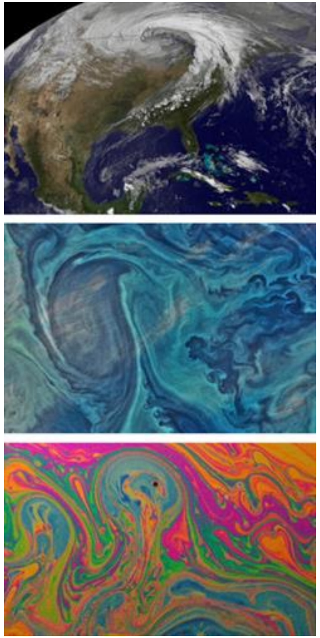
UCSB LOCUS
Low-Cost Underwater Sensing

Winter Quarter Review

Problem



Large-scale eddies in the atmosphere (top), ocean (middle) and soap film (bottom)

Ocean mixing results in dissipation of mechanical energy. Ocean turbulence occurs at the kilometer scale all the way to the millimeter scale.

Current oceanographic models do not resolve the millimeter scale of turbulence in the ocean.

However, these millimeter scales are the ranges where the majority of energy dissipation occurs.

Goal: Quantify and observe the turbulent dissipation in ocean flow through the use of velocimetry techniques.

Applications

Fig. 4. Kármán vortex wake system behind a circular cylinder (Re = 110).

M. Gharib and P. Derango, "A liquid film tunnel to study two-dimensional flows," Physica D 37, 406–416 (1989).

Small scale turbulence contributes to the energy dissipation in a fluid system. More data points would help refine oceanographic models contributing to things like weather forecasting.

Velocimetry Methods

Knowing the velocity of ocean currents at the millimeter scale enables the calculations for kinetic energy dissipation.

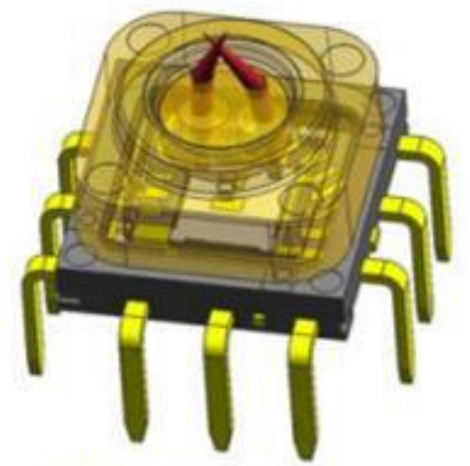
Methods:

1. Laser Doppler Sensor
2. Piezoelectric Sensor Probe
3. Differential Pressure Sensor

Method 1: Laser Doppler Sensor

Reflected laser will cause fluctuations in the power of laser which can then be related back to the doppler frequency. The doppler frequency can be used to calculate the speed relative to the reflected surface.

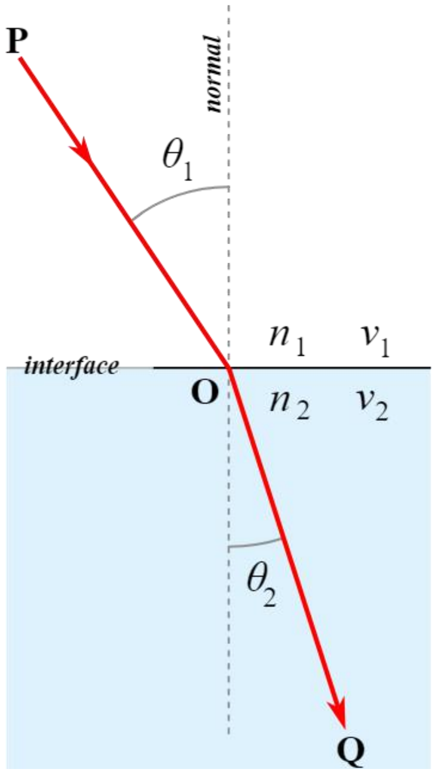
Results showed that the laser performed poorly when submerged in water due to lack of a well-defined plane that the laser could use as a surface to reflect off of.

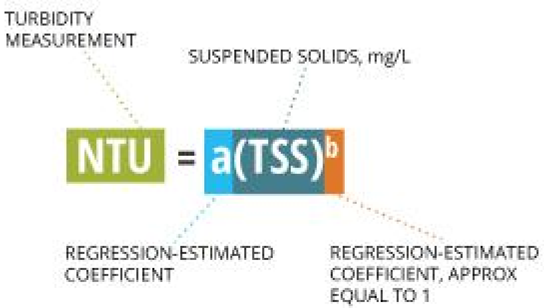


PLN2020 with lens

Problems with Initial Tests

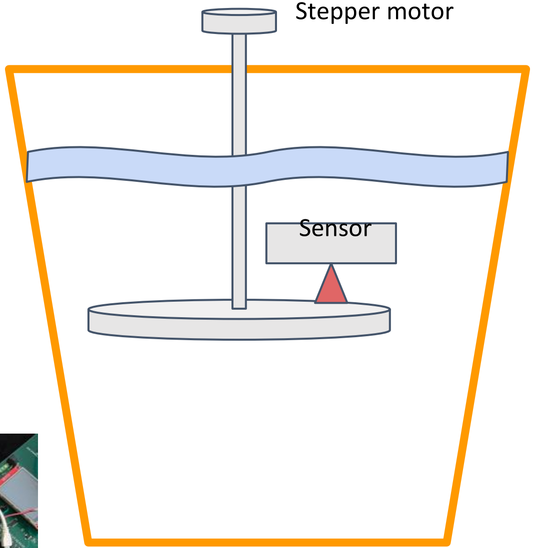
- Sensor focal point could move due to refraction in water
- Scattering in water instead of coherent reflections
- Turbidity (opaqueness) could affect light reflection
    - More particles - more reflection





Testing: Range Calibration & Turbidity

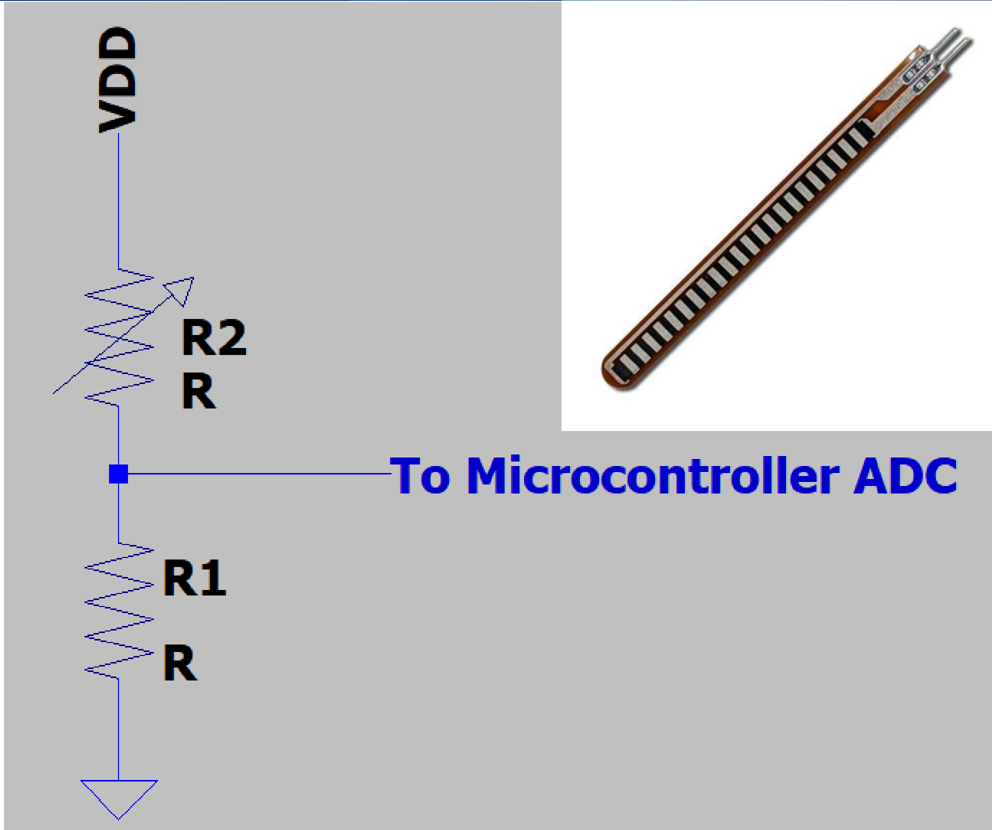
- Range Calibration
  - Tests sensitivity of sensor in multiple ranges in air and in water
  - Sensor and disk suspended into bucket
  - Disk rotated by a stepper motor
- Turbidity
  - Test sensitivity in multiple levels of particle concentration



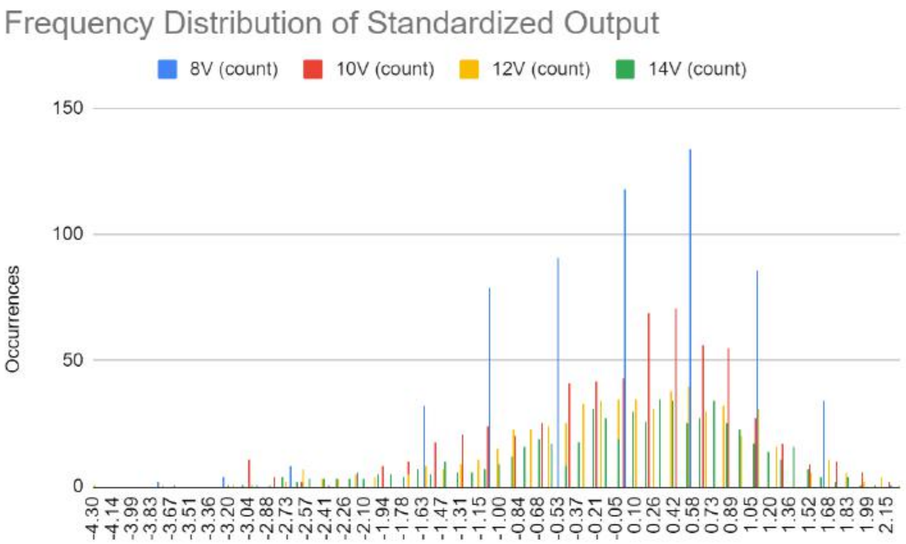
Method 2: Piezoelectric Sensor

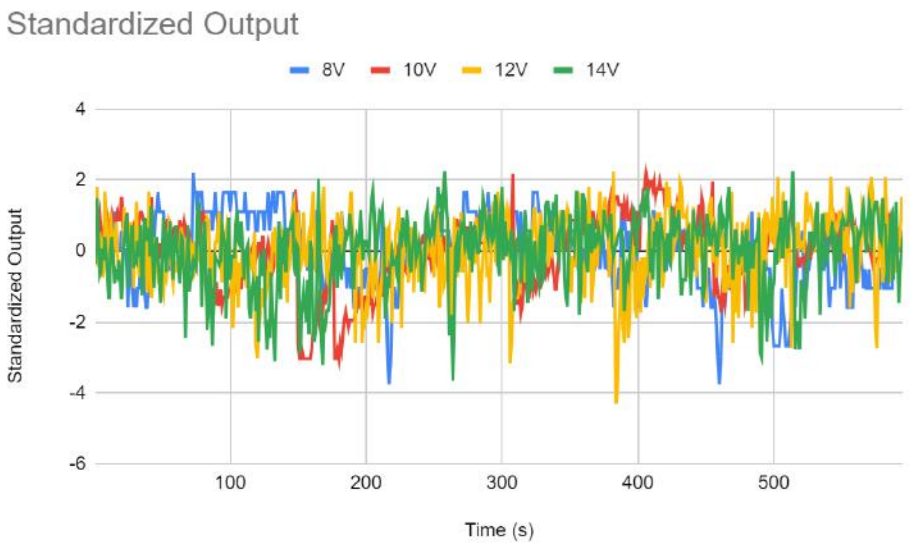
Operation

- Functions like a potentiometer
- When under stress electrical charge is shifted and creates a voltage drop across the sensor
- Voltage drop across the sensor can be mapped to the pressure or velocity of the water against the sensor
- Calibration is needed to ensure accuracy of the sensor especially in underwater conditions
- Need multiple sensors for 2 dimensional measurements



Piezoelectric Sensor Initial Results

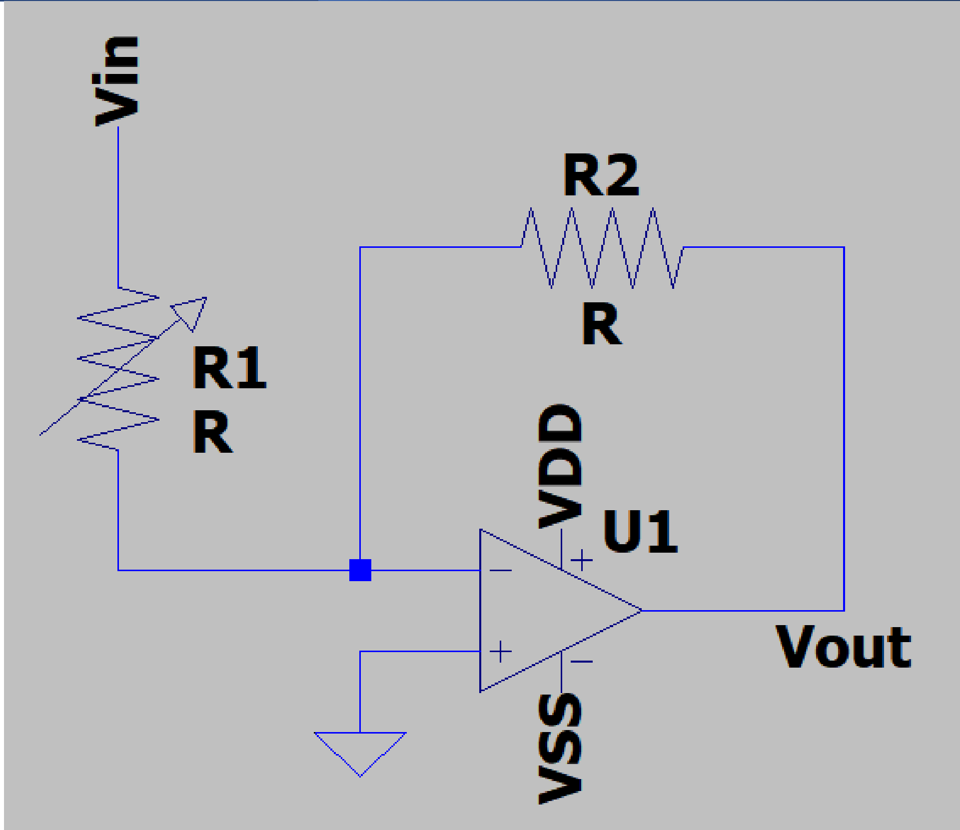




	8V	10V	12V	14V
STD	0.009028593390	0.022495968843	0.034343205521	0.044657532073

Piezoelectric Improvements

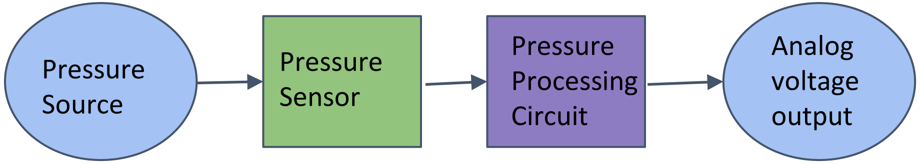
- Need a change in the output voltage at very low degrees of bending
- Negative input with feedback resistor will have very low impedance
- Voltage Divider Gain: A = R1/(R1+R2)
- Inverter Gain: A = -R2/R1
- Increase Sampling Frequency
- Adjust exposed length of sensor

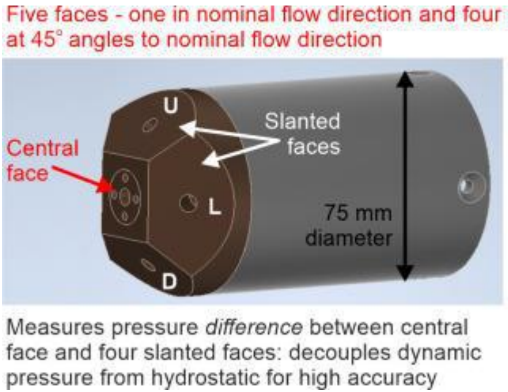


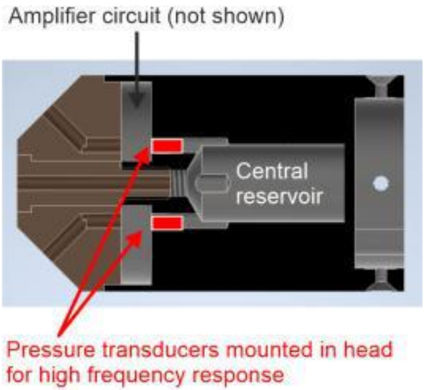
Method 3: Differential Pressure Sensor

Operation

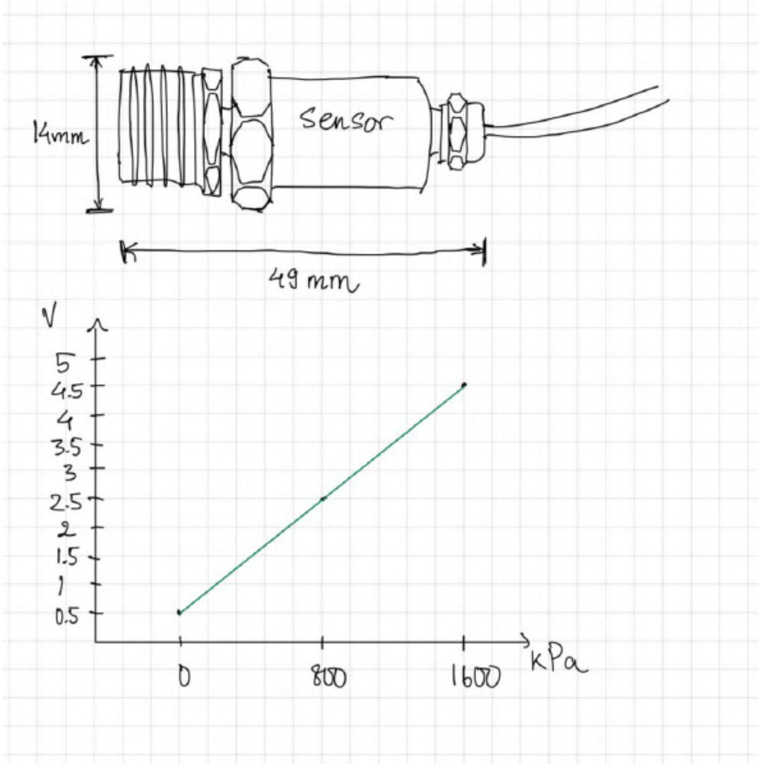
- Multiple pressure transducers on 4 slanted and 1 straight face
- Angled water flow will create pressure differential between sensors
    - Calculate water velocity and direction from data
- Can detect Velocity +/- 30 degrees from front face
    - Flow separation

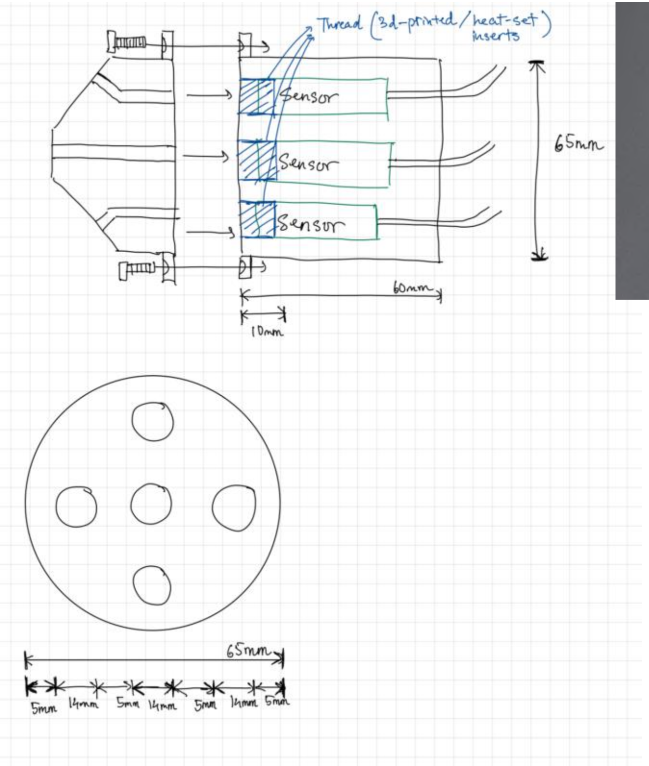




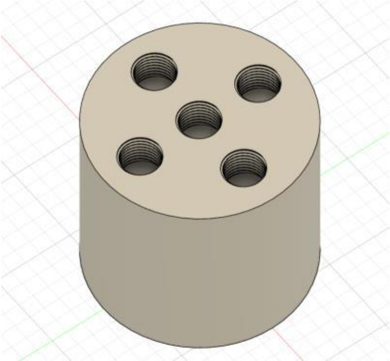


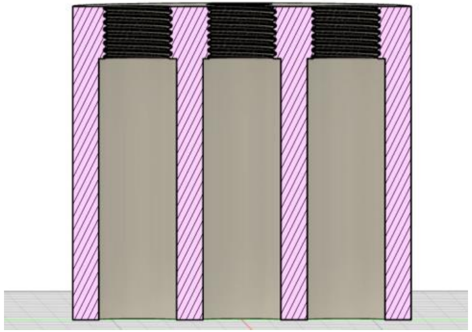
Method 3 Design

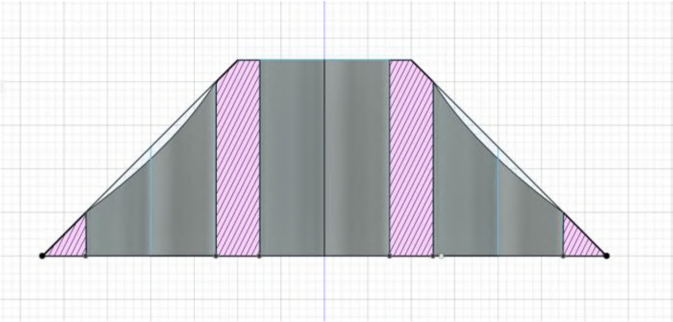


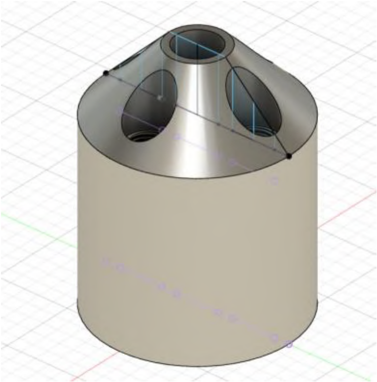


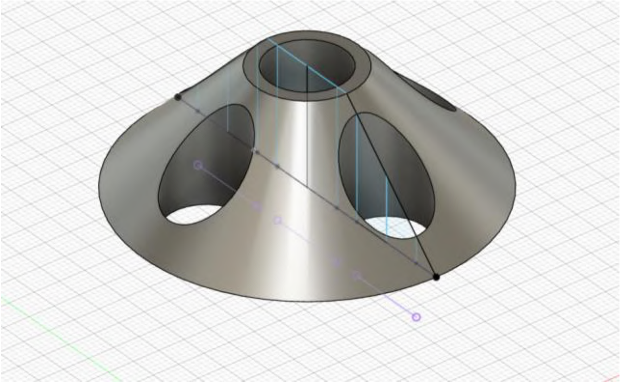
Method 3 CAD



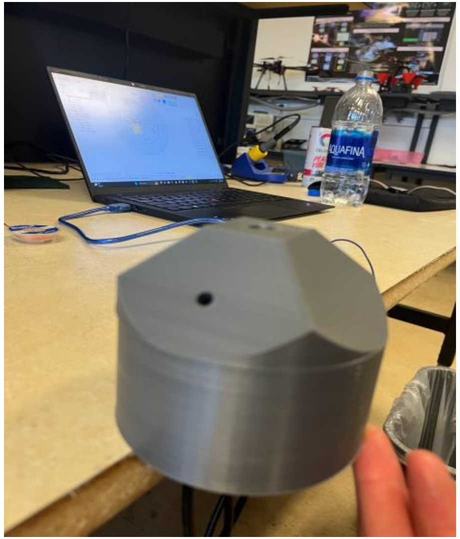


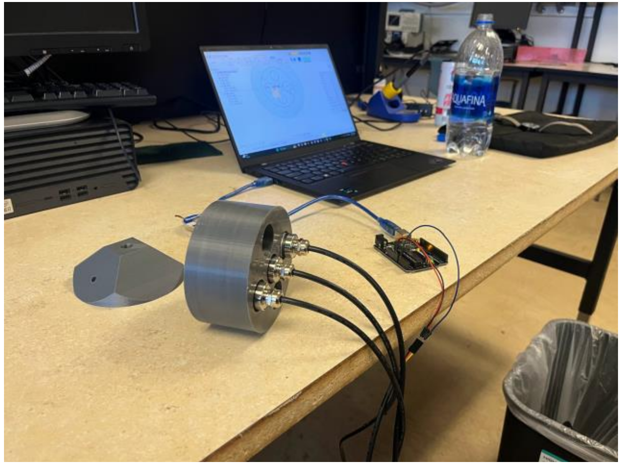






Method 3 Assembly





Current Progress & Tentative Schedule

Tentative Schedule

Remaining Winter Quarter:

- Create test setups for integrating both the piezo senor and the pressure sensors

Spring Quarter:

- Create final sensor rig
- Design pcb for integrated product
- Fully integrate the best sensor for measuring flow velocities into a torpedo robot and test for full deployment under the ocean.
- Implement features that make data logging and calculation easier and more fluid.

Thank you for listening