Team ROVarine (2050-002)

Sea Perch ROV 2017-18

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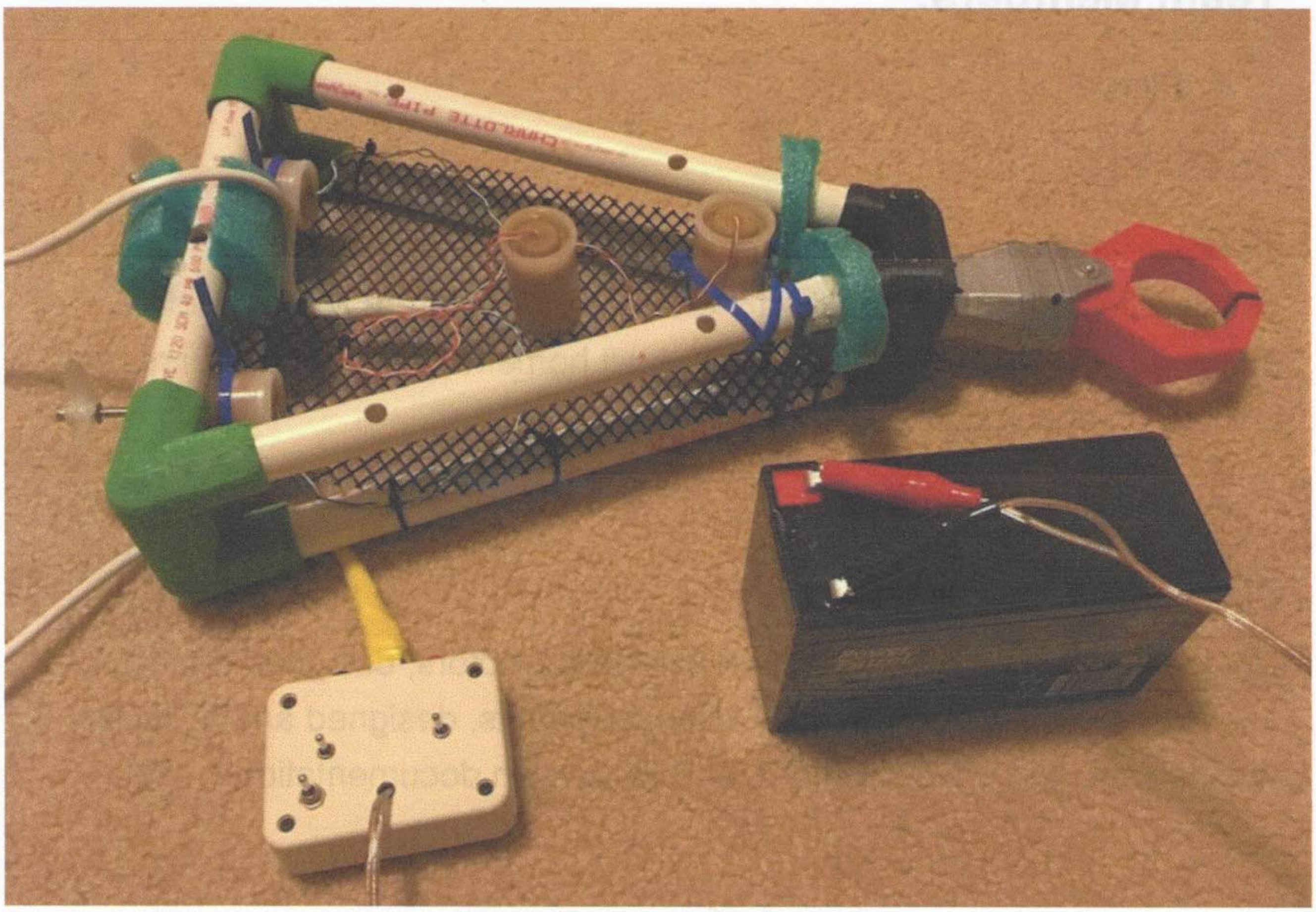
Wednesday January 31, 2017



Team Information:

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Advisors:

- Allison, Kent- kent.allison@dcsdk12.org
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Team Members:

- Pierce

Grade- 9

Designed unique frame shape, designed 3D printed parts for the construction of the frame, wired the circuitry for the remote and motors, designed and built claw mechanism, built homemade practice course, and worked on documentation.

- Brian

Grade- 10

Designed unique frame shape, waterproofed motors, designed project specific layout and construction of motor mounts, designed and built claw mechanism, test driver for ROV, and worked on documentation.

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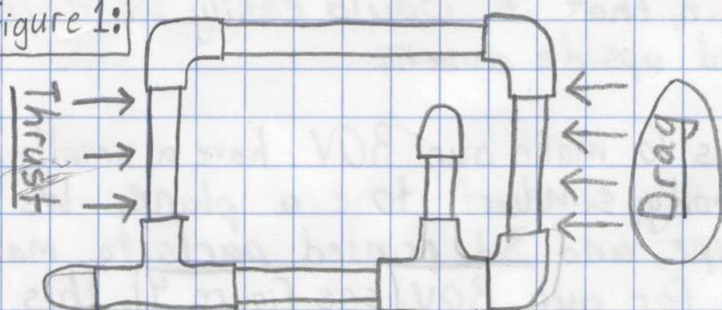
The Frame: Designing its Shape

→ Is there a better shape for the ROV?

Ask: The normal Sea Perch frame for the underwater ROV is shaped like a cube. After discussing with eachother, we decided that the cubical shape would create too much drag when moving forward and turning. We decided that we wanted to create our own frame shape that would help reduce drag while in the water. How can we acheive this?

Figure 1:



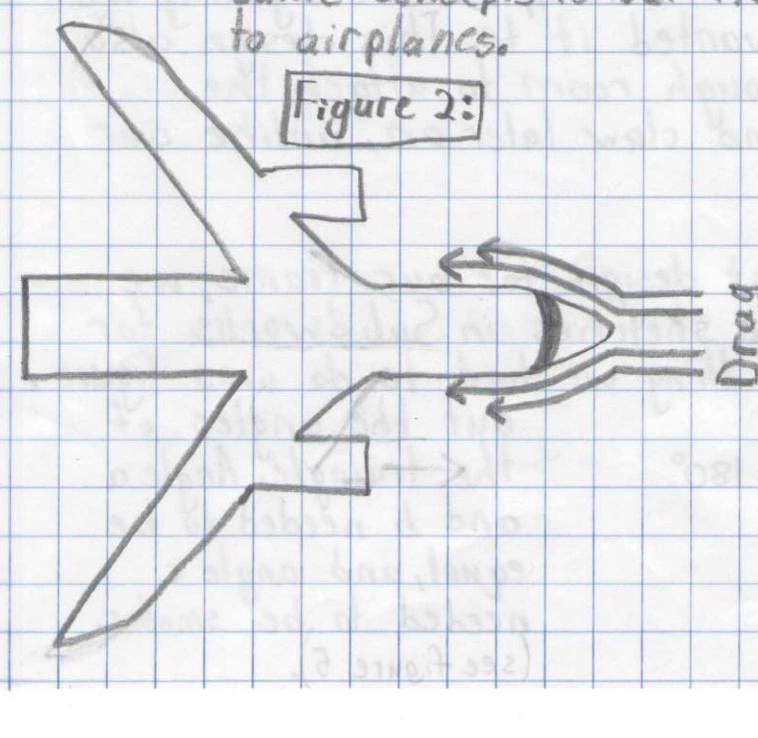
Side view of recomended frame

When moving forward, the high surface area of the front creates a lot of drag (see figure 1).

The benefit of this frame is that it is easy to control, and there are already instructions online to construct it.

Imagine: To design the shape of our frame, we decided to look at something that has already been heavily researched; airplanes! Air can flow, classifying it as a fluid. Therefore, we can apply the same concepts to our ROV that engineers apply to airplanes.

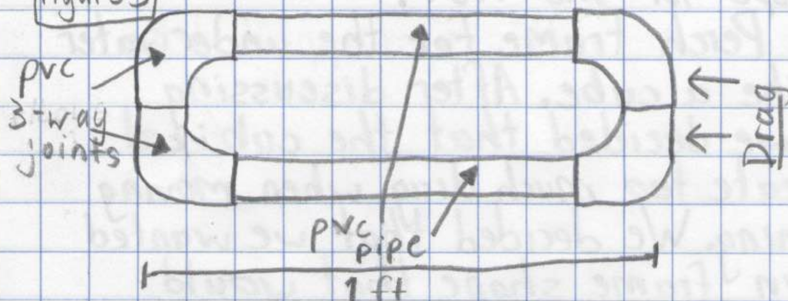
Figure 2:



The narrow, triangular shaped nose reduces the drag on the airplane because it can efficiently "cut" its way through the air. This reduces the amount of drag because the air isn't running straight into the airplane. It is being split off onto either side (see figure 2).

Ideas • Our first idea was to make our ROV thinner and shorter. We would use four pvc pipes, and eight pvc three-way joints to make the frame (see figure 3).

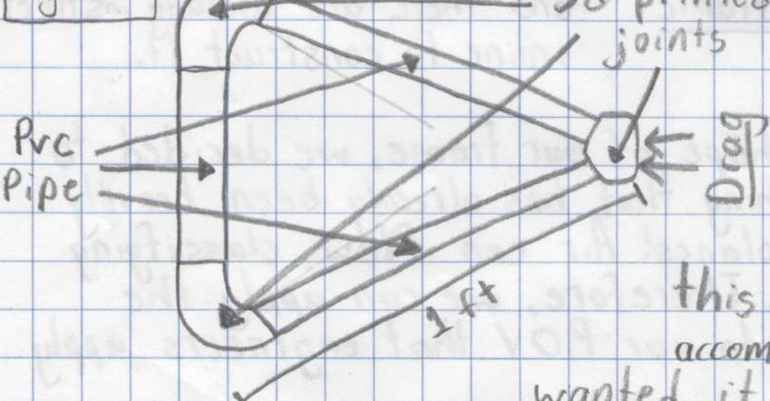
Figure 3



Although this idea would reduce drag due to its small front surface area, we soon decided that it would not be too practical. It would be impractical because we would run into problems keeping the ROV upright. This design is so thin, that it would easily flip to the side and upside down.

•Our second idea was to make our ROV have a small nose and a wider body, similar to a plane. We would use pvc pipe, and 3d printed parts to make a triangular shape for our ROV (see figure 4). This idea would reduce drag due to the smaller nose, and provide stability for the ROV, so that it wouldn't flip. We ended up chosing this idea because it accomplished everything we wanted it to. This design also leaves us with enough room to attach the propellers, elevator, and claw later on, unlike our first design.

Figure 4



Plan: After selecting the best design for our frame, we started to make some sketches in Solidworks for the joints. The first thing we had to do was figure out the angles of the triangle. Angle a and b needed to be equal, and angle c needed to be smaller. (see figure 5).

Figure 5

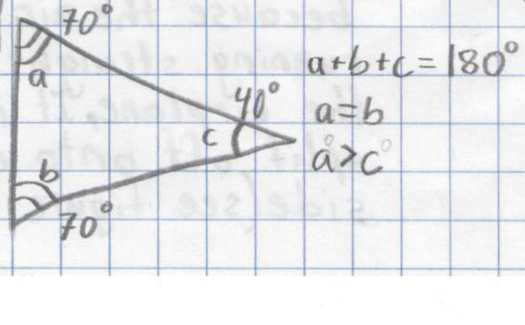
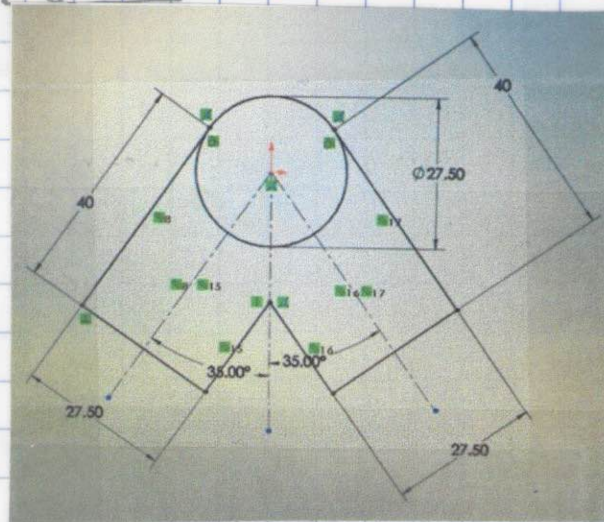
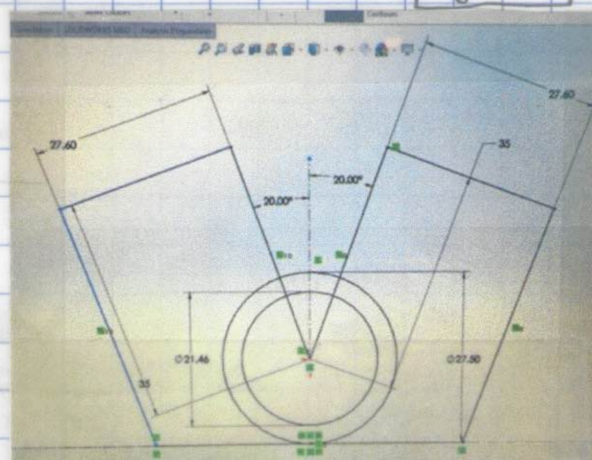


Figure 6



We began to make the sketches on the top plane in <u>Solidworks.</u> The first piece we made was the two back joints of the ROV. To make sure we got the 70° angle correct, we drew reference lines, and designed the piece around them. That way, we knew we had the correct angle (see figure 6).

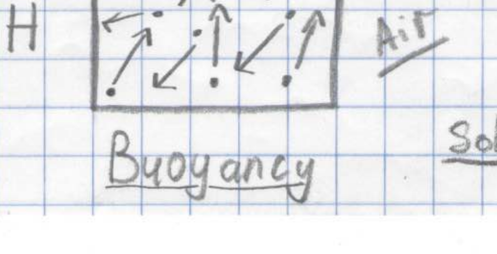
Figure 7



After designing the back joints, we started to design the nose of our ROV. Similarly to the back joints, we started by drawing reference lines to design off of. We made this joint wider to have room to run the claw through it later on in the process (see figure 7).

<u>Create:</u> After finishing designing the joints for our ROV, we <u>3d printed</u> them. Once the pieces were done printing, we realized that they were filled with air. This would make our pieces much more buoyant than the surrounding water (see figure 8).

Figure 8



<u>Buoyancy</u>

<u>Problem</u>
Our pieces were filled with air making them buoyant in water. This means that the particles are less dense and have a higher pressure. This means that the pieces would float because high pressure always traveles to lower pressure. At first we thaught that this would be a big problem, but then we decided

<u>Solution</u> to use the pieces instead of the pool noodles. for buoyancy.

Figure 9

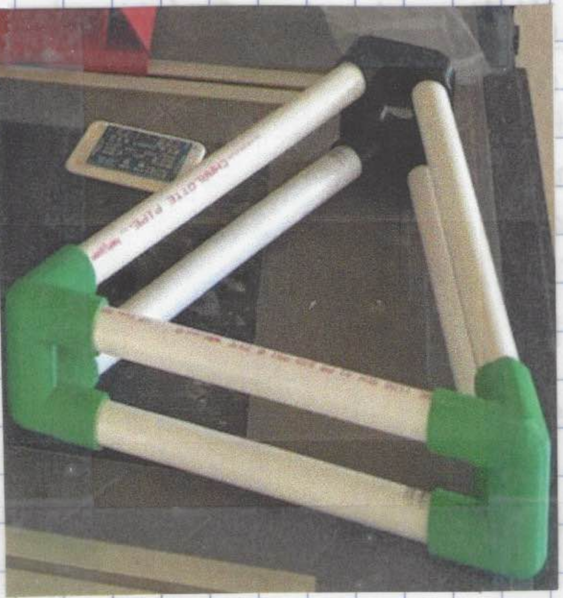
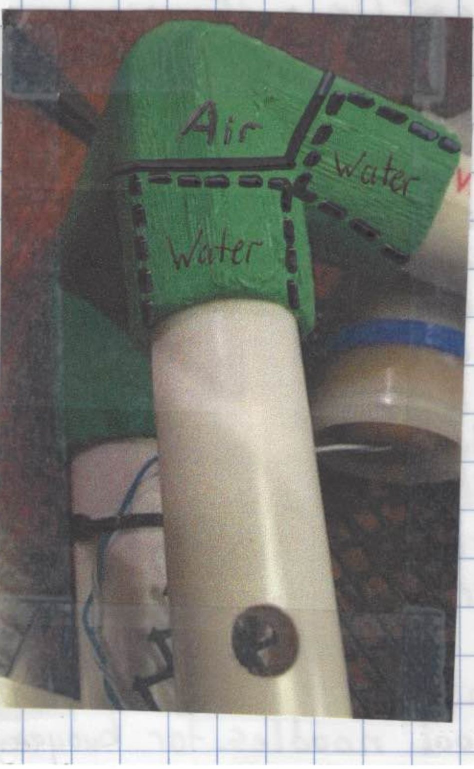


Figure 9 is an image of our frame fully assembled. The black 3d printed part is the nose of our ROV, and the green pieces are the back of the ROV. The sides of the submarine are one foot long and the back is eight inches long. This frame reduces drag on the ROV when moving forward, and still provides stability to the machine while moving.

Test: After finishing assembling the frame, we put it in water to see if it would float or sink. It was very buoyant in water.

Improve: Our frame was too buoyant in water, so we ended up drilling holes in the pvc to equal out the bouyancy of the ROV. We still wanted it to float because we still needed to add motors and the claw onto the frame. They will make the submarine even heavier.

Figure 10



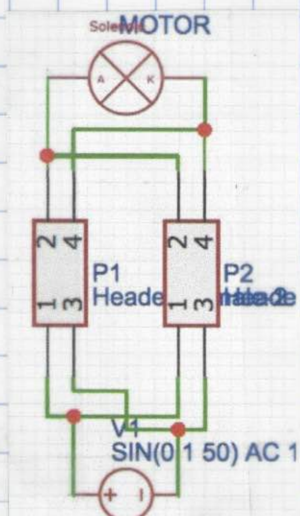
The holes in the pvc pipe allow water to get into the pipes. However, there is a layer of PLA filament blocking the water from getting into the 3d printed parts. This keeps the submarine buoyant because there is air inside (see figure 10).

Wiring the ROV

Ask: For our ROV, we wanted to have an automated claw to grab things underwater. In the instructions, it says that we are not allowed to attach a line to the submarine. This means that we needed to design a way to hook the claw and all the motors to the same remote. How do we incorporate a claw?

Imagine: •Our first idea was to have two different buttons that we could use to enable current to go through them. They each would have the current go in a different direction. So if we push the right button, the current would make the motor spin clockwise. If we pushed the left motor, it would reverse the current, making the motor spin counterclockwise. There are some disadvantages of this remote. It is difficult to fit it all into the remote, meaning it is prone to have a straight circuit in a bunch of places.

Figure 1

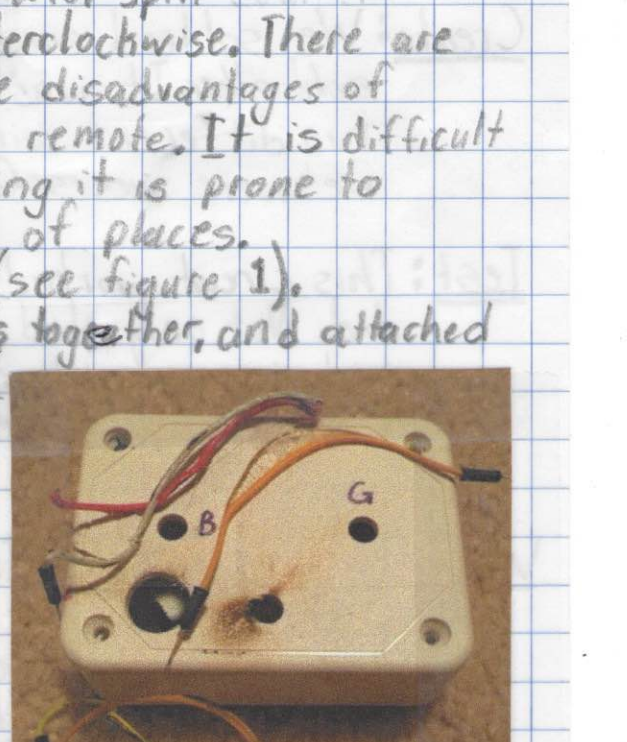


The advantages of this design are that the cost would be less, and it would be easier to control.

Box

Plan: We created a schematic online (see figure 1).

Create: We solderd all the components together, and attached it to the remote. figure 4

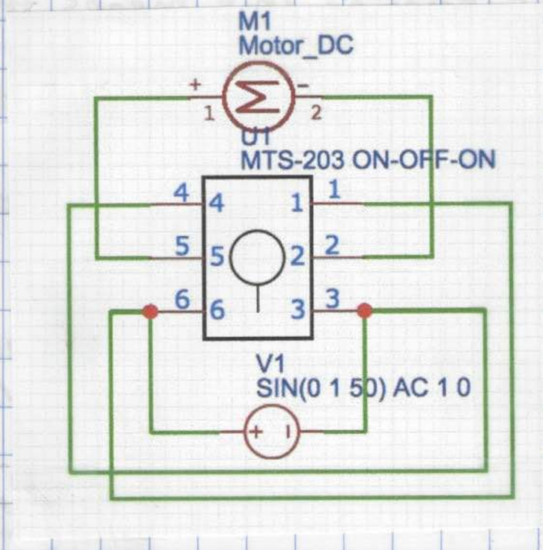


Test: Once the circuit was attached to the remote, we hooked it up. As soon as we plugged it in, it started to smoke, and caught fire. After it cooled off, we figured out that the buttons we used couldn't handle 12 volts from the battery.

Improve: We decided not to continue with this idea, and try a new idea.

Imagine: Our first idea didn't work, so we went back to the planning stage. This time, we wanted to use a toggle switch. We wanted to use a toggle switch because we knew it could handle the voltage, and we would easily be able to change the direction of the current.

Figure 3



Advantages of this circuit design

- We would only be adding one button.
- It would be easy to use.
- It would be a lot more reliable.
- It wouldn't burn out with 12V.

Disadvantages of this design

- It is harder to make
- It is more expensive
- It is harder to fit into the remote box.

Plan: We created the sdematics in figure 3 to illustrate what our plan was, and to visualize if it would work or not.

Create: We solderd everything in the schmatics above to each other. It was a little bit difficult soldering two different wires to one pin, but eventually we were successful in both.

Test: This circuit worked a lot better than the first one did. Not only did it do its job it did it smoothly and consistently. Once we knew that it worked, we drilled a hole for the switch in the remote, and screwed it on.

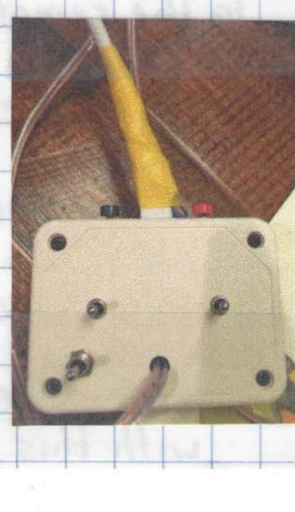


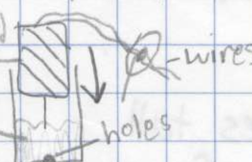
Figure 4

Wiring the extra switch: The circuit board didnt have a spot for the extra switch, so we had to open the cable and solder the switch directly to the wires to connect it to the ROV. We wrapped the open wires in electrical tape to keep them all together (see figure 4).

Engineering Challenge: Waterproof and Design The Mounts And Orientation Of Our Motors

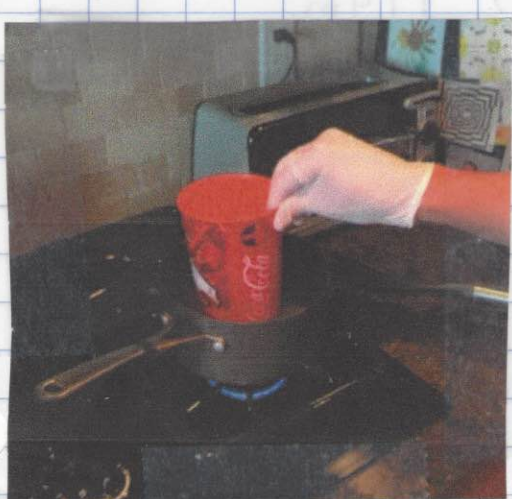
Q: How are SeaPerch motors waterproofed?

A: A 12 VDC motor is submerged in melted bowl wax inside of a 35 mm film canister with holes drilled on both ends. The motor is wrapped with electrical tape to protect the inside of the motor. Wires, attached previously, exit through the lid of the canister.



Constraints:
- Due to a shortage of materials, we do not have a plastic dropper to take heated wax and put it into our canister.
- We do not want to burn the wax.
- Our parents do not want to ruin metal pots.

Solutions:
- Eliminate necessity of dropper by pouring carefuly
- Submerge wax in boiling water
- Use cheap plastic Broncos cup to hold the bowl wax.
  - Along with this, we decided to use a big plastic Spoon to hold down the cup because our hands were hot.



Problem: On motor #2, an air bubble rose to the top of the film canister, exposing wires connecting to the motor.

Solution: We used a hair dryer to remelt the wax and eliminate the air bubble.

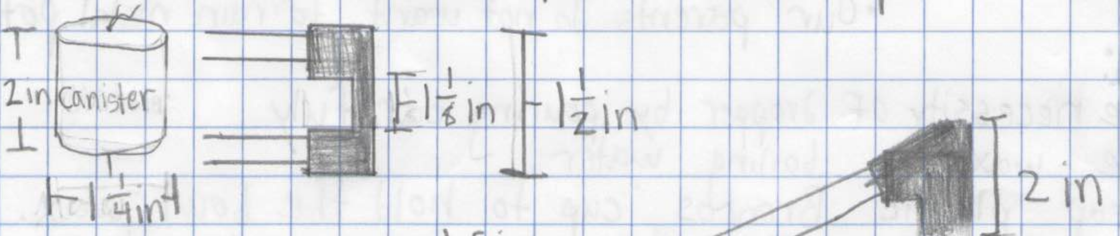
Testing: We submerged all motors in a bath tub and used a battery on the other end of the wire. No blind spots found.

Engineering Challenge: Design Motor Mounts and Orientation

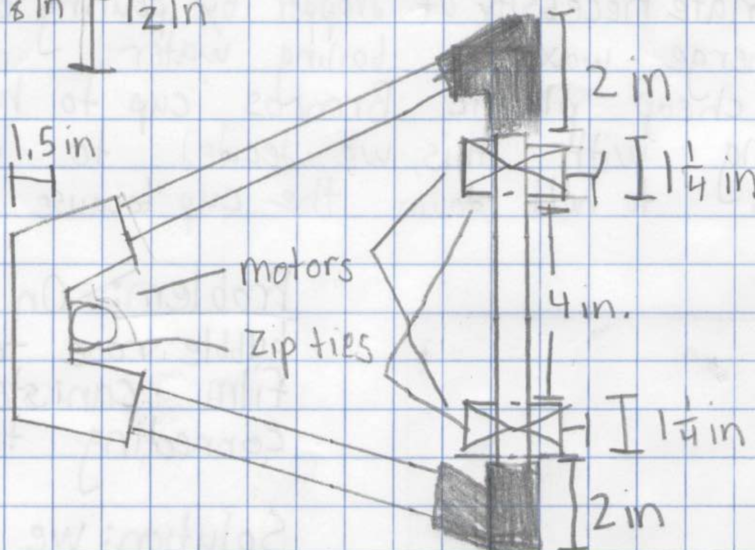
Q: With our unique frame design, what are the best locations of our motors?

Constraints:
- Because of the shape of our frame, attatching motors on the side (as opposed to above or below) of a pvc pipe is not viable because of the inefficient angle of thrust
- Cost
- Type of free material available

Information needed:
- Size of film canister = $1\frac{1}{4}$ in. diameter, 2 inches tall
- Distance between top and bottom part of connector piece = $1\frac{1}{8}$ in.
- Distance between top and bottom pvc = $1\frac{1}{2}$ in.



First Design:



The goal of this design is to make the ROV control like a video game. Because of this, motors are switched so the ROV turns in the direction of the switch as opposed to controlling the motor on the switche's side! The elevator is in the front to control the nose.

Engineering Challenge: Design Motor Mounts and Orientation

Problem with design: Having the elevator in the front of the frame leaves no room for future claw construction.

Solution: Move elevator more towards the center of the ROV. (but not fully in the center)

Explanation: By the principles of rotation on a 3D plane, any force applied anywhere outside of an object's center of mass will cause a rotation. This allows us to still control the ROV's nose.

Challenge of new idea: Mounting the elevator without a connecting PVC pipe.

Possible Solutions:

- Attatch a PVC pipe to the top center of the ROV.

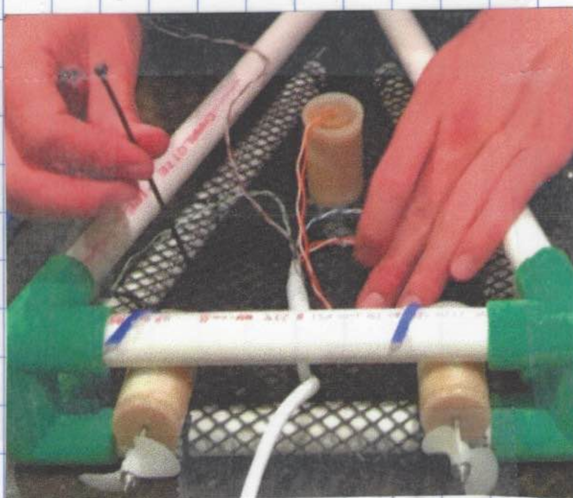
- Attach black polyethylene mesh to the top of bottom layer of pvc using zip ties.

Our decision: The black mesh is more cost effective, as no new materials are needed to be purchased.

Side note: Another benefit to the black mesh is increased stability of the back motors, as well as providing a way to attach future claw components.

Engineering Challenge: Design Motor Mounts and Orientation

Assembly: Step 1 - Attach black mesh to frame using evenly spaced zip ties. 3 on the sides 2 in the back. Cut off excess mesh.

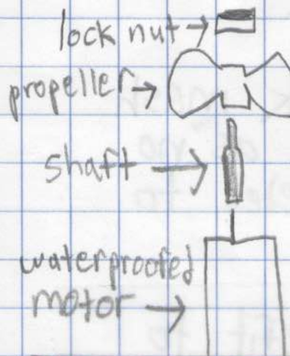


Step 2 - Secure back motors 2 in. from the side of the ROV with even distribution on both sides of the pvc.

Step 3 - Secure back motors by looping a blue zip tie through the mesh and around motor. Cover with hot glue.

Step 4 - Hot glue elevator motor $6\frac{3}{4}$ inches from front of frame in the center of the mesh. Axel is going through a hole in the mesh.

Step 5 - Attach propellers to motors using a shaft, followed by the propeller, secured with a lock nut.



Testing: Consists of two tests:

- Out of water - check for blind spots
- Basic turning in bathtub - 3x of each of the following: 360° left, 360° right, forward tub length, backward tub length.

(We are holding the wire for the future claw mechanism out of the water)

Engineering Challenge: Design Motor Mounts and orientation

Problems identified during test 1: • ROV is rear heavy
• ROV floats on surface of water rather than floating in the waters equilibrium.

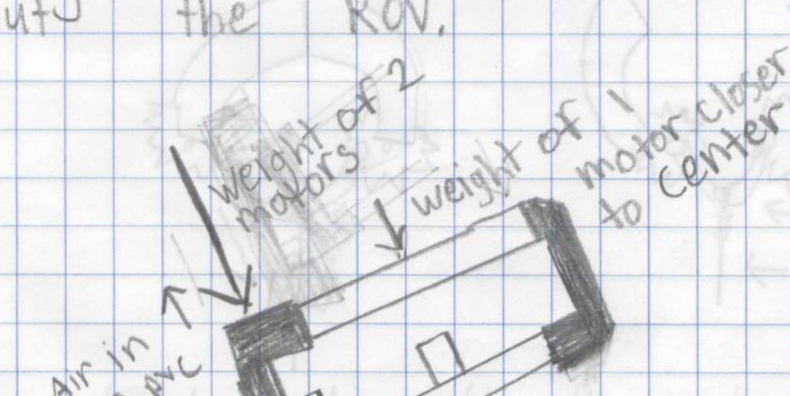
Cause: We believe the cause of the high buoyancy is the air trapped within the pvc pipes.

Solution: We are going to drill holes in the top pvc pipes to allow water into them and eliminate air. If it is not enough we will drill holes in the bottom pvc.

Test 2 results: The ROV is still too buoyant, floating just a few feet under the surface.

Changes made: holes have been drilled in the bottom side pvc pipes. (Not bottom back pvc)

Results of test 3: The buoyancy is about right. By keeping air in the back bottom pvc, the ROV is less rear heavy. Ballast weights will be needed upon completion, unless the weight of the claw mechanism balances out the ROV.



Engineering Challenge: Design a Working Claw Mechanism

Q: What does a typical SeaPerch ROV use to grab rings and cubes?

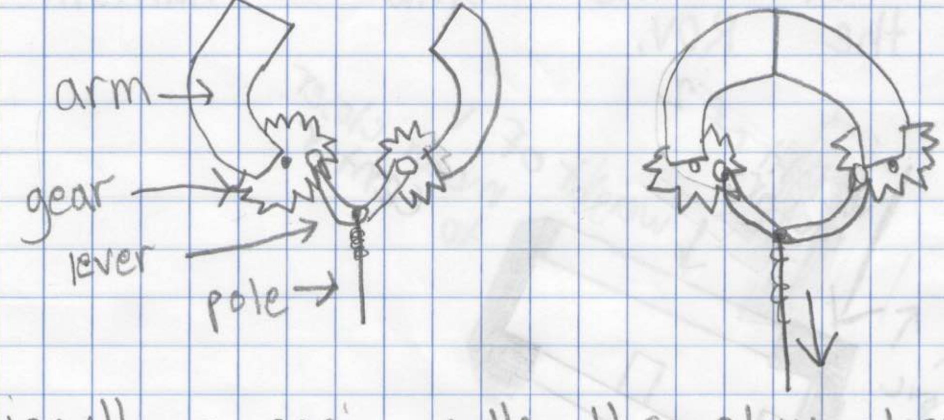
A: A typical SeaPerch ROV uses a straight piece of pvc pipe to thread through rings and cubes.

Q: What makes a claw superior to pvc pipe?

A: The claw is superior because when it closes, it captures everything between the arms, meaning we don't have to be as accurate when capturing rings/cubes, and because when the claw closes, it eliminates the possibility for the ring or cube to drop.

What we need to know: How does a claw work?

Answer: After purchasing a toy claw and taking it apart, we learned that it works by having a metal shaft pull on two levers that pull on two gears which connect to the claw's arms.



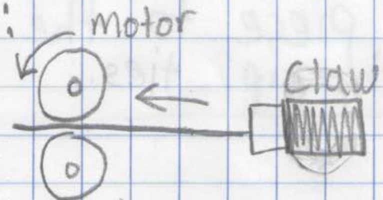
Additionally, a spring pulls the claw closed when force is not on the metal shaft. and a piece of plastic on the gear clicks.

Engineering Challenge: Design a Working Claw Mechanism

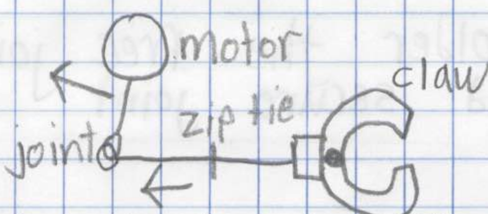
Constraints:
- Cost – we cannot afford anything but a motor
- Strength of motor (weak)
- Claw takes much force to pull (greater than a motor pulls)

Solution to claw's resistance: We have removed the spring and piece that creates the clicking sound, making it possible for a motor to run the claw.

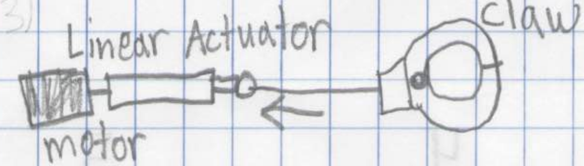
Ideas:



1) use wheels to pull lever



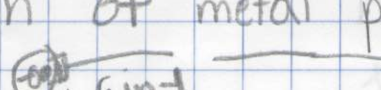
2) A joint pulls the claw closed



3) use a linear actuator

Decision: We have decided to use idea #2 because we dont have to buy any materials, just repurpose the claw's metal shaft.

Procedure:
1) cut 6 in of metal pole off the claw.



2) Bend end of pole into a loop.

See pictures on next page

3) Bend remaining pole into a loop around previous loop.

procedure continues →

Engineering Challenge: Design a Working Claw Mechanism

4) Solder a washer on the end of a motor.

5) Use an X form zip tie formation to secure the motor 3.5 inches from the front of a side pvc pipe.

6) Glue a 2 in pvc piece to back of claw mechanism and secure the claw to the earlier referenced claw hole.

7) Solder the free joint piece to the washer and secure joint with zip ties.

1 2-3 4 5

6 7

Problem: Claw only closes and does not open.

Solution: Use a rubber band to pull claw open when motor is off. Rubber band is connected to the shaft and the black mesh.

Engineering Challenge: Design a Working Claw Mechanism

Q: Did it work?

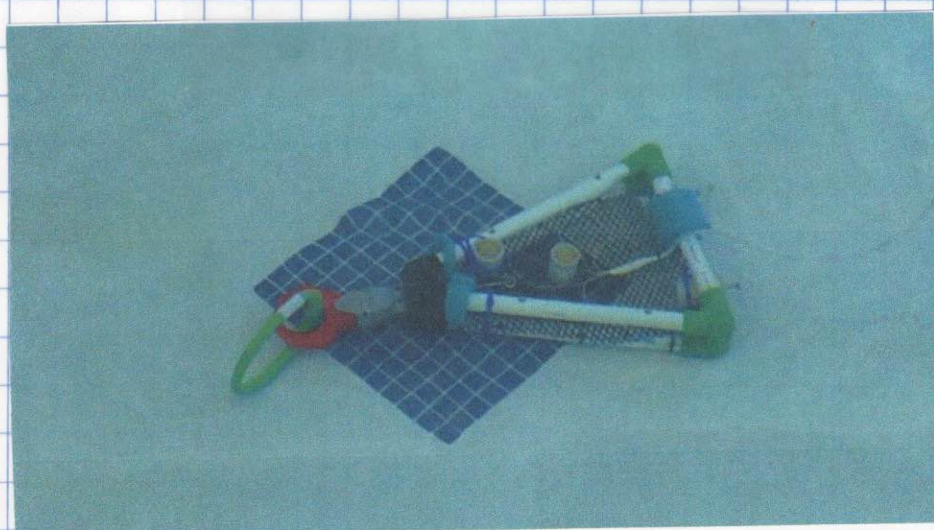
A: No, the claw was unable to open.

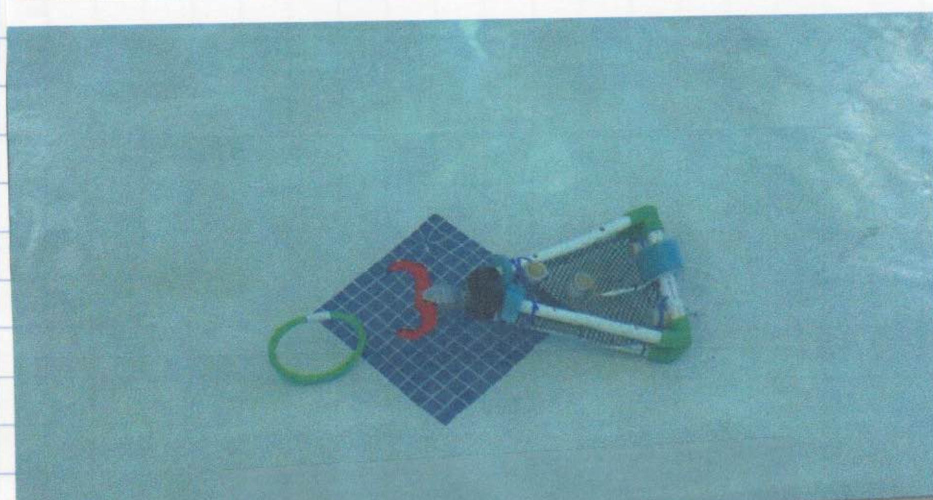
Possible Cause: The resistance of the rubber band is too strong for the motor to handle.

Solution: Change the wiring of the circuit switch from one way to two way.

Q: Was it a success

A: Yes, the claw is now capable of opening and closing.



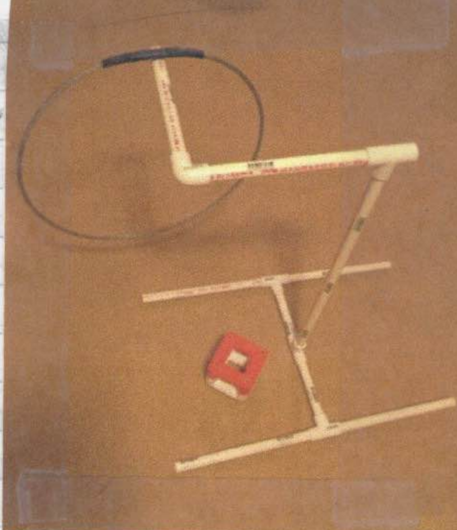


Preparation for Pool Testing

Ask: We had done multiple tests of our ROV in our bath tub, but all that it really showed us was that it was waterproof. To get better test results, we reserved a pool at our local recreation center. But first, we needed a way to effectively test our ROV.

Ask: How can we create a more effective and realistic way to test our ROV?

Imagine: We decided that we would make a mock cube, obsticle course ring, and stand to help us test and practice driving our ROV.



Constraints: We didn't have much information online about how to construct the items, so we had to use the information that we had to construct them as close as we could to regulation.

Plan: Ring: Use cable and heat shrink to hold the ends together. We needed to create an 18" diameter ring, so we used the equation "circumfrance = diameter • π ($18 \cdot 3.14159 = 56.548$ in.) to figure out how much cable to buy.

Cube: Use 8 pvc 3 way elbows and 12 pvc connecters to make a cube, spray paint half of it orange, then use pool noodles to make it perfectly buoyant in the water.

Stand: Use pvc pipe, elbows and T's to create a stand that can be moved and change shape to create harder challenges during testing.

Create: Creating the objects went just as planned. We used a lighter to shrink the heat shrink, and we used pvc cutters to cut the pvc pipe. Overall, the objects turned out really well!

Testing Buoyancy of our ROV-Pool

Problem: We didn't follow the usual format for the Sea Perch ROV, so we didn't know how big or where our pool noodles needed to be to be perfectly buoyant.

(We weren't creating anything for this step, so we skipped straight to testing).

Test: All we could really do to test and find the proper placement and size for the pool noodles was to test, then adjust. We knew that we would need a bigger pool noodle on the front right in order to counteract the weight of the extra motor. We also knew that we would need a large pool noodle in the back because the back of the ROV is much heavier. After testing, we found that a 1" noodle on the front right will counteract the weight of the motor, and a 5" noodle on the back will even out the whole submarine. The ROV was still a little uneven, so we added a 0.5" noodle to the front left.

Our ROV is now perfectly balanced and bouyant in the water. It slowly sinks, which we think makes it easier to drive rather than it floating. It is also even on all sides, so it doesn't flip or stay crooked while in the water. This lets us control the ROV with precision, and drive it through the water a lot easier than before.

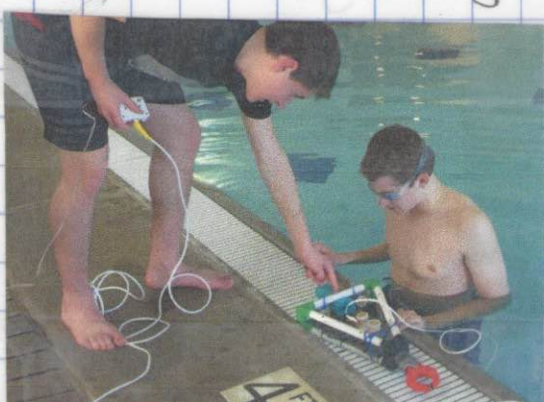
Pool Testing

Day 1:

Question: What problems did we encounter and how can we fix them?

Problem: When we drive the ROV through the water, the mechanism moves out of alignment.

Possible cause: The solder on our motor shaft is not properly bonding to our washer due to smooth surface on our motor shaft.

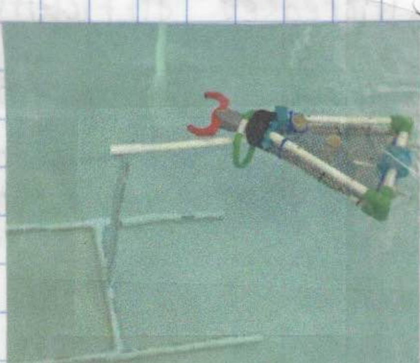


Solution: We replaced the solder with epoxy. We also scuffed up the shaft with 80 grit sand paper to help the glue bond.

Success?: Yes, the claw is now solidly attached to the motor.

Problem: It is difficult to align the pool ring with the pvc test stand during our homemade challenge course run-through.

Cause: When we use the claw to pick up the ring, the ring floats around inside of our claw, making it hard for us to control where the ring is placed.



Solution: By letting the ring pass over a closed claw, then opening the claw, we can secure the ring in an optimal position on the claw and release the ring easily onto the target.

Success?: Yes, now we can control where the ring is placed

Side note: This alternative method of picking up rings is not used on cubes.

Pool Testing Continued

Day 2:

Problem: Upon testing our claw mechanism on our Home made cube, we noticed our cube was too heavy for the ROV to lift.

Possible cause: Unlike regulation cubes, our cube lacks a foam interior.

Possible solutions: 1) Make the cube air tight.

Problem: The cube would float.

2) Attach pool noodles to the top of the cube.

Problem: The cube is harder to grab.

3) Cut up pool noodle and insert foam pieces into the cube.

Problems: Cube is super glued shut. Foam could shift and throw off balance of the cube.

Our decision: We decided to attach pool noodles to the top of the cube. The increased difficulty improves our operational skills in driving the ROV.

Problem: Battery is cumbersome and prohibits us from following the ROV on the pool side without pulling the wires off the battery.

Solution: Rather than setting the battery on the pool deck, we placed the battery in the Sea Perch bag, so we could carry the battery with us.

Pricing of our ROV:

We got the extra motor and extra canister from the spare parts bin in our tech room. The claw was a toy from our childhood that we had in our basement. Since we already had these parts, we looked online to find out how much money it would take to procure the materials.

3D printed joints -- $0.05 per gram: 66.49g + 47.43g + 47.43g = 161.35g x $0.05 = $8.06

Final Price:

$3.49 Motor
$2.99 Canister
$4.89 Claw
$8.06 3D printed parts

$19.43