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% ENGR 130 Module 2.2 Report
% Section E
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Lab 3 Discussion Questions:

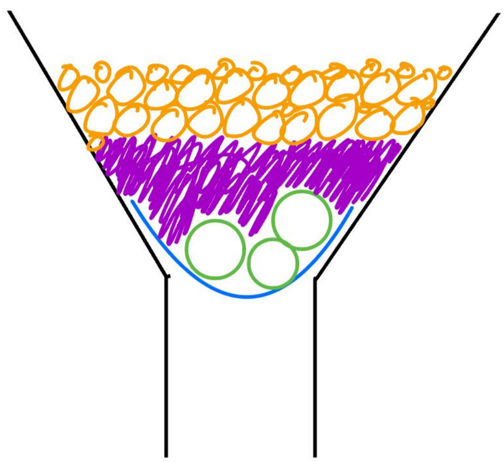
1. The 0 NTU sample had a higher voltage than the 1000 NTU sample. This matches our expectations regarding how the sensor measures turbidity as clearer water, which is represented as 0 NTU, results in a higher voltage value due to a greater amount of light being received on the sensor.
2. The equation for NTU in terms of measured voltage was determined to be
   NTU = -31.66v^2 - 1348.83v + 5018.32 .
3. Expected Value = 250 NTU
   Observed Value = 305.655 NTU
   % error = $\frac{|observed\ measurement - expected\ value|}{expected\ value} * 100$
   % error = $\frac{|305.655 - 250|}{250} * 100$ = 22.26%
4. Possible sources of error:
   - Sensor not being fully submerged due to human error - stability of their hand
   - Sensor was not calibrated well and gave inconsistent readings
   - The sensor was not rinsed thoroughly between the various NTU samples

We expected to get a quadratic graph from our data, but we got a linear graph instead. This suggests that the sensor was not properly calibrated, causing our voltage readings to be incorrect values. The representative quadratic fit line we received does represent OUR data, but it cannot be applied to a more general situation. Although our percent error was not egregiously large, it is still noticeable enough to reflect a possibly incorrect relationship between NTU and voltage. More trials would need to be conducted to create an accurate relationship. We did not seem to experience lack of consistency, as checking our voltage vectors mid experiment failed to reveal anything obviously off. The same can be said for the sensor not being rinsed enough, as the readings didn't seem to be fluctuating much at the beginning of trials.

5. Criteria:
   a. Stability of each layer in the filter
   b. Can be built easily in a short amount of time
   c. Proportion of materials that would filter efficiently
   d. Able to filter water efficiently (<1fl. Oz in 5 min) and effectively (clear water adn low NTU value)
   e. Enough room to pour a substantial amount of water without causing an overflow

Lab 4 Discussion Questions:

1. Final design



Design Characteristics

- 2 layers of cheesecloth (blue line) at the mouth of the filter
- 3 cotton balls (green balls) stuffed on top of the cheese cloth to hold the sand and gravel above
- About ⅓ of the funnels volume filled with sand (in purple)
- About ¼ of the funnels volume filled with small gravel pebbles

2. Our filter did perform as expected in terms of time due to the fact that we assumed that the cotton balls would have slowed down the drainage, however we did anticipate that the water drained out would be a bit more clear due to those cotton balls. We think that the biggest design factor that affected the performance of the filter was the flow rate; the cotton balls may have played a great role in this and maybe using a different proportion of cotton balls, or none at all, could've helped to improve our filter's performance.

3. One way to fine tune the turbidity sensor is to see if the sensor will give the same voltage reading in a completely dark room. The turbidity sensor works by having two "legs" in which light is shot out of one leg and is detected by the second leg. The amount of light that reaches the second leg will determine the amount of voltage the sensor will display. Thus, in a sample of dirty water, some of the light will get blocked by particulates in the water thus resulting in a lower voltage reading. The highest voltage reading that a turbidity sensor will give is when it is not in a liquid and in a dark room. These conditions ensure no solid or extra light will interfere with the light traveling between the legs of the sensor. So to ensure that the sensor is working properly, multiple trials can be run in the dark room in which the sensor is raised in the air and the voltage is measured. If the voltage reading remains consistent for each trial, the sensor has been calibrated properly. If the voltage is not consistent, then the issue could be in the light projector or the light sensor.

4. If there was more time available, we would have tested more variations of the filter design to optimize the water filter efficiency. This could have meant adjusting the amount of or the ratio of the different materials in the filter to optimize both speed and clarity of the filtered water. We may have found success in layering more sand on top of the gravel already in our filter, or by placing more cheesecloth in between filter layers. Additional materials such as anthracite, a material often used in water filters, would also have been very useful particularly in improving the clarity of the water.