1. ABSTRACT

This report explains how Team Leatherbacks built and improved their remotely operated vehicle (ROV) to compete in the 2022 Seaperch Challenge. Their design goals were to improve velocity, maneuverability, and functionality of their current robot in different ways, testing drastic changes in order to fine-tune the ROV's performance. Between September of 2021 and April of 2022, Team Leatherbacks designed and tested eight distinct prototype ROVs. This report explains the use of the Engineering Design Process (EDP) to continually improve prototypes to efficiently accomplish the challenge course tasks. This report also discusses what makes this team's ROV design unique. Future plans will also be included. The EDP was used to design and utilize the following:

- **Servo gripper-** a servo gripper clamps down on course objects for transportation.
- **Servo controller-** a servo controller allows for an extra pilot to control the ROV's gripper. This helped the team learn how to work together while completing the challenge course tasks.
- **Various colored parts-** various colored parts enabled the team to track the ROV's orientation.
- **Undermount hook-** an undermounted hook enables elevating and easy transport of the batteries.
- **Lightweight Frame-** with a weight of 19g, a lighter frame improves performance.
- **Improved waterproofing method for motors-** the Leatherbacks' unique waterproofing method involves putting tape on the motor with a 3D-printed cap (to improve hydrodynamics) and then applying a coat of standard polymer resin. This causes less drag and splits the water better when submerged than the waterproofing method involving toilet bowl wax around the metal pole of the motor and insulating the entire component in a small film canister. The standard Seaperch motors had a surface area of 871.54mm while the surface area of the motors the Leatherbacks use were 648.03mm for a 17% reduction in size of the motor housing.

2. TASK OVERVIEW

Challenge course- The challenge course consists of four tasks.

- **Task 1-** this task includes unlatching the panel and opening the panel. To unlatch the panel, the Leatherbacks rotated the latch clockwise. Then they latched onto the rope and pulled the gate open.
- **Task 2-** in this task, the Leatherbacks are required to "unplug" power cables from batteries located in the compartment. The Leatherbacks approached this task by utilizing an undermounted hook to unlatch the cables. The purpose of the undermounted hook is to hook onto the cable and pull it free. The power cables are originally magnetically connected to the batteries; therefore, it requires force (New Netherland Institute, n.d.) to remove the cables from their position.
- **Task 3-** this task has two subtasks. The Leatherbacks are required to move the used batteries to the battery pallet and then transport the new batteries into the battery compartment. It is required to pull the batteries in and out of the panel door. Because of the neutral buoyancy in the batteries, they altered the buoyancy accordingly. If a battery sank, they would be unable to retrieve it.
- **Task 4-** in this task, team Leatherbacks need to grab three tools and transport them to the tool caddy. The tools are buoyant, so the Leatherbacks modified their buoyancy to adapt to this. Only one tool may be put on each individual hook. Because of this, the Leatherbacks innovated their servo-operated gripper to be further away from the ROV to fit the tools on the tool caddy.

Obstacle course- the obstacle course requires the Leatherbacks to move through five hoops as fast as possible while surfacing at the opposite side and backtracking afterwards. They modified their ROV to reduce drag, increase velocity, and increase hydrodynamic performance. The Leatherbacks changed the height and width of the ROV to make it more hydrodynamic by reducing drag. They modified the ROV to make it have only one panel in the center to downsize the surface area.

3. DESIGN APPROACH

The design process they followed this past year has been essential in the creation of their **ROVs**. This design process consists of seven steps.

Step 1 (Ask Questions)- What can they do to make their ROV efficient?
Step 2 (Research)- Research the materials that are necessary.
Step 3 (Imagine)- Imagine what they will do.
Step 4 (Plan)- Gather materials and draw what they will build.
Step 5 (Create)- Construct the ROV they planned for.
Step 6 (Test)- See if what they constructed is effective.
Step 7 (Improve)- Proceed to further make the ROV cutting-edge.

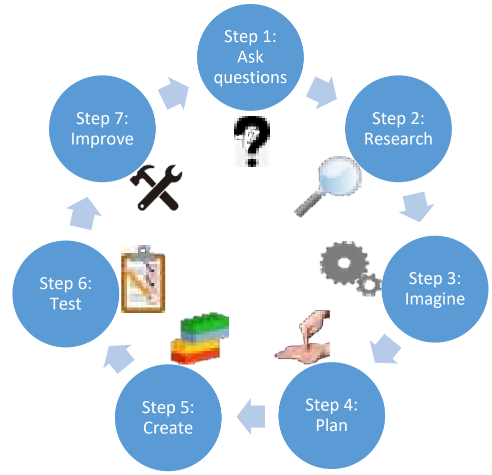

Figure 1 – Engineering Design Process (EDP)

ROV #1 – The Leatherbacks used the standard Seaperch design, which is large, cubical, and heavy, making it slow. The buoyancy was pool foam, which compresses under pressure. When they tested it, the Leatherbacks figured out that while it had stability (Engineering ToolBox, 2008), it wasn't fast.
Height: 18cm **Width:** 16.5cm **Length:** 30cm **Weight:** 712g
Velocity: 0.305m/second

Figure 2 – ROV #1

ROV #2 -They made their second ROV smaller and lighter to improve speed and decrease drag. They modeled it after the original ROV, but they made it 33% smaller in size. When they tested it, they found the buoyancy medium (the green foam on figure 3) wasn't working to the full extent they wanted it to because the buoyancy (Moore, S. W., Bohm, H., Jensen, V., & Johnston, N., 2010) decreased over time while underwater.
Height: 12cm **Width:** 10.5cm **Length:** 21.5cm **Weight:** 507g
Velocity: 0.271m/second

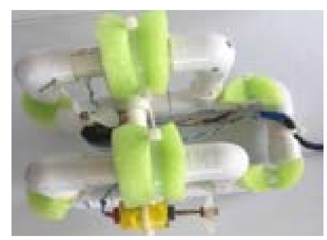

Figure 3 – ROV #2

ROV #3 - The Leatherbacks further downsized the original design and changed the type of pipe in this ROV. Since Cross-Linked Polyethylene (PEX) pipe is smaller, and **much** lighter than regular Polyvinyl Chloride (PVC) pipe, it allows the ROV to have less drag. They changed the buoyancy to plastic bottles instead of foam because the bottles provided a constant buoyancy. Therefore, the less mass, the more velocity. This is an example of the thrust-to-mass ratio.
Height: 10cm **Width:** 8.25cm **Length:** 16cm **Weight:** 230g
Velocity: 0.378m/second

Figure 4 – ROV #3

ROV #4 – The Leatherbacks innovated their fourth ROV using skills they learned from ROVs one, two, and three. They curved the front and back pipes, and also made the vertical motor facing downward to prevent ripples on the water's surface. They used the syntactic foam (small pieces of glass compacted together) center piece to hold everything together and having two halves of PEX pipe to hold on the forward and reverse motors.
Height: 8.89cm **Width:** 17.145cm **Length:** 20.32cm **Weight:** 156g

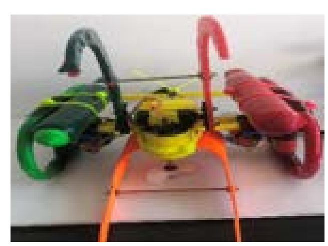

Figure 5 – ROV #4

ROV #5 – This ROV is fast, light, agile, and hydrodynamic (Boatman, 2019). This is the first time the Leatherbacks used a 3D model with a servo and bottom fork. While it is fast and agile, one weakness is how fragile it is because of thickness of the 3D filament.
Height: 10.16cm **Width:** 13.97cm **Length:** 17.78cm **Weight:** 111g

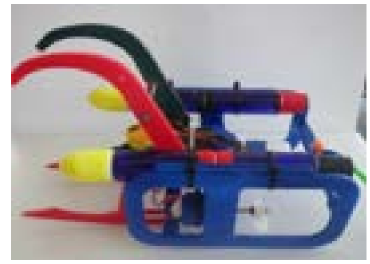

Figure 6 – ROV #5

ROV #6 – The Leatherbacks modified this ROV by making it flat, therefore decreasing drag (Khan Academy, n.d.) and increasing its hydrodynamic performance. It has a carved piece of syntactic foam (similar to ROV 4), corks on the cord, and a servo. It has holes in the frame to let the water in. They also included their bulldozer servo attachment that connects to their gripper. This made it easier to bump out the floating trash in task three of the 2021 Seaperch Challenge Course last year.
Height: .9525cm **Width:** 17.78cm **Length:** 15.24cm **Weight:** 60g
Velocity: 0.732m/second

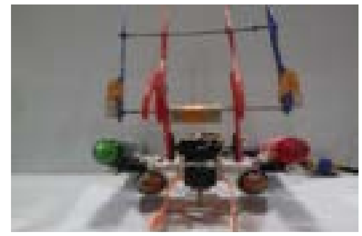

Figure 7 – ROV #6

ROV #7 – This design went through many changes due to the 2022 Seaperch challenge course. The Leatherbacks removed the bulldozer attachment to better adjust to the 2022 Seaperch challenge course. Since they were moving into open class, they decided to use other materials other than PVC pipes like 3D filament which was used for this ROV.
Height: 9.15cm **Width:** 12.45cm **Length:** 17.78cm **Weight:** 84g

Figure 8 – ROV #7

ROV #8 (FINAL DESIGN): One of the most noticeable changes that happened between ROVs 7 and 8 was that the Leatherbacks reduced the width by an entire side panel. In ROV 7, there were 2 side panels with a middle section. The Leatherbacks changed that and innovated a singular panel with the components attached. The Leatherbacks considered different hook designs and ended up with servo-operated grippers, nicknamed "chopsticks". It has a hole near the end to lock the rope of the tools in the gripper. A sword-like bottom hook was added to transport batteries and unplug charging cords. The chopsticks and bottom hook are storable on the frame for the obstacle course to improve agility and handling of the bot. The Leatherbacks decided to use nylon bolts because they weigh less than steel bolts. Plexiglass material was also considered and was tested but they ultimately chose to go with 3D filament material due to its buoyancy and rigidity. The Leatherbacks also added extra holes in the frame because they found that when you add a hole, it makes a ridge on its edges which increased the stability. The Leatherbacks used multiple colors to increase visibility. That was a technique that they learned from previous ROVs. The standard SeaPerch propellers were replaced with RC Boat Speed Propellers because the Leatherbacks found that when the propellers turn toward the middle of the ROV, the ROV drives straighter than the normal propellers. This is since the counterrotating props have more balanced force.
Height: 9.9cm **Width:** 10.9cm **Length:** 10.8cm **Weight:** 19g **Velocity:** 0.823m/second

Figure 9 – ROV #8 (FINAL DESIGN)

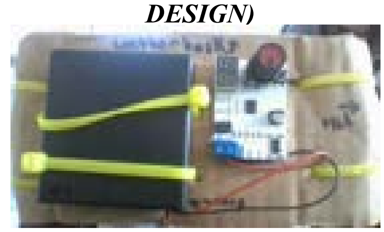

Figure 10 – ROV Servo Controller

Servo Controller – They cannibalized pieces from previous frames to make the frame and put the batteries & the circuit board on a slab of cardboard and zip tie that onto the frame. It controls the servo connected to the ROV. It has a 90º turn button and a 180º dial. Because it requires a second teammate, it helps reduce the workload on the driver and builds trust and teamwork when the driver and line tender communicate.

4. EXPERIMENTAL RESULTS

While testing their ROVs, the Leatherbacks discovered many variables that impacted their design. Their replicated course reflected the specifications required for their final testing. The velocities they discovered testing ROVs 1 and 2 were slow because of their big, bulky designs. When shifting from ROV 2 to ROV 3, they improved the average time by 15 seconds. The Leatherbacks further decreased the size of their ROVs. These improvements in design resulted in faster ROVs, which resulted in moving from place to place faster than ROVs 1-3. Their times decreased, helping them get the courses finished in the best possible time.

Velocity Test: They timed their ROVs from one end of the pool to the other and back (17.1m) to measure their average velocities in meters per second.

Cable Test: They tested different cable lengths, strand types, and the number of wires to see which combination would produce the most RPMs. This test revealed that by doubling the copper the cables produce more velocity which means that it increases RPMs (600).

Maneuverability Test: The Leatherbacks found that maneuverability was determined by how well prototype ROVs navigated through a typical Seaperch obstacle course.

Functionality Test: Functionality was determined on both pool courses depending on the overall performance while being driven.

Thrust Test: A thrust stand was constructed to discover which propeller generates the most thrust and to discover the thrust of the motor. The Leatherbacks tested the propellers as shown in figure 13. They tested the speed of the props in the pool after discovering the new propellers. The time difference that changed from the standard Seaperch propellers and the RC Boat Speed propellers improved thrust by 7%. Also, the time difference that changed from the RC Boat Speed propellers to the counter rotating Seaperch propellers decreased by 20% because there was less distance to travel because the ROV drove straighter from the props. As mentioned in the design approach, the ROV drove straighter because of the propellers turning in opposite directions. From this data, the Leatherbacks concluded the RC boat propellers achieved the most velocity.

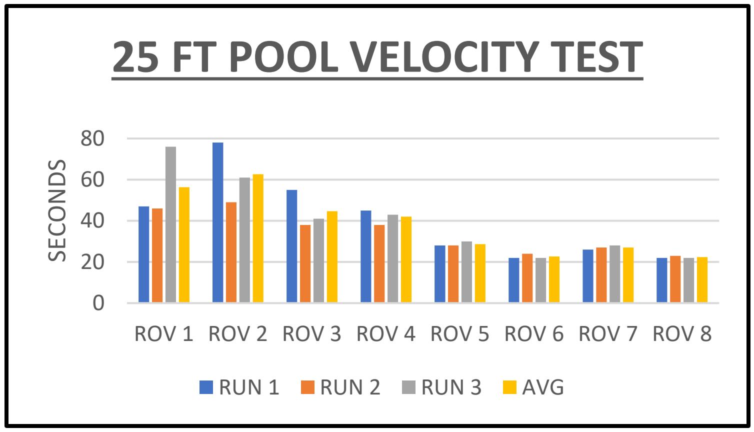

Figure 11 – ROV Velocity Test Results

Figure 12 – Thrust Stand

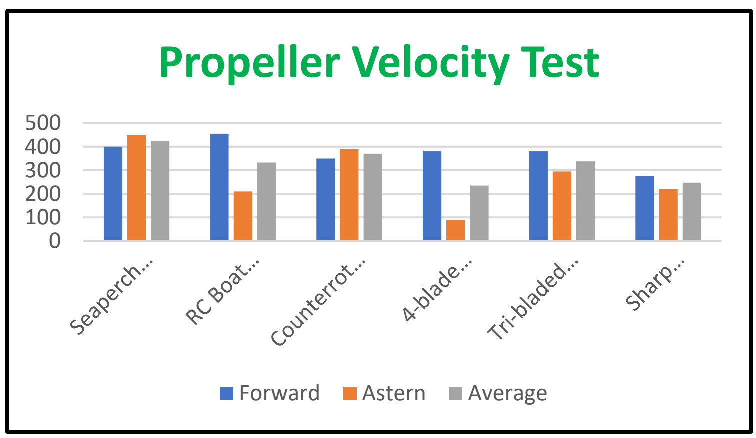

Figure 13 – ROV Propeller Thrust Test Results

5. REFLECTION & NEXT STEPS

EDP Reflection

Over the past 8 ½ months, the Leatherbacks used the engineering design process (EDP), detailed in their design approach, to build and improve their series of 8 prototype ROVs. The EDP consists of 7 steps. Step #1 is to ask a question. They asked questions to generate ideas for improving their ROVs. By improving their ROVs, their runs through the obstacle course and challenge course will increase the efficiency. Step #2 is to research. They researched materials and methods to increase their ROV's performance. By researching materials and methods, they can experiment with different concepts and find which one fits best. Step #3 is to imagine. The Leatherbacks imagined how the ROV might be redesigned using these materials and methods. By imaging their ROV redesigns, they can infer which new design would help them the most in the challenge course and obstacle course. Step #4 is to plan. The Leatherbacks thought out their approach to the tasks that they imagined (coordinating with step 3). By planning, they have an idea on what to do next based on their ROV. Step #5 is to create/build. Over the past 7 months, they relocated motors, reconfigured frames, adjusted buoyancy and upgraded their ROV to include a servo. By creating and building, they are making ROVs to further work on. Step #6 is to test. The Shanklin house is where the Leatherbacks practice on Tuesdays and Saturdays. They have a flat-bottomed pool where the Leatherbacks test their ROVs. By testing, they can figure out which adjustments work, and which adjustments don't, which helped them adjust and improve their ROV. Finally, Step #7 is to improve (and, in a way, start the process all over again). By improving, their ROV will better fit their goal to have a ROV which is effective in both the obstacle course and challenge course. After they ask questions, research, imagine, plan, build/create, and test their ROVs, the Leatherbacks always think and start the whole process over. Before they start asking more questions about what would and wouldn't work, they always reflect over what they have done. Using the EDP has been essential in getting us where the Leatherbacks are now. After the competition, their team will come back next year and compete with a different ROV.

Next Steps for ROV

The Leatherbacks are planning to use an Arduino board to improve the performance of the tasks by enhancing the maneuverability as well as controlling velocity. They will also use a thrust stand to test the thrust of the motors. The Arduino board will be used to create a wireless controller. Depending on how hard you press on the analog stick, the faster the ROV will drive in a certain direction and vice versa. The thrust stand is useful when testing the average thrust of the motors that the Leatherbacks would use on their ROV. The thrust stand is used in the experimental results to test the multiple variations of propellers to see which one best fits the challenge course and obstacle course. The propellers will be tested to find out which one generates the most thrust.

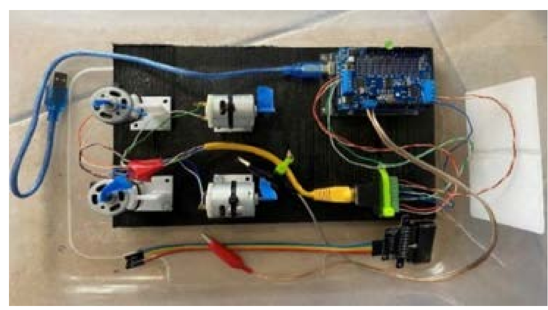

Figure 14- Arduino Board

Next Steps for Team

Next year, The Leatherbacks have considered incorporating more people onto the team. With more teammates, it is possible to split the work up between more people, and it is also possible to get more work done with additional people doing more things. Another benefit is that it is less likely to be short on people, even if a person is absent, there will be more team members available to replace the team member that is absent. A significant drawback to this is that there will likely be more conflict among team members. This is because having a broader number of people on the team increases the chance of bickering and dispute. This can be resolved by conducting a majority vote. The Leatherbacks have considered this tradeoff along with many others.

6. ACKNOWLEDGEMENTS

The Leatherbacks would like to thank their parents, coaches, and sponsors who have helped them achieve their success this season. Their sponsors are TIAA Bank and GoFundMe donors. Their donations gave them the funds to purchase their materials for their ROVs.
The Leatherbacks would also like to thank their coaches, Mr. Hudson & Mr. Shanklin. They have coached, challenged, and encouraged the Leatherbacks since they joined the club.
Their parents have put in just as many hours of work as they have in the robotics club because they drive them to practice, they stay and help them in tasks that they can't do alone or without parent supervision (drilling, soldering, etc.), they give them useful advice, and they have stuck with them throughout the competitions. The Leatherbacks are consequently thankful for their parents, sponsors, and coaches' support.

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APPENDIX A: Budget

Component	Vendor	How was component used?	Cost (in USD)
ROV Center Frame (1-22 Grams)	Self-designed/printed	ROV Frame	$1.10
ROV Motor Mount (1-12 Grams)	Self-designed/printed	ROV Frame	$0.60
ROV Buoyancy Mount (1-12 Grams)	Self-designed/printed	ROV Frame	$0.60
3D Motor Caps (6-1 Grams each)	Self-designed/printed	Motor Waterproofing	$0.30
3D Hook Holders (2-3 Grams each)	Self-designed/printed	Mounting of Hook to Frame	$0.30
3D Gripper Fingers (2-6 Grams each)	Self-designed/printed	Gripper Fingers	$0.60
3D Servo Holder Part 1 (1-6 Grams)	Self-designed/printed	Servo Mount	$0.30
3D Servo Holder Part 2 (1-2 Grams)	Self-designed/printed	Servo Mount	$0.10
3D Bottle Caps (2-3 Grams each)	Self-designed/printed	Buoyancy	$0.30
Servo (SG90) (1)	Amazon	Gripper Actuator	$2.09
Servo Controller (1)	Amazon	Servo Operation	$9.99
4 Pack Battery Holder (1)	Amazon	Servo Power	$2.96
1.5V Batteries (4)	Amazon	Servo Power	$0.84
Servo Wiring (CAT 5 – 40 Feet)	Amazon	Servo Power	$2.40
Counter Rotating RC Speed Propellers	Amazon	Propellers	$5.00
30ml Plastic Bottles (2)	Amazon	ROV Buoyancy	$1.50
15ml Plastic Bottles with Cap (2)	Amazon	ROV Buoyancy	$1.12
Cable Sheathing Red (40 Feet)	Amazon	Cable Collection	$6.60
Heat shrink (6 pcs)	Amazon	Motor Wire Strengthen	$0.09
Lube Compress Packing Seal	Amazon	Motor Shaft Waterproofing	$0.30
SLA Resin	Amazon	Motor Waterproofing	$0.30
Marine Grease	Amazon	Motor Waterproofing	$0.08
Nylon Screws and Nuts (6 Screws, 6 Nuts)	Amazon	Hook Hardware	$0.24
Plastic Cutting Board (<50% used)	Dollar Store	Hook	$0.63
TOTAL COST OF SEAPERCH COMPONENTS			$38.34

APPENDIX B: Fact Sheet

See next page

Team Leatherback

Mayport Coastal Sciences Middle School Jacksonville, FL

OPEN CLASS (3D)

2 Years participating in SeaPerch

1 Times at the International SeaPerch Challenge

Our SeaPerch is unique because: (100 words MAX)

Superlight frame: Our 19g frame increases the thrust to mass ratio.
Very colorful: The ROV is bright so we can see its current position.
Undermount hook: Our undermount hook enables easier lifting of course batteries.
Servo gripper: Our servo-operated gripper provides better hooking of the tools on the challenge course.
Servo controller: Our servo controller provides less responsibility for the driver and good communication skills.

SeaPerch Design Overview: (100 words MAX)

We used the SeaPerch design process to start building & improving our frame. We originally used regular PVC on our ROV and gradually became a smaller 3D frame to reduce drag and increase its speed. To overcome the challenges of the course, we added a servo gripper. We used 3D filament which increased buoyancy and stability. Overall, our ROV is awesome because our ROV can easily overcome all the challenges we throw at it!!!!!!!

Our biggest takeaway this season is: (100 words MAX)

We learned that teamwork is important to making decisions and then acting on those decisions. We also learned that good communication is critical. Communication allowed us to complete and test 8 prototype ROVs in 15 months. Finally, we learned that successfully making ROVs requires including everyone's ideas, brainstorming which idea is best, conduct repeated, detailed testing, and practice, practice, practice!

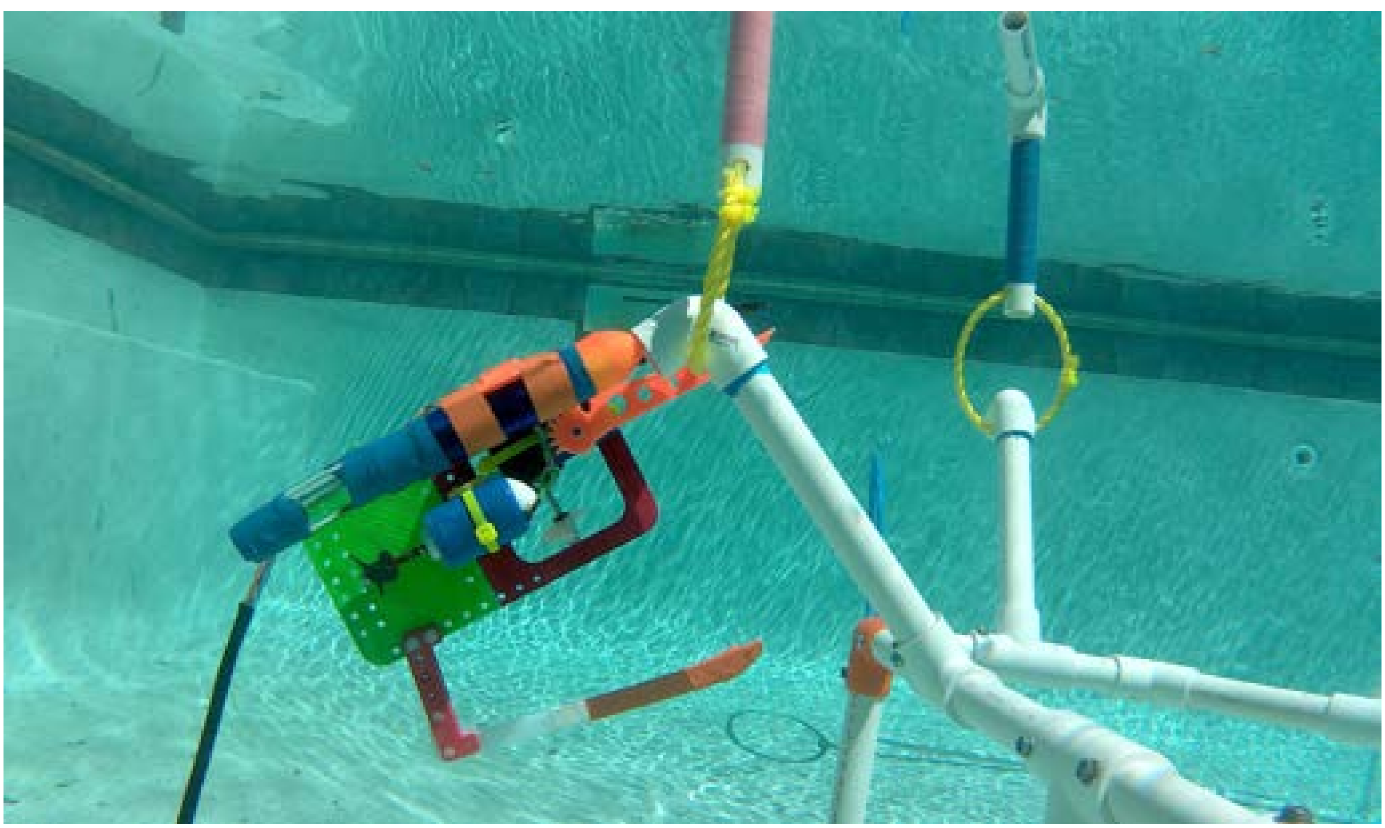
School or club name: Mayport Coastal Sciences Middle School

City, State: Atlantic Beach, Florida

Team name: Team Leatherbacks

ROV name: ROV#8

Seaperch 2021-2022
Engineering Notebook



TEAM INFORMATION PAGE

ADVISOR NAME:	Mr. William Hudson
ADVISOR CONTACT:	hudsonw@duvalschools.org, (716) 239-6640
TEAM NAME:	Leatherbacks
TEAM PARTICIPANTS:	Brendan, 7th Grade Gavin, 7th Grade Maddox, 7th Grade Naurielis, 8th Grade
SCHOOL:	Mayport Coastal Sciences Middle School
SCHOOL DISTRICT:	Duval County, Florida

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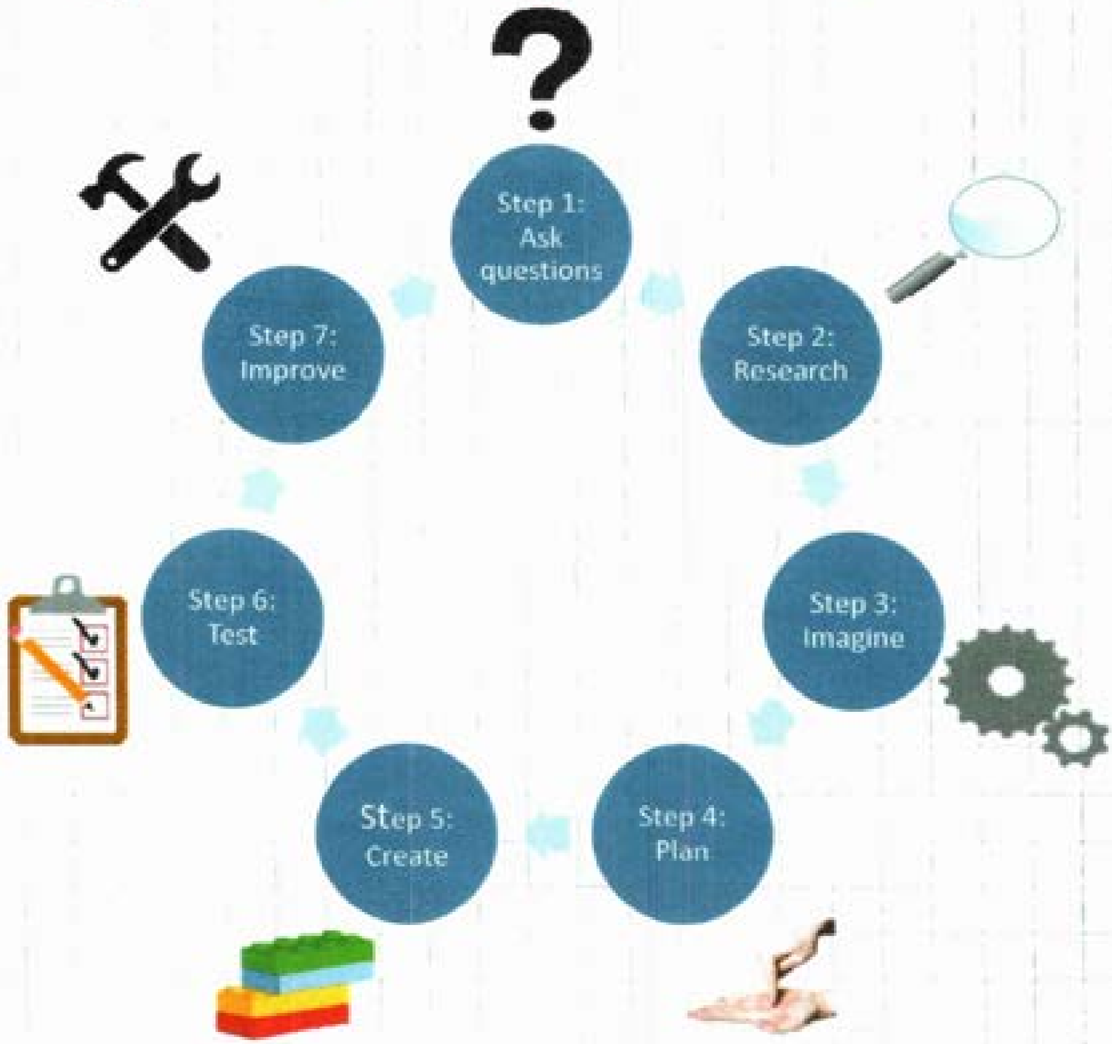
Engineering Design Process II

3/20/21



Engineering Design Process (EDP)

We decided to use this EDP to help build our ROVS and it's accessories.

Team Goals

- [ ] To work together as a team and have fun!
- [ ] To build the best ROV possible.
- [ ] To make it to internationals and win.

Design Terms

Buoyancy- the overall tendency of an object to float in a fluid

Voltage- a unit of electro-motive force used in both the metric and imperial systems of measurement.

Thrust- an actively generated, energy-requiring, propulsive force used specifically to cause or control vehicle movement.

Mass- a measure of an object's intrinsic resistance to acceleration; regarded as a good measure of the amount of matter in an object.

Pitch- 1.) the foward/backward angle through which a vessel, such as a boat or plane, has tipped away from it's normal upright position.

2.) the theoretical distance a propeller would move foward through the air or water after exactly one full revolution, based on the blades' angle, if there was no slip.

Roll- the angle of sideways leaning to the right or left.

Trim- adjusting the bouyancy, pitch, and roll of a vechicle

ROV #1

3/20/21

Our team asked what is the best way to build an ROV?

We researched ROV basics online.

We imagined SeaPerch designs but established to use the SeaPerch design.

We gathered the Seaperch Kit and materials.

As a team, we used the SeaPerch construction Manual to build our first ROV.

ROV #1 side view

ROV #1 front view

Very easy to control, but very slow because of it's big size.

Dry weight: 712g

Bouyancy: positive

control: easy, but slow

average run time: 56 sec/ 1ft per sec

We decided as a team, to make ROV #2 smaller to decrease hydrodymanic drag and increase thrust to mass ratio.

ROV#2

3/20/21

"How can we make our ROV faster?

ROV#2 side view

We researched how drag and hydrodynamics affect speed.

We imagined that by scaling down the size, our drag would decrease, by improving the hydrodynamics.

We planned to scale down the measurements of the height, width, and length of ROV#1.

ROV#2 front view

We created a scaled down of ROV#1 using shorter tubes.

average run time: 63 sec /0.89ft per sec

Dry Weight: 507g

☐ maneuverability test: We drove ROV#2 through hoops to test how well it goes through objects.

☐ velocity test: We drove ROV#2 to the end of the pool and back to test its speed.

To make our next ROV better, we need to improve the drag, hydrodynamics, and weight.

ROV#3

3/20/21

what other material can we use to improve hydrodymanics?

We researched which materials can be used to improve hydrodymanics

ROV#3 side view

We imagined that by changing the foam for bottles, our buoyancy would be affected less and by scaling down the size, our ROVs hydrodymanics would improve.

We planned to change the foam for bottles and to scale down the measurements of height, length, and width of ROV#2.

We created a scaled down version of ROV#2 using cpvc and used bottles instead of foam used in ROV#2.

ROV #3 front view

Dry weight: 230g

average run time: 45 sec/1.24ft per sec

☐ maneuverability test: We drove ROV#3 through hoops to test how well it goes through objects.

☐ Velocity test: We drove ROV#3 to the end of the pool and back to test its speed.

To make our next ROV better, we need to improve the hydrodymanics by making the frame out of thinner material, we need to add a servo, so we can use the ROV for challenge courses, and add more visibles colors on the ROV for the water

ROV #4

3/20/21

How do we make a ROV thats easy to use in the challenge course?

We reaserched what kind of boyancy and pitch would be best to complete the challenge course effectively.

We imagined by sealing the ROV with epoxy, the boyancy and pitch will be effected less.

We planned to spray paint vibrant colors on the ROV, seal the ROV with epoxy, add a bottom fork, and a servo to pick up floating and suken trash.

We created a ROV with different colors on each side to distinguish direction. We sealed our ROV with epoxy. We added a servo and a bottom fork. (made of gutter) We user thinner pipes to decrease dray.

average run time: 42 sec/1.33ft per sec

ROV #4 side view

ROV #4 front view

☐ functionality test: We drove ROV#4 through the challenge course. We noticed that the ROV picked up trash efficiently because of the servo and balanced boyancy

☐ Velocity test: We drove ROV#4 to the end of the pool and back to test its speed

To make our next ROV, we need to improve boyancy by trying to to make it more lightweight and stable using 3D printing.

ROV#5

3/20/21

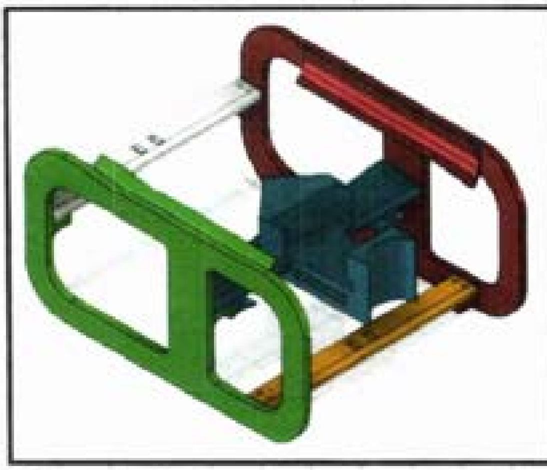
How do we improve the speed and Stability of our ROV.

We researched which program to use to make a 3D printed frame and how to use the program.

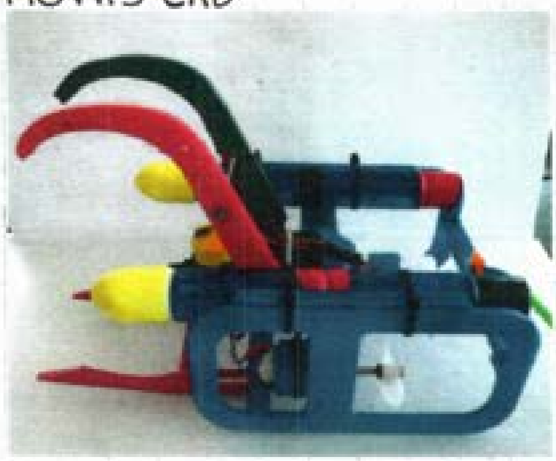
We imagined that by using a 3D printed frame, the boyancy, pitch, and speed will improve.

We planned to make a 3D printed version of ROV#4 by using a computer aided design (CAD) program.

We created a 3D printed frame based on ROV#4 using CAD.



ROV#5 CAD



ROV#5 front view

Dry weight: 110g   average run time: 28sec/2ft per second

☐ Velocity test: we drove ROV#5 to end of the pool and back to test its speed.

☐ Functionality test: we drove ROV#5 trough the challenge course. We noticed one of the motors fell off, so the ROV could not finish the chalenge course.

☐ Stability and speed improved Significally

To make improve our ROV, we are going to try to make our frame Strong enough so it does not break easily by making it thicker.

ROV#6

4/24/21

How can we make our ROV less wide and more compact?

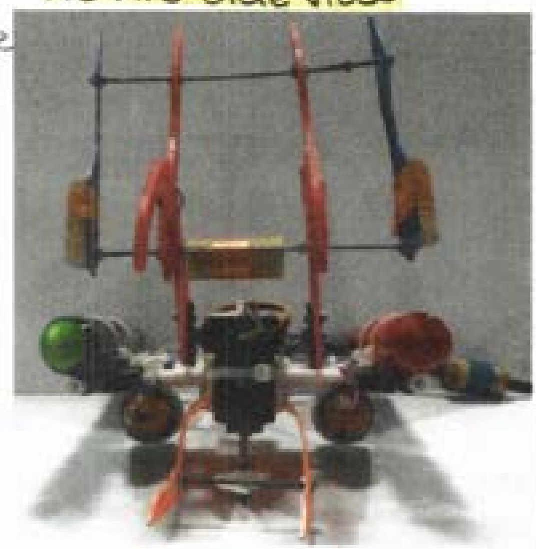
We researched how making our frame less wide and more compact would affect our ROV in terms of hydrodymanics, stability, and speed.

ROV#6 Side view

We imagined that by making our frame less wide and more compact, the ROV would increase speed, hydrodymanics, and stability while driving in the pool.

We planned to decrease width, length, and height of ROV#6.

We created our previous ROV but with a decreased height, width, and length by shortening our tubes.



ROV#6 front view

Average run time: 23 sec/2.43ft per second

Bouyancy: positive

control: medium difficulty

Dry weight: 60g

To improve, we can try to increase the control of our ROV.

ROV#7

4/16/22

?

How can we incorporate 3D design into our ROV?

We researched how we could improve our previous 3D design from ROV#5.

We imagined that by improving our 3D design frame from ROV#5, our ROV will increase in stability, sturdiness, and agility.

We planned to slightly increase the thickness of the previous 3D designed frame of ROV#5 due to it's weak frame.

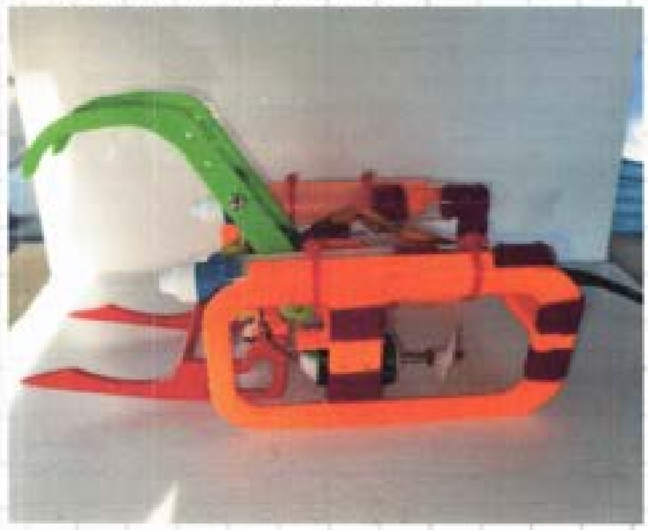
We created a 3D printed frame based on ROV#5's frame with the new modifications. We also modified the frame to include a smaller servo.

Dry weight: 84g

Height: 9.15cm Width: 12.45cm Length: 17.78cm

To improve, we plan to modify our ROV to effectively complete the tasks of the 2022 SeaPerch Challenge Course.

ROV#7 front view



ROV#7 side view

ROV#8

4/16/22

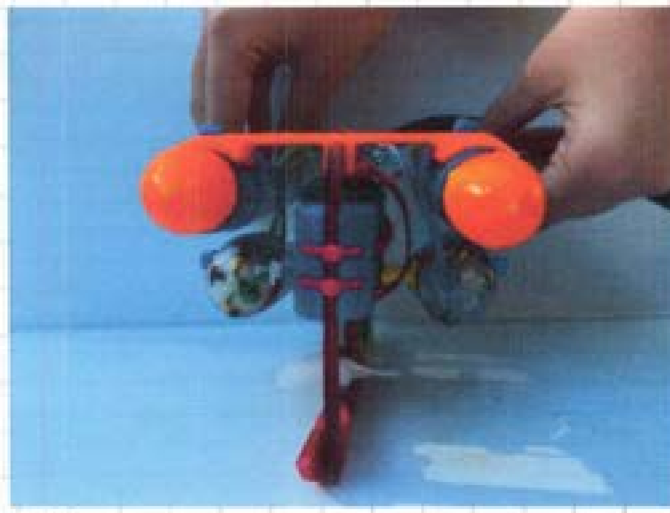
How can we change our ROV to complete the tasks of the 2022 Seaperch Challenge Course in an efficiently?

We reserched how to modify the gripper and frame to the tools and batteries of the new challenge course.

ROV#8 Side view

We imagined that by scaling down the frame, adding a hook, and scaling down the gripper, our ROV can pick up the tools and batteries properly.

We planned to print a new 3D designed frame and gripper, as well as adding a hook.



We created a new 3D printed frame and gripper. We also created a hook based on the new modification ideas.

ROV#8 front view

Dry weight: 19g Average run time: 2.7 ft/second

Height: 9.9cm Width: 10.9cm Length: 10.8cm

To improve, we plan to use to an arduino board.

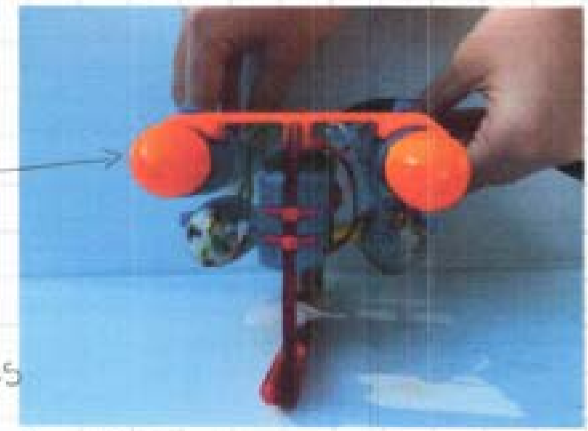
Final Design

Servo gripper to grab tools

hook to pick up batteries

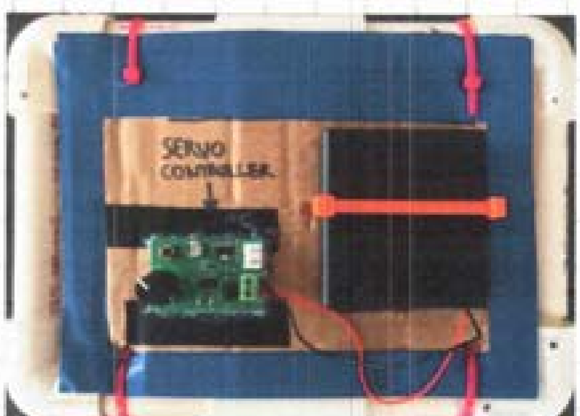
ROV#8 side view

colorful frame to help see the ROV in the pool.



bottles with 3D-printed caps to improve hydro-dynamics

ROV#8 front view



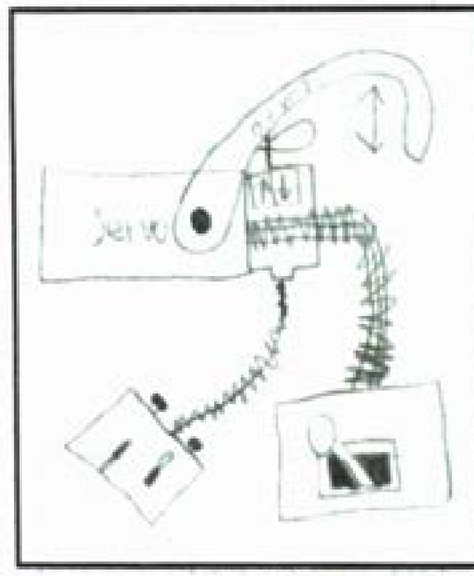
Servo controller top view

Servo Controller

3/20/21

What is the best way to control a servo?

We researched how to controll a servo and then researched how to build a servo controller. Lastly we researched how to use a servo controller.

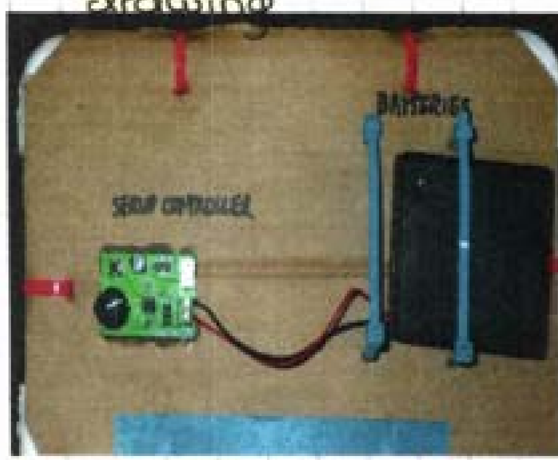


Servo controller drawing

We imagined that a separate controller for the servo and driving the ROV will help with the cordinuation of the challenge.

We planned to create a controller that has a Knob that can close and open the servor gripper at different degrees.

We created a custom motherboard with a Knob and a battery pack to supply power to the servo.



Servo controller top view

☐ functionality test: We used the servo controller in the challenge course. The ROV was able to open and close the gripper properly to grab th trash efficiently.

We in future may try to improve the Knob and motherboard to add more functionalitity that could include a digital display that could tell the power of the controll.

Thrust Stand

4/16/22

How can we discover which motor generates the most thrust?

Thrust Stand front view

We researched contraptions that can help us test the the thrust of a propeller.

We imagined that by building a thrust stand, we can use the propeller that achieves the most velocity.

We planned to construct a thrust stand with the data from research to test our propellers' thrust.

We created a thrust stand that can test our propellers' thrust.

Seaperch propellers' Thrust average: 425
RC Boat Speed propellers' Thrust average: 332.5
Counterrotating Seaperch propellers' Thrust average: 370
4 blade Seaperch propellers' Thrust average: 235
Tri-bladed RC Speed propellers' Thrust average: 337.5
Sharp ended Tri bladed propellers' Thrust average: 247.5

To improve, we plan to use the propeller that generates the most thrust based on the data collected from the thrust stand. In the future, we plan to consider other contraptions to test our ROV.

Speed Graph

4/24/21

How would we get more RPM's out of our motors?

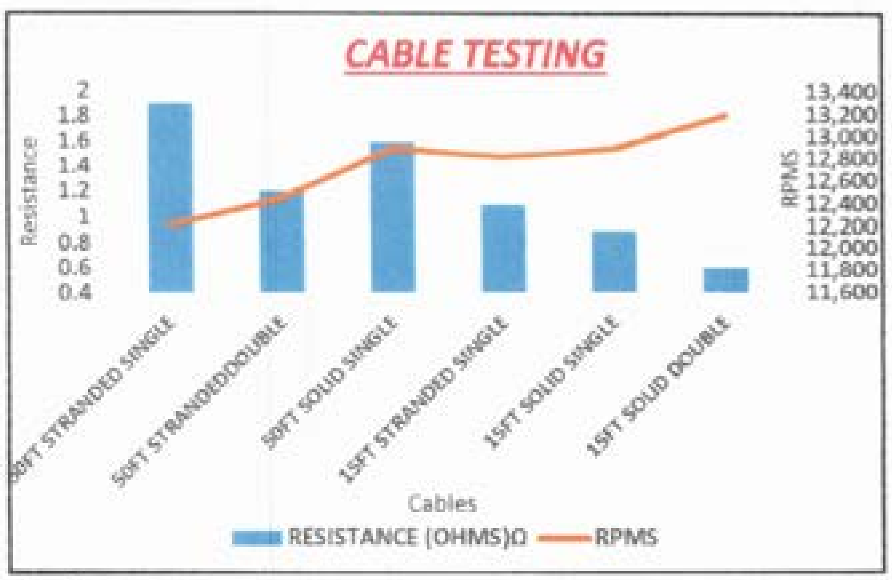
We researched how to increase current in our cable to increase RPM.

We imagined shortening our cable length would help increase our RPM.

We planned to decrease our cable length.

We created 6 cables to test, some were 15ft, 50ft, single stranded, double stranded, and solid stranded.

we tested RPM's and resistance on all 6 cables to see which cable was best for compitition.



Cable testing Graph

We found out the 15ft solid double cable is the best. We will contiune to research to improve our RPM.

Engineering Log

9/7- Conducted an experiment with connecters to test the time to set each one up. Discussed on future ROV designs. Conducted test runs with ROV#5 in hoops course.

9/18- We put gripper and forks on ROV#5 to practice driving in the hoops course and the mini-obstacle course. We took pictures of the connectors and created a notebook sheet for it. We brainstormed ideas for our future ROV. Lastly, we soldered the Arduino boards.

9/21- We made modifications to our 3D designed ROV. We looked over our technical report feedback. We worked on our notebook (wire splicing techniques). We spray painted the board for our audrino board.

10/2- We took photos of ROV#7. We drove ROV#7 through the hoops course and tested the servo of ROV#7. We took the weight of ROV#7 (Dry weight: 84g). We put the photos of ROV#7 in the notebook and technical design report.

10/6- We went to the duval school board meeting to get recongination for our awesome work.

10/9- We worked on batteries for the challenge course. We also tested out the challenge course. We fixed the bouancy of the batteries and also worked on making the tools of the challenge course. We observed the thrust stand.

10/12- We tested out the challenge course.

10/16- We worked on task overview. We adjusted the challenge course. We experimented with a single hook for the top and bottom.

10/19- We worked on 3D-designed hook designs.

10/23- We worked on 3D-designed hook designs. We tested ROV#7 with the hoops course.

10/26- We took our 3D-designed hook designs and 3D-designed it with Paul.

Engineering Log

10/30- We tested our 3D-designed hook in the challenge course and the hoops course. We conducted runs in the challenge course with another team's ROV. We conducted practice runs with ROV#7 in the hoops course.

11/6- We planned for modifications with the servo gripper (chopsticks).

11/9- We tested the "chopsticks".

11/16- We waterproofed the servos

11/20- We continued conducting practices with our ROV in the challenge course.

11/23- We tested a thin frame in the challenge course.

11/30- We prepared for a plexiglass frame by making a sketch of our current frame. We conducted practice runs with the hoops course.

12/4- We assembled ROV#8, a thin plexiglass frame by drilling holes, putting the hook and servo on, as well as adding the motors on. We timed ROV#8 from the start to the end of the pool three times and averaged it. We tested out and considered an undermounted hook.

12/7- We discussed on how to modify ROV#8 and decided on making a 3D-designed frame for ROV#8 and having an undermounted hook. We conducted practice runs with ROV#8 in the challenge course and hoops course.

12/11- We made a new set of motors for competition. We also spliced in two new left and right motors and tested them. We tested out the new frame and hook after assembling them.

12/14- We conducted practice runs with ROV#8 in the hoops course. We waterproofed the motors. We designed a 3D-printed frame.

Engineering Log

12/18- The 3D-printed frame we designed and 3D-printed was used to figure out the placement of our attachments such as the undermounted hook.

12/22- We tested out our new foldable hook in the challenge course, then discussed if we should use the new hook instead of the cutting board hook. Our decision was to use the cutting board hook, as it causes general drag and reduces height by a difference of 10mm compared to the foldable hook, when stored.

1/8- A new vertical motor has been spliced in. The discussed idea for the bottle holders has been showcased, and other ideas have been planned beforehand (The idea is to shorten the ROV by flipping the holders. The bottles will be held upside-down.) We also discussed storage of the "chopsticks" gripper.

TESTING: We were about to test the new buoyancy setting and had to super glue the left motor because it was colliding with the buoyancy bottle.

1/18- We worked on the technical design report. We also put the motors on our ROV.

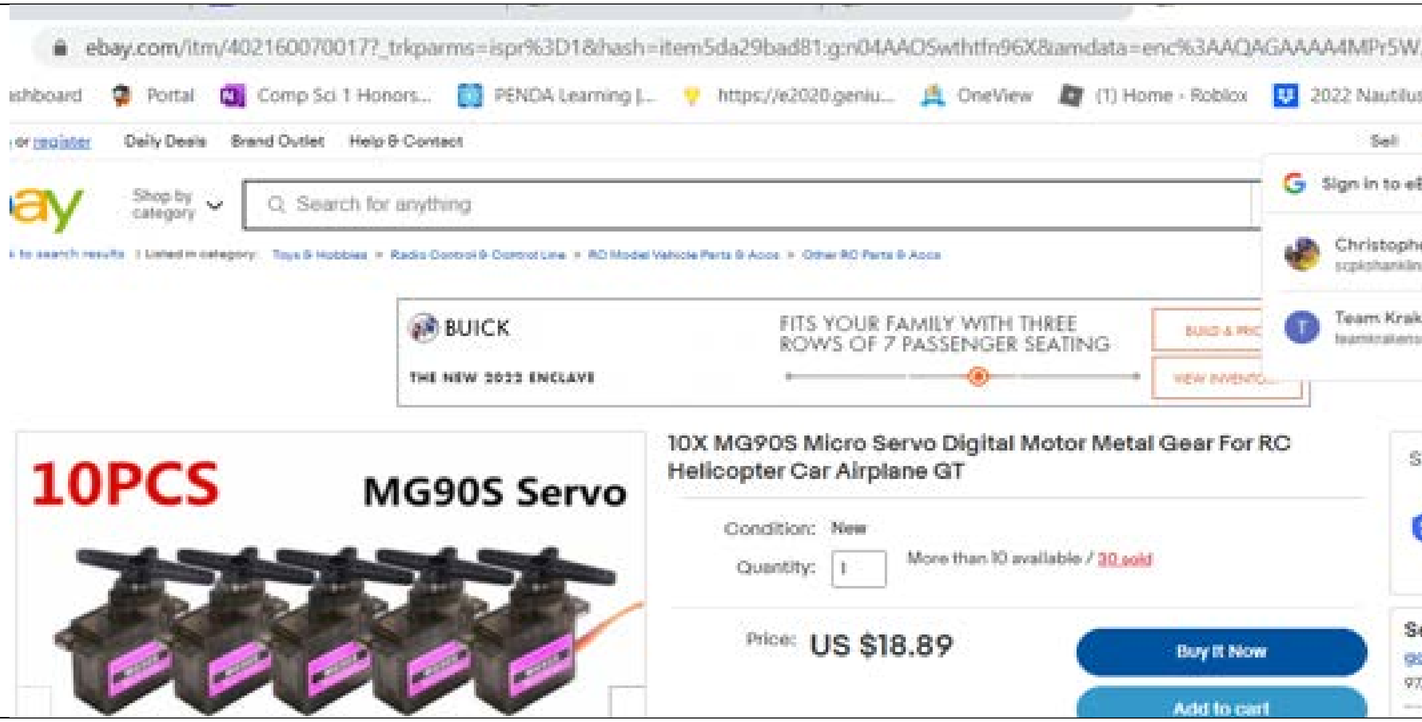
1/25- We got rid of white space on the technical design report. The standard props were tested in the pool, but the ROV capsized while testing the black props.

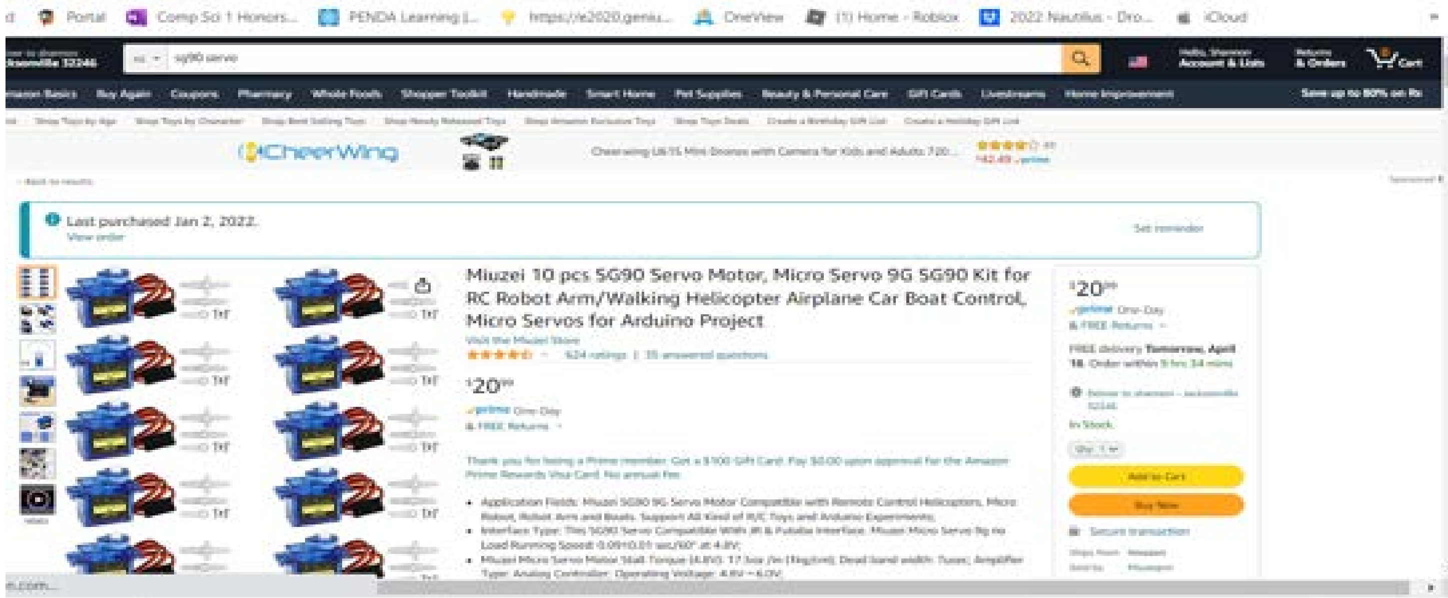
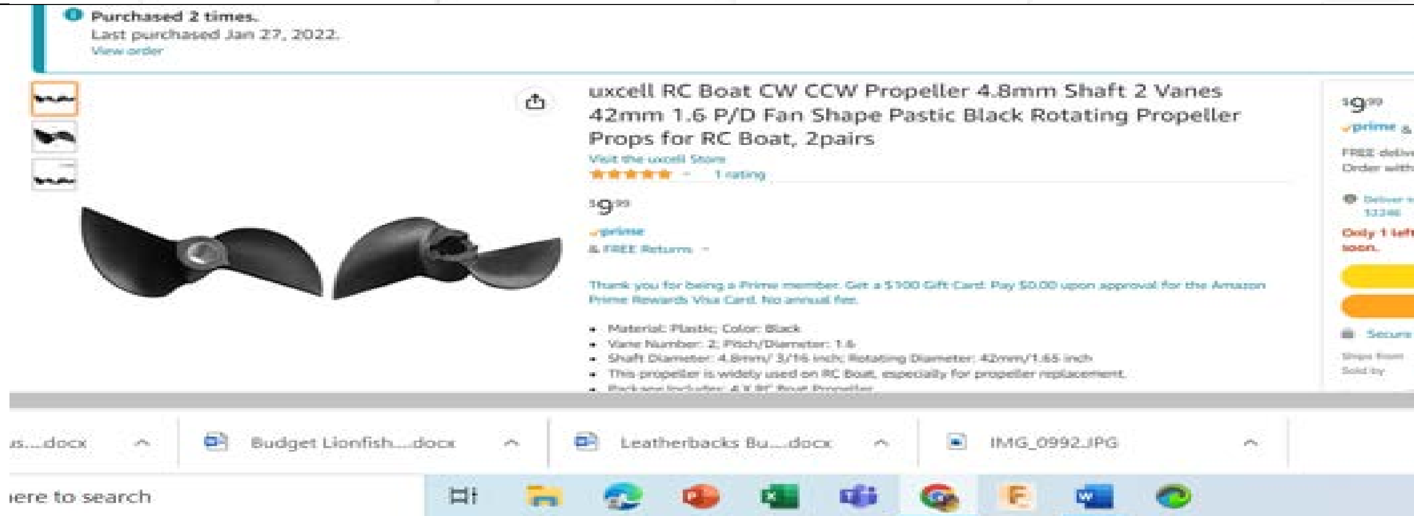
2/6- We configured the hook to the ROV to have a bigger gap to efficiently acquire batteries and to reduce the time frame. One of the grippers was loose, because the bolt fell out so replaced it with a longer screw and a new bolt. The vertical motor was loose so we applied super glue to it and let it dry.

BUDGET/MATERIALS

Component	Vendor	How was component used?	Cost (in USD)
ROV Center Frame (1-22 Grams)	Self-designed/printed	ROV Frame	$1.10
ROV Motor Mount (1-12 Grams)	Self-designed/printed	ROV Frame	$0.60
ROV Buoyancy Mount (1-12 Grams)	Self-designed/printed	ROV Frame	$0.60
3D Motor Caps (6-1 Grams each)	Self-designed/printed	Motor Waterproofing	$0.30
3D Hook Holders (2-3 Grams each)	Self-designed/printed	Mounting of Hook to Frame	$0.30
3D Gripper Fingers (2-6 Grams each)	Self-designed/printed	Gripper Fingers	$0.60
3D Servo Holder Part 1 (1-6 Grams)	Self-designed/printed	Servo Mount	$0.30
3D Servo Holder Part 2 (1-2 Grams)	Self-designed/printed	Servo Mount	$0.10
3D Bottle Caps (2-3 Grams each)	Self-designed/printed	Buoyancy	$0.30
Servo (SG90) (1)	Amazon	Gripper Actuator	$2.09
Servo Controller (1)	Amazon	Servo Operation	$9.99
4 Pack Battery Holder (1)	Amazon	Servo Power	$2.96
1.5V Batteries (4)	Amazon	Servo Power	$0.84
Servo Wiring (CAT 5 – 40 Feet)	Amazon	Servo Power	$2.40
Counter Rotating RC Speed Propellers	Amazon	Propellers	$5.00
30ml Plastic Bottles (2)	Amazon	ROV Buoyancy	$1.50
15ml Plastic Bottles with Cap (2)	Amazon	ROV Buoyancy	$1.12
Cable Sheathing Red (40 Feet)	Amazon	Cable Collection	$6.60
Heat shrink (6 pcs)	Amazon	Motor Wire Strengthen	$0.09
Lube Compress Packing Seal	Amazon	Motor Shaft Waterproofing	$0.30
SLA Resin	Amazon	Motor Waterproofing	$0.30
Marine Grease	Amazon	Motor Waterproofing	$0.08
Nylon Screws and Nuts (6 Screws, 6 Nuts)	Amazon	Hook Hardware	$0.24
Plastic Cutting Board (<50% used)	Dollar Store	Hook	$0.63
TOTAL COST OF SEAPERCH COMPONENTS			$38.34

MATERIALS

ITEM	PERCENT USED	PICTURE
MG 90S SERVO	Cost per unit $1.89	

SG 90 servo	$2.09 each	
Counter rotating props	$5.00 each	

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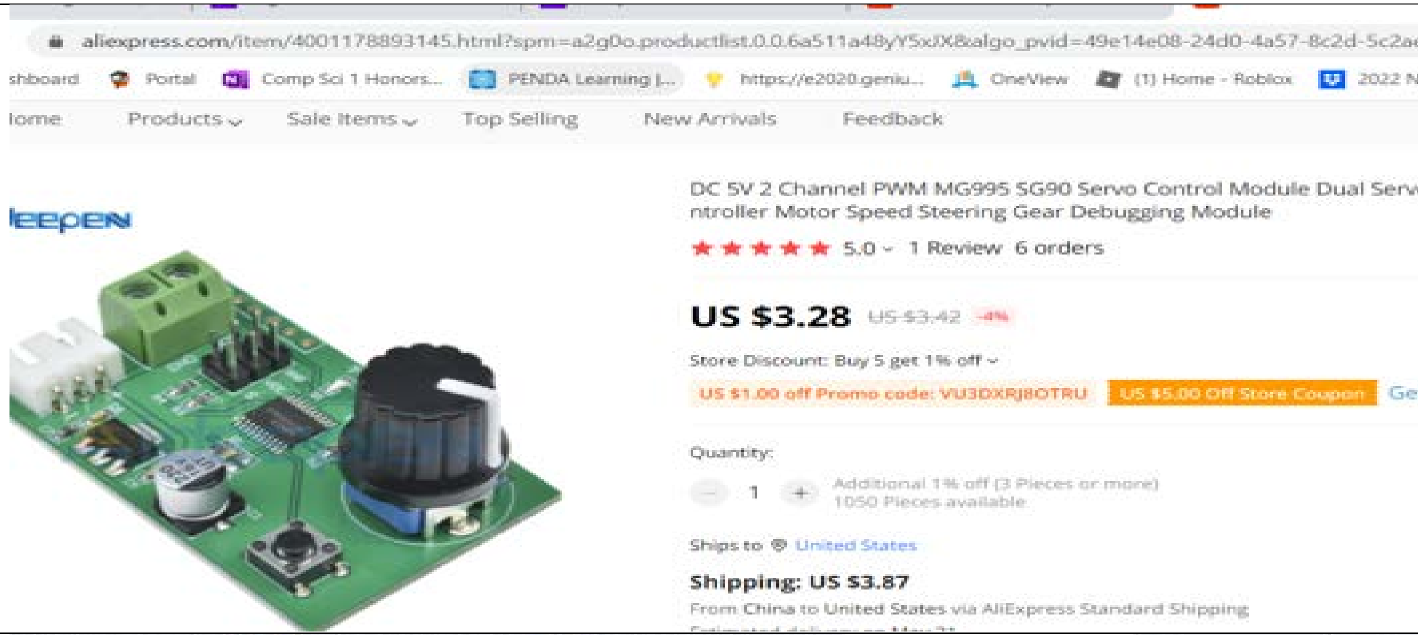
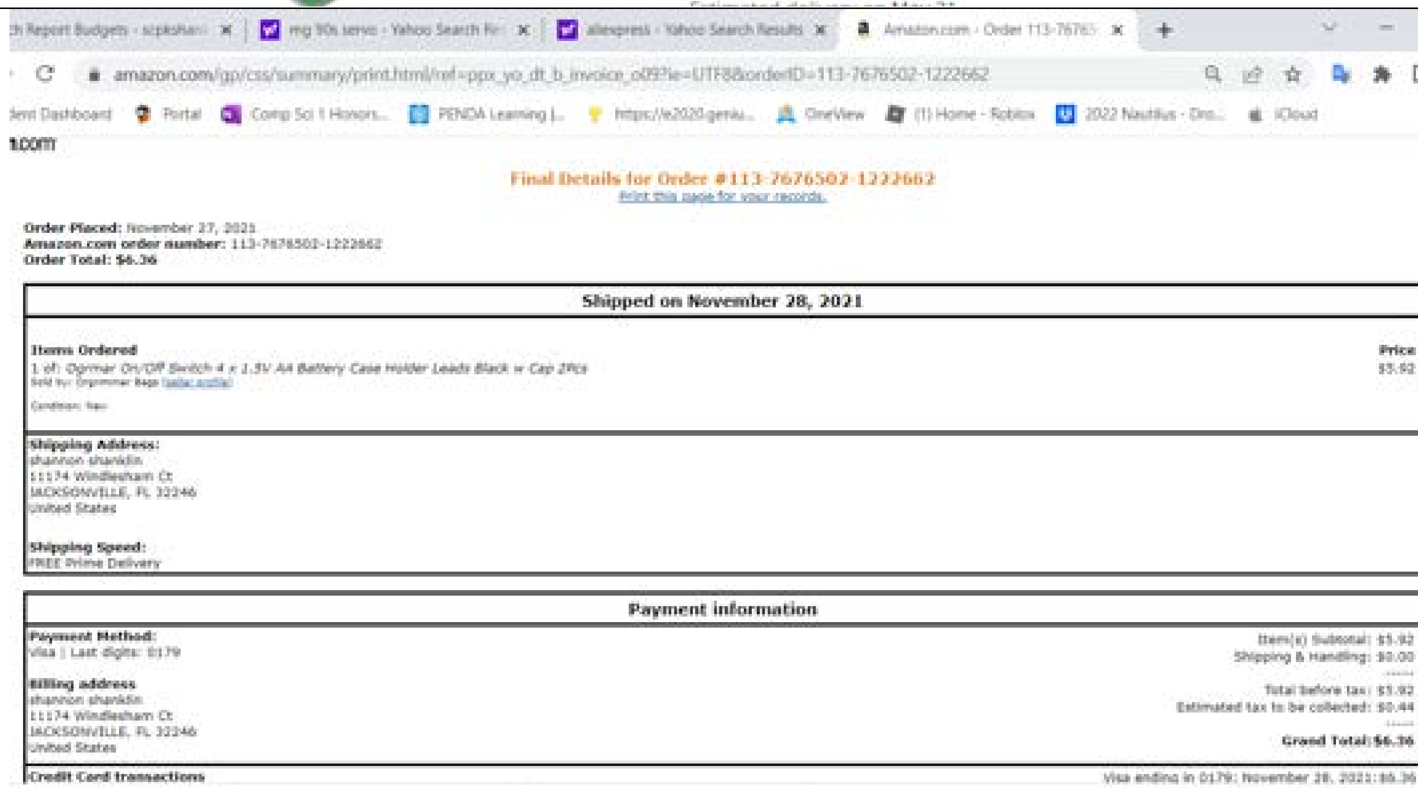
<tr><td>Servo Controller</td><td>$3.28 each</td><td>
</td></tr>
<tr><td>Battery Holder (when purchased)</td><td>$2.96 each</td><td>
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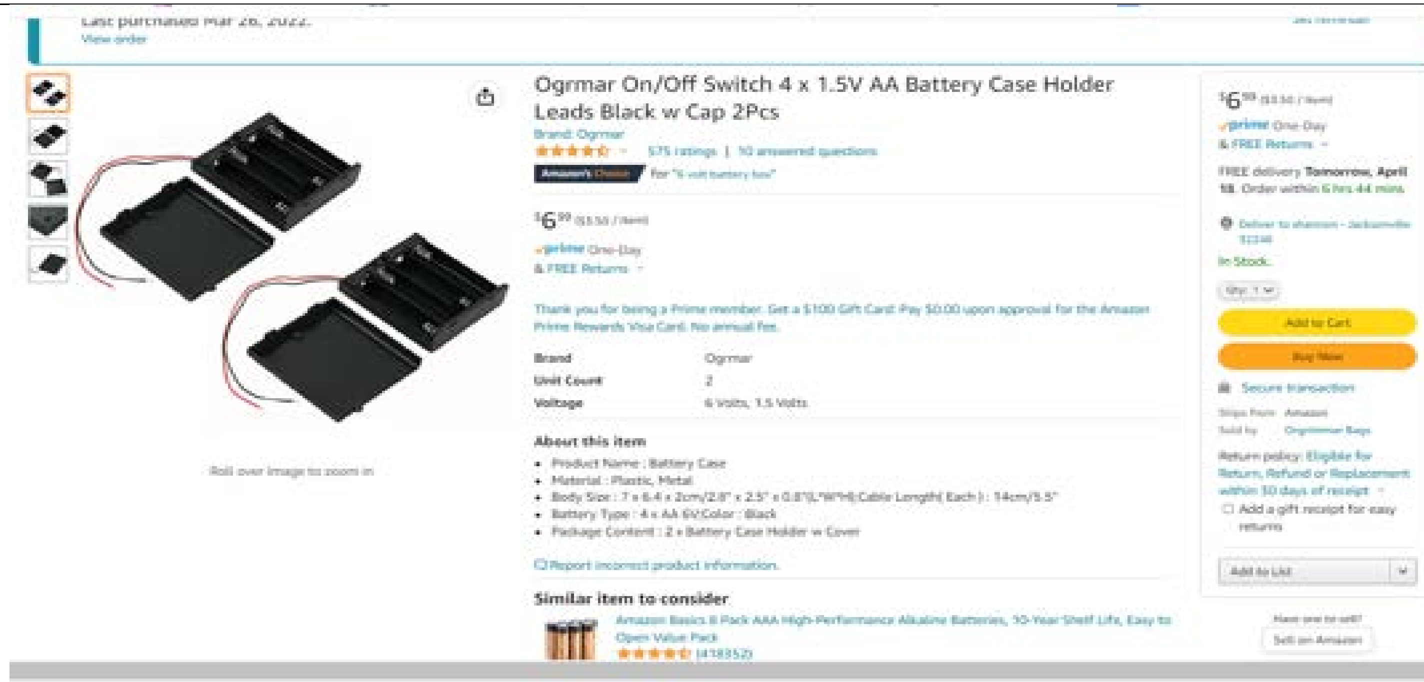
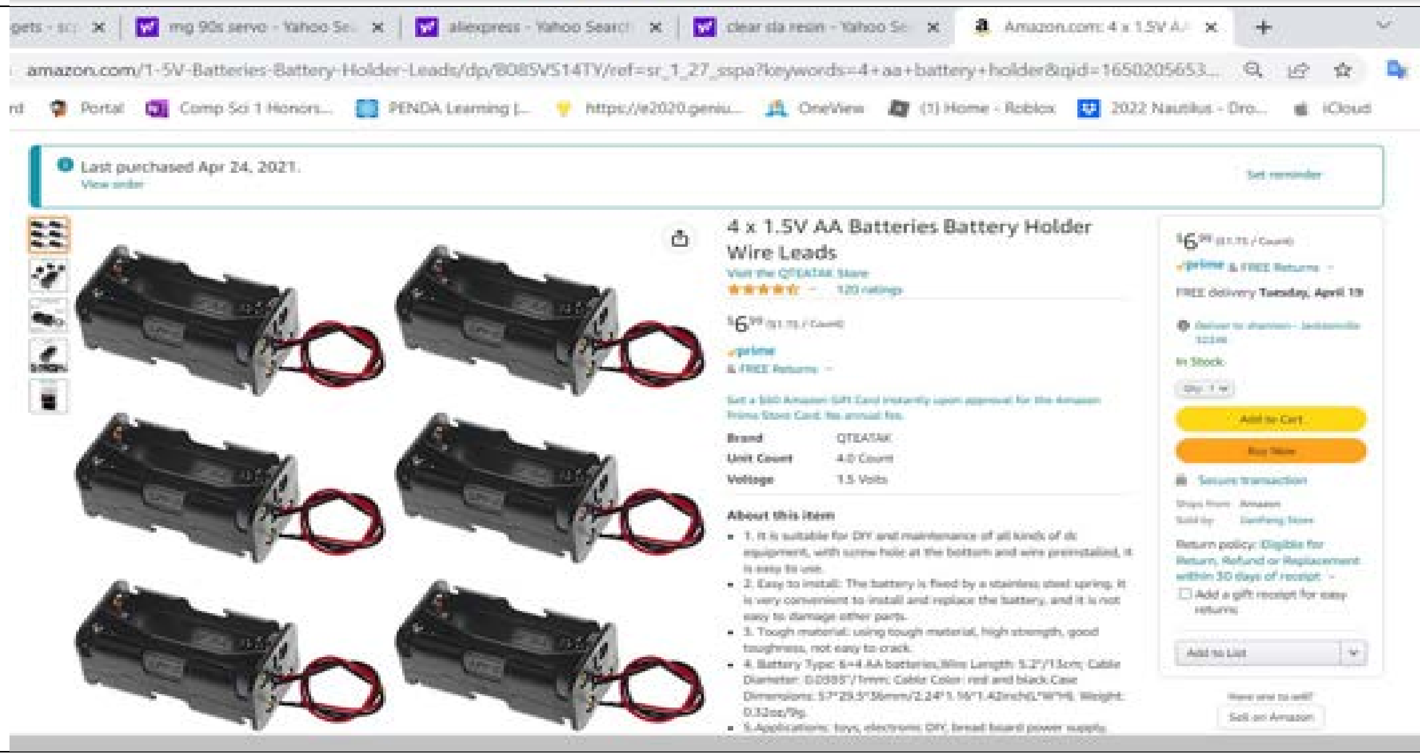
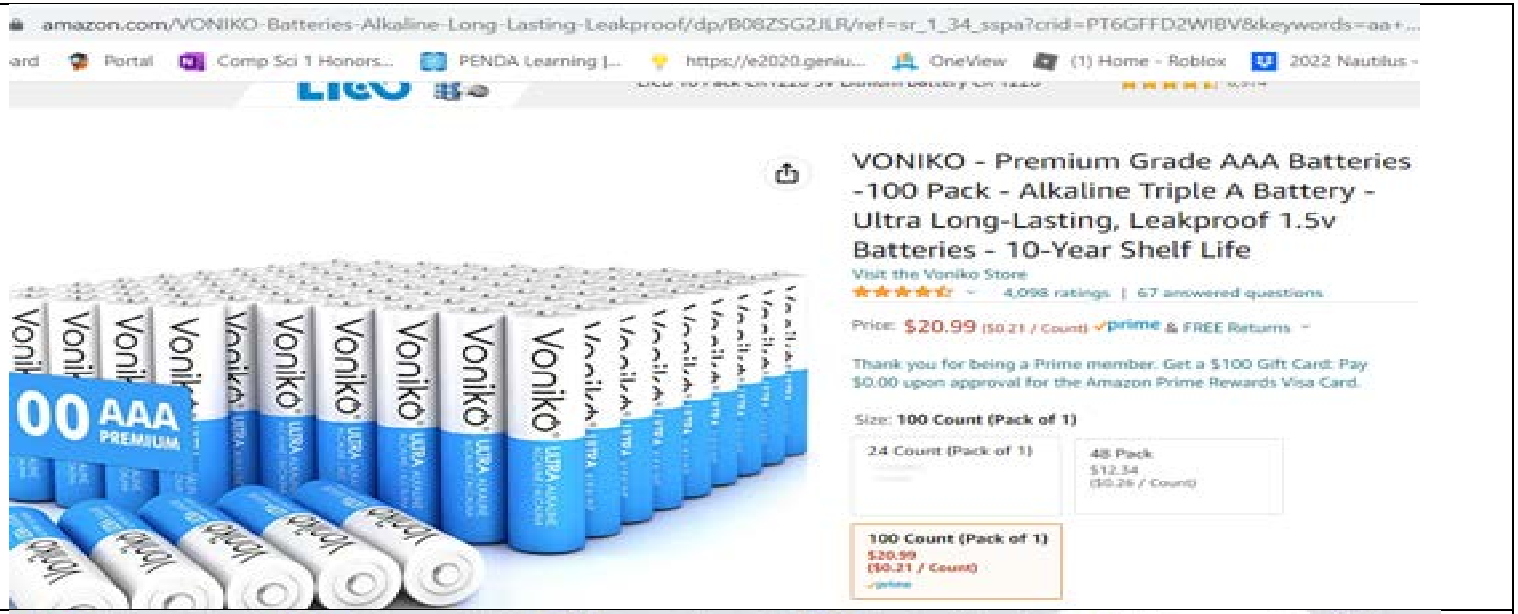
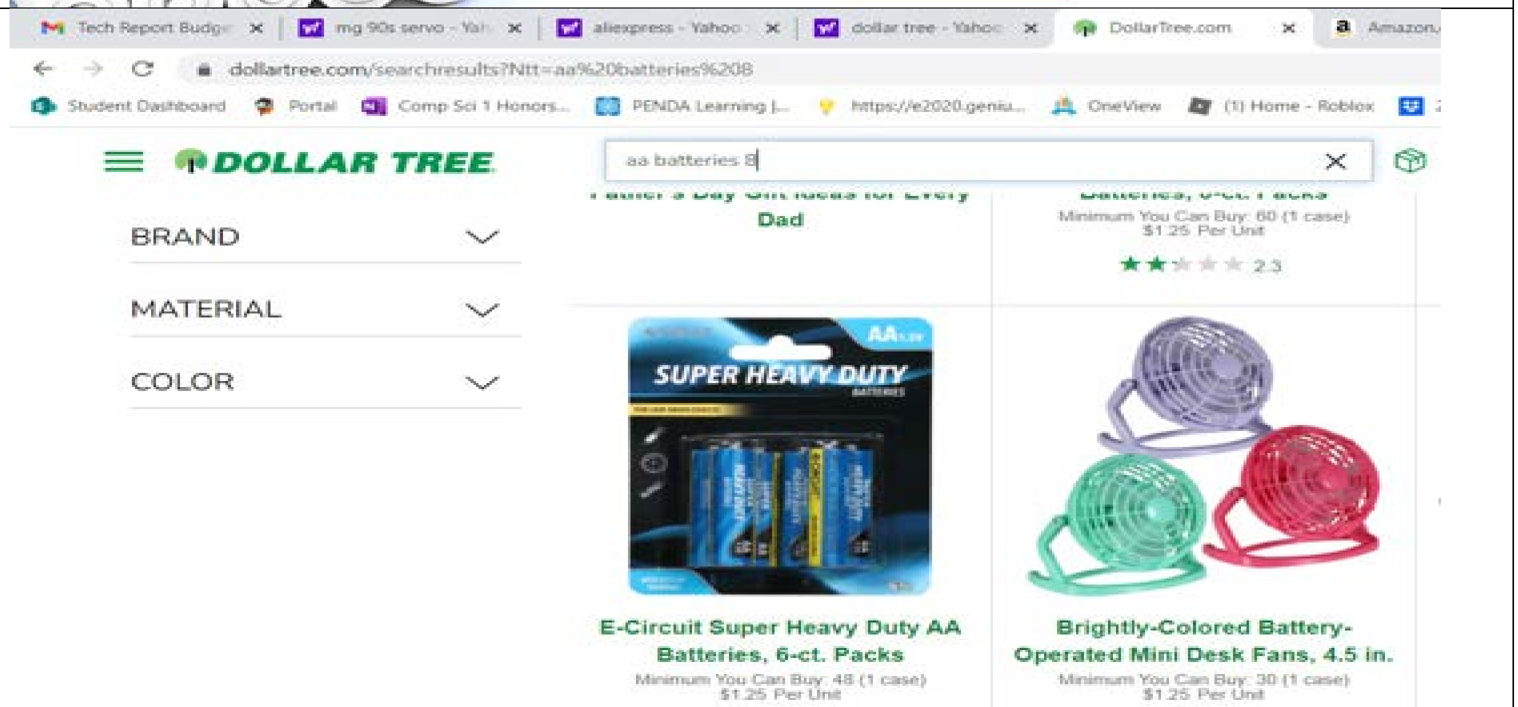
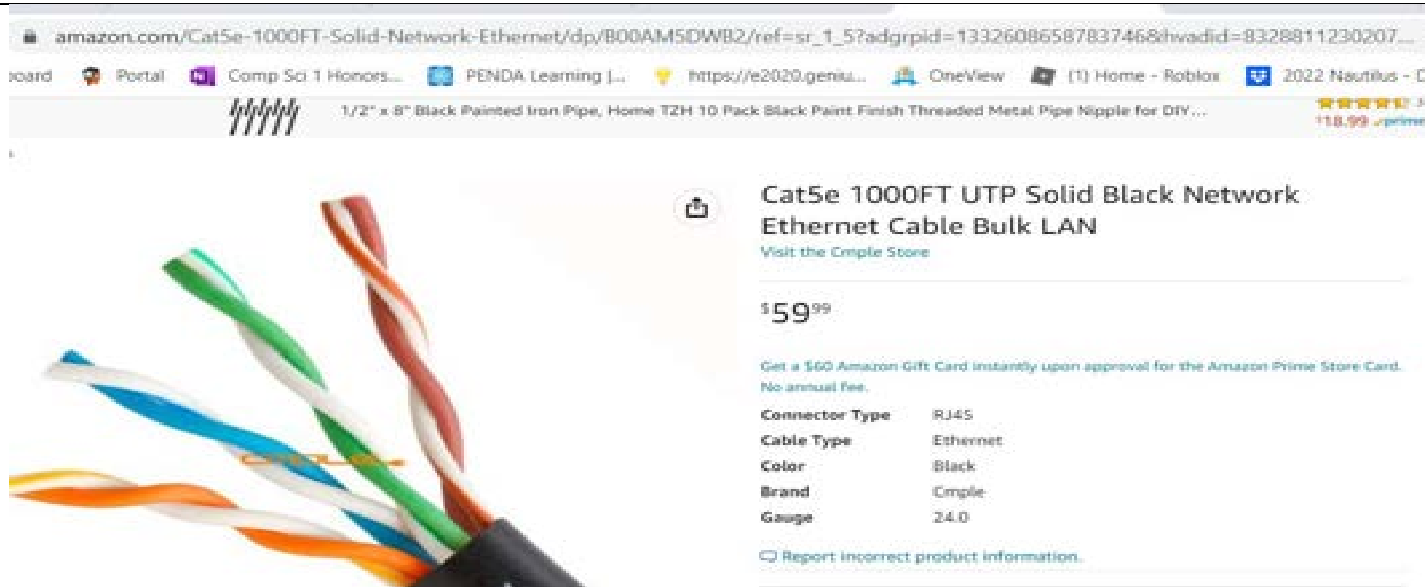
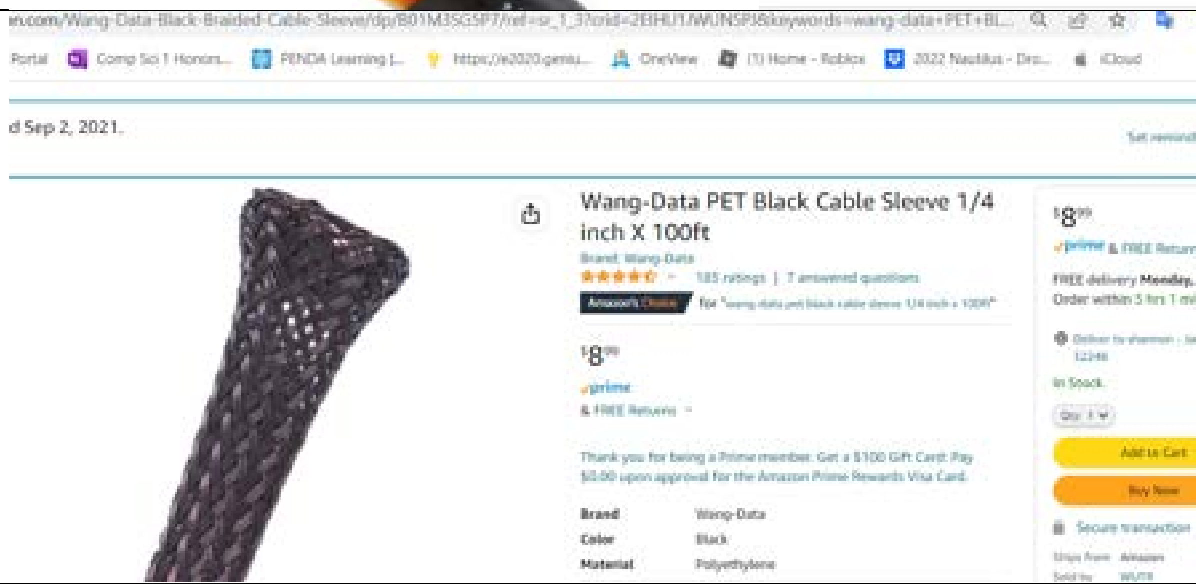
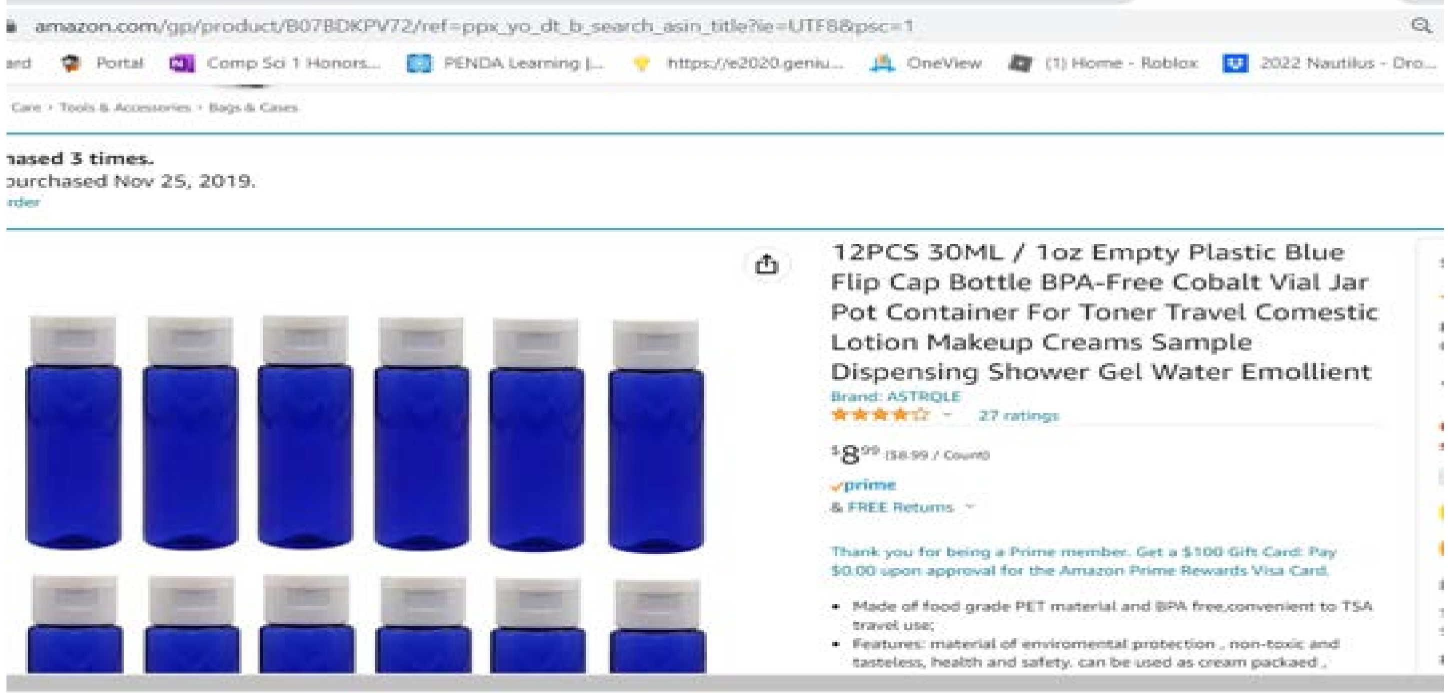
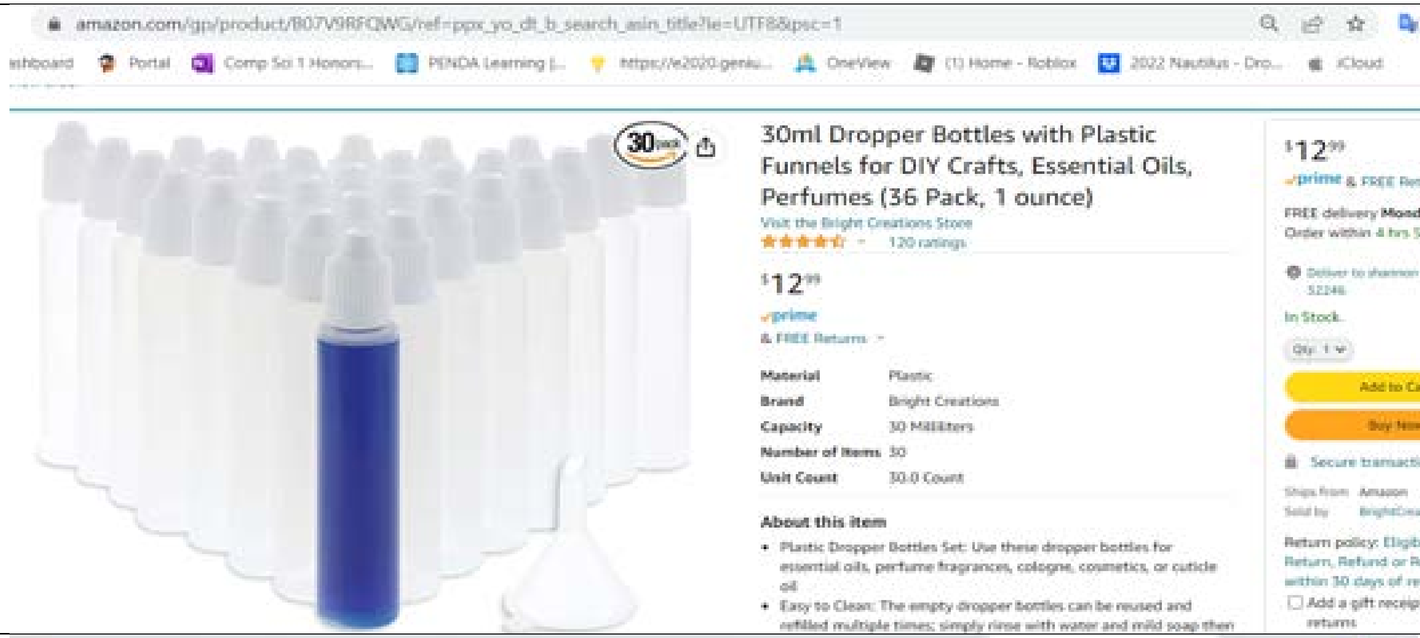
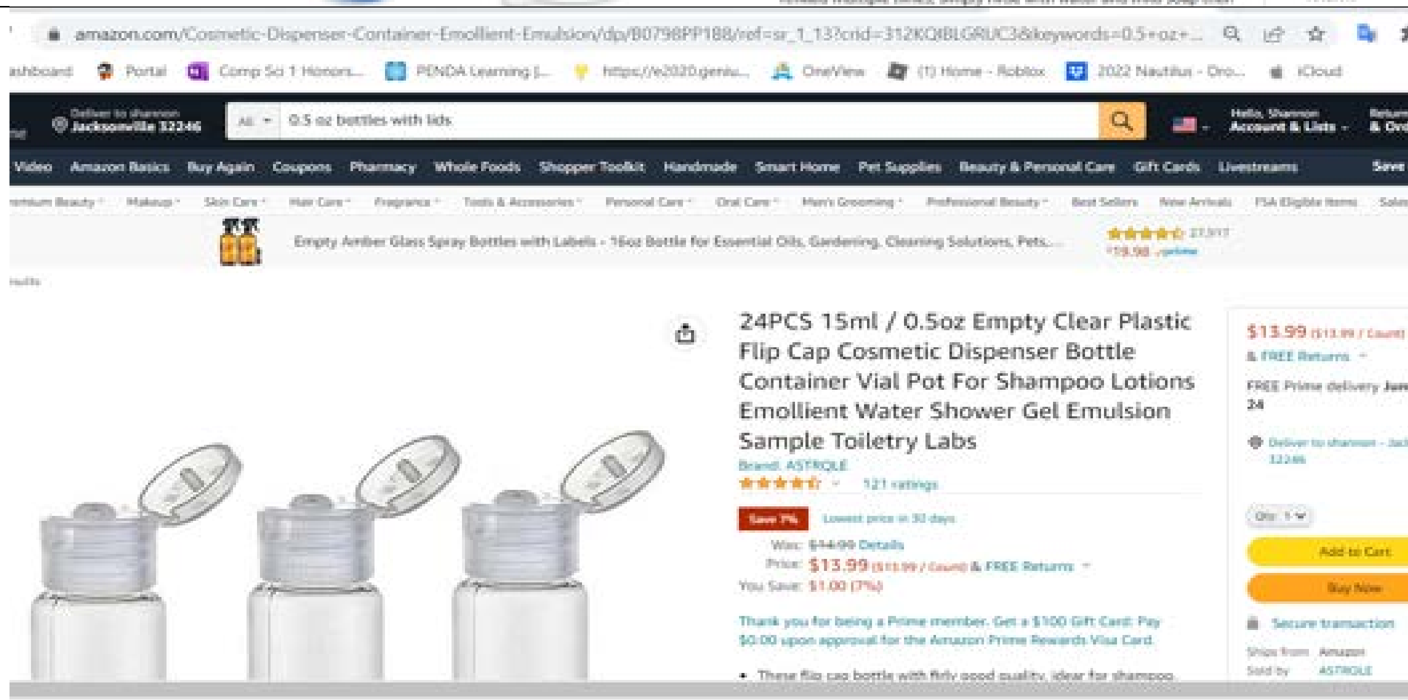
Battery Holder (current price)	$3.50 each	
Battery Holder we have if budget is tight – teams can switch to	$1.75 each	

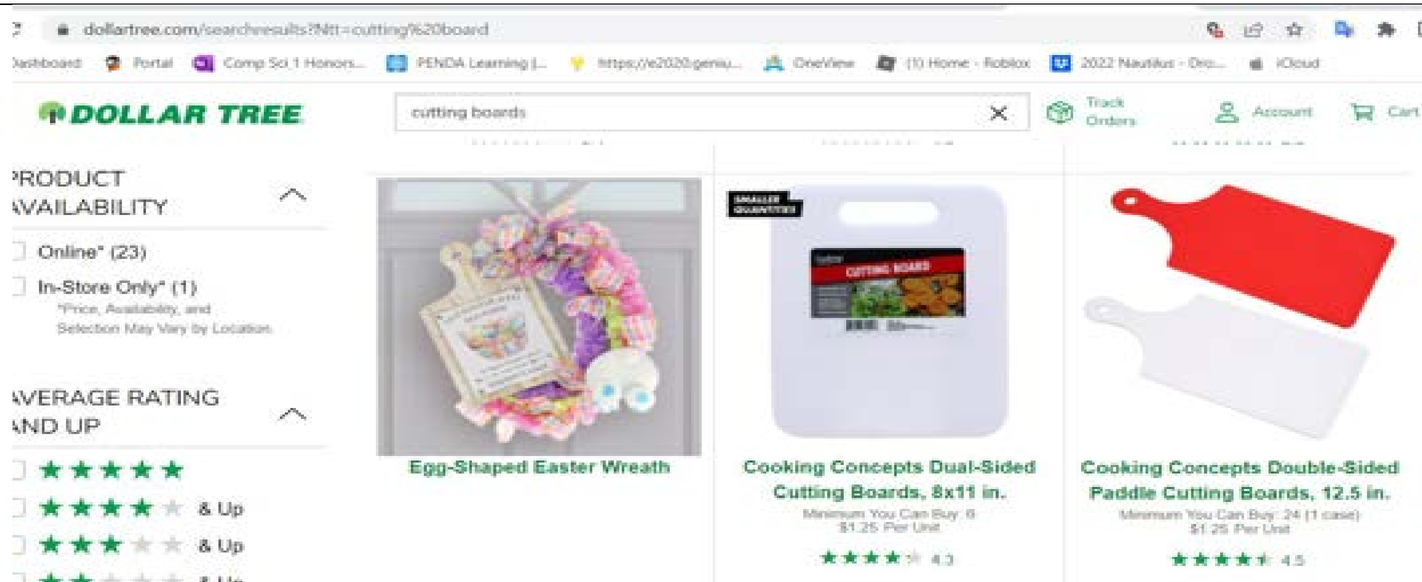
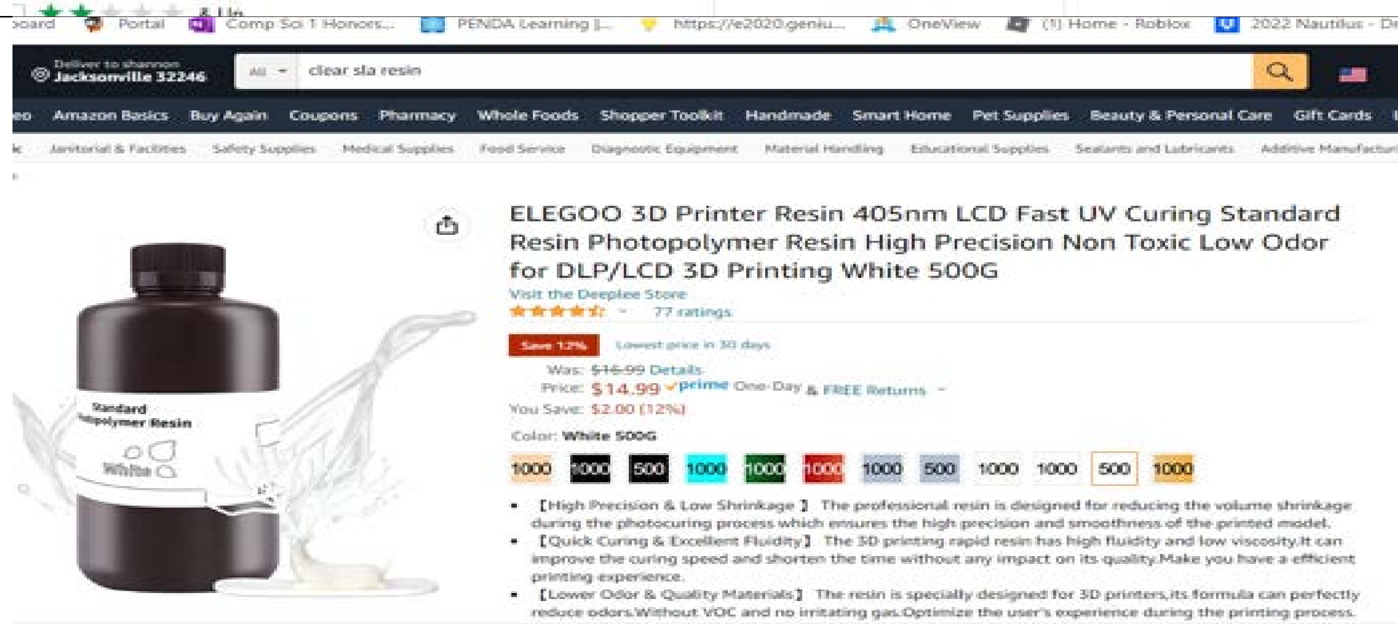
AA Batteries	$0.21 each, 4 needed for $0.84 total	
AA Batteries- Dollar Store	$0.21 each, $0.84 for 4	

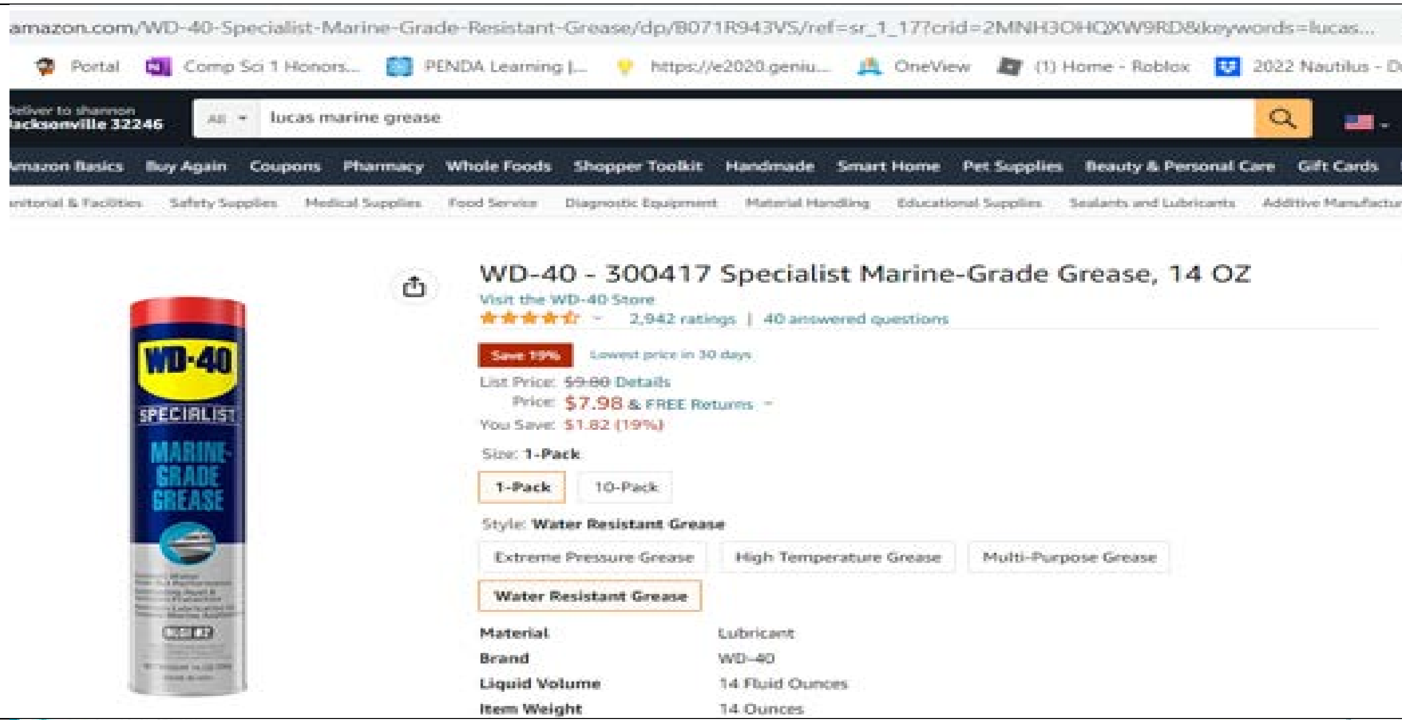
CAT 5 cable for servo wiring	40 FT equals $2.40	
Expandable Cable Sheathing	40FT = $3.60	

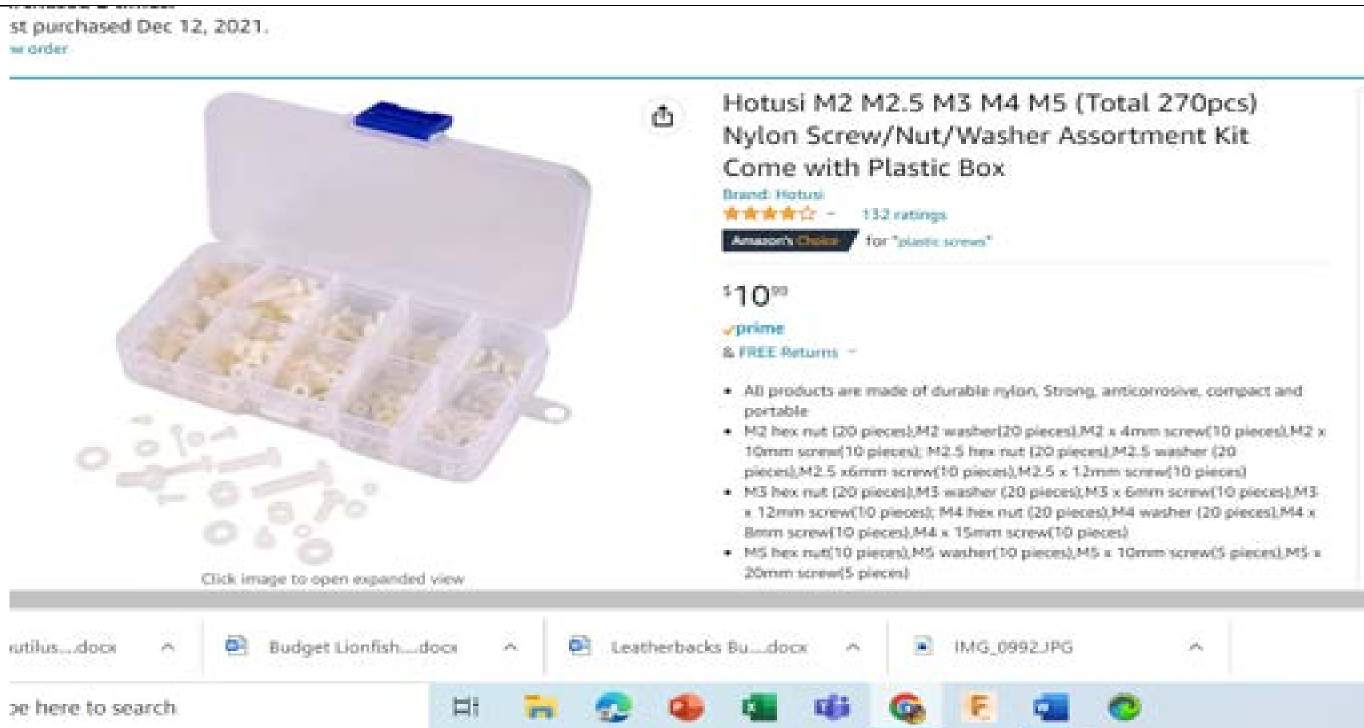
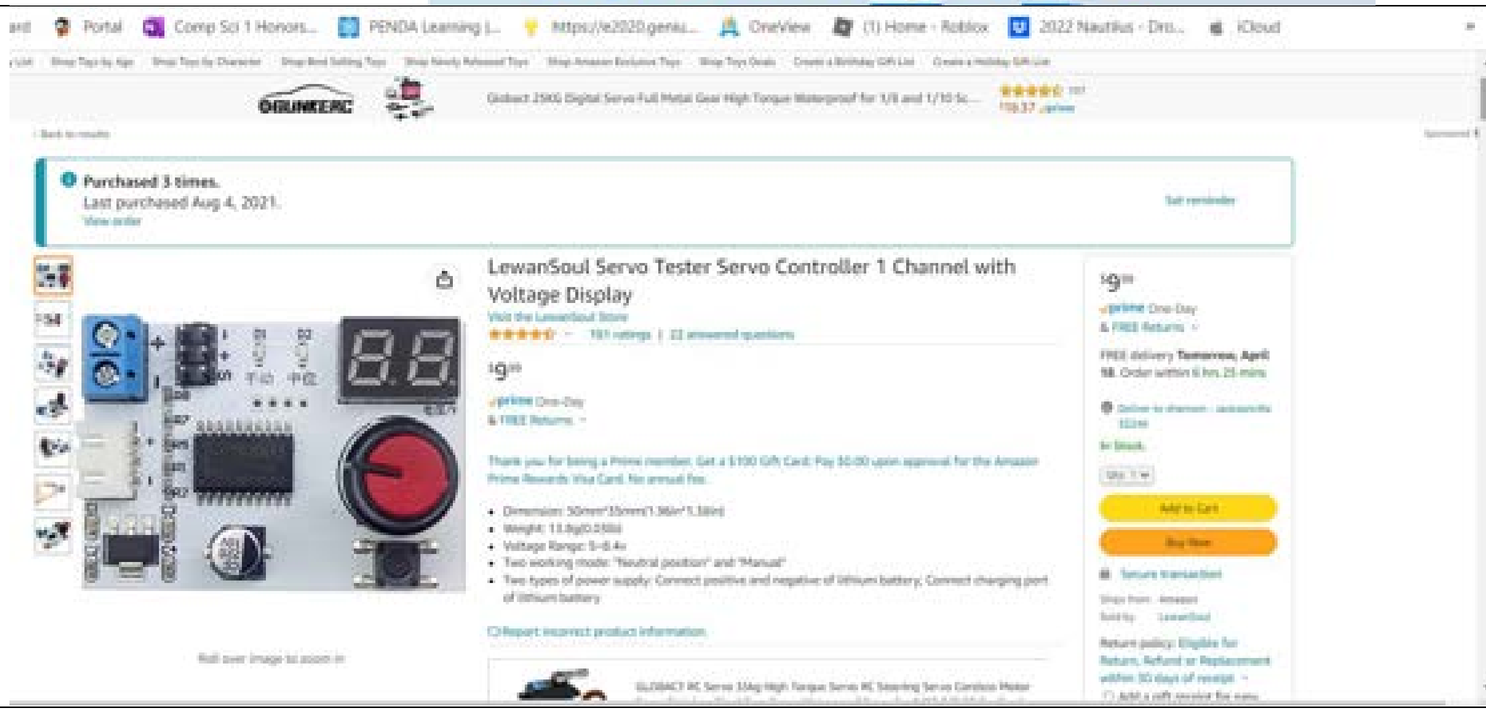
¼ inch expandable sheathing (40FT)	$6.60	
½ ounce buoyancy bottle	$0.75 each	

1 ounce buoyancy bottles	$0.36	
½ ounce buoyancy bottles	$0.58 each	

Heat Shrink	$0.01 cent each, each ROV uses 9 pieces	
Bolts and nuts for mounting hook	$0.05 cents each	

Cutting Board for fins and hooks	$1.25 for each board, we use less than 50% - $0.63	
SLA Resin for waterproofing motors	We use less than 2% each time because it goes a long way, equals $0.30	

Marine Grease for waterproofing motor caps	We use less than 1% , equals $0.08 per ROV	
Lube packing seal for waterproofing motors	We use 2 inches for 3 motos. 5Ft equals 60 inches. Cost for 3 motors equals $0.30	

<table>
<tr><td>Nylon screws</td><td>Equals $0.04 each screw or nut</td><td>
</td></tr>
<tr><td>Open class Servo Controller</td><td>$9.99 each</td><td>
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