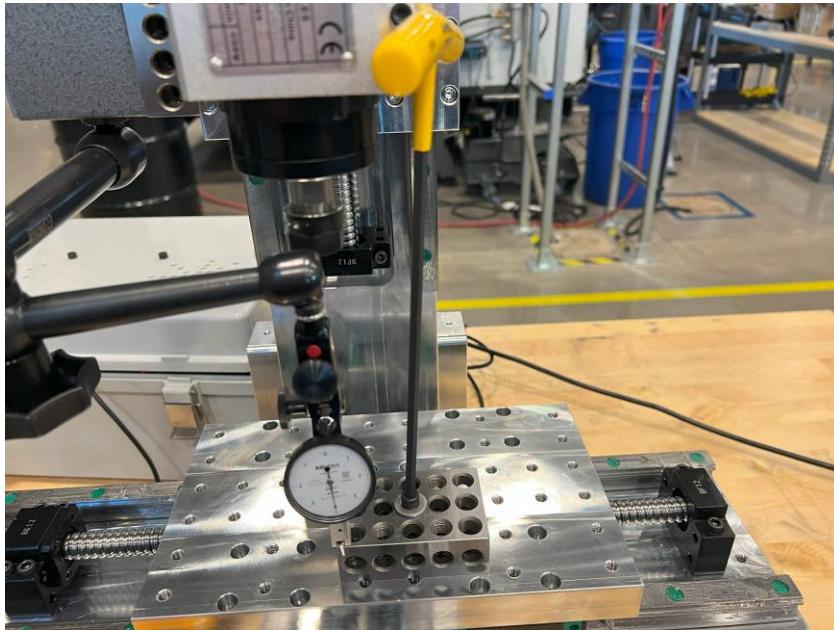
7. Using the rubber handle of the T-handle hex key (15), tap the 1-2-3 block in a corner that will give the desired direction of correctional rotation.



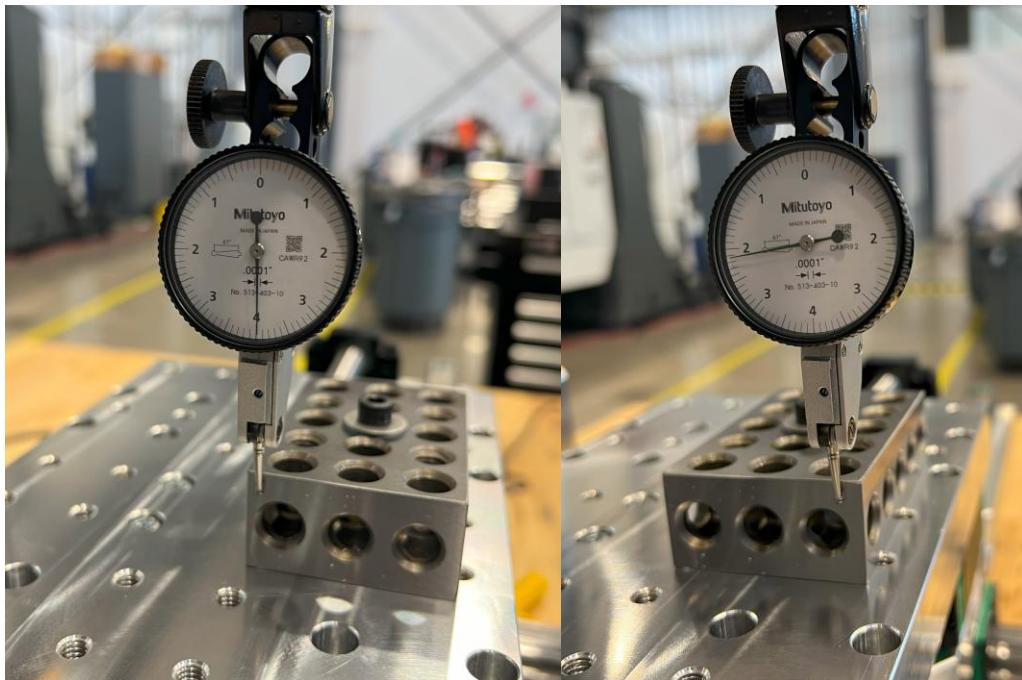
8. Move back to step 5 and repeat until the dial indicator shows almost no difference from one corner of the block to another (less than a couple tenths).



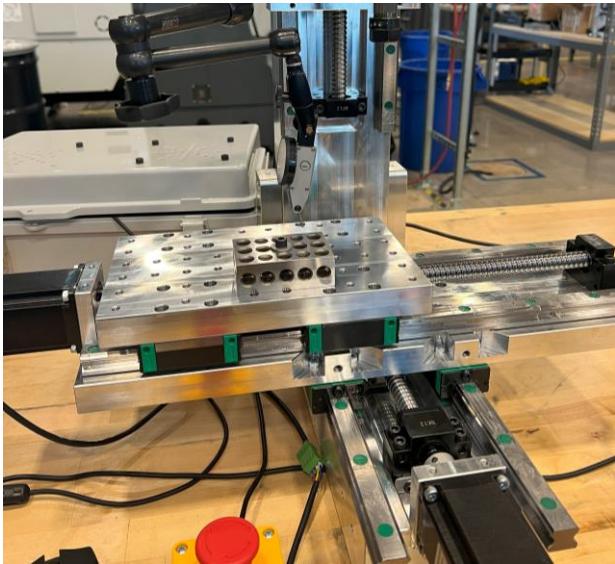
9. Fully secure the 1-2-3 block to the X-carriage without moving the dial indicator. Pass the indicator back and forth across the face of the block one more time to be sure that it did not move significantly.



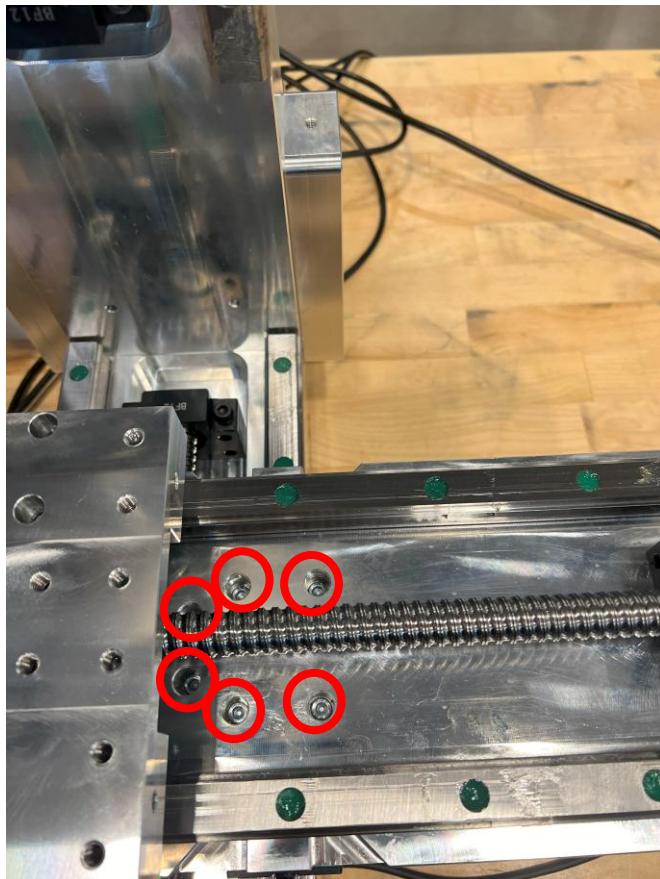
10. The Y-axis must now be checked in the same way. Set the dial indicator, as in steps 4-5, to one corner of a perpendicular face of the 1-2-3 block. Pass the dial indicator across the top of the face as in step 6. It is very likely that the Y-axis will not be straight at first; take careful note of the direction the dial turns as you pass along the surface, but do **not** loosen the bolt or adjust the 1-2-3 block to correct.



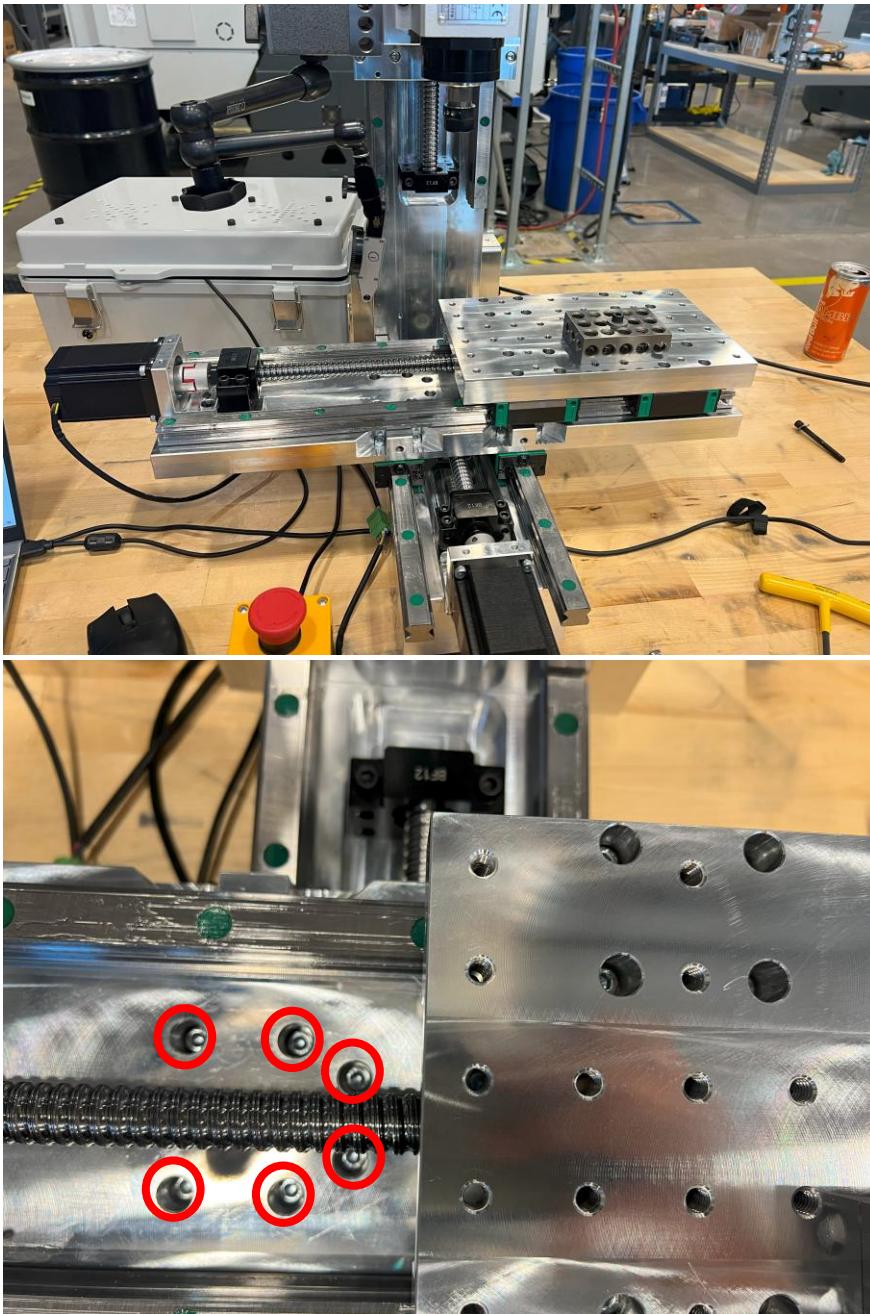
11. The Y-axis error will be corrected with the machine saddle. After making note of Y-axis offset, carefully move the dial indicator out of the X-carriage's path. Now jog the X-axis all the way to one end.



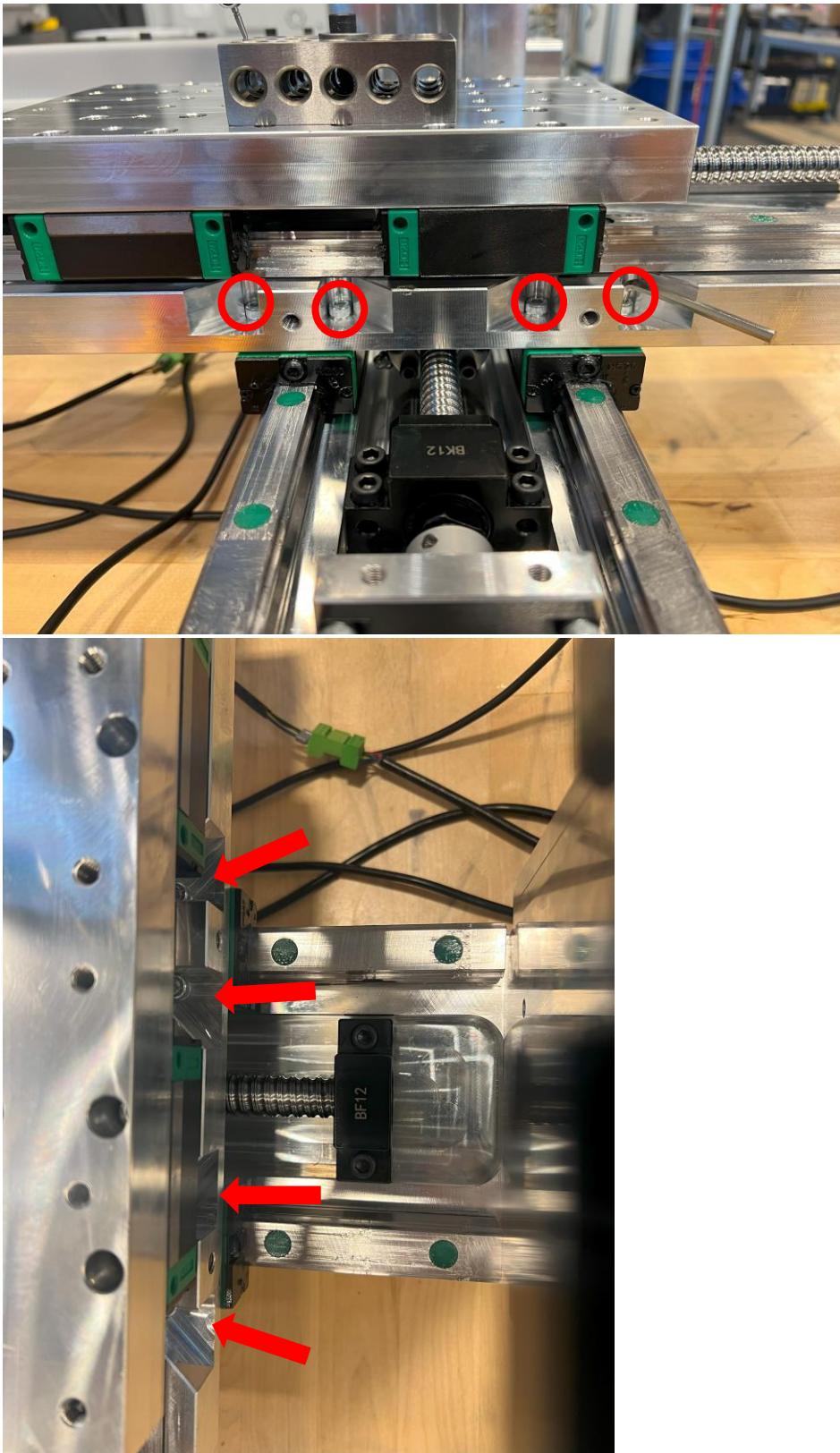
12. Loosen the marked bolts. No bolt should need more than one turn for this adjustment. Do not remove any bolts.



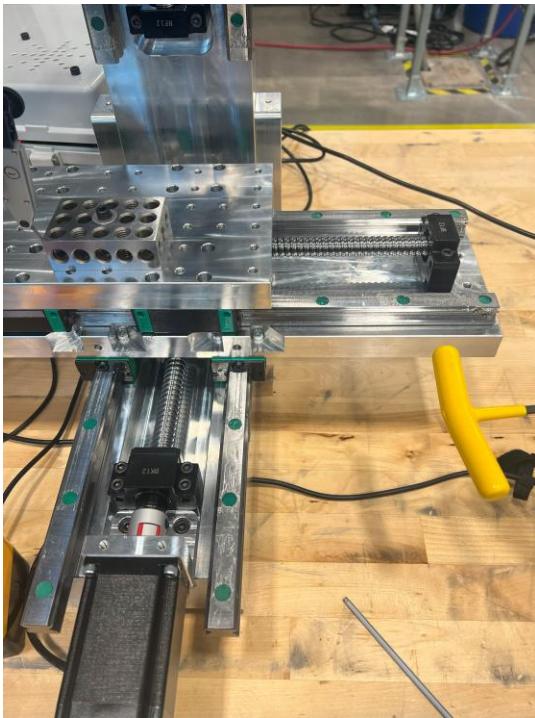
**13.** Jog the X-axis to the other end and loosen the circled bolts in the same way.



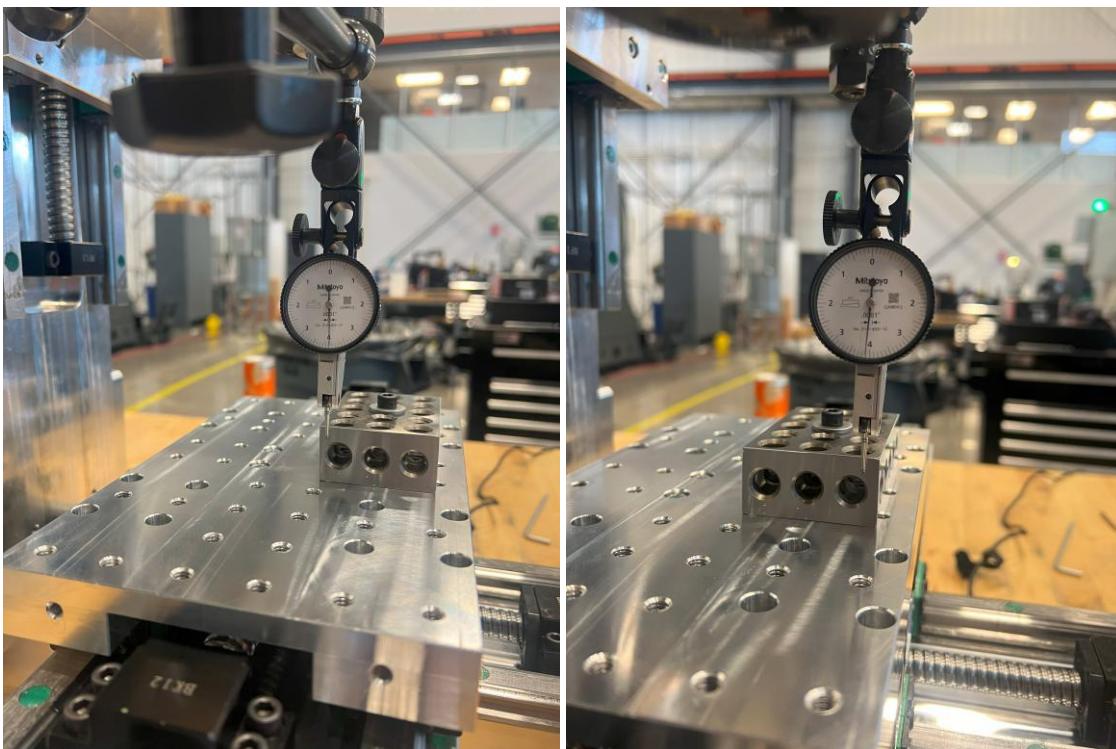
14. Finally, using the short nose Allen key (9), loosen the bolts on either side of the saddle, marked below.



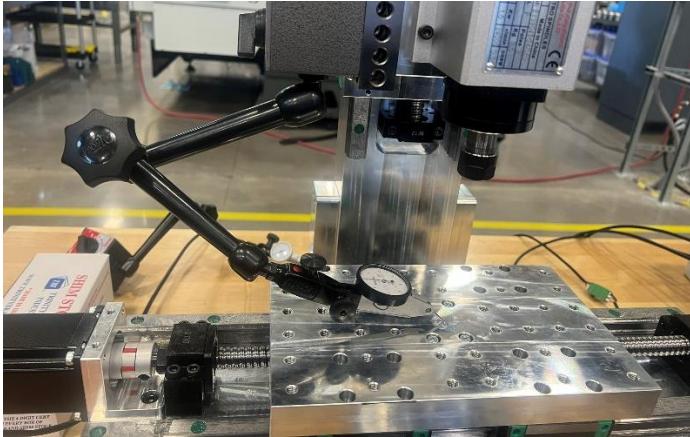
15. The saddle can now be gently tapped with the handle of the T-handle to achieve the desired correction.



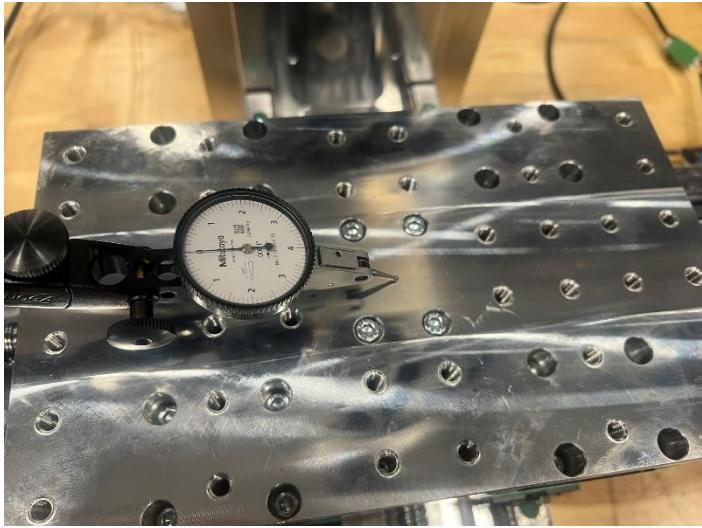
16. Set up and repeat the sweeping process on the Y-axis from step 10. This time, continue correcting the saddle error (step 15) until satisfactory accuracy is achieved on the Y-axis (again, less than a few tenths across the swept face).



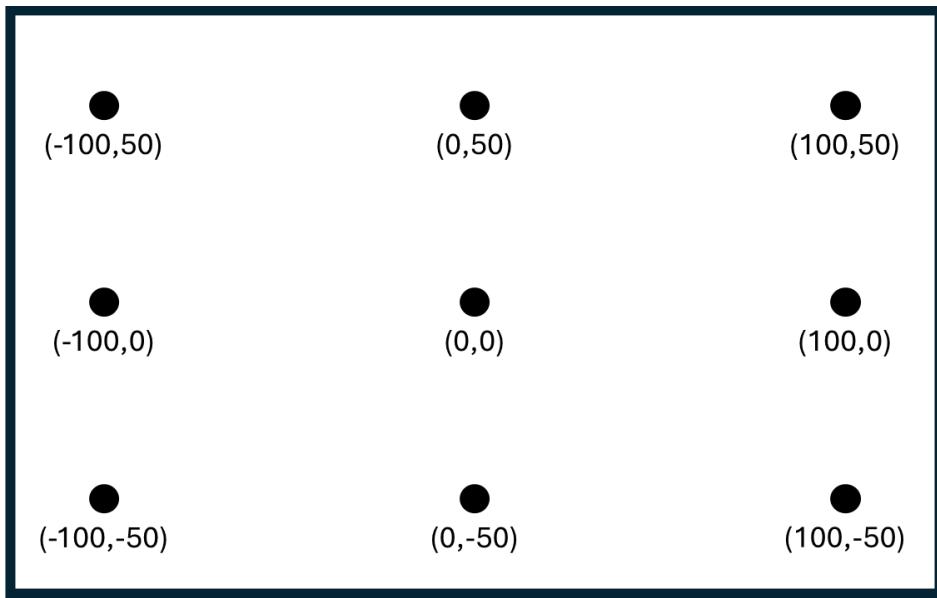
17. Tighten the bolts that were loosened in step 14. Do not jog the X-axis yet. Sweep the Y-axis again to ensure no significant movement occurred while tightening. If the error has worsened, move back to step 14.
18. Much like steps 11-13, move dial indicator and jog X-axis to tighten all bolts marked in step 12 and 13.
19. Set up and repeat the sweeping process on the Y-axis from step 10 to confirm Y-axis accuracy. Then repeat steps 4-6 to confirm the X-axis accuracy (this time, of course, with the 1-2-3 block firmly in place). This should show good tolerance in both directions. If there is a significant error, examine the setup and repeat steps as necessary. Check to make sure all bolts from step 14 are well tightened. Remove the bolts from steps 12-13 **one at a time** and apply thread locker. Tighten fully **before** removing another bolt to ensure the squaring changes are held. Do **not** apply thread locker to **any** bolts marked in step 14.
20. Once the X and Y are squared with the Z head, remove the 1-2-3 setup block. Now move the dial indicator to measure the top face of the X-carriage as seen below. Center the gauge tip on the X-carriage. Before measuring, be sure that the X-axis can be safely jogged 100mm in both directions (+X, -X). Be sure that the Y-axis can safely jog 50mm in both directions. If not possible, jog and reposition the indicator to accommodate the travel.



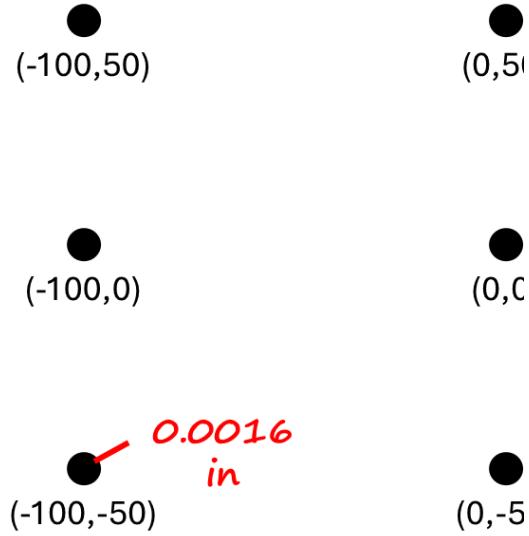
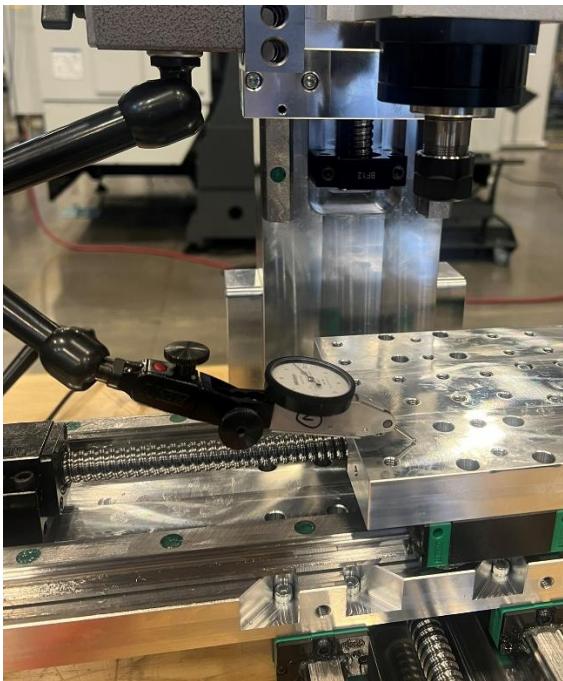
21. Carefully bring the indicator tip into contact with the face. For this measurement, it is recommended that the needle be referenced from 0 rather than 4. Allow the needle one full rotation before stopping at 0 to avoid possible mismeasurement.



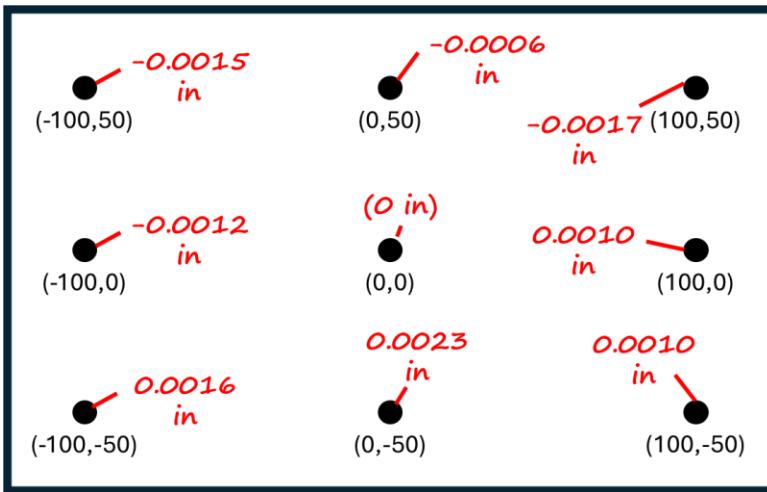
22. To keep track of and visualize measurements made on this face, draw a diagram like the one below. This represents the nine points on the face of the X-carriage that will be measured as seen from above (using machine coordinates).



23. The dial indicator will be jogged **one axis at a time** (avoiding holes) to every point on this diagram. The coordinates shown represent realistic distances in mm of travel. Once the indicator is set to a certain coordinate, record the gauge reading and move to another point. If the indicator moves clockwise from its reference, record as a positive number, and vice versa. See example below, where the indicator is measuring at the point (-100, -50). The dial gauge's reading is recorded on the diagram. None of these measurements should read over a few thousandths of an inch.

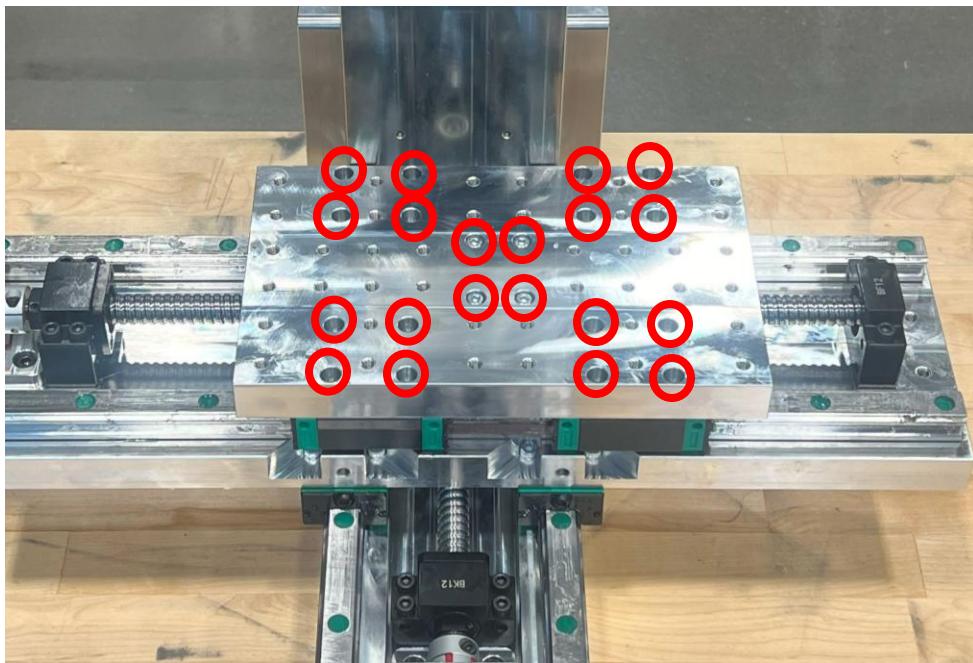


24. After every point is measured and recorded, assess the diagram to determine where to place shim stock. An example is shown below:



It is likely that these measurements will not represent a perfect plane. This is a very small measurement that can be affected by the quality of machined surfaces, axis alignments, fastener forces, and other factors. However, it is clear in this example that the +Y axis is consistently lower than the -Y. Thus, shim stock should be placed under the +Y side of the X-Carriage. Similarly determine where to place shim stock.

**25.** Loosen but do not remove the 20 bolts that hold the X-carriage to the linear rails.



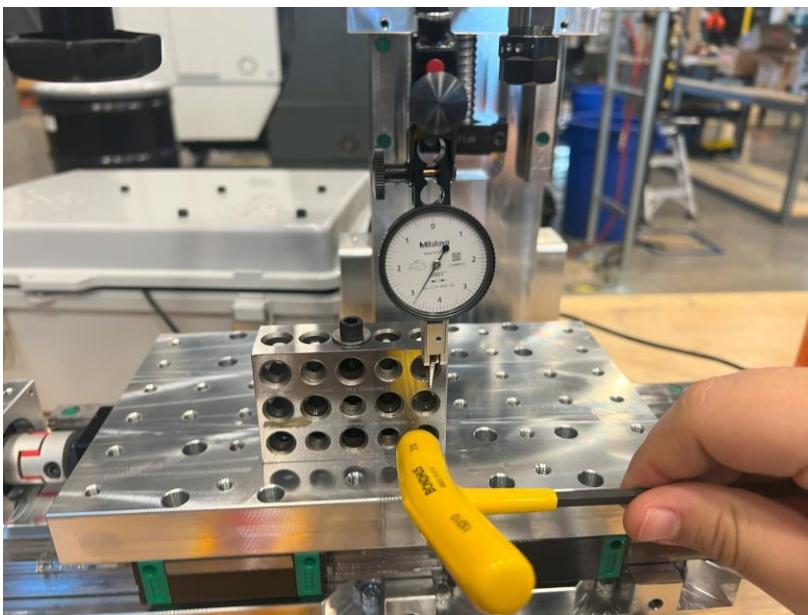
**26.** Cut a piece of shim stock and slide between the linear rail block and X-carriage on the desired side of the X-carriage. Trim to size if necessary.



27. Tighten the bolts loosened in step 25. Repeat step 23. If there is some improvement in the readings, move on to step 28. If not, continue from step 24.
28. As before, remove bolts marked in step 25 **one at a time** and apply thread locker before tightening again.
29. Place the 1-2-3 block on the X carriage again, this time on its side as seen below. Secure the block but leave loose enough for small adjustments as with the previous setup.



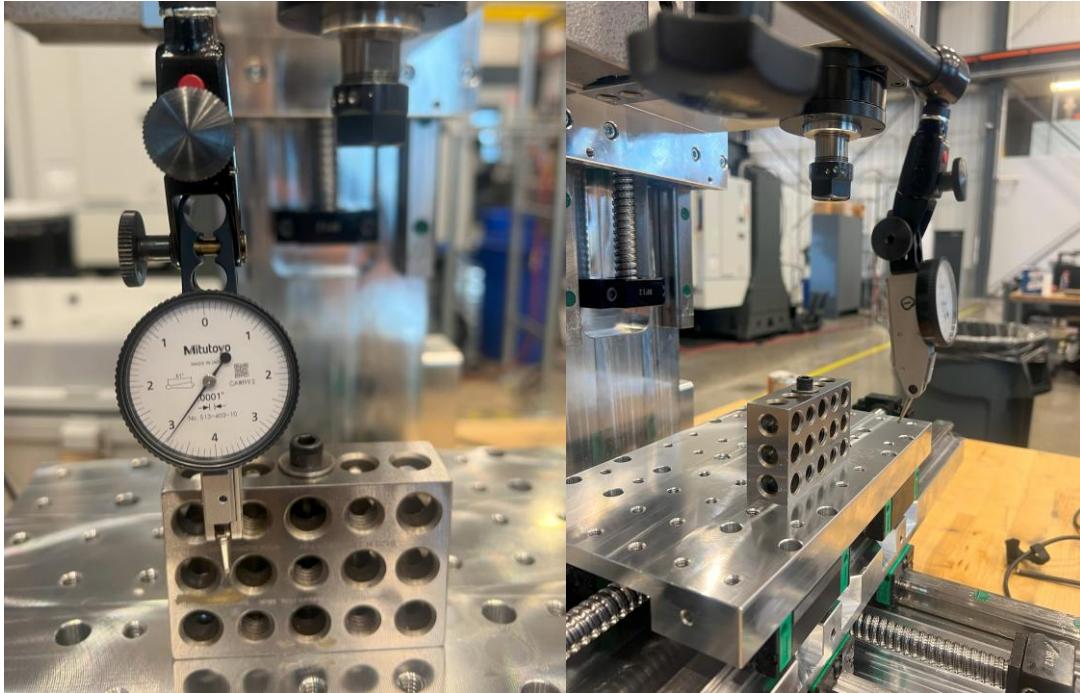
30. Now follow steps 5-9 to square the 1-2-3 block to the X-axis. Be sure to pass the indicator across a surface with no holes.



- 31.** Once the block is successfully squared, move the dial indicator to a position which will allow vertical movement across a flat surface as seen below.



- 32.** Set the dial indicator as in step 5. Carefully jog the dial indicator down the Z-axis. As before, be sure to note the direction of travel on the dial gauge. After recording and confirming the needle travel direction, move the dial indicator off the 1-2-3 block as shown.



33. Now repeat step 23, but with the dial indicator against the perpendicular side face as shown below. **Use the left face of the block as seen from the front of the machine.** After recording and confirming the needle travel direction, move the dial indicator off the 1-2-3 block.



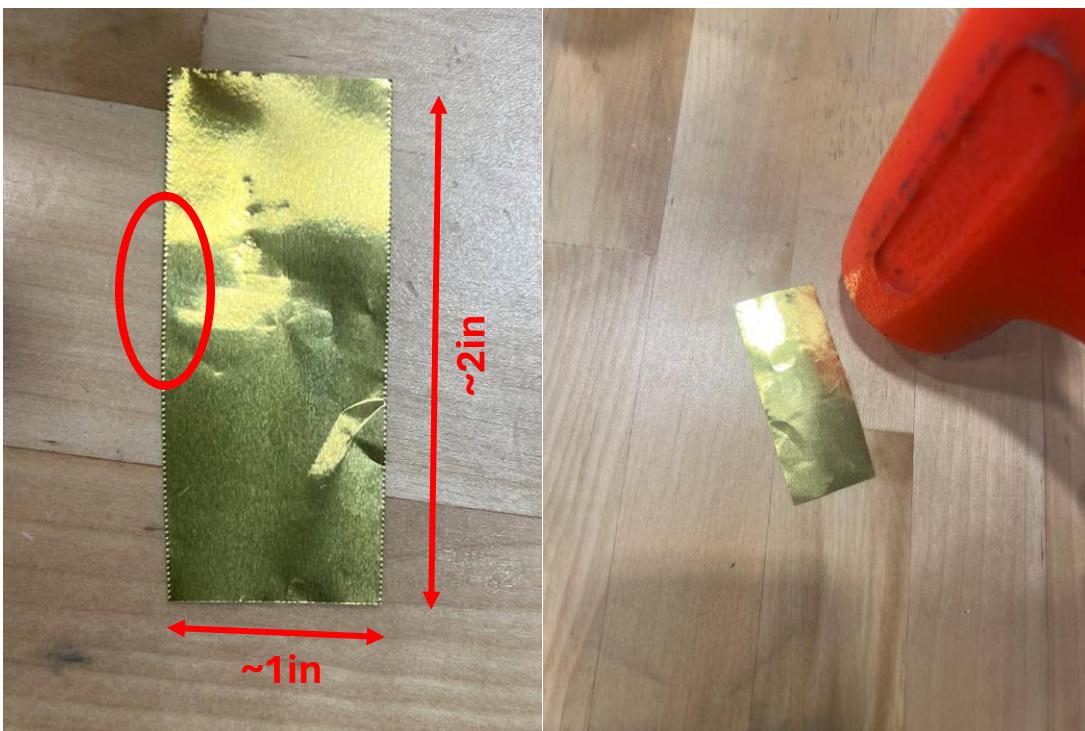
34. This error will be corrected using shim stock wedged under the column. NOTE: This step requires moving and supporting the machine. It is recommended that at least one other person help with these actions. Move the machine to the end of a table to access the column bolts as shown. Loosen bolts holding the column to base. Do not remove them.



35. Now loosen but do not remove all marked bolts on the column and bracings.



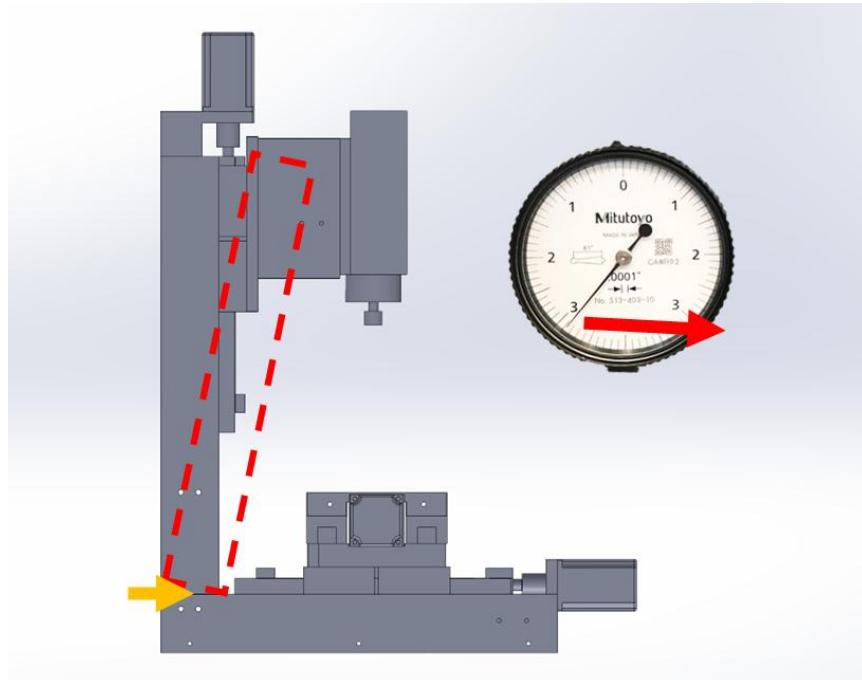
36. Cut a piece of shim stock to approximately 1in x 2in (any scissors will do). Note the serrated edges after cutting. Take the rubber mallet and hammer the rough edges of the shim stock until it is flat along all edges.



37. Using the dial indicator reading, determine how the column must be adjusted.

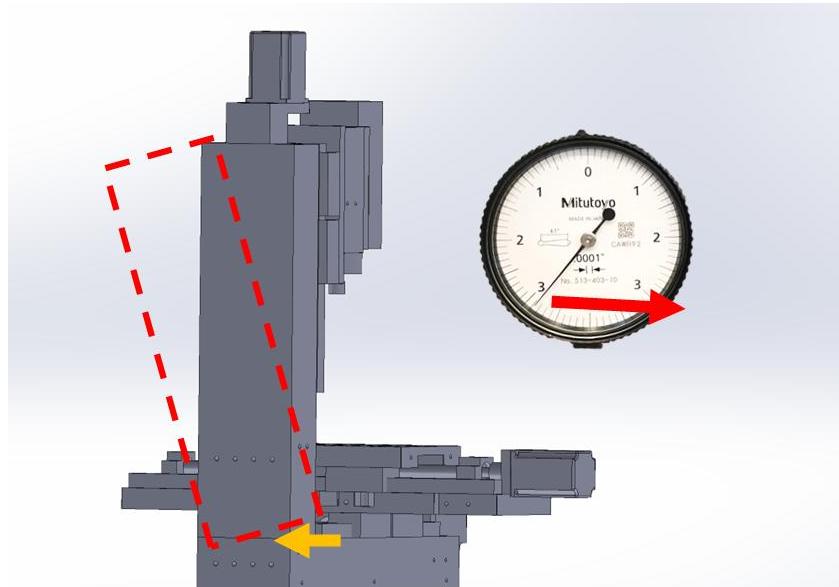
**FRONT FACE:**

To move the dial indicator counterclockwise, place shim stock under the back of the column, and vice versa.



**SIDE FACE (only if dial was read from the left face of the 1-2-3 block as seen from the front of the machine):**

To move the dial indicator counterclockwise, place shim stock under the left side of the column (as seen from the front of the machine), and vice versa.

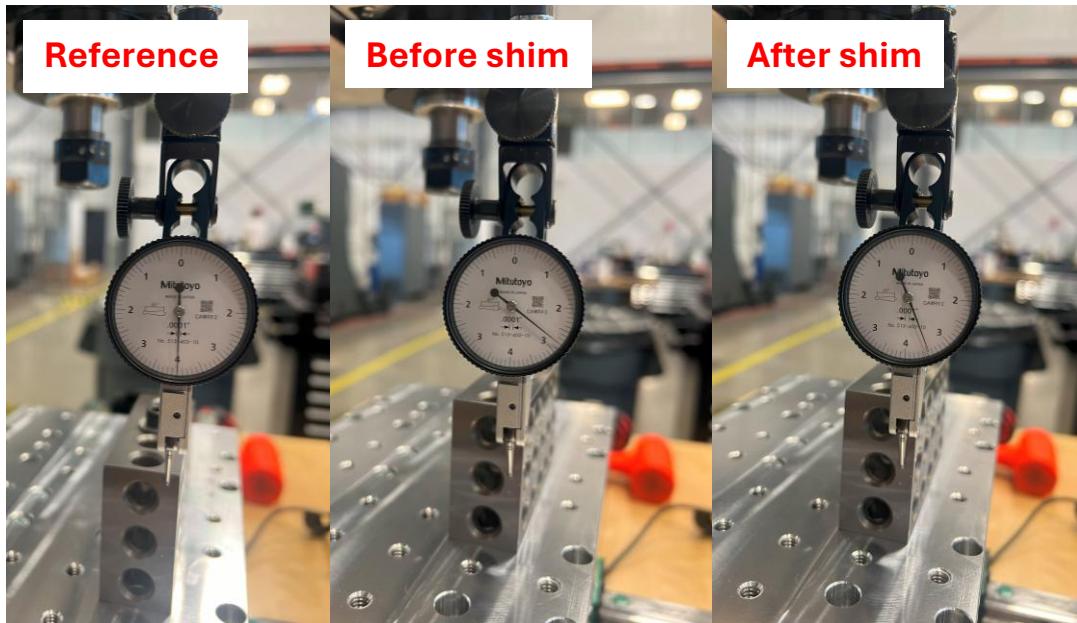


38. Carefully slide the shim stock between the column and base in an area corresponding to the needed adjustment. In the first example, the shim stock is added to the front side of the column. In the second, shim

stock is added to the side of the side of the column. Remove the large rear bracing for access if shim stock is needed on the rear of the machine. Remove the corresponding small side bracing for access if shim stock is needed on the side of the machine. If your piece of shim stock is too big (it may butt against the bolts in the column), trim with scissors or a knife for a flush fit.



39. Tighten the column bolts marked in step 25 and check for improvement by sweeping the faces of the 1-2-3 block as in steps 22-24. See below for an example of before-and-after. Once results are satisfactory and column bolts are tight, replace all bracings and secure as previously outlined in the machine instructions.



40. Remove the dial indicator but leave the 1-2-3 block. Gather the collet set and  $\frac{1}{4}$ " gauge pin.



41. Place the  $\frac{1}{4}$ " collet inside the spindle collar. Press until it clocks in and is centered as seen below.



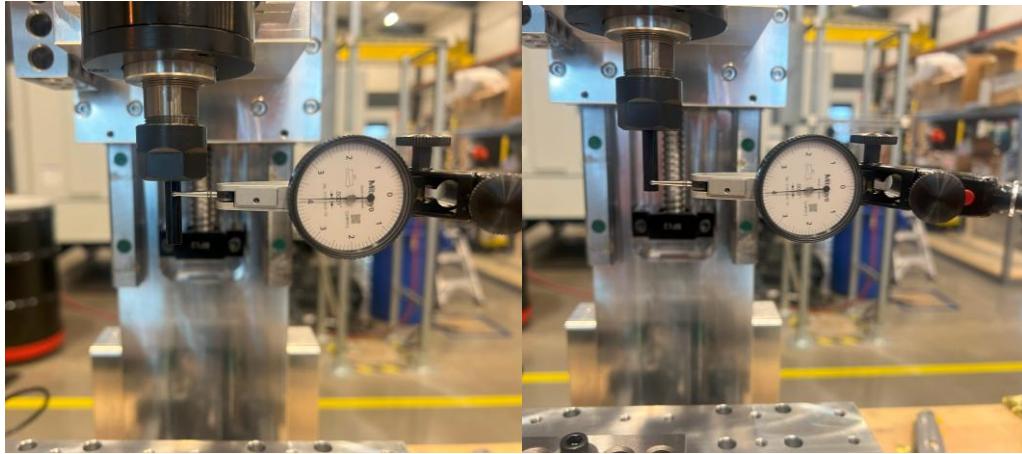
42. Begin screwing the collar and collet back on to the machine. Before fully tightening, slide the gauge pin into the collet so that it is secure but sticking out. Tighten the collar fully.



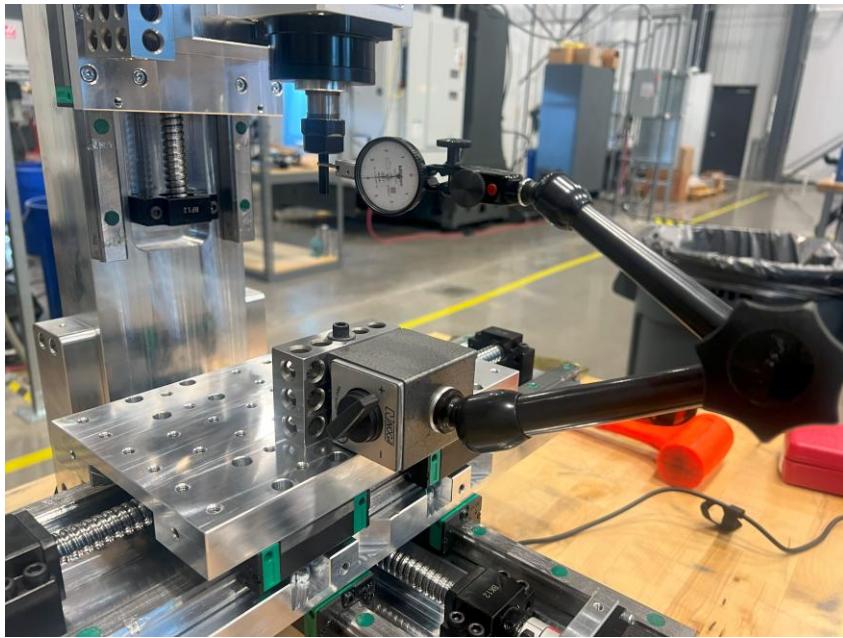
43. Now attach the dial indicator to the front of the 1-2-3 block. Position it so that the tip of the indicator is against the gauge pin and parallel to the Y-Z plane of the machine.



44. Set the dial indicator to a reference point as before and jog along the Z axis. Record the needle travel as the indicator travels along the gauge pin.



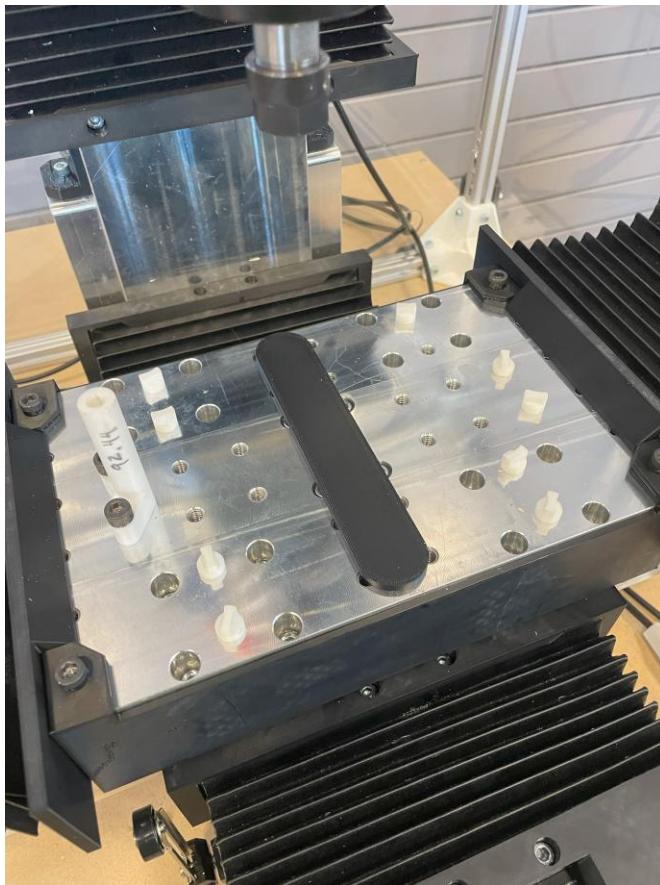
45. Reposition the indicator to the same position but parallel to the X-Z plane of the machine (90 degree rotation about the spindle axis). Jog the Z axis and record the motion on the gauge.



46. These tolerances should be satisfactory for now, but record for potential future use. Remove the dial indicator arm and 1-2-3 setup block.

## **Desktop CNC Milling Machine: Vise Setup and Tramming**

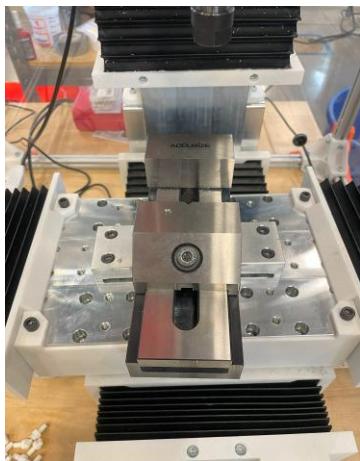
47. For all demonstration parts, we will use the vise for work holding. The vise must be trammed to be aligned with the machine's axes. Begin by cleaning the surface of the X-carriage.
48. Place the vise insert on the X-carriage as seen below. When placing the vise on the table in step 49, ensure that the insert fits inside the channel of the vise.



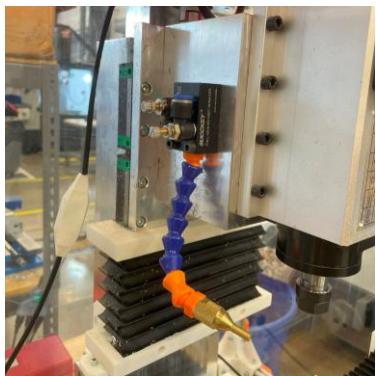
- 49.** Place the vise on the X-carriage and orient it so that the vise is roughly centered, then place one machined toe clamp on either side of the vise. The clamps should fit into the channels on each side of the vise. These clamps will be secured to the circled holes with  $\frac{1}{4}$ -20 x  $\frac{3}{4}$ " hex bolts. Begin threading but do not fully tighten bolts.



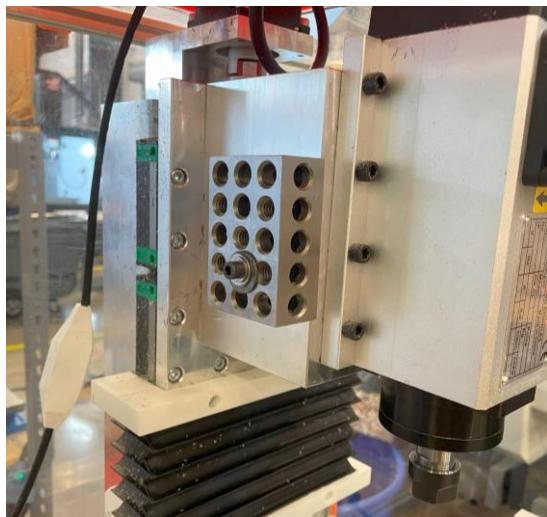
- 50.** Thread the bolts in most of the way. The bolts should be in place but allow vise movement.



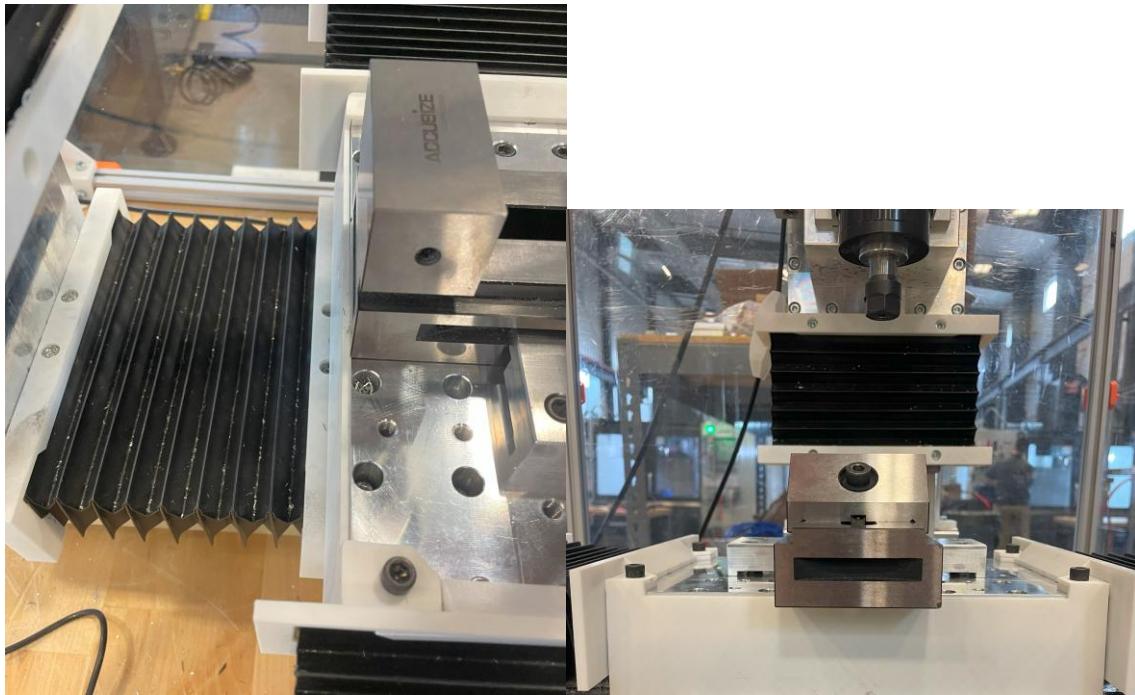
- 51.** If your machine tool is equipped with a coolant hose, remove it from the Z-head by removing the 2 holding bolts.



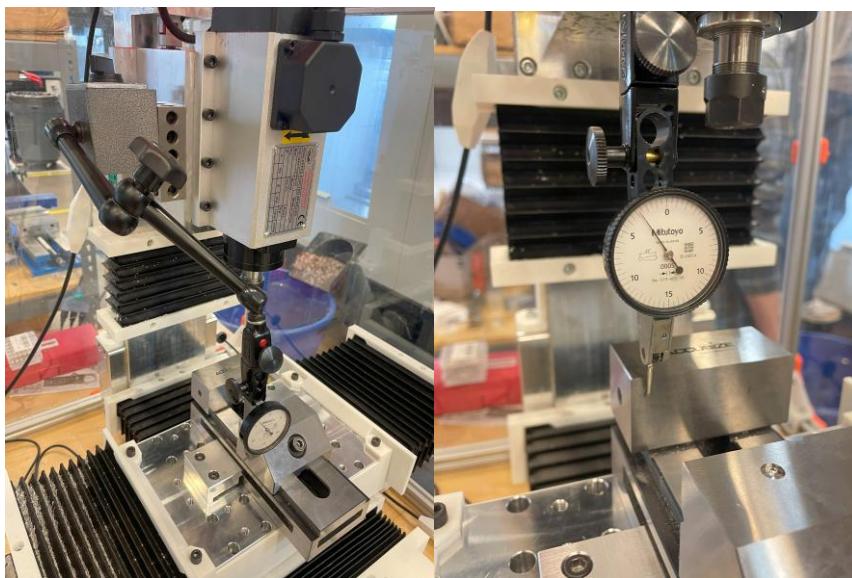
- 52.** As in the squaring process, we will need a dial indicator and 1-2-3 setup block. Attach the setup block to the side of the Z-head with its bolt and washers.



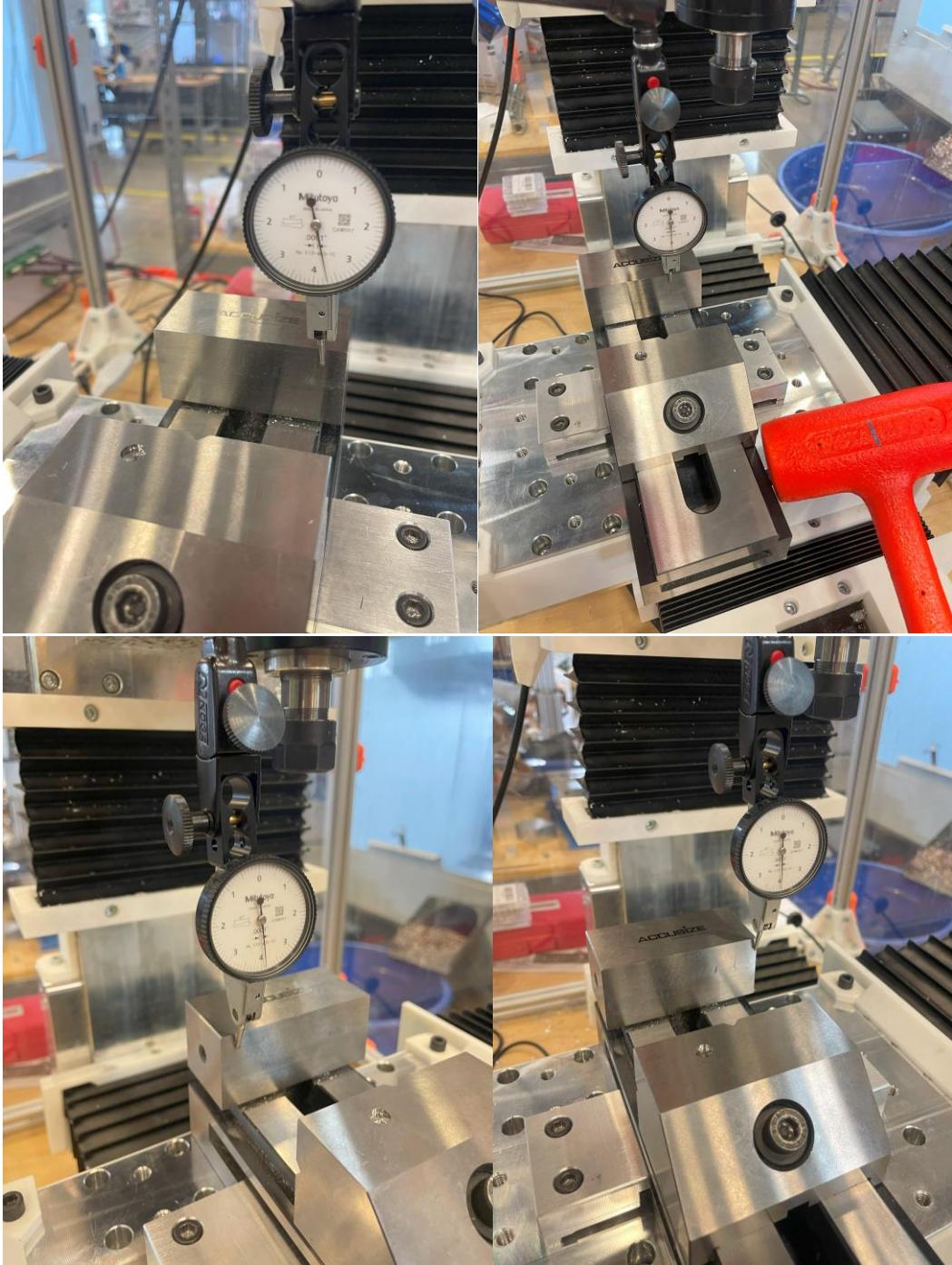
53. Move the vise so that it is as centered as possible on the X-axis and roughly flush with the back of the X-carriage. Tighten one bolt enough to allow vise movement only when struck lightly with a mallet or the handle of the T-shaped hex tool as seen in the squaring process.



54. Connect the electrical box to the machine tool. Do NOT power the spindle. Jog the x- and y-axes to roughly center.
55. Secure the dial indicator to the 1-2-3 block. Move the indicator so that it rests on a corner of the BACK vise jaw. Carefully jog the x-axis to ensure that the indicator can travel the length of the back jaw safely.



56. As in the *Squaring instructions*, set the dial indicator to a reference point, jog across the back jaw face, and determine how to adjust the vise orientation. Adjust with light taps and measure again. Repeat until the dial indicator reads almost identically from one end of the vise jaw to the other.



- 57.** Fully tighten all four bolts and pass the dial indicator across the jaw face one more time to ensure no movement occurred while fastening.
- 58.** Remove the dial indicator and 1-2-3 block. Replace the coolant/air hose. The vise is now trammed and ready for holding mill workpieces.