The water level measurement experiment was constructed during the November 2017 Barnraising in Cocodrie LA. The initial experiment design is described in the Public Lab Note titled “Depth Sensor Proposal.” Two modifications were determined to be necessary to the proposal. The first modification was constructed by adding a weight to the end of the tube releasing the bubbles in order to facilitate moving it up and down in the water column. The second modification was to add a valve to control the air flow from the pump.

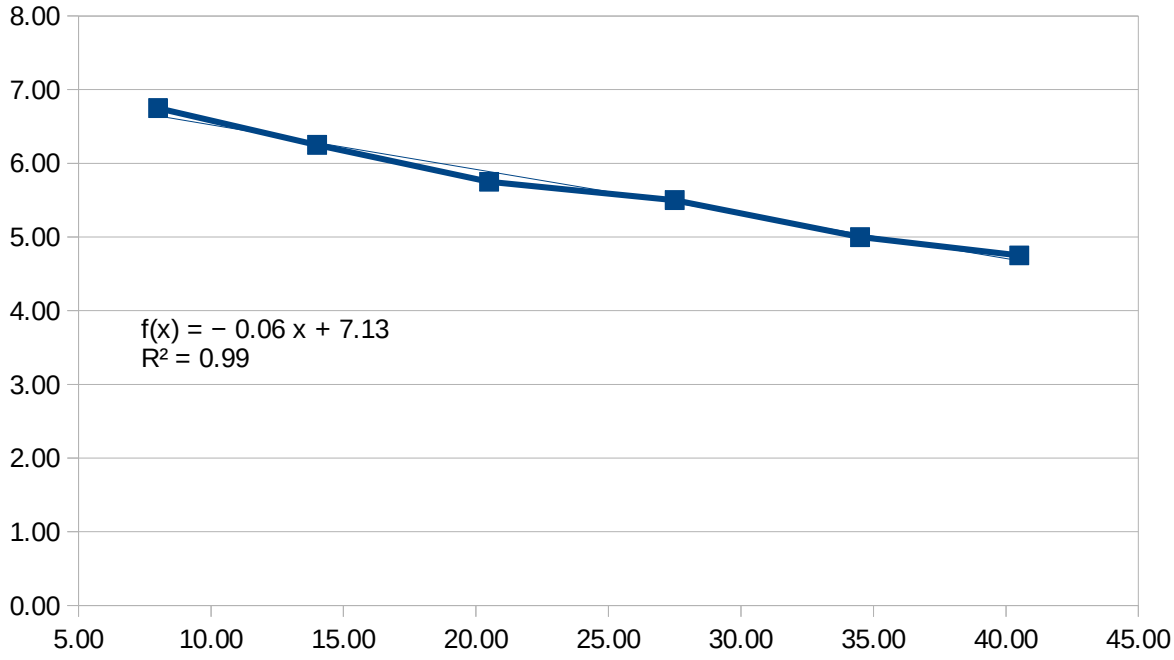
Equipment involved in the experiment consisted of aquarium tubing, flow valves, “Y” connectors, and pump. Additionally a water column was constructed from a clear plastic florescent tube protector and a PVC end cap that was super glued to one end. The assembly was stabilized in a sink as a safety precaution and the manometer was taped to the side of the water column tube. The pressure differential is adjusted with the needle valve across the manometer to obtain an appropriate span for the depth to be measured.

It was discovered that the manometer was difficult to fill without bubbles. The final solution was to use the hose fitting on the lab sink to fully fill the manometer thus eliminating all bubbles and then to blow out half of the remaining water. This resulted in a functioning bubble free manometer.

Data collection number 1 was done with the full pressure output of the aquarium pump. A ruler was used to measure the head value, being the distance between the end of the tube emitting bubbles and the water surface. It was difficult to measure this value because of the large amount of bubbles at the water surface. The pressure was measured as the difference between the two water levels in the manometer.

Data collection 1:

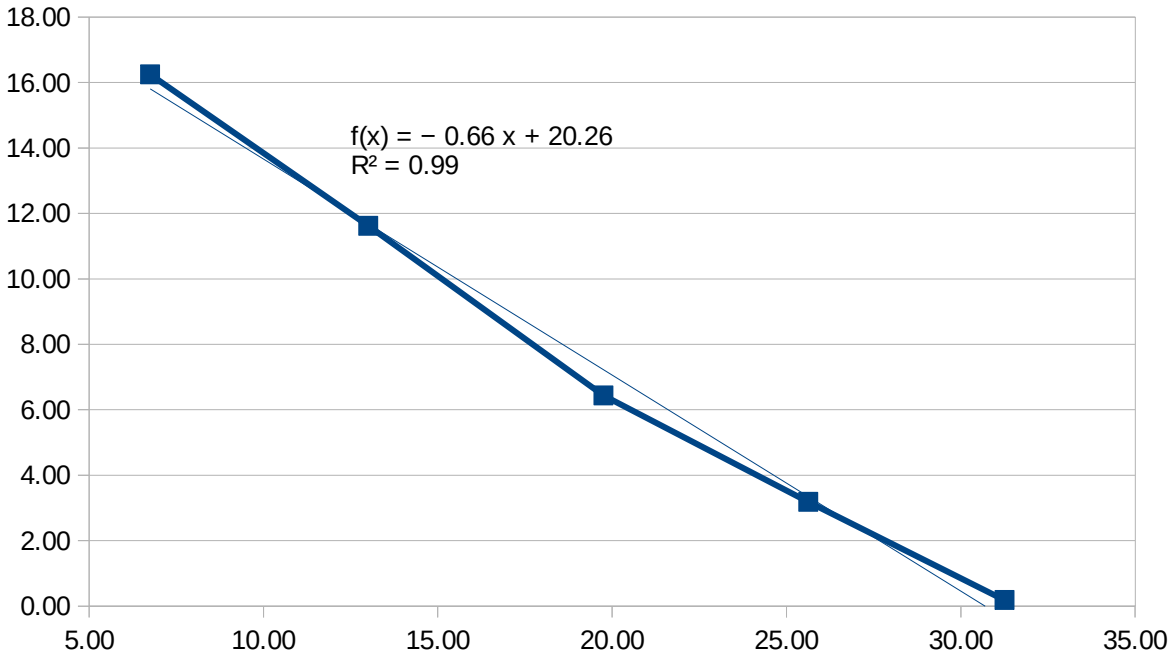
Head	Manometer
40.50	4.75
34.50	5.00
27.50	5.50
20.50	5.75
14.00	6.25
8.00	6.75



Data collection 2 was performed with a reduced air pressure in order to address the difficulty of measuring the water surface level. A valve was added at the pump to release a controlled amount of pressure to produce a minimal amount of bubbles at the maximum depth to be measured. This pressure was not adjusted during the data collection. Data was subsequently collected the same way as done initially.

Data collection 2:

Head	Manometer
31.25	0.19
25.63	3.19
19.75	6.44
13.00	11.63
6.75	16.25



Analysis of the data shows a strong linear relationship indicated by the R^2=.99 in both measurements. This is confirmation that the system can be used as an accurate source of water depth measurement.

There are a few sources of error. The main concern would be the variability of the aquarium pump pressure over time. These pumps are designed to be reliable and to run continually for very long periods. It is thus expected to not be of significant concern. The tubes require protection from damage that would result in any flow restrictions or leaks. If a significant distance is required between the pump and the level measurement location then it may be advantageous to increase the tube diameter to reduce pressure loss. An operational concern involves intermittent operation and fouling of the immersed tube. It is expected that with continuous air flow the tube should not have fouling issues due to the continual bubble emissions. If the pump is shut off for a significant interval then fouling is likely to occur and will either plug up the system or change the calibration curve. Additionally, temperature fluctuations have not been investigated. It would seem critical that the needle valve remain undisturbed both mechanically and thermally once the calibration has been accomplished.

Practical use requires continuous power for the pump, accurate calibration, and a pressure measurement system. The system should be constructed with the plumbing as close to the final configuration as practical and then calibrated by measuring actual tube depth and verifying that bubbles are produced at the maximum depth that is to be expected. The manometer can be used if manual depth monitoring is desired. If an electronic measurement is desired the manometer should be replaced with an appropriately sized differential pressure sensor.