April 30, 2021

Mr. Christopher Galati, PE, MBA
Shiley School of Engineering
University of Portland
Portland, Oregon

Dear Professor Galati,

The WAVES capstone team submits their final report titled "Willamette River Erosion Control" to communicate the work and accomplishments of the year-long senior project.

The purpose of the Willamette Anti-Erosion Versatile Energy System (WAVES) project is to design, build, and test a wave attenuation device that dissipates at least 50% of the incoming wave energy produced by recreational boating activity on the Willamette River in the Newberg Pool. Additionally, a wave measurement device using an accelerometer attached to a buoy to measure wave height displacement was designed and implemented to verify the reliability of the video processing method that was used to calculate wave energy from wave height and period.

After initial research into current wave attenuation technology, the team split up to work on each project's different goals for Fall 2020 semester work. Rachel Anderson and Kaitlyn Gores took the initiative to design a wave attenuator prototype. Ernesto Zurita Ruiz and Davey Robeck worked together on designing and assembling a measuring device. Jeremiah Eriksen worked on modeling and creating an energy generating device. The team designed a prototype over the Fall 2020 semester and purchased materials for the prototype's assembly. For Spring 2021 semester work, the team focused on testing the attenuator prototypes, improving the attenuator design, and refinement of the wave energy measuring device. Frequency response analyses were conducted for the attenuator prototypes to model their behavior and response to waves.

Results from the attenuator analysis found that both the jute and cable attenuators are capable of dissipating at least 50% of the energy from the incoming waves used in the test field. Video processing techniques, a wave measurement device, and frequency response models were used to determine that the jute attenuator design connected with rope is the optimal design for wave energy dissipation. Work on the energy generating device model was discontinued to focus work on wave attenuation, the primary concern for homeowners.

Thank you for your support. The team is also thankful for the support of the capstone advisor, Dr. Farina, as he was actively encouraging and informative when the team needed guidance throughout the course of the project.

Rachel Anderson

Davey Robeck

Jeremiah Eriksen

Ernesto Zurita Ruiz

Kaitlyn Gores

Willamette River Erosion Control

WAVES Capstone Team

Team Members
Rachel Anderson, Jeremiah Eriksen, Kaitlyn Gores, Davey Robeck, Ernesto Zurita Ruiz

Faculty Advisor
Jordan Farina, Ph.D

Capstone Instructor
Mr. Christopher Galati, PE, MBA

University of Portland

April 30, 2021

Table of Contents

Executive Summary

Homeowners with property on the Willamette River in the Newberg Pool are concerned about bank erosion along their property. The Willamette Anti-Erosion Versatile Energy System (WAVES) capstone team researched, designed, and developed a floating wave attenuator device that reduces erosion of property by dissipating energy from waves produced from recreational boating activities. The project's success was measured by regulatory compliance and cost-effectiveness of the wave attenuator relative to the homeowner's next available option.

Figure 1 - Picture of an attenuator prototype and how it is used.

The team established a set of criteria that a design should comply with to meet project requirements. A wave attenuator was to meet the primary criteria of dissipating wave energy, adhering to state and federal environmental regulations, be mobile and simple for homeowners to work with, cost effective, and be implemented at approximately 50% or less of the cost of the next available option for erosion control. Using these criteria, the team designed and produced four attenuator designs that were units of logs binded by either steel cable or jute netting. These attenuators were tested in the Willamette River on the River Campus of the University of Portland.

Video processing analysis was used to determine the amplitudes of waves before and after being attenuated by the different attenuator prototypes. With the amplitude data for each prototype, percent energy dissipation was calculated. The team found that all the designs attenuated at least 50% energy from the incoming waves. A wave measurement device utilizing an accelerometer verified the effectiveness of the video processing analysis Frequency response models were used with the results from the video processing analysis to conclude that the jute attenuator connected via rope is the best available option for dissipating wave energy from the waves created for testing.

The team operated on a $825 budget awarded through the Shiley School of Engineering at the University of Portland. 72.2% of that budget was spent during the duration of the project running from August 2020 through April 2021.

Introduction

The WAVES capstone team is tasked with addressing riverbank erosion of homeowner property on the Willamette River. The purpose of the WAVES project is to design and implement a wave attenuation device that dissipates at least 50% of the incoming wave energy produced by recreational boating activity on the Willamette River.

In the summer of 2018 wake surfing was officially allowed in some portions of the Willamette River. Homeowners noticed issues with erosion control along their properties and they reached out to the University of Portland Shiley School of Engineering for help. A research group was created to observe the impact of the wake surfing boats along the Newberg Pool portion of the Willamette River. Homeowners started to look into changing legislation and rules regarding boat activity on the Willamette. While working on legislation changes, homeowners would find ways to protect their shorelines from erosion which were all expensive and would require homeowners to obtain costly permits. The goal of this capstone project is to provide an easier and more cost-effective alternative to protect homeowner property from erosion through wave attenuators.

Any wave attenuator design drafted by the team is set to adhere to the following criteria: dissipate wave energy, comply with state and federal environmental regulations, be mobile and simple for homeowners to work with, and be implemented at cost smaller than the homeowner's next available option for erosion control.

To determine the performance of the designed wave attenuator in dissipating at least 50% of wave energy, a test plan with a procedure and data collection method will need to be drafted by the team. Previous years' research worked with game cameras to determine wave energy through video processing in MATLAB. The WAVES capstone team will adopt and improve this method for quantifying attenuator performance. A wave measurement device using an accelerometer attached to a buoy to measure wave height displacement will be designed and tested to compare the reliability of the video processing method in measuring wave energy.

After conducting research on wave attenuation devices, four wave attenuator prototypes were designed using the material decision from the team criteria. The purpose of this report is to communicate the design process that led the WAVES capstone team to build the four attenuator prototypes, the test methods used to quantify the performance of the prototypes in reducing wave energy, and how the attenuators would fare as an option for erosion control compared to the homeowner's next available option for erosion control.

Background

The WAVES project builds upon research initially conducted by a team at the University of Portland in the summer of 2019 led by Dr. Dillon and Dr. Poor. This team studied waves in the Newberg Pool, river miles 30-50 of the Willamette River. Homeowners living along the studied portion of the Willamette River noticed issues with bank erosion along their properties similar to what is shown in Figure 2. This discovery surfaced around the time of the legalization of wake surfing boats on certain portions of the Willamette River. Wake surfing involves boats with increased weight to the displacement of the hull. These recreational boats create larger than average wakes that allow individuals to surf on the wakes without being pulled by the boat (WakeMAKERS, 2020). Within the Newberg Pool, there are three different types of zones: slow zone where no activity is allowed, wake activity zone where everything but wake surfing is allowed, and wake surfing zones where wake surfing is allowed in addition to other water recreation activities (Oregon State Marine Board, 2020).*

Figure 2 - Undercutting at Champoeg Park.

*Boating regulations have been updated since testing in the summer of 2019.

There are limited options available for homeowners to protect their banks. One option is to line the bank with riprap which protects the bank by covering it with rocks. This solution is considered to be highly effective but expensive. In addition to the cost of the rocks, several forms need to be filled out and permits approved. This can accumulate to costs upwards of $3,000 according to homeowners. Currently, some homeowners are tying fallen trees to their docks and other points along the bank to help mitigate erosion. While other homeowners placed buoys a legal distance from their docks to keep the boats at a safe distance from the banks, some found their buoys cut by boaters.

Figure 3 - Example of riprap on a riverbank.

An attenuator is a type of wave suppression device that floats in water. There are no attenuators available on a scale designed for homeowners or rivers. Most attenuators currently in production are aimed towards lakes and oceans. Their main uses are for protecting marinas or placed out in the open ocean to collect wave energy.

An attenuator reduces the energy carried by waves through two main methods as depicted in Figure 4:

1. Change in momentum.
2. Dissipated heat from viscous drag interactions.

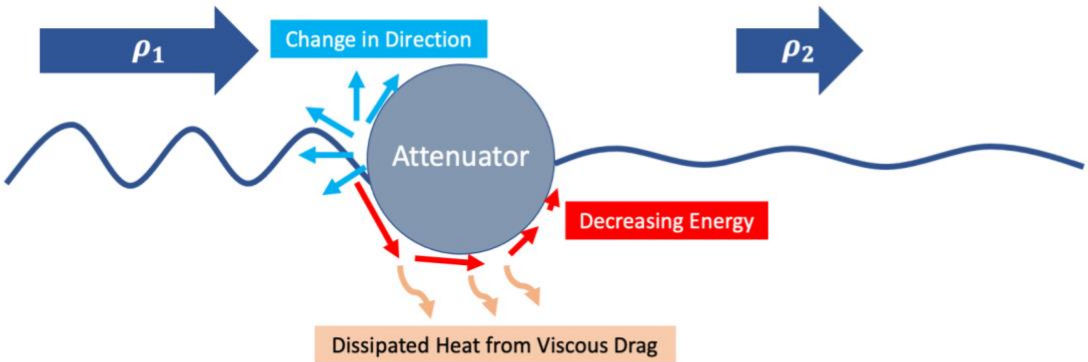


Figure 4 - How attenuators dissipate energy.

In the first method, the attenuator forces fluid particles to change their direction of motion such that waves that do manage to get past the attenuator carry less momentum. The second method takes advantage of drag forces where the viscous interaction between the attenuator and the fluid particles transform wave energy into dissipated heat. A good wave attenuator takes advantage of both methods to achieve the desired performance given the design constraints.

The energy of a wave is calculated by using Equation 1. The equation uses the average period (T) and the average amplitude (H).

$$E = (\rho g^2/64\pi)H^2T \quad [W/m] \tag{1}$$

Design Criteria

After understanding the problem and researching existing erosion control solutions, the team drafted a list of criteria to measure the success of the wave attenuator design. In total, the team ranked ten design considerations to quantify the end goal for the product. Homeowners expressed that their primary needs in a product are inexpensive prices compared to current available methods, more consumer friendly than erosion mitigation alternatives, little to no permitting, aesthetically pleasing, and easy to install. The team created a decision matrix based on these needs and other essential aspects. Figure 4 shows the ranking for each design criterion.

Table 1 - Criteria ranking.

Ranking	Criteria
1	Reduce Erosion (Energy Attenuation)
2	Adhere to Environmental Regulations
3	Mobility (seasonal tides, boats)
4	Simplicity
5	Price/Value (<$3,000)
6	Appearance
7	Sustainable/Recycled Material
8	Longevity
9	Maintenance
10	Energy Capture

There are three paths homeowners could take to attenuate energy carried by waves to decrease bank erosion: wave attenuation, energy capture, and reverting to conventional methods. Conventional methods include obtaining multiple permits for the placement of riprap or large rocks on the shoreline, illegally placing rocks on the shoreline, and securing downed trees found in the river to the dock in an orientation parallel to the shore. The permitting process for riprap costs at least $3,000. The illegal dropping of rocks on the shore can result in fines. A homeowner cannot be certain that a tree will wash up on their property for use as a wave attenuator. For these reasons it is worthwhile for homeowners to invest in an alternative solution rather than their current options. The capstone team had to decide between wave attenuation or energy capture as a means to satisfy the needs of the homeowners.

Engineering Standards (Environmental Regulations)

The team was not able to find any specific engineering standards related to attenuator design. However, any attenuator design had to adhere to environmental regulations set forth by the U.S. Army Corps of Engineers (USACE), Portland District, the Oregon State Marine Board, and the Oregon Department of Environmental Quality (DEQ).

As provided by the USACE, Portland District office, some standards and regulations to consider abiding by include: the Endangered Species Act, the Magnuson-Stevens Fishery Conservation and Management Act, the Nationwide Permit 5 - Scientific Measurement Devices, and the National Historic Preservation Act. Failure to comply with all terms and conditions set by the

USACE permitting process and verification would invalidate the authorization of the obtained permit and could result in a violation of Section 10 of the Rivers and Harbors Act.

Example of Design Criteria Process

Multiple ideas were shared and the team selected an attenuator design. The rejected designs were either too complicated, were energy capture devices, were made primarily from plastic, or would likely require permitting. An example of a rejected design is a fixed attenuator which can be seen in Figure 5. To fix an object to the bottom of the river requires multiple permits, for this reason the group selected a floating attenuator which does not require the same extensive permits. The floating attenuator also allows for a more mobile device so the homeowners can move them as needed.

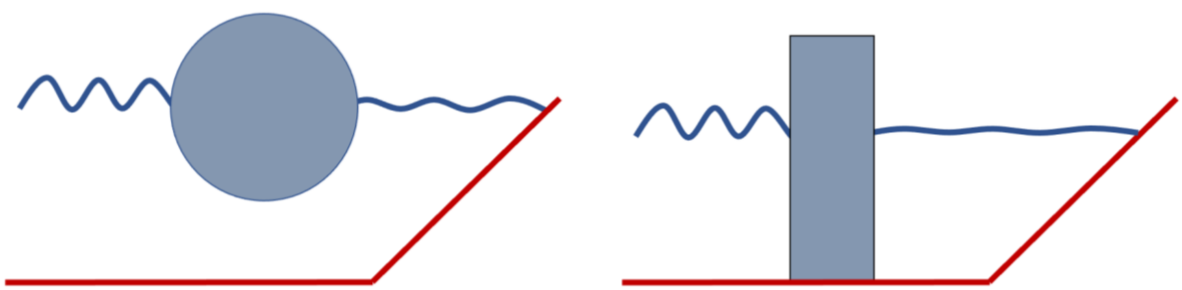


Figure 5 - Floating versus fixed attenuator.

The Willamette is home to many different species of wildlife, increasing the importance of the attenuator created by the capstone to be environmentally friendly. Salmon species are currently located in the river and they are protected under the Endangered Species Act(NOAA). Drafted designs would need to be environmentally friendly as to not harm any of the wildlife. Mobility of the design was important since the Willamette River experiences large changes in water levels over the course of the year in addition to regular storms. By making attenuators easily mobile, homeowners can adjust their location or remove them from the river entirely.

Simplicity was an important criterion for this project as the design would need to be simple enough for homeowners to assemble the units themselves. Creating a basic design also allowed for a lower cost. A homeowner provided an estimate that to protect their shoreline from erosion would cost an average of $3,000. With many homeowners not willing to pay this higher cost, keeping the cost to buy materials and assemble the attenuator low will make the project's product appealing to more homeowners also worried about riverbank and property erosion.

Energy capture ranks last on the criteria as capturing energy does not translate to energy dissipation. The team expressed interest in capturing energy from the waves as a secondary objective as long as wave attenuation was addressed first and effectively.

Project Schedule & Budget

The WAVES capstone team worked on this project from August 28, 2020 through April 30, 2021. The team was awarded an $825 budget from the Shiley School of Engineering for the duration of the project which spanned two academic semesters. The project charter can be found in Appendix VI. The team met on a weekly basis with occasional bi-weekly meetings when necessary. All team meeting notes and check-in summaries are found in Appendix X and Appendix XI respectively.

<u>Schedule</u>

Figure 6 lays out the Fall 2020 schedule for the WAVES capstone team. The main events of the project have been grouped together based upon their respective categories in order to provide visual clarity and help the team categorize major goals. The purple bars represent integral events necessary prior to designing a prototype. The green bar displays budgeting events. The yellow bars lay out the documentation and deliverables for EGR 483. The blue and orange bars represent events for developing a prototype. These events include the ordering of material and assembly for both the attenuator prototype and wave energy measuring device circuitry.

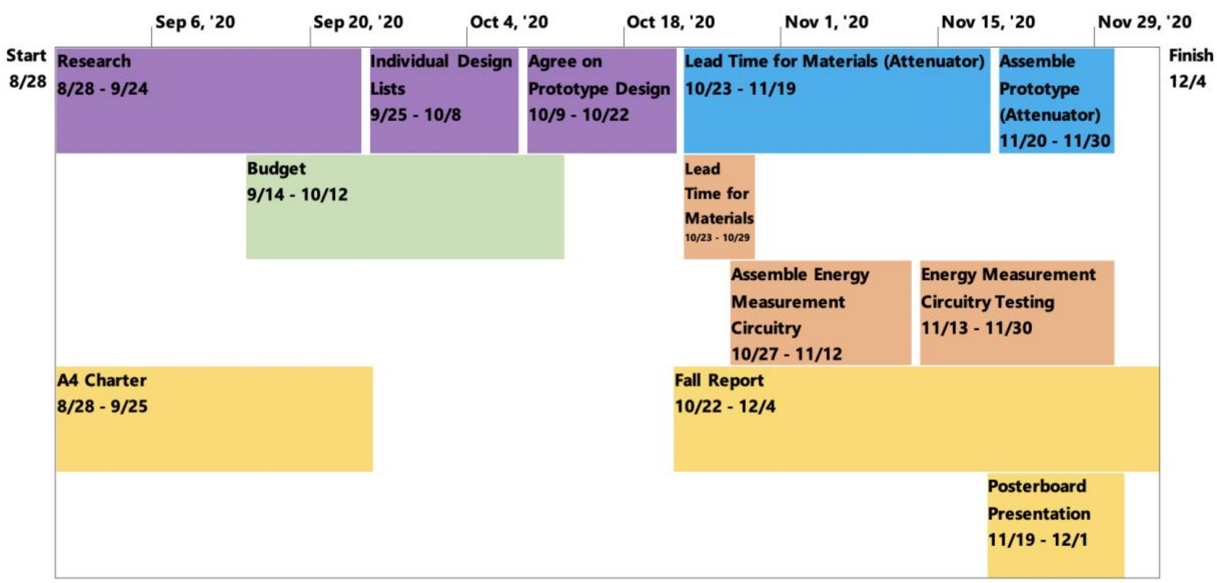


Figure 6 - Project timeline for Fall 2020.

Initial research began on August 28, 2020 and was conducted in three steps: understanding the problem, determining the knowledge gap, and finalizing preliminary research. Once preliminary research was complete, each team member worked on individual design lists for a wave attenuator and wave energy measuring device. After individual lists were presented, the preliminary prototype design for both devices were discussed and agreed upon on October 22, 2020. During this time, the draft and final project charters were completed.

The next major steps involved ordering materials and prototyping. For the wave attenuator, materials were ordered and wood was collected. The initial prototype was assembled on

November 28th. For the wave energy measurement device, materials were ordered and shipped from October 23 through October 29, 2020. Once the circuitry components arrived, the circuitry portion of the device was assembled and testing was completed by the last week of November 2020.

The schedule for Spring 2021 can be seen in Figure 7. Similar to the Fall 2020 schedule, the main tasks were grouped by categories: green being field testing and data collection, blue being analysis of data found in the field and analyses regarding improving field testing , and yellow being documentation and deliverables for the capstone class, EGR-484.

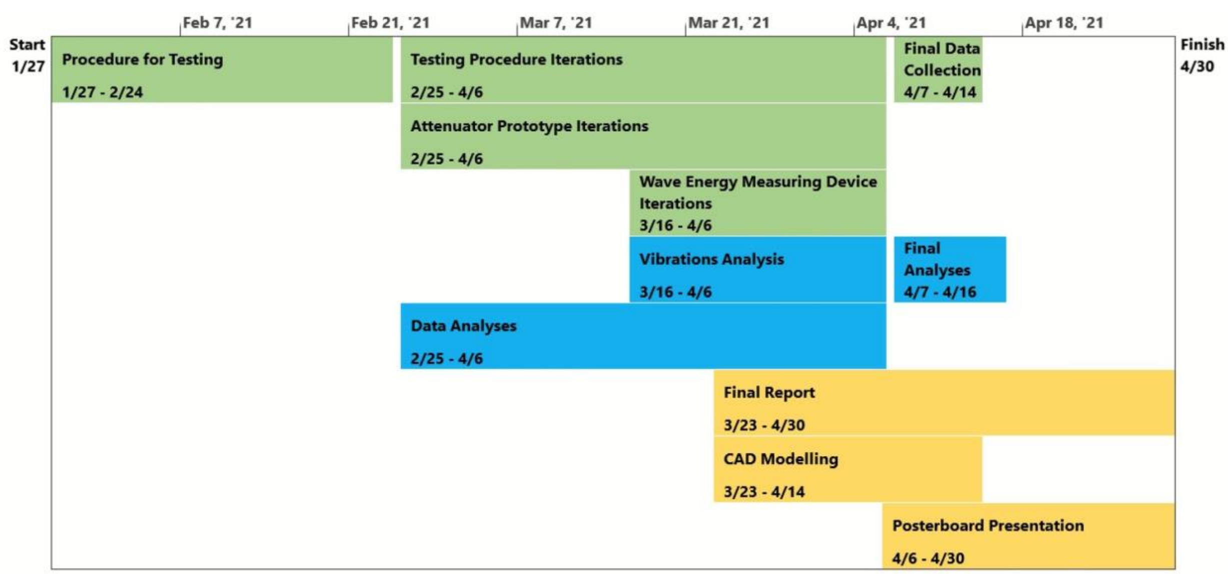


Figure 7 - Project timeline for Spring 2021.

Starting January 27, 2021, the focus at the beginning of spring semester was establishing a precise and repeatable procedure for testing the wave attenuators. The general procedure took around a month to be established. On February 25, 2021, the team moved into iterative processes in conjunction with data analyses from video processing. These iterative processes regarded the attenuator testing procedure and the attenuator prototypes. On March 16, 2021, the team moved into vibrations analysis of the attenuator system as well as iterations of the wave energy measurement device. On April 7, 2021, final iterations were made to finalize the procedure, attenuators, and wave energy measurement device. Final data collection and analyses were completed during this time.

Project Budget

In order for the Shiley School of Engineering to provide the capstone team with funds, a budget request had to be submitted to the School of Engineering in the early stages of the capstone project. As the team was in the research phase of the project, a budget was drafted based on anticipated incurred costs during the project. The full budget request is summarized in Appendix VII. The total budget request amounted to $824.00 of which was submitted on October 09, 2020. The Shiley School of Engineering approved a budget of $825.00 for the capstone team on

October 15, 2020. This budget was to fund the prototype of a wave energy measuring device and the initial prototype of a small-scale wave attenuator. All purchase requests throughout the academic year are summarized in Appendix VIII.

An initial purchase request amounting to $127.43 was made on October 25, 2020. The need of this purchase request was for building the wave energy measuring device's circuitry that included a Raspberry Pi 4 Model B and an Adafruit ADXL345 Triple-Axis Accelerometer. A second purchase request was submitted on November 5, 2020 for the purpose of building a first concept design of a wave attenuator. The purchase request totaled $97.51 that included a 120ft^2 jute netting roll.

At the beginning of the Spring 2021 semester, $600.06 of budget funds remained. It was anticipated that a purchase similar to the first purchase request would have been made to develop a second wave energy measuring device as there was a need to measure the energy carried by the incident wave (before contact with the attenuator) and by the transmitted wave (after contact with the attenuator). When the budget was first drafted in September 2020, the plan was to use most of the funds for prototyping a technically designed wave attenuator after a successful concept prototype of an all-natural, simple wave attenuator.

This, however, was not pursued due to new team direction with the project. Instead, the Spring 2021 semester was used for establishing a repeatable procedure for testing the attenuators. This time was also used to clean up the python code and MATLAB script to improve the data collection and analysis of the data collecting equipment. Vibrations analysis to develop the frequency response for each attenuator to model and predict the attenuator behaviors for different wave frequencies were also performed in this semester. As such, the remaining budget was used for testing equipment and refinement of the jute and cable attenuators. At the end of the project, $229.66 of the original $825.00 budget remained unspent.

Wave Attenuator Designs

Initial Wave Attenuator Prototypes

The team designed and assembled two wave attenuator prototypes during the Fall 2020 semester. The design sketches for the two prototypes can be seen in Figures 8 and 9. These prototypes have the same material foundation of three cylindrical wood logs, Gardner staples, and marine grade rope but differ in their assembly. The prototype seen in Figure 8 is held together by galvanized steel cables. Figure 9 shows the prototype bound by jute netting.

The basis for these designs came from the team design criteria ranking table (see Table 1). The top seven criteria were prioritized and met: reduce erosion, adhere to environmental regulations, mobility, simplicity, price, appearance, and sustainability. The ability of the attenuators to reduce erosion required more testing. These attenuators adhered to environmental regulations as they float as opposed to attaching them to the river floor. Additionally, the materials in the attenuator are not expected to release any toxins into the water. These attenuators are fairly mobile and can be removed from the water easily. They are simple, relatively inexpensive ($100-$170 per 15 linear feet), have a natural-looking appearance, and are mostly made of renewable and sustainable materials.

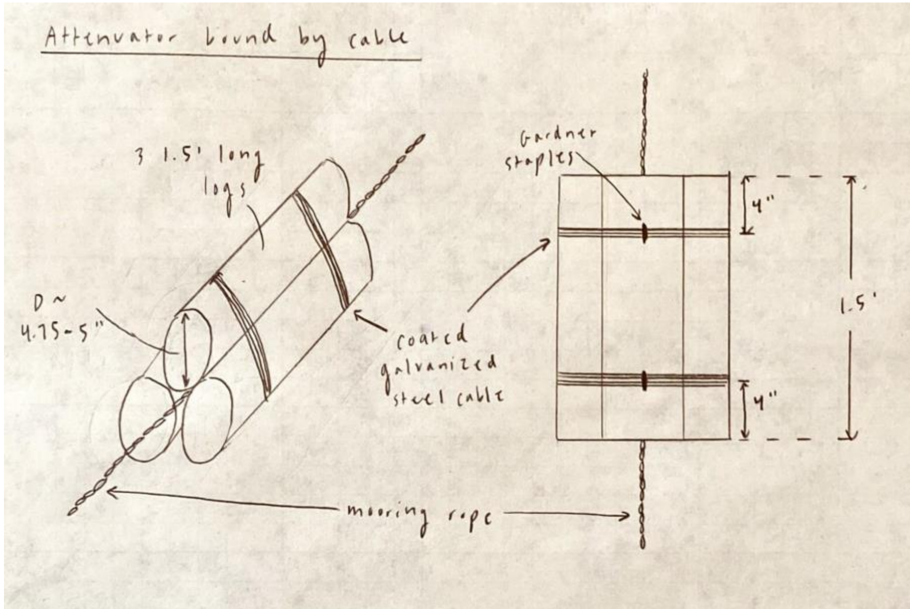


Figure 8 - Preliminary attenuator bound by galvanized steel cable.

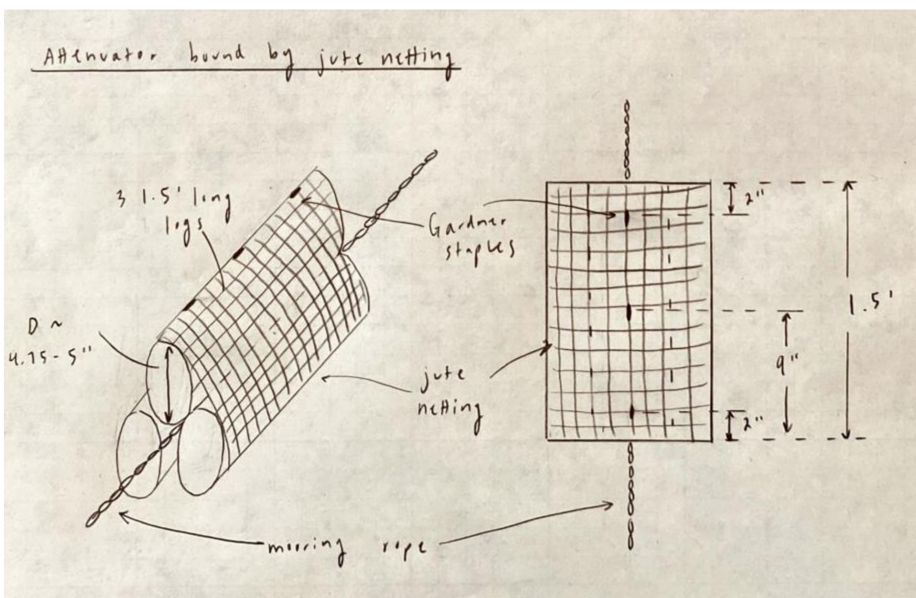


Figure 9 - Preliminary attenuator bound by jute netting.

The two prototypes were assembled in accordance with the sketches in Figures 8 and 9. A CAD technical drawing for the jute with rope attenuator can be found in Appendix V. The physical photographs of the two attenuator prototypes are shown in Figures 10 and 11. Two separate attenuator prototypes were made to determine which binding method is the most effective. The jute netting is a natural method of binding and will naturally degrade within the water over time. This provides a more natural solution than the steel cable method. However, the strength of jute as a binding method was unknown in the Fall 2020 semester.

Figure 10 - Preliminary attenuator prototypes.

Figure 11 - Preliminary attenuator prototype plan view.

Wave Attenuator Iterations

During the Spring 2020 semester, the team moved into testing the initial attenuator prototypes from the fall semester. Once testing began, the team's design criteria was able to be more accurately assessed. The two main criteria that needed to be examined were the attenuator's ability to reduce erosion and the mobility of the attenuators.

In testing the initial prototypes, the team noticed that the attenuators tended to rotate independently from each other when waves were present. It was theorized that the attenuators might be more efficient if they had connections that made them behave more like a unit, rather than as independent attenuators. It was also noted that the attenuators were quite heavy when all on the same rope, making them quite difficult to move and transport. For these reasons, the team came up with a new connection system.

This connection system consists of eye bolts screwed into each log except for the outermost logs, and carabiners connecting each eye bolt screw. Details of this system can be seen in Figure 12. These carabiner connections allowed for the attenuators to be much more mobile as each attenuator unit can be carried one at a time. They also allow for the attenuators to be much more customizable as any amount of attenuators can be connected based upon the linear feet of the riverbank needing protection from erosion. This connection system was tested for both the cable and jute attenuators. These attenuators can be seen in Figures 14 and 15 respectively.

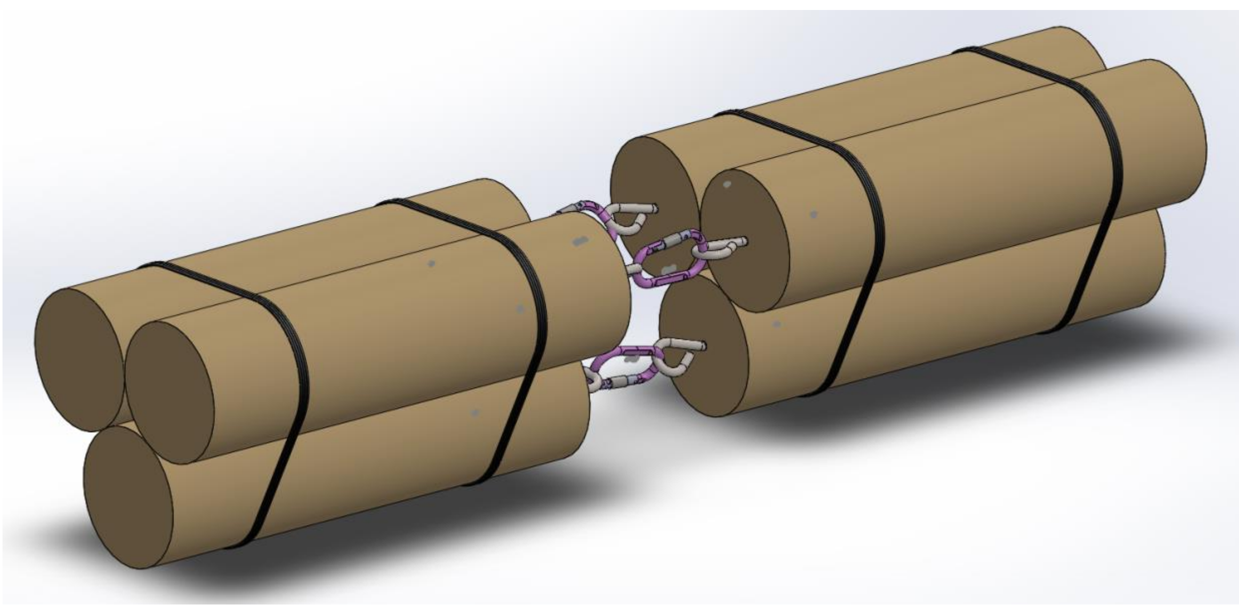


Figure 12 - Steel cable with carabiner.

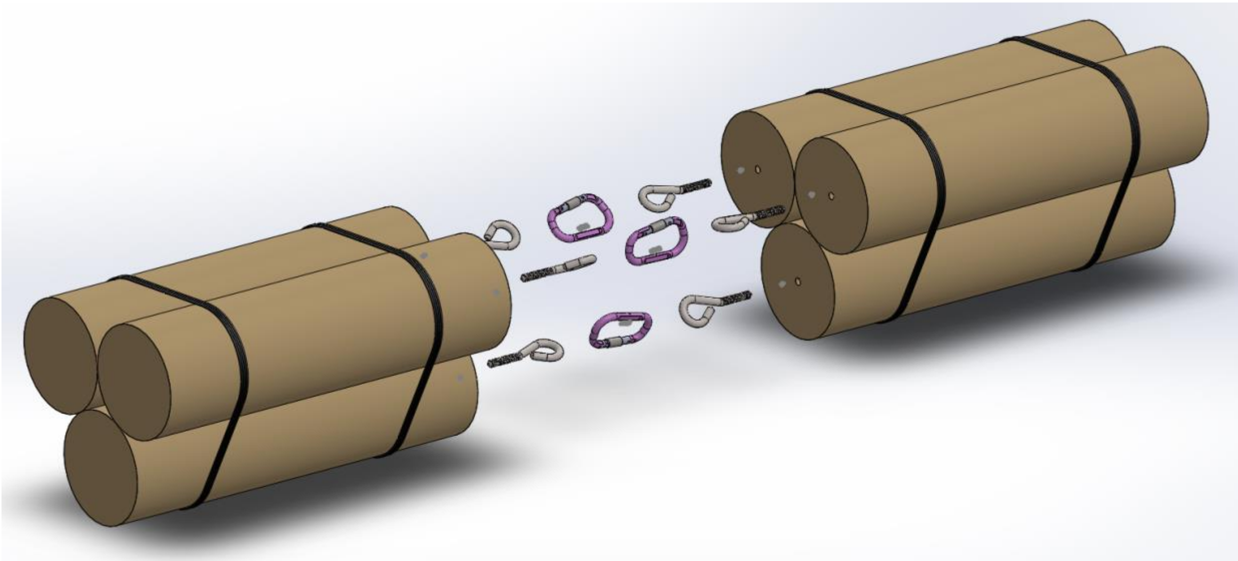


Figure 13 - Steel cable with carabiner exploded view.

Figure 14 - Cable attenuator with carabiner connections.

Figure 15 - Jute attenuator with carabiner connections.

Energy Generating Device

During the Fall 2020 semester, the concept of an energy generating device was explored in parallel with the design of the wave attenuators. The team later decided to continue without the energy generating device for the Spring 2021 semester as it was not providing a wave attenuation benefit for the homeowners. However, future teams can build from the research and concept designs drafted by the WAVES capstone team.

To determine the ideal energy generating device, research was conducted on current devices used to generate energy from waves. The concept for the energy generating device utilized a magnet passing through a copper coil to induce electricity. The magnet is forced up and down by a buoy heaving with the motion of the waves.

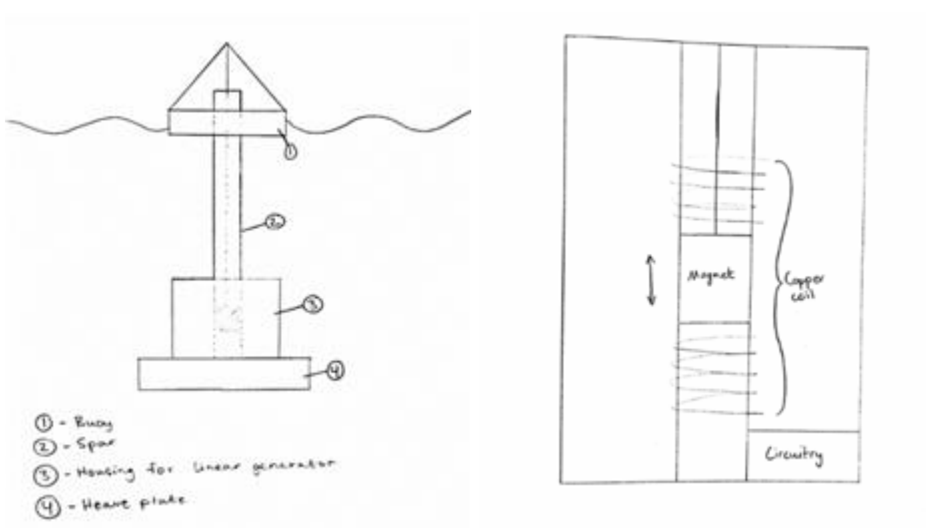


Figure 16 - Energy Generating Device General Design.

Figure 16 shows the concept of the energy generating device, as well as the general design the team would have wanted to prototype if this option was pursued. Work on the energy generating device involves understanding how a model would be affected by the waves and how to adjust the model accordingly.

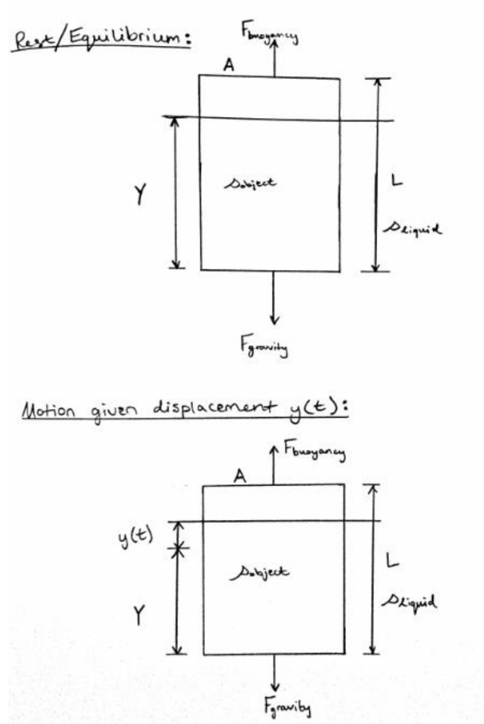


Figure 17 - Models for energy generating device.

The forces and dynamics of the system then had to be modeled, as shown in Figure 17. A Free Body Diagram (FBD) was devised to determine the forces acting on the system at rest. A state of rest is defined as no wave displacement. A second FBD of a system was devised when given the displacement caused by the forcing frequency of the waves. Based on these equations, a system can be designed to model an expected displacement of the system being measured.

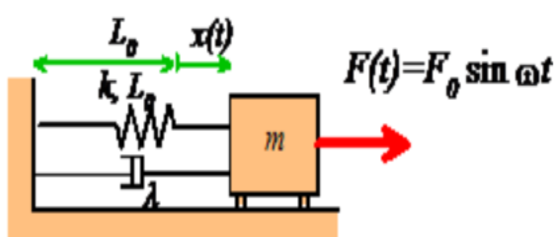


Figure 18 - Schematic model for vibrations of the system (Brown University School of Engineering, 2020).

Work was done to understand the forcing frequency of the waves and the natural frequency of the system. As shown in Figure 18, a system with a single degree of freedom was to be used where oscillation from the waves are modeled as springs and dampers using Laplace equations. Additional work must be done to understand the system response to the forcing frequency of the waves to model a prototype if a future team is to pursue this option.

Wave Energy Measuring Buoy

Analysis in the Fall 2020 semester was primarily focused on instrumentations and controls calculations for designing a low-cost wave energy measuring device. The team agreed that a reliable but low-cost wave energy measuring device was needed to quantify wave energy reduction by the prototyped wave attenuators. Data was to be collected on the scale of hours to record the waves produced by boats passing infrequently through the testing area.

Because the time scale of data collection would be in terms of hours, a computer that could write and store large amounts of data at a fast speed was necessary. A Raspberry Pi 4 Model B was chosen for this purpose as the team could write data onto a 64 GB microSD card and the write speed was sufficient for data collection purposes.

From wave data gathered in previous years' research in the Willamette River near the Newberg pool, an average frequency of about 0.5 Hz was used for design purposes of the measuring device. Assuming that the maximum frequency would be 1.5 times the average frequency, a minimum viable sampling frequency was determined to be 7.5 Hz using Equation 2 below.

$$fs = 10 \cdot fmax \quad (2)$$

In instrumentation and controls theory, getting from the input to the output involves three entities: the sensor, the signal condition, and the analog-to-digital converter (ADC) as summarized in Figure 19.

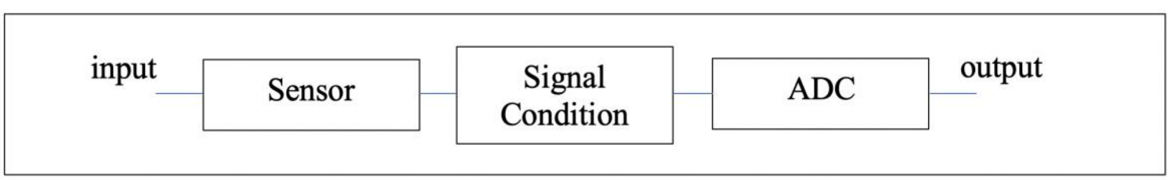


Figure 19 - Instrumentations and controls theory schematic.

Most of the accelerometers compatible with Python (for use with Raspberry Pi) had an onboard ADC. By finding an accelerometer compatible with the Raspberry Pi and that met the design needs, the measurement system would be complete without the need of an ADC. An important consideration was finding accelerometers without high resolution as the team is not interested in measuring high frequency vibrations but instead wave motion at low frequencies. A bit rate greater than 8 was also important to reduce the maximum quantization error or output resolution.

After considering several products, the Adafruit ADXL345 Three-Axis Accelerometer was selected for the design. At an input range of ±2g, a 10-bit rate provides a quantization error of 0.0038 m/s2 which appears good for the design needs of creating a low-cost and simple wave energy measuring device.

The measuring device consisted of a Raspberry Pi 4 Model B, an Adafruit ADXL345 Three-Axis Accelerometer, and a 10,400mAh battery with a 3A discharge rate (necessary for proper operation of the Raspberry Pi) through a USB-C port. Figure 20 is a schematic of the wave energy measuring device designed by the team.

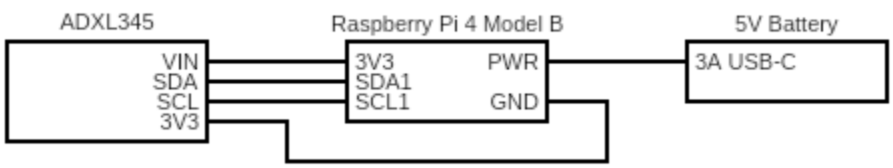


Figure 20 - Schematic of the wave energy measuring device.

The accelerometer was coded using Python through the Raspberry Pi. The default sampling rate of 100 Hz and a range of ±2g was used for initial test trials. Figure 21 shows a 10-second sample of acceleration values.

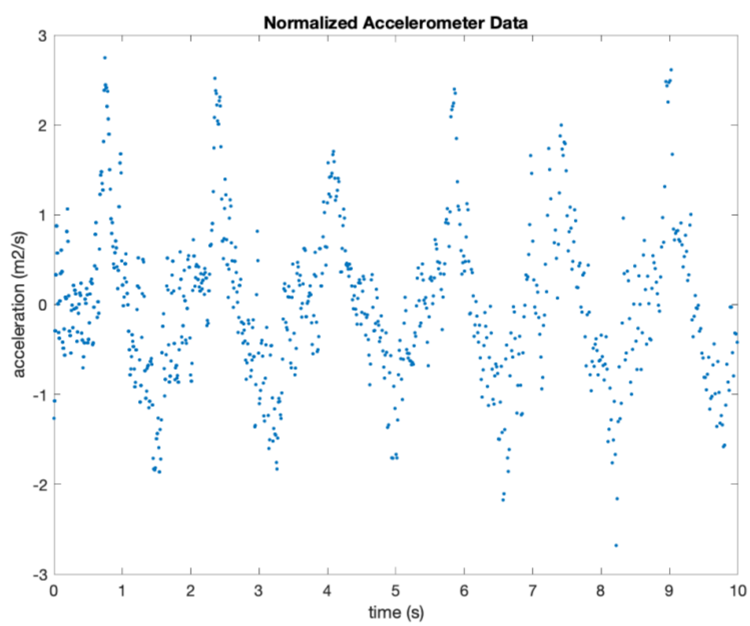


Figure 21 - Normalized accelerometer data in 10-second sample test.

Using a 4th order Butterworth low-pass filtering technique, the accelerometer values were cleaned up (see Figure 22), which allowed the team to use a 2-step trapezoidal numerical integration technique to calculate individual height values from data between a negative peak and a positive peak acceleration value. Obtaining a complete position graph for the whole test run was not feasible as too much noise in the acceleration data caused large deviations and inaccuracies over time. This was acceptable as the team only required obtaining individual wave heights and wave periods for calculating the energy of each individual wave.

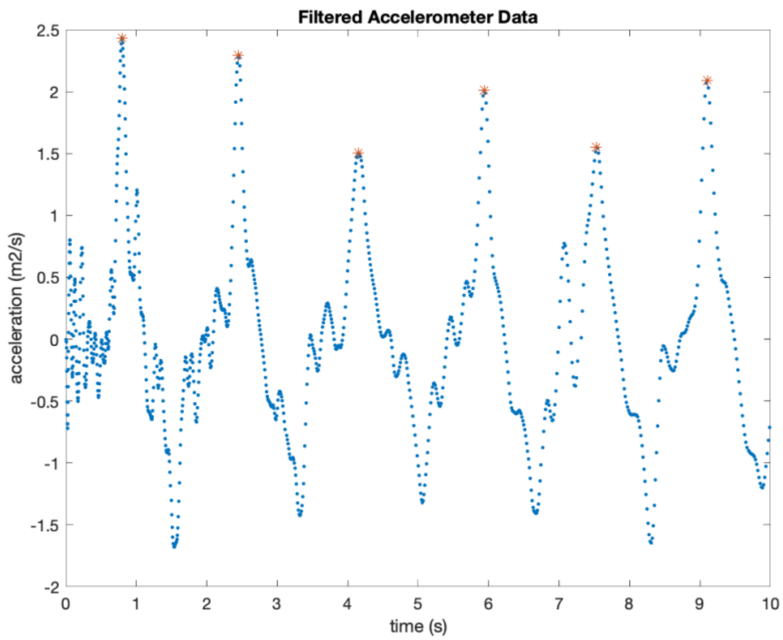


Figure 22 - Accelerometer data after passing through a 4th order Butterworth low-pass filter.

It was noticed from Figures 21 and 22 that the accelerometer's sampling rate was decreasing over time. At the beginning, the sampling rate was about 233 Hz and decreased to a steady 65 Hz by 7 seconds of data recording.

The dynamic sampling rate finding was further explored by plotting the at-rest acceleration values from the accelerometer (see Figure 23). After 3 seconds of data recording, three straight bands can be witnessed at about 9.81 m/s^2, 9.84 m/s^2, and 9.88 m/s^2. These bands turn out to be the quantization error of 0.038 m/s^2. What is more evident is that as the sampling rate approaches 65 Hz, the randomness or noise in the data decreases and is more aligned to the three bands.

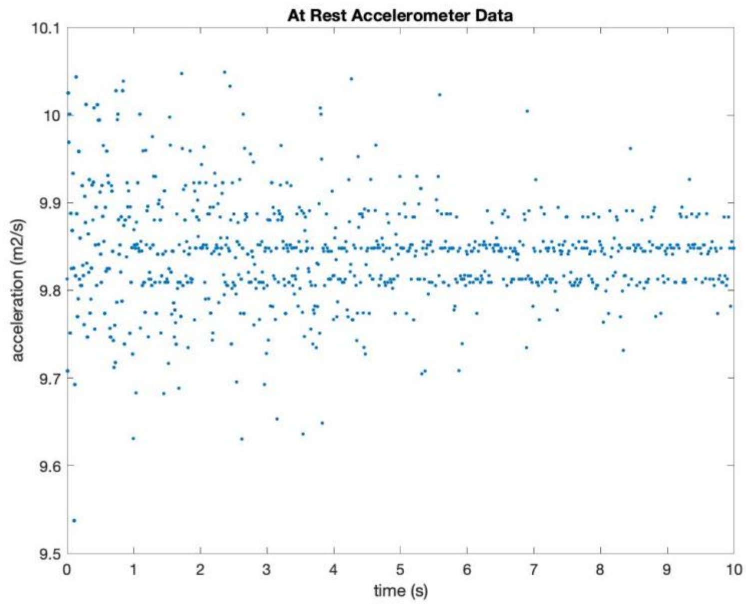


Figure 23 - At-rest accelerometer data.

To address this issue, the team fixed the sampling rate of the accelerometer to 50 Hz to avoid the large noise that could mitigate the ability to integrate and obtain accurate position values. Data is to be recorded only after a minimum 20 seconds of data collection to allow the noise to reduce and become stable. One future recommendation for a team is to look into filtering out the highest and lower bands using a filtering technique. A future team should also look into the scaling effects on the accelerometer data when applying filters. It was noticed that the period of the wave was slightly out of time after applying the Butterworth filter but was not critical to the team's ability to calculate wave heights or peaks.

A second concern of the wave energy measuring device was the inability to recognize tilt. Without knowing tilt, determining the vertical acceleration would have been difficult. This could be solved by including a gyroscope to the system. But for simplicity of the system, the team incorporated the accelerometer to the buoys being used to measure wave energy using the camera method. The Wave Energy Measuring Buoy (WEMB) was designed by the team and 3D printed using polylactic acid (PLA) filament. While the accelerometer is lodged in a slot on the WEMB, the rest of the electrical components were housed in a sealed food container with desiccant as a prevent measure in the case that water manages to infiltrate as seen in Figure 24.

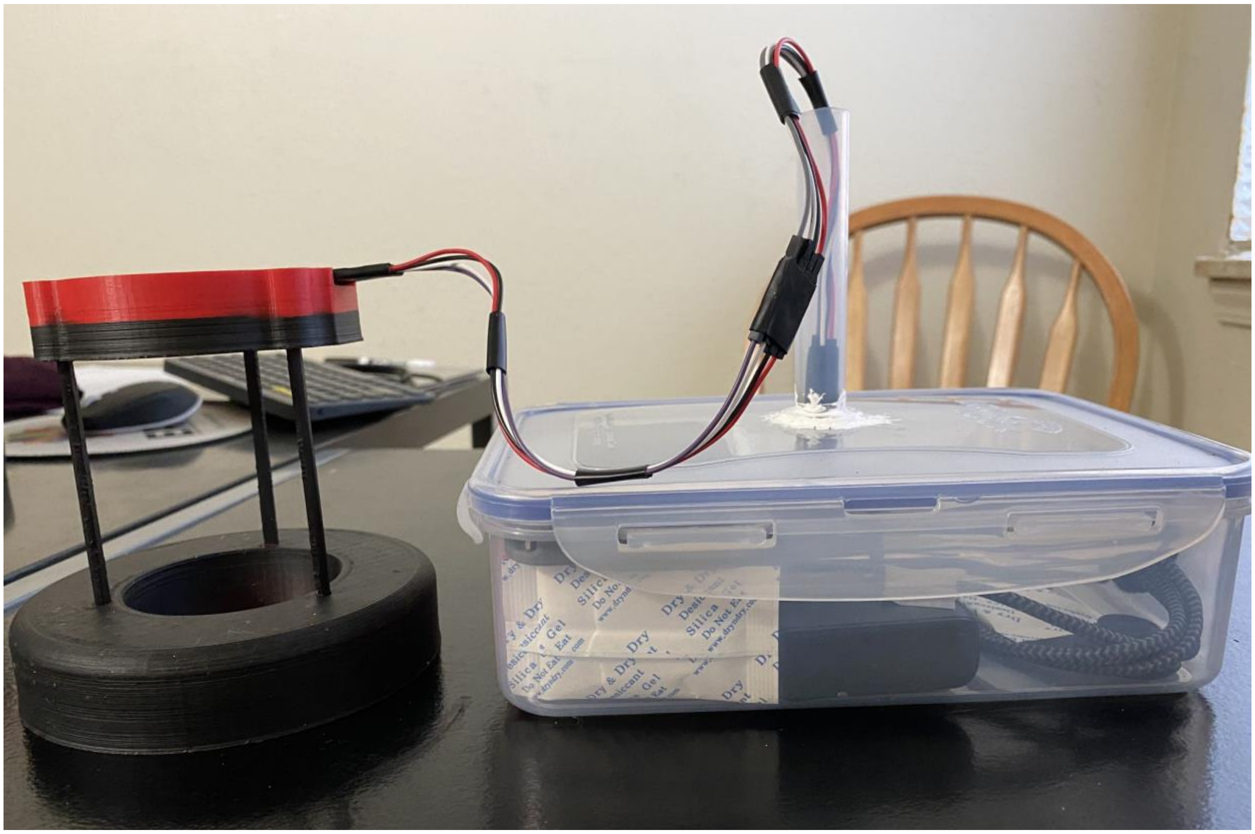


Figure 24 - Wave Energy Measuring Buoy and electrical component housing.

Testing

In order to properly determine which wave attenuators were the most efficient, a repeatable procedure had to be created. This procedure had to involve creating consistent waves and having an accurate way to measure the wave energy before and after attenuation. Ideally, this procedure would have involved a wave tank, where consistent artificial waves could be created. Because the Shiley School of Engineering only has a 6 inch-wide flume, the team had to produce an alternative procedure.

After consideration of different water sources, it was determined that the cove at the university's River Campus would be the best testing environment as it is very accessible, there are many dock pilings present to connect the attenuator, and it is relatively protected from the large, long-period waves created by boats in the Willamette River. Some alternatives considered included a small kiddy pool and testing at the Westmoreland Casting pond.

Multiple wave creation methods were considered. These included pushing water with a plastic bin lid, pushing water with the oar of a kayak, and dropping a large log in the water. It was determined that the best way to create consistent waves was by anchoring a kayak at a fixed distance from the attenuators and rocking the kayak back and forth in counts of five waves. This method created steady waves that travelled more linearly than other methods. Limiting the trials to five waves at a time minimized error due to reflection of waves off of the bank.

For the video processing method, a few alternative methods were considered. The first method involved a ping pong ball floating in the water and tracking its displacement before and after the attenuator. This method included a great deal of uncertainty. The team was influenced by the ping pong alternative to create the current system which involves a 3D printed buoy constrained by a PVC pipe fixed to the river floor via a shovel. This system eliminates many of the uncertainties associated with the ping pong alternative, such as lateral movement, and makes tracking the energy of the wave much more accurate. In using a video processing method to record wave height and periods, the team found alternatives for how videos of the wave test runs were to be recorded. The team's first iteration was recorded using game cameras as they are easily attachable to the dock pilings. These cameras had too low of a frame rate (27 fps) to conduct an in-depth analysis, so the team decided to record using cellphone cameras with a higher frame rate (60 fps).

Taking all of these factors and iterations into consideration, the team established the testing method described in detail below. Figure 25 illustrates the wave attenuation device's spatial arrangement and the wave energy measuring device positions relative to the attenuators.

Test Materials

- 2 Water waders.
- 1 Inflatable 2-person kayak.
- 2 2" diameter, 10' length PVC pipes (preferably dark colored).
- 2 shovels (straight handle).
- 2 5-gallon buckets.
- 2 25' long marine grade ropes.
- 2 3D printed floating rings.
- 2 phones with video recording of at least 1080p at 60 fps.
- 2 phone running bands w/ 2 short bungee cords.
- 3 wave attenuators in series.

Test Procedure

1. Inflate the 2-person kayak to proper pressure as suggested by the manufacturer.
2. Fill the two buckets half-way with sand and 1-2 medium sized rocks from the shoreline to serve as anchors.
3. Secure a rope to each bucket's handle with a proper knot that will not undo itself.
4. Wearing water waders, bring the wave attenuators into the water and tie them between 2 wooden pier posts that open out to an empty body of water that is deep.
5. Wearing life jackets, send two people out to the water on the kayak carrying the bucket anchors with them.
6. Using a PVC pipe, measure the kayak to a distance of 10 FT away from the wave attenuator.

7. Drop bucket anchors into the water once 10 FT distance has been reached. One bucket anchor on each side of the kayak. Make sure the loose ends of the ropes do not leave the kayak.
8. Secure the loose ends of the ropes on the kayak such that enough tension runs in the rope to keep the kayak as immobile as possible.
9. Using a PVC pipe, measure the depth of the water underneath the wave attenuators. Record the value.
10. Place a shovel upright on one side of the wave attenuator so that it is as immobile as possible. Repeat for the other side.
11. Slide one floating ring onto a PVC pipe.
12. Place the PVC pipe with the floating ring in water so that it goes over the shovel handle. Make sure labels on the PVC pipe are upright.
13. Repeat steps 11 and 12 for the other side of the attenuator.
14. Set up phone cameras on pier posts with at least 6 FT distance from the PVC pipe they will be filming. One is aimed to capture the incident waves, one aimed to capture the transmitted wave. The phone cameras will be secured using phone running bands and short bungee cords. Avoid capturing direct sunlight.
15. Measure and record water temperature.
16. Record the water depth gauge on each PVC pipe.
17. Start phone camera recording at about the same time when ready to start testing.
18. Create waves by having the two people on the kayak rock the kayak side-to-side in sync. Produce waves for 5 counts, stop to rest, and repeat these two actions for 10 total wave producing actions.
19. Stop recording on the phone cameras.
20. Clean up.

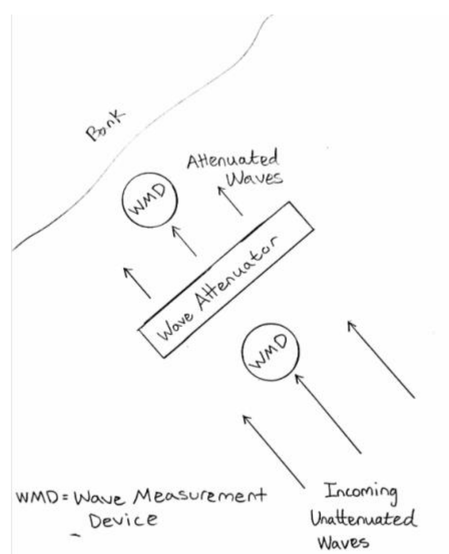


Figure 25 - Attenuator and measuring devices in testing.

Attenuator Analysis

The team's mechanical engineers approached the analysis of attenuator performance using frequency response analysis and video processing using MATLAB.

Video Processing Method

MATLAB was used to analyze the videos of the waves to establish an approximation for the average wave energy. This was accomplished by tracking the red portion of the buoy as seen in Figure 26. The MATLAB code takes the original video of a single wave trial and is cropped down to a 100 by 100 pixel video focused on the buoy. This is adjusted so all the red scale values are changed to white and then it is changed to grayscale. This cropped view can be seen in the top right corner of Figure 26. A vertical line of pixels is selected and the code looks for the brightest pixel in the array of pixels. This vertical line is represented by the green line in the cropped view and the red circle marks the brightest pixel for that particular frame. The graph in the bottom right corner of Figure 26 shows the grayscale value of each pixel along the green line for the current frame. The higher the grayscale value, the brighter the pixel. The locations of the brightest value for each frame are collected and are put onto the same graph in the lower left corner of Figure 26.

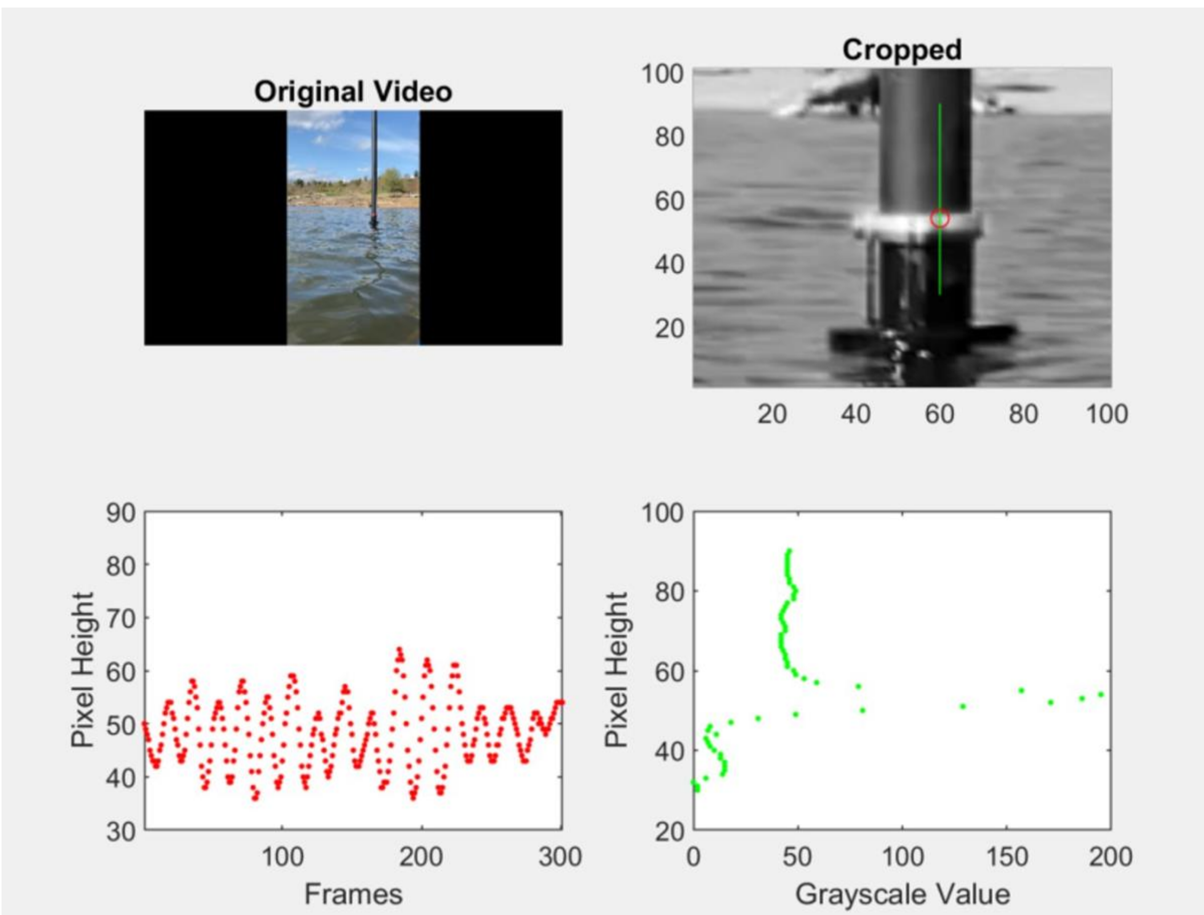


Figure 26 - MATLAB Analysis View.

After the MATLAB code ran for the duration of the video, MATLAB produced an output graph of the height of the wave in meters over time as seen in Figure 27. The graph is created from the pixel height over frames graph. The conversion is made using a pixel conversion ratio, which uses known dimensions of an object and compares the value to the same dimension in terms of pixels. The other conversion uses the ratio seconds over frames for the video. In addition to the graph, MATLAB would output four different variables: maximum amplitude, average amplitude, average period, and average wave energy. The code for the video processing method can be found in Appendix I.

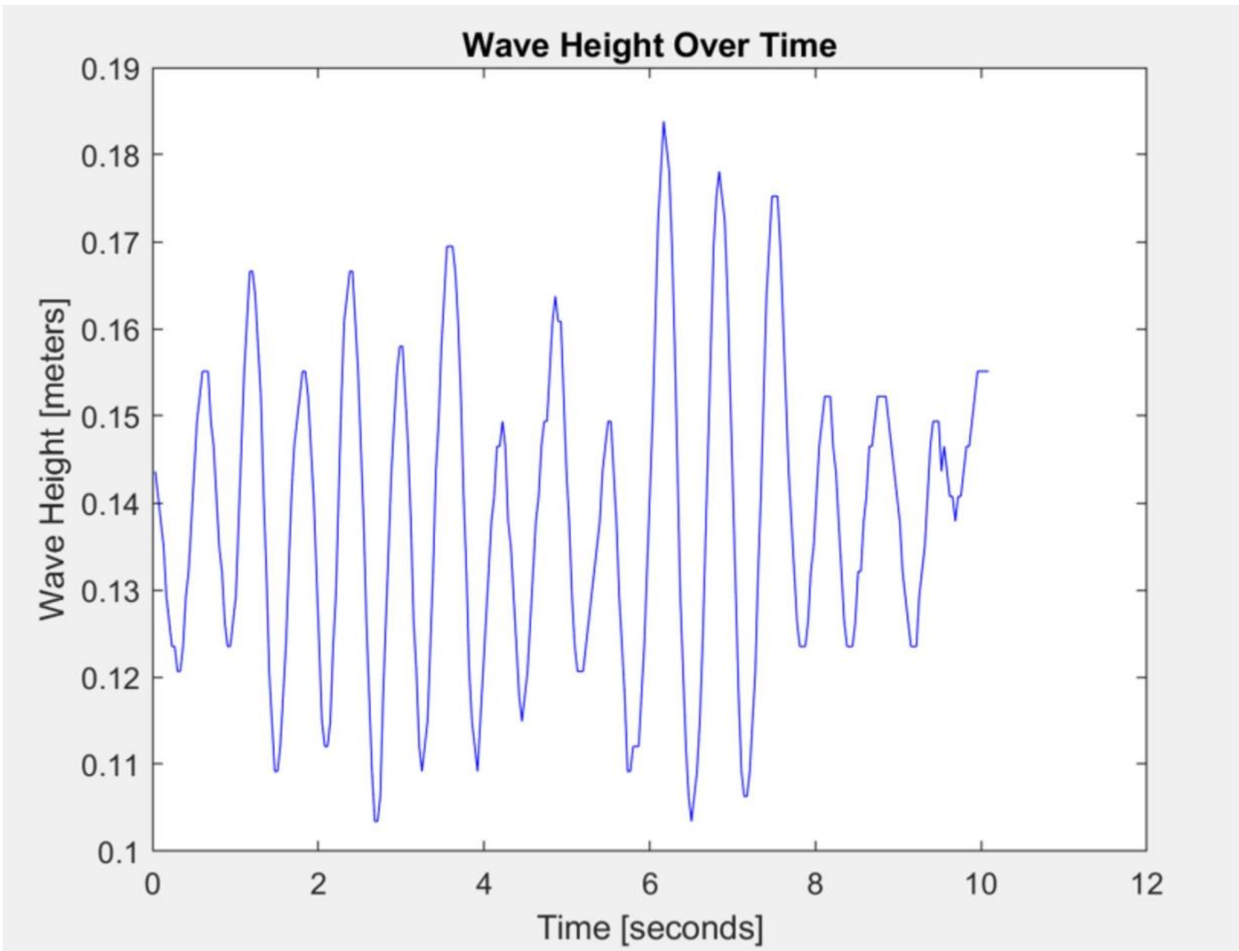


Figure 27 - MATLAB Output Graph.

Table 2 - Results from video processing method.

Type	Time	Maximum Amplitude (m)	Average Amplitude (m)	Average Period (s)	Average Energy (W/m)	Energy Dissipation (%)
No Attenuator	before	0.0623	0.0457	1.39	1.41	27.8
	after	0.0579	0.041	1.36	1.13	
Jute with Rope	before	0.0897	0.0604	1.51	2.73	82.0
	after	0.0404	0.0247	1.57	0.469	
Jute with Carabiners	before	0.0858	0.0577	1.51	2.47	77.2
	after	0.0358	0.0462	1.58	0.538	
Cables with Rope	before	0.0709	0.0536	1.38	2.14	80.1
	after	0.0399	0.0242	1.38	0.391	
Cables with Carabiners	before	0.0894	0.0688	1.64	3.77	72.5
	after	0.0531	0.0344	1.56	0.913	

The results show the most successful attenuator is the jute netting with the rope acting as the connector between the individual attenuators, with an average energy dissipation of 82%. This is a 54.2% increase from the control trials of no attenuator, which dissipated 27.8% of energy on average. For both the jute and the steel cable attenuators, the energy dissipation was higher when the rope was acting as the connector. The jute netting attenuators dissipated more energy in comparison to the steel cable in regards to the connection method used.

With the testing methods used, there are potential sources of error. The before PVC pole and buoy would be hit with a higher energy that led to some horizontal movement in addition to the vertical movement of which the code tracked. The horizontal motion was never an issue with the after PVC pole and buoy as it always had a lower wave energy, allowing all of the energy to translate into the vertical movement. Instances where there was horizontal movement in the before buoy lowers the energy dissipation as the full initial energy is not being calculated.

<u>Accelerometer Method</u>

In the testing field at the university's River Campus, the Wave Energy Measuring Buoy with an onboard accelerometer was turned on and the Raspberry Pi's Python script ran automatically for 3 minutes of data collection. The Raspberry Pi would automatically write the data onto the onboard SD card as long as the script was allowed to run to completion. The Python script is found in Appendix IV.

After completing testing, the accelerometer's data was imported to MATLAB where a script would normalize the acceleration data and apply a 4th order Butterworth filter to then estimate the wave heights through numerical integration of data from the high and low acceleration peaks. The MATLAB script for the acceleration method is found in Appendix II. Figure 28 shows the accelerometer data before and after applying the Butterworth filter.

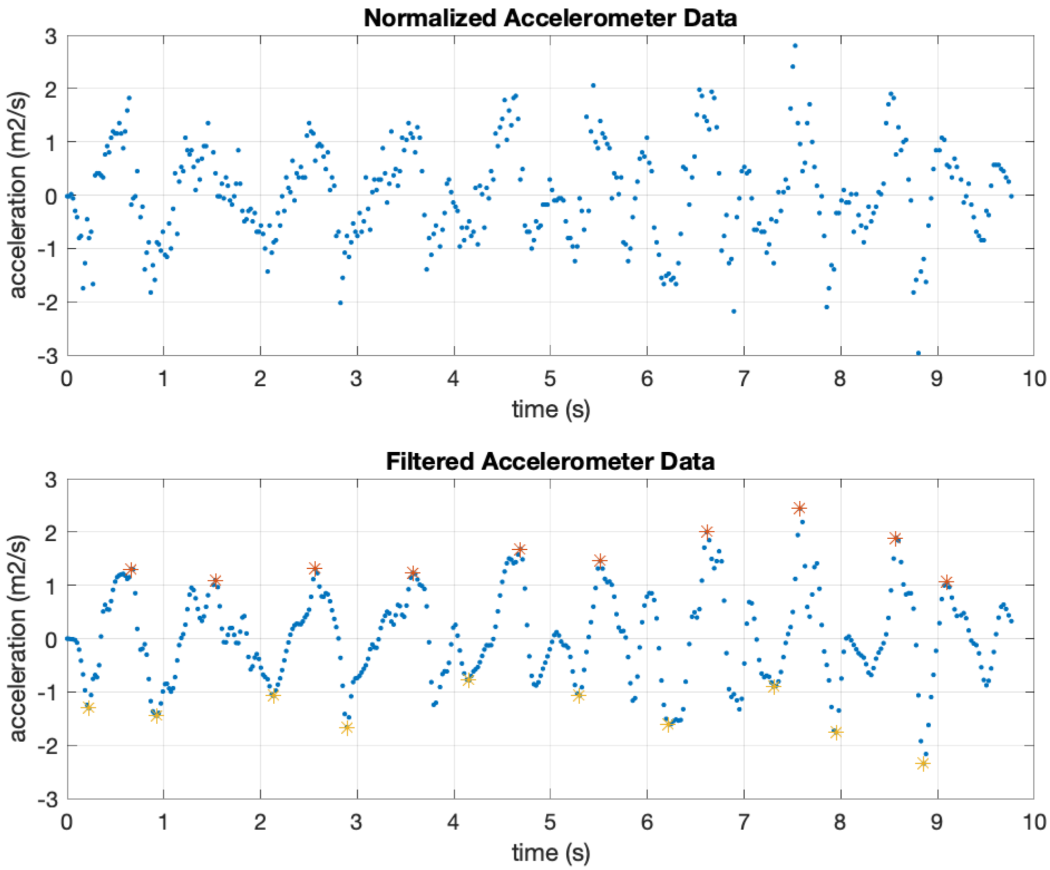


Figure 28 - Normalized accelerometer field data before and after applying Butterworth filter.

The estimated height values from the accelerometer were compared to that given through the video analysis method. An example comparison for a specific wave test run is shown in Figure 29. At first glance, there is a noticeable difference between the wave heights given between the two methods. The accelerometer seemed to give a more varied wave height difference compared to the video analysis method. But both methods are in agreement with the trend of successive wave heights in a wave test run.

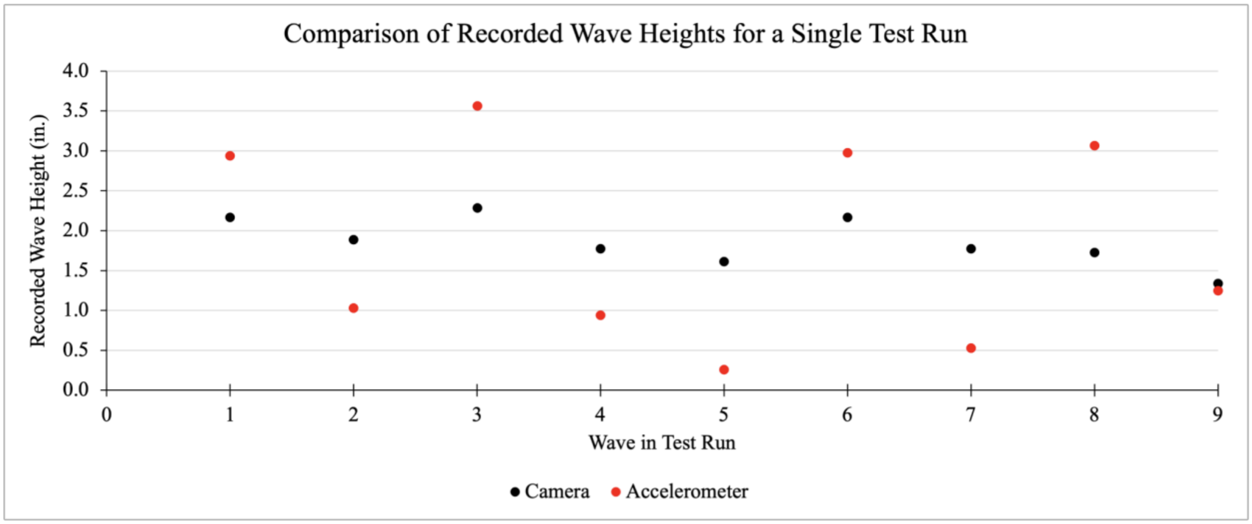


Figure 29 - Comparison of recorded wave heights for a single test run between video processing method and accelerometer method.

The video analysis method is conservative in that it will take minimum peaks. It would not be surprising to find wave heights around 3 inches. The accelerometer method's sources of error may include how the filter is applied such that it skews the peak heights. However, it is suspected that the main contributor to error is the accelerometer's quantization error of 0.038 m/s^2 that can make a difference when integrated over two powers to obtain position.

Because there is no certainty in whether the video processing method or the accelerometer's output wave heights are accurate over the other. A future capstone team should design a test that will help determine the precision and accuracy of both methods to a controlled oscillatory motion with known height.

Frequency Response Analysis

The team decided to use frequency response analysis as another method to determine the effectiveness of the prototypes. Modeling the system characteristics of the attenuators used for the video processing method would also allow new designs to be made for any waves based on the period and amplitude of the waves.

Logarithmic decrement was used to find two important vibrational characteristics of the attenuators: spring stiffness and damping constant. The logarithmic decrement denotes the rate at which the amplitude of a freely vibrating system decreases. It is determined from the natural logarithm of the ratio of two successive amplitudes or peaks, and the time response of vibration or period between two peaks.

An attenuator unit was first displaced under the water to get the initial displacement of the system. The attenuator unit was then released from its initial displacement so that subsequent peaks and periods could be estimated when playing back a recording of the test. Figure 30 shows an example using a cable attenuator where the initial displacement is the image on the left and then the image on the right was used to approximate a peak of oscillation of the attenuator. Based on the time stamp at the peak estimation, the period could be measured. With the successive peaks and time response measured, the system characteristics of the attenuators were determined which included the spring stiffness, damping constant, undamped natural frequency, and damping ratio.

Figure 30 - Initial condition (left) and a peak (right) used for logarithmic decrement.

From Table 3, the jute attenuator had more mass and damping than the cable attenuator which could be attributed to the jute netting being water absorbent as that would increase the weight and decrease the buoyancy of the attenuator in the water. The attenuator would therefore be more rigid in the water keeping it from oscillating with incoming waves which would be more effective for wave dissipation.

Table 3 - System characteristics of the jute and cable attenuators.

System Characteristic	Jute Attenuator	Cable Attenuator
Mass (kg)	13	10
Spring Stiffness (N/m)	540	710
Damping Coefficient (N*s/m)	49	28
Undamped Natural Frequency (rad/s)	7	9
Damping Ratio (-)	0.3	0.2
Magnification Factor at Undamped Natural Frequency of the Waves (10.83 rad/s)	0.7	1

With the known characteristics of the attenuators, the displacement and velocity of the attenuators can be plotted over time while they attenuate incoming waves by using the frequency of oscillations from the waves experienced during testing, and then compared to the response of the waves if the response of the waves is assumed to be simple and sinusoidal. This was achieved by modeling the system as a base-excitation system. This model assumes that the excitation frequency of the waves is the only external forcing element that affects the attenuator system's motion. In reality, there are other forces coming into play such as viscous drag, buoyancy force, and gravitational force. However, including all these forces would make the model too complex to derive equations of motion needed to generate the frequency response of the model. Figure 31 depicts a schematic of the base excitation system. From Figure 31, the equation of motion could be derived, as shown by Equation 3. With the equation of motion, the magnification factor function could be derived, as shown by Equation 4.

$$f(t,x) = \frac{Ak\sin(\omega t)}{m} + \frac{Ac\omega\cos(\omega t)}{m} - \frac{c}{mx_1} - \frac{k}{mx_2} \quad (3)$$

$$T(j) = \frac{cj\omega + k}{-m\omega^2 + cj\omega + k} \quad (4)$$

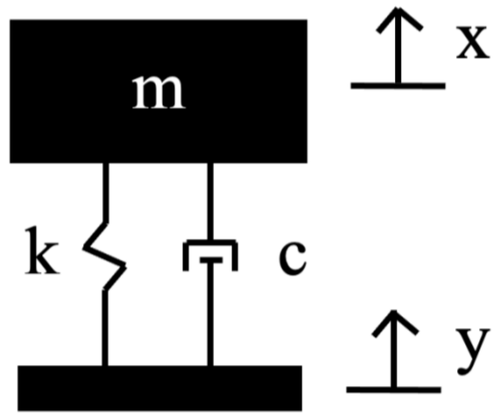


Figure 31 - Base excitation model schematic.

The cable attenuator's displacement and velocity are greater in magnitude than the jute attenuator according to Figure 32. Both curves for the jute and cable attenuators are also shifted in phase from the wave profile. These results do not indicate which attenuator would best attenuate the waves as the displacement and velocity plots are for the attenuators, not the profile of the waves after they have been attenuated. Though, the plots are useful in providing confidence in the models used for frequency response as the displacement and velocity curves match what was observed by the team visually when testing the attenuators using the video processing method.

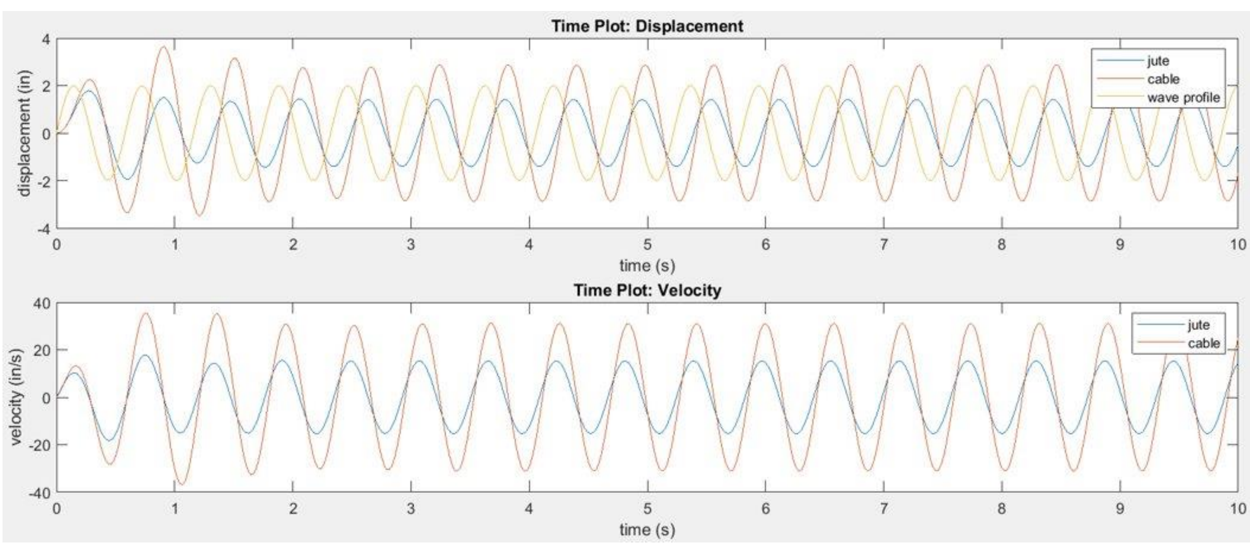


Figure 32 - Displacement and velocity plots of the jute and cable attenuators.

The frequency response plots indicate that the cable attenuator oscillates at a higher amplitude when excited at the frequency of the waves used for testing. This can be observed by comparing the magnification factors in Table 3 where the cable attenuator has a value of 1, and the jute attenuator has a value of 0.7. The team observed that when the period of the waves was low enough and the amplitude of the waves were high enough, the attenuator would oscillate with the waves and not attenuate the waves. The team assumed then that when an attenuator has a higher magnification factor at the frequency of oscillation of the waves, they will not dissipate wave energy as effectively as a lower magnification factor. Figure 33 indicates that the cable attenuator also has an excitation frequency closer to the undamped frequency of the waves used for testing than the jute attenuator. The magnification factor at that excitation frequency of the cable attenuator also has a higher magnitude than the jute attenuator's magnification factor. Both these factors led the team to conclude that the jute attenuator was the better design for dissipating wave energy.

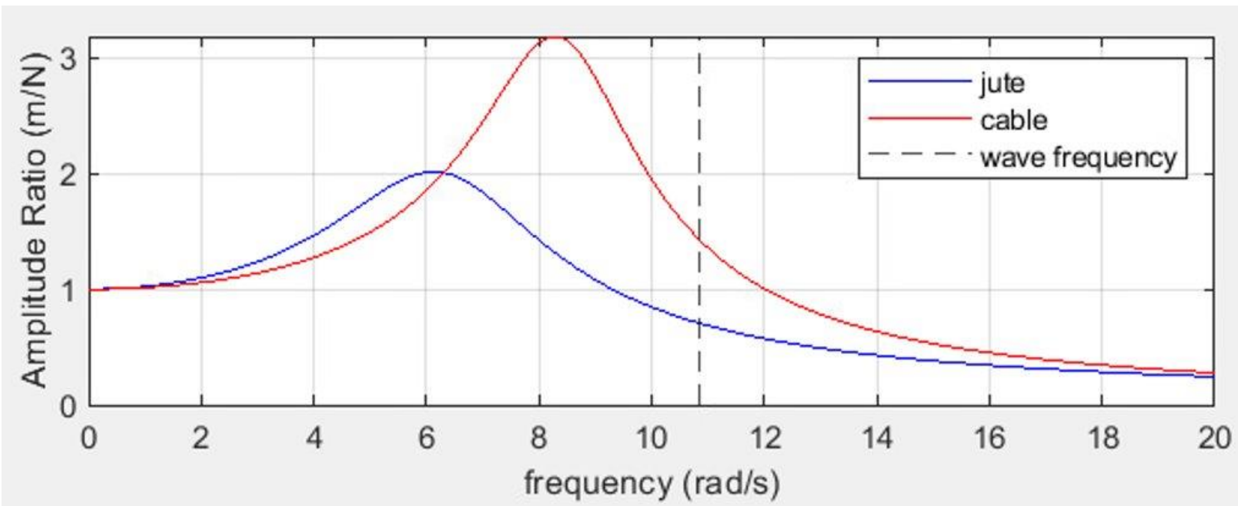


Figure 33 - Frequency response plot comparison of the jute and cable attenuators, with an asymptote at the frequency of the waves used for testing.

Future improvements to the frequency response models could include a more complex model accounting for additional degrees of freedom such as buoyancy and gravity effects. An analysis on the effects of drag and how to incorporate those forces into the response would also strengthen the accuracy of the models.

Cost Estimate

A cost estimate was drafted to forecast how the team's attenuator solutions, if implemented for homeowner use, would compare to the next available option that a homeowner would resort to protect the riverbank lining their property. Riprap is that next available option for many homeowners. The problem with riprap is that the State of Oregon and the USACE requires homeowners to file and obtain permits to place riprap in the river. The scale of riprap placement often means that homeowners will find a contractor to apply riprap on their property which can become very expensive depending on the cubic yards of riprap that must be applied and the condition of the embankment they will be working in.

Table 4 summarizes the cost estimate for protecting 15 linear feet of riverbank while Table 5 summarizes the cost estimate for protecting 150 linear feet of riverbank. Both tables show that riprap is a significantly more expensive erosion control method compared to using the team's attenuator solution. The attenuators are significantly more affordable options compared to riprap, a typical next available option for homeowners. The more expensive configuration of the attenuators is about 50% of the cost of putting down riprap. A more thorough estimate is found in Appendix IX.

Table 4 - Cost estimate of protecting 15 linear feet of riverbank.

Erosion Control Method	Estimated Cost
Riprap	$650
Jute Attenuator with Rope	$100
Jute Attenuator with Carabiner	$170
Cable Attenuator with Rope	$170
Cable Attenuator with Carabiner	$240

Table 5 - Cost estimate of protecting 150 LF of riverbank.

Erosion Control Method	Estimated Cost
Riprap	$4,650
Jute Attenuator with Rope	$990
Jute Attenuator with Carabiner	$1,755
Cable Attenuator with Rope	$1,705
Cable Attenuator with Carabiner	$2,475

It is important to note that the cost estimate for the attenuators assumes that no permits will be required to be filed and obtained by the homeowner. This assumption is based on interactions with homeowners in the Willamette River area of study who already have docks or other pilings in place where the wave attenuators can be tied to. In the case that a homeowner does not have two pilings in the river that can serve as attenuator tie points, a permit may be required if the homeowner is to insert a new piling or pole in the river to serve as a tie point to secure the attenuators in place so they do not float away.

A second assumption in the cost estimate is that there will be no installation costs. The team's vision is to have this erosion control method be simple enough for a homeowner to build and install using their own hands and tools. But if homeowners do not have the capability to do this by themselves, they may want to hire someone to build and install these attenuators for them.

A third assumption is that the homeowner will purchase the logs needed to build these attenuators. The cost estimate is based on obtaining 5" diameter logs at $5.00 for each 1.5-foot length attenuator unit. However, it is already common for some homeowners on the Willamette River to have access to such logs that wash up on their property during heavy rains and floods, or they readily have such wood available on their property. In such a case, attenuator costs will be much less than estimated in the tables above.

Conclusion

The purpose of the WAVES capstone project was to design a wave attenuation device that dissipates at least 50% of the incoming wave energy produced by recreational boating activity on the Willamette River. Four wave attenuator designs were drafted, built, and tested on River Campus of the University of Portland on the Willamette River.

The team met and exceeded the original scope of the project as all four attenuator options attenuated more than 50% of the incoming wave energy in the test environment. The most effective attenuator configuration was the jute netting with rope which averaged an 82% energy dissipation. However, the effectiveness of the attenuators on boat wakes in the Newberg Pool portion of the Willamette River is unknown. Wake boating season starts in May so the team was unable to test in the conditions the attenuators would be used in. There is data on waves in this portion of the river from research performed in the summer of 2019, but due to changes in data collection and new boating regulations, correlation between waves previously experienced and the capstone data cannot be accurately guaranteed. Another factor of attenuators being effective is the boaters themselves. If boaters follow speed regulations and stay closer to the center of the river, the attenuators will be more successful in attenuating the waves.

The models created from frequency response analysis will aid in the design process for future improvements to the wave attenuator designs. Using expected frequency of the waves, users can input the wave characteristics into the model and alter the system characteristics of the attenuator model to achieve a frequency response that would be ideal for attenuating that particular wave. With the altered system characteristics, the user can have an idea of what mass, stiffness, or damping a design should achieve rather than blindly building a device without any confidence or data to predict that it will attenuate the waves.

The team met the five main design criteria for the project as follows: reducing erosion, adhering to environmental regulations, being mobile, being simple, and costing under $3,000 (the homeowner's next available option). The prototype reduced energy that would cause erosion. As the prototype floats freely and is simply tied to preexisting structures, it does not require a state permit to add the system and it follows environmental regulations. Additionally, the prototype is primarily built from sustainably sourced materials and is not expected to significantly add toxic or regulated materials to the river. The prototype is relatively lightweight and can be easily put together and taken apart by the homeowner. Its simple design has few parts that can be put together in about ten minutes. Lastly, the prototype is cost effective and is estimated to cost about two times less than riprap, the homeowner's next available option for erosion control.

For future improvements to the attenuator design, a future team can look into adding fins to keep each attenuator unit from spinning and reduce its motion in the direction of the wave. It would also be good to improve the frequency response model and explore how viscous drag, gravity, buoyancy force, and other variables affects the prototype's response to an excitation force.

The WAVES capstone team had several ideas that were not explored in this project due to time constraints. Future teams can instead look into these ideas and pick up where the current WAVES team left off. One idea is to conduct attenuator tests during summer months in the locations in the Newberg pool to see how wave energy variation changes across the seasons. Additionally, a future team can find a boat owner willing to generate waves that would be expected of recreation boating activity in the Willamette River. This will provide test data that can help the team refine their attenuator design to perform better under expected wave amplitudes and periods. There is also an opportunity to explore the wave energy capture device concept further and develop a prototype that a homeowner will obtain value from.

Acknowledgements

Special thanks to Dr. Dillon, Dr. Poor, Dr. Doughty, Dr. Farina, Mr. Galati, ORSPA, Matt Libby (Outdoor Pursuits Program), and the University of Portland Shiley School of Engineering.

References

Ahmad, M. F., Yusoff, M.F., Husain, M. L., Wan Nik, W. M. N., & Muzathik, A. M. (2011, July). *An investigation of boat wakes wave energy: a case study of Kamaman River Estuary.* University Malaysia Terengganu. http://www.seu.ac.lk/staff/academic/fe/muzathik/papers_conference/An%20Investigation%20of%20Boat%20Wakes%20Wave%20Energy%20A%20Case%20Study%20of%20Kemaman%20River%20Estuary.pdf

Brown University School of Engineering. *Introduction to Dynamics and Vibrations.*

Craig, J. (n.d.). *Generating Energy from Boat Wake Using Ocean Buoy Technology.* https://ufdcimages.uflib.ufl.edu/AA/00/06/92/10/00001/JCraig_Final_Submission_Research_Thesis.pdf

Dorava, J.M., & Moore, G. W. (1997). *Effects of Boatwakes on Streambank Erosion Kenai River, Alaska.* U.S. Geological Survey. https://pubs.usgs.gov/wri/1997/4105/report.pdf

D'Aquino, C., Scharlau, C., & Vecchia, L. (2019, January 22). *Evaluation of energy extraction of small-scale wave energy converter.* Universidade Federal de Santa Catarina. https://www.scielo.br/scielo.php?script=sci_arttext&pid=S2318-03312019000100213

Figurski, J. D., Malone, D., Lacy, J. R., & Denny, M. (2011). *An inexpensive instrument for measuring wave exposure and wave velocity.* Limnology and Oceanography, Inc.https://aslopubs.onlinelibrary.wiley.com/doi/abs/10.4319/lom.2011.9.204

Fisheries, N. O. A. A. (2021, February 26). *Upper Willamette River Chinook Salmon*. NOAA. https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/upper-willamette-river-chinook-salmon#:~:text=The%20Upper%20Willamette%20River%20Chinook,under%20the%20Endangered%20Species%20Act.

Gaffney, D., & Munoz, R. (2010, November 16). *Effectiveness of floating wave attenuators for restoring and protecting coastal marsh.* Restore America's Estuaries. https://www.yumpu.com/en/document/read/36399455/wave-attenuation-restore-americas-estuaries

Gore, G. (2006, June 28). *Scaled modeling and Simulation of Ocean Wave Linear Generator Buoy Systems.*

Goshow, C. (2019, December 4). *Understanding Floating Wave Attenuators.* International Waterfront Consultants. https://docksexpo.com/wp-content/uploads/2018/12/Wave-Attenuators-Goshow.pdf

Hales, L. Z. (1981, October). *Floating Breakwaters: State-of -the-Art Literature Review.* U.S. Army Corps of Engineers. https://apps.dtic.mil/dtic/tr/fulltext/u2/a110692.pdf

Hendry-Brogan, M. (2004, September). *Design of a Mobile Coastal Communications Buoy.* Massachusetts Institute of Technology. https://dspace.mit.edu/handle/1721.1/33584

Johnson, C., Affolter, M. D., Inkenbrandt, P., & Mosher, C. (2020, August 5). *12.1: Waves and Wave Processes.* Salt Lake Community College. https://geo.libretexts.org/Bookshelves/Geology/Book%3A_An_Introduction_to_Geology_(Johnson_Affolter_Inkenbrandt_and_Mosher)/12%3A__Coastlines/12.01%3A_Waves_and_Wave_Processes

Lent, B. (2018, September 11). *Simple Steps to Selecting the Right Accelerometer.* Fierce Electronics. https://www.fierceelectronics.com/components/simple-steps-to-selecting-right-accelerometer-0

Mack, P. (n.d.). *Marine Energy Potential in New Zealand.* https://personal.ems.psu.edu/~fkd/courses/egee_497/2017/final/mackphillip.pdf

M. A. S. P. D, *Evaluation of ocean-energy conversion based on linear generator concepts.*

Monterey Bay Aquarium Research Institute. (2012, May 14). *Floating "Power Buoy" Creates Electricity from Ocean Waves.* SciTechDaily. https://scitechdaily.com/floating-power-buoy-creates-electricity-from-ocean-waves

Mraz, S. (2004, July 8). *Finding the right sensor for linear displacement.* MachineDesign. https://www.machinedesign.com/automation-iiot/sensors/article/21832514/finding-the-right-sensor-for-linear-displacement

Oregon State Marine Board. (n.d.). *Watching your Wake.* https://static1.squarespace.com/static/5a0ba0f9e5dd5bce46ef4ed2/t/5b095af16d2a73781cf260a6/1527339774803/Watch+Your+Wake.pdf

Oregon State Marine Board. (2020). *Towed Watersports Education Program.* Oregon.gov. https://www.oregon.gov/osmb/boater-info/Pages/Towed-Watersports-Education-Program.aspx

Oregon State Marine Board. (2020). *Waterway Markers.* Oregon.gov. https://www.oregon.gov/osmb/boater-info/Pages/Waterway-Markers.aspx

Raspberry Pi Foundation. (2020). *Raspberry Pi 4 Tech Specs.* https://www.raspberrypi.org/products/raspberry-pi-4-model-b/specifications/?resellerType=home

Reimagine Seaside Engineering. (n.d.). *Wave Attenuator Systems.* R.S.E. http://warnerparkbeach.weebly.com/wave-attenuator-systems.html

Ruezga, A., & Canedo, J. (2020, April). *Buoy Analysis in a Point-Absorber Wave Energy Converter.* IEEE Journal of Oceanic Engineering. https://ieeexplore.ieee.org/document/8630594

Sandbaggy.com. *Jute Netting Roll - Erosion Control Matting.* https://sandbaggy.com/products/jute-netting?variant=32793005817961&currency=USD&utm_source=google&utm_medium=cpc&utm_campaign=google+shopping&utm_campaign=gs-2019-01-17&utm_source=google&utm_medium=smart_campaign&gclid=Cj0KCQjw28T8BRDbARIsAEOMBcwMx5S0KkdyQlHbmmXHmg6MNzH_kHgm26iuB7AaNSRA5i-htHik1poaArZdEALw_wcB

Scientific and Technical Advisory Committee. (2017, May 12). *Review of boat wake wave impacts on shoreline erosion and potential solutions for the Chesapeake Bay.* STAC Publication. http://ccrm.vims.edu/2017_BoatWakeReviewReport.pdf

The European Marine Energy Centre LTD. (2020). *Wave Devices.* EMEC. http://www.emec.org.uk/marine-energy/wave-devices/

Thurman, H. V., & Trujillo, A. P. (2001). *Essentials of Oceanography: Seventh edition.* Prentice Hall.

Vranish, J. (2014, October 12). *Using the Raspberry Pi as a Simple Current and Power Meter.* Atomic Object. https://spin.atomicobject.com/2014/10/12/raspberry-pi-current-power-meter/

WakeMAKERS. (2020). *WakeMAKERS How-To: Weighting Your Boat For Wakesurfing.* https://www.wakemakers.com/resources/how-to-weight-your-boat-for-wakesurfing

Appendices

Appendix I

MATLAB Code for Video Processing Analysis

```
%% Wave frequency and height
% Heather Dillon
% revised by Rachel Anderson

clear all
close all

%% Things to change for every video
% Movie Name
mymovie = VideoReader('Apr_09_after_jute_c_10.mp4') % <- change
the filename here


% read the video
vidframes = read(mymovie);
% find the number of frames
numFrames = get(mymovie,'numberofFrames');
% find the duration of the movie
duration = get(mymovie,'duration');
% establish the frame rate of the video
frate = duration/numFrames; %sec/frame

% Input the starting and ending frame
start= 1; %Default here is 1.
%stop = start + 50; % add 50 - 100 frames to the start to test
the code and
%de-bug
stop = numFrames; % use this line to analyze the full video
% find the frame length of the video
framelength=stop-start;



%% Things to change or check for each new batch of videos
% X and Y start for cropping. Currently crops to a 100 by 100
frame.
xstart = 900;
ystart = 500;

% Location information for the green vertical line. this needs
to be
% adjusted to sit over the red portion of the buoy
% Column for analysis
w = 45; % x location for the bottom of the green line
v = 30; % y location for the bottom of the green vertical line
h = 60; % Height of the green line. Default for this is 50, but
you may need to incre
```

```
d = 65; % Height for single pixel tracker

% The unit conversion. Use the small grayscale image and measure
a known
% width.
convert = 2.375/21; %inches of known item/pixels of known item


%% Import Movie

% Loop through each frame and process it. Time consuming so do
it with just
% a couple frames

for k = 1:stop
    mov(k).cdata = vidframes(:,:,:,k)
    mov(k).colormap = [];
end

% Plot one frame for calibration
figure;
IM = frame2im(mov(3));
IM = rgb2gray(IM);%convert to greyscale
IM = double(IM);%double precision
IM = flipud(IM);
%IM = imresize(IM,[m,n]);
%imshow((IM)) %plot image
pcolor(IM)
shading interp
colormap(gray)
drawnow


% % %% Create MATLAB Video
%  vv = VideoWriter('AnalysisVideo','MPEG-4')%creates a video
file
%  open(vv);%opens video in order to add frames

% For Loop above loops through each Frame and operates on it,
show in Matlab figure window
%% Analysis Code
 m = 100;%crop image
 n = 100;%crop image


figure;
for j = start:stop
```

```
     %Assign current frame to name IM and convert to an image
     IM = frame2im(mov(j));
     IM1 = IM;%renames image for imshow command later
     subplot(2,2,1)
     imshow((IM)) %plot image
     title('Original Video')

    % IM2 = rgb2gray(IM);%convert to greyscale
     IM2 = IM(:,:,1);%grab red matrix only
     IM2 = double(IM2);%double precision
     IM2 = flipud(IM2);
     IM2 = IM2(ystart:ystart+n, xstart:xstart+m); %crop the
frame
     subplot(2,2,2)
     pcolor(IM2)
     shading interp
     colormap(gray)
     drawnow
     hold on
     plot([w,w],[v,v+h],'g-')
     drawnow
     hold on
     title('Cropped')

    vector = IM2(v:v+h,w);
    height = v:v+h;
    [val,ind] = max(vector); %max is the whitest, min is the
darkest. White is 256
    hs(j-start + 1) = height(ind); % save the height each time,
in pixels
    vs(j-start + 1) = val;

    % add this to the plot
    hold on
    plot(w,hs(j-start + 1),'ro') %plot the pixel that has the
max/min color
    drawnow
    dpixel(j-start + 1) = IM2(w,d); % save the color at a
specific location


    subplot(2,2,3)
    plot(start:j,hs,'r.')
    axis([1 stop v v+h])
    xlabel('Frames')
    ylabel('Pixel Height')
```

```
    subplot(2,2,4)
    plot(vector,height,'g.')
    %hold on
    %plot(val, hs(j),'ro')

    xlabel('Grayscale Value')
    ylabel('Pixel Height')


%       F1 = getframe(gcf); %puts figure into a frame
%       writeVideo(vv,F1);
%
end

%Convert to inches and seconds
hsin = hs*convert; %now in inches
time = (1:framelength +1)*frate;
figure;
plot(time(1:framelength +1), hsin(1:framelength +1),'b-')
xlabel('Time [seconds]')
ylabel('Wave Height [inches]')


%Convert to meters and seconds
hsm = hs*convert*0.0254; %now in meters
time = (1:framelength +1)*frate;
figure;
plot(time(1:framelength +1), hsm(1:framelength +1),'b-')
xlabel('Time [seconds]')
ylabel('Wave Height [meters]')
title('Wave Height Over Time')

% Find peaks
[pks,locs] = findpeaks(hsm,time,'MinPeakDistance',1);

% Determine the valleys
[vpks,vlocs] = findpeaks(-1*hsm,time,'MinPeakDistance',1);
for i=1:length(vlocs)
    valleys(i) = hsm(time==vlocs(i));
end

%adjust peaks and valleys arrays if one is longer than the other
    if length(valleys) > length(pks)
        peak = pks;
        valley = valleys(1:length(valleys)-1);
    end
    if length(valleys) < length(pks)
```

```
        valley = valleys;
        peak = pks(1:length(pks)-1);
    end
    if length(valleys) == length(pks)
        valley = valleys;
        peak = pks;
    end
 % calculate an initial amplitude array
for i=1:length(peak)
    amp(i) = peak(i)-valley(i);
end


% Valleys again
for i=1:length(pks)-1
    loc1 = find(time==locs(i));
    loc2 = find(time==locs(i+1));
    test = hsm(loc1:loc2);
    [val1, valloc] = min(test);
    valleys2(i) = val1;
    vlocs2(i) = valloc;
    amp(i) = pks(i)-val1;
end


% plot with the peaks and valleys circles to indicate locations
figure;
plot(time(1:framelength +1), hsm(1:framelength +1),'b-')
xlabel('Time [seconds]')
ylabel('Wave Height [meters]')
hold on
plot(locs,pks,'bo')
hold on
plot(vlocs, valleys,'go')
%savefig(outfigure)

period = diff(locs);%calculate period
avgperiod = mean(period) %seconds

% find max and average amplitude
avgamplitude = mean(amp) %m
maxamp = max(amp) %m

average_energy
=(997*(9.8^2)*avgamplitude^2*avgperiod)/(64*3.14)%calculate avg
energy
```

```
% Save the key data
%save(outfile, 'time', 'hsm', 'amp', 'pks');

%       F1 = getframe(gcf); %puts figure into a frame
%       for l=1:4
%       writeVideo(vv,F1);
%       end
%
% %
% close(vv)
% %
%
%
%
%
```

Appendix II

MATLAB Code for Accelerometer Analysis

MATLAB Code for Accelerometer Method

```
clear all
close all
clc

% Code for calculating individual wave heights from accelerometer data
% Data is imported from Raspberry Pi CSV file of test data.

%% Import Accelerometer Data Here
data_raw = readmatrix('20210413-181324.csv'); %imports accelerometer data
time_raw = data_raw(:,1);
time_raw = time_raw.*10^(-9);
x_raw = data_raw(:,2); % m/s^2 (static)
y_raw = data_raw(:,3);
z_raw = data_raw(:,4);
%accel = sqrt(x_raw.^2+y_raw.^2+z_raw.^2);
accel = y_raw; % z-axis corresponds to accelerometer y-axis
g_norm = 10.02; %modify until average centered around zero
%g_norm = 9.8665; %Adafruit Code

% Normalize time data
for i = 1:length(time_raw)
    t(i) = time_raw(i)-time_raw(1); % seconds
end
t = t';

%crop data
t(end) = [];
accel(end) = [];

% plot(x_raw)
% hold on
% plot(y_raw)
% plot(z_raw)
% plot(accel)
% legend('x','y','z','mag')

%% Normalize acceleration data
for i = 1:length(accel)
    accel_z(i) = accel(i)+g_norm; %acceleration should go negative first
end

figure(1)
plot(t,accel_z,'-.')
xlabel('time (s)')
ylabel('acceleration (m2/s)')
title('Normalized Accelerometer Data')
grid on

%% Reset time at a zero acceleration that will increase.
norm_indx = 1420; %adjust to where acceleration is near zero before peaking.
adj = t(norm_indx); % time point where zero velocity occurs.
t_adj = t;
t_adj(1:(norm_indx-1)) = [];
```

```
for i = 1:length(t_adj)
    t_adj(i) = t_adj(i)-adj; %for numerical integration
end

accel_adj = accel_z;
accel_adj(1:(norm_indx-1))=[];

%norm_indx = 411; % time point for cut off
norm_indx = 414;
t_adj((norm_indx+1):end) = [];
accel_adj((norm_indx+1):end)=[];

figure(2)
subplot(2,1,1)
plot(t_adj,accel_adj,'.')
xlabel('time (s)')
ylabel('acceleration (m2/s)')
title('Normalized Accelerometer Data')
grid on

%% Apply filter to acceleration data
accel_adj = filter_accel(t_adj,accel_adj);

subplot(2,1,2)
plot(t_adj,accel_adj,'.')
hold on
grid on

% Find Positive Peaks
[peak_val_pos,peak_t_pos] =
findpeaks(accel_adj,t_adj,'MinPeakProminence',1,'MinPeakDistance',0.5);
% plot(peak_t_pos,peak_val_pos,'*')
% xlabel('time (s)')
% ylabel('acceleration (m2/s)')
% title('Filtered Accelerometer Data')

% Find Negative Peaks
[peak_val_neg,peak_t_neg] = findpeaks(-
accel_adj,t_adj,'MinPeakProminence',1,'MinPeakDistance',0.7);
peak_val_neg = -peak_val_neg;
% plot(peak_t_neg,peak_val_neg,'*')
% hold off
% xlabel('time (s)')
% ylabel('acceleration (m2/s)')
% title('Filtered Accelerometer Data')

% Correct any peaks
peak_val_neg(5) = accel_adj(190);
peak_t_neg(5) = t_adj(190);

peak_val_neg(8) = accel_adj(319);
peak_t_neg(8) = t_adj(319);

% Remove unnecessary peaks
peak_val_pos(7) = [];
```

```
peak_t_pos(7) = [];

plot(peak_t_pos,peak_val_pos,'*')
plot(peak_t_neg,peak_val_neg,'*')
xlabel('time (s)')
ylabel('acceleration (m2/s)')
title('Filtered Accelerometer Data')

%% Calculate heights
for i = 1:length(peak_val_pos)
    indx_low = find(t_adj == peak_t_neg(i));
    indx_hi = find(t_adj == peak_t_pos(i));
    a = accel_adj(indx_low:indx_hi);
    t = t_adj(indx_low:indx_hi);

    % Numerical integration using trapezoidal method
    v(i,1) = 0; %begin at zero velocity
    x(i,1) = 0; %initial position does not matter, we want displacement
    for j = 2:length(t)
        dt = t(j)-t(j-1);
        v(i,j) = (a(j)+a(j-1))/2*dt+v(i,(j-1));
        x(i,j) = (v(i,j)+v(i,(j-1)))/2*dt+x(i,(j-1));
    end

    h(i) = -min(x(i,:)); %wave heights

    figure(3)
    subplot(2,1,1)
    plot(t,v(i,1:j),'*')
    hold on
    xlabel('Time (seconds)')
    ylabel('Velocity (m/s)')

    subplot(2,1,2)
    plot(t,x(i,1:j),'*')
    hold on
    xlabel('Time (seconds)')
    ylabel('Position (m)')
end
```

MATLAB Function Code – Filter to complement height calculating code

```
function [x_filtered] = filter_accel(t,x)
% Function to create a lowpass filter for accelerometer data

% Normalized frequency (DFT)
x_mags = abs(fft(x));
num_bins = length(x_mags);

%figure(1)
%plot(t,x)
%figure(2)
%plot([0:1/(num_bins/2-1):1],x_mags(1:num_bins/2)/max(x_mags))
%xlabel('Normalized frequency (\pi rads/sample)')
%hold on

% 4th order filter using butterworth design technique
[b,a] = butter(4,0.35,'low');
H = freqz(b,a,floor(num_bins/2));
%plot([0:1/(num_bins/2-1):1],abs(H),'r')
%hold off

x_filtered = filter(b,a,x);

%figure(3)
%plot(t,x_filtered,'r')

end
```

Appendix III

MATLAB Code for Frequency Response Analysis

MATLAB Code for Frequency Response Method

```
clear all
close all
clc

%% Buoy characteristic properties
m1 = 12.65; %kg, jute attenuator wet
k1 = 547.3020; %N/m, estimated spring stiffness
c1 = 49.2315; %N*s/m, estimated damping coefficient
zeta1 = 0.2958; %damping ratio, estimated
m2 = 9.88; %kg, cable attenuator wet
k2 = 713.45; %N/m, estimated spring stiffness
c2 = 28.134; %N*s/m, estimated damping coefficient
zeta2 = 0.1675; %damping ratio, estimated

%% Wave profile, Y(t)
period1 = 0.58; %seconds
omega_wave1 = 2*pi/period1;
height1 = 4; %inches, trough to crest
height1 = height1*0.0254; %convert inches to meters
amp1 = height1/2; %meters
wavelength1 = 6; %inches
wavelength1 = wavelength1*0.0254; %convert inches to meters
period2 = 0.58; %seconds
omega_wave2 = 2*pi/period2;
height2 = 4; %inches, trough to crest
height2 = height2*0.0254; %convert inches to meters
amp2 = height2/2; %meters
wavelength2 = 6; %inches
wavelength2 = wavelength2*0.0254; %convert inches to meters
%Assume Y(t) is a simple sinusoid, Y = sin(2*pi/T*t)
y1 = @(t) amp1*sin(omega_wave1*t); %meters
y_dot1 = @(t) amp1*omega_wave1*cos(omega_wave1*t);
y2 = @(t) amp2*sin(omega_wave2*t); %meters
y_dot2 = @(t) amp2*omega_wave2*cos(omega_wave2*t);

%% Time Response
% Known initial conditions
xo1 = 0; %inch, initial displacement
xo1 = xo1*0.0254; % convert inches to meters
vo1 = 0; %m/s

to1 = 0; %seconds, initial time
tend1 = 10; %seconds, final time
```

```
f1 = @(t,x) [x(2);(y1(t)*k1/m1+y_dot1(t)*c1/m1-c1/m1*x(2)-
k1/m1*x(1))];
[ts1,xs1] = ode45(f1,[to1,tend1],[xo1;vo1]);
xs1 = xs1*39.3701; %convert meters to inches

xo2 = 0; %inch, initial displacement
xo2 = xo2*0.0254; % convert inches to meters
vo2 = 0; %m/s

to2 = 0; %seconds, initial time
tend2 = 10; %seconds, final time

f2 = @(t,x) [x(2);(y2(t)*k2/m2+y_dot2(t)*c2/m2-c2/m2*x(2)-
k2/m2*x(1))];
[ts2,xs2] = ode45(f2,[to2,tend2],[xo2;vo2]);
xs2 = xs2*39.3701; %convert meters to inches

figure(1)
subplot(211)
plot(ts1,xs1(:,1))
hold on
plot(ts2,xs2(:,1))
title('Time Plot: Displacement')
xlabel('time (s)')
ylabel('displacement (in)')
hold on
plot(ts1,y1(ts1)*39.3701) %convert meters to inches
legend('jute','cable','wave profile')

subplot(212)
plot(ts1,xs1(:,2))
hold on
plot(ts2,xs2(:,2))
title('Time Plot: Velocity')
xlabel('time (s)')
ylabel('velocity (in/s)')
legend('jute','cable')

%% Frequency Response
omega1=0:.01:20;
T1=(c1*j.*omega1+k1)./(-m1*(omega1.^2)+c1*j.*omega1+k1); %rad/s
jute attenuator response.
mag1 = abs(T1);
omega2=0:.01:20;
T2=(c2*j.*omega2+k2)./(-m2*(omega2.^2)+c2*j.*omega2+k2); %rad/s
cable attenuator response.
mag2 = abs(T2);
```

```
figure(2)
subplot(211)
plot(omega1,(abs(T1)),'b-')
hold on
plot(omega2,(abs(T2)),'r-')
hold on
ylabel('Amplitude Ratio (m/N)')
xlabel('frequency (rad/s)')
xline(omega_wave1,'--k')
legend('jute','cable','wave frequency')
grid on

subplot(212)
plot(omega1,angle(T1),'b-')
hold on
plot(omega2,angle(T2),'r-')
hold on
ylabel('Phase (rad)')
xlabel('frequency (rad/s)')
xline(omega_wave1,'--k')
legend('jute','cable','wave frequency')
grid on
```

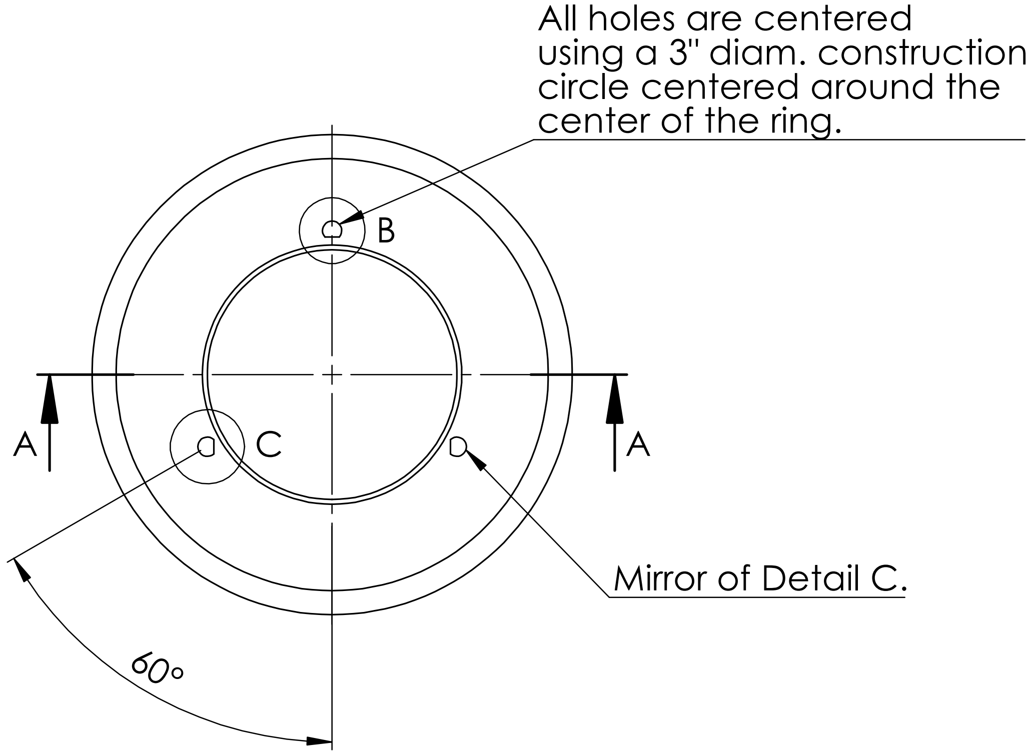
Appendix IV

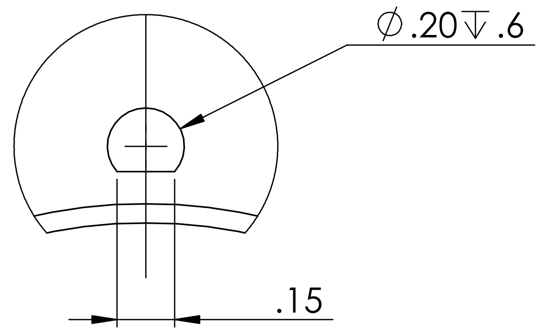
Python Code for Raspberry Pi

```
#Python Code for ADXL345 Accelerometer Running on Raspberry Pi 4 Model B
#File name: ‘accelerometer.py’

import time
import board
import busio
import adafruit_adxl34x
from adafruit_adxl34x import ADXL345, Range, DataRate
import sys

#Set up code using the open source Adafruit ADXL345 Python code package
i2c = busio.I2C(board.SCL, board.SDA)
accelerometer = adafruit_adxl34x.ADXL345(i2c)
accelerometer.data_rate = DataRate.RATE_50_HZ
accelerometer.range = Range.RANGE_2_G
accelerometer.enable_motion_detection(threshold=12)
coordinates = []
time.sleep(60) #time delay of 60s due to start up interference
timestr = time.strftime("%Y%m%d-%H%M%S")

start_time = time.time()
seconds = 150 #data collection run-time

#Loop code
while True:
        current_time = time.time()
        elapsed_time = current_time - start_time

        x,y,z = accelerometer.acceleration
        coordinates.append([time.time_ns(),x,y,z])
        #print("%f %f %f"%accelerometer.acceleration)
        #print("Motion detected: %s" %accelerometer.events['motion'])
        #time.sleep(0.015) #sample time at 66Hz

  #Write data onto a new CSV file
        import csv
        with open(timestr+'.csv',mode='w') as accel_data:
                writer = csv.writer(accel_data)
                writer.writerows(coordinates)

  #Break loop when run-time limit is reached
        if elapsed_time > seconds:
                sys.exit()
```

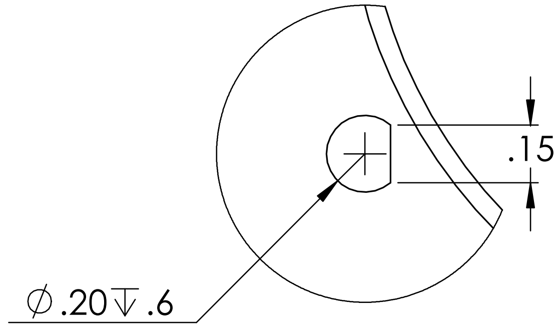
Appendix V

SolidWorks CAD Drawings

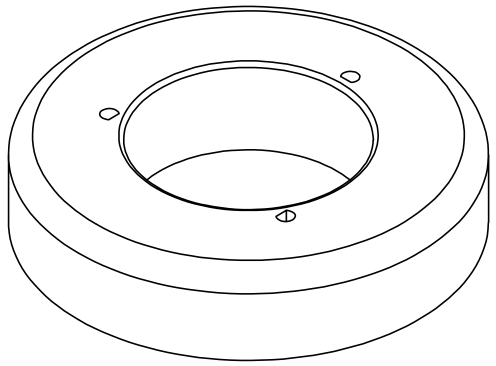


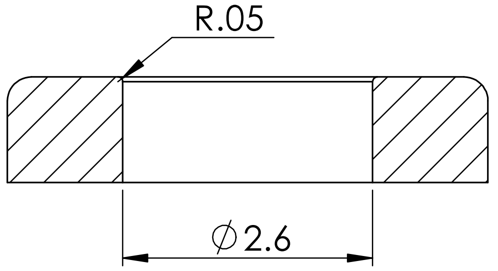


DETAIL B
SCALE 2 : 1

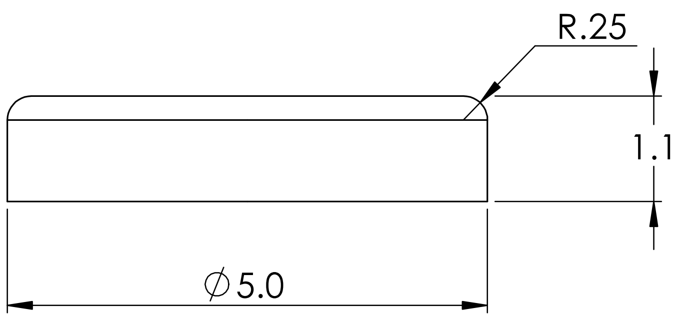


DETAIL C
SCALE 2 : 1

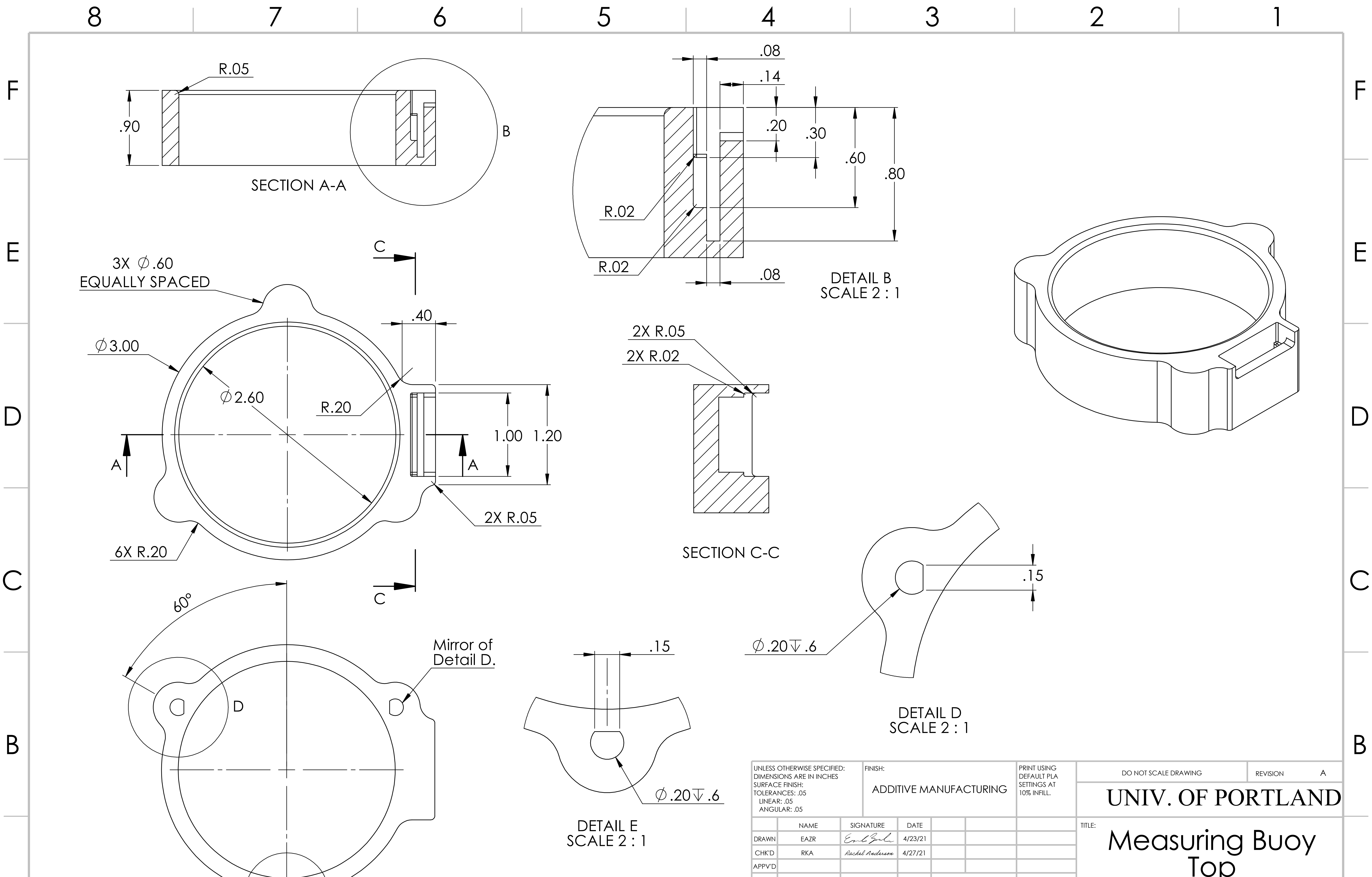




SECTION A-A



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES SURFACE FINISH: TOLERANCES: .05 LINEAR: .05 ANGULAR: .05	FINISH: ADDITIVE MANUFACTURING		PRINT USING DEFAULT PLA SETTINGS AT 10% INFILL.	DO NOT SCALE DRAWING	REVISION A
				UNIV. OF PORTLAND	
	NAME	SIGNATURE	DATE	TITLE: Measuring Buoy Bottom	
DRAWN	EAZR		4/23/21		
CHK'D	RKA	Rachel Anderson	4/27/21		
APPV'D					
MFG					
Q.A			MATERIAL: PLA	DWG NO. WMB001	A3
			WEIGHT:	SCALE:1:2	SHEET 1 OF 8

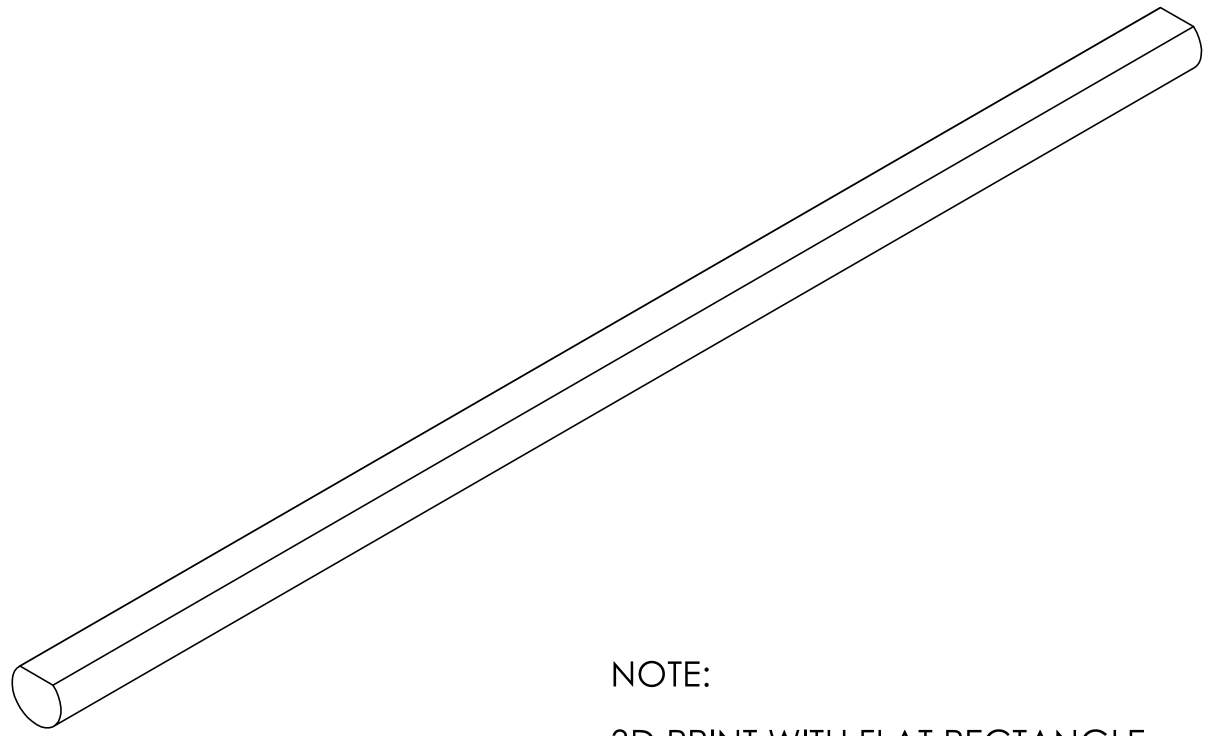


All holes are centered using a 3" diam. construction circle centered around the center of the ring.

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES SURFACE FINISH: TOLERANCES: .05 LINEAR: .05 ANGULAR: .05	FINISH: ADDITIVE MANUFACTURING		PRINT USING DEFAULT PLA SETTINGS AT 10% INFILL.	DO NOT SCALE DRAWING	REVISION A
	NAME	SIGNATURE	DATE	UNIV. OF PORTLAND	
DRAWN	EAZR	[signature]	4/23/21	TITLE: Measuring Buoy Top	
CHK'D	RKA	Rachel Anderson	4/27/21		
APPV'D					
MFG					
Q.A			MATERIAL: PLA	DWG NO. WMB002	A3
			WEIGHT:	SCALE:1:1	SHEET 2 OF 8

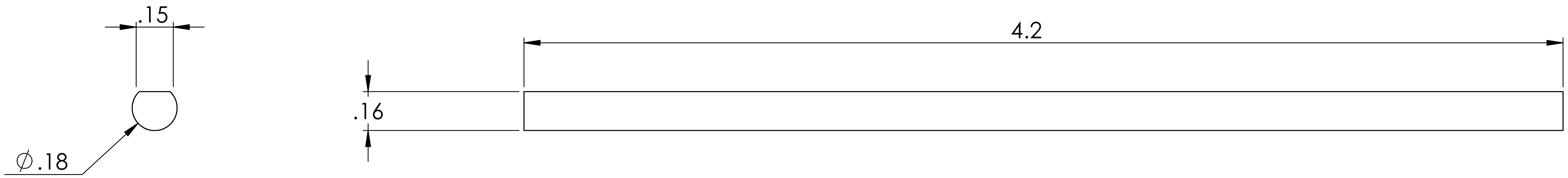
5 4 3 2 1

SOLIDWORKS Educational Product. For Instructional Use Only.

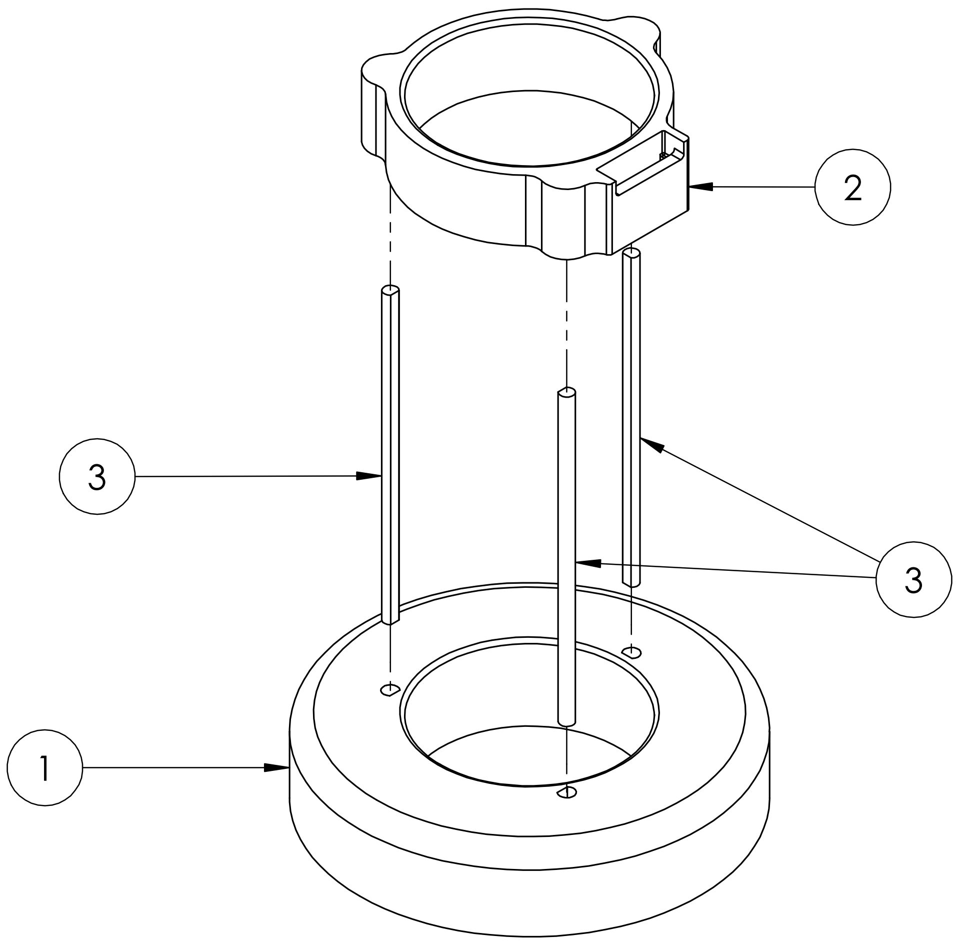


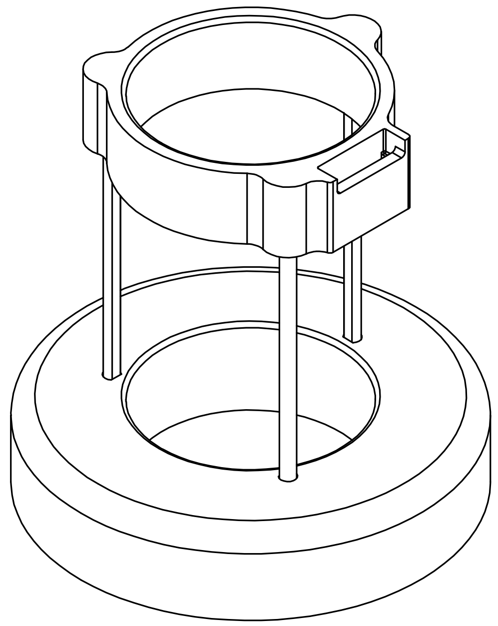
NOTE:

3D PRINT WITH FLAT RECTANGLE FACE DOWN ON PRINTER PLATE.



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES SURFACE FINISH: TOLERANCES: .05 LINEAR: .05 ANGULAR: .05	FINISH: ADDITIVE MANUFACTURING			PRINT USING DEFAULT PLA SETTINGS AT 90% INFILL.	DO NOT SCALE DRAWING	REVISION A
					UNIV. OF PORTLAND	
	NAME	SIGNATURE	DATE		TITLE: Measuring Buoy Rod	
DRAWN	EAZR	[signature]	4/23/21			
CHK'D	RKA	Rachel Anderson	4/27/21			
APPV'D						
MFG						
Q.A				MATERIAL: PLA	DWG NO. WMB003	A3
				WEIGHT:	SCALE:2:1	SHEET 3 OF 8





ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	WMB001	Measuring Buoy Bottom	1
2	WMB002	Measuring Buoy Top	1
3	WMB003	Measuring Buoy Rod	3

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH: ADDITIVE MANUFACTURING

DEBURR SHARP EDGES OF ROD ENDS FOR TIGHT FIT.

DO NOT SCALE DRAWING

REVISION A

UNIV. OF PORTLAND

	NAME	SIGNATURE	DATE
DRAWN	EAZR	[signature]	4/23/21
CHK'D	RKA	Rachel Anderson	4/27/21
APPV'D			
MFG			
Q.A			

TITLE: Measuring Buoy Assembly

MATERIAL: PLA

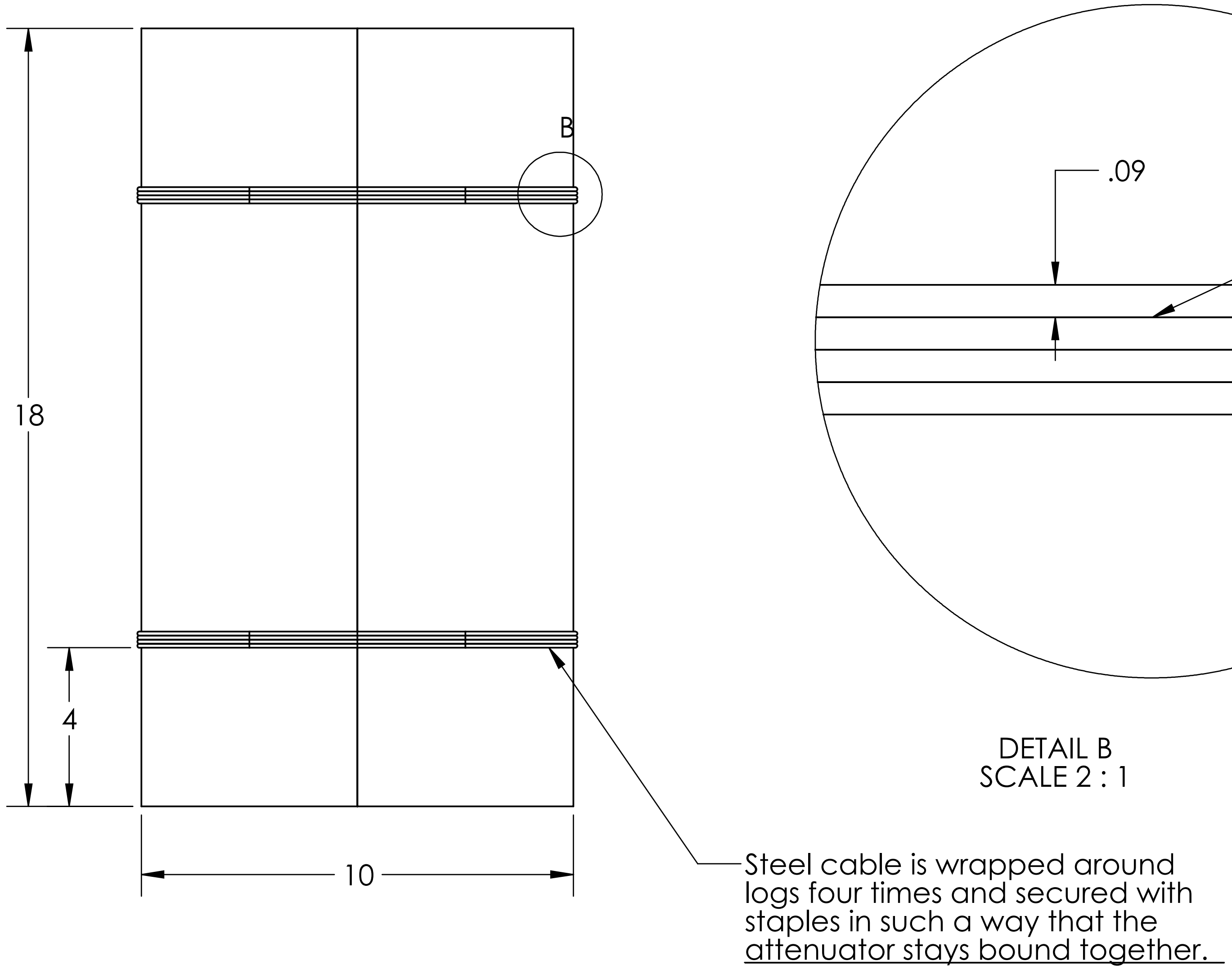
DWG NO. WMB_ASSY

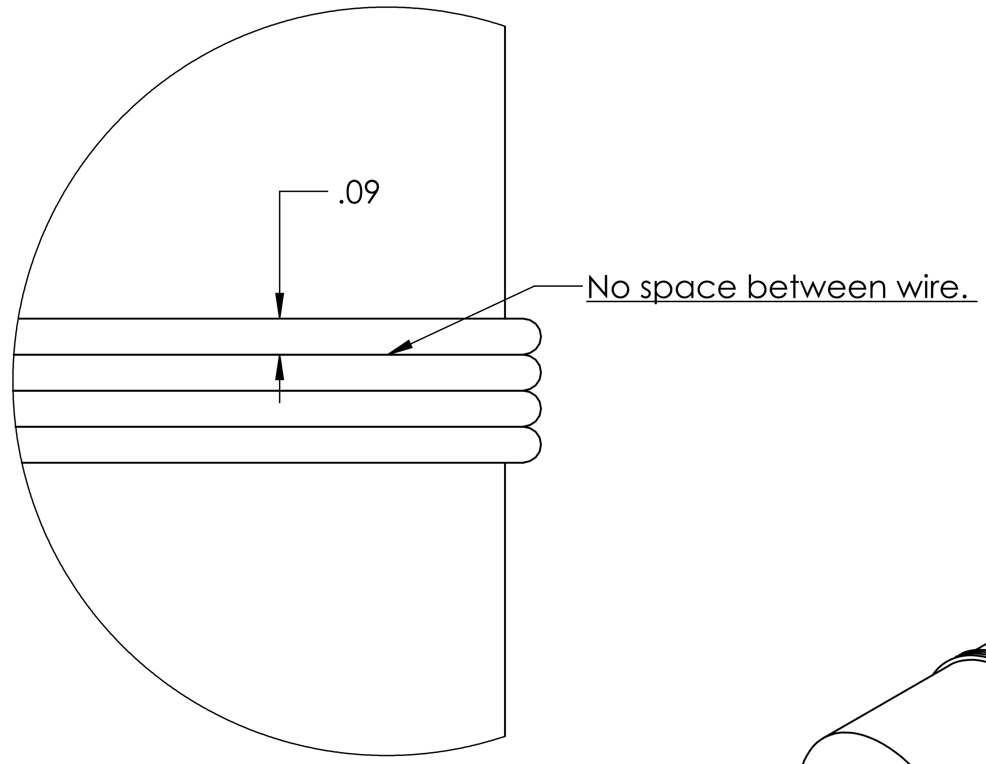
A3

WEIGHT:

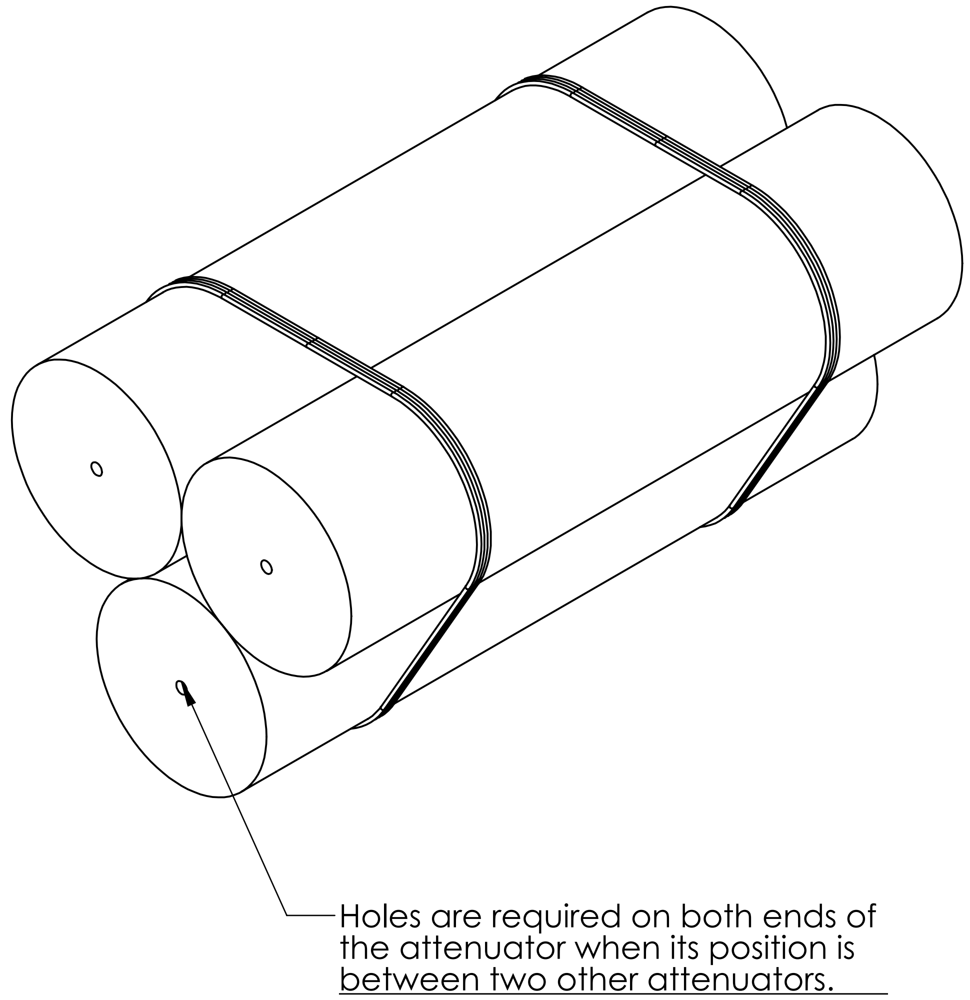
SCALE:1:2

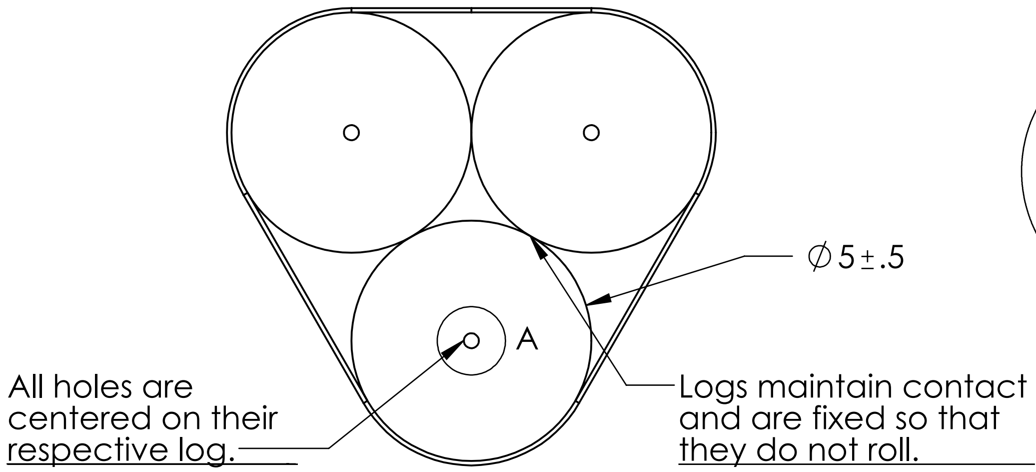
SHEET 4 OF 8

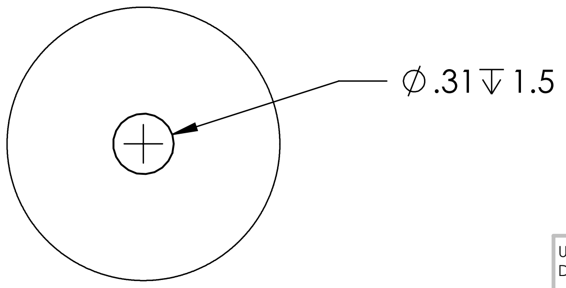




DETAIL B
SCALE 2 : 1

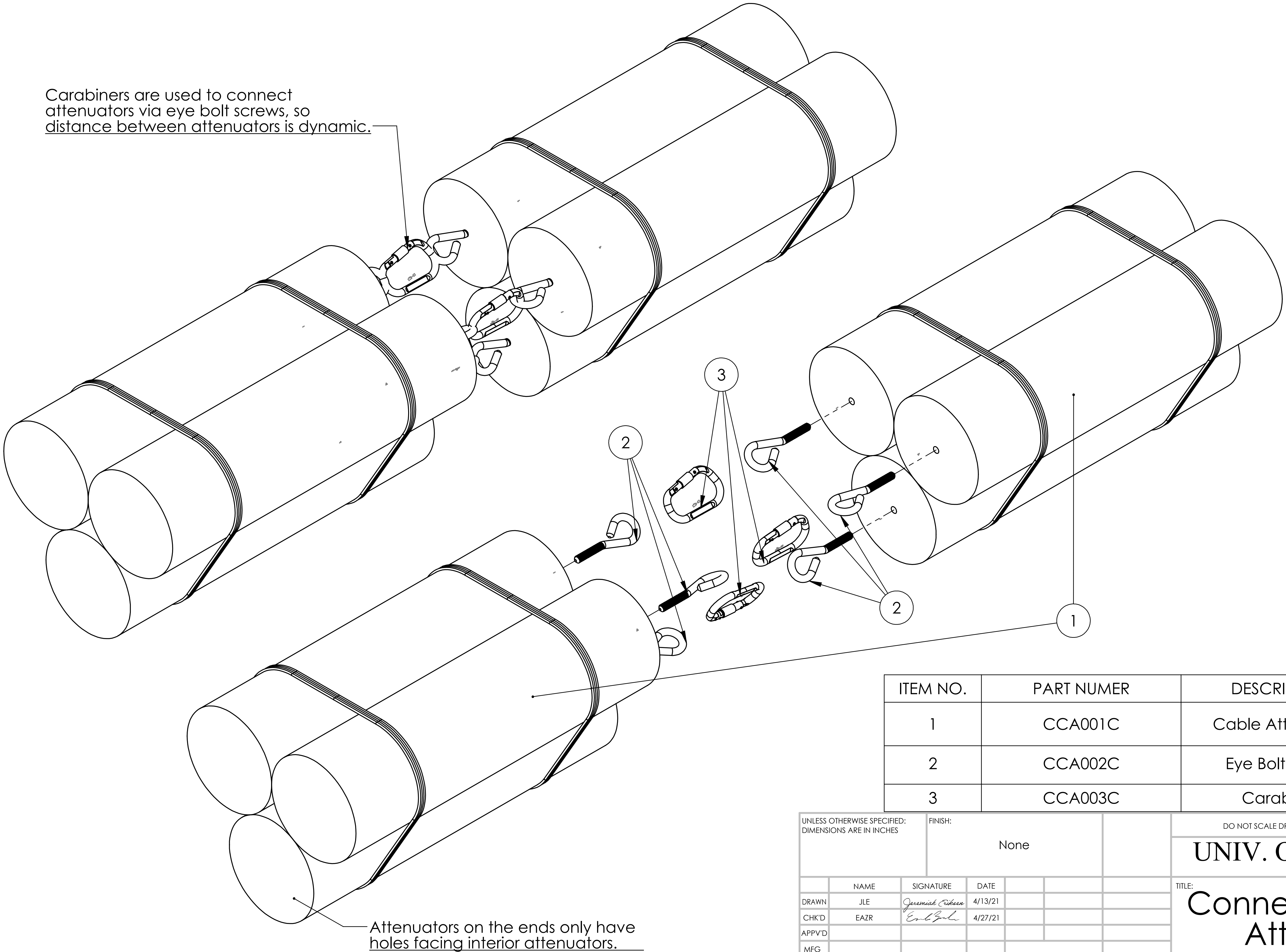






DETAIL A
SCALE 1 : 1

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES		FINISH: None		DO NOT SCALE DRAWING / REVISION A
	NAME	SIGNATURE	DATE	UNIV. OF PORTLAND
DRAWN	JLE	Jeremiah Eriksen	4/13/21	TITLE: Connected Cable Attenuator
CHK'D	EAZR	[signature]	4/27/21	
APPV'D				
MFG				
Q.A			MATERIAL: Wood & Steel Cable	DWG NO. CCA001C / A3
			WEIGHT:	SCALE:1:8 / SHEET 5 OF 8



ITEM NO.	PART NUMER	DESCRIPTION	QTY.
1	CCA001C	Cable Attenuator	2
2	CCA002C	Eye Bolt Screw	6
3	CCA003C	Carabiner	3

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES	FINISH: None	DO NOT SCALE DRAWING	REVISION A
		UNIV. OF PORTLAND	

	NAME	SIGNATURE	DATE
DRAWN	JLE	Jeremiah Eriksen	4/13/21
CHK'D	EAZR	[illegible]	4/27/21
APPV'D			
MFG			
Q.A			

TITLE: Connected Cable Attenuator

MATERIAL: See Table

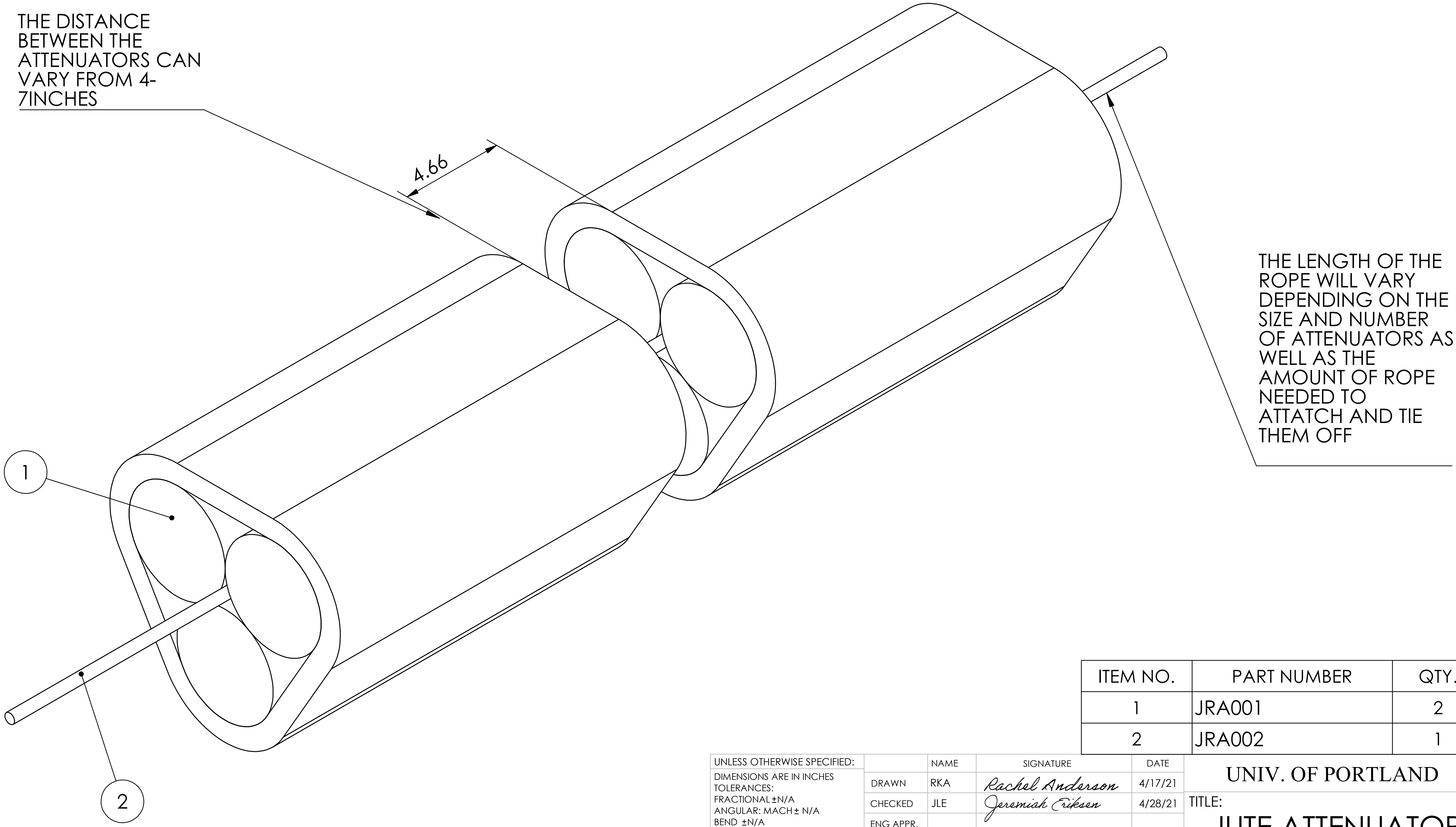
DWG NO. CCA_ASSY

A3

WEIGHT:

SCALE:1:12

SHEET 6 OF 8



ITEM NO.	PART NUMBER	QTY.
1	JRA001	2
2	JRA002	1

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±N/A
ANGULAR: MACH ± N/A
BEND ±N/A
TWO PLACE DECIMAL ±N/A
THREE PLACE DECIMAL ±N/A

INTERPRET GEOMETRIC TOLERANCING PER: N/A
MATERIAL
WOODEN LOGS, JUTE NETTING AND ROPE
FINISH
N/A
DO NOT SCALE DRAWING

	NAME	SIGNATURE	DATE
DRAWN	RKA	Rachel Anderson	4/17/21
CHECKED	JLE	Jeremiah Eriksen	4/28/21
ENG APPR.			
MFG APPR.			
Q.A.			

COMMENTS:

UNIV. OF PORTLAND

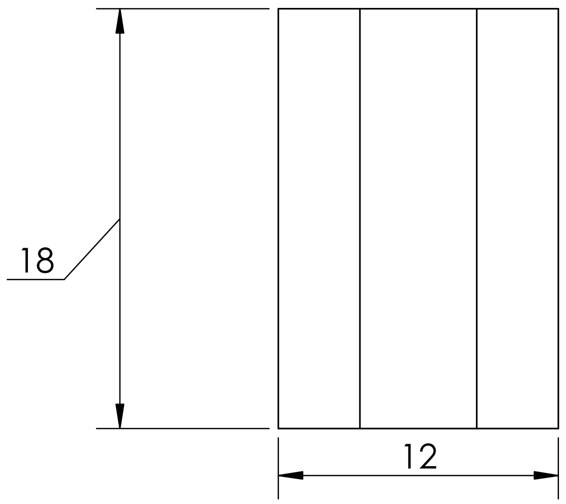
TITLE:
JUTE ATTENUATOR WITH ROPE

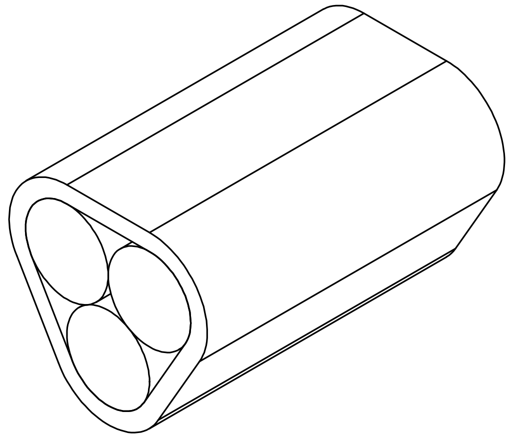
SIZE **B** DWG. NO. JRA_ASSY REV

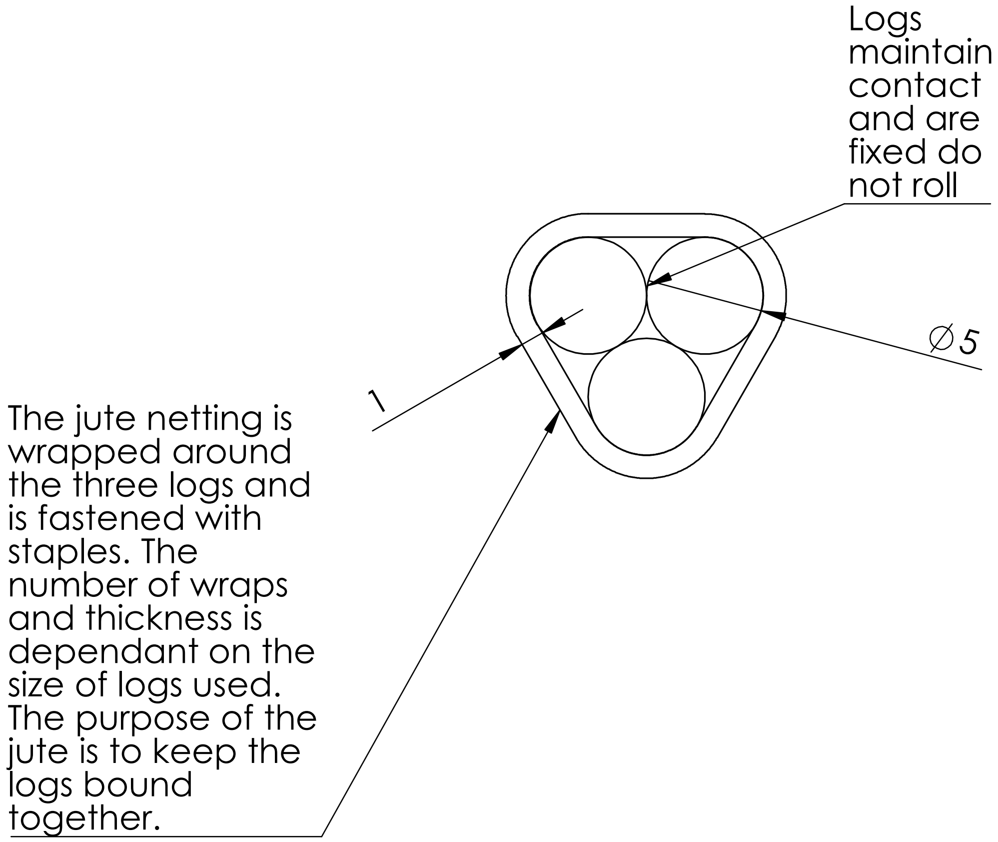
SCALE: 1:12 WEIGHT: SHEET 7 OF 8

4 3 2 1

B







A

UNLESS OTHERWISE SPECIFIED:		NAME	SIGNATURE	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±N/A ANGULAR: MACH ±N/A BEND ±N/A TWO PLACE DECIMAL ±N/A THREE PLACE DECIMAL ±N/A	DRAWN	RA	Rachel Anderson	4/17/21
	CHECKED	JLE	Jeremiah Eriksen	4/28/21
	ENG APPR.			
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER: N/A	Q.A.			
MATERIAL WOODEN LOGS AND JUTE NETTING	COMMENTS:			
FINISH N/A				
DO NOT SCALE DRAWING				

UNIV. OF PORTLAND

TITLE:

JUTE ATTENUATOR

SIZE	DWG. NO.	REV
B	JRA001	
SCALE: 1:8	WEIGHT:	SHEET 8 OF 8

4 3 2 1

Appendix VI

A4 Charter

A3 Project Charter EGR 483	**Project Title:** W.A.V.E.S	**Team Members/Majors:** Rachel Anderson(ME), Davey Robeck (CE), Jeremiah Eriksen (ME), Kaitlyn Gores (CE), Ernesto Zurita (ME)		**Faculty Advisor:** Dr. Farina	**Industry Advisor:**	**Instructor:** Chris Galati galatic@up.edu	**REV NO./DATE** REV 0. 9/1/2020

PROJECT DEFINITION: {Project name and short description; problem statement—what are you trying to improve or what problem are you addressing? May include location or setting of project; project criteria}

Homeowners along the Willamette River, at the Newberg pool, are concerned about bank erosion along their property lines. Project TEAM W.A.V.E.S. will research, design, and develop a prototype technology that reduces erosion by dissipating energy from the waves. The prototype success will be measured by regulatory compliance and cost-effectiveness relative to current technologies.

ANALYSIS OF CURRENT CONDITION {What construction, product, or device is being created to address the problem? What similar situations have been encountered and what was created to resolve these situations? How are you planning to use the previous information as part of your project?}

Residents' options include tying downed trees to their docks and/or placing large rocks (riprap) along the bank (legally or illegally). To legally add riprap to their property, homeowners need to fill out government forms and pay minimum fees of $3,000. The current homeowners are looking for more cost-effective methods to protect their property and to avoid having to deal with government legalities.

PROJECT GOALS
{Define the deliverables of the project—how would a successful result look? What are the specifications that will be used to measure outcome?}

A successful prototype will dissipate 50% energy from the measured wave energy using dynamometer (or equivalent) during testing along river miles of interest. Wave energy will be calculated using the wave energy equation that uses the measured wave height and period of the waves.

RESOURCES REQUIRED
{What is needed for success—lab technician support, software, lab materials, travel? What is anticipated budget?}

As a prototype, Team W.A.V.E.S. will require access to prototyping equipment not limited to 3D printer and metal fabrication tools. For testing, a specified number of team members will drive down to Wilsonville area in the Newberg Pool and may require reimbursement for travel expenses. Materials will not be limited to 3D printing filament, sheet metal, electrical materials and tools. For testing, materials will not be limited to duct tape, batteries, and game cameras (which are included in the laboratory on campus), and the Dynamometer. Software requirements include CAD software, 3D printing software, and Matlab. The anticipated budget is estimated at: $400

ACTION PLAN (ACTIVITIES AND MILESTONES) Major Milestones

Project Goals/Deliverables	Actions/Metrics	Who	When
#1 – • **Finalize preliminary research and agree on a measurement tool.**	- Compiled research folder answering initial knowledge gap questions	All members	Sept. 24
#2 – • **Each member has a list of design concepts, where the team agrees on one design to move forward with.**	- List of three devices per person that measure and quantify energy from the wake waves of boats - List of three designs per person that dissipate energy from waves	All members	Oct. 22
#3— • **Prototyped Design(s) Materialized**	- Completed assembly of prototype design(s)	**All members**	Nov. 19

UNRESOLVED ISSUES
{What subsequent actions could be taken by others? Is there other scope that was purposefully not addressed?}

Bonus Scope: Dr. Farina and Team W.A.V.E.S. will publish on Research Gate (or equivalent journal) Spring of 2021.

FOLLOW-UP AND REVIEW
{How will you know that you have accomplished your goals? What are your metrics?}

Team W.A.V.E.S. will compare the wave energy of the prototyped device in the water to when the device is absent and verify that the measured difference in wave energy meets or exceeds the minimum energy dissipated per the project's criteria.

Appendix VII

Budget Request

Project Budget Request

Project Title: W.A.V.E.S. Capstone Team

Team Member Names — **Date: Oct. 02, 2020**

1. **Davey Robeck**
2. **Ernesto Zurita-Ruiz**
3. **Kaitlyn Gores**
4. **Rachel Anderson**
5. **Jeremiah Erikson**
6. ____________________

Faculty Advisor's Name: **Dr. Jordan Farina**

Course Instructor's Name: **Christopher Galati**

Project Category

Industry	Faculty	Student	Competition
	X		

MECOP TEAM (yes/no): NO

Visa Cardholder/Team Purchaser's Name: Ernesto Abimelek Zurita Ruiz

Project Materials/Supplies (Any single item under $500)

	Item	Cost
1.	Neodymium Magnets	$ 90.00
2.	18 AWG Copper Wire	$ 40.00
3.	PVC Pipe and Caps	$ 75.00
4.	Compression Springs (for Measuring Device)	$ 20.00
5.	2.5 Gal Bucket w/ Screw Lid	$ 35.00
6.	Caulking/Adhesive (20 oz)	$ 20.00
7.	Glue	$ 15.00
8.	Resistors/Misc. Breadboard Items	$ 10.00
9.	Step-Up Transformer (Breadboard Type)	$ 10.00
10.	Raspberry Pi Model B	$ 75.00
11.	MicroSD Card (64 GB)	$ 20.00
12.	PETG Filament	$ 25.00
12.	Steel Sheet Metal	$ 40.00
13.	Coir Mesh (4' x 30')	$ 100.00
14.	Wood (Cedar)	$ 80.00
15.	Synthetic Nylon Rope	$ 20.00
16.	Eyebolts	$ 20.00
17.	Fasteners	$ 20.00
18.	Hinges/Angle Brackets	$ 15.00
19.	Duct Tape	$ 4.00
20.	Batteries (AA)	$ 10.00
	SUBTOTAL	$744.00

Capital Equipment (Any single item over $500)

	Item	Cost
1.		
	SUBTOTAL	$0.00

Travel (Outside of the Portland metro area only)

	Item	Cost
1.		
	SUBTOTAL	$0.00

Miscellaneous

	Item	Cost
1.	Shipping Costs	$ 80.00
	SUBTOTAL	$80.00
	TOTAL	**$824.00**

For request over $400 attach a detailed description why these funds are necessary to complete the project.

As faculty advisor for this capstone team, you are acting as an agent of the University of Portland. Your signature indicates that you find the budget to be reasonable for the project. You have carefully reviewed the project budget and identified any potentially hazardous materials and/or equipment with elevated safety risks. You have obtained the required school and/or university approvals associated with these articles. All articles with elevated safety risk will be shipped to a university address under your name and will remain on campus until proper disposal or transfer of responsibility. You are also acknowledging that you have reviewed these safety policies with your student team.

University of Portland — Shiley School of Engineering

Faculty Advisor's signature: ____________________

Course Instructor's signature: ____________________

Appendix VIII

Purchase Requests

Purchase Requests Summary

Team Name: Team 13 - Wave Energy in the Willamette

Team Member Making Request: Ernesto Abimelek Zurita Ruiz

Operating Budget	$825
Total Purchase Requests	9
Total Amount Purchased	$595.34
Unspent Budget	$229.66

PURCHASE REQUEST #1 October 26, 2020

Item	Description	Price	QTY	Ext. Price
1	Raspberry Pi 4 Model B (8GB)	$ 75.00	1	$ 75.00
2	Adafruit ADXL345 Triple-Axis Accelerometer	$ 17.50	1	$ 17.50
3	SanDisk Ultra microSD Card (64GB), UHS-I	$ 12.49	1	$ 12.49
4	Compact Rechargeable Battery for Raspberry Pi (10,400 mAh)	$ 14.95	1	$ 14.95
5	USB-C to USB-C Cable	$ 7.49	1	$ 7.49
6	PiShop Shipping	$ 7.95	1	$ 7.95
7	Adafruit Shipping	$ 11.85	1	$ 11.85
				$ 147.23

PURCHASE REQUEST #2 November 09, 2020

Item	Description	Price	QTY	Ext. Price
1	Jute Netting Roll - Erosion Control Matting, 1 roll, 4 ft x 30 ft	$ 48.00	1	$ 48.00
2	Amarine Made, 1/2" 20 ft Double Braid Nylon Dockline, Mooring Rope	$ 19.99	1	$ 19.99
3	Galvanized Steel Wire Rope, Lubricated (Nylon), 1/16" diam, 25 ft length	$ 0.48	25	$ 12.00
4	Cast Wire Rope Clamps, **Zinc-Plated Iron**, 1/16" (wire rope diam.)	$ 0.34	25	$ 8.50
5	Shipping	$ 9.02	1	$ 9.02
				$ 97.51

PURCHASE REQUEST #3 February 04, 2021

Item	Description	Price	QTY	Ext. Price
1	Charlotte Pipe, Schedule 40 PVC Pipe, 2" diameter x 10 ft	$ 8.99	2	$ 17.98
2	Galvanized Steel Wire Rope, Lubricated (Nylon), 1/16" diam, 25 ft length	$ 0.48	100	$ 48.00
3	Shipping	$ 11.04	1	$ 11.04
				$ 77.02

PURCHASE REQUEST #4 February 11, 2021

Item	Description	Price	QTY	Ext. Price
1	Extreme Max 1/2"x50' 16-Strand Diamond Braid Utility Rope	$ 17.87	1	$ 17.87
2	Duck Brand Color Duct Tape, 1 Roll, 15 Yards, Flourescent Lilac	$ 3.48	1	$ 3.48
				$ 21.35

PURCHASE REQUEST #5 February 22, 2021

Item	Description	Price	QTY	Ext. Price
1	PLA "Translucent Yellow" 3D printer filament, 1 kg, 1.75mm	$ 19.99	1	$ 19.99
2	Goyunwell Stainless Eye Hooks for Wood, 2-1/2"	$ 7.19	1	$ 7.19

3	SGT Knots Marine Grade Bungee Cord, 1/4" x 10 FT, Black	$ 12.93	1	$ 12.93
4	Onwon Aluminum Carabiner D-Ring Locking Key	$ 12.98	1	$ 12.98
5	Dry & Dry Silica Gel Packs Desiccant	$ 7.97	1	$ 7.97
				$ 61.06

PURCHASE REQUEST #6 March 10, 2021

Item	Description	Price	QTY	Ext. Price
1	Rust-Oleum Black Spray Paint, 12oz	$ 3.50	1	$ 3.50
				$ 3.50

PURCHASE REQUEST #7 March 16, 2021

Item	Description	Price	QTY	Ext. Price
1	SGT Knots Marine Grade Bungee Cord, 1/4" x 25 FT, Black	$ 15.95	1	$ 15.95
2	Lock & Lock Food Storage Container, 54oz (6.5" x 9.1" x 2.7")	$ 6.99	1	$ 6.99
				$ 22.94

PURCHASE REQUEST #8 March 29, 2021

Item	Description	Price	QTY	Ext. Price
1	Ram-Pro Rubber Grommet Set of 18 Sizes	$ 10.99	1	$ 10.99
2	Silicone Tube 12mm ID x 16mm OD, clear flexible	$ 9.99	1	$ 9.99
3	Stainless Steel Eye Hooks for Wood, self-tapping, 2-1/2"	$ 8.95	2	$ 17.90
4	Onwon Aluminum Carabiner D-Ring Locking Key, 10 Pieces	$ 13.98	1	$ 13.98
				$ 52.86

PURCHASE REQUEST #9 April 05, 2021

Item	Description	Price	QTY	Ext. Price
1	Raspberry Pi 4 Model B 8GB	$ 75.00	1	$ 75.00
2	3M Marine Adhesive Sealant 5200FC Fast Cure	$ 14.39	1	$ 14.39
3	Shipping	$ 22.48	1	$ 22.48
				$ 111.87

Appendix IX

Cost Estimates

WAVES Attenuator Cost Estimate

Prepared on Apr. 23, 2021
by Ernesto A. Zurita Ruiz,
Finance & Purchasing Engineer

Protecting 15 LF of Property Bank		ROUNDED
	Est. Cost	Est. Cost
Riprap	$ 650.00	$ 650.00
Jute Attenuator w/ Rope	$ 99.00	$ 100.00
Jute Attenuator w/ Carabiner	$ 167.00	$ 170.00
Cable Attenuator w/ Rope	$ 171.00	$ 170.00
Cable Attenuator w/ Carabiner	$ 239.00	$ 240.00

Protecting 150 LF of Property Bank		ROUNDED
	Est. Cost	Est. Cost
Riprap	$ 4,650.00	$ 4,650.00
Jute Attenuator w/ Rope	$ 986.00	$ 990.00
Jute Attenuator w/ Carabiner	$ 1,754.00	$ 1,755.00
Cable Attenuator w/ Rope	$ 1,706.00	$ 1,705.00
Cable Attenuator w/ Carabiner	$ 2,474.00	$ 2,475.00

NOTE:
Attenuator costs assume no permits will be required;
assumes no installation costs.

Jute Attenuator w/ Rope

Item #	Description	Price	QTY	Unit	Unit Price
1	Logs, 5" diam, x3	$ 5.00	1.5	LF	$ 3.33
2	Jute Nettting Roll	$ 48.00	30	LF	$ 1.60
3	Gardner Staples	$ 3.38	100	EA	$ 0.03
4	Mooring Rope, 16-strand diamond braid, 1/2"	$ 17.87	50	LF	$ 0.36

Jute Attenutator w/ Carabiner

Item #	Description	Price	QTY	Unit	Unit Price
1	Logs, 5" diam, x3	$ 5.00	1.5	LF	$ 3.33
2	Jute Netting Roll	$ 48.00	30	LF	$ 1.60
3	Gardner Staples	$ 3.38	100	EA	$ 0.03
4	Carabiner	$ 13.98	10	EA	$ 1.40
5	Eye Hooks, self tapping, 2-1/2"	$ 8.95	10	EA	$ 0.90

Jute Attenuator w/Rope

Per 15 LF of protection (10 attenuators)	Per 150 LF of protection (100 attenuators)
$ 50.00	$ 500.00
$ 24.00	$ 240.00
$ 6.76	$ 67.60
$ 17.87	$ 178.70
$ 98.63	$ 986.30

Jute Attenuator w/ Carabiner

Per 15 LF of protection (10 attenuators)	Per 150 LF of protection (100 attenuators)
$ 50.00	$ 500.00
$ 24.00	$ 240.00
$ 6.76	$ 67.60
$ 37.75	$ 415.21
$ 48.33	$ 531.63
$ 166.84	$ 1,754.44

Cable Attenuator w/ Rope

Item #	Description	Price	QTY	Unit	Unit Price
1	Logs, 5" diam, x3	$ 5.00	1.5	LF	$ 3.33
2	Nylon-coated, Galvanized steel wire rope. 1/16"	$ 12.00	25	LF	$ 0.48
3	Gardner Staples	$ 3.38	100	EA	$ 0.03
4	Mooring Rope, 16-strand diamond braid, 1/2"	$ 17.87	50	LF	$ 0.36

Cable Attenutator w/ Carabiner

Item #	Description	Price	QTY	Unit	Unit Price
1	Logs, 5" diam, x3	$ 5.00	1.5	LF	$ 3.33
2	Nylon-coated, Galvanized steel wire rope. 1/16"	$ 12.00	25	LF	$ 0.48
3	Gardner Staples	$ 3.38	100	EA	$ 0.03
4	Carabiner	$ 13.98	10	EA	$ 1.40
5	Eye Hooks, self tapping, 2-1/2"	$ 8.95	10	EA	$ 0.90

Cable Attenuator w/ Rope

Per 15 LF of protection (10 attenuators)		Per 150 LF of protection (100 attenuators)
$ 50.00		$ 500.00
$ 96.00	*20 LF/attenuator	$ 960.00
$ 6.76		$ 67.60
$ 17.87		$ 178.70
$ 170.63		$ 1,706.30

Cable Attenuator w/ Carabiner

Per 15 LF of protection (10 attenuators)		Per 150 LF of protection (100 attenuators)
$ 50.00		$ 500.00
$ 96.00	*20 LF/attenuator	$ 960.00
$ 6.76		$ 67.60
$ 37.75		$ 415.21
$ 48.33		$ 531.63
$ 238.84		$ 2,474.44

Riprap, 15 LF

Item #	Description	Price	
1	OR 2021 Fee for Rock Placement (Normal)	$ 250.00	
2	Rip Rap placement (~$40/CY)	$ 400.00	*Approx. for 15 LF, 20 FT width, 1FT deep (10 CY)
		$ 650.00	

Riprap, 150 LF

Item #	Description	Price	
1	OR 2021 Fee for Rock Placement (Normal)	$ 250.00	
2	Rip Rap placement (~$40/CY)	$ 4,400.00	*Approx. for 150 LF, 20 FT width, 1FT deep (110 CY)
		$ 4,650.00	

Appendix X

Meeting and Research Notes

WEEK 01 Research (Sep. 04-10)

Rules and Regulations:

- Willamette River/ Newberg Pool(RM 30-50) broken up into zones
    - Slow/ no wake zone: any area within 100 feet of a dock or a marina (Boones Ferry)
    - Wake Activity Zone: Any water recreation activities except wake surfing
    - Wake Zone: Any water recreation activities is allowed including wake surfing
- Wake surfing is not supposed to happen within 300 feet of the bank despite wake zones being less than 600 feet wide.
- Watch your Wake Brochure
- Towed Water Sports Education Program (now required for the Newberg Pool)
- Newberg Pool Interactive Map
- Info on buoy-like objects allowed in the river
- Forms need to be filled out if the object goes into the soil under the river

Background info

- Part 1of 6 of video of presentations in summer 2019 (each video is about 30 minutes)
- Effects of Boatwakes on Streambank Erosion Kenai River, Alaska
    - “Bank loss in the non-motorized segment of the river was about 75 percent less than that observed in the highest boat-use area of the river and 33 percent less than that observed in the lowest boat-use area of the river”
    - Peak boat activity coincided with peak measured bank erosion
    - No substantial erosion was measured along protected banks which used methods such as riprap and fallen trees.

Energy capture devices

- Water Lily
    - Consumer ready device
    - water(river) and air turbine
    - Small, portable
    - Used for energy collection
- “Sea snake”
    - Used for energy collection
    - Rubber based
    - Type of linear absorber

WEEK 02 Research (Sep. 11-17)

General wave energy research:

- Wave energy is proportional to the square of the wave height (E ~ h^2)
    - Note this video does a great job at explaining wave energy.
    - Wave height is measured from the wave's trough to its crest. The trough is the bottom of the front of the wave, and the crest is the unbroken top of the wave.
- Wave Energy Converter Machines: shows good visuals on different kinds of wave capturing devices
    - Idea: rotating masses linked together similar to floating attenuators?

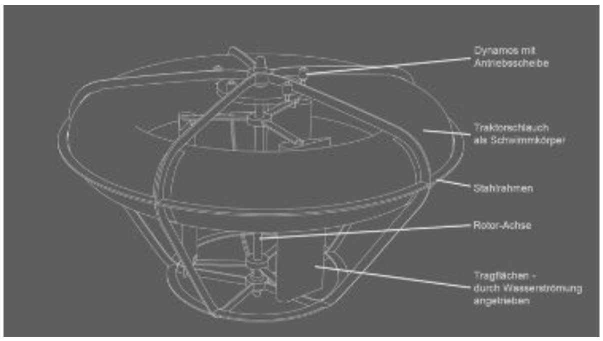
Wave Attenuators

- Website provides good overview of different wave attenuators.
- Great presentation on why wave attenuators work and benefits of each type of attenuator. Plus provides technical vocab and equations we need to consider in our design.
- WhisprWave by Wave Dispersion Technologies
    - Maritime coastal erosion mitigation
    - This one is primarily for military use
    - It is a form of a tethered breakwater
    - Awesome demonstration video
- "Ecosystem" wave attenuator by Walter Marine
    - Again, for coastal projects
    - Supported by pilings.
    - Watch minute 2:15 to see why it works. Very interesting.
    - This uses that concept of *concentrating* wave energy like we had discussed, only in this one, the absorbed energy is lost instead of captured for future use.
- Wave attenuator by MariCorpsUS
    - Looks like a steel floating structure
    - I am thinking out loud, but after watching these videos, I am seeing that these devices provide a "cavity" where turbulent water is either redirected or allowed to mix, which allows it to leave that cavity with less energy than what it came in with.
- Wahoo Wave by Wahoo Docks
    - Material seems less expensive than other wave attenuators and still does a good job at reducing wave energy at the surface.
    - Con: supported by several pilings.
- Wave eater
    - Consumer friendly
    - $150 per foot
    - Easily removed and installed by consumer
    - Site shore erosion control as one of its main benefits

Energy collection devices

- WEBS(Wave Energy Buoy that Self-deploys)

- Uses an anchoring system that does not need to go into the ground
- Suspended weight system

- [Mobile Hydro]
    - Uses swirling of river to turn its blades
    - Generator captures the energy and transfers power to a battery and transformer kit on bank
    - New prototype aims for continuous power output of 300 watts (could power TV or fridge)
    - 

WEEK 03 Research (Sep. 18-24)

Wave Energy:

- https://www.scielo.br/scielo.php?script=sci_arttext&pid=S2318-03312019000100213
- Froude # choices:
    - Shallow water Froude #: F_h = u/sqrt(g*h)
    - Deep water Froude #: F_L = u/sqrt(g*L)
    - Increasing speed geometrically increases wake plus makes the wakes more normal to the banks (increases angle of attack).

Wave Attenuators:

- Several types of floating wave attenuators, limited by wave period (~3 seconds).
    - Floating wave attenuators
        - Cons: Limited effectiveness with longer period waves; larger footprint.
        - Pros: Cheaper, less reflection.
    - Fixed wave screens
        - Cons: Aesthetics (height), wave reflection, costly
        - Pros: Effective for longer period waves (up to about 8 seconds).
- Keywords: Streambank erosion
- Questions:
    - Do we want to reduce momentum -> reduce wave velocity?
        - In active dissipation methods, momentum is added in order to break up the wave train momentum and scatter it to reduce the wave height.
    - We want to reduce the cross-flow momentum (there is already a natural momentum by flow going in the direction of the flow).
        - Could we potentially get more energy for generation by considering momentum in the direction of flow?
    - What departments do we have to worry about? USACE, Oregon Department of FIsh and Wildlife, Oregon State Marine Board.
        - Contacts I received from USACE (regulatory branch). Search up by county (are we Clackamas?).

Performance:

- Basic methods that a floating breakwater reduces wave energy: reflection, dissipation, interference, and conversion of the energy into non-oscillatory motion. (PDF page 32)
    - Waves should not exceed 4 feet in height, or exceed 4 seconds in time period.
    - Design should consider extreme waves, not the average. (PDF page 33)
    - Energy dissipated by drag is a small component of wave energy due to low relative velocities between the breakwater and the fluid particles.
        - But if a substantial increase in relative velocity is achieved, energy dissipation due to drag can become the most important mode. (see tethered-float breakwater). (PDF page 172)

    - Dissipating wave energy by reflection (effective reflector to particle motion) requires that breakwaters remain relatively motionless. (PDF page 190)
        - See perforated portable floating breakwaters.
            - Primarily dissipated by reflection of the perforated wall, the rest is then dissipated by drag when the wave passes through the porous wall in a jet-like manner (turbulence, a.k.a faster speed = higher drag).
                - Transfer of momentum.
    - Most effective natural mechanism of wave energy dissipation is wave breaking. (PDF page 204).
        - Active wave attenuation systems (e.g. pneumatic and hydraulic breakwaters) produce and inject kinetic energy for total or partial breaking of the wave train.
- Performance criterion:
    - Generally accepted criterion is to use the transmission coefficient, C_t: (PDF page 32)
        - C_t = H_t /H_i
        - (H_t is the transmitted wave height, H_i is the incident wave height).
        - Valid as long as waves are regular. If area is prone to short-crested irregular waves, take the ratio of the square of the heights.
- Free floating (no mooring a.k.a cabled to the ground) has pretty poor wave attenuation compared to moored floating bodies. (PDF page 53 is great)
    - Open mooring made it worse (even compared to free).
    - Cross-spring moorings work best for certain width to wavelength ratios.
- Effectiveness also relies on small amplitude motions of the floating structure to avoid generating waves into protected region. This is done by: (PDF page 55)
    - Incorporating large mass
    - Natural period of oscillation which is long with respect to the period of the waves.
        - Done by combining large mass with small internal elastic response of the entire system.
            - Bulk of the mass should be below the water surface at all times.
            - Moorings provide additional elastic restraining force.
    - Breakwater is deep enough in the water so that little of the incident wave kinetic energy is transmitted below the structure.

Floating Breakwaters:
- Tire floating breakwater construction, U.S. Army Corps, 1981 (PDF page 149).
- Twin-log floating breakwater, U.S. Army Corps, 1981 (PDF page 156).
- Twin-cylinder floating breakwater (PDF page 159)
    - Effective for deepwater applications.
- A-frame floating breakwater (PDF page 162).
- Tethered-float breakwater (PDF page 172).

    - Wave-excited buoy motion transforms wave energy into water turbulence and then into heat into the wake of the buoy.
    - Relies primarily on drag over scattering and reflection for energy dissipation.
- Open-Tube Floating breakwater (PDF page 195)
    - An economic option designed for the following requirements: (a) maximum wave attenuation, (b) maximum energy dissipation with minimum reflection, (c) minimum mooring forces, (d) mobility, and (e) ease of construction.
    - Concept: extend the reflecting and energy dissipating action over a wider span of the wavelength; scatter the periodic motion associated with regular waves, thereby dissipating the energy into turbulence.

Code Information:

- Matlab based
- Takes video and breaks down into frames and converted to greyscale
- Each frame is cropped to look at a smaller set of pixels
- A vertical line of pixels is selected to be observed for each frame
- The line of pixels is used to find the lightest or darkest pixels - depending on the site
    - This is used to track the height of the dock/wave
- These values are converted to inches and meters based on a pixel measurement ratio
- Min and max values are found and used to establish max wave height, average wave height, and average period
- Energy calculations used these values outside of the code
- Check powerpoint poster I uploaded for data summary and some other generic info about the research

Patents of Existing Designs:

- V-shaped
- Connecting repeating shapes

This is a picture from google maps of one of the docks we may be able to use to test prototypes.

WEEK 04 Research (Sep. 25 - Oct. 01)

Videos:

- Wave Energy (Coastal) Demonstration

Review of Existing Products

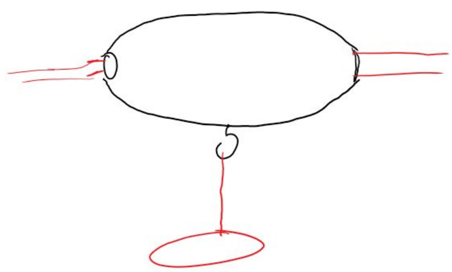
- Wave Whisper
  - The concave design facing the incident wave seems to act as a "recurl wall" that allows part of the wave to be redirected away from the shore.
  - 
  - The sections of the waves that go through the areas lacking the concave design are then shot up where they breakup and tumble as to create turbulence and change in momentum, essentially scattering the wave.
  - The concave design on the transmitted wave side of the structure seems to trap any turbulent water above the structure within the structure (again acting like a small recurl wall), allowing that water to mix with the incoming turbulent water from the incident side.
  - Do the "bumps" on the structure act as turbulent point creators (like on a golf ball)?
  - A similar prototype demonstration in China is not as effective.
    - Notice that the Wave Whisper demonstration above consists of two seemingly "unattached" rows of the wave breaker. In this prototype demonstration, the wave breaker rows are rigidly fixed together.
    - You can see in the initial video how two rows of the wave breakers that are "unattached" are much more effective than the attached ones.
- Here is a wavebreaker from Narval Brise-Lames Technologies
  - Notice the water overtops the first float but then gets somewhat trapped in by the second float.
  - As the water overtops, it speeds up (gains momentum) thus increasing dissipation.

    - What if we can use that momentum to spin a turbine. Over the length of the series of breakwaters, could the generated energy add up significantly?
- Floating Power Buoy
    - Uses hydraulic cylinder with a piston inside to force fluid through a hydraulic motor which then goes to an electrical generator
    - Pneumatic spring and nitrogen gas to move piston

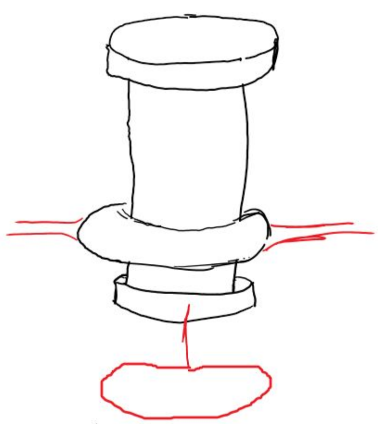
Material

- A list of 3D printing filaments good for waterproofing prints.

Designs



- Use wood or 3D print
- Hollow middle cylinder for rope/cable
- Eye hook in the bottom to attach weights(mesh bag with rocks or soil)
- Could alter designs to have and a and b side to connect each piece via joints
- Possibility to be energy collecting if a device can be incorporated into weight suspension



- Power generating
- Based off of the power buoy model we looked at in week 3 of research
- Weight the column and the circular portion around it will float and move with the waves
- Connect to non-energy generating buoys or other ones that do

Research for power generating buoy:

- Generating Energy from Boat Wake Using Ocean Buoy Technology

(JCraig_Final_Submission_Research_Thesis.pdf)

- Scaled modeling and Simulation of Ocean Wave Linear Generator Buoy Systems

(GaneshReport_ken_Fdbk_von.pdf)

BioHaven Breakwater

More info

-Sustainable option

-Floating breakwater

-Recycled materials (BioHaven used Polyethylene terephthalate (PET)) (non-toxic)

-Hydroponic vegetation on top (habitat for wildlife)

-Some water quality improvement

-Adjusts with depth of river

-PET bonded together in matrix, good for strength, filtering

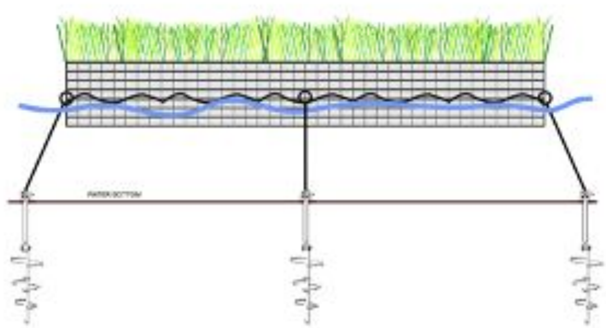
-Matrix layers bonded with marine foam (buoyancy)

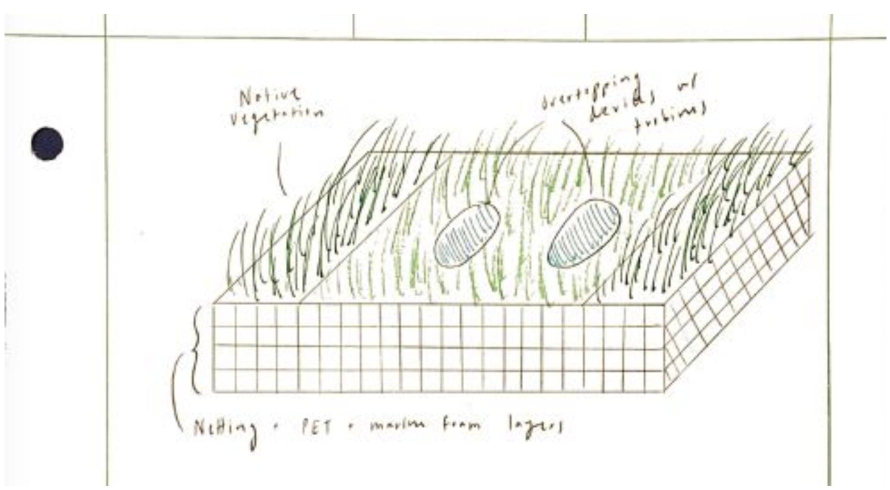
-Nylon netting added for anchoring

-Reduces transmitted wave height by 60%

-Reflects wave energy and dissipates kinetic energy

-Use overtopping/terminator device in some of the holes





Rankings of Importance:

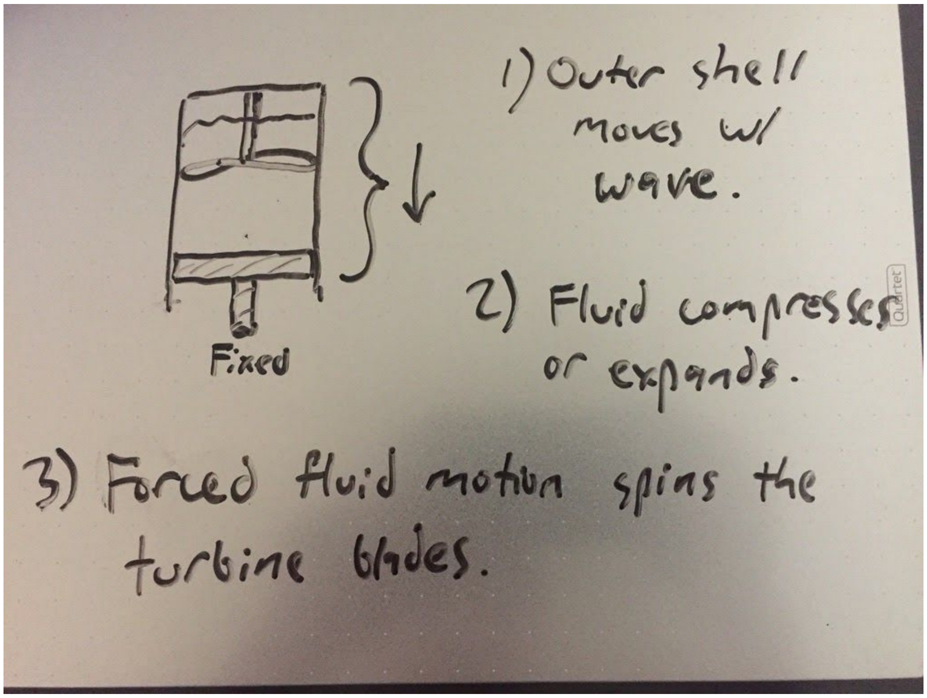
- (1) Reduce erosion (attenuation)
- (2) Adherence to environmental regulation.
- (3) Mobility (seasonal, boats)
- (4) Simplicity (simple to work with/understand)
- (5) Price (less than the next available option(~$3000)/reasonability for price)
- (6) Appearance (aesthetic)
- Use sustainable/recycled.
- Longevity
- Maintenance
- Energy capture

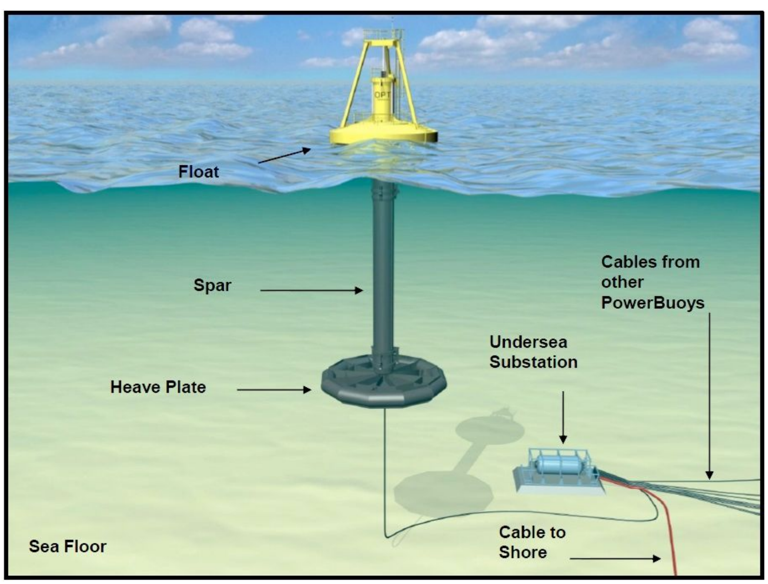
Regulations/Law:

- Attaching things to the bottom of the river.
- Can we attach rocks/logs (washed)
- What can be “floated” / placed in the water.
- Environmental restrictions/regulations
    - Materials
    - Fish passage
    - Sharp edges (turbines)
    - Use of natural resources

WEEK 05 Research (Oct. 02 - Oct 08)

Hydraulic turbine concept:



- Could we borrow from automotive shock absorbers:
    - Video of how a monotube shock absorber works.
    - Video of how a twin-tube shock absorber (more common) works.
    - If we go with this concept, we will need to ensure we provide adequate pressure and temperature changes to prevent foaming and cavitation.
- Hydraulic mechanism is similar to point absorbers
    - 

    - Correct term would be Wave Energy Converter (WEC)

    - Aquabuoy is pretty cool too. Here is a video demo. It uses a Pelton turbine.

Point Absorbers

- Source: “Buoy Analysis in a Point-Absorber Wave Energy Converter” by Aldo Ruezga and Jose M. Canedo (IEEE)
    - For point buoys, they are the only WEC where orientation does not matter.
    - To provide an optimum performance, the natural frequency of the oscillating system must be in tune with the incident wave frequency (page 1).
    - These are good for low amplitude, low period waves!
    - A conical bottom shape provides a better power absorption than a hemi-sphere shape (page 2).
- Slide 10 in this presentation is a pretty cool design of just attenuation.
- Design outline for floating point attenuators article.

Random

- Video of waves created from wakeboarding.

Floating Gardens:

- BioHaven Floating Island:
    - Pretty cool pictures in a powerpoint presentation.
    - Very simple design and seems effective (or can be made more effective).

Urethane Marine Foam:

-In BioHaven system, marine foam used to adhere together matrices of PET and provide buoyancy

-Buoyancy of BioHaven = 15lbs/ft^2

-US Composites has variety of densities of urethane foam

-Recommended for void filling in nonstructural applications

-Can be poured underneath decks and inside cavities where a lightweight floatation foam is needed to provide buoyancy

-95-98% closed cell = resists absorbing water

Alternatives to Marine Foam:

-EPA’s list of substitutes

  -factors such as ozone depletion potential, global warming potential, toxicity, flammability, and exposure potential taken into account

Coir (Coconut husk fiber): **how durable is this though???? - testing?**

-100% natural coir (coconut husk) twines woven together

-can be alternative to polyurethane foam

-effective for erosion control when placed on river embankment in mesh form. Stabilizes bank

-holds in soil, but allows for vegetation to grow through

Polyethylene terephthalate (PET):
-In BioHaven, matrix sheets of PET adhered together with marine foam
-100% recyclable, most recycled plastic worldwide
-Good information on PET here
-Commercial polymer used for packaging, fabrics, films, molded parts for automotive…etc.
-General-purpose thermoplastic polymer that belongs to the polyester family of polymers
-Recycled PET can be converted to fibers, fabrics, sheets for packaging and manufacturing automotive parts
-Very strong and lightweight
-Known for its good gas (oxygen and carbon dioxide) and moisture barrier properties

Aesthetics:
-Maybe need to look into asking stakeholders what they prefer
-Generally, something natural and vegetated is preferred to look at, rather than an attenuator like a mat breakwater made of tires
-This presentation stated that height is a factor in aesthetics (wave attenuator more aesthetically pleasing than wave fixed wave screen)

WEEK 06 Research (Oct. 09 - Oct. 15)

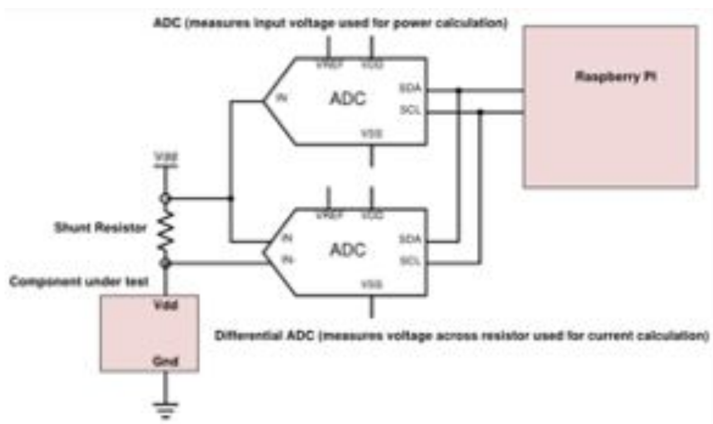
- Sensors:
    - Accelerometers are capacitive or piezo sensors.
        - For motion purposes, VC (variable capacitance) accelerometers may be best (low-level, low-frequency vibration).
        - It is pretty inexpensive and seems to be what a lot research papers are using (however, not sure if it is the best for scaling down model for test).
        - Xtrinsic MMA8451Q (maybe? Need to explore if compatible).
    - Inductive sensors:
        - High resolution, contact-free (good for harsh environments)
        - LVDT
            - Low hysteresis
            - Measure displacements between 0.25-250mm
    - We may want to consider working with current signals over voltage signals to prevent frequency interference (EMI). We will need to convert the current signal to a voltage signal before it can be read by ADC. We can probably do this via a shunt resistor.

- A voltage signal can have any load across it and it will still output approximately the same voltage. Conversely, a current signal regardless of load will give approximately the same current. Source
- In order to communicate with voltage, you put enough current into the load to get the voltage you need. In order to communicate with current, you put enough voltage into the load to get the current you need.
- However, we may consider using voltage in order to reduce power consumption (i.e. reduce current draw).
  - If EMI is not a problem, then we are good. If it is a problem, minimize travel distance between components.

- Attenuator shape
  - Spoke design
  - Extended spoke attenuator
  -

WEEK 07 Research (Oct. 16 - Oct. 22)

If we want to measure current:



Microcontroller:

- Raspberry Pi 4 Model B
  - Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
  - 2GB, 4GB or 8GB LPDDR4-3200 SDRAM
  - 5V DC via USB-C connector (minimum 3A*)

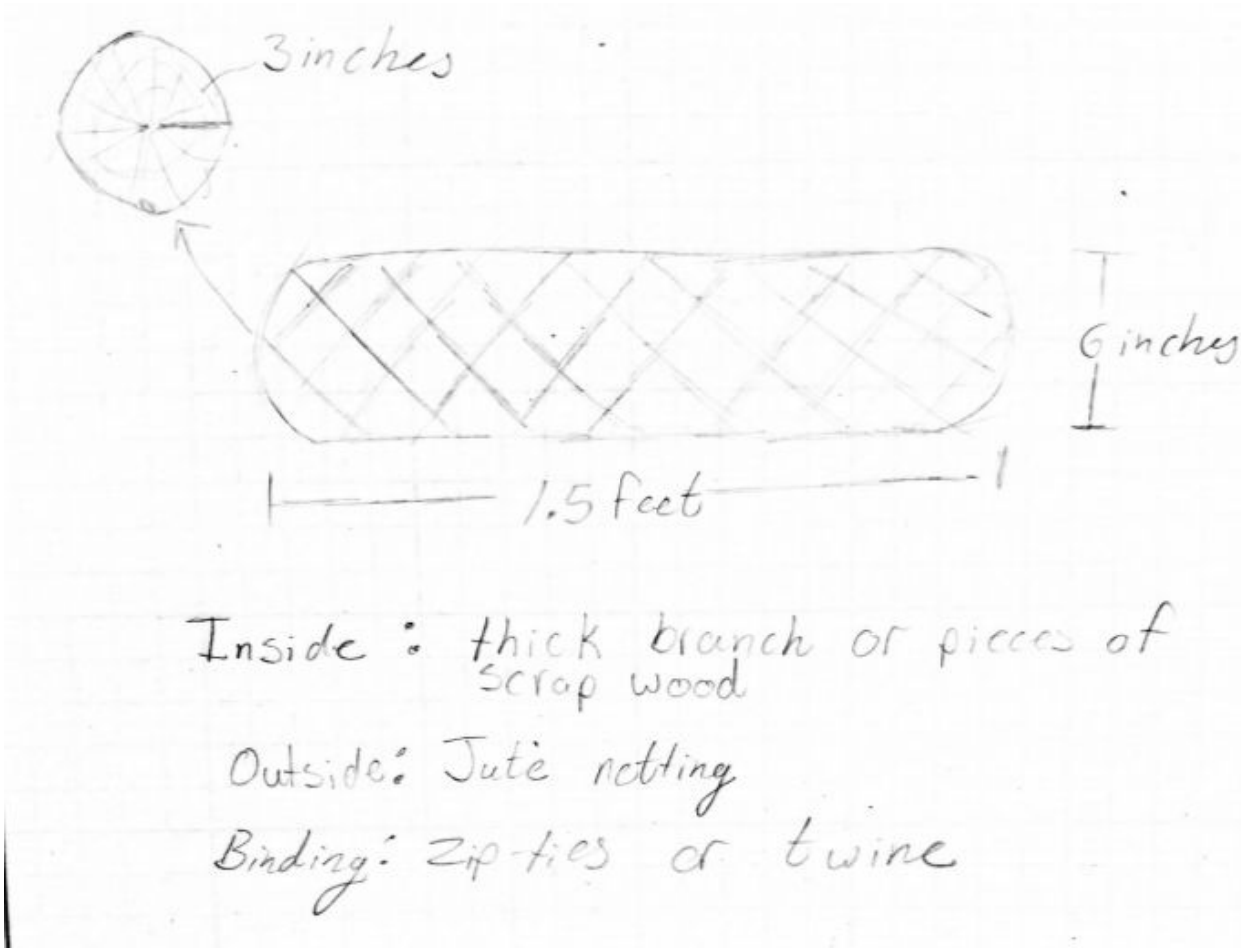
Accelerometer:

- ADXL345
  - 3-axis digital accelerometer

- Low power (as low as 23 microamps in measurement mode, 2.5V)
- Fixed 10-bit resolution
- Full resolution, where resolution increases with *g* range, up to 13-bit resolution at ±16 *g* (maintaining 4 mg/LSB scale factor in all *g* ranges)

- ADXL362 or ADXL363
  - Do not alias input signals by undersampling; they sample the full bandwidth of the sensor at all data rates.
  - https://www.sparkfun.com/products/11446 (no headers, soldering required)

Natural Prototype idea:



Jute netting instead of coir: cheaper

Joints/Configuration Ideas:

-grid pattern/semi grid (used when needs to be installed over period of time) not as effective as sawtooth or straight line

-sawtooth (higher percentage of wave attenuation than straight line)

-straight line (used when wave frequency is short (less than 10 ft)) good for shore erosion mitigation

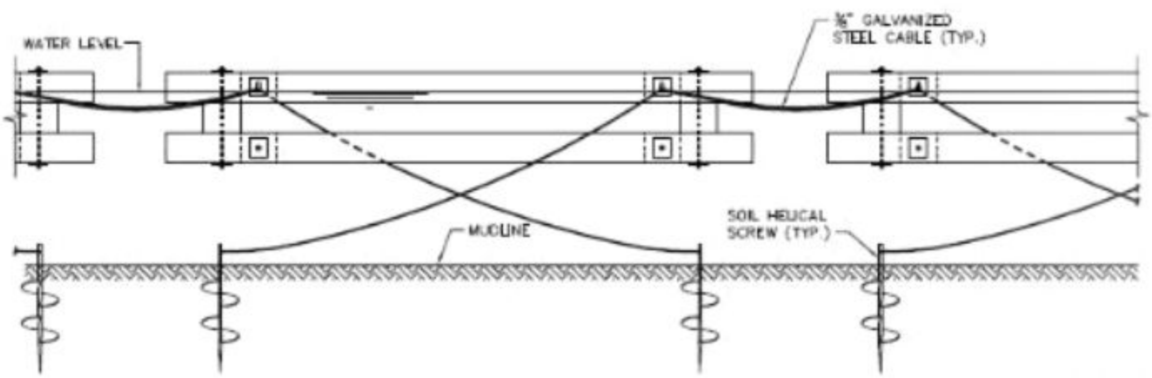
-MarineTek: wave attenuator pontoon made of reinforced concrete

-uses cables as joints (semiflexible with sufficient rigidity to enable breakwater to work)

Sustainable/Low Tech/Natural Systems:

-Good presentation about design considerations

-Timber Bundle or Timber Matrix attenuator



Significantly more cost effective

Type	Materials	Labor and Equipment	Total
WaveBraakker	$640,000	$150,000	$1,198,000
Timber Log Bundle	$100,000	$175,000	$415,000
WaveBreak	$765,000	$150,000	$1,388,000
Floating Island	$440,000	$165,000	$921,000

WEEK 08 Research (Oct. 23 - Oct. 27)

Power Supply:

- 5V DC at min 3A = 15W. 15W at 1 HR = 15Wh.
- 15Wh to mAh (assuming nominal voltage of 3.7V): 4054 mAh
- 10,000 mAh battery will allow runtime of 2 HR.
- 10,400 mAh battery that satisfies our needs

Accelerometer:

- ADXL362
  - Data rates at 12.5 – 400Hz. We might want more flexibility with sampling rates at lower sampling rates.
  - Less than 2 µA at a 100 Hz output data rate and 270 nA when in motion triggered wake-up mode.
  - 12-bit resolution
- Adafruit MSA301
  - Triple Axis Accelerometer
  - 14-bit resolution
  - 1.95 Hz to 500 Hz sampling rate (Note: Raspberry Pi 4 Model B clocks at 250 MHz)
  - As low as 2uA current draw in low power mode
  - Sensitivity: 12 bit/g (@2g)
- SparkFun MMA8452Q
  - Triple Axis
  - 12-bit/8-bit
  - 1.56Hz to 800 Hz output
    - Can recognize as low as 0.52 Hz input.
  - 6µA – 165µA
  - Sensitivity: 8 bit/g (@2g)
  - Using with Raspberry Pi microcontroller (???)
- ADXL345 (From Adafruit)
  - 10-bit resolution
  - 0.1 Hz to 3200 Hz bandwidth
  - 30 µA for less than 10Hz bandwidth
  - Sensitivity: 8 bit/g (@2g)
  - Works with Python!!
- Sampling rates in:
  - Lysekil project (2004): triaxial accelerometer sampled at 8Hz
- Troubleshooting our acceleration data to determine displacement.

Pools

- Inflatable
  - 22 inches deep
- Collapsible
  - Varying sizes only up to 1 foot deep
- Prop up
  - 1 foot deep
  - Potentially build our own with a similar design

WEEK 09 Research (Oct. 28 - Nov. 5)

Information about scaling for prototypes

- This powerpoint has a lot of good information about how to properly do model and prototype ratios
- Starting on slide 21 there is Model testing in water specific information
- Once we learn more about the dimensions of the how we will test it we can figure out the dimensions of the model
    - We will need to look at the dimensions of the testing area and the wave sizes possible.

https://www.homedepot.com/p/Everbilt-1-8-in-x-30-ft-Vinyl-Coated-Steel-Wire-Rope-Kit-810632/204394877

https://www.homedepot.com/p/Everbilt-1-16-in-x-50-ft-Galvanized-Vinyl-Coated-Steel-Wire-Rope-811062/300019543

Galati suggested going to Westmoreland Park Casting Pond to do tests. Going to a standing body of water will likely be our safer option compared to going to a river during the wet season.

Fastening Options:
Eye-bolts
U-bolts
Rope through middle
Staple gun for Jute-netting

WEEK 10 (Nov. 6 - Nov. 12

WEEK 11 (Nov. 13 - Nov. 19)
Wave Energy Measuring Device

- Buoy Design
    - Here is a cool simple buoy design for our wave energy measuring device.

Appendix XI

Weekly Check-Ins

Weekly Report-Out

Team: WAVES | Today's Date: 9/3/2020

1	What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)		Labor Hours
	Customer	Commitment Description	
	All	Project scope	12
	JE, RA, EZ, HD, JF	Meeting w/ Dr. Dillon (Former Faculty Advisor)	5
	All	Team Introductory Meeting	5

2	What work will you complete this week (by our next session)? (let others know what they can depend on)		
	Customer	Commitment Description	
	All	Research	15

3	What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
	No industry advisor	Chris is looking for one	All

4	Overall, are you still on track to meet your commitments to the project?
	Yes, on schedule (schedule to be finalized)

5	Weekly: Team Meeting and Faculty Advisor Meeting Notes
	See attached page of notes.

Weekly Report-Out

Team: WAVES | Today's Date: 09/10/2020

#	Customer	Commitment Description	Labor Hours
1	**What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)**		Labor Hours
	Customer	Commitment Description	
	All	Research	15
	All	Team Meeting with Dr. Farina	9
	All	A4 Charter meeting	5

#	Customer	Commitment Description	
2	**What work will you complete this week (by our next session)? (let others know what they can depend on)**		
	Customer	Commitment Description	
	All	Continue research (measuring devices)	15

#	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
3	**What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)**		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
	No industry advisor	J. Farina is working with K. Rohl	All

#	
4	**Overall, are you still on track to meet your commitments to the project?**
	Yes, on schedule (rough schedule is drafted)
5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**
	See attached page of notes.

Weekly Report-Out

Team: WAVES | Today's Date: 09/17/2020

#	Customer	Commitment Description	Labor Hours
1	**What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)**		Labor Hours
	Customer	Commitment Description	
	All	Research	15
	All	Team Meeting with Dr. Farina	9

#	Customer	Commitment Description	Labor Hours
2	**What work will you complete this week (by our next session)? (let others know what they can depend on)**		
	Customer	Commitment Description	
	All	Continue research as needed and start coming up with design ideas	20

#	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
3	**What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)**		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
	No industry advisor	J. Farina is working with K. Rohl	All

#	
4	**Overall, are you still on track to meet your commitments to the project?**
	Yes, on schedule (rough schedule is drafted)
5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**
	See attached page of notes.

Weekly Report-Out

Team: WAVES — Today's Date: 09/24/2020

#	What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)		Labor Hours
1	Customer	Commitment Description	
	All	Research and looked at existing designs	25
	All	Team Meeting with Dr. Farina	9

#	What work will you complete this week (by our next session)? (let others know what they can depend on)		
2	Customer	Commitment Description	
	All	Start sketching basic design ideas	20
	EZ	Budget drafting and collecting information on pricing	5
	JE, DR	Contacting Jared (Lab Tech.) on Microcontrollers	3

#	What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)		
3	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
	No industry advisor	J. Farina is working with K. Rohl	All

#	
4	**Overall, are you still on track to meet your commitments to the project?**
	Yes, on schedule (draft river)
5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**
	See attached page of notes.

Weekly Report-Out

Team: WAVES | Today's Date: 10/01/2020

1	**What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)**		Labor Hours
	Customer	Commitment Description	
	All	Start sketching basic design ideas	20
	All	Team Meeting with Dr. Farina	12
	EZ	Budget drafting and collecting information on pricing	5
	JE, DR	Contacting Jared(Lab Tech on Microcontrollers	3

2	**What work will you complete this week (by our next session)? (let others know what they can depend on)**		
	Customer	Commitment Description	
	All	Enhance designs and conduct further research	20
	EZ	Budget drafting and collecting information on pricing	5

3	**What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)**		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
	No industry advisor	J. Farina is working with K. Rohl	All

4	**Overall, are you still on track to meet your commitments to the project?**
	Yes, on schedule (draft river)
5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**
	See attached page of notes.

Weekly Report-Out

Team: WAVES

Today's Date: 10/08/2020

1	What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)		Labor Hours
	Customer	Commitment Description	
	All	Start sketching basic design ideas	20
	All	Team Meeting with Dr. Farina	10
	EZ	Budget drafting and collecting information on pricing	5
	All	Student Team meeting	4

2	What work will you complete this week (by our next session)? (let others know what they can depend on)		
	Customer	Commitment Description	
	RA KG	Enhance designs for initial prototyping of natural attenuator	10
	EZ	Final draft of budget	5
	EZ DR	Finalizing circuitry of the wave energy device	10
	JE	Draft design of prototype concept for wave energy device	5

3	What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
	No industry advisor	J. Farina is working with K. Rohl	All

4	Overall, are you still on track to meet your commitments to the project?
	Yes, on schedule (draft river)

5	Weekly: Team Meeting and Faculty Advisor Meeting Notes
	See attached page of notes.

Weekly Report-Out

Team: WAVES | Today's Date: 10/15/2020

1	**What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)**		Labor Hours
	Customer	Commitment Description	
	RA KG	Enhance designs for initial prototyping of natural attenuator	10
	RA EZ JE	Team Meeting	3
	EZ	Final Draft of Budget	5
	EZ DR	Finalizing circuitry of the wave energy device	10
	JE	Draft design of prototype concept for wave energy device	5

2	**What work will you complete this week (by our next session)? (let others know what they can depend on)**		
	Customer	Commitment Description	
	RA KG	Enhance designs for initial prototyping of natural attenuator with budgeting	10
	JE	Draft design of prototype concept for wave energy device with budgeting	5
	EZ DR	Finalizing component list for wave energy measuring device	10

3	**What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)**		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
	No industry advisor	J. Farina is working with K. Rohl	All

4	**Overall, are you still on track to meet your commitments to the project?**
	Yes, on schedule (draft river)
5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**
	See attached page of notes.

Weekly Report-Out

Team: WAVES | Today's Date: 10/22/2020

1	**What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)**		Labor Hours
	Customer	Commitment Description	
	RA KG	Enhance designs for initial prototyping of natural attenuator with budgeting	10
	Everyone	Team Meeting	10
	EZ DR	Finalizing component list for wave energy measuring device	10
	JE	Draft design of prototype concept for wave energy device with budgeting	5

2	**What work will you complete this week (by our next session)? (let others know what they can depend on)**		
	Customer	Commitment Description	
	RA KG	Finalize designs for initial prototyping of natural attenuator with budgeting	10
	JE	Draft design of prototype concept for wave energy device with budgeting	5
	EZ DR	Finalizing component list for wave energy measuring device	10
	EZ	Submit purchase request for wave measuring device electrical components	1
	Everyone	Report draft	5

3	**What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)**		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
	No industry advisor	J. Farina is working with K. Rohl	All
	Shiley lab access	Jeremiah submitted request	K. Rohl

4	**Overall, are you still on track to meet your commitments to the project?**
	Yes, on schedule (draft river)
5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**
	See attached page of notes.

Weekly Report-Out

Team: WAVES | Today's Date: 10/29/2020

1	**What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)**		Labor Hours
	Customer	Commitment Description	
	RA KG	Finalize designs for initial prototyping of natural attenuator with budgeting	10
	Everyone	Team Meeting	5
	EZ DR	Finalizing component list for wave energy measuring device	10
	JE	Draft design of prototype concept for wave energy device with budgeting	5
	Everyone	Report draft	5
	EZ	Submit purchase request for wave measuring device electrical components	1

2	**What work will you complete this week (by our next session)? (let others know what they can depend on)**		
	Customer	Commitment Description	
	RA KG	Research scaling for prototype attenuator	10
	JE	working with Farina on dynamic simulation or model	5
	EZ DR	working on the circuit and coding	10
	Everyone	Report draft	5

3	**What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)**		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
	No industry advisor	J. Farina is working with K. Rohl	All
	Shiley lab access	Jeremiah submitted request	K. Rohl

4	**Overall, are you still on track to meet your commitments to the project?**
	Yes, on schedule (draft river)
5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**
	See attached page of notes.

Weekly Report-Out

Team: WAVES | Today's Date: 11/05/2020

1	What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)		Labor Hours
	Customer	Commitment Description	
	RA KG	Research scaling for prototype attenuator	10
	Everyone	Team Meeting	5
	EZ DR	working on the circuit and coding	10
	JE	working with Farina on dynamic simulation or model	5
	Everyone	Report draft	5
	EZ	Submit purchase request for wave measuring device electrical components	1

2	What work will you complete this week (by our next session)? (let others know what they can depend on)		
	Customer	Commitment Description	
	RA KG	Research connectors and assembling ideas	10
	JE	working with Farina on dynamic simulation or model	5
	EZ DR	Meet in SH104 lab to work on circuit/coding	10
	Everyone	Report draft	5
	EZ DR	Submit 2nd purchase order (coir netting, nylon rope, steel cable)	1

3	What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
	No industry advisor	J. Farina is working with K. Rohl	All

4 Overall, are you still on track to meet your commitments to the project?

Behind original schedule (due to waiting on lab access to be granted), but on track.

5 Weekly: Team Meeting and Faculty Advisor Meeting Notes

See attached page of notes.

Weekly Report-Out

Team: WAVES   Today's Date: 11/12/2020

1	**What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)**		Labor Hours
	Customer	Commitment Description	
	RA KG	Research connectors and assembling ideas	10
	Everyone	Team Meeting	5
	EZ DR	Meet in SH104 lab to work on circuit/coding	10
	JE	working with Farina on dynamic simulation or model	5
	Everyone	Report draft	5
	EZ	Submitted 2nd Purchase Request to L. Bassett	1

2	**What work will you complete this week (by our next session)? (let others know what they can depend on)**		
	Customer	Commitment Description	
	KG	Start prototype assembly	5
	JE	Reach out to Dr.Doughty	5
	EZ DR	Continue to work on the circuit	10
	Everyone	Report draft	5
	RA	Start powerpoint and look at Website options	5

3	**What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)**		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
	No industry advisor	J. Farina is working with K. Rohl	All

4	**Overall, are you still on track to meet your commitments to the project?**
	Behind original schedule (due to waiting on lab access to be granted), but on track.

5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**
	See attached page of notes.

Weekly Report-Out

Team: WAVES   Today's Date: 11/19/2020

1	**What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)**		Labor Hours
	Customer	Commitment Description	
	KG	Start prototype assembly	5
	Everyone	Team Meeting	8
	EZ DR	Continue to work on the circuit	10
	JE	Reach out to Dr.Doughty	5
	Everyone	Report draft	5
	RA	Start powerpoint and look at Website options	5

2	**What work will you complete this week (by our next session)? (let others know what they can depend on)**		
	Customer	Commitment Description	
	KG	Start prototype design	5
	JE	Continue work on the dynamic modelling	5
	EZ, DR	Finalize MATLAB Script to Calculate Wave Energy, Raspberry Pi	10
	Everyone	Report draft and work on presentation slides	5
	RA	Reach out to Mirza about the website and attenuator assembly and sketches	5

3	**What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)**		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
	No industry advisor	J. Farina is working with K. Rohl	All

4	**Overall, are you still on track to meet your commitments to the project?**
	Behind original schedule (due to waiting on lab access to be granted), but on track.

5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**
	See attached page of notes.

Weekly Report-Out

Team: WAVES Today's Date: 11/24/2020

1 What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)

Customer	Commitment Description	Labor Hours
KG	Start prototype assembly	5
Everyone	Team Meeting	8
EZ DR	Continue to work on the circuit	10
JE	Continue to model the generating device	5
Everyone	Report draft	5
RA	Reach out to Mirza about website and attenuator assembly and sketches	5

2 What work will you complete this week (by our next session)? (let others know what they can depend on)

Customer	Commitment Description	
KG	Continue prototype assembly	5
JE	Continue work on the dynamic modelling	5
EZ, DR	Finalize MATLAB Script to Calculate Wave Energy, Raspberry Pi	10
Everyone	Report draft and work on presentation slides	5
RA	Work with Kaitlyn on prototype assembly	5

3 What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns...)

Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
No industry advisor	J. Farina is working with K. Rohl	All

4 Overall, are you still on track to meet your commitments to the project?

Behind original schedule (due to waiting on lab access to be granted), but on track.

5 Weekly: Team Meeting and Faculty Advisor Meeting Notes

See attached page of notes.

Weekly Report-Out

Team: WAVES | Today's Date: 12/03/2020

1	What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)		Labor Hours
	Customer	Commitment Description	
	KG	Finished prototype	3
	Everyone	Team Meeting	8
	Everyone	Record Presentation	15
	Everyone	Report draft	15

2	What work will you complete this week (by our next session)? (let others know what they can depend on)		
	Customer	Commitment Description	
	Everyone		

3	What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?

4	Overall, are you still on track to meet your commitments to the project?
	Behind original schedule (due to waiting on lab access to be granted), but on track.

5	Weekly: Team Meeting and Faculty Advisor Meeting Notes
	No notes, worked on the fall draft

Weekly Report-Out

Team: WAVES | Today's Date: 1/29/2021

1	What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)		Labor Hours
	Customer	Commitment Description	

2	What work will you complete this week (by our next session)? (let others know what they can depend on)		
	Customer	Commitment Description	
	RA	Website check in	1
	RA	MATLAB code	4
	KG,DR,JE,EZ	work on testing	8
	EZ	Submit new part order	1

3	What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
	Solidworks issues		Chris Galati

4	Overall, are you still on track to meet your commitments to the project?
	yes

5	Weekly: Team Meeting and Faculty Advisor Meeting Notes
	The team came together and discussed progress made over the break. At the meeting the team discussed possible ideas for testing and times to go out to river campus

Weekly Report-Out

Team: WAVES | Today's Date: 2/05/2021

1	**What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)**		Labor Hours
	Customer	Commitment Description	
	Everyone	Meeting	5
	RA	Website check in	1
	RA	MATLAB code	4
	KG,DR,JE,EZ	work on testing	8
	EZ	Submit new part order	1

2	**What work will you complete this week (by our next session)? (let others know what they can depend on)**		
	Customer	Commitment Description	
	everyone	create website accounts	1
	RA	remove extra graphs and add energy reading	4
	KG,DR,JE,EZ	Work on testing	8
	KG,DR,JE,EZ	Create new attenuators and measuring devices	12

3	**What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)**		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?

4	**Overall, are you still on track to meet your commitments to the project?**
	yes
5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**
	-Disscussed details for testing -fine tuned the needs for the coding -created and updated testing plan

Weekly Report-Out

Team: WAVES | Today's Date: 2/12/2021

1	What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)		Labor Hours
	Customer	**Commitment Description**	
	Everyone	Meeting	5
	RA	remove extra graphs and add energy reading	4
	KG,DR,JE,EZ	Work on testing	8
	KG,DR,JE,EZ	Create new attenuators and measuring devices	12

2	What work will you complete this week (by our next session)? (let others know what they can depend on)		
	Customer	**Commitment Description**	
	RA	edit down videos into smaller clips	1
	RA	start running data through MATLAB	4
	KG,DR,JE,EZ	Work on testing	8
	KG,DR,JE,EZ	Test waterproofing options	8

3	What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?

4 Overall, are you still on track to meet your commitments to the project?

yes

5 Weekly: Team Meeting and Faculty Advisor Meeting Notes

-moving meeting times
-developed new ideas to make waves so there is not cresting over the marker
-ways to waterproof wave energy devices

Weekly Report-Out

Team: WAVES | Today's Date: 2/19/2021

1	What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)		Labor Hours
	Customer	Commitment Description	
	Everyone	Meeting	5
	RA	Edit down videos and start running those through matlab	2
	everyone	work on new attenuator designs	5
	EZ	Work on waterproofing energy capture device	6

2	What work will you complete this week (by our next session)? (let others know what they can depend on)		
	Customer	Commitment Description	
	RA	keep matlab data going	4
	RA,JE,EZ	start modelling if possible	4
	KG,DR,JE,EZ	Work on testing	8

3	What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?
	Delayed testing due to waether		
	Still waiting on Solid works software key		

4	Overall, are you still on track to meet your commitments to the project?
	yes
5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**
	-discussed how to create new versions of the attenuators -discussed ording all things we may need in the next week

Weekly Report-Out

Team: WAVES | Today's Date: 2/26/2021

1	What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)		Labor Hours
	Customer	Commitment Description	
	Everyone	Meeting	5
	RA	Running matlab data	4
	KG,DR,JE, EZ	testing	10
	EZ	Work on waterproofing energy capture device	4

2	What work will you complete this week (by our next session)? (let others know what they can depend on)		
	Customer	Commitment Description	
	RA	keep matlab data going	4
	RA,JE,EZ	start modelling	4
	KG,DR,JE,EZ	Work on testing	8

3	What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?

4 Overall, are you still on track to meet your commitments to the project?

yes

5 Weekly: Team Meeting and Faculty Advisor Meeting Notes

- Discussed new testing strategy - Discussed the implementation of additions to prototypes

Weekly Report-Out

Team: WAVES | Today's Date: 3/05/2021

1	What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)		Labor Hours
	Customer	Commitment Description	
	Everyone	Meeting	5
	RA	Running matlab data and	6
	KG,DR,JE, EZ	testing the attenuatuator to see how it moves in the water and arduino device	10
	JE, EZ	Met with Dr, Doughty	2

2	What work will you complete this week (by our next session)? (let others know what they can depend on)		
	Customer	Commitment Description	
	RA	keep matlab data going, make adjustments for vibration models	4
	RA,JE,EZ	start modelling	4
	KG,DR,JE,EZ	Work on testing	8

3	What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?

4	Overall, are you still on track to meet your commitments to the project?
	yes
5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**
	- talked about ways to make testing videos easier to move into matlab - discussed potential modifications to the attenuators - future use for vibration modeling

Weekly Report-Out

Team: WAVES   Today's Date: 3/12/2021

1	What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)		Labor Hours
	Customer	Commitment Description	
	Everyone	Meeting	5
	RA	Running matlab data and developing data sheet to track various testing	6
	KG,DR,JE, EZ	testing the wave height with and without the attenuator for comparison analysis and testing the arduino device and other modeling options	12

2	What work will you complete this week (by our next session)? (let others know what they can depend on)		
	Customer	Commitment Description	
	RA	keep matlab data going, make adjustments for vibration models	6
	RA,JE,EZ	start modelling	4
	KG,DR,JE,EZ	Work on testing	12

3	What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?

4	Overall, are you still on track to meet your commitments to the project?
	yes
5	Weekly: Team Meeting and Faculty Advisor Meeting Notes

	- talked about ways to alter the testing process to make the move into matlab easier and more accurate - discussed how we can effectilve ensure we acheive the original scope of the project - planned on the best way to encorperate the vibration model and to collect data for it	

Weekly Report-Out

Team: WAVES | Today's Date: 3/19/2021

1	What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)		Labor Hours
	Customer	Commitment Description	
	Everyone	Meeting	5
	RA	Running matlab data and developing data sheet to track various testing	6
	KG,DR,JE, EZ	worked with the testing equipment to make minor changes which could help the code run smoother	12

2	What work will you complete this week (by our next session)? (let others know what they can depend on)		
	Customer	Commitment Description	
	RA	continuing with Matlab and work on data entry	6
	RA,JE,EZ	start modelling	4
	KG,DR,JE,EZ	More testing with updated equipment and attenuators	12

3	What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?

4	Overall, are you still on track to meet your commitments to the project?
	yes
5	Weekly: Team Meeting and Faculty Advisor Meeting Notes

	- talked about more ways to alter the testing process to make the move into matlab easier and more accurate based on the previous data collected - discussed implementations of attenuator variations (bungee cords, jute vs steel cables)	

Weekly Report-Out

Team: WAVES | Today's Date: 3/26/2021

1	**What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)**		Labor Hours
	Customer	Commitment Description	
	Everyone	Meeting	5
	RA	Running matlab data updates to the data table and include code perameters for each run	6
	KG,DR,JE, EZ	tested attenuators with minor changes made to clean up the data	16

2	**What work will you complete this week (by our next session)? (let others know what they can depend on)**		
	Customer	Commitment Description	
	RA	continuing with Matlab and work on data entry	6
	RA,JE,EZ	start modelling (finish by April 14th)	4
	KG,DR,JE,EZ	more testing if more data is needed	8
	everyone	Start working on paper/ presentation	5

3	**What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)**		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?

4	**Overall, are you still on track to meet your commitments to the project?**
	yes
5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**

	- updated the schedule for the rest of the semester(3D models by 4/14 Presentation and paper work done by 4/16) - Focused on how to explain the scope of the project within the presentation and the paper	

Weekly Report-Out

Team: WAVES | Today's Date: 4/02/2021

1	What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)		Labor Hours
	Customer	Commitment Description	
	Everyone	Meeting	5
	RA	Running matlab data updates to the data table and include code perameters for each run	6
	KG,DR,JE, EZ	tested attenuators with minor changes made to clean up the data	16
	RA,JE,EZ	work on modeling	12

2	What work will you complete this week (by our next session)? (let others know what they can depend on)		
	Customer	Commitment Description	
	RA	continuing with Matlab and work on data entry	6
	RA,JE,EZ	Continue touching up models and editing	4
	KG,DR,JE,EZ	more testing to fill in and to take pictures and photos	8
	everyone	Start working on paper/ presentation	5

3	What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?

4	Overall, are you still on track to meet your commitments to the project?
	yes
5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**

	- discussed how to work with the data collected and what other data may be needed - Some changes to made as to how to do an analysis of the waves by looking at what types of waves were best attenuated by our prototypes	

Weekly Report-Out

Team: WAVES | Today's Date: 4/09/2021

1	**What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)**		Labor Hours
	Customer	Commitment Description	
	Everyone	Meeting	10
	RA	Running matlab data updates to the data table and include code perameters for each run	10
	KG,DR,JE, EZ	tested attenuators more set ups and fill in data lost in the previous week	16
	RA,JE,EZ	work on modeling/editing models	12

2	**What work will you complete this week (by our next session)? (let others know what they can depend on)**		
	Customer	Commitment Description	
	RA	continuing with Matlab and work on data entry	10
	RA,JE,EZ	Continue touching up models and editing	9
	KG,DR,JE,EZ	more testing to fill in and to take pictures and photos	12
	everyone	Continue working on paper/ presentation	5

3	**What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)**		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?

4	**Overall, are you still on track to meet your commitments to the project?**
	yes
5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**

	- went over results so far and everything looks good but having missing data for a few sections - Discussed the best way to show the analysis of the results within the paper and the presentation verbal vs visual	

Weekly Report-Out

Team: WAVES — Today's Date: 4/16/2021

1	What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)		Labor Hours
	Customer	Commitment Description	
	Everyone	Meeting	15
	RA	Finish running Matlab	20
	KG,EZ	Tested the arduino device	4
	RA,JE,EZ	work on modeling/editing models	12
	everyone	working on the paper/ presentation	10

2	What work will you complete this week (by our next session)? (let others know what they can depend on)		
	Customer	Commitment Description	
	everyone	record presentation and work on the report	15
	RA,JE,EZ	Continue touching up models and editing	9

3	What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?

4	Overall, are you still on track to meet your commitments to the project?
	yes
5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**
	- discussed how to discuss the results and the potential sources for error - finalized who would be presenting certain portions of the presentation and how much time will be spent on each slide

Weekly Report-Out

Team: WAVES | Today's Date: 4/23/2021

1	**What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)**		Labor Hours
	Customer	Commitment Description	
	Everyone	Meeting	5
	Everyone	Recorded the presentation	10
	Everyone	Writing the report	15
	RA,JE,EZ	Finish up solidworks models	6

2	**What work will you complete this week (by our next session)? (let others know what they can depend on)**		
	Customer	Commitment Description	
	everyone	Finalize presentation	5
	everyone	Finish writing and editing the report	20

3	**What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)**		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?

4	**Overall, are you still on track to meet your commitments to the project?**
	yes
5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**
	- Went over what the presentation looked like and made edits to the slides included - Scheduled out time to spread out report editing over dead week

Weekly Report-Out

Team: WAVES | Today's Date: 4/30/2021

1	**What commitments have you completed since our last check-in? (let others know you've kept your commitments, declare work "done" so it can be accepted)**		Labor Hours
	Customer	Commitment Description	
	Everyone	Meeting	5
	Everyone	Finalize Presentation	10
	Everyone	Finish the Report	30

2	**What work will you complete this week (by our next session)? (let others know what they can depend on)**		
	Customer	Commitment Description	

3	**What constraints are keeping you from getting your work done? (ask for help, declare a breakdown, raise concerns…)**		
	Concern, breakdown, or help you need	Resolution (Action by When)	Who's Responsible?

4	**Overall, are you still on track to meet your commitments to the project?**
	yes
5	**Weekly: Team Meeting and Faculty Advisor Meeting Notes**
	- watched the presentation to see if any last changes needed to be made before submitting - Discuss what portions of the report still need to be completed

Appendix XII

Team Resumes

Rachel Anderson

275 S Garden Way Appt 205
Eugene, Oregon, 97401
4256477003
Andersor21@up.edu
https://www.linkedin.com/in/rachel-anderson-6746a419b/

SUMMARY

Passionate mechanical engineering student eager to learn and demonstrate innovative engineering skills and methods. Determined, driven, responsible, and self-reliant on any project or task.

- Knowledgeable in the 2020 Microsoft Office 365 Suite
- Experience with the Windows 10 and MacOS 10.13 desktop environments, including Microsoft and VMware remote desktop clients
- Proficient in MATLAB and SOLIDWORKS

EDUCATION

UNIVERSITY OF PORTLAND **Expected Graduation: May 2021**
Bachelor of Science Mechanical Engineering, minor in Environmental Engineering

EXPERIENCE

University of Portland Undergraduate Student **Portland, Oregon**
Senior Capstone, W.A.V.E.S.(Willamette Anti-Erosion Versatile Energy System) *May 2020– Present*

- Continuing work performed as a research student to find a solution to erosion
- Working with students of multiple majors
- Designing a prototype which will reduce energy of the waves
- Implementing energy collection devices if possible

Engineering Graphic Design, Reverse Engineering Project *January 2019 – May 2019*

- Independently disassembled consumer equipment into labeled and documented parts for individual measurement and recreation in the SOLIDWORKS CAD tool
- Used SOLIDWORKS to accurately reconstruct the equipment using verified physical measuring devices
- Compiled the set of components into an assembly to fully realize a precise digital version of the original consumer equipment

Research Student **Portland, Oregon**
University of Portland *May 2019 – Present*

- Worked with industry professionals to research the potential erosive impacts of wakeboarding craft on major Oregon rivers
- Facilitates the completion of government permits for research approval
- Performs field work on a weekly basis to collect primary data including environmental samples and media
- Uses the MATLAB environment to analyze collected data, including intelligent video parsing
- Performs standardized tests according to procedure to analyze samples collected
- Further the legislative discussion on the impact of wake surfing within the state of Oregon

Kohls **Redmond, Washington**
Sales Associate *May 2017 – August 2017*

- Worked independently and in groups to complete various internal and customer facing tasks
- Individually prioritized and completed multi-day projects
- Communicated directly with customers to ensure a smooth and pleasant experience on the sales floor

Foundry10 **Seattle, Washington**
Student Intern *September 2015 – March 2016*

- Collaborated with diverse stakeholders to define and test innovative learning and studying techniques for a diverse range of secondary school students
- Independently developed and deployed iOS 9.x.x applications using self-taught web development skills

Relay for Life **Redmond, Washington**
Event Organizer *Fall 2014 – Spring 2017*

- Engaged local and national businesses to encourage charitable participation and donations
- Managed day-of activities and events
- Performed financial accounting for proceeds from event

REFERENCES

Cara Poor PhD, PE — **University of Portland Professor – Led Research Project**
503-943-8743 — *May 2019 – Present*
poor@up.edu

Heather Dillon PhD — **University of Portland Professor – Programming Lead for Research Project**
hedillon@uw.edu — *May 2019 – Present*

Kim Arent — **Relay for Life Volunteer Supervisor**
kimmiarent@gmail.com — *September 2016 – June 2017*

275 S Garden Way Appt 205 Eugene, Oregon, 97401 4256477003 andersor21@up.edu

JEREMIAH ERIKSEN

17415 SW Arborcrest Way
Beaverton, OR 97003
503-504-8571
eriksen21@up.edu

EDUCATION

University of Portland Portland, Oregon
Bachelor of Science in Mechanical Engineering — Expected May 2021
GPA: 3.42/4.0

EXPERIENCE

Plus Corporation Beaverton, OR
Warehouse Shipping and Receiving Associate — Summer 2013 - 2019

- Completed hands on work and physical labor in a fast-paced environment.
- Assisted in shipping and updating accounting information.
- Actively worked with coworkers to complete deadlines.

Umajimaya Beaverton, OR
Cashier — Summer 2017 – 2018

- Provided quality customer service and support.
- Reliably worked on a team and built positive relationships with coworkers and management.
- Balanced work with full time school responsibilities.

ACADEMIC PROJECTS

Machine Design Final Project — Spring 2020

- Collaborated with team to design a transmission for a prototype of a pulley-plow system.
- Conducted research and testing to determine the right type of transmission and gear ratio.

Reverse Engineering Project — Spring 2019

- Dissected a real assembly and inspected its geometry.
- Created parts and assemblies in SolidWorks.
- Built professional quality part and assembly drawings using SolidWorks.

Freshman Design Project — Fall 2017

- Designed/constructed a windmill using balsa wood, Legos, LEDs, and an Arduino setup.
- Communicated effectively with a team to establish goals and deadlines.

TECHNICAL SKILLS

- SOLIDWORKS CSWA Mechanical Design ASSOCIATE certification as of April 2019.
- MATLAB, Excel, Word, PowerPoint.

6728 N Monteith Portland, OR 97203
(253) 306-0235
kaitlyn.gores@gmail.com
www.linkedin.com/in/kaitlyn-gores-713aa516b

Kaitlyn Gores

College senior majoring in Civil Engineering and minoring in Environmental Engineering. Track record of using excellent personal, communication and organization skills to problem solve and complete tasks effectively and efficiently. Team player with excellent communication skills, high quality of work, driven and highly self-motivated. Passion for innovation and sustainability.

Relevant Experience

AUGUST 2020 – PRESENT

Willamette Wave Attenuator Capstone Project/ University of Portland, Portland, Oregon

-Team IT/Webmaster with four multidisciplinary engineers.
-Researching the problem of erosion in the Willamette River.
-Designing and building a wave attenuator prototype to decrease land erosion and capture wave energy.

JANUARY 2020 – APRIL 2020

Sustainable Design/University of Portland, Portland, Oregon

-Performed life cycle assessments on products and materials.
-Evaluated the sustainability of products based on energy usage, water footprint, carbon footprint, and recycling/reuse.
-Learned about environmental regulations regarding water treatment and building codes.

AUGUST 2018 – DECEMBER 2018

Running Path Design Project/University of Portland, Portland, Oregon

-Worked with a team of Civil Engineering students to design a running path for the University of Portland River Campus.
-Used surveying equipment, ArcGIS, and AutoCAD to design a path that took into account stakeholder needs and environmental needs.

JANUARY 2019 – APRIL 2019

Environmental Engineering & Lab/University of Portland, Portland, Oregon

-Became familiar with common analytical tools for analyzing water and wastewater as well as best practices for water sampling.
-Applied chemistry and microbiology to analyze environmental phenomenon and design processes to protect the natural environment.

Skills

Proficient with Microsoft Office • AutoCAD, ArcMap, ArcGIS, MatLAB, and R experience • Team player • Excellent time management skills • Written & oral communication skills

Education

AUGUST 2017 - PRESENT

Bachelor of Science in Civil Engineering/University of Portland, Portland, Oregon

Minor in Environmental Engineering
Member of Society of Women Engineers
Member of College Ecology Club

Davey Robeck
Portland, OR | robeck21@up.edu

PROFILE

Diligent outgoing leader who expresses energetic and caring qualities as shown through role as a First Year Workshop Leader. Effective communicator shown through both written and verbal instruction. Organized and facilitated events to promote community.

EDUCATION

University of Portland | Portland, OR — Expected May 2021

B.S., Major: Civil Engineering, Minor: Environmental Engineering

ENGINEERING EXPERIENCE

Project Lead, WAVE Energy Capstone, University of Portland, Shiley School of Engineering — Fall 2020-Present

- Lead group of 4 in the continuation of Wave Energy Analysis Research Project
- Organize weekly meetings to discuss research of energy capturing or dispersing devices and prototype ideas
- Track schedule of individual and group progress on delegated weekly tasks and goals
- Support team members through individual conversation and check-ins

Engineering Intern, SGA Engineering, Vancouver, WA — June 2020-Present

- Independently design and produce stormwater plan for 10 single family households under review of licensed P.E.
- Used AutoCAD and GIS to design elements including
- Modify and adapt Subdivision plans to illustrate As-built features
- Generated Reports using standard formatting to illustrate code compliance of the project

Undergraduate Research Assistant, University of Portland, Shiley School of Engineering — Summer 2019- Fall 2019

- Independently defined questions, processes and scope of project examining wave energy on the Willamette River using MATLAB to analyze videos captured by motion activated cameras.
- Collaborated with homeowners to gain support and understand concerns
- Participated in a conference with a variety of stakeholders to discuss erosion concerns caused by wake surfing
- Generated map using GIS to illustrate the scope of work as well as the different boating regulation zones
- Performed lab tests evaluating water nutrients such as Nitrate or Total Nitrogen and navigated ambiguous results
- Present results at both OSBEELS 2019 Symposium and the University of Portland Summer Research Conference

Engineering Graphic Design, Jogging Path Project — Fall 2018

- Worked with a team to create and map points for a jogging path using input from client interview to meet needs
- Used GPS Surveying to define points for the path
- Designed walkway using AutoCAD

LEADERSHIP

Returning First Year Workshop Leader, University of Portland — Summer 2018-Present

- Interviewed and hired as a Returning Workshop Leader following 2 successful years as Workshop Leader
- Participate in training of new team members and provide resources to students and First Year Workshop Leaders
- Instruct and modify lesson plans to meet needs of virtual learners and adapt schedule to accommodate students
- Attended weekly workshop leader meetings to collaborate with peers on how to effectively teach lessons

Events Coordinator, Schoenfeldt Hall Council, University of Portland — Fall 2017 - Fall 2018

- Coordinated events in which hall members participated
- Used leadership to encourage and support community

SKILLS

Software:	AutoCAD, MATLAB, GIS, MS Teams, Moodle, Zoom, Outlook, Excel, Word,
Surveying:	Differential Leveling, Total Station, GPS

Ernesto A. Zurita Ruiz

+1 (360) 931-3768 | ernesto.a.zurita@gmail.com | Portland, OR Metro Area
www.linkedin.com/in/ErnestoZuritaRuiz

Profile

Proactive mechanical engineering undergraduate student seeking opportunities to apply and expand intellectual skills in heat transfer, thermofluids, and machine design, especially when relating to renewable and nuclear energy. Strong work ethic, independent, and unafraid to seek help. Is always in a positive learning mindset and brings a genuine smile to the workplace.

Education

University of Portland, Portland, OR — May 2021
B.S. Mechanical Engineering, Minor: Entrepreneurship & Innovation Management — GPA 3.73

- Entrepreneur Scholars, 2019-2020

Technical Skills & Certifications

MATLAB:	Image Processing, Audio Processing, Linear Algebra, Thermal Systems Modeling
ANSYS:	Finite Element Analysis.
CAD/Drafting:	Solidworks, Autodesk Inventor, Technical Drafting.
Technical Writing:	Standard work procedures, government estimate reports, government contract specifications.
Cleanroom Experience:	Gowning, cleanliness protocol, safety.
Languages:	English (Native), Spanish (Proficient), French (Basic).
Certifications:	Hazardous Energy Control Program (HECP), U.S. Army Corps of Engineers – Completed May 2020.

Engineering Experience

Finance & Purchasing Engineer, W.A.V.E.S. Capstone Team, University of Portland — Aug. 2020 – Present

- Mechanical engineering team member of the Willamette Anti-Erosion Versatile Energy System (W.A.V.E.S.) senior capstone team at the University of Portland.
- Advised the capstone team in the development of the project schedule and other project management best practices.
- Led the team in developing the Bill of Materials (BOM) required to build a prototype for the capstone project.
- Developed a budget for the capstone project using previous industry experience in cost estimating.

Project Engineer - Student Trainee, U.S. Army Corps of Engineers (USACE), Cascade Locks, OR — May 2020 – Aug. 2020

- Project Engineer and Government Quality Assurance Representative (GQAR) for the Construction and Engineering branch of the Portland District, USACE.
- Managed contract modifications for construction projects under the USACE construction Residence Office at Bonneville Dam involving mechanical, electrical, and civil engineering work scopes.
- Assisted in the preparation of Request for Proposals (RFPs), engineering plans, designs, specifications, and standards of construction projects.
- Reviewed project and payment schedules for construction projects, especially after COVID-19 related delays.
- Prepared contract modification negotiations from proposal and prices analyses of the Contractor's submittals.
- Reviewed contractor Accident Prevention Plans and Quality Control Plans.
- Quality Assurance (QA) of construction activities by codes (NEC, NFPA, NEMA).
- Projects in fire protection, electrical, HVAC, and transformer supply & installation.

Cost Engineer - Student Trainee, U.S. Army Corps of Engineers (USACE), Portland, OR — May 2019 – Jan. 2020

- Cost Engineer for the Construction and Engineering branch of the Portland District, USACE.
- Managed several concurrent construction projects, working with members of multidisciplinary project development teams.
- Developed class 5, 3, 1 estimates and Independent Government Estimates (IGEs) for project contracts and reports using historical data, software based on RSMeans data, quotes, bid abstracts, and escalation calculations.
- Developed cost and construction schedules for government projects.
- Reviewed mechanical system technical plan drawings/specifications to assist cost engineers in their estimates.
- Advised civil and electrical cost engineers using knowledge of mechanical systems such as piping, gears, and motorized equipment as required by projects.
- Contacted and worked with vendors for quotes and lead times on products and services, determining the right products for construction project requirements.
- Conducted Abbreviated Risk Analyses for projects to develop tailored contingencies for construction costs.
- Interpreted structural, electrical, civil, and mechanical drawings to develop accurate project cost estimates.
- Field exposure to weld and paint Quality Assurance (QA).

Engineering Technician Intern, Applied Materials, Hillsboro, OR — May 2018 – Mar. 2019

- Assisted in the manufacturing builds of optical tools and the R&D of optical tools and components.
- Took charge of logistics relating to supplies and components critical to the manufacturing builds of products at the Hillsboro, Oregon facility.
- Practiced inventory management, particularly in component and build tracking with spreadsheets.
- Ordered any materials needed to complete day-to-day manufacturing functions of the facility.
- Used MATLAB for image processing using output data during Research and Development (R&D) of optical tools.
- Worked with and managed Bill of Materials (BOM) necessary for builds of optical tools.
- Helped with miscellaneous facility repairs.

Laser Metrology Intern, SEH America, Vancouver, WA — June 2016 – Aug. 2016

- Used Microsoft Office Excel to review output data from laser metrology equipment for use in calibration verification, equipment performance review reports, and certification in accordance to Quality Assurance (QA) testing standards.
- Used clear, specific, action-oriented technical writing language to revise and develop standard work procedures for process control of 3 laser particle inspection measurement testing tools, conforming to SEH's Kaizen and 5S manufacturing guidelines.
- Delivered presentations and communicated with engineers, operators, translators, and other industry employees.
- Trainings: Quality management inspection measurement testing in calibration; technical and standard work procedure writings.

Academic Experience

Selected Participant, Nuclear Science and Engineering Winter School, MIT, Cambridge, MA — Jan. 2020

- Learned about fusion, fission, and reactor design technologies being researched by MIT graduates and faculty and opportunities in their graduate school programs.
- Conversed with faculty on two-phase flow research in reactor cooling design, leading to a personal visit to the Red Laboratory at MIT.

Mechanical Engineering Analysis, Audio Processing Study — Fall 2019

- Analyzed the effectiveness of the Fast Fourier Transform in digitally recreating the musical timbre of guitar, flute, and human voices using MATLAB.
- Unpublished paper on results from this semester long independent study.

Extracurricular & Leadership Experience

President, Society of Hispanic Professional Engineers (SHPE), University of Portland — Apr. 2018 – Present

- Elected President following a successful year as engaged and active member.
- Led a recently new, small chapter during an unprecedented online academic year.
- Took proactive steps in delegating work among officers to plan a virtual Career Fair, resume review workshops, and creating community service projects as a focus for the academic year.

Team Lead, Accord-On, Portland, OR — Apr. 2020 – Sep. 2020

- Collaborated with team of 3 to ideate and prototype an add-on product to teach people how to play the accordion.
- 3D printing, microcontroller coding (Arduino), Android app development, PCB design.
- Presenting final progress to community of entrepreneurs and inventors.
- A musical tech venture that flowered from Entrepreneur Scholars; currently in competition at Invent Oregon.

Additional Experience

Entrepreneur Scholar, University of Portland — Aug. 2019 – May 2020
Vice-President, Blue Key Honor Society, University of Portland — Apr. 2020 - Present
Member, Circle K, University of Portland — Aug. 2019 - Present

Appendix XIII

ABET Outcomes

ABET Outcomes 2a, 2b, 2d, 2e, and 2f

To design a great product, the needs of the consumer are critical. Therefore ABET outcome 2a was important in identifying the stakeholder or consumer. The primary stakeholders for this project are: recreational boaters, environmentalists, fishermen, anyone who enjoys or uses the river for a purpose not noted. The major stakeholders for this project are the homeowners along the Willamette River. Due to the complexity of the consumer's needs, several design considerations were considered when drafting the prototype design. Two additional ABET outcomes were analyzed and played a role in the final design. ABET outcome 2e was important as the project affects many individuals and involves legislation. The political and societal factors guiding design are the effect of this project on recreational boating and the environmental regulations within the river.

ABET outcome 2f was critical in the design process because of the project's direct affects on the public and on water quality. The public health and welfare factors included creating a product that presents no additional boating or recreation hazards and selecting materials that do not leak chemicals. Additional factors for outcome 2f include reducing the hazardous motion of docks by attenuating the energy of the waves and preventing severe erosion that has made several embankments too dangerous to navigate.

ABET Outcomes 5b, and 5d

A group dynamic is the life blood of a project and thus can make or break the success of the project. ABET outcomes 5b and 5d are concerned with group dynamics including organization, scheduling, and communication.The group organized itself by creating goals at the beginning of the academic year and developing a comprehensive timeline that included deadlines and sufficient time for all deliverables. Upon finishing the first semester, the group met before winter break to reflect on the work completed and discuss goals for the future. Then at the beginning of the second semester the group met again and created a similar schedule of deadlines and dates for the deliverables necessary for the completion of the project. The group was organized throughout the semester, rarely missing a self-set deadline. The interaction with group members was always positive and productive, and left all members more knowledgeable on various subject matters regarding the project. The meetings with the faculty adviser were always valuable even if it was a simple update meeting, because Dr. Farina almost always had a great idea for either an additional item to work on or a potential solution. The group did a great job at helping members when they were under immense workload outside of capstone. For example, when a member gave notice that they had a heavy test week and could not meet the deadline, the other group members happily picked up additional work to finish before the deadline to help this member out. The group also kept the faculty adviser updated on the project and were not afraid to ask questions and ask for help. The team lead of the group was labeled as the lead but everyone within the group was a leader in some fashion. This made the group a collection of brains and a democracy rather than a dictatorship, which made the project more enjoyable and successful. Every member had their talents and stepped up as a leader at multiple points throughout the semester. This is not to say the team lead was a background character and did not lead the team, it just means the team lead was not barking out orders and commands to the fellow members. The members just naturally played to their leadership strengths. The group had to make many decisions throughout the semester, and did so with a simple majority, after hearing what all sides had to say.

ABET Outcomes 7a, and 7b

This capstone project allowed members of the team to experience hands-on learning not taught in their engineering curriculum. ABET outcome 7a and 7b deal with learning outside of the classroom. An example of this would be independent research and learning by group members throughout the project especially during the fall semester of the capstone project. While classroom content on waves was briefly covered as a means for hydroelectric power, the group conducted additional research on the effects of waves and wave mitigation, measurement, and energy capture. For example, those working on the wave energy measurement device with the Raspberry Pi had to determine how to apply theory from Instrumentations and Controls to a design that would be tested in the field.