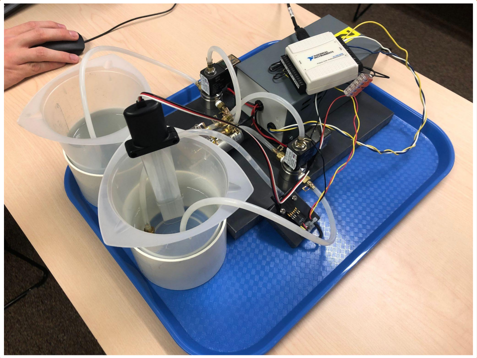
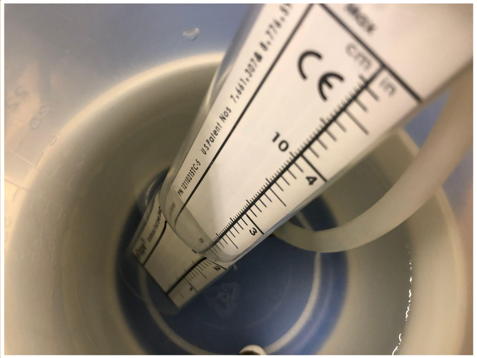
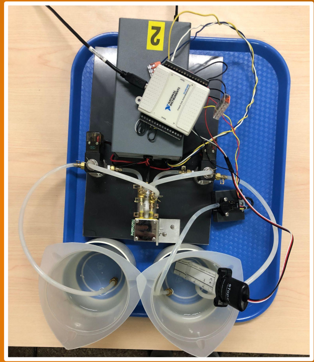
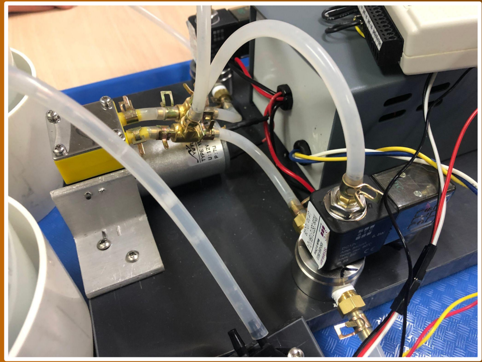
Water Level Control









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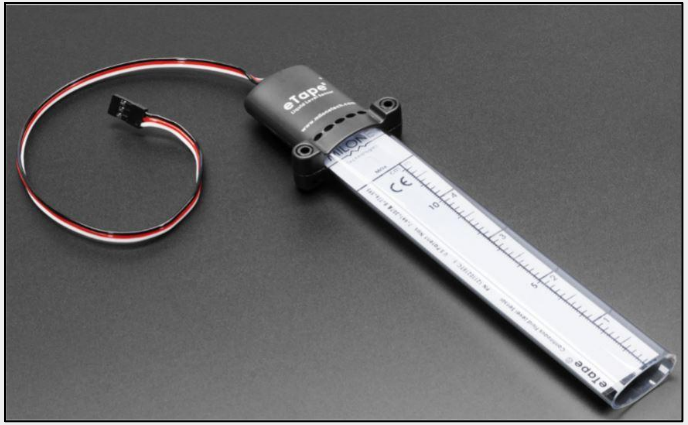
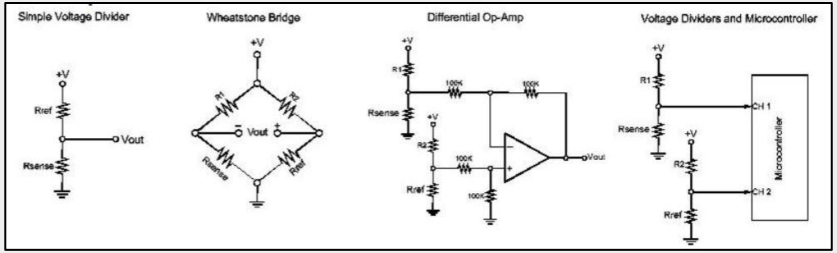
5/3/21 | Group 23 | Kate Gleason College of Engineering | MECE 211 | BM 50%, AB 50%

Background and Theory, Level Sensor:

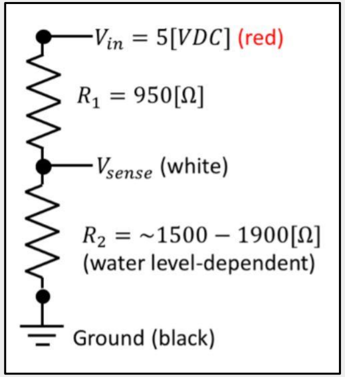
-The eTape Continuous Fluid Level Sensor (5 inch model) that is used in the measurement of the fluid level in the experiment is shown to the right. It utilizes the hydrostatic pressure of the fluid it is submerged in to compress a sensor envelope that in turn varies the voltage output of the sensor. After calibration, a certain voltage can be used to calculate the height of the fluid.

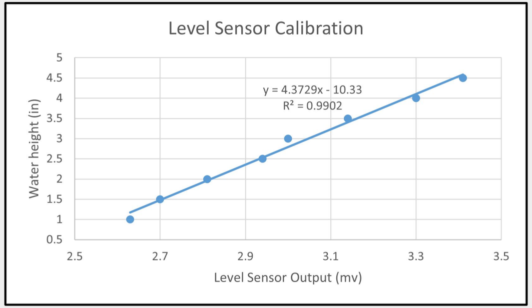




- Shown above are the circuits utilized to create the voltage output of the Level Sensor.

-Shown Right, the Level sensor Wiring Diagram

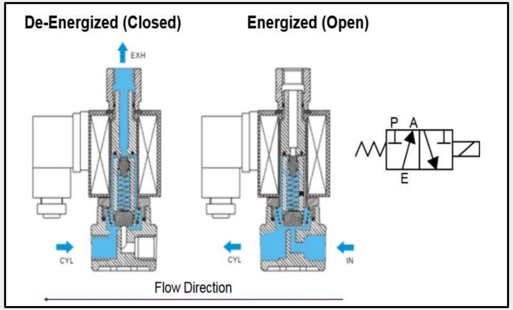




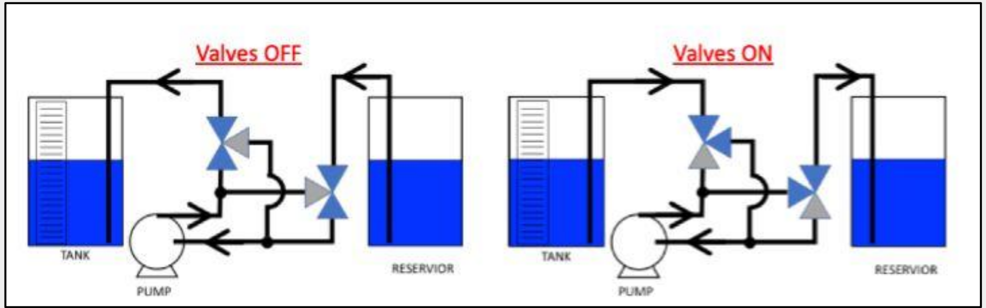
-Shown above is the level sensor calibration curve

Background and Theory, 3-Way Valves:

-The Solenoid Valves operate based on the typical electromagnetic principles found in most solenoids. The require only an input or output voltage to operate. Shown right is a diagram displaying their internals.



-Shown left is the STC 3S012 - A Series 3 - Way Stainless Steel Direct Acting Universal Solenoid Diverter / Selector Valve. Two of these valves are responsible for switching the direction of the pump flow in the system.



-Because the valves operate as 3 - way flow diverters, only two are needed to reverse the flow of the water (without changing the pump direction). Shown left are the two used flow configurations and the possible flow routes.

Background and Theory, Diaphragm Pump:

-The YW02 diaphragm pump is the main component of the system. It is responsible for moving the water back and forth between the two reservoirs. Diaphragm pumps differ from regular centrifugal impeller pumps in that they move the water with a diaphragm that moves back and forth inside the pump housing, forcing the water to be displaced.

-A diaphragm pump is useful in this application because they will not be damaged from 'dead head' conditions, and are able to self prime when ran dry.

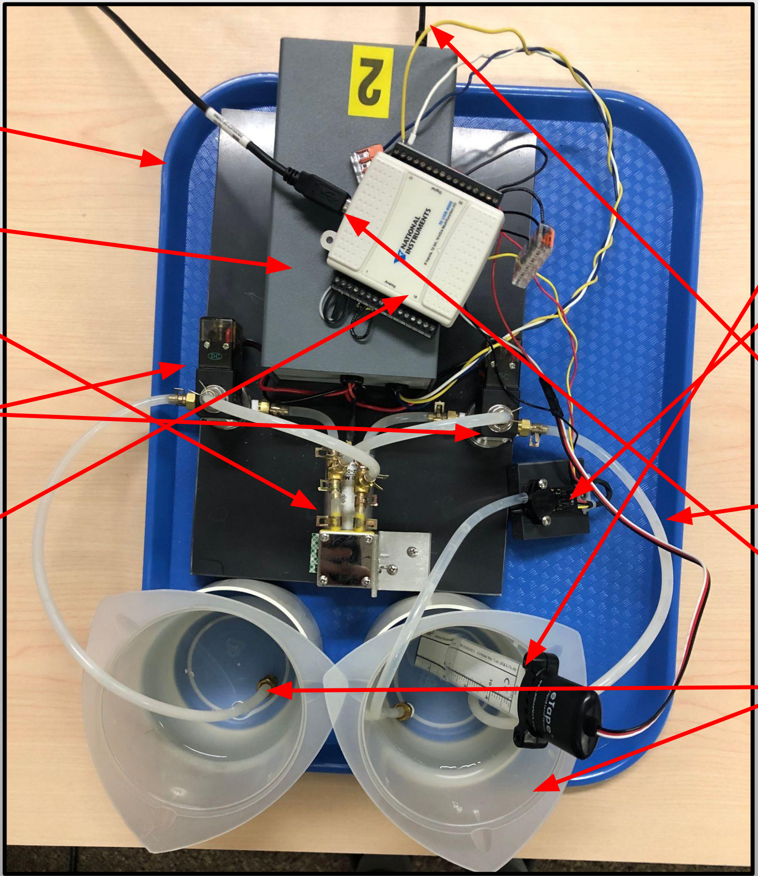
-These types of pumps are also useful for applications where there may be particles or contaminants in the water that would clog or damage an impeller pump.

Model	Liquid flow	suction head	pressure head	motor	voltage
YW02-A	320ml/min	3m	10m	DC,BLDC	12v,24v
YW02-B (dual head)	600ml/min	3m	10m	DC,BLDC	12v,24v

-Shown left are the operating parameters for the pump. Note that the experiment uses the 'A' mode.

Test Apparatus Setup:

1. Tray base
2. Electronics Box
3. Diaphragm Pump
4. Solenoid Valves
5. Data Acquisition Device

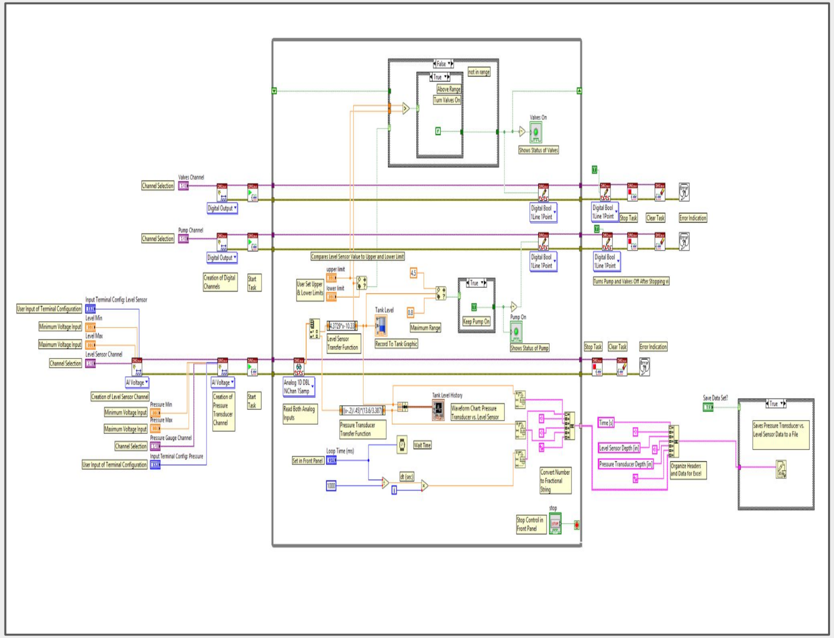


7. Level Sensor
8. Pressure Transducer
9. Power Supply
10. Tubing
11. USB Connector
12. Water Reservoirs

-Note that the electronics box contains two relays for the solenoids and power supplies for the level sensor, pressure transducer, and pump.

Experimental Details - Description of VI

1. The VI has two analog input channels and two digital output channels.
    a. Analog Input Channels
        i. Pressure Transducer
        ii. Level Sensor
    b. Digital Output Channels
        i. Diaphragm Pump
        ii. 3-way Solenoid Valves
    c.
2. In a while loop, both analog signals are converted to water height in inches through transfer functions.
3. The level sensor height is recorded into a tank and plotted against the pressure transducer in a waveform chart.
4. The level sensor height is compared to a user set lower and upper limit.
    a. If within range
        i. Valves stay in same orientation as last while loop iteration
    b. If out of range
        i. Level sensor height is compared to the upper limit
            1. If greater than upper limit
                a. Valves switched on (on configuration drains the tank)
            2. If less than upper limit
                a. Valves switched off (off configuration fills the tank)
5. Level sensor height is compared to a master range of 0.8 - 4.5 [in].
    a. If within range
        i. Pump stays running
    b. If out of range
        i. Pump turns off
6. Pump and valves are turned off when the VI is stopped.
7. The user has the option to save the data from the pressure transducer and level sensor.



General Procedure:

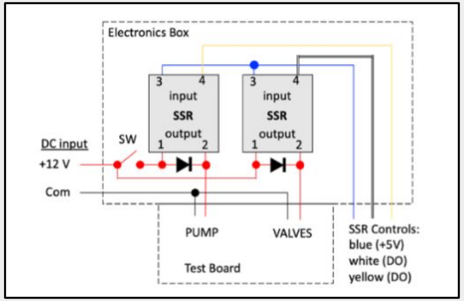
1. The pump system is set up as previously shown.

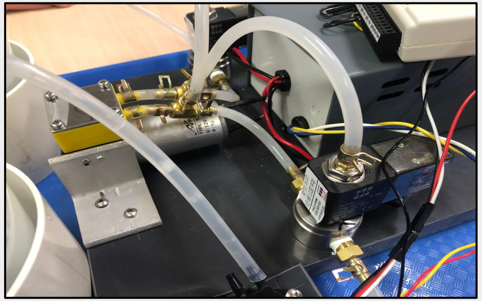
2. The level sensor is calibrated, and the calibration curve is inputted into the VI. The calibration curve of the pressure transducer is given by the manufacturer.

3. Using the VI, the system cycles through three fill-drain cycles from a depth of one inch to three inches and the level data from both the level sensor and pressure transducer is recorded.

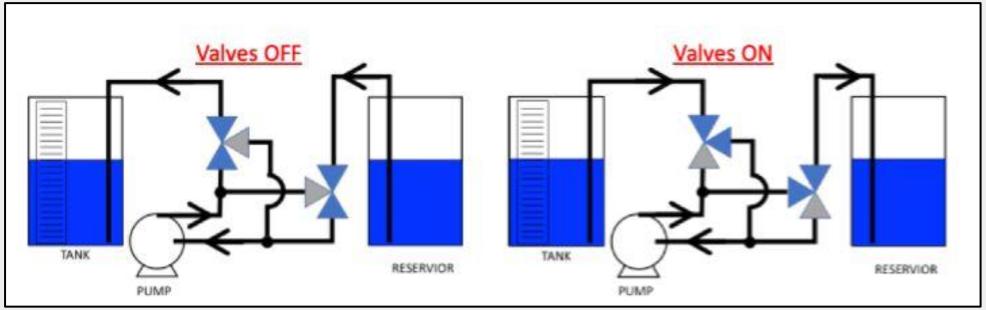
4. The two sets of level data is plotted in excel so that the discrepancies between the two methods can be compared.

5. Using the level sensor data, the nominal flow rate of the pump is found.



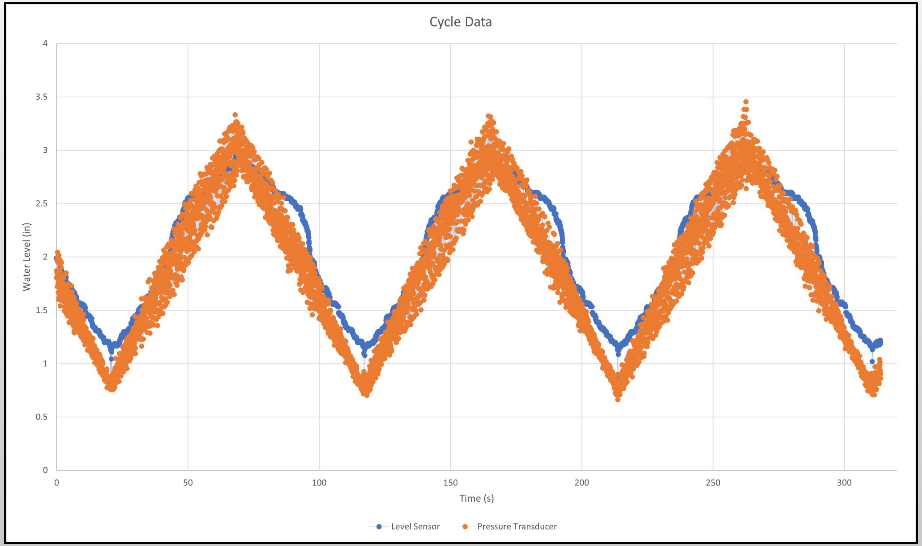


Shown above is the controls wiring diagram (left) and the pump and valve system (right). Shown below are the schematics of the two running configurations of the pump and valve system.

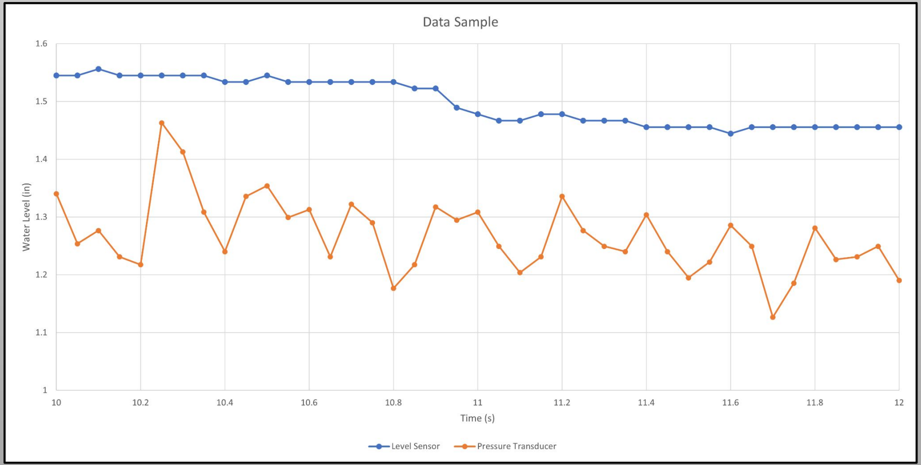


Results:

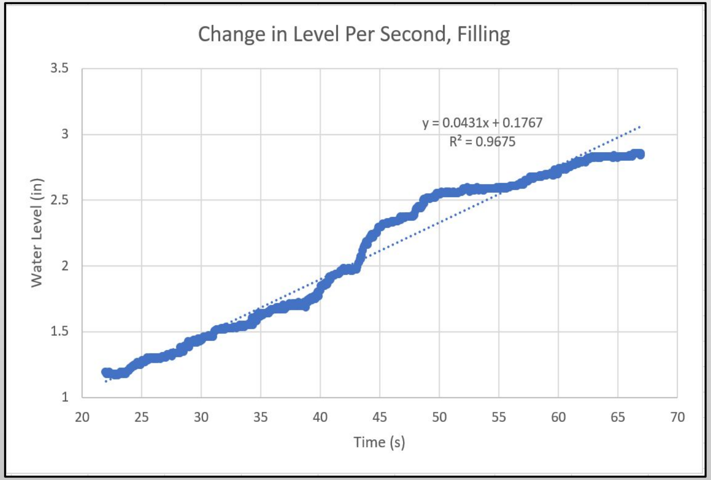
-This graph shows the measured level of water from both the level sensor (blue data) and pressure transducer (orange data) over three fill-drain cycles of the system from 1 inch depth to 3 inch depth. Note that the level sensor input was used as the determinant value to switch the system from filling to draining and vice versa.

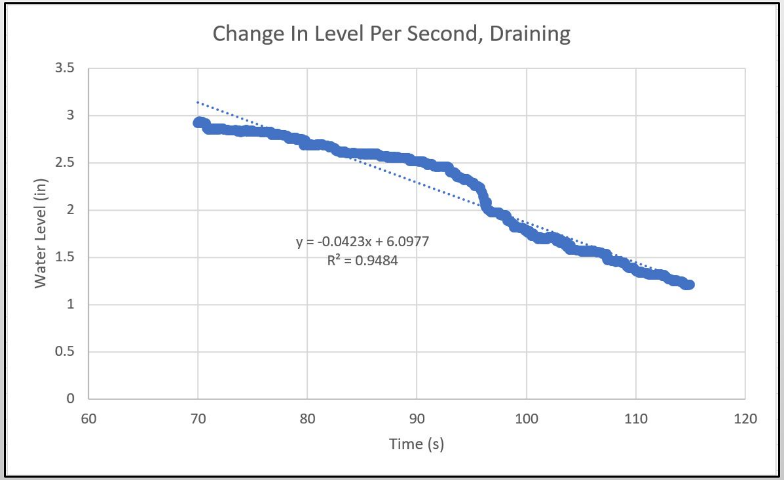


-Here, a sample section of data is shown to illustrate the disparities between the two pumps. The level sensor continuously outputs a depth value that is about .15in - .2in greater than the pressure transducer output value. As the level sensor is calibrated to the system, it is most likely that the pressure transducer output is inaccurate. Note that the variation and jaggedness of the pressure transducer data is largely from the water flow, as the diaphragm pump moves the water in rapid pulses, thus creating small pressure spikes in the reservoir.



Results:





	Units	Value	Cup Diameter	Cup Area (in^2)	Rate (in^3/s)	Manufacturer Flow Rate (in^3)	% Error
Flow Rate Filling	(in/s)	0.0431	3.5	9.621	0.415	0.325	21.6245
Flow Rate Draining	(in/s)	-0.0423	3.5	9.621	-0.407	-0.325	20.1423

The flow rate of the pump is found by plotting a level vs time curve for both a filling and draining period (curves shown above). The slope of these curves gives an in/s value, and when multiplied by the cross sectional area of the reservoir it equals the volumetric change in the reservoir per second, which is the flow rate. Note that the flow rate is not steady due to the pump pumping the water in pulses.

Conclusion

1. Controlling the level of water with the level sensor is fairly accurate because the level sensor is calibrated in the actual system. However, as seen in the results section the level sensor does not give as linear of an output as the pressure transducer. This results in the top and bottom end of the data being slightly skewed.

2. As previously discussed, the level sensor outputs a depth that is around .15 - .20 [in] greater than the value from the pressure transducer. The level sensor is also less noisy compared to the pressure transducer. This is likely due the operating principle of the pressure transducer as it is affected by the pressure spikes from the diaphragm pump.

3. The diaphragm pump is more resistant to abrasion and corrosion, and is better for pumping viscous fluids and fluids that may have large particles in them. A diaphragm pump can also run for a reasonably longer time if exposed to dry running conditions unlike a centrifugal pump, and will self prime when in a deadhead configuration. However, a centrifugal pump creates a much smoother flow than a diaphragm pump, which creates a pulsating flow. Diaphragm pumps are more susceptible to damage that occurs from pressure spikes and also have a lower flow rate and head compared to centrifugal pumps.

4. The advantages of using two three way valves is that the flow direction can be switched very easily without switching the direction of the pump output flow. If four two way valves were used, they would essentially need to be configured into two three way valves to give the same results. A two way valve would be connected to another two way valve to create a three way valve that is more complex, more expensive, and needs more programming in order to run properly than a regular three way valve. For these reasons, it is better to use the three way valves.