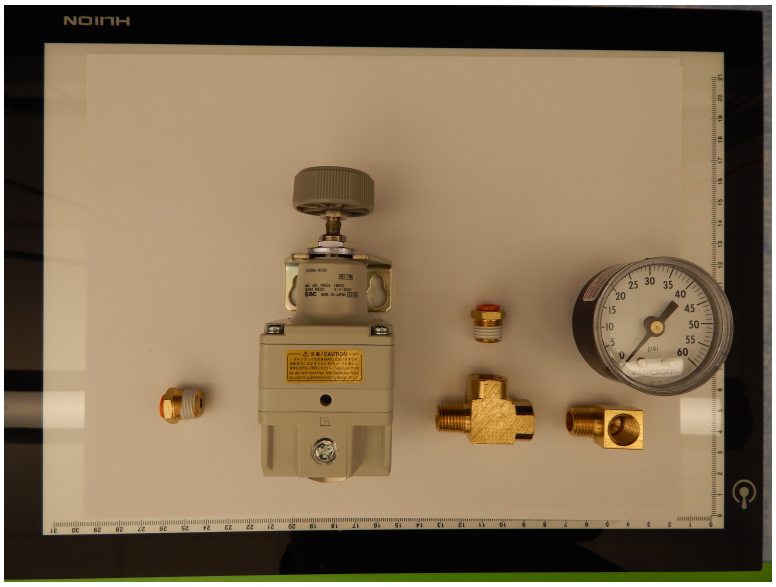
Step-by-Step Setup Guide

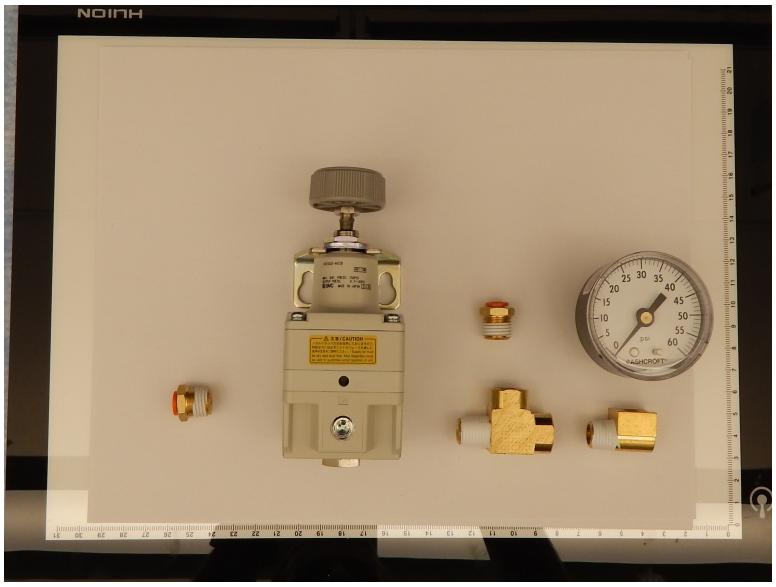
Pneumatic Control System Module 1: Flow Control Board and Pressure Manifolds

Part 1: Individual Part Assembly

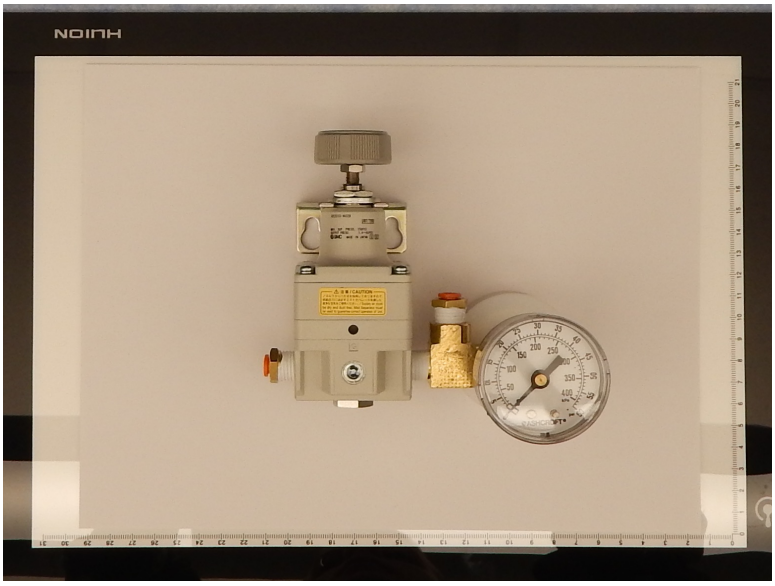
1. Begin by assembling **Parts A - E** for the manifold regulators. These assemblies globally regulate control line reservoir pressures for chip-valve actuation and reservoir loading.



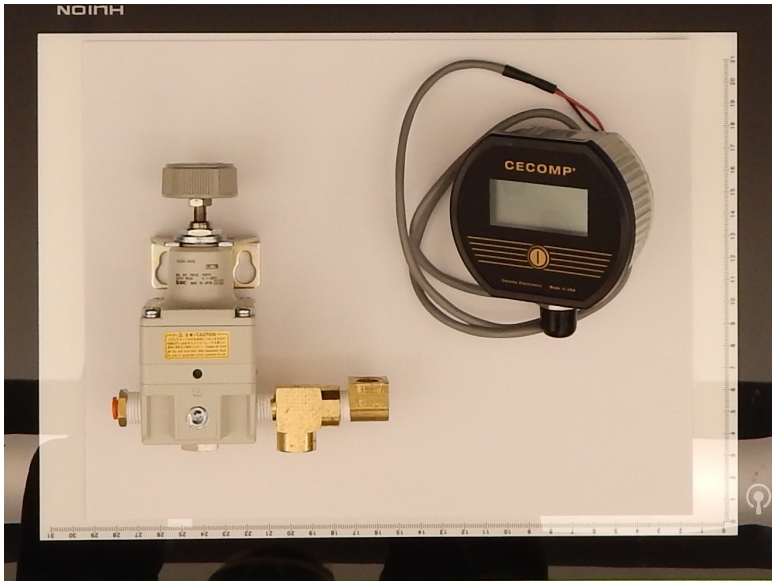
2. Use Teflon tape to tightly wrap the threads of any metal-to-metal male fitting to create a leak-free junction. All metal male fittings must be Teflon-wrapped in all future steps.



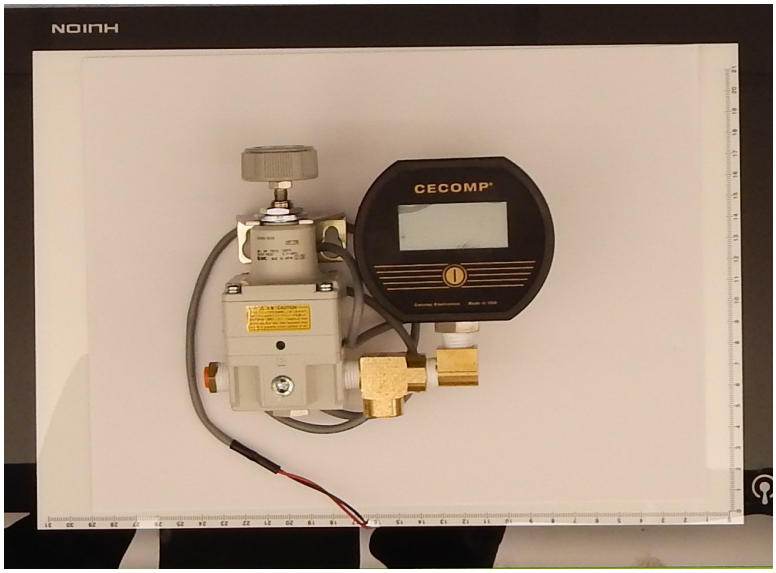
3. Assemble the Regulator parts as shown below by carefully threading the male fittings into the corresponding female fittings. Tighten with a wrench to full tightness. This is important to prevent air leaks at junctions.



4. Similarly, assemble **Parts C-E** and **Parts F, G** for the digital manifold regulators. These regulators control flow line pressures when connected to devices via flow control manifolds.



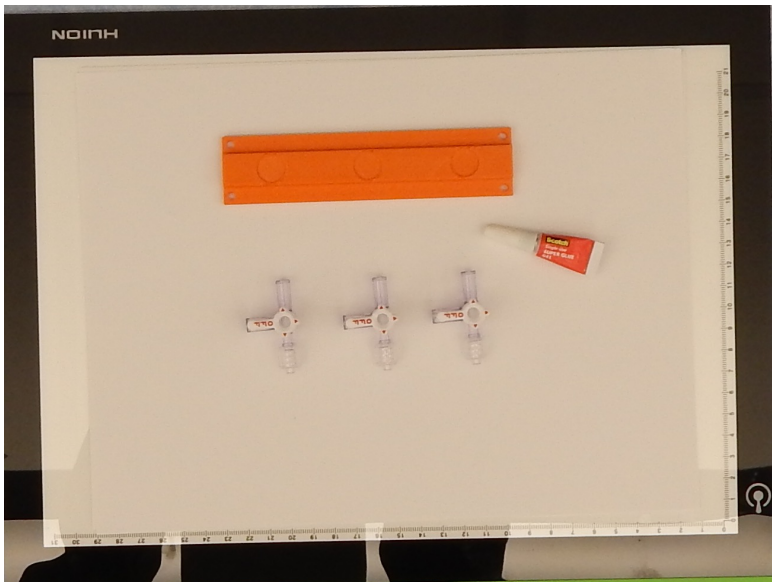
5. Attach the digital regulator display **Part G** last, being careful to properly thread the display to face outward.



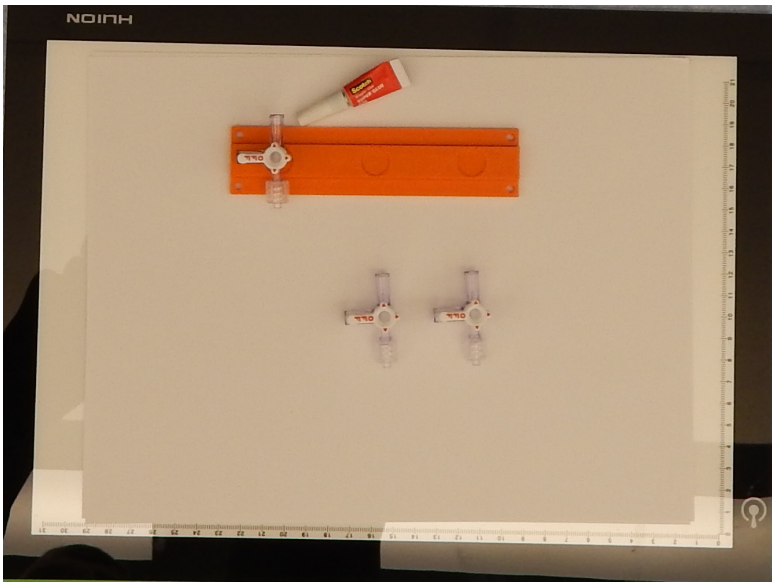
6. Add the push-to-connect tube fitting **Part C** after alignment of the digital display (from the previous step). Tighten fully for a leak free junction.

Before (above) and After (below) addition of **Part C**

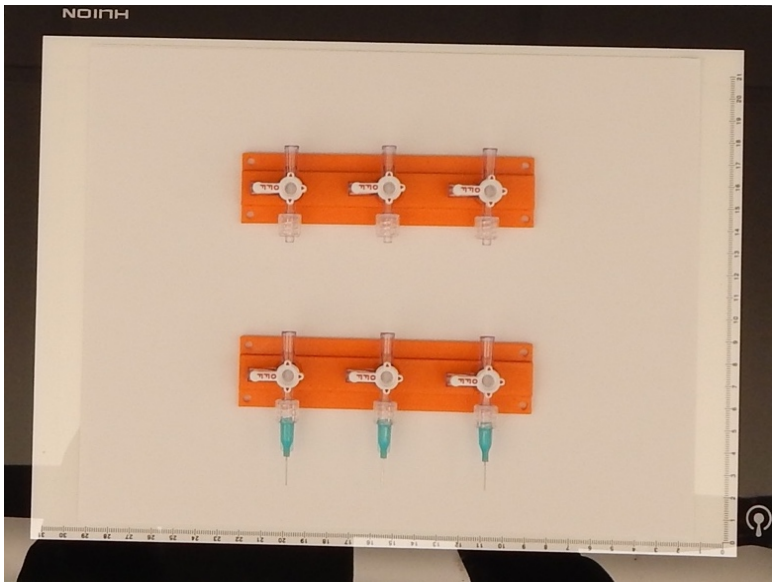
7. Assemble **Parts K - O** and the **3D Printed Part "Flow Control Manifolds *stopcock-mount*"** to make the flow manifolds. These control the pressurization state of individual flow lines by selectively turning on or off the 4-way stopcocks during a device run. Print the 3D printed part with high-density material and let dry at ambient temperature for 1 hour after printing before attempting to glue parts.



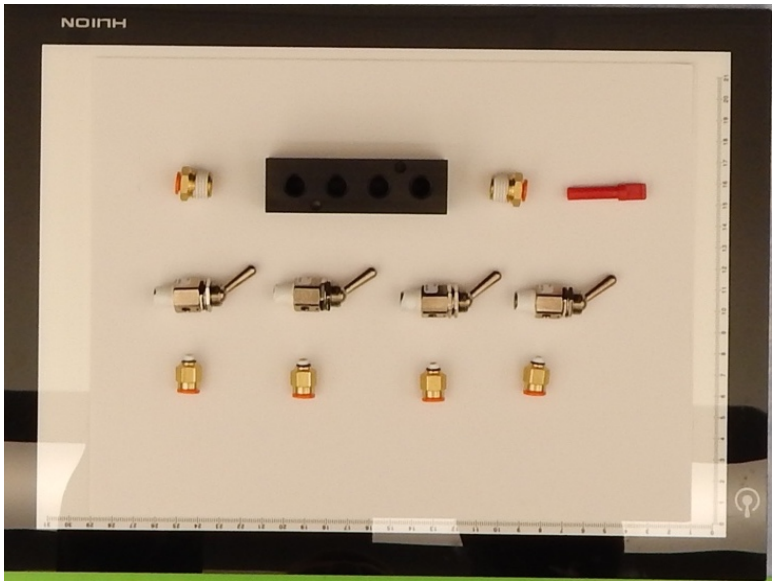
8. Using SuperGlue, carefully glue the back of the 4-way stopcock (**Part N**) to the 3D printed flow manifold. When all 3 stopcocks are in place, let dry 1 hour.



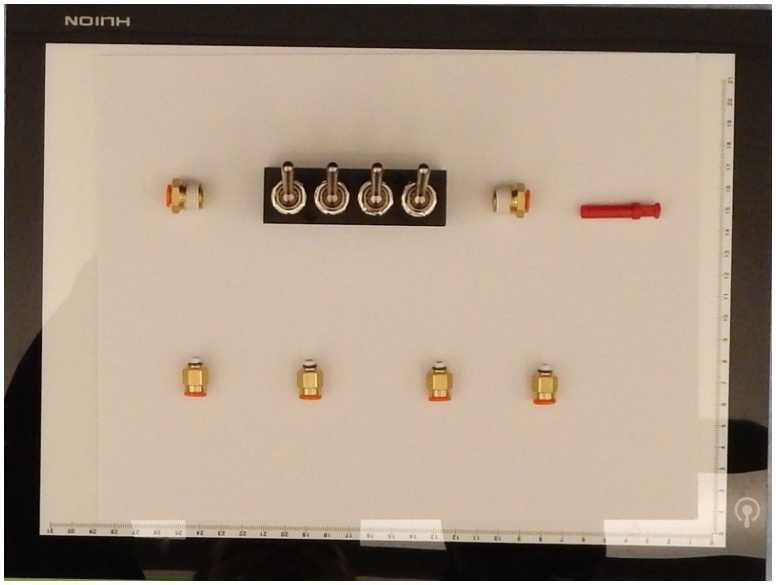
9. When dry, lock on a luer-lock blunt tip needle (**Part O**) to each stopcock. Complete 5 additional manifolds for the full build described in the main text (or the number of manifolds desired for your application).



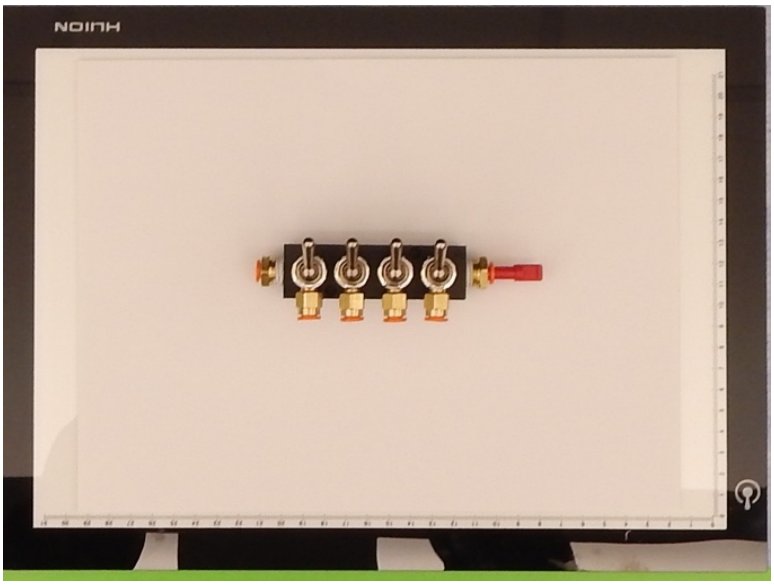
10. Gather **Parts P-S** and **Part C** for global pressure manifold control switch boxes. These switch boxes selectively pressurize control reservoirs connected to the manifold regulators, making it possible to turn control line banks on or off before and after experiments.



11. Thread in the dented toggle switches (**Part Q**) on the outer box (**Part P**).

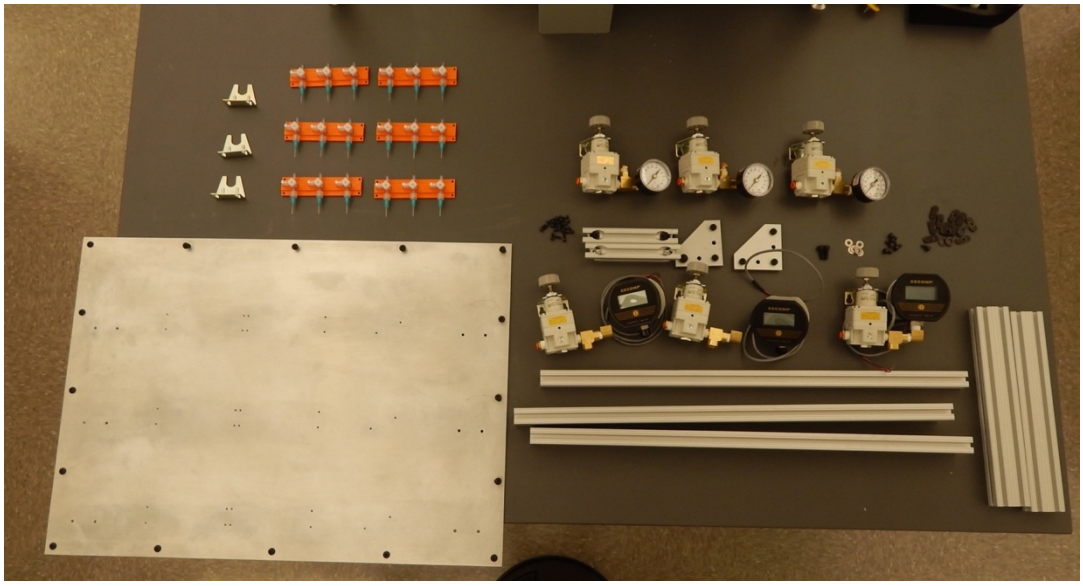


12. Connect the 10-32 UNF connectors (**Part R**) to the 10-32 output of the dented toggle switches and assemble the other connectors (**Parts C, S**) as shown. Set aside.

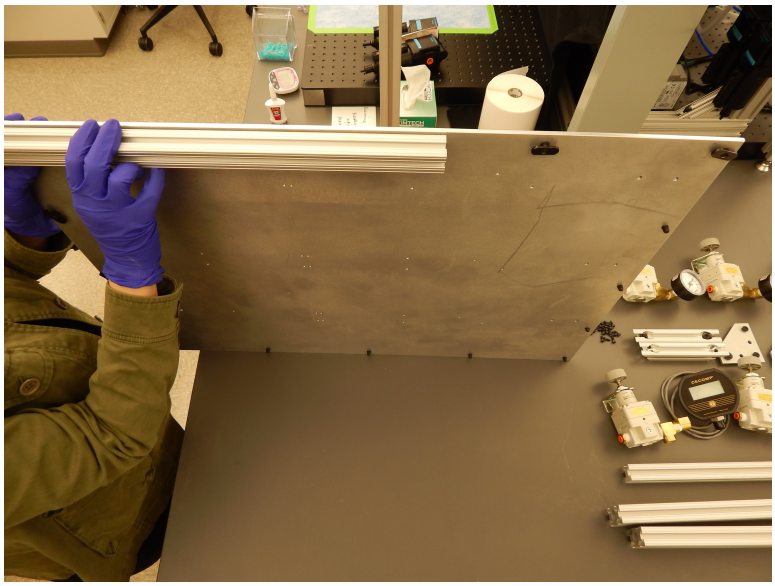


Part 2: Base Board Construction

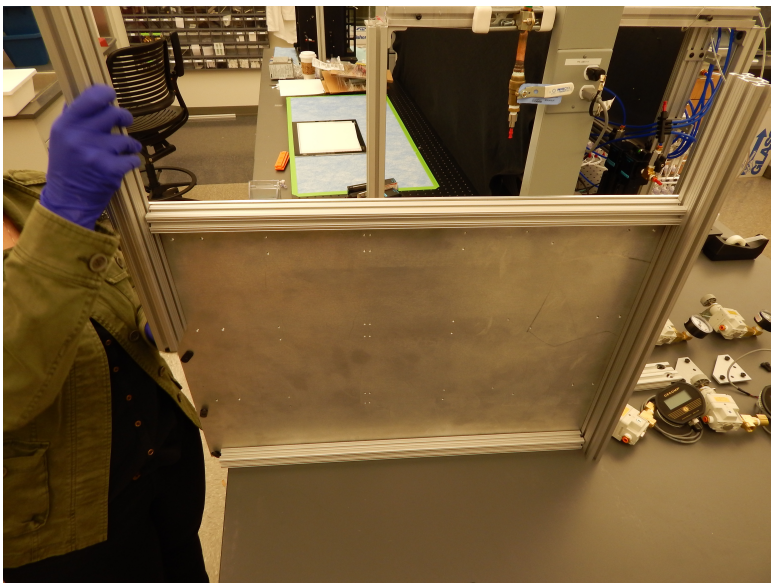
13. Machine the Flow Control Board (**"Base Board *backboard-full*"**) according to the given engineering drawings. Acrylic can be used instead of aluminum, if desired. Holes for regulator attachments must be tapped according to the drawing. Gather **Parts b1-b8** to assemble the Flow Control Board and supporting mounts. Additionally, gather the pressure manifold regulators, digital flow regulators and flow manifolds assembled in **Steps 1-12** of **Part 1**. Place the 80/20 screw fasteners (**Part b5),** without wings, on the Flow Control Board (**"Base Board *backboard-full*"**) as shown.



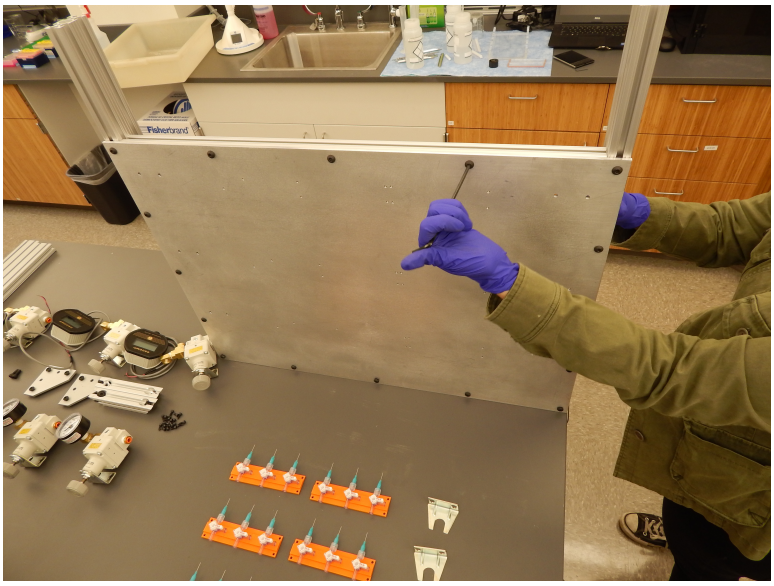
14. Gently attach wings to the end-feed fasteners (**Part b5**) on the top back of the Flow Control Board and gently guide the first piece of 80/20 (**Part b2**) through the wings.



15. Repeat for the 3 other sides of the back Flow Control Board, using the 26" x 2" x 1" 80/20 (**Part b2**) laterally and the double 26" x 2" x 2" 80/20 (**Part b1**) vertically as shown below.

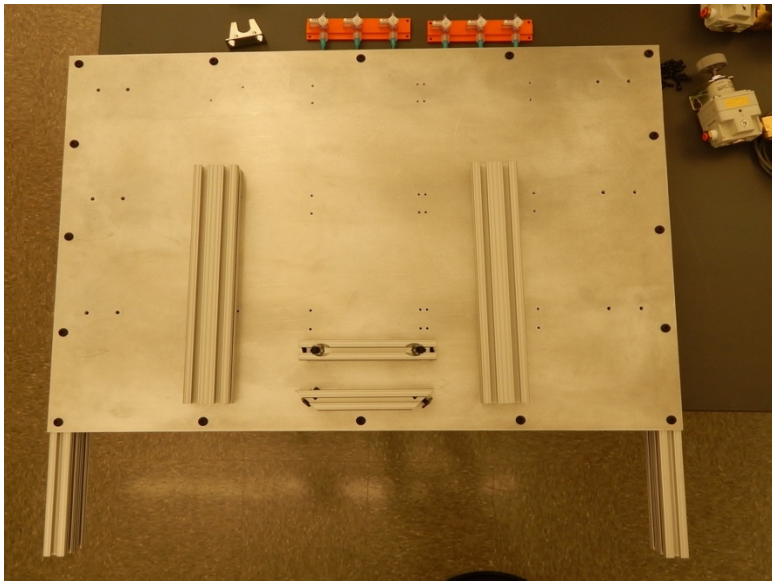


16. Fasten each end-feed fastener (**Part b4**) from the front of the Flow Control Board using an appropriate sized hex key. Check the stability of the rig by moving each 80/20 back and forth, and adjust screws until the fasteners don't move when wiggled.

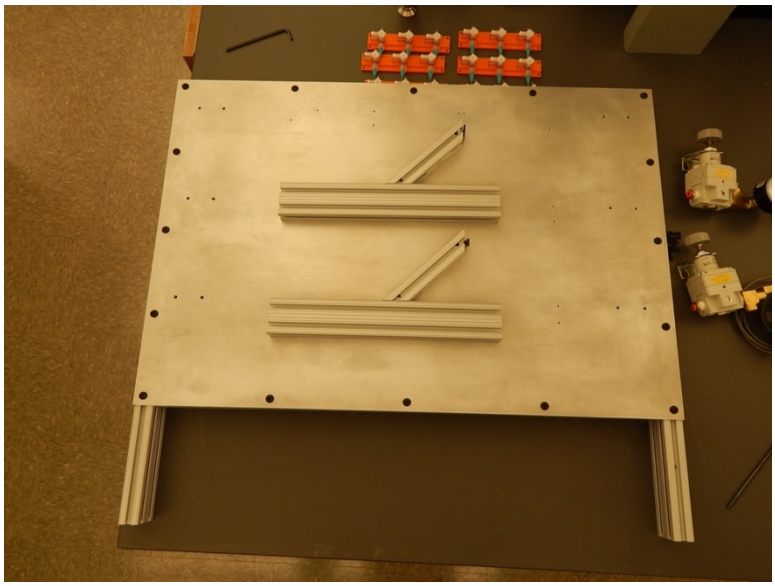


17. When the initial structural support is completed, your setup should look like the following image from the back.

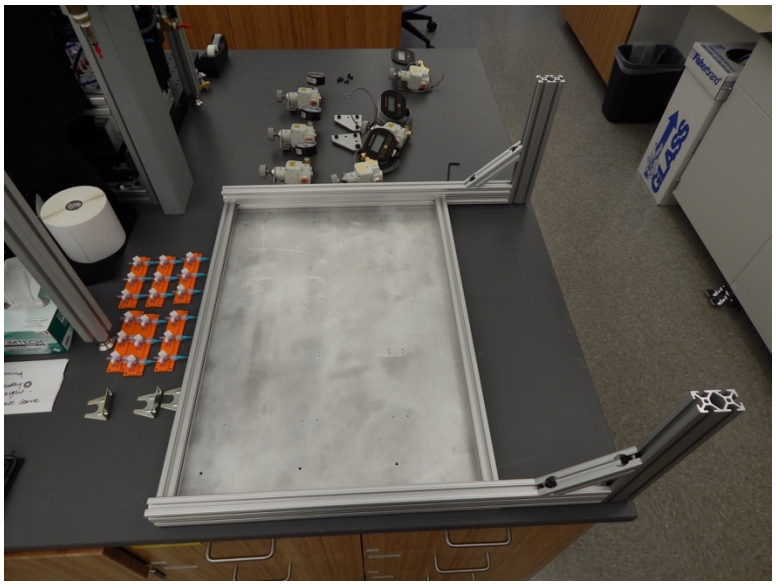
18. Assemble the support legs (**Parts b3, b4**) with accompanying fasteners.



19. Slide the wing nut of the diagonal 80/20 (**Part b3**) into the 12" x 2" x 1" support leg **(Part b2**) and loosely fasten. Allow enough give for the diagonal to easily slide along the leg. This pre-assembly will help during stabilization and alignment.



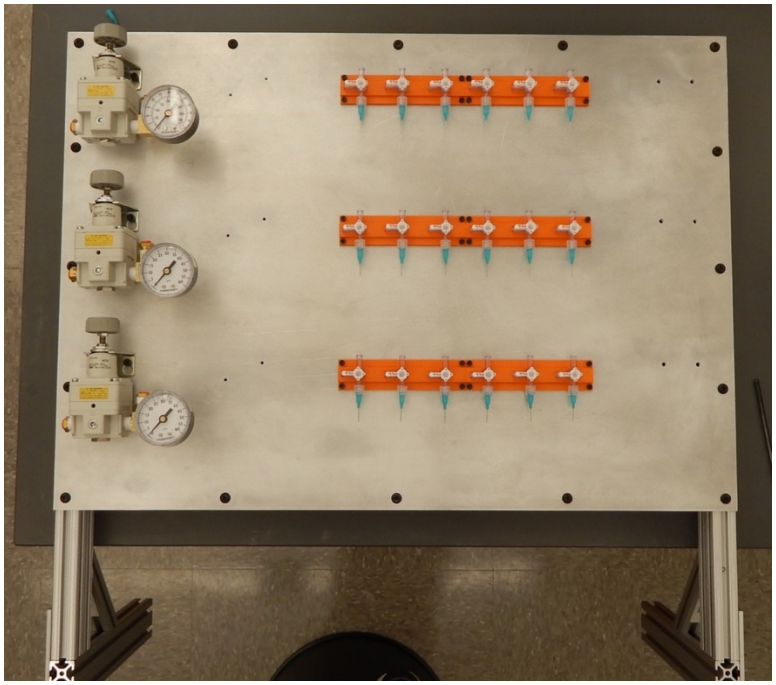
20. Assemble the support legs as shown from the back of the Flow Control Board. Tighten with a hex key and ensure the structure is level upon standing.



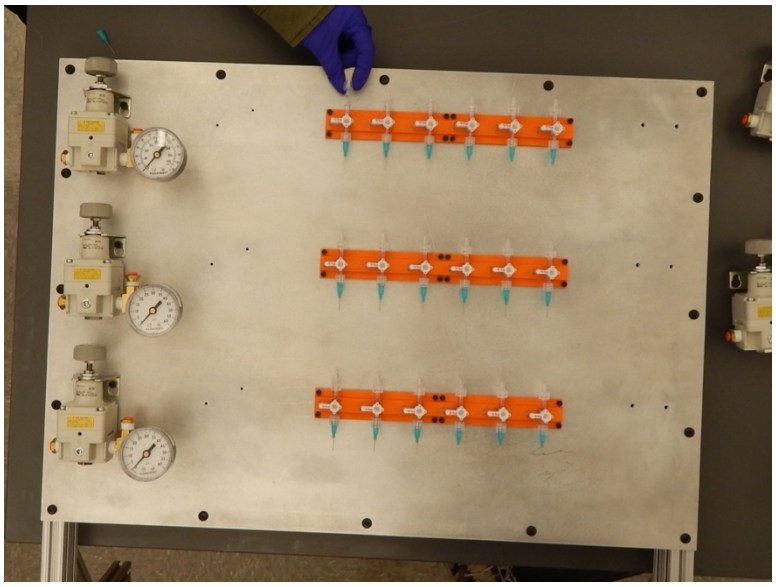
21. Stabilize the support leg structure with a 5-hole corner surface bracket (**Part b8**). Tighten with a hex key.

Part 3: Base Board Attachments

22. Attach the pressure manifold regulators and flow manifold parts with 10-32 screws (**Part s1**) to the shown positions on the Flow Control Board. Tighten with a hex key.

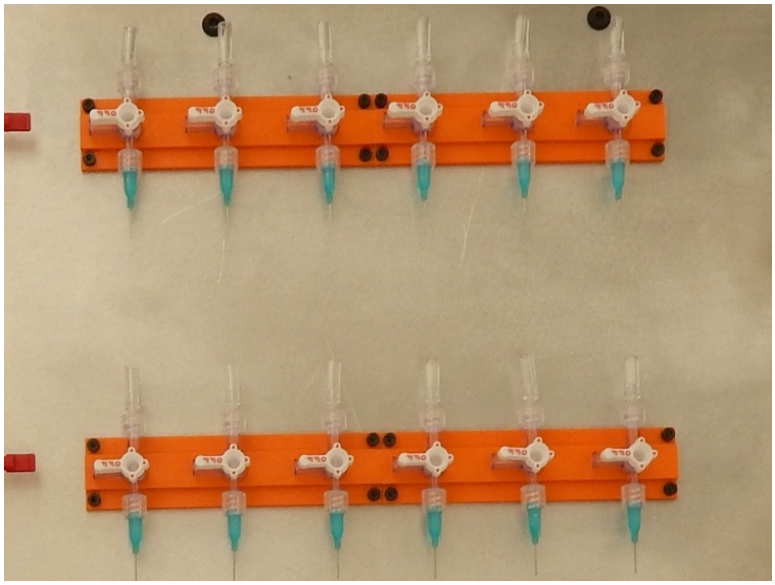


23. Carefully attach the male luer integral ring lock (**Part M)** to the female luer connector on each 4-way stopcock (**Part N**) of the flow manifolds. Optionally, these steps can be completed before affixing the manifolds to the Flow Control Board. In our experience, the board adds additional stability for mounting the manifold components.

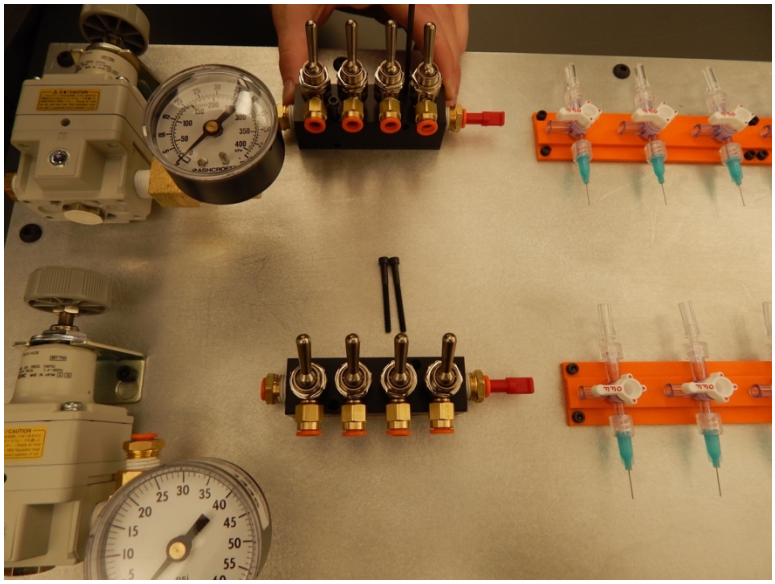


24. Cut approximately 50 - 1/2" segments of **Tubing T2** with scissors. Attach a segment to each integral ring lock (**Part M**) stopcock assembly by firmly pressing the tubing past the barb. Save the remaining segments for the later T-junction top assembly (using **Part K**).

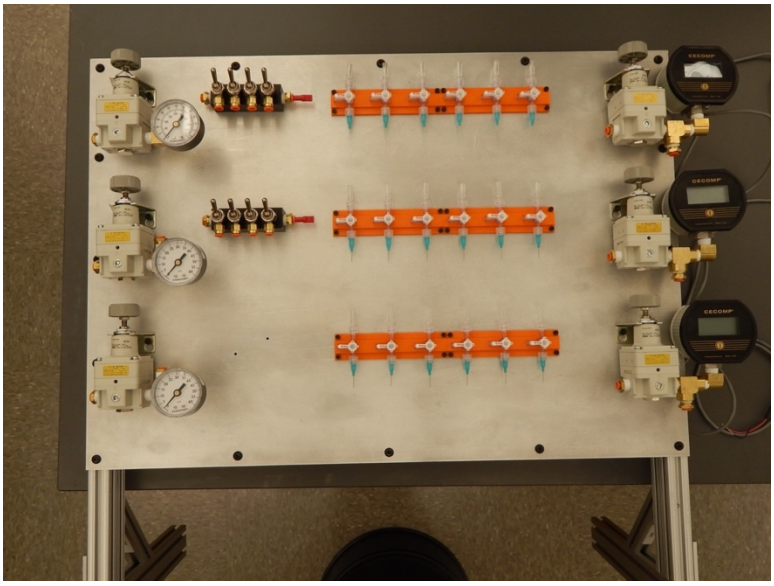
(!) **Tip:** You can use a heat gun to help attach the tubing segment by expanding the tubing.



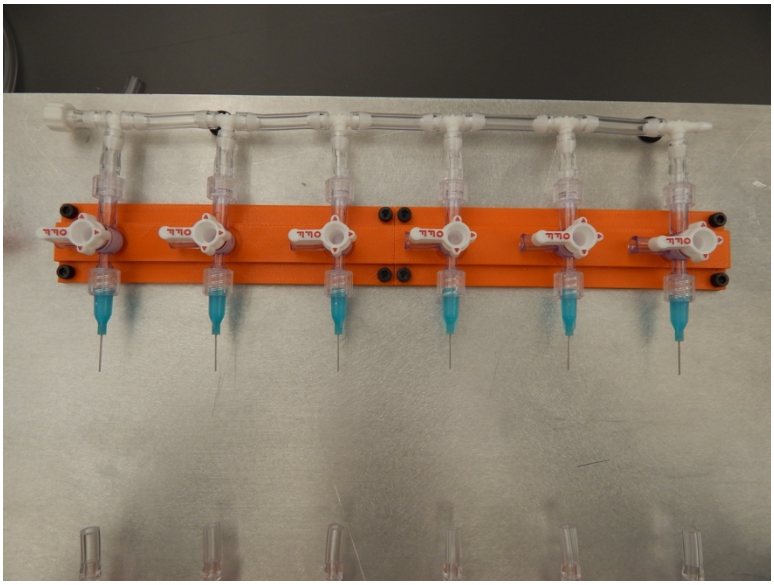
25. Install the manifold control switchboxes on the Flow Control Board with the long mounting screws (**Screw s2)** using a hex key and carefully aligning the control box to the tapped holes as shown.



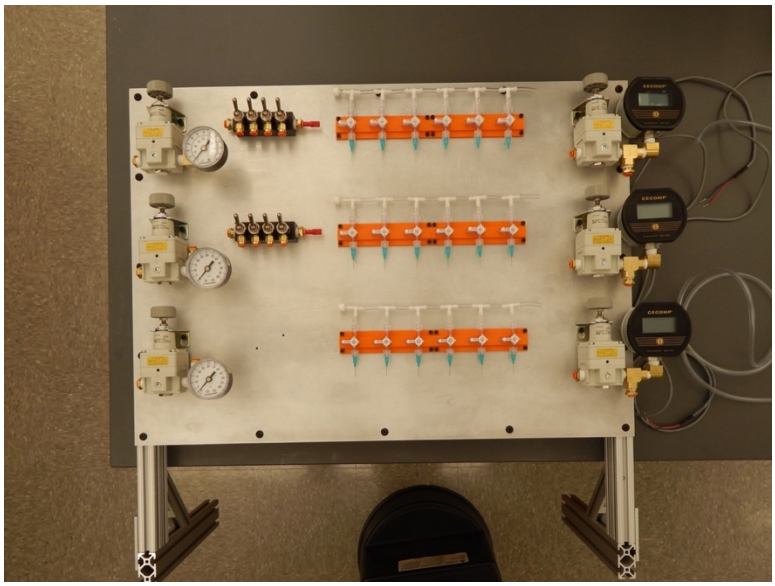
26. Attach the digital flow control regulator assembly from Step 6 with the 10-32 screws (**Screw s1**) at the baseboard positions shown below. At this point, the Flow Control Board should appear like this:



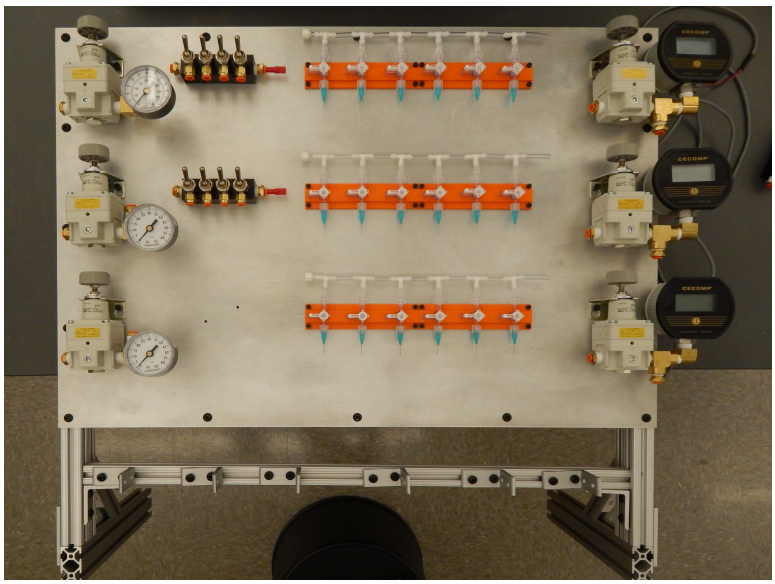
27. Using the 1/2" segments of **Tubing T2** from Step 24, connect the T tube fittings (**Part K**) and luer plug cap (**Part L)** to the 4-way stopcock flow manifold assembly and associated tubing lines as shown below. This step completes the air pressurization system for the flow manifold assembly, which selectively pressurizes flow lines on the microfluidic device.



28. The Flow Control Board assembly should now appear like this:

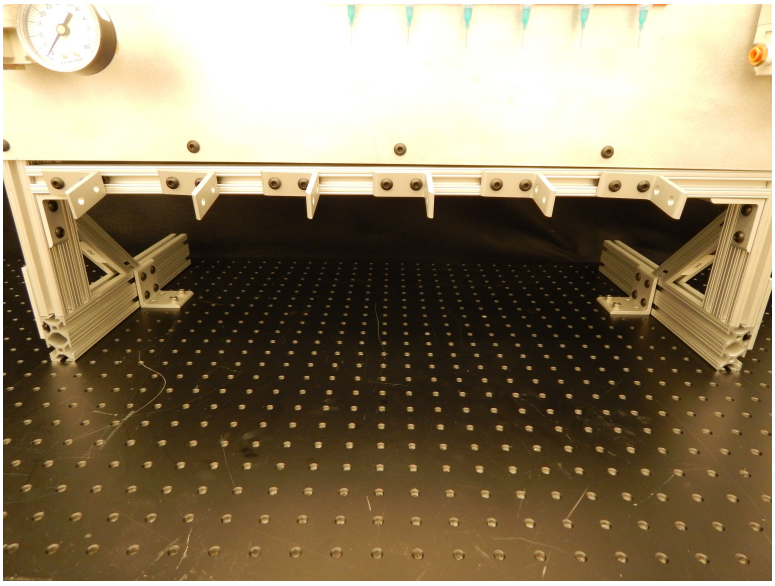


29. After finishing the Flow Control Board regulator and flow manifold components, add on an additional 80/20 26" x 2" x 1" (**Part b2**) support using 2 elbow brackets (**Part b6**) with fasteners to brace the support. The support should be placed 2 inches below the bottom of the board. This support will be used to mount the control water reservoirs and solenoid valve arrays for control line modulation. Additionally, attach 6 more elbow brackets (**Part b6**) at regular intervals along the bottom 80/20 as shown below. These will be used for mounting control valve manifolds in **Module 3.**



Part 4: Tubing Connections

30. After finishing all the baseboard component connections in previous steps, mount the entire assembly to an optical breadboard or bench of your choice. Here we use an extended corner bracket (**Part b7**) on each side of the bottom legs to lock down our setup. Alternatively, c-clamps or other attachment means can be used. Locking down the setup is important before proceeding to future modules if the full build is desired.

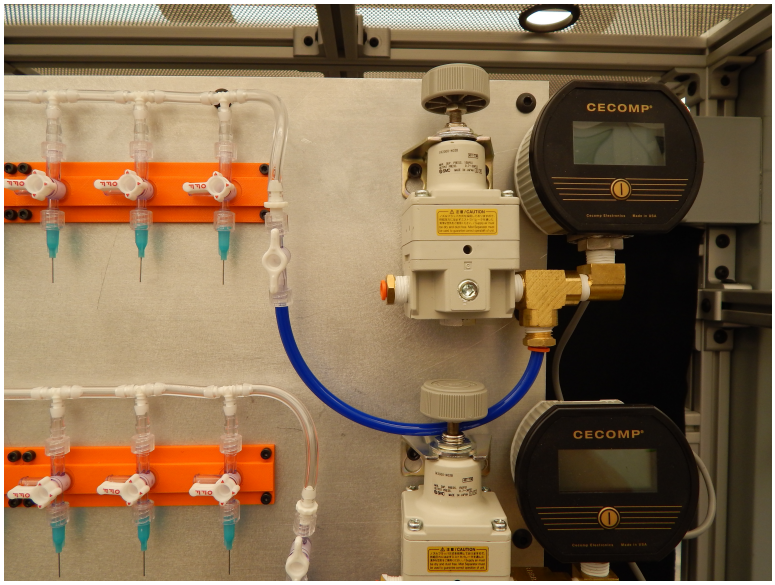


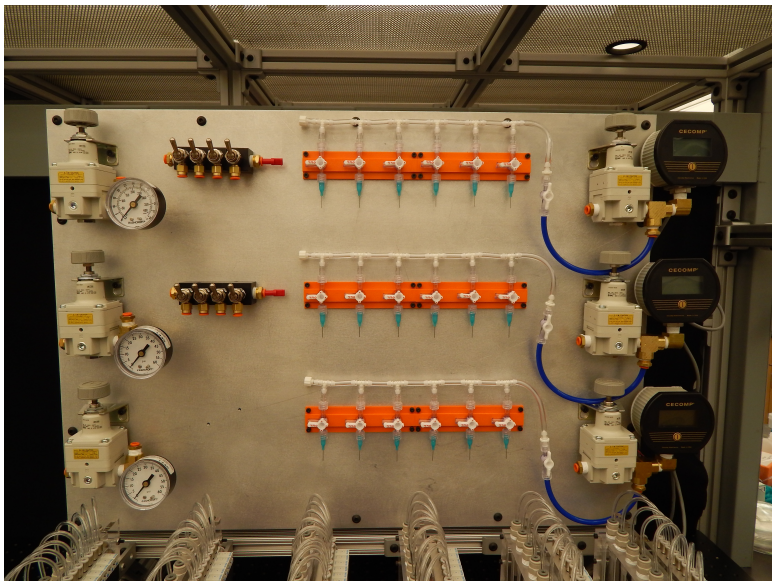
31. To begin tubing connections, assemble generous 7" cuts of **Tubing T1** and **Parts H-J**. These parts are used to connect the flow regulator assemblies to the flow manifold and selectively pressurize the manifolds to prevent back pressure. We use these assemblies as additional level of control. **Parts H-J** can be optionally excluded from the build if global manifold control is not needed.

Pause Point!

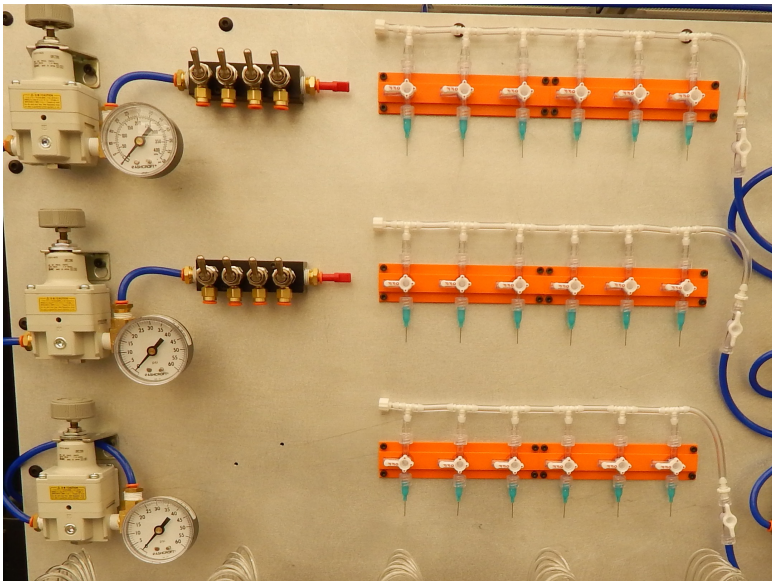
(!) **Tip:** It is arbitrary when you decide to complete your tubing connections during your build. We often proceed to **Modules 2, 3** and **4** before completing tubing connections so that we can complete all final connections at one time. If you decide to do so, return here after completion.

32. Using the push-to-connect fittings (**Part C**) attach **Parts H-J** and **Tubing T1** as shown in the Module schematic. Use **Tube T2** to complete the connection to the flow manifolds (**Part K – T2 – J**).





33. Subsequently, use small 3" cuts of **Tubing T1** to connect the control regulators to the control manifolds on the left side of the setup as shown below.



You're finished with Module 1!
Proceed to subsequent modules, if you haven't already.