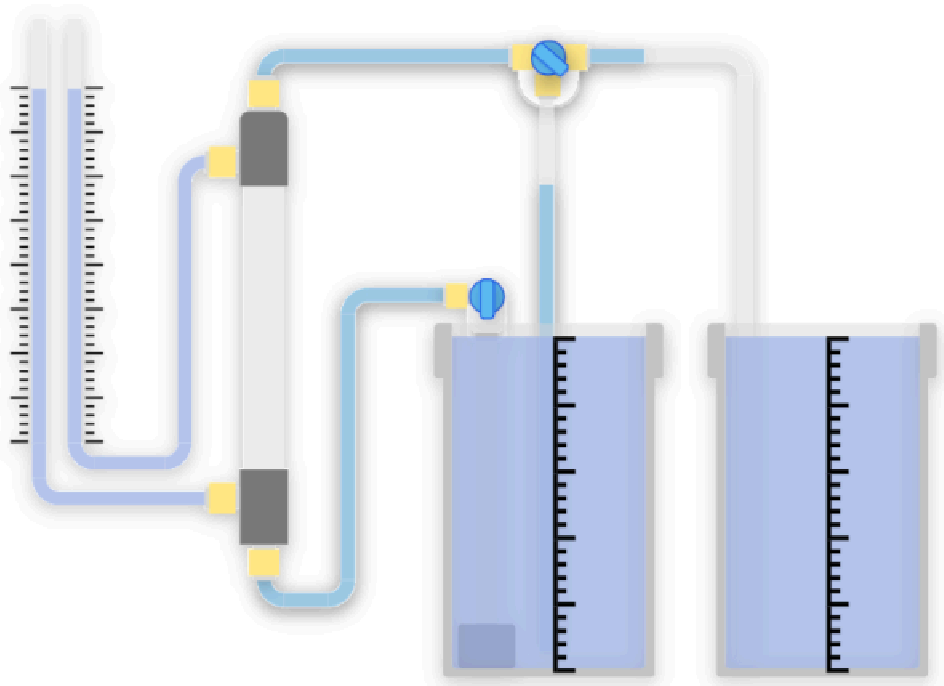
May 27, 2025
Fluidized bed questions meeting

Screenshot of simulation so far:



The screenshot is taken directly after clicking on the second valve, which is a three-way valve that determines whether the water is recycled back to the feed beaker or put in a separate beaker for catch and weigh.

Questions

1. **Tubes emptying after shut-off:** The tubes empty out when there is not liquid flowing inside for clarity purposes. However I know that if the tubes are small and the system is airtight, they would not empty at a reasonable rate without the apparatus being disassembled. Thus, should there be an emptying animation for the rest of the apparatus when the pumps are turned off?

2. **Venturi meter:** This is how students will take measurements. If the pump is giving enough head that the tubes above are flowing, the water in each tube will be at minimum the height of the tubes on top. However, for a browser simulation, this does not make sense with the layout. The videos from WSU show a setup similar to this, but with the tubes extending upwards past the apparatus.

In short, should I put the venturi meter here and embrace that only the relative pressure difference is accurate, or do something to make it clear the absolute pressure is higher?

- I can try to make a scrolling animation where it shows a clear break (with a jagged Z-line) and tells the user with a tooltip the height of the lowest water column?
- Alternatively, since the important part is the pressure difference across the bed, we can make it clear that the absolute pressure shown is incorrect and only the proportional difference is correct.

3. **Pump deadheading:** You can drag the connected valve with your mouse to rotate it up to 90 degrees, like how the worksheet says the real valve works. This angle will be directly proportional to the valve lift. However, the worksheet says that you can adjust the flow rate to zero this way, and while it is a small pump, I wasn't sure if we want the student to be able to deadhead the pump since that is a safety and maintenance hazard in the real world? Should there be consequences or restrictions so the student does not do this?

4. **Fluidization velocity math:** I know from my friend's research that it is often unideal and looks like a "smoothed out" version as opposed to the "linear-constant-linear" theoretical model. According to the worksheet:

Fluidization begins when;

Pressure drop across bed = Weight of the bed per unit area – Buoyant force of the bed per unit area

$$\Delta P = g(1 - \varepsilon)\left(\rho_p\right)L - g(1 - \varepsilon)(\rho)L \qquad (1)$$

$(\rho = \rho_{fluid})$

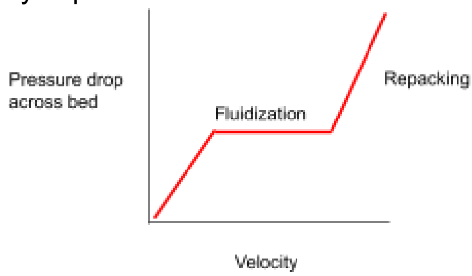
For the initial fluidization, ε is the minimum porosity, ε_M, then pressure drop across the bed becomes;

$$\frac{\Delta P}{L} = g\left(1 - \varepsilon_M\right)\left(\rho_p - \rho\right) \qquad (2)$$

Combine the Ergun equation (4) for ε_M *and* V_{0M};

$$\frac{\Delta P}{L} = \frac{150 V_{0M} \mu}{\Phi_s^{\ 2} D_p^{\ 2}} \frac{(1-\varepsilon_M)^2}{\varepsilon_M^{\ 3}} + \frac{1.75 \rho V_{0M}^{\ \ 2}}{\Phi_s D_p} \frac{(1-\varepsilon_M)}{\varepsilon_M^{\ 3}} \tag{3}$$

- What do these mean? How does this look?
- My impression of the ideal math:



- I know in reality the data almost never looks this clean, and you would rather look for the inflection point to find fluidization velocity; How can I make the math look more “unideal” like this?