School: Patriot High School

City, State: Nokesville, VA

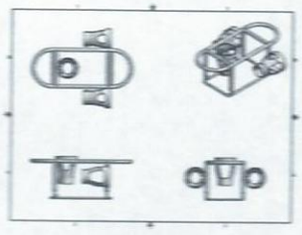
Team name: The Keepers

ROV name: Beacon

Patriot High School

The Keepers

Engineering Notebook 2018



seaperch

TEACH • BUILD • BECOME

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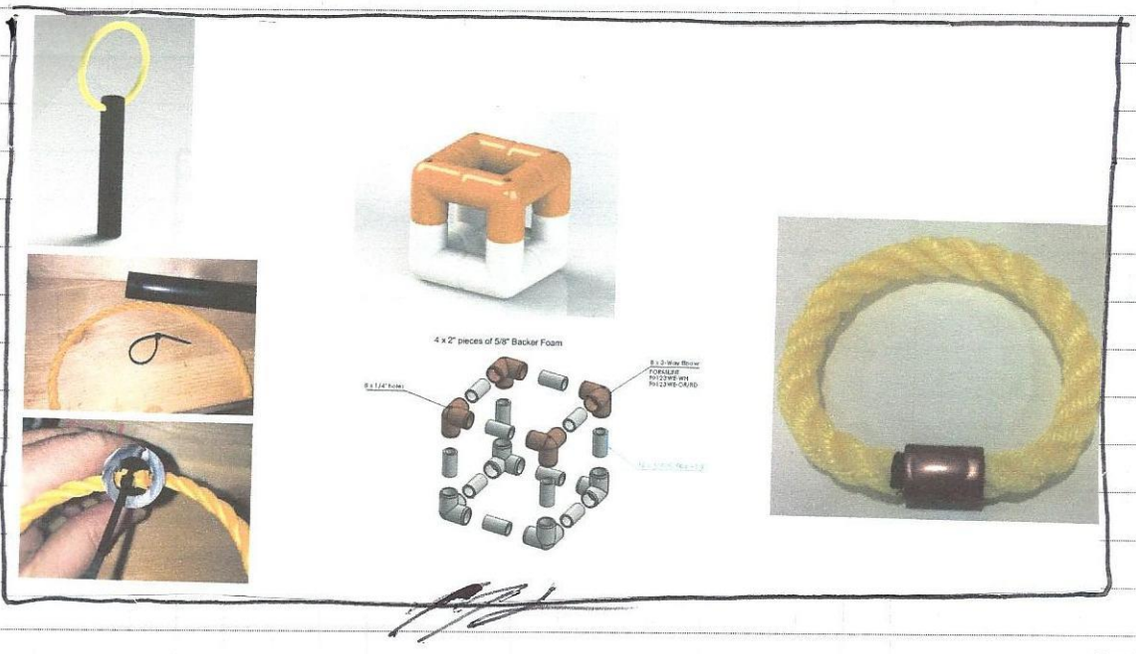
DESIGN BRIEF

- DESIGNERS: RYAN MILLER (BUILDER), JARRETT LASH (NOTEBOOK)
- COACH: GREG QUAST quastga@pwcs.edu
- PROBLEM STATEMENT: SEAPERCH's 2018 COMPETITION INCLUDES CONSTRUCTING A REMOTE OPERATED VEHICLE THAT CAN BOTH COMPLETE THE NATIONAL CHALLENGE AND THE OBSTACLE COURSE
- REQUIREMENTS: STOCK CLASS
  - TEAM BUDGET MUST BE UNDER $20.00 IN ADDITION TO THE KIT
  - TEAM MAY ONLY UTILIZE THREE THRUSTERS
  - ATTACHMENTS AND HOLES MAY NOT BE ADDED BETWEEN ROUNDS
  - ROV SHOULD FIT THROUGH AN 18" HOOP
- CONSTRAINTS
  - TEAMS MAY ONLY UTILIZE JAMECO ELETRONICS P/N 232022 MOTORS FOR PROPULSION
  - ROV MAY ONLY USE SIMPLE SWITCHES OR BUTTONS
  - ROV'S MUST USE ONLY A 12 VOLT BATTERY



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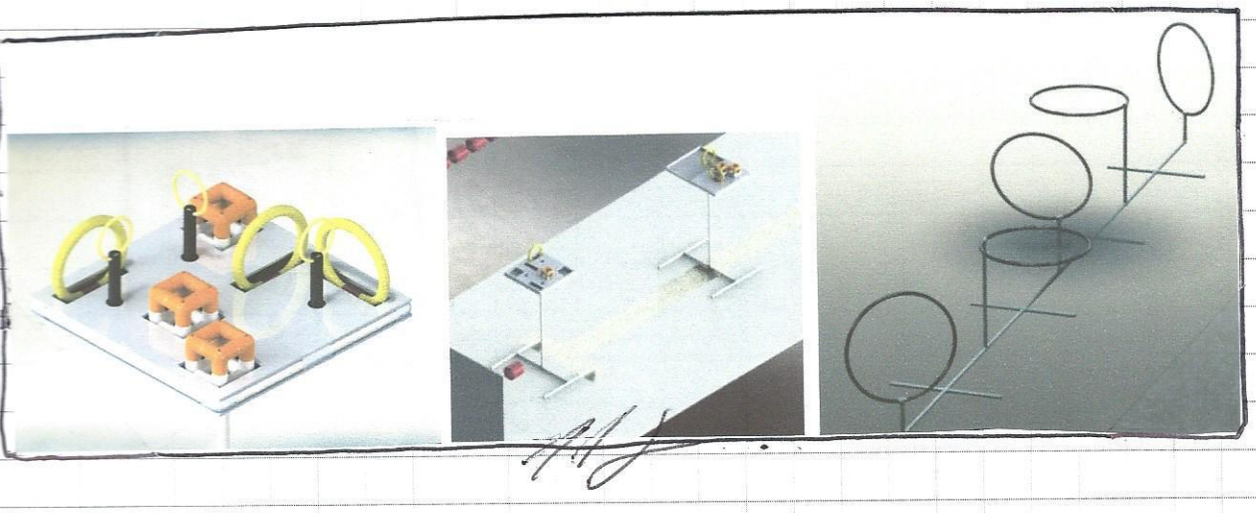
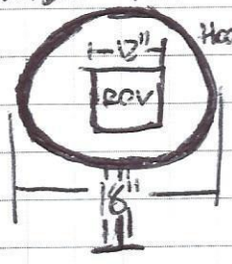


- TEAM CONSTRAINTS
  - MAXIMIZE 3D PRINTED PARTS FOR SPECIFICITY AND COST
  - DESIGN NO WIDER THAN 12" TO HELP PASS THROUGH HOOP



- CAN COMPLETE ALL FOUR REGIONAL CHALLENGES
  - RECOVERY, SPEED, NATIONAL CHALLENGE, OBSTACLE COURSE

References

What is buoyant force? (n.d.). Retrieved May 4, 2018, from https://www.khanacademy.org/science/physics/fluids/buoyant-force-and-archimedes-principle/a/buoyant-force-and-archimedes-principle-article

What Is Generative Design | Tools & Software | Autodesk. (n.d.). Retrieved May 4, 2018, from https://www.autodesk.com/solutions/generative-design

MatterHackers. (n.d.). How to Succeed when Printing with PETG Filament. Retrieved May 4, 2018, from https://www.matterhackers.com/news/how-to-succeed-when-printing-with-petg-filament

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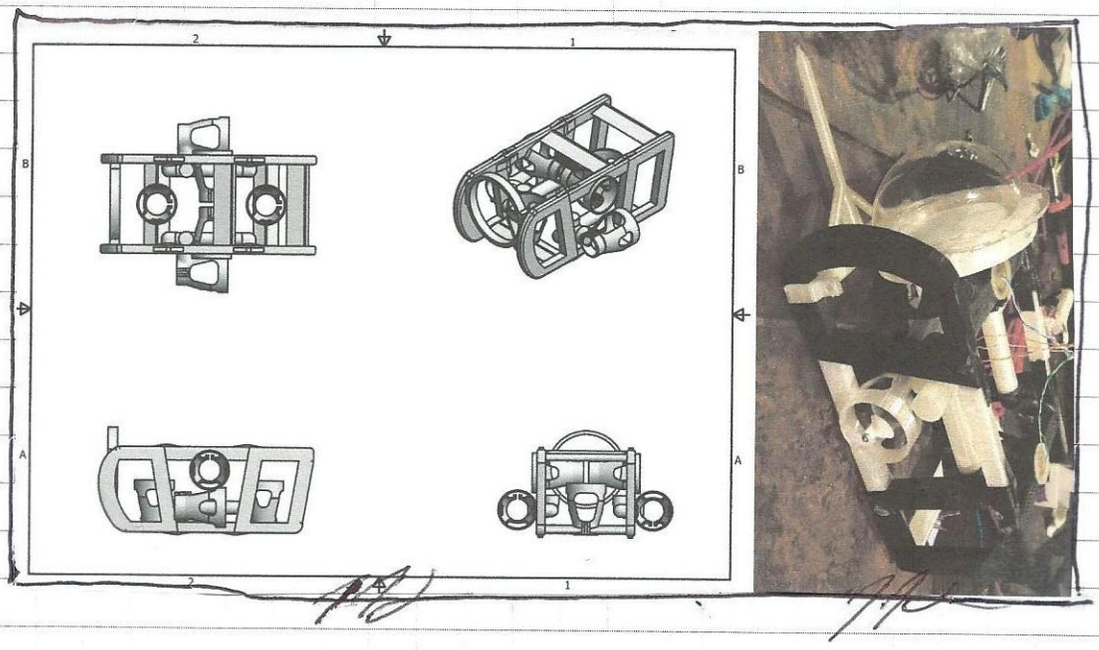
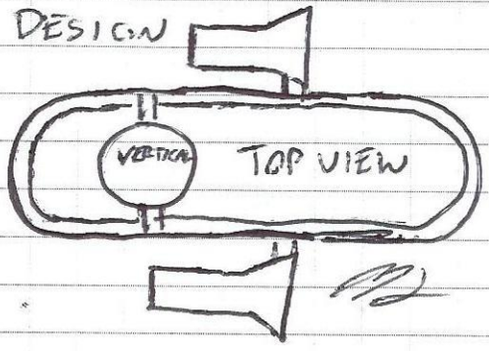
BRAINSTORMING

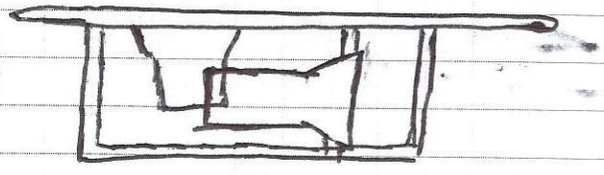
WE PLAN TO 3D PRINT MOST OF OUR VESSEL THIS SEASON JUST AS WE DID LAST SEASON TO ACHIEVE THE SMALL SIZE WE WISH FOR

OUR ROV FROM NATIONALS IN THE OPEN CLASS WAS DESIGNED FOR STABILITY WITH SIX MOTORS TWO VERTICAL, TWO FOWARD THRUSTERS AND TWO SIDE STRAF MOTORS WITH AN ON BOARD IMAGE DETECTING CAMERA



WE PLAN TO SLIM DOWN THIS DESIGN TO FIT STOCK CLASS REQUIREMENTS AND HAVE A SMALLER OVERALL DESIGN





SIDE VIEW

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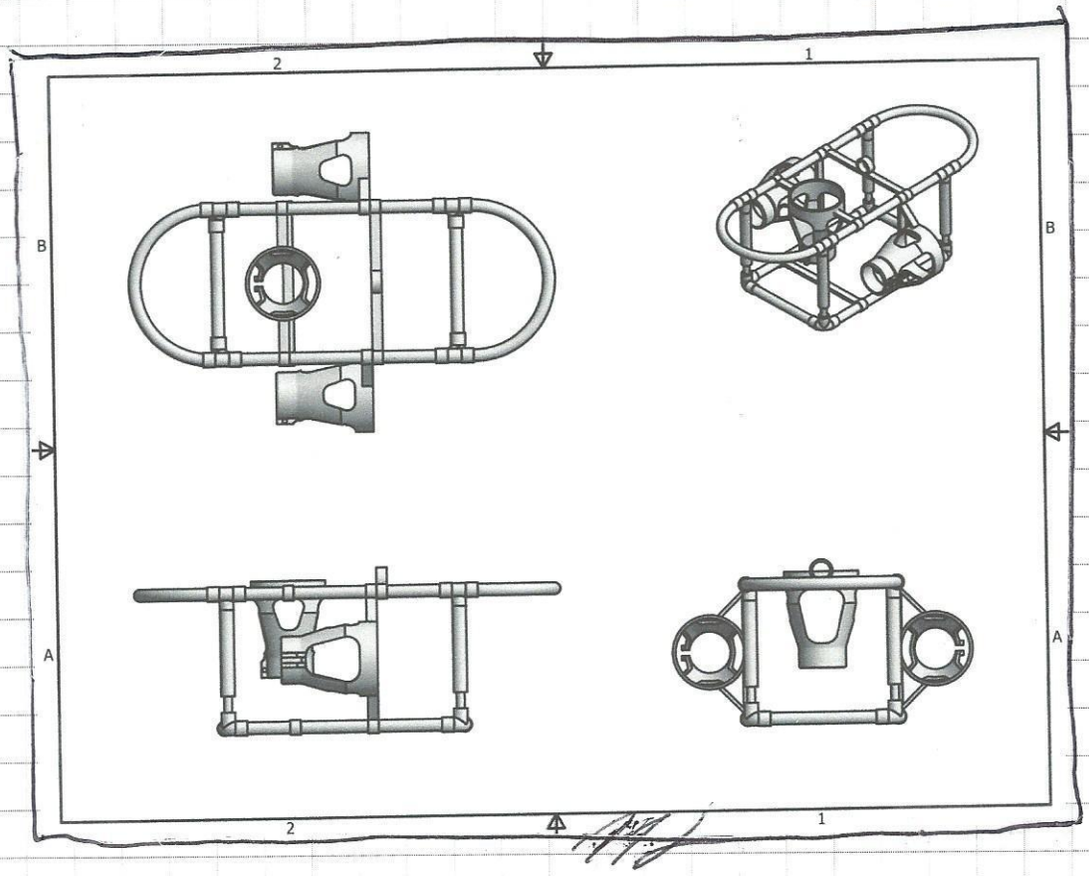
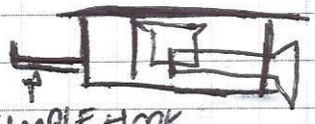
RYAN TOOK TO CAD TO CREATE THE DESIGN



NOW THAT WE HAVE THE BASIC SHELL WE NEED TO DESIGN A MANIPULATOR THAT CAN LIFT THE CUBES, RODS AND HOOPS

WE HAVE TWO IDEAS, ONE SIMPLE AND ONE COMPLEX.

1) THE SIMPLE DESIGN IS TO SIMPLY ADD A HOOK TO THE FRONT OF THE ROV.



SIMPLE HOOK

THIS DESIGN HOWEVER PLACES THE BALANCE POINT OF THE ROV FURTHER OUT WHERE OUR ROV IS CURRENTLY PERFECTLY BALANCED

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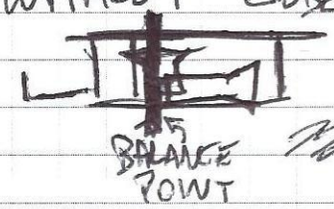
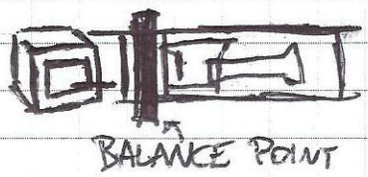
WITHOUT CUBE BALANCE



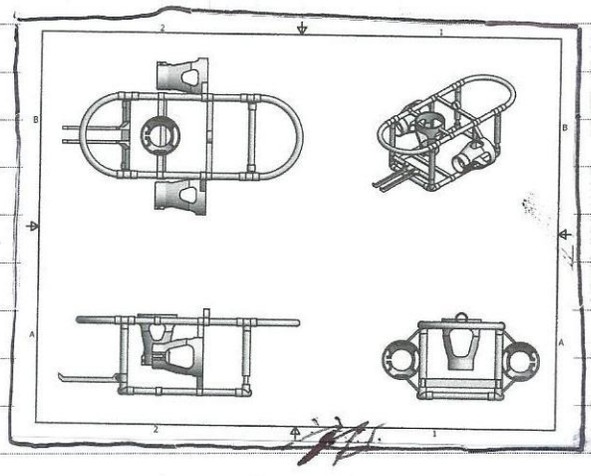
BASED ON INVENTOR THIS IS BALANCED HERE

WITH CUBE BALANCE

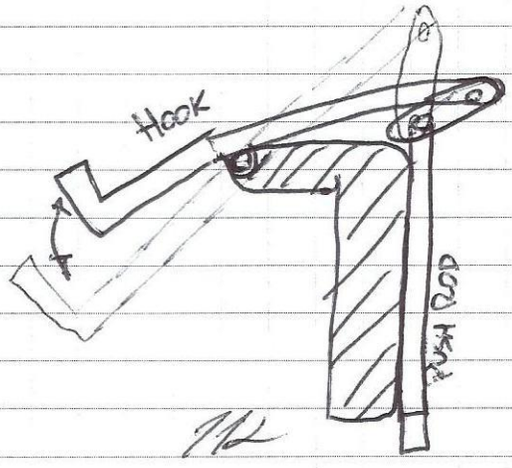


THIS COULD CAUSE ROV TO TIP FORWARD

THE DESIGN WOULD BE AS SEEN BELOW



2) THE SECOND IDEA WE HAVE IS TO CREATE A PASSIVE LOCK THAT WILL KEEP OUR WEIGHT CENTERED BY PICKING THE WEIGHT FROM THE BOTTOM



= SOLID BRACING

WHEN THE PUSH ROD HITS THE GROUND IT PULL UP THE HOOK AND LATCHES UNTIL IT IS PUSH BACK, ALMOST LIKE A PEN SPRING

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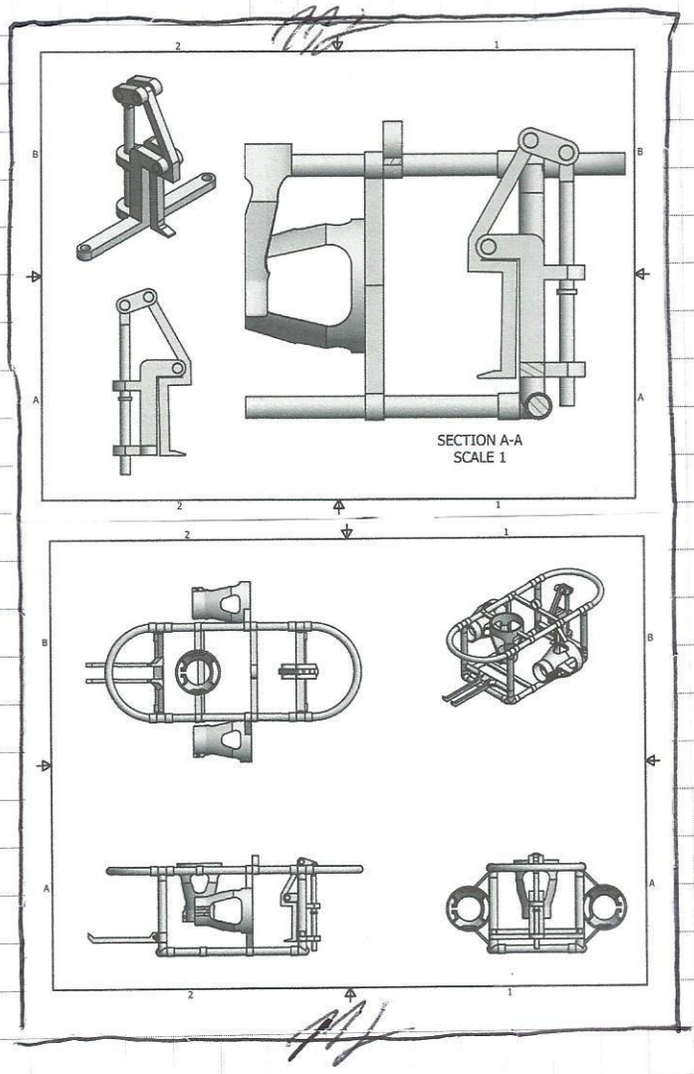
THE CAD FOR THE DESIGN ARE AS FOLLOWS



AFTER REVIEWING BOTH DESIGNS WE ARE GOING TO USE THE SIMPLE HOOKS FOR THE PERCH OFF THIS WEEK AND WILL WORK ON THE PASSIVE LOCK FOR REGIONALS IN MARCH

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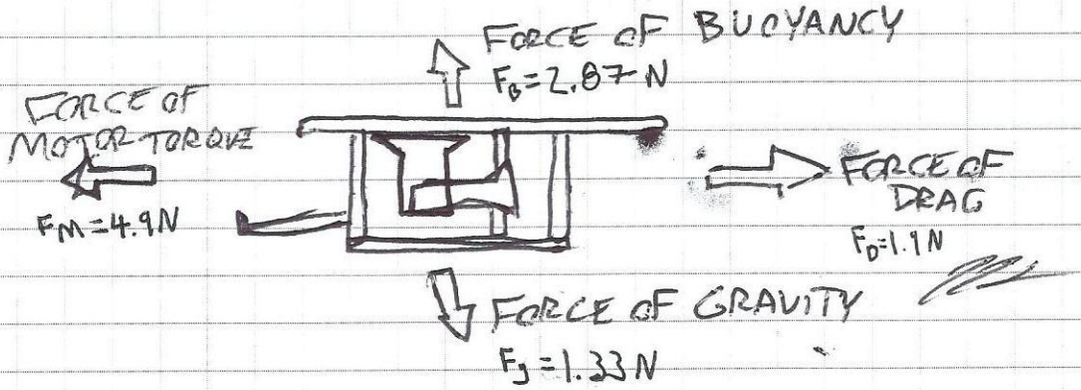
DEVELOP AND PROTOTYPE SOLUTION

NOW THAT WE HAVE OUR DESIGN WE ARE GOING TO START TO CONSTRUCT IT.

BOTH MEMBERS OF THE TEAM HAVE 3D PRINTERS SO FABRICATION IS VERY QUICK FOR THE ROV. WE HAD PRINTED THE ROV IN PLA PLASTIC LAST YEAR BUT DECIDED TO USE PETG THIS YEAR DUE TO ITS HYDROPHOBIC QUALITIES WHICH WILL PREVENT CRACKS FROM GETTING COMPLETELY FILLED WITH WATER.

TO FINALIZE OUR ROV FOR PRINTING, WE RAN THE DESIGN THROUGH GENERATIVE DESIGN SOFTWARE, WHICH TAKES INTO ACCOUNT ALL FORCES EXPECTED TO BE PLACED ON THE ROV TO THEN ALLOW ARTIFICIAL INTELLIGENCE TO OPTIMIZE OUR BRACING TO MEET THE STRENGTH REQUIREMENTS WHILE KEEPING THE DESIGN AS LIGHT AS POSSIBLE

THE FORCES PLACED ON THE ROV CAN BE SEEN IN THE FREE BODY DIAGRAM BELOW



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TO CALCULATE THE REQUIRED FORCES, WE FOUND THE EXPECTED MASS OF THE ROV FROM THE KNOWN WEIGHT OF THE MOTORS AND THE EXPECTED WEIGHT OF THE 3D PRINTED PARTS, FOUND ON INVENTOR BY SETTING THE MATERIAL PARAMETERS

FIRST WE CALCULATE THE DENSITY of OUR ROV WITHOUT FLOATATION BY USING THE CUMULATIVE DENSITY OF ROV, $d_{total} = (M_1/M_{total}) * d_2 + etc.$ All ~~of the masses~~ OF THE MASSES AND DENSITIES ARE FROM RESEARCH AND INVENTOR CALCULATIONS AS DEFINED ABOVE.

M_1 IS THE MASS OF THE FIRST OBJECT; M_{total} IS THE TOTAL MASS; d_1 IS THE DENSITY OF THE FIRST OBJECT

NEXT WE CALCULATE THE NEEDED POOL FLOATIES TO GET THE DENSITY EQUAL TO WATER ($1\ g/cm^3$) USING SIMILAR FORMULA $d_{water} = (M_{ROV}/(M_{ROV}+M_{Fluid})) * d_{ROV} + (M_{Fluid}/(M_{ROV}+M_{Fluid})) * d_{Fluid}$

WE CAN CALCULATE THE PRESSURE WATER IS EXERTING ON AN OBJECT SUBMERGED IN WATER USING THE FORMULA $P_{total} = P_{atmosphere} + (\rho \cdot g \cdot h)$

ρ (rho) IS ~~THE DENSITY OF THE FLUID~~ THE DENSITY OF THE FLUID $1000\ kg/m^3$; g IS THE ACCELERATION of GRAVITY $9.8\ m/s^2$; h IS THE HEIGHT OF THE FLUID ABOVE THE OBJECT WHICH IS 5.5 ft (1.67m) AT THE BOTTOM of AN AVERAGE POOL.

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FROM THIS WE CAN DETERMINE HOW MUCH PRESSURE WILL BE PLACED ON THE ROV AND HOW MUCH FORCE WE WILL NEED TO OVERCOME. TO DO SO, ONE NEEDS TO MULTIPLY THE PRESSURE DETERMINED BY THE PERCIEVED VOLUME OF THE WATER EXERTING THE FORCE ON THE ROV

FINALLY WE CAN DETERMINE THE BUOYANCY ON OUR ROV USING THE FORMULA $F_B = \rho V g$

ρ (rho) IS THE DENSITY OF THE FLUID 1000 kg/m^3; V IS THE VOLUME DISPLACED; g IS THE ACCELERATION of GRAVITY 9.8 m/s^2

THIS

1) $d_{total} = (m_{printed}/m_{total}) * d_{printed} + (m_{pvc}/m_{total}) * d_{pvc} + 3(m_{motor}/m_{total}) * d_{motor}$

$d_{total} = (149.312/430.485) * 1.25 + (146.19/430.485) * 1.524 + 3(45/430.485) = 1.669$

$d_{total} = 1.47 g/cm^3$

THIS IS SHOWING THE AVERAGE DENSITY OF OUR ROV WITHOUT FLOATATION. FOR IT TO FLOAT IT MUST HAVE A DENSITY LESS THAN OR EQUAL TO WATER OR 1.47 g/cm^3

2) $d_{water} = (m_{ROV}/(m_{ROV}+m_{float})) * d_{ROV} + (m_{float}/(m_{ROV}+m_{float})) * d_{float}$

$1 = (430.485/(430.485 + m_{float})) * 1.47 + (m_{float}/(430.485 + m_{float})) * 0.353$

$1 = 632.813/(430.485 + m_{float}) + m_{float} * 0.353/(430.485 + m_{float})$

$m_{float} = (430.485 - 632.813)/(0.353 - 1)$

$m_{float} = (-202.328)/(-0.647)$

$m_{float} = 312.7 g = 0.689 lbs$

THIS IS SHOWING THE AMOUNT of PRESSURE OUR ROV WILL BE EXPECTING TO EXPERIENCE UNDER 5.5 FT OF WATER. TO RISE UP, OUR BUOYANCY NEEDS TO BE ABLE TO OVERCOME THIS FORCE

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B) $F_B = \rho V g$

$F_B = 1000\ kg/m^3 \cdot 0.00029284\ m^3 \cdot 9.81\ m/s^2$

$F_B = 2.87\ N$

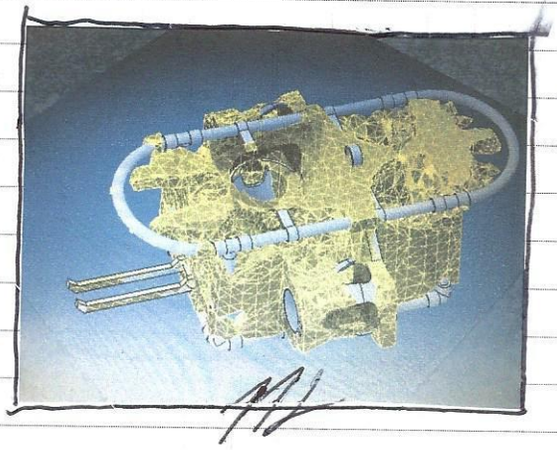
$P_{total} = P_{atmospheric} + (\rho \cdot g \cdot h)$

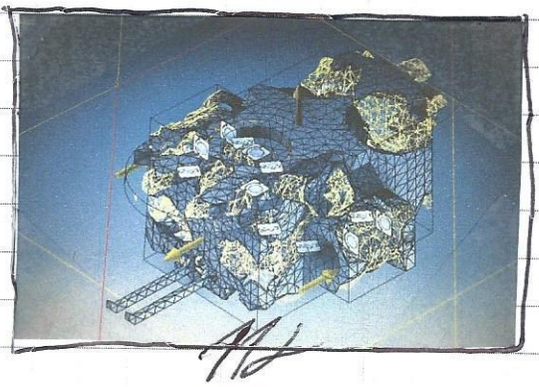
$P_{total} = 101325\ Pa + (1000\ kg/m^3 \cdot 9.81\ m/s^2 \cdot 1.667\ m)$

$P_{total} = 117697.7\ Pa = 17.07\ psi$

TO OVERCOME THE FORCE OF THE WATER AT 17.07 PSI WE WILL NEED TO GIVE 2.87N TO THE FORCE OF BUOYANCY OF UPWARD FORCE AT 5.5' OF WATER PRESSURE

KNOWING OUR FORCE PARAMETERS WE CAN DEFINE THE FORCES THAT WILL BE PLACED ON THE ROV





THESE IMAGES SHOW WHAT THE GENERATIVE DESIGN DEFINES AS THE STRONGEST DESIGN DUE TO OUR PARAMETERS AROUND OUR BASIC SHELL

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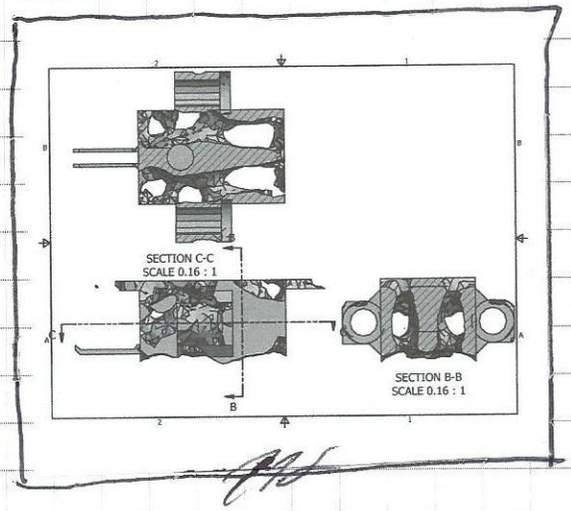
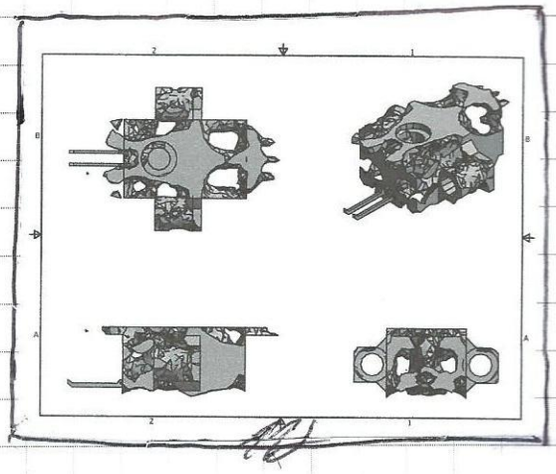
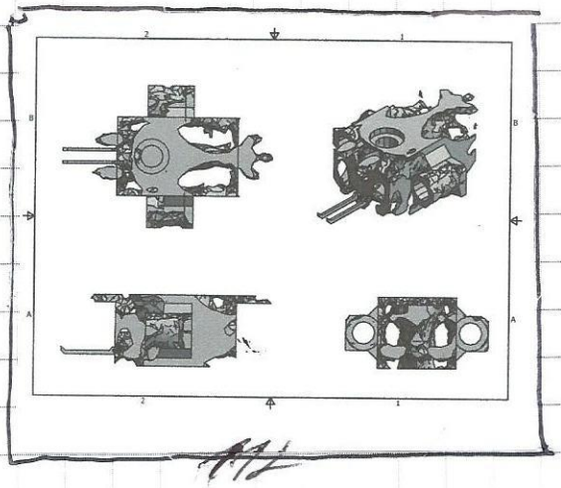
A FEW OF THE GENERATED DESIGNS ARE AS FOLLOWS







EACH DESIGN SOLVES THE SAME ISSUE UNDER THE SAME PERAMETER TO ALLOW FOR THE USER TO SELECT THE DESIGN THAT IS BEST SUITED.

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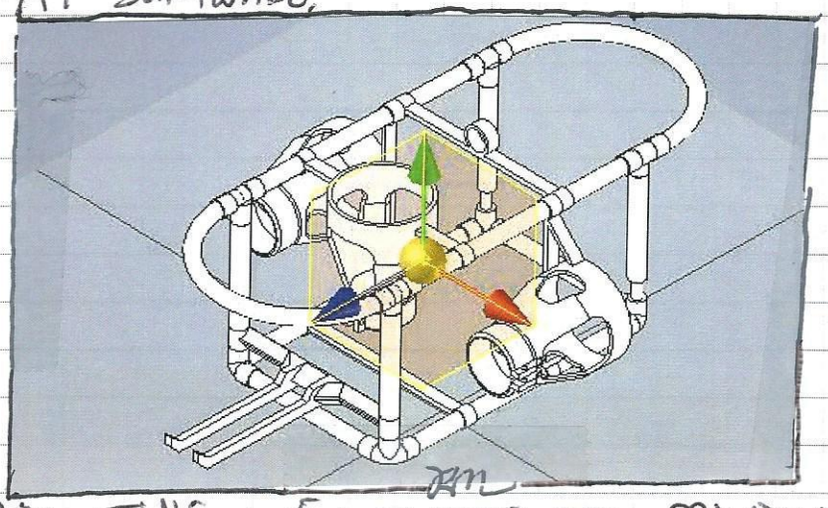
FOLLOWING, RYAN DEFINED THE BRACING TO MAKE IT INTO A MORE COMPREHENSIVE A SUITABLE DESIGN FOLLOWING THE GUIDELINES SET BY THE A1 SOFTWARE.



FROM THIS WE WENT ONTO PRINTING. TO ENSURE THE PLA to PETG FILAMENT COMPARISON WAS SUITABLE.

SET 10% INFILL

TIME IN WATER	PLA	PETG
TEST 1		
0 MIN	5.0 grams	5.6 g
1 MIN	5.8 g	6.4 g
5 MIN	6.4 g	6.1 g
TEST 2		
0 MIN	5.2 g	5.6 g
1 MIN	6.0 g	6.2 g
5 MIN	6.2 g	6.1 g

THIS TEST WAS CONDUCTED BY SUBMERGING THE 3D PRINTED PART FOR 5 TOTAL MINUTES TO SHOW INCREASED WEIGHT FROM WATER

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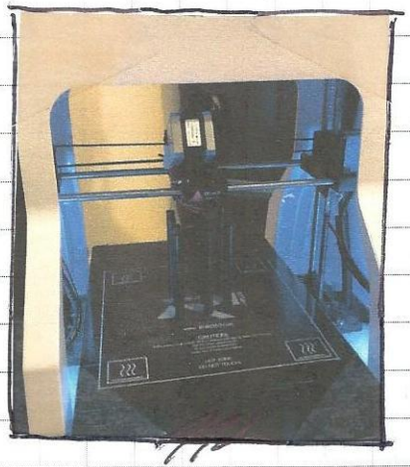
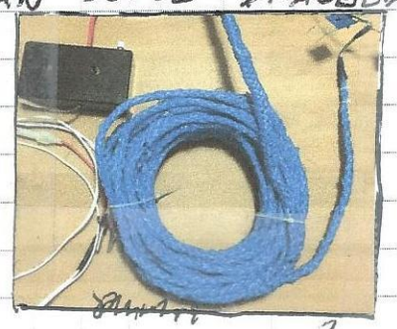
THE PETG, ALTHOUGH STARTED HEAVIER, HAD A MUCH MORE CONSISTENT WEIGHT, MAKING IT MORE SUITABLE TOWARDS BEING USED IN THE WATER DUE TO ITS HYDROPHOBIC QUALITIES.

WE FELT COMFORTABLE MOVING FORWARD AND FABRICATING THESE PARTS



WHILE THESE WERE PRINTING WE CREATED OUR CONTROL BOX AND TETHER.
WE DECIDED THIS YEAR TO CREATE A FLOATING TETHER. THAT HELPS TO REDUCE THE DEAD WEIGHT OUR ROV HAS TO TOW BEHIND IT, STREAMLINING ITS USE OF TORQUE DIRECTLY ONTO THE ROV
TO DO THIS, WE SPLIT THE WAX COATING ON THE TETHER WIRE AND STRIPPED IT COMPLETELY OFF.
THEN WE FED THE WIRE THROUGH A BUOYANT DOCKLINE
THE RESULT IS A TETHER THAT SITS ABOVE THE WATER RATHER THAN BEING DRAGGED BEHIND



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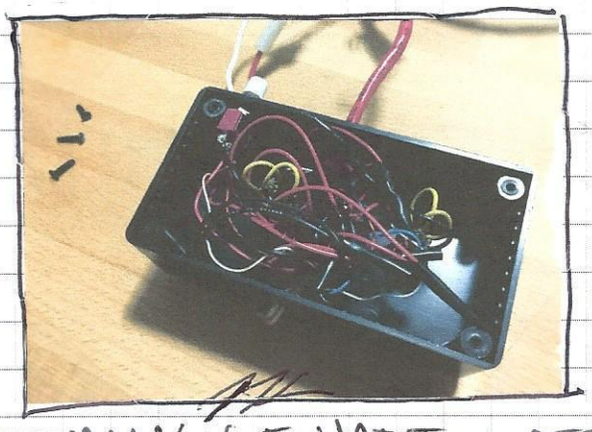
THE MARKINGS FOR OUR CONTROL BOX ARE COMPLETED BY SIMPLY GRABBING THE BOX NATURALLY SO THAT THE BOTTONS ARE IN A CONFORTABLE POSITION UNDERNEATH THE HAND



ADDITIONALLY WE HAD TO WATER PROOF OUR MOTORS. WE FOUND INCONSISTENT WEIGHT IN THE MOTORS LAST YEAR FROM THE WAX COATING METHOD OFTEN LEAVING AIR BUBBLES, NOT TO MENTION THAT THE WAX IS INCREDIBLY HEAVY TO BEGIN WITH. THAT IS WHY THIS YEAR WE DECIDED TO USE 1inch SHRINK WRAP TO COVER OUR MOTORS WE FIRST WRAPED THEM

THEN HEATED THEM TO SHRINK

WE TESTED THE MOTORS IN A BOWL FOR THEIR WATERPROOF CAPABILITIES AND THEY RAN PERFECTLY, THUS WE SEE THIS AS A SUITABLE REPLACEMENT

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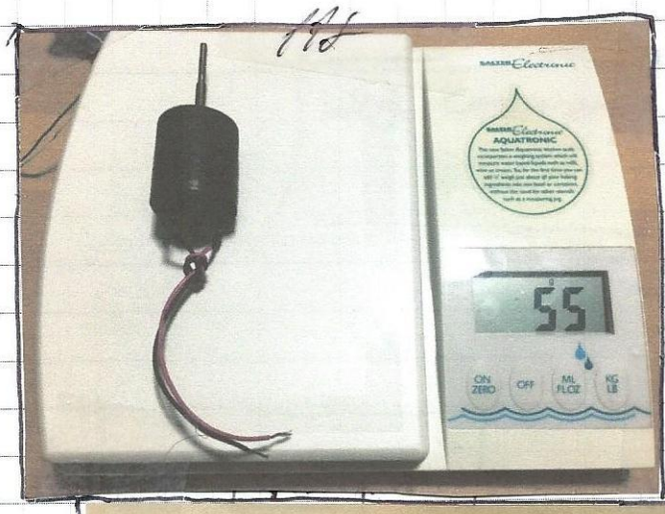
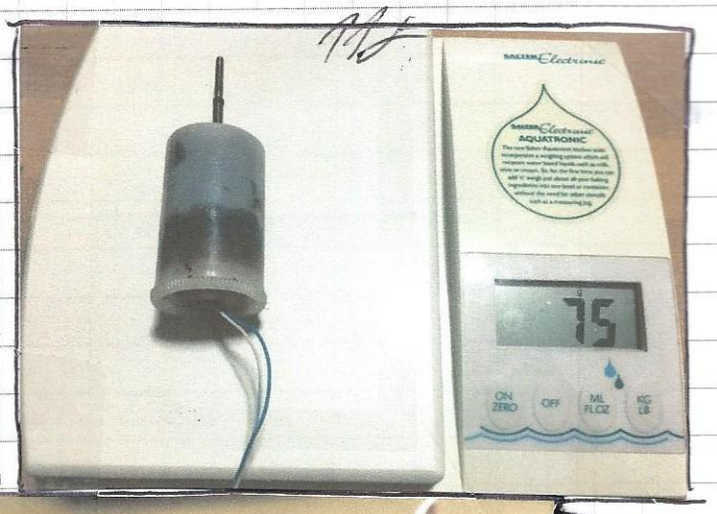
OUR NEW METHOD OF WATER PROOFING WILL DECREASE THE OVERALL WEIGHT OF OUR ROV BY 60 GRAMS





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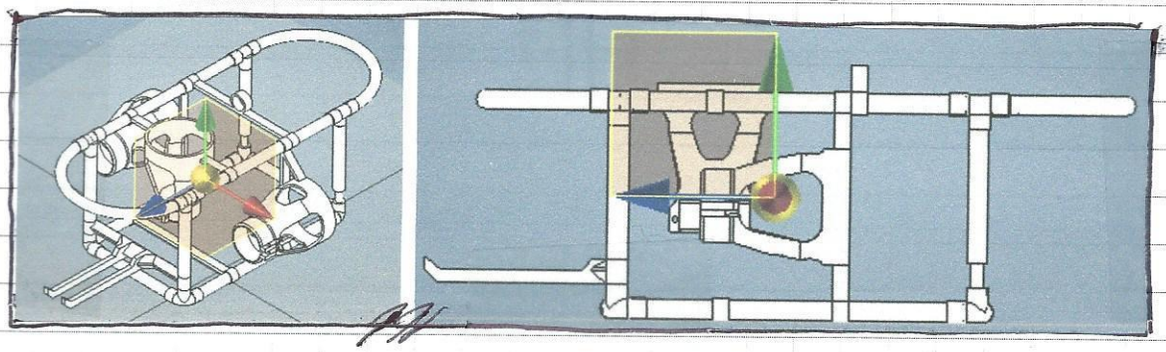
TEST SOLUTION

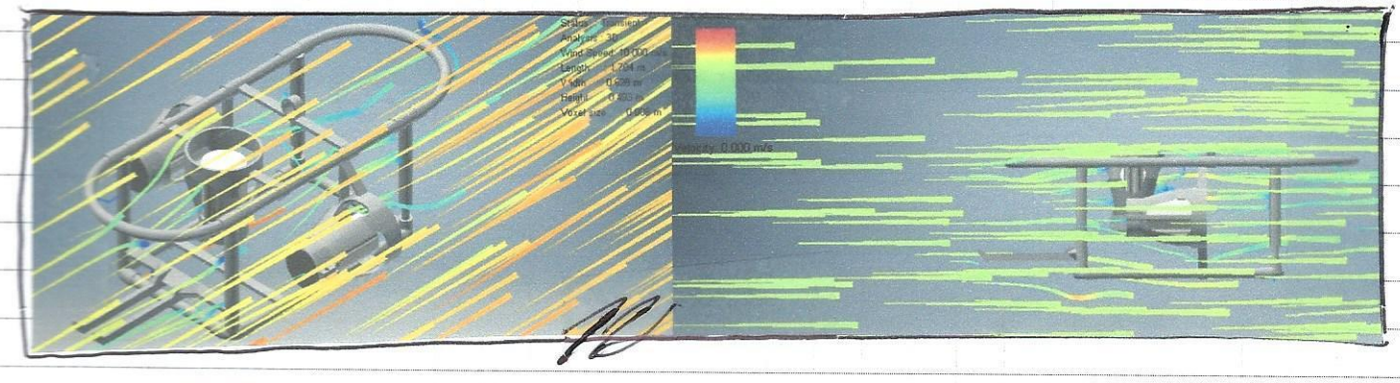
WE WENT BACK TO RUN SOME DESIGN MODEL TESTING WITH SOFTWARE TO FIND ANY FINAL FLAWS BEFORE WE FINISHED THE FABRICATION of PARTS AND ASSEMBLY

FIRST WE RAN A VERY SIMPLE CENTER of GRAVITY TEST WITH THE NEW WEIGHTS OF OUR MOTORS



THIS SHOWS THAT OUR CENTER OF GRAVITY (COG) IS QUITE CENTRAL ON THE ROV BUT SLIGTLY FORWARD THIS IS IDEAL SO THAT OUR COG SHIFT WILL NOT BE TOO GREAT WHEN ADDING THE WEIGHT OF THE CUBE

NEXT WE CHECKED THE FLOW OF OUR ROV BY RUNNING A HYDROFLUID TEST



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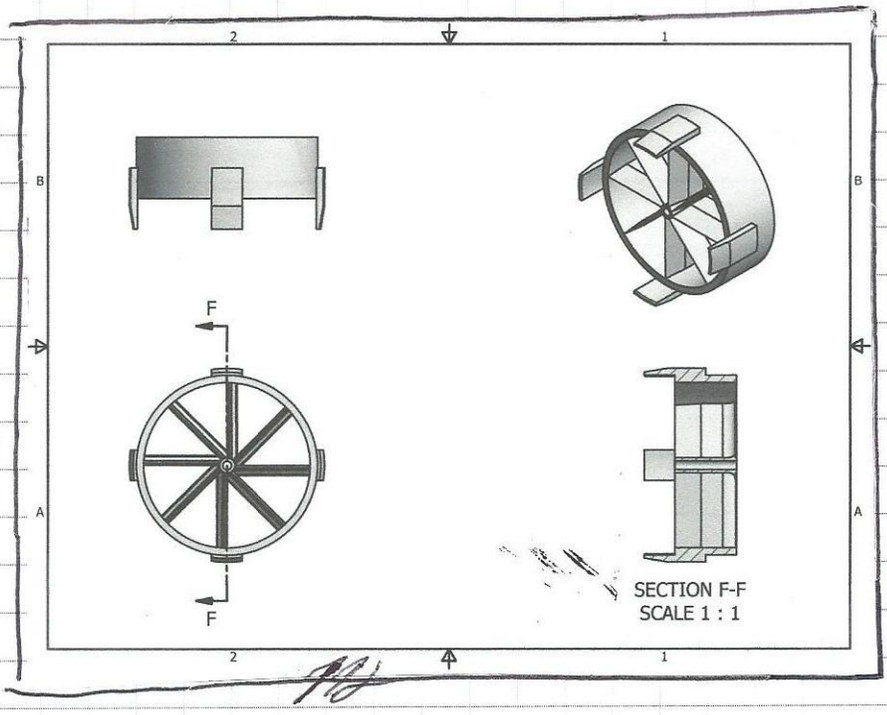
THIS IS USED TO ENSURE THERE IS PLENTY OF SPACE INSIDE OF THE ROV TO ALLOW THE FLUID TO PASS THROUGH, LOWERING OUR AMOUNT OF DRAG.

DUE TO OUR PIPING BEING SMALL AND HAVING A PRACTICALLY HALLOW ROV, DRAG WAS VERY MINIMAL. SMALL BITS OF EXPECTED DRAG FORMED AROUND THE MOTORS, BUT OUR SHELL DID NOT ADD TO THE DRAG.

WE DO KNOW FROM PRIOR EXPERIENCE THAT OFTEN THE AMOUNT OF TORQUE OUTPUT FROM THE MOTORS OVERWHELMS THE ROV'S BALANCE. TO COMPENSATE WE DESIGNED REMOVABLE STRATORS THAT HELP TO LIMIT THE TORQUE BIAS ON THE ROV BY FURTHER DIRECTING THE FLOW ONTOP OF WHAT THE SHROUD IS ALREADY DOING



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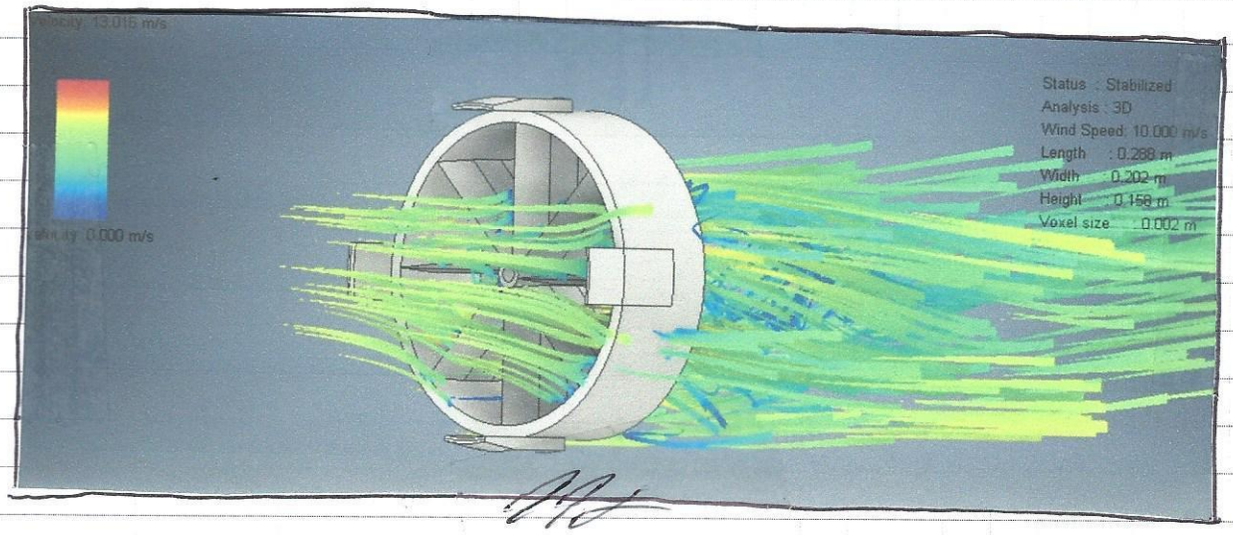
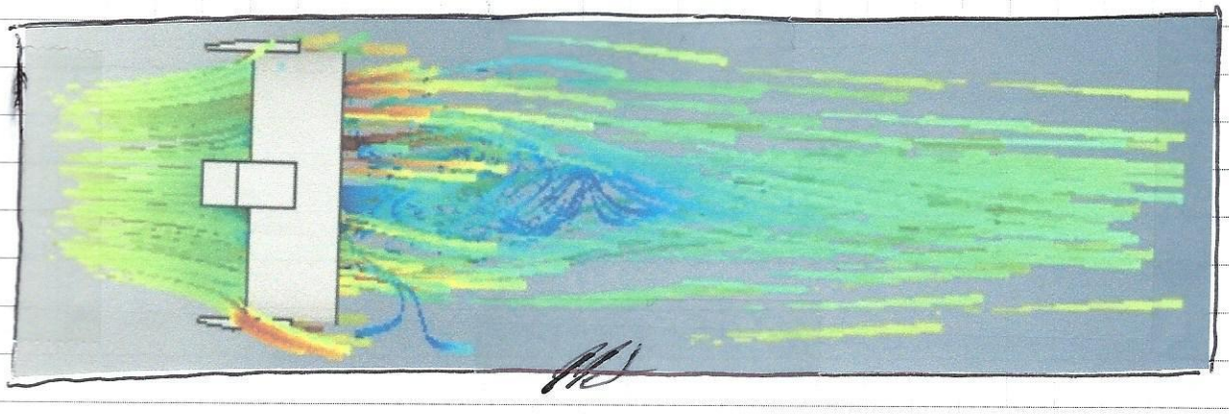
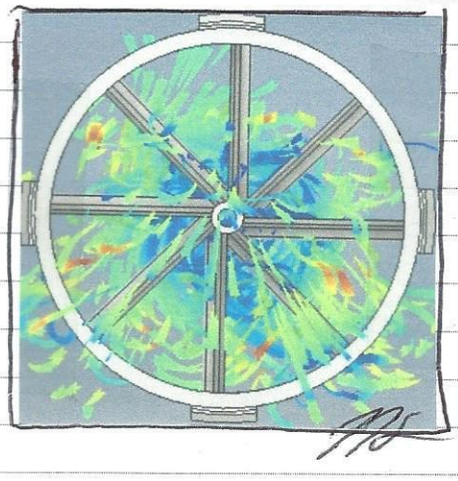
WE THEN RAN MORE HYDRODYNAMIC TESTING ON THEM TO SHOW THE CAPABILITY TO SIMPLIFY AND DIRECTION CHAOTIC FLOW FROM THE PROPELLERS







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PROTOTYPE & TEST AGAIN

WE PLACED FIRST AT OUR TEAM; SCHOOL PERLHOFF BUT DID NOT HAVE TIME TO USE OUR GENERATIVE DESIGN BOT

WE WILL NOW PRINT THAT OUT TO BE USED AT THE REGIONAL COMPETITION

PRINTING THE PARTS REQUIRES AT LEAST A BED SIZE OF 6" x 10" x 10" TO ENSURE THERE IS PLENTY OF ROOM

PRINTING THESE PARTS WITH PETG WILL YIELD THE BEST RESULTS WITH THE FOLLOWING SETTINGS

EXTRUDER TEMP: 280°F
BED TEMP: 75°F
PLACE SUPPORTS ON NEEDED AREAS
SUPPORT CONTROLS
AMOUNT: 20°
Z GAP: 3mm
PATTERN SPACING 3mm
NORMAL CONTROLS ELSEWHERE
INFILL: 0.07
SPEED: 100 mm/s For Infill
80 mm/s ~~INSIDE PERIMETERS~~ INSIDE PERIMETERS
70 mm/s ~~OUTSIDE PERIMETER~~ OUTSIDE PERIMETERS
30% for FIRST LAYER SPEED

TOTAL PRINT TIME APPROX: 16 HRS

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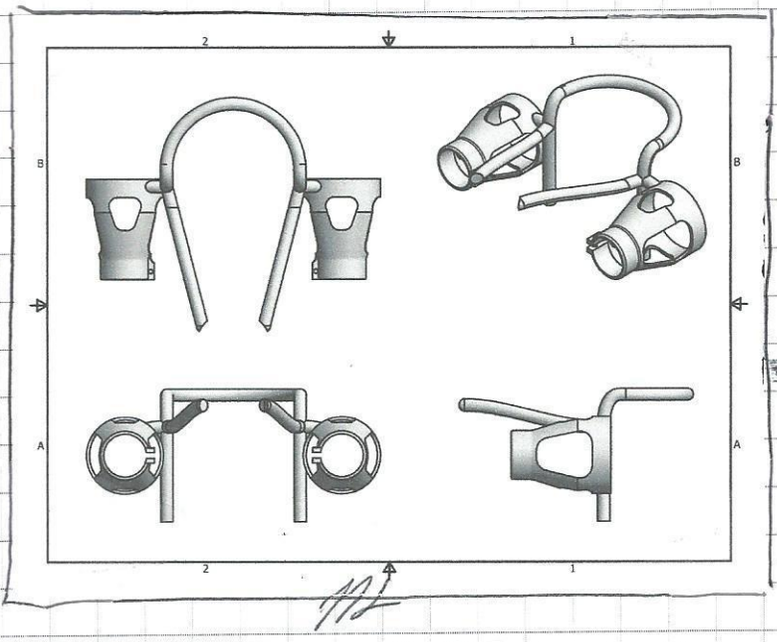
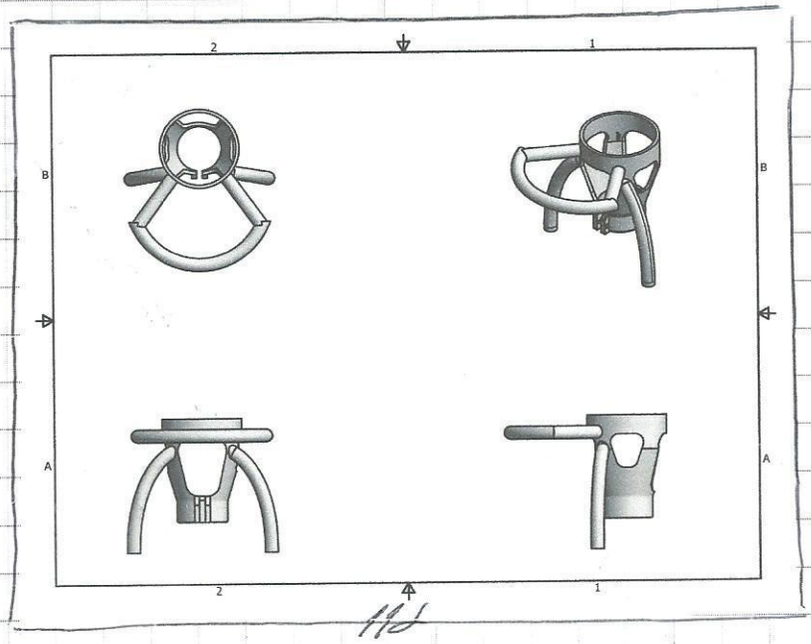


THIS PART IS THE BACK OF THE ROV THAT INCLUDES THE TWO FORWARD THRUSTERS. THE BOTTOM PRONGS HAVE HOLES TO INSERT INTO THE BOTTOM SECTION OF THE ROV



THIS PART IS THE FRONT OF THE ROV THAT INCLUDES THE VERTICAL THRUSTER. THE BOTTOM PRONGS HAVE HOLES TO INSERT INTO THE BOTTOM SECTION OF THE ROV. THE LONG CURVED PRONGS OF THE BACK PIECE ARE TO BE GLUED AND WELDED TO THE VERTICAL THRUSTER MOUNT

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PROPRIETARY INFORMATION

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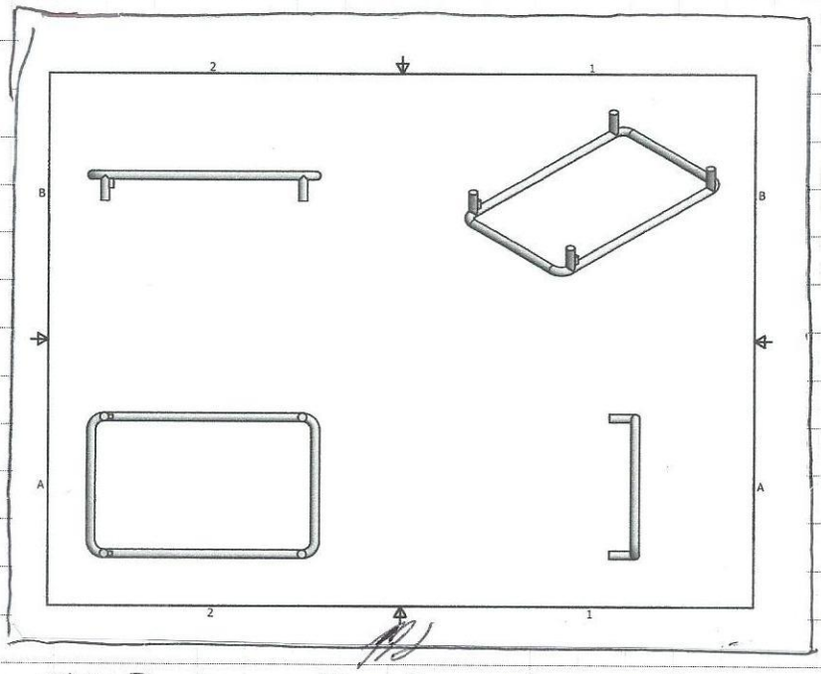
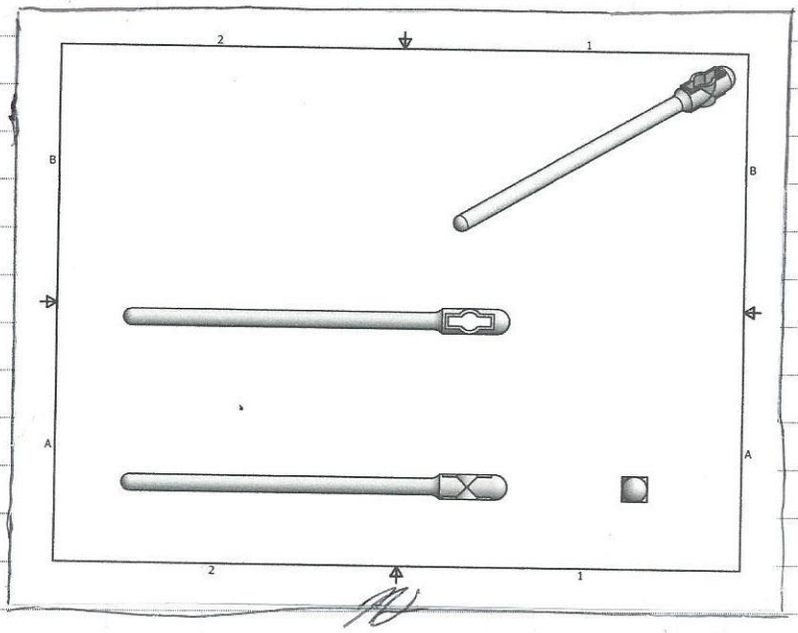


THE BOTTOM OF THE ROV ADDS THE STABILITY FOR THE WHOLE ROV AS WELL AS A STRONG POINT OF BRACING FOR THE TWO UPPER PIECES



THE HOOK HERE IS TO BE PRINTED TWICE. THE HOOKS HAVE NOTCHES TO LOCK INTO PLACE ON THE BASE. THEY CAN TURN INTO THE ROV TO BE OUT OF THE WAY FOR THE OBSTACLE COURSE

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FINAL ROV

THE TWO FRONT PRONGS (HOOKS) CAN BE USED FOR RECOVERY. THEY THEN TURN AROUND INTO THE ROV TO RUN ALONG THE BASE TO BE OUT OF THE WAY

THE HOOK ON THE UNDERSIDE IS USED FOR THE COMPETITION AND KEEPS THE WEIGHT UNDER THE CENTER OF BALANCE; CRUCIAL FOR THE HEAVY CUBES

FLOATATION CAN QUICKLY BE ADDED OR TAKEN AWAY DEPENDING ON THE CHALLENGE

Final Budget

3D Printed Parts (112G)	$5.60
40ft Floating Dock Line	$2.95
1" Heat Shrink Wrap	$3.49
Total	$12.04

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