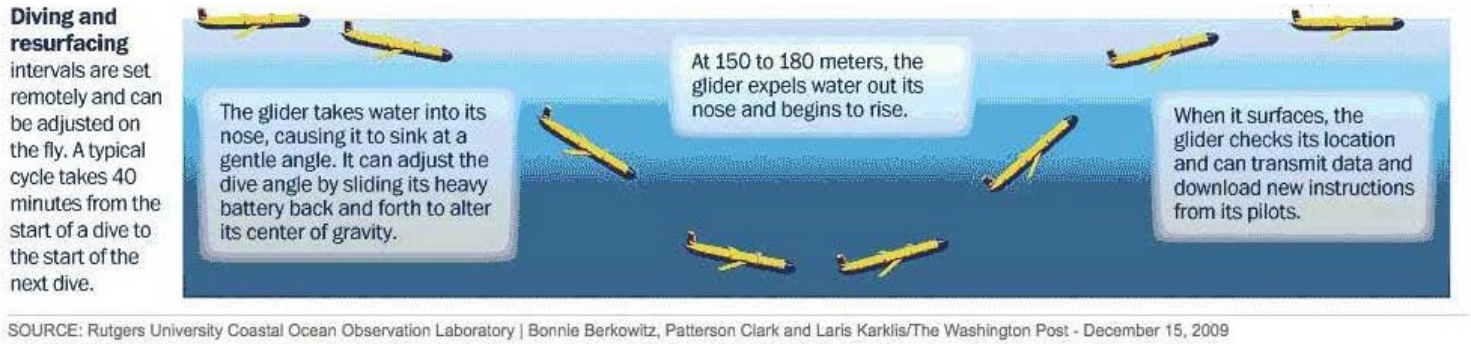
SeaGlide – Small-Scale Buoyancy Glider

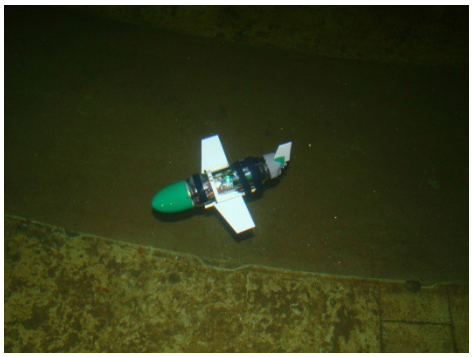
Introduction

An underwater buoyancy glider is an autonomous (non-tethered) robot that has no propeller and uses very little energy. It moves by changing its pitch and buoyancy, often by taking in or expelling water. This change in buoyancy causes the glider to rise and sink in the water. As the glider moves up and down and changes pitch, its wings generate lift, which propels the glider forward.



Buoyancy gliders can run for months at a time and cover great distances on very little power. Gliders carry sensors that can help scientists better understand and model the ocean. In 2009, Rutgers University's Scarlet Knight (RU 27) became the first AUV to cross the Atlantic Ocean. It made 11,000 dives and 11,000 ascents to the surface during its 221 day voyage that covered approximately 7,400 km.

Carderock's small-scale buoyancy glider, SeaGlide, operates on the same basic principles as the Scarlet Knight. It has a buoyancy engine, pitch control, wings, and a rudder as well as sensors. With lift provided by its wings, it glides forward both as it dives and as it rises. A pressure sensor collects data to determine depth and position over time. This information can be correlated with data from a temperature sensor.



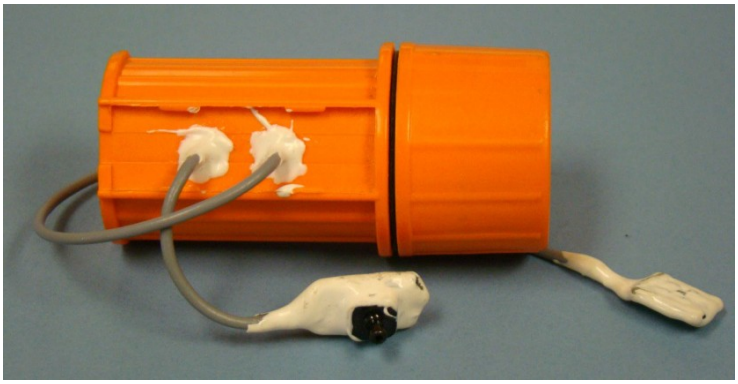
SeaGlide in a Dive

Arduino Pro Mini

SeaGlide kit builders first learn about basic electronics and then progress to circuit board soldering and programming with Arduino Pro Mini microcontrollers. They build servo driven buoyancy engines, each with a large 100cc syringe and a moveable mass, to manage buoyancy and pitch. A critical final step is to ballast gliders for proper underwater flight.

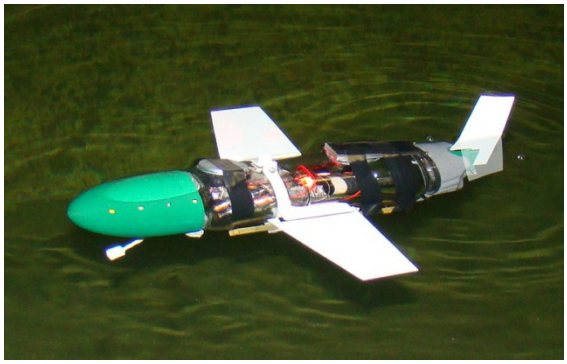
SeaGlide Sensor Pod

New developments in the SeaGlide project include a sensor pod, which measures temperature and pressure. Most electronics are housed in a waterproof case with waterproofed sensors exposed to the outside aquatic environment.

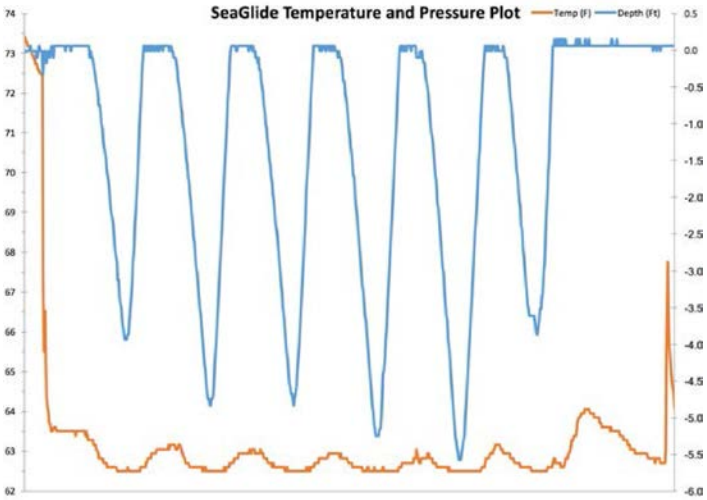


SeaGlide Sensor Pod for Temperature and Pressure

The sensor pod is housed within a plastic nosecone on the bow of the glider. The pressure sensor is outside the pod, but inside the free flooding nosecone. The nosecone shields the pressure sensor from dynamic pressure caused by the motion of the glider. The temperature sensor protrudes from the nosecone in order to measure temperature outside the boundary layer. This allows for more accurate measurement of the surrounding water



SeaGlide with Nosecone and Sensors



Depth &Temp over Time from 0-6ft. Depth (6 Yo Cycles)

Data is recorded on a microSD card inside the sensor pod. After a sampling run, the microSD card is retrieved and data is transferred to a computer for analysis.

SeaGlide Kit

The SeaGlide kit is packed with a contents sheet that corresponds to Build Instructions found at www.seaglide.net/build-instructions
Please read and follow guidelines of various manufacturer's safety sheets for specific items. These are also included in the kit.

Kit Contents

The kit contains six labeled bags that include tools, parts, and other materials. There are also two larger items that are loose in the box:

- A water bottle (The Glider Hull)
- A Sheet of Polystyrene plastic (wing & rudder material)

Parts List: Kit Contents, v1.0

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seaglide

Visit www.SeaGlide.net/resources for Build Instructions

Kit Contents, v1.0

Tools

Item #	Part Label	Qty
T1	Screwdriver, Reversible Blade, Flat/Phillips	1 ea
T2	Drill Bit, 3/32", Hex Drive	1 ea
T3	Synthetic Grease, 1oz	1 pkg
T4	Latex Glove, Powder Free, Medium	3 ea
T5	Push Pin	4 ea

Power Supply & Limit Switch

Item #	Part Label	Qty
PS1	Battery Charger, Wall Mount, 8.4V, 300mA, w/ 9V Battery Snap	1 ea
PS2	Ribbon cable, 24 Ga, 14 Strand	10 Inch
PS3	Power Switch, Push-Push, with 6" Leads	1 ea
PS4	9V Battery Snap Pigtail	1 ea
PS5	Pushbutton Limit Switch	1 ea
PS6	2-pin JST Pigtail	1 ea
PS7 / PS8	9V, Li-Ion Battery	2 ea
PS9	Heat-Shrink Tubing, 1/8" Diameter	6 Inch

Buoyancy Engine

Item #	Part Label	Qty
BE1	BBs Ballast	250 g
BE2	Syringe, 100cc	1 ea
BE3	Drive Bolt, 5/16"-18 x 2.5", Hex Head	1 ea
BE4	Drive Nut, 5/16-18	1 ea
BE5	3/8" Washer	1 ea
BE6	#2 x 3/8", Countersunk Wood Screw	14 pcs
BE7	#4 Washer	12 pcs
BE8	Servo-Motor	1 ea
BE9	3D Printed Glider Parts	1 set
BE10	#6x1/2", Thread Cutting Screw	18 pcs

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Circuit Board

Item #	Part Label	Qty
CB1	2-pin JST Power Jack, PCB Mount	1 ea
CB2	Trim Potentiometer	1 ea
CB3	4.7Ohm, Resistor	1 ea
CB4	SeaGlide v1.0 PCB	1 ea
CB5	Right Angle Male Pin Header	24 pins

Arduino Pro Mini

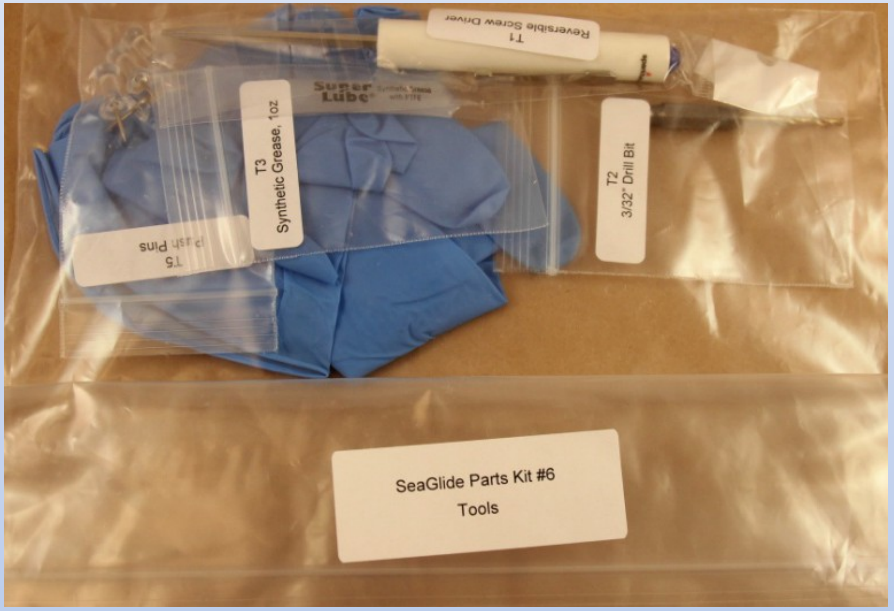
Item #	Part Label	Qty
MC1	IR Receiver	1 ea
MC2	IR Remote	1 ea
MC3	RGB LED	1 ea
MC4	FTDI USB to Serial Converter	1 ea
MC5	Arduino Pro Mini	1 ea
MC6	6-pin, Female Right Angle Header	2 pcs
MC7	Machine Pin Socket Header	8 pcs

Bottle Prep & Ballast

Item #	Part Label	Qty
BB1	Glider Hull (Water Bottle)	1 ea
BB2	Dura-Lock Industrial Velcro	8.25 in
BB3	Round Ballast Magnets	8 ea
BB4	Marine Epoxy 04003, 2-Part	1 pkg
BB5	Polystyrene Sheet, 10" x 10" x 1/16"	1 pcs
BB6	Clear Tygon Tubing, 1.25 in	2 pcs
BB7	Painted Steel Bar Ballast, (2 x 6" Long, 1 x 2.75" Long)	1 set
BB8	Large Zip Ties	8 pcs
BB9	Small Zip Ties	4 pcs

AXIOM manufacturing

Tools



Tools		
Item #	**Part Label**	**Qty**
T1	Screwdriver, Reversible Blade, Flat/Phillips	1 ea
T2	Drill Bit, 3/32", Hex Drive	1 ea
T3	Synthetic Grease, 1oz	1 pkg
T4	Latex Glove, Powder Free, Medium	3 ea
T5	Push Pin	4 ea

You'll need the tools for the Buoyancy Engine build, Bottle Prep, & Ballast prep.

Note - The metal shaft of the screwdriver (shank) can be removed from the handle and reversed to switch from Phillips to flathead.

Other Tools/Materials Needed

- Soldering iron
- Solder
- Tip activator
- Tip cleaner (brass sponge)
- Electrical tape
- Wire strippers
- Needle nose pliers
- Flush cutters
- Small vise or helping/3rd hand
- Heat gun
- Heavy duty scissors (medical trauma scissors work well)
- Sharpie
- Hot glue & hot glue gun
- Box top to contain small ballast
- Paper plates
- Paper cups
- Graph paper
- Ruler
- Utility knife (optional)
- ½" transparent tape
- Safety glasses (required)
- Digital Multi Meter
- ~10" cardboard square (Used as soldering work surface)

Power Supply & Limit Switch

Power Supply & Limit Switch		
Item #	**Part Label**	**Qty**
PS1	Battery Charger, Wall Mount, 8.4V, 300mA, w/ 9V Battery Snap	1 ea
PS2	Ribbon cable, 24 Ga, 14 Strand	10 Inch
PS3	Power Switch, Push-Push, with 6" Leads	1 ea
PS4	9V Battery Snap Pigtail	1 ea
PS5	Pushbutton Limit Switch	1 ea
PS6	2-pin JST Pigtail	1 ea
PS7 / PS8	9V, Li-Ion Battery	2 ea
PS9	Heat-Shrink Tubing, 1/8" Diameter	6 Inch

Parts needed to solder together the Power Supply circuit and Limit Switch.

Buoyancy Engine

Buoyancy Engine		
Item #	**Part Label**	**Qty**
BE1	BBs Ballast	250 g
BE2	Syringe, 100cc	1 ea
BE3	Drive Bolt, 5/16”-18 x 2.5”, Hex Head	1 ea
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BE5	3/8" Washer	1 ea
BE6	#2 x 3/8", Countersunk Wood Screw	14 pcs
BE7	#4 Washer	12 pcs
BE8	Servo-Motor	1 ea
BE9	3D Printed Glider Parts	1 set
BE10	#6x1/2", Thread Cutting Screw	18 pcs

Leftover 3D printed parts (wing yoke & rudder mount) and #6x1/2” screws will be used later in the Bottle Prep & Ballast instructions.

Circuit Board

Circuit Board		
Item #	**Part Label**	**Qty**
CB1	2-pin JST Power Jack, PCB Mount	1 ea
CB2	Trim Potentiometer	1 ea
CB3	4.7Ohm, Resistor	1 ea
CB4	SeaGlide v1.0 PCB	1 ea
CB5	Right Angle Male Pin Header	24 pins

There are extra pins on the Right Angle Male Pin Header that will used in the Arduino Pro Mini build.

Arduino Pro Mini

Arduino Pro Mini		
Item #	**Part Label**	**Qty**
MC1	IR Receiver	1 ea
MC2	IR Remote	1 ea
MC3	RGB LED	1 ea
MC4	FTDI USB to Serial Converter	1 ea
MC5	Arduino Pro Mini	1 ea
MC6	6-pin, Female Right Angle Header	2 pcs
MC7	Machine Pin Socket Header	8 pcs

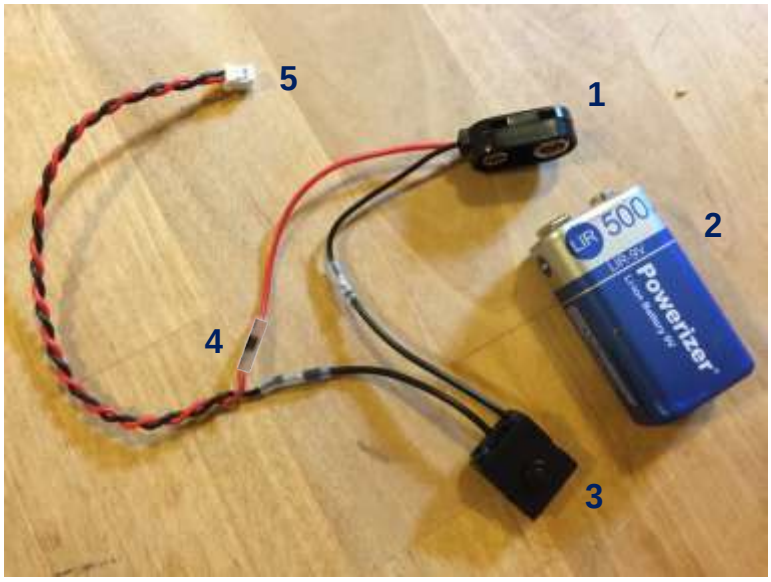
Extra pins on the Right Angle Male Pin Header from the Circuit Board build will also be needed for this soldering project.

Bottle Prep & Ballast

Bottle Prep & Ballast		
Item #	**Part Label**	**Qty**
BB1	Glider Hull (Water Bottle)	1 ea
BB2	Dura-Lock Industrial Velcro	8.25 in
BB3	Round Ballast Magnets	8 ea
BB4	Marine Epoxy 04003, 2-Part	1 pkg
BB5	Polystyrene Sheet, 10" x 10" x 1/16”	1 pcs
BB6	Clear Tyron Tubing, 1.25 in	2 pcs
BB7	Painted Steel Bar Ballast, (2 x 6" Long, 1 x 2.75" Long)	1 set
BB8	Large Zip Ties	8 pcs
BB9	Small Zip Ties	4 pcs

The Glider Hull (water bottle) and Polystyrene Sheet will be found separate in the box. Leftover 3D parts and #6 screws from the Buoyancy Engine build will also be needed.

1. Power Supply and Limit Switch



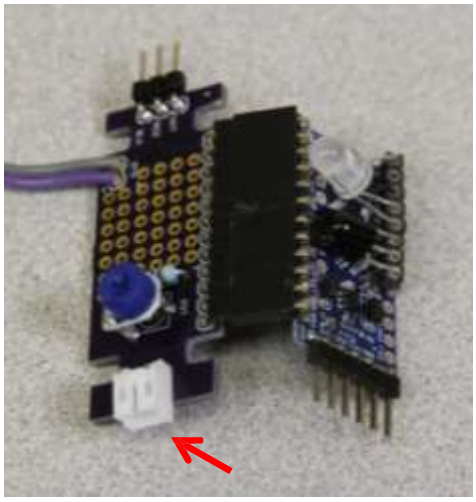
The power supply provides 8.4 volts of direct current to the buoyancy engine controller where the voltage is reduced to approximately 7 volts by a resistor. The power supply includes a snap connector, 9 volt rechargeable Lithium battery, pushbutton power switch, and an inline protection diode.

The power supply also includes a plug that connects to the buoyancy engine controller by sliding into the power supply jack on controller's circuit board.

The main components of the power supply are:

1. BATTERY SNAP CONNECTOR – Connects battery to power supply circuit.
2. LITHIUM BATTERY – Provides 8.4 volts of rechargeable power.
3. PUSHBUTTON POWER SWITCH – The ON/OFF control for the circuit.
4. PROTECTION DIODE – Allows current to flow in one direction in the circuit, but not the other.
5. POWER SUPPLY PLUG – Provides power to the buoyancy engine controller by plugging into the power supply jack.

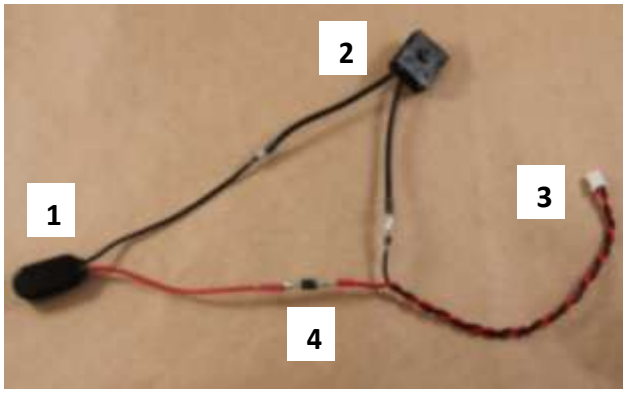
Buoyancy Engine Controller



Power Supply Jack

To solder together the power supply circuit, please see the instructions below.

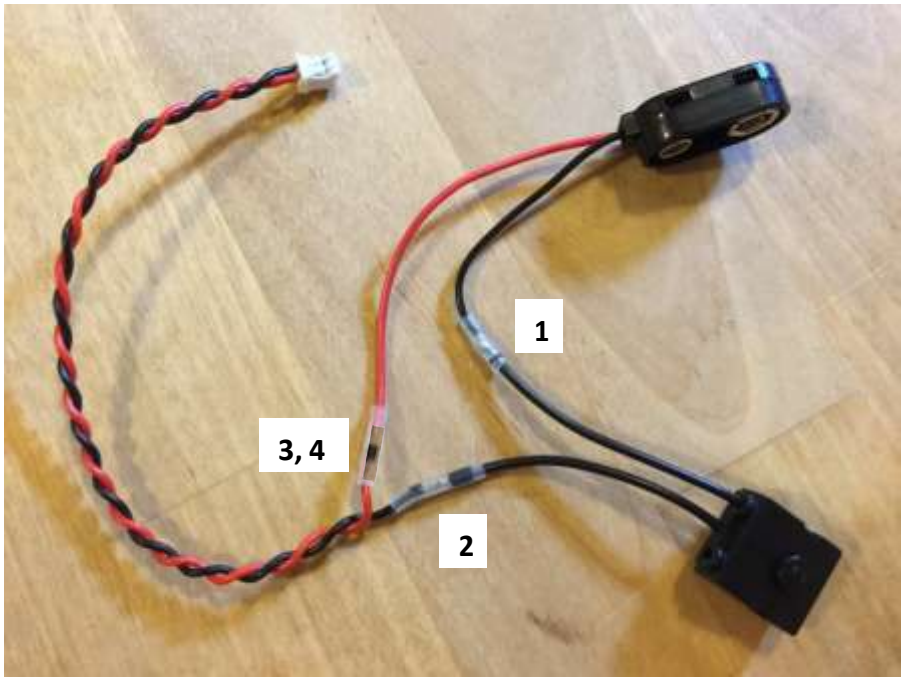
Power Supply Build with Diode & Pushbutton Limit Switch



1. The power supply circuit includes a 9 volt snap connector (1), pushbutton power switch (2), JST pigtail (power supply plug) (3), and diode (4).

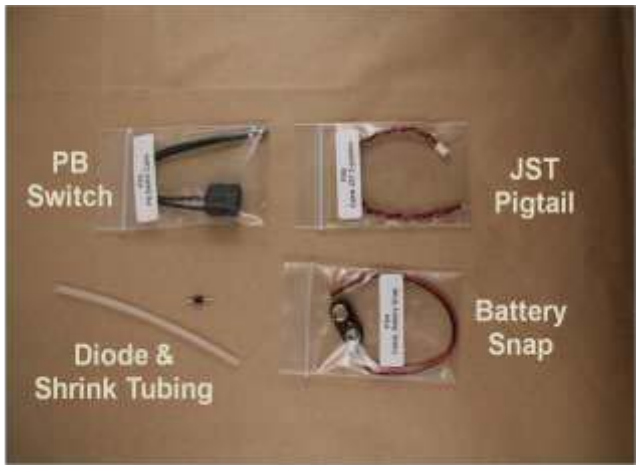
Safety Glasses/Goggles Required

Power Supply Circuit

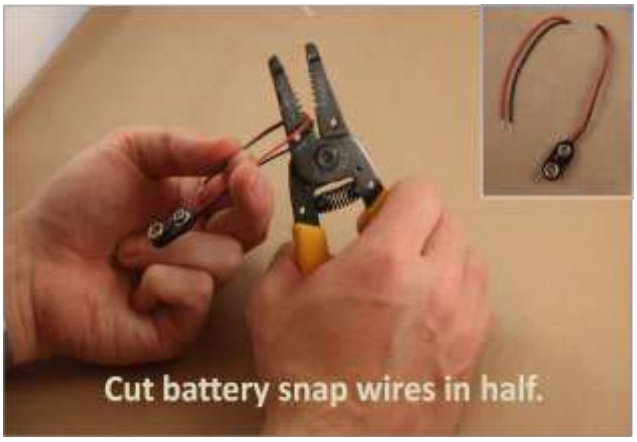


There are four solder joints that need to be insulated with shrink tubing:

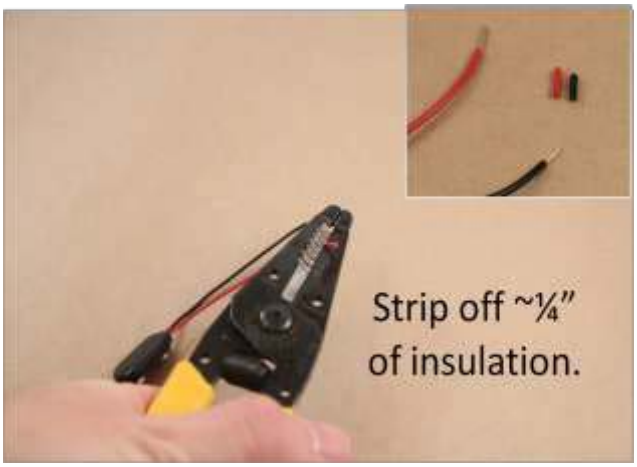
1. **Black** wire of 9V snap connector to **black** wire of pushbutton.
2. **Black** wire of pushbutton to **black** wire of JST pigtail.
3. **Red** wire of JST pigtail to inline diode and (4) inline diode to **red** wire of snap connector.



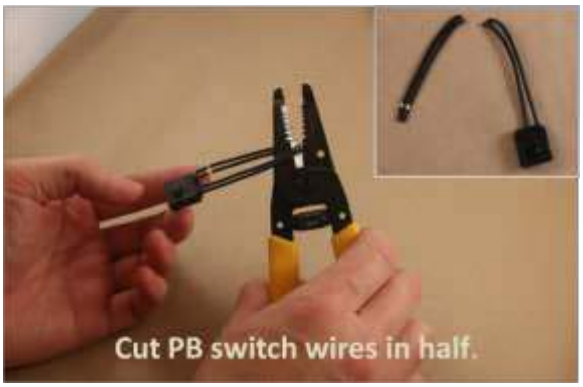
2. Gather these parts from the Power Supply & Limit Switch bag in the SeaGlide kit.



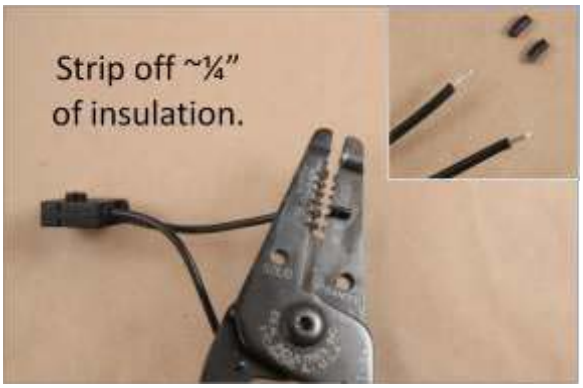
3. Prepare 9V battery snap connector for soldering by cutting wires in half.



4. Strip approximately ¼" of plastic insulation from the battery snap wires to expose metal strands.

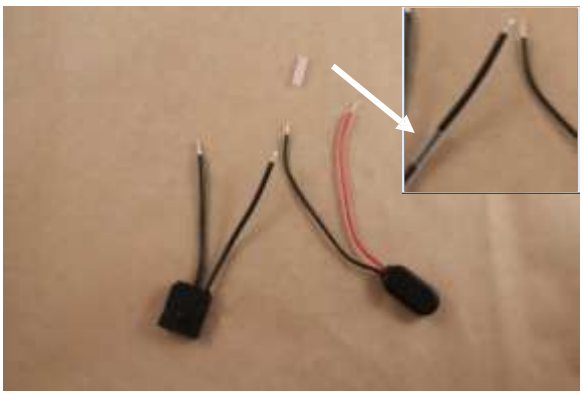


5. Cut pushbutton switch (PB switch) wires in half.

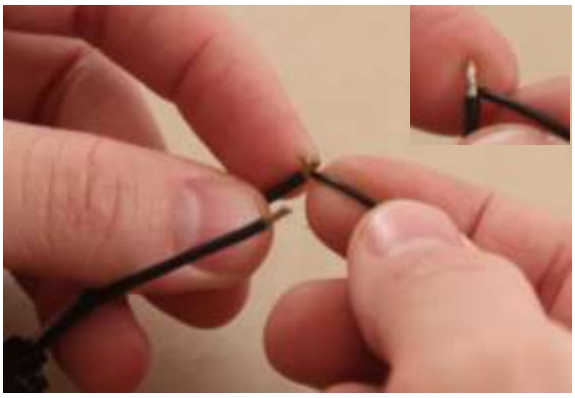


6. Strip approximately ¼" of plastic insulation from PB switch wires to expose metal strands.

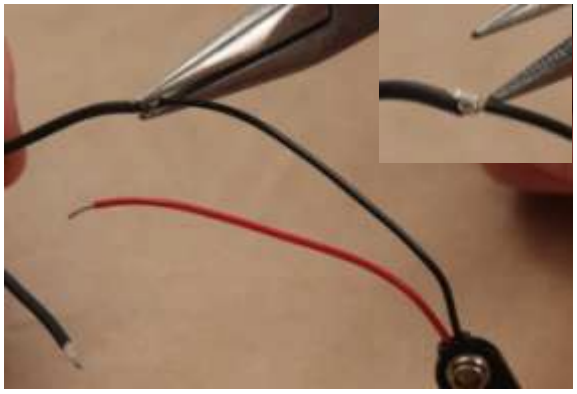
7. Cut off a ⅜" to ½" piece of heat-shrink tubing. The tubing will be used to reinforce the solder joint between two black wires of the PB switch and battery snap as well as help prevent an electrical short circuit.



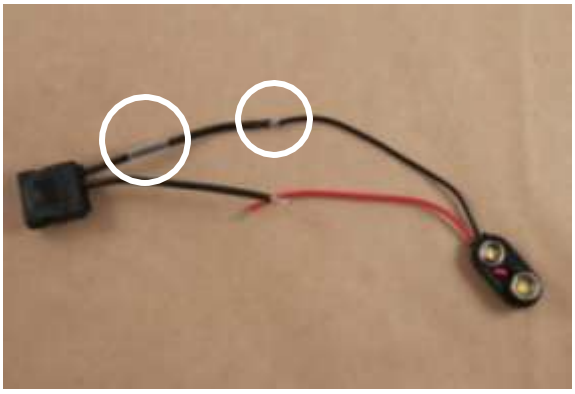
8. Prepare to solder the black wire of the battery snap to one of the black wires on the PB switch (either one will work). Slide the shrink tubing onto one of the wires that will be joined.



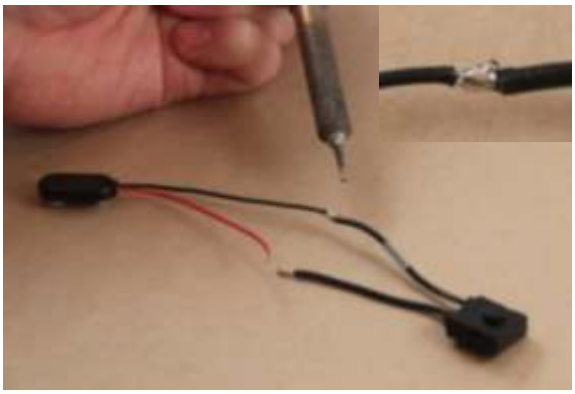
9. After ensuring that the shrink tubing is in place, twist the metal strands of the wires together.



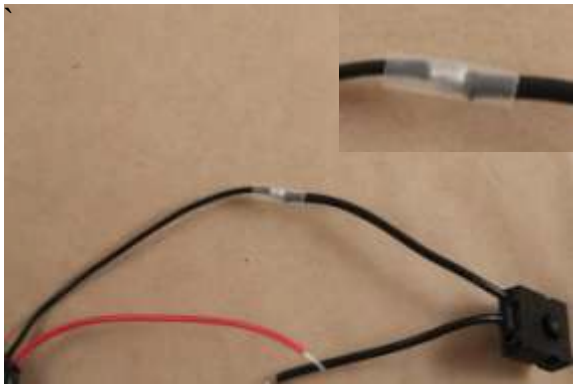
10. Compress the twisted wires flat with needle nose pliers.



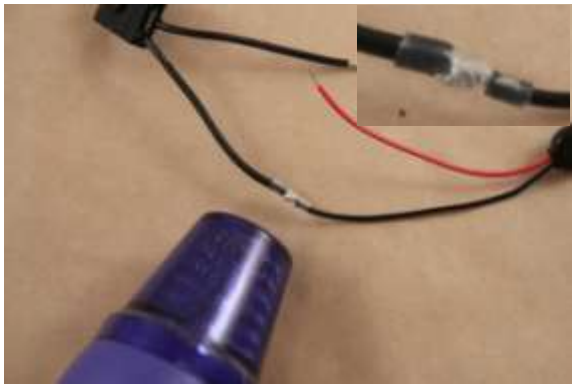
Ready for Soldering: Two Black Wires Twisted together with Shrink Tubing Inline



11. Solder wires together.

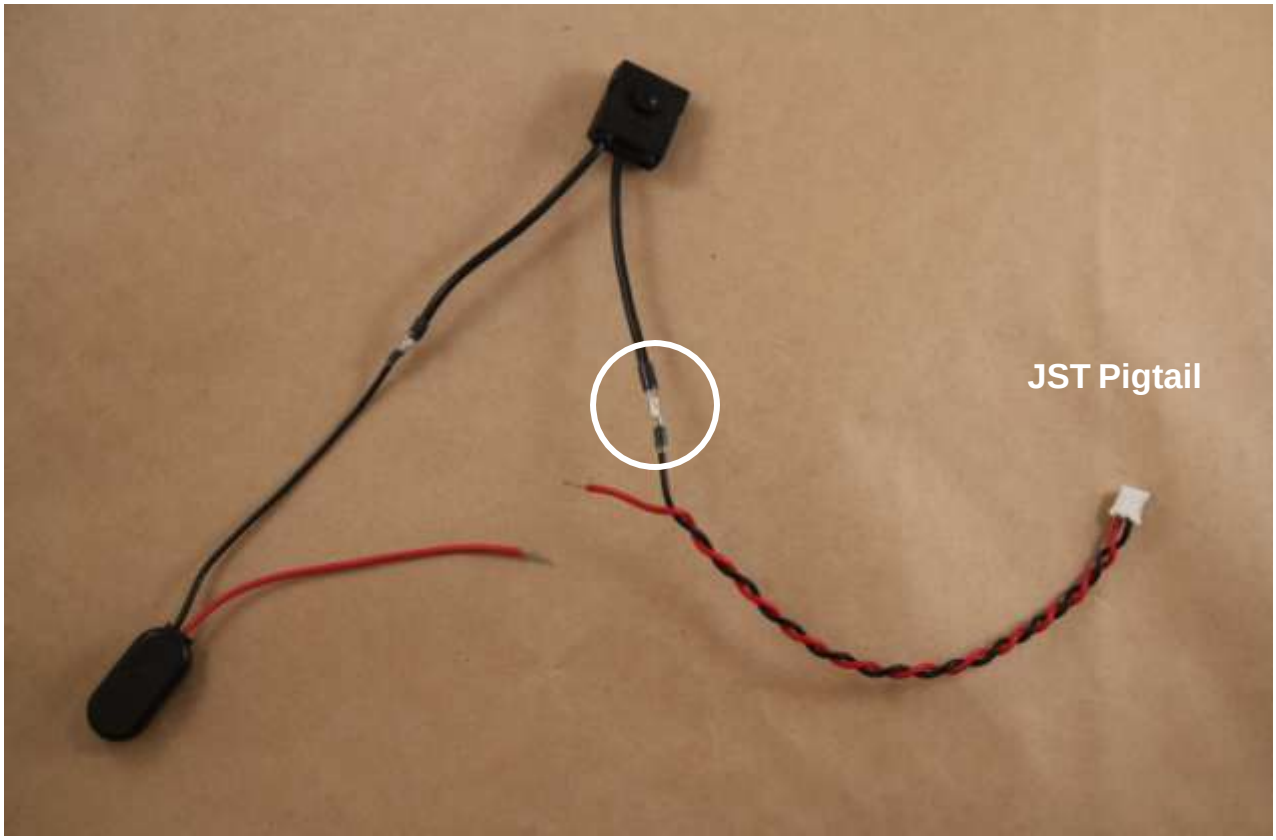


12. Slide the shrink tubing over the solder joint.

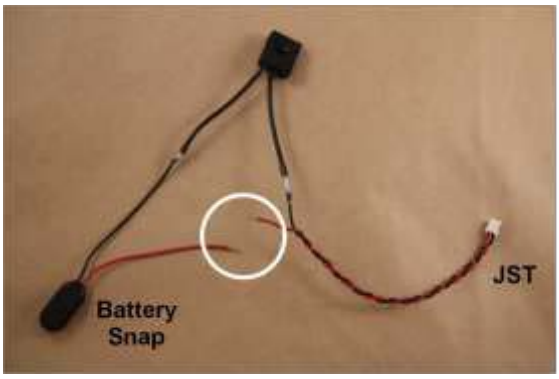


13. Use a heat gun to shrink the tubing around the solder joint. (Follow manufacturer's safety instructions.)

14. Repeat the process above and join the remaining black PB switch wire with the black wire on the JST pigtail. Don't forget the **shrink tubing**.

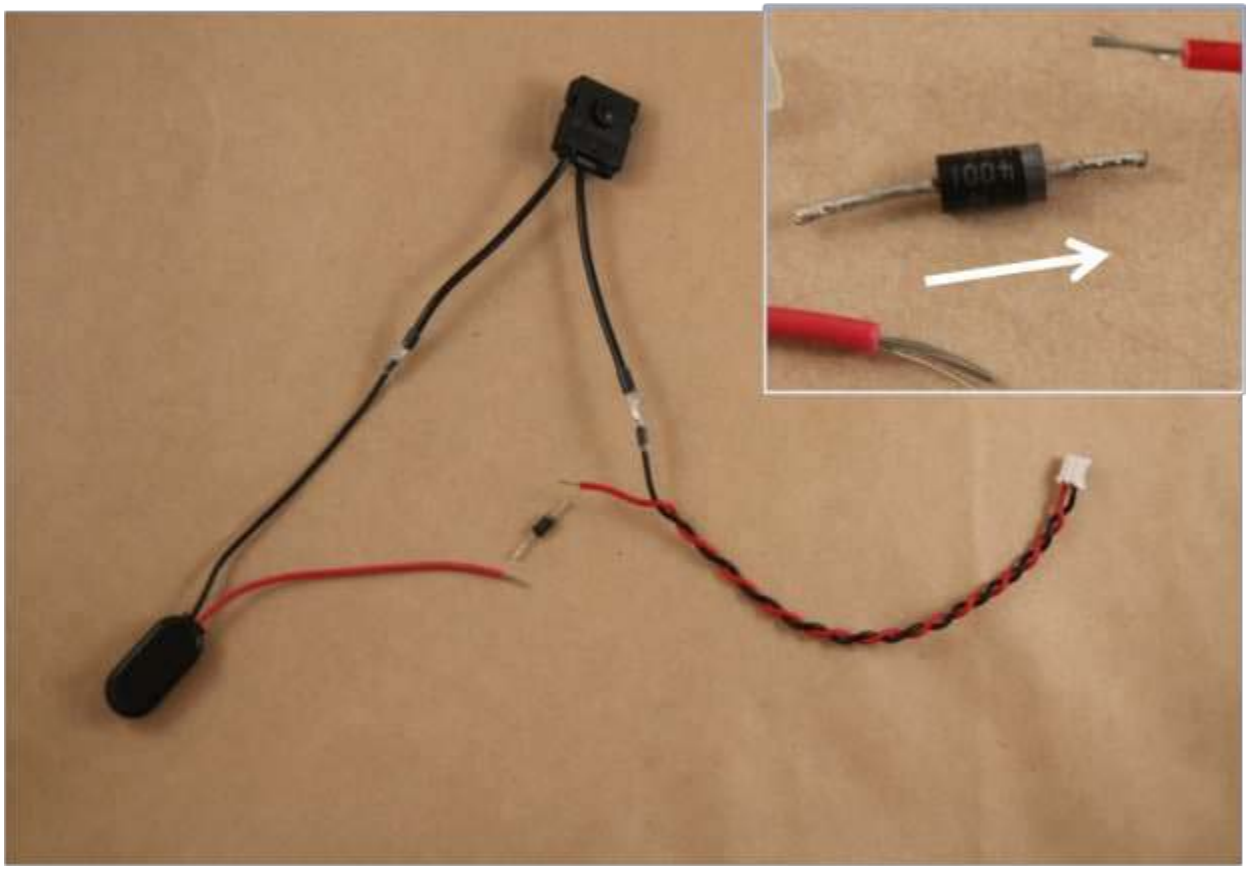


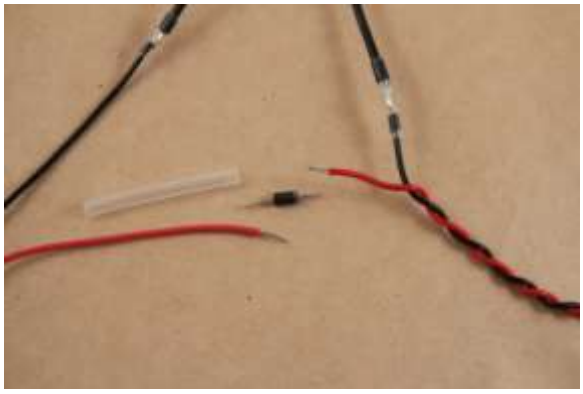
Add Diode to Power Supply Circuit



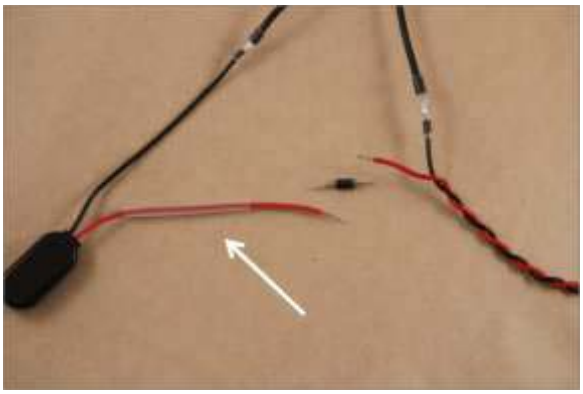
15. The protective diode goes between the battery snap and the JST pigtail to ensure that electrical current can only flow in the correct direct.

16. The grey band on the diode **must be** positioned towards the JST pigtail.

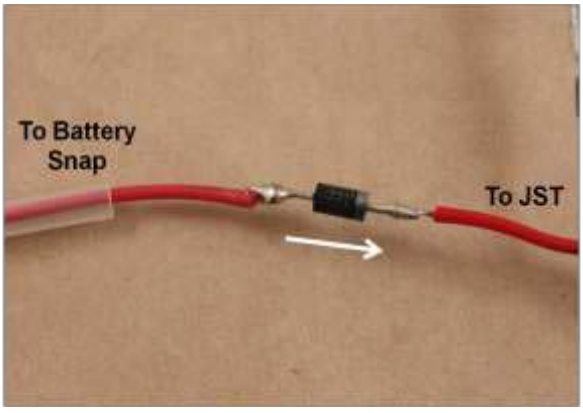




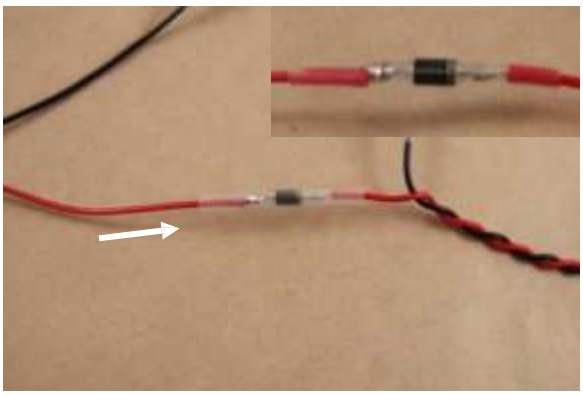
17. Use heat-shrink tubing.



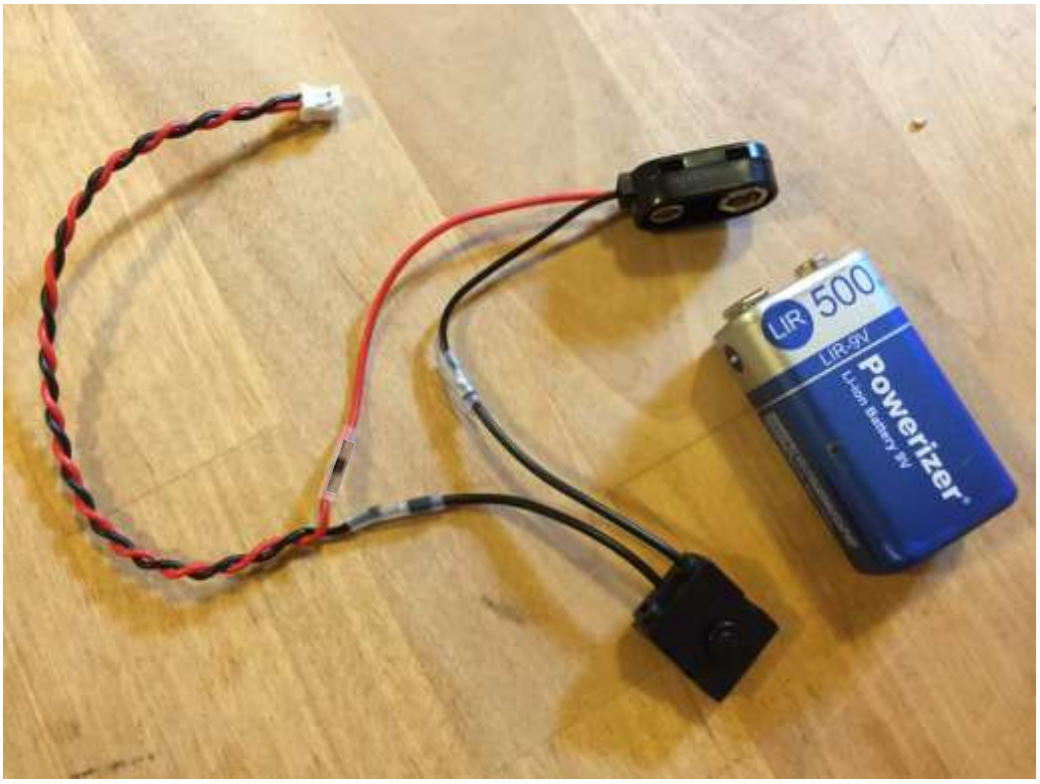
18. Position the tubing on the longer red battery snap wire prior to soldering.



19. Use electrical tape or a vise to hold wires in place then solder the diode in position with the grey band facing the JST connector.



20. Slide heat-shrink tubing over the solder joints and diode. Use a heat gun to shrink the tubing.



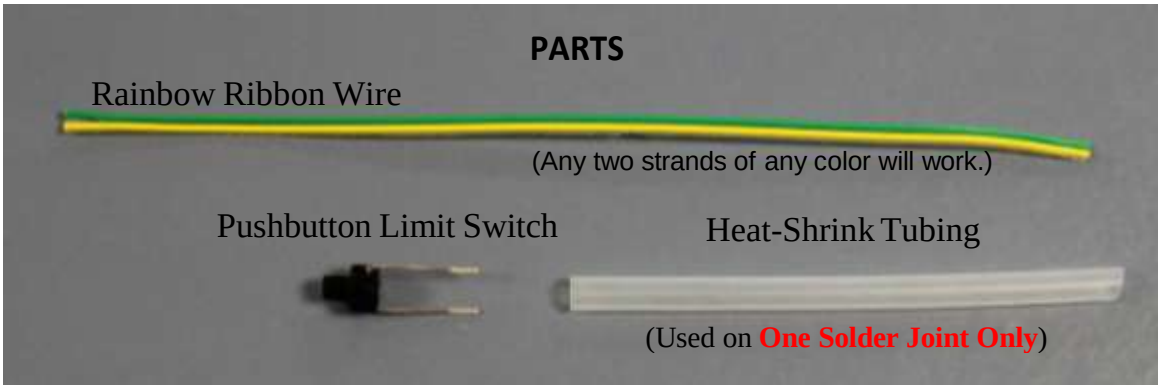
Power Supply Circuit with 9 Volt Lithium Rechargeable Battery

Looks good! More fun ahead!

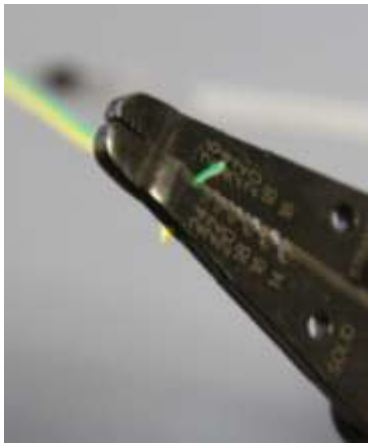
You can charge you battery with the Smart Charger included in your SeaGlide Kit. Read and follow the Operating and Safety Instructions provided with the charger. (Be sure to only use an appropriate lithium-ion battery smart charger.)

When charged, set the battery aside for later use testing the Buoyancy Engine.

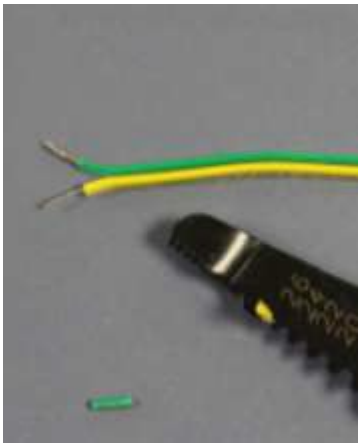
While your soldering iron is hot, you may as well prepare the Pushbutton Limit Switch. This will be needed in the next set of build instructions – #2 Buoyancy Engine.



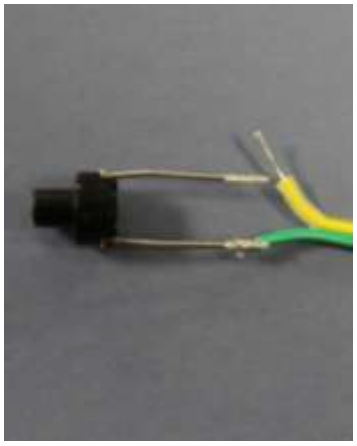
Strip Wires



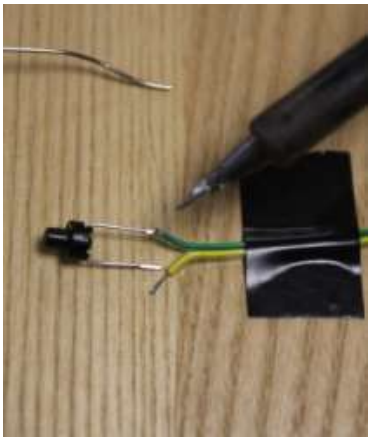
Remove ~¼" of Insulation



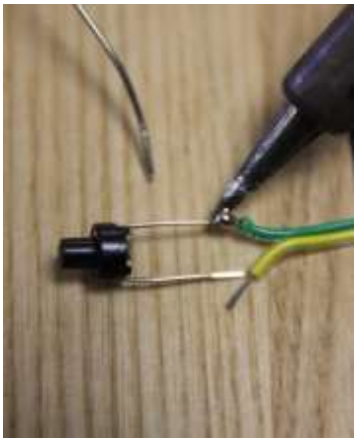
Wrap one Wire around a Pin



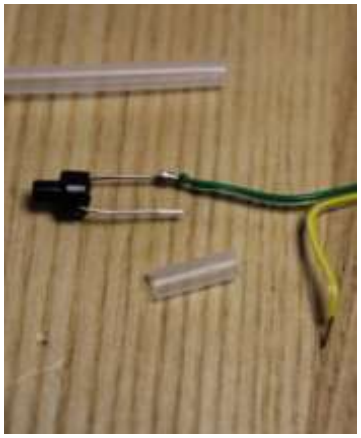
Secure Wire



Solder

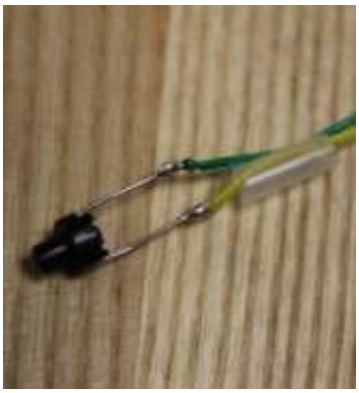


Use Shrink Tubing
Only on One Wire



Wrap Wire around Pin

Solder



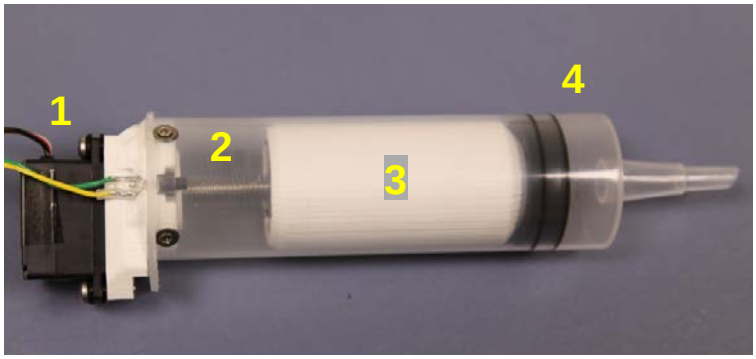
Position Tubing and Shrink

Save the Wired Pushbutton Switch for the Buoyancy Engine Build

The pushbutton switch will act as a “Limit Switch”* in the buoyancy engine to prevent the travel of the cylinder plunger from crashing into the servo. It provides a reliable position at which the cylinder plunger will change direction… You’ll see.

*Prevents the travel of an object in mechanism past a predetermined point.

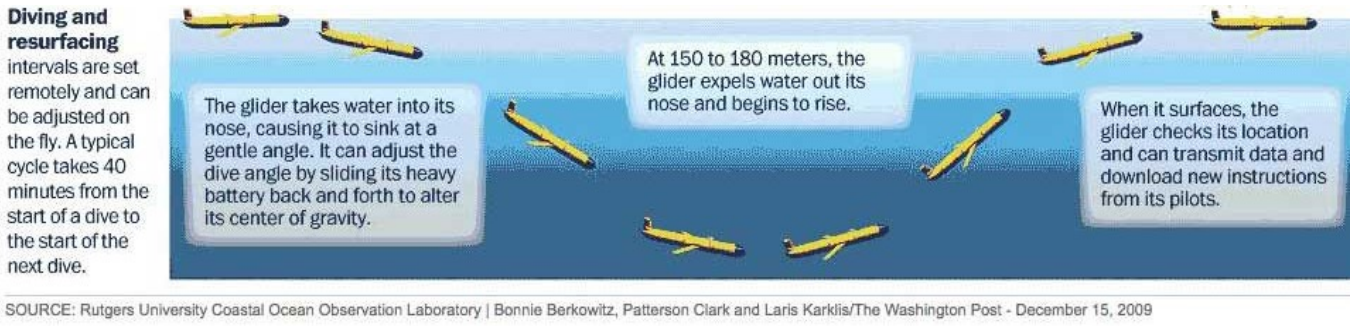
2. Buoyancy Engine



The buoyancy engine is a major component inside the glider. It changes buoyancy and pitch. As the buoyancy engine's large syringe takes in water, the glider becomes heavier and sinks. When it expels water, the glider becomes lighter and rises.

Pitch changes when the weight-filled plunger moves backwards and forwards. This tilts the angle of the glider either downward or upward.

The change in both buoyancy and pitch enable the wings on the glider to generate lift and thus forward motion as the glider dives or rises in water. (See illustration below for a typical dive cycle of a commercial underwater glider.)



The main components of the buoyancy engine are:

1. SERVO MOTOR – Drives the lead screw backwards and forwards.
2. LEAD SCREW – Provides mechanical advantage to push and pull the plunger.
3. CYLINDER PLUNGER – Contains ballast for pitch control.
4. 100ml SYRINGE – Provides the casing for the buoyancy engine.

To assemble the buoyancy engine follow the build instructions below.

Build an Underwater Glider

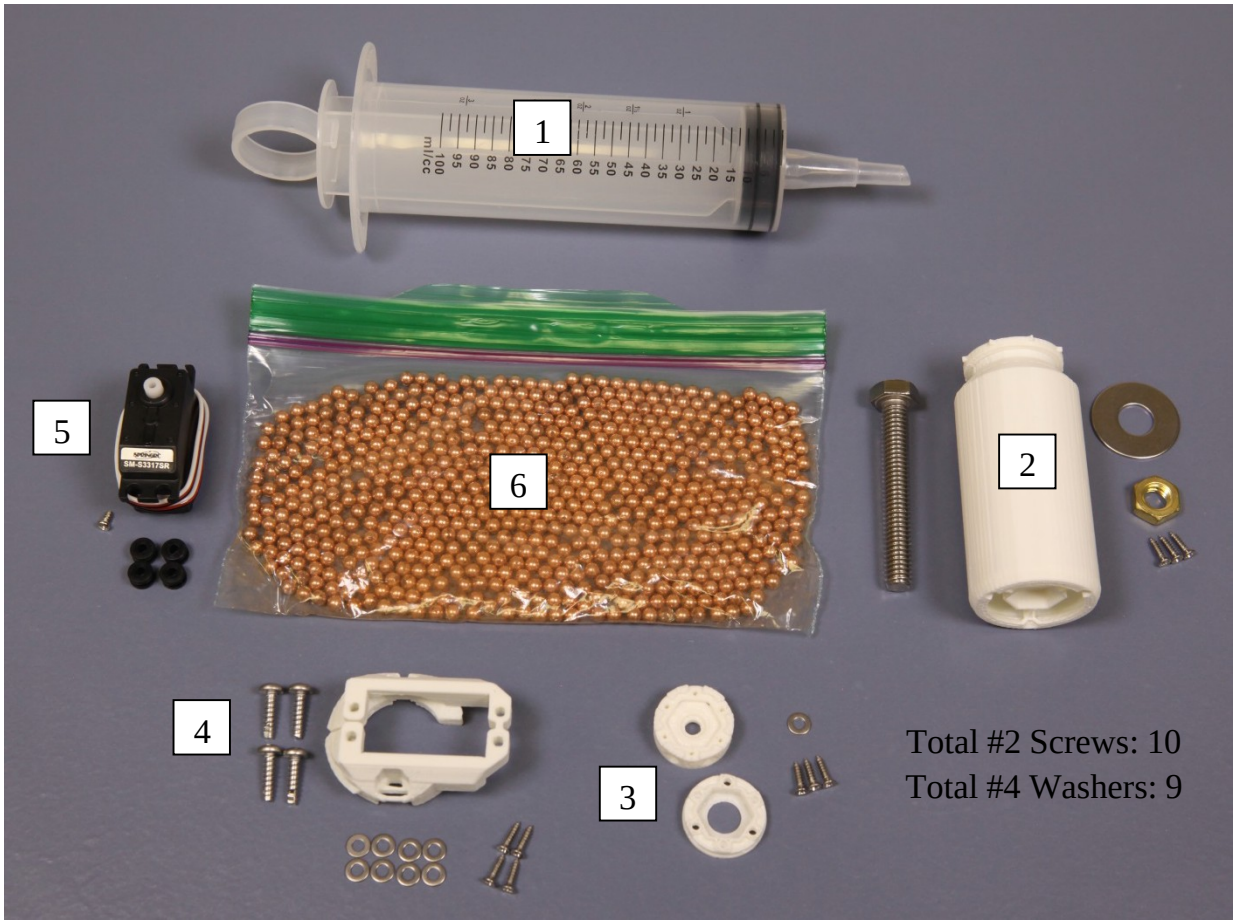
BUOYANCY ENGINE KIT

Assembly instructions for the **100ml Buoyancy Engine** follow:

KIT PARTS:

1. **100 ml/cc Syringe** with original plunger.
2. 3D printed **Plunger Cylinder** with hex-head bolt, fender washer (3/8"ID 1"OD), brass nut, and three small screws (#2x3/8").
3. **Two-Piece Shaft Coupling** with three small screws (#2x3/8") and small washer (#4).
4. **Servo Mount** with four thread-cutting screws (#6x1/2"), eight small washers (#4), and four small screws (#2x3/8").
5. **Continuous Rotation Servo** with a tiny servo screw and four rubber grommets.
6. **BBs** for ballast.

Buoyancy Engine Kit



ASSEMBLY:

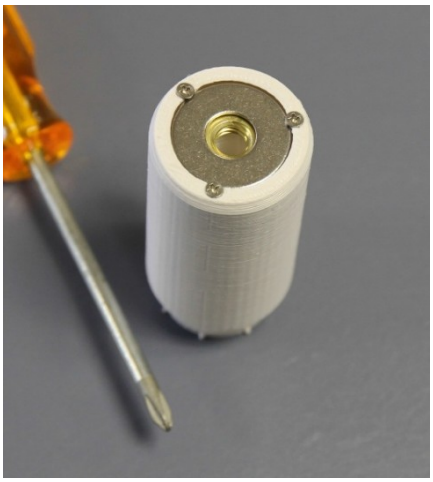
Just follow the photos. (You know you aren't going to read these instructions anyway.)*

1. Grab that white cylinder thing and drop the brass nut in the slot provided.
2. Throw the fatty washer on top and place three #2 screws in the pilot holes.
3. Tighten those suckers down! But not too tight!

Brass Nut in Slot

Fatty Washer on Top
Start three Screws

Tighten those Suckers
Down until Flush



Okay, nice job. Now…

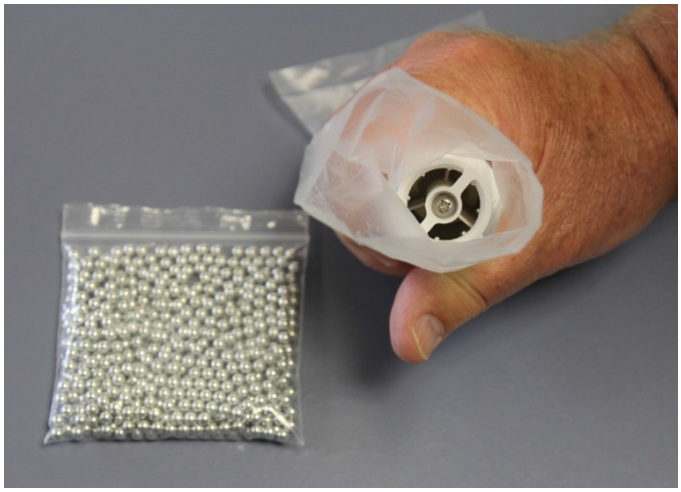
1. Flip the white cylinder thing over. (Oh yeah, your cylinder thing could be printed in a different **c**o**l**o**r** plastic other than white – you figure it out.)
2. Grab the stuff in the photo below. That long bag is the thing the syringe came in. You saved it, right?

Cylinder Thing (Cylinder Plunger), BBs and Syringe Bag

*My colleagues tell me that I should encourage reading. Okay, so read the instructions… I'll keep 'em short.

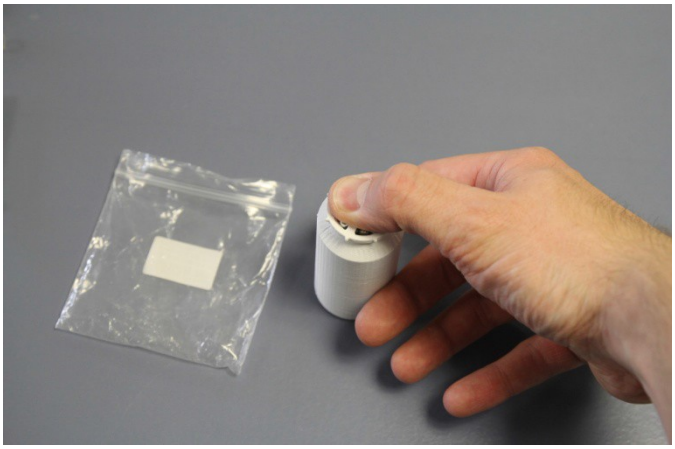
3. Squeeze the syringe bag snuggly around the cylinder and fill it with BBs. **Follow the Photo Instructions:**

Squeeze Syringe Bag around Cylinder



Fill the Cylinder with BBs

Compress the BBs in Cylinder



Cylinder with BBs should weigh 220-232g

Yes, BBs can also be Copper Colored

A Box Top helps to corral BBs

Get those BBs covered up or they'll be all over the floor! Here's how:

You'll need the Syringe

Remove the Plunger

Hey! Don't touch that black rubber tip on the plunger. It has **One-of-a-Kind Oil on it!**

Pry up the Rubber Tip with a Screwdriver

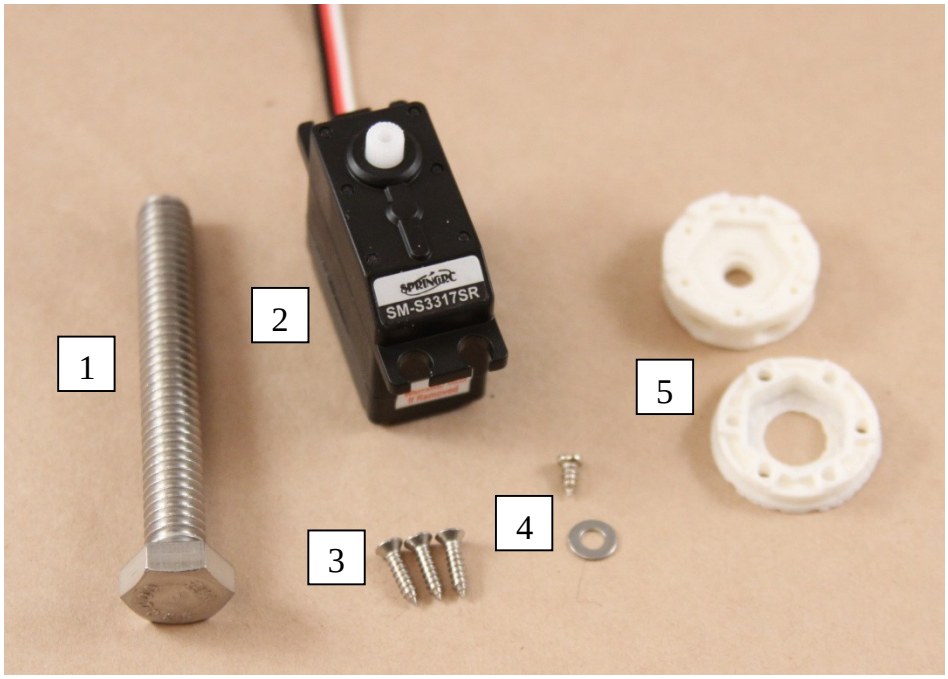
Cover your Hand with a Bag and Remove Tip

Seal the open end of the Cylinder with the Rubber Tip

Push the BB filled Cylinder Plunger into Syringe until it is past the Opening

Congratulations! Take a break! You earned it!

Now… from your set of parts find all the items in the photo below:

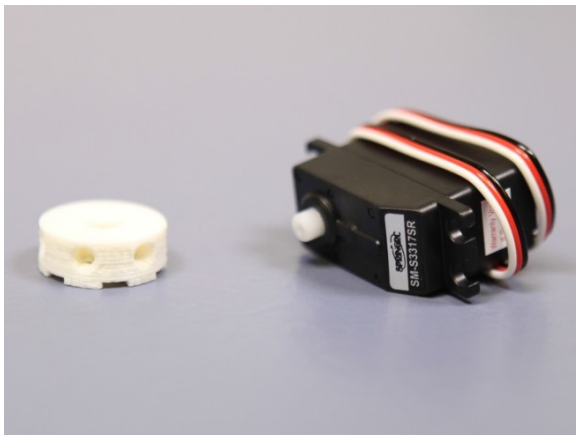


Large Bolt (1), Servo (2), Three #2 Screws (3), small Servo Horn Screw* with #4 Washer (4), and Two-Piece Shaft Coupling (5)

*If this screw is lost, it may be replaced by a #2 screw using TWO washers.

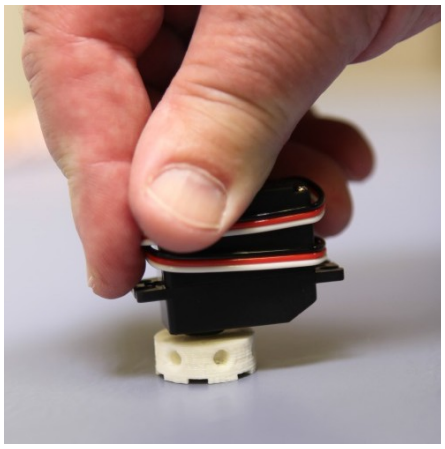
Press servo output gear into small center hole in coupling. **Follow the Photo Instructions:**

Small-Hole-Coupling with smooth Side up

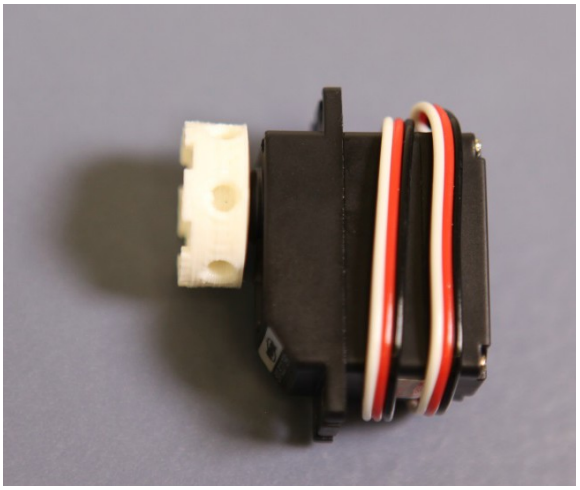


Position servo Output Gear over Hole

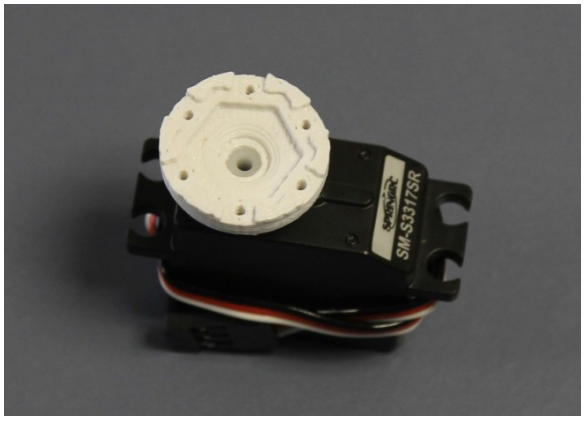
Press down with heal of Hand until Output Gear slides into Coupling



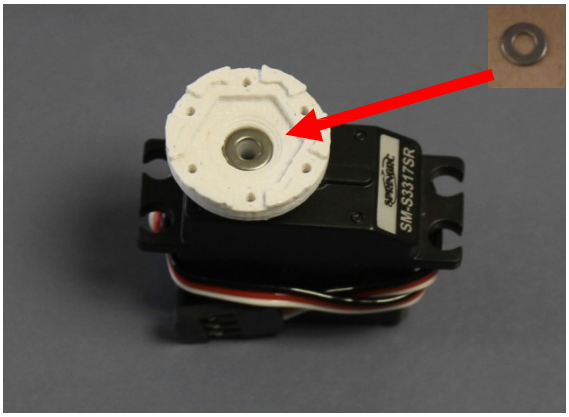
Servo with attached Coupling



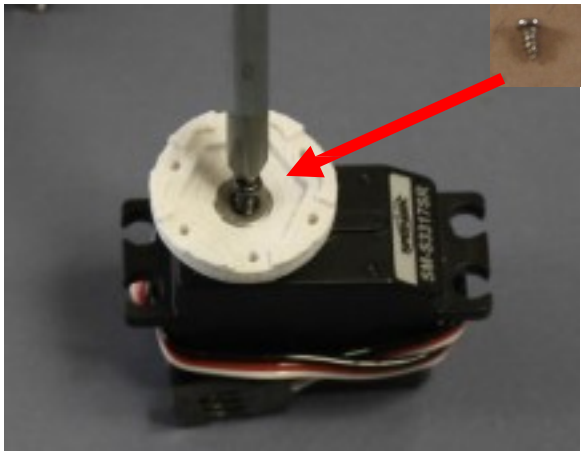
Coupling fitted over Servo Output Gear



Place a **SMALL WASHER** into the center recess

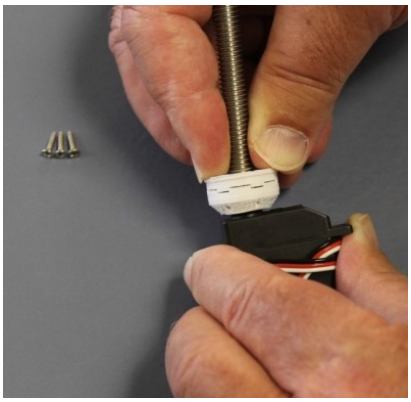


Screw the small **Servo Horn Screw** (black or silver) into the Servo Output Gear



Push the Bolt through the indented Side of the Large-Hole-Coupling

Matchup the Indentations on the Couplings and Push them Together



They fit like Puzzle Pieces

Place the three Small #2 Screws in the open Holes and Tighten

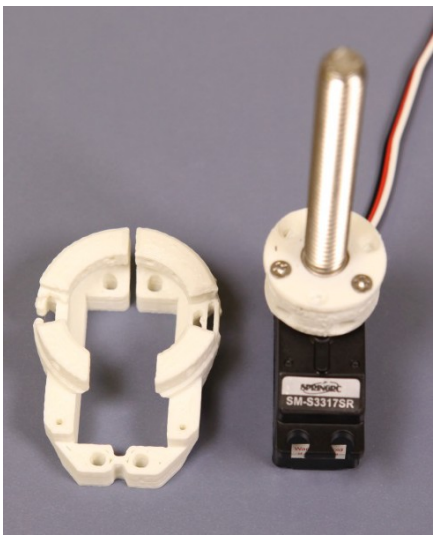
Tighten until screw heads are **FLAT** and **SMOOTH** with the top of the shaft coupling.

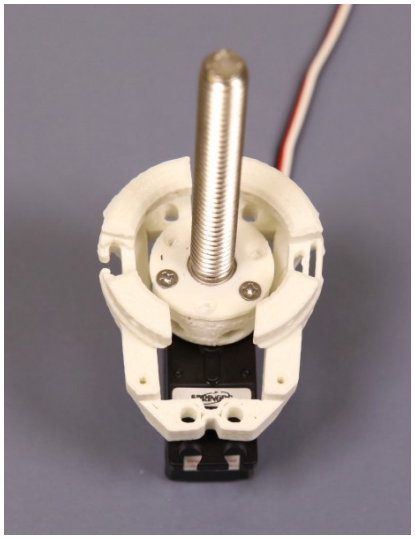
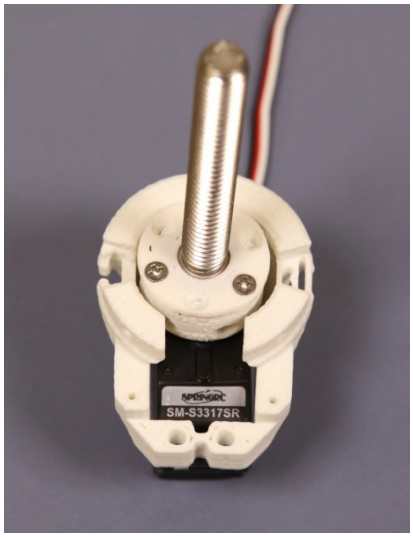
Wonderful!

Next, we'll expand the servo assembly to include the servo mount. Here's what you need:

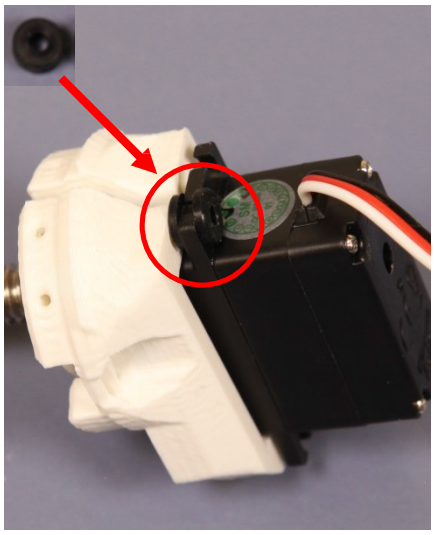
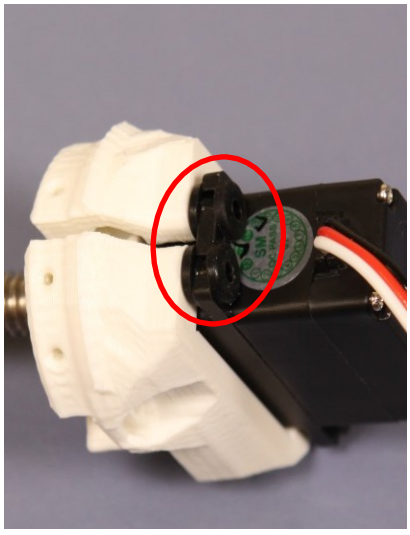
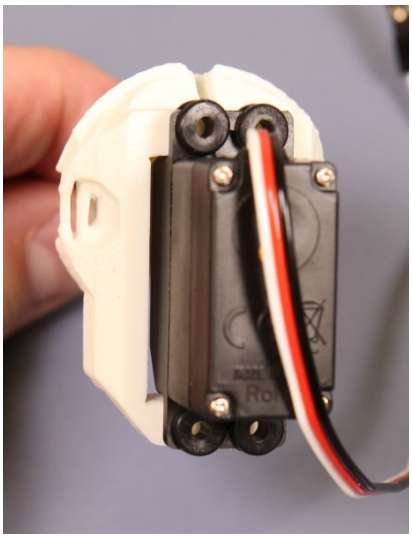
Four # 6 Thread-Cutting Screws, Four Rubber Grommets (from servo hardware bag), Servo Mount and the Servo Assembly

Fit Servo Mount over the Servo Assembly as shown

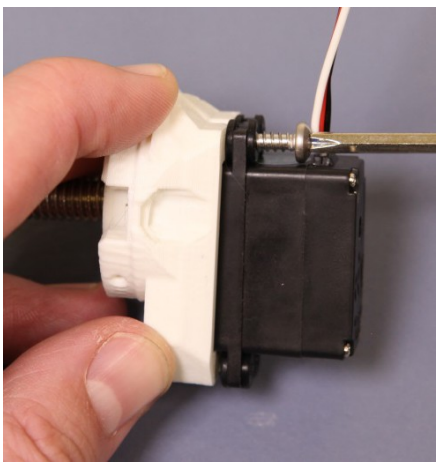
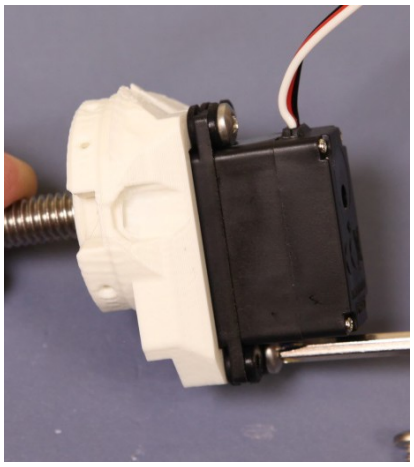
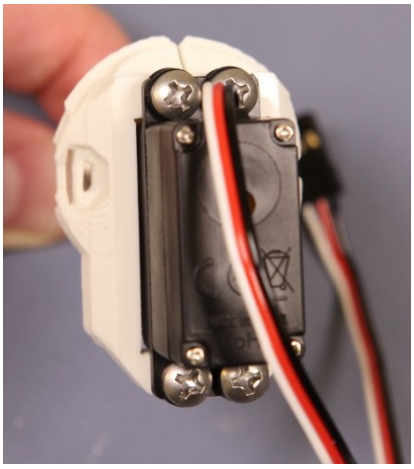


Fit Grommets into four screw-hole Slots in Servo

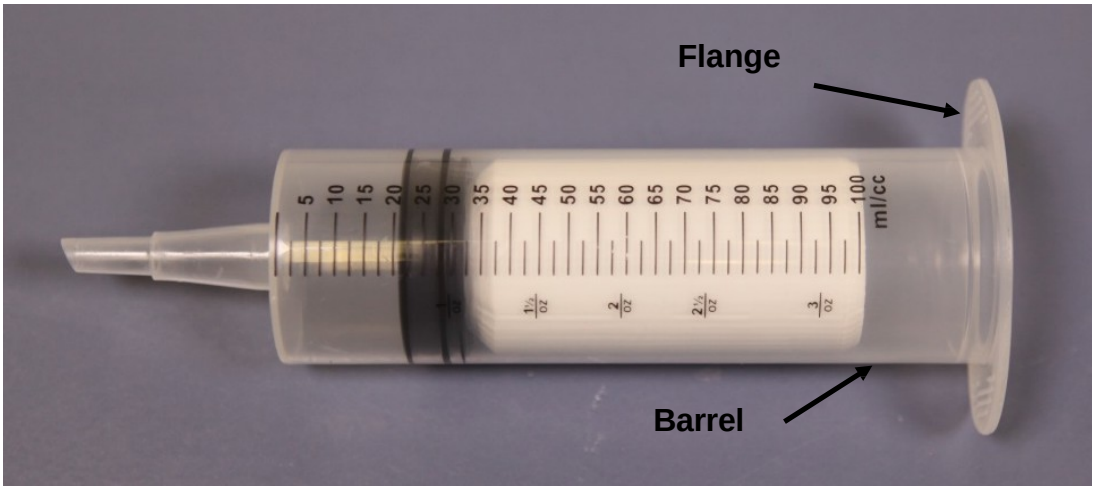




Use four #6 thread-cutting Screws to secure the Servo to the Servo Mount

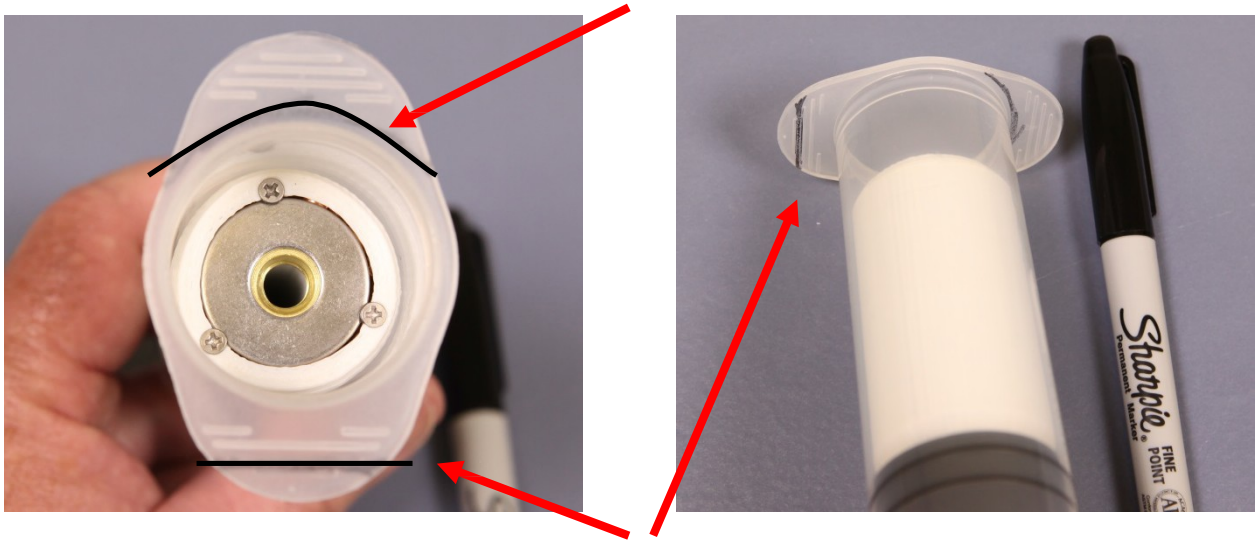
That was Fun! (Set the servo assembly aside for now.)

Okay, now… you trim the flange around the syringe so that it will smoothly fit into the glider bottle. You need:



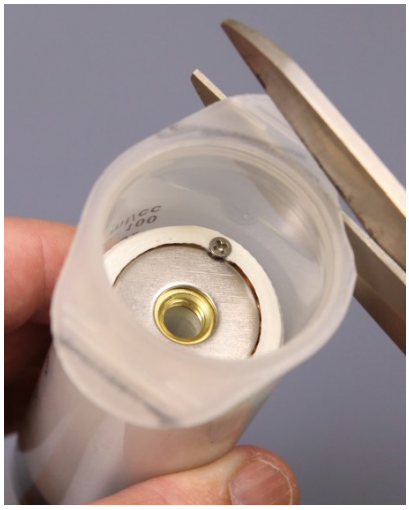
The Syringe Assembly, heavy duty Scissors, and a Marker

Mark one side of the flange with a curved line 1/16th inch from the syringe barrel.

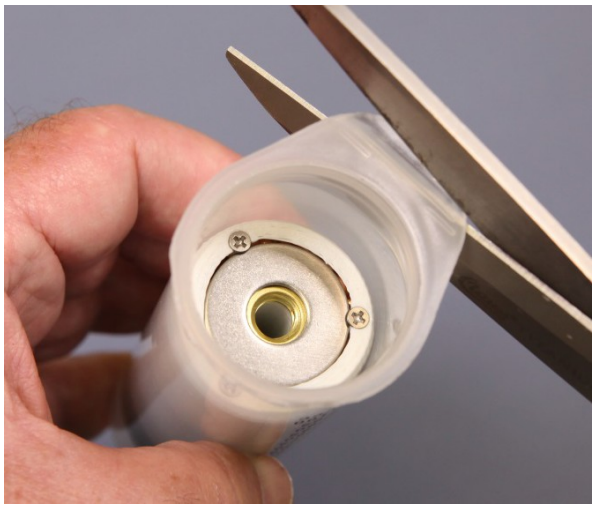


Mark the other side with a straight line following the second ridge from the outside.

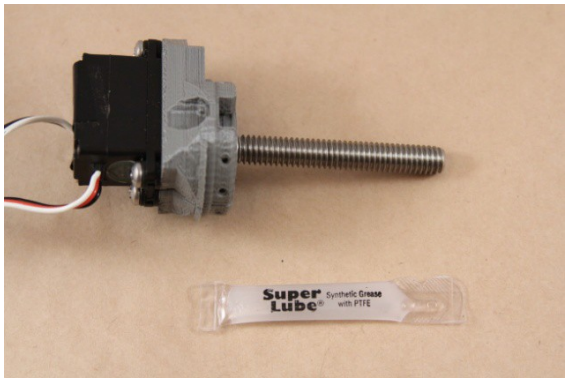
Trim both Marked Sides of the Syringe Flange.



Use Short Snips to Avoid Cracking the Plastic



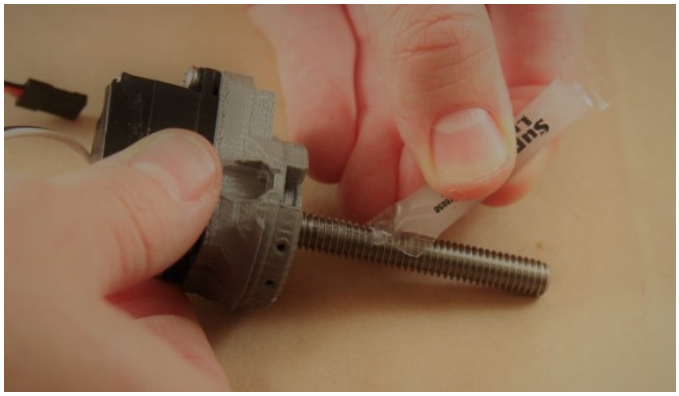
Lubricate the bolt. You will need:



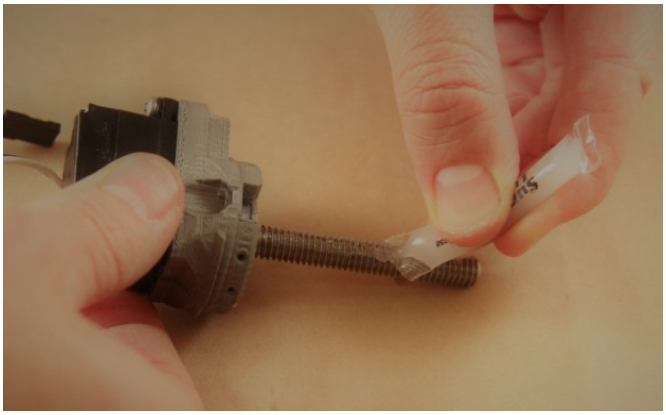
The Servo Assembly and Synthetic Grease found in the Kit bag of tools.

Tear open Packet

Apply Grease to Bolt

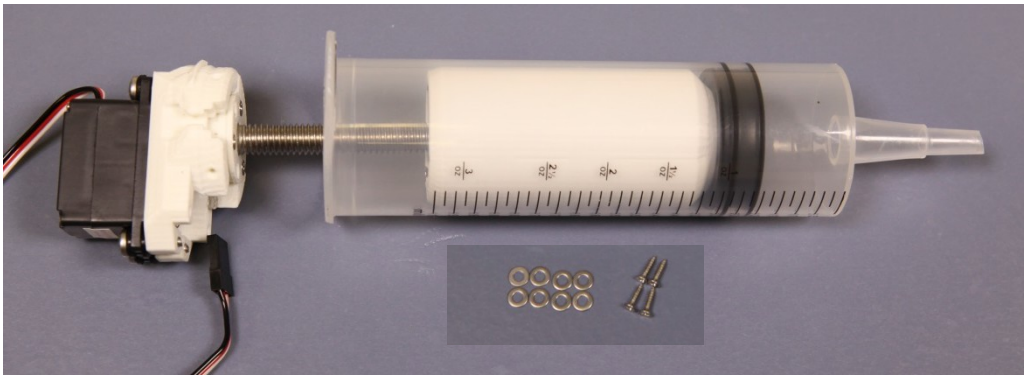


Apply to the Total Length of the Bolt



Seal Grease with Tape for Later Use

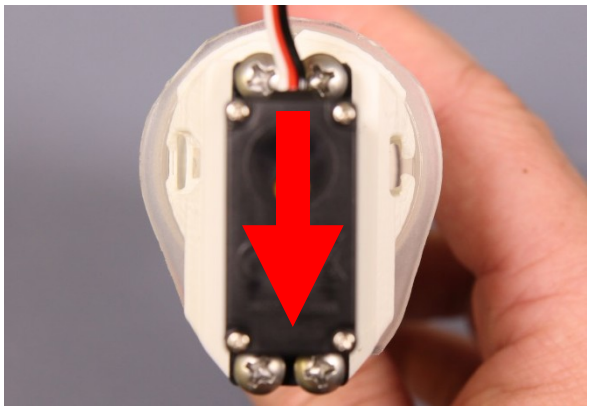
Put It All Together! You will need:



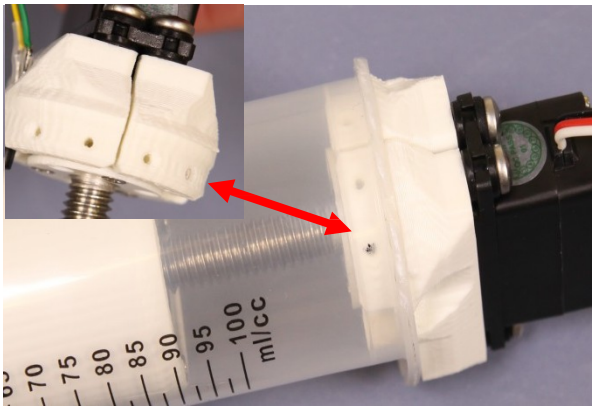
Servo Assembly, Syringe Assembly, 8 small #4 Washers and 4 small #2 Screws

Screw the Servo Assembly into Plunger Cylinder until it reaches Syringe Flange

Align elongated end of Servo with extended end of the Syringe Flange

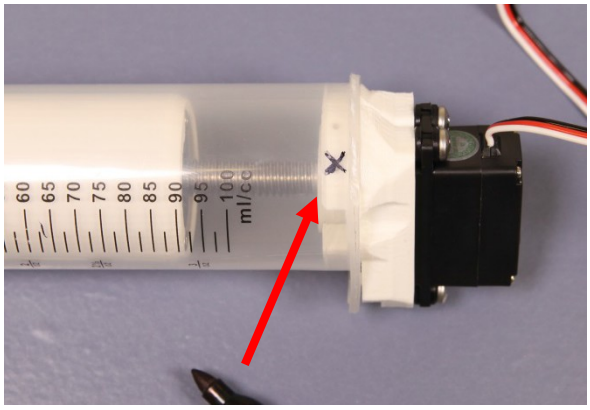


Mark the Position of this Hole on the Outside of the Syringe Barrel*

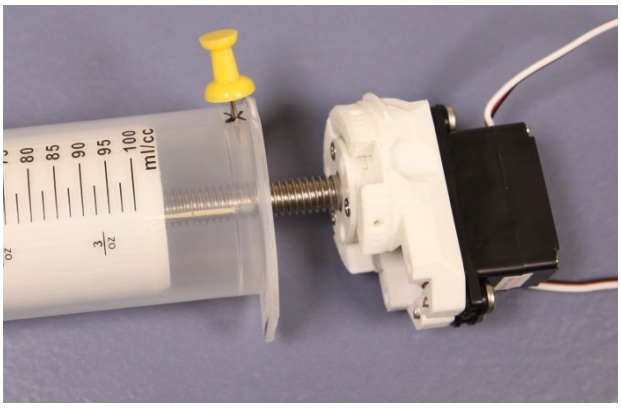


*This is the non-elongated side of the syringe flange. There is a set of four holes on this side of the servo mount. **Only the two holes on either end of this set will be used**.

Position for Anchor Screw

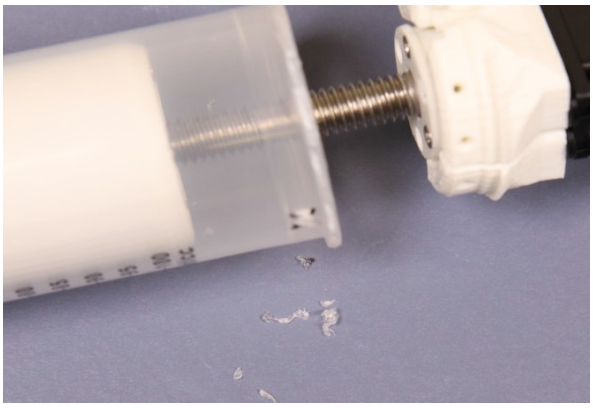


Make Pilot Hole with Push-Pin

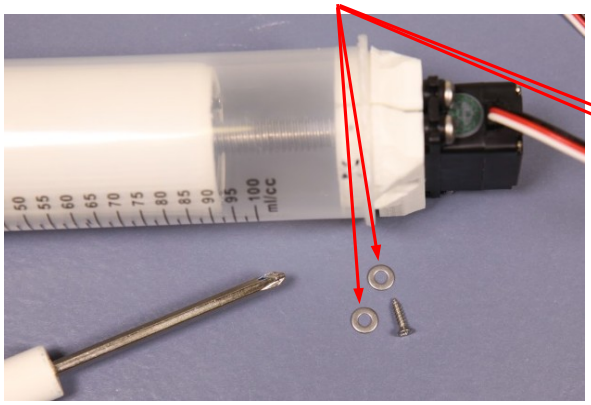


Hand drill Hole Larger with 3/32 Bit

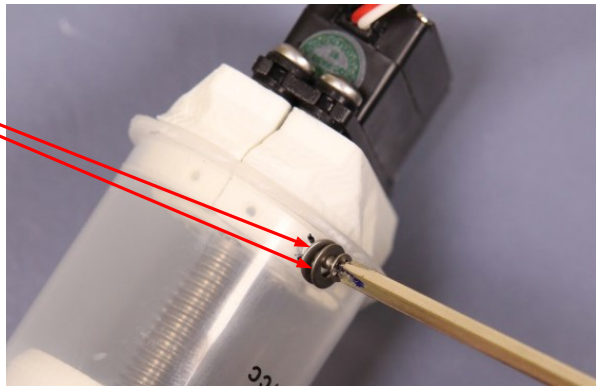
Remove excess Plastic



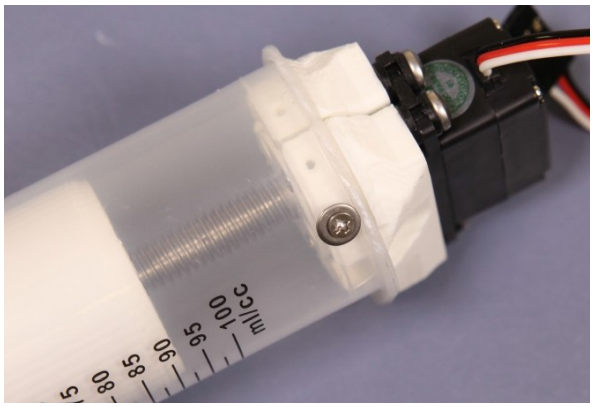
Use **TWO WASHERS** and a Screw



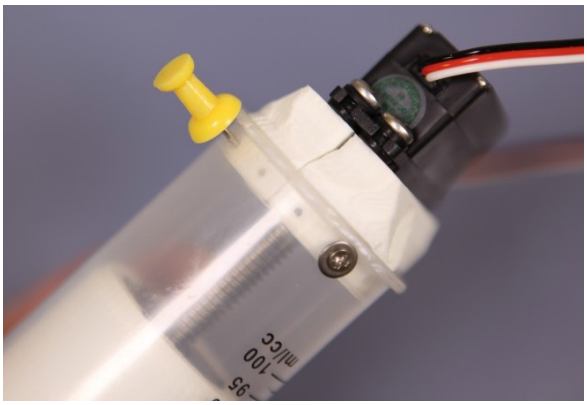
Secure Servo Assembly in Place



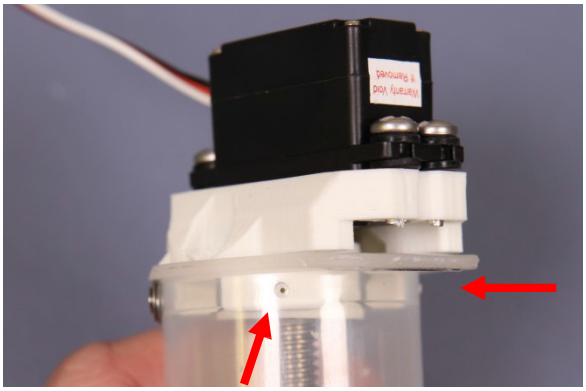
Avoid over Tightening



Make a Pilot Hole with Push-Pin on other end of the four-hole Set



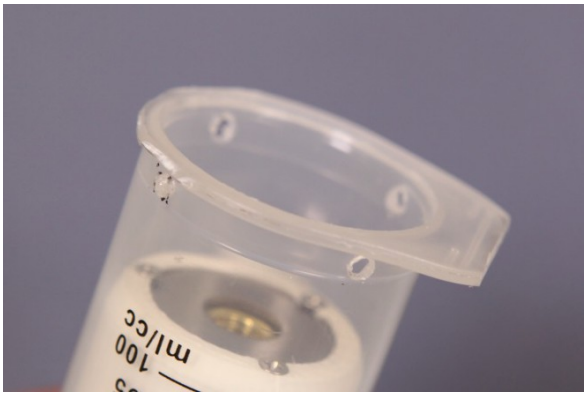
Make two Pilot Holes under the elongated End of the Syringe Flange



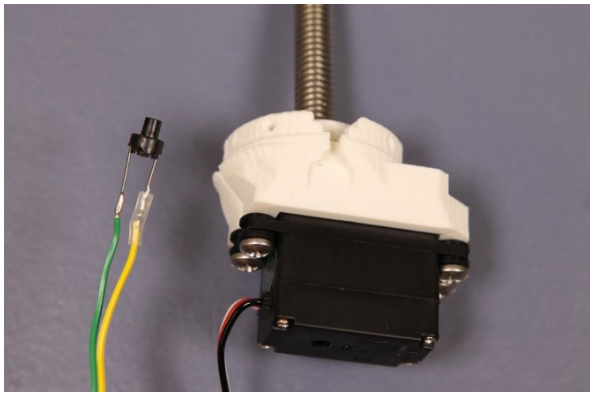
Remove the servo assembly and hand drill the pilot holes with a 3/32 drill bit. There should be a total of four holes spaced around the barrel of the syringe as pictured below.

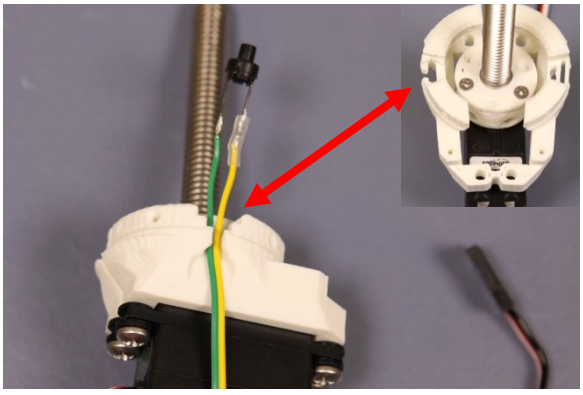
Enlarge Pilot Holes

Remove Plastic Cuttings



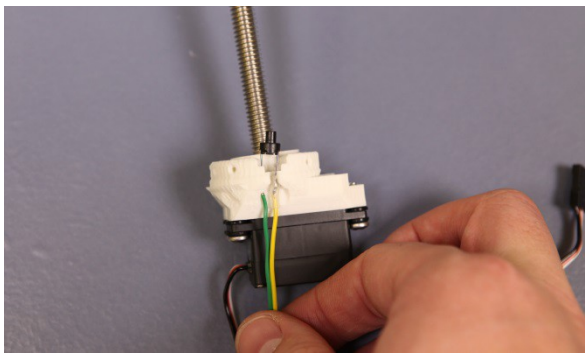
Attach Pushbutton Switch to the Servo Assembly

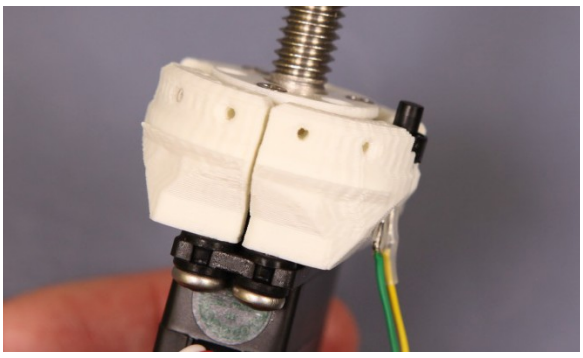




Slide the pushbutton switch with soldered wires into the open-slot on the side of the servo assembly as shown.

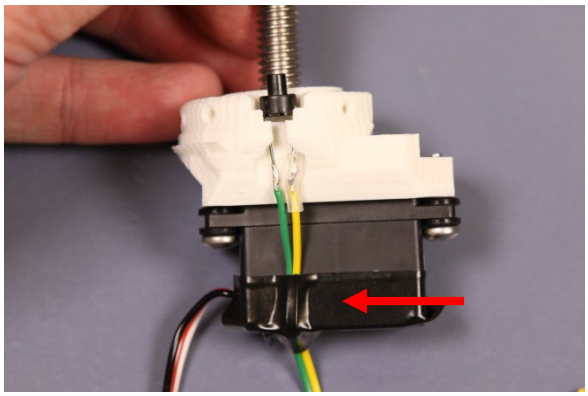
Pushbutton Switch should fit securely in Slot



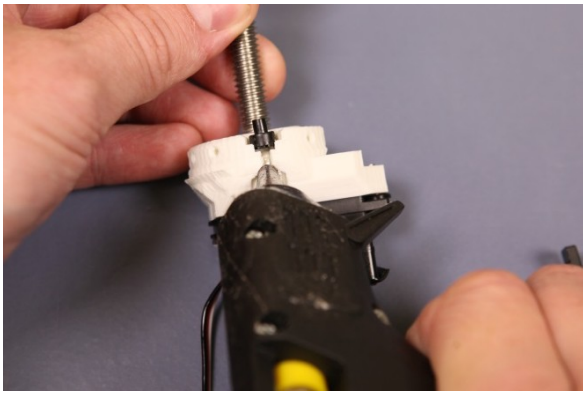


The pushbutton should be perpendicular to the rim of the servo mount and extend beyond the shaft coupling as shown above right.

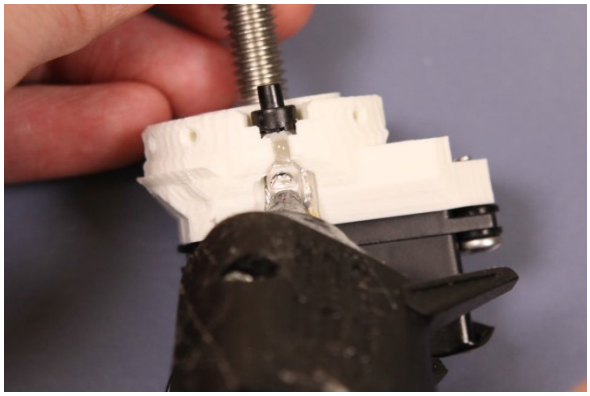
Tape Wires in Place

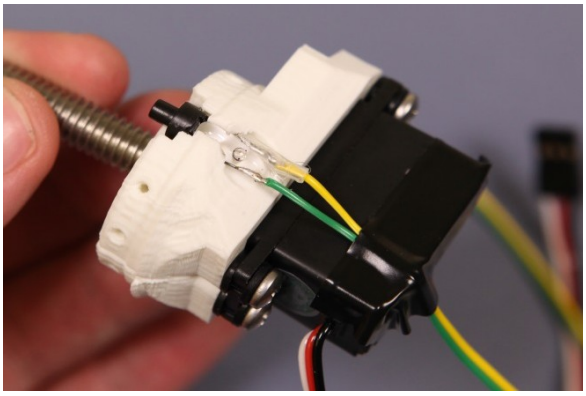


Hot Glue Switch in Place



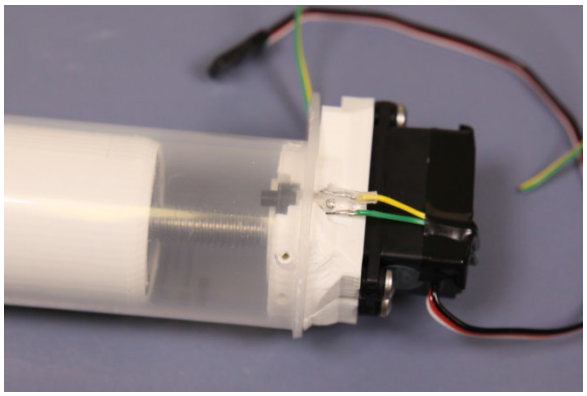
Ensure that Glue does not bulge out beyond the Circumference of the Servo Mount



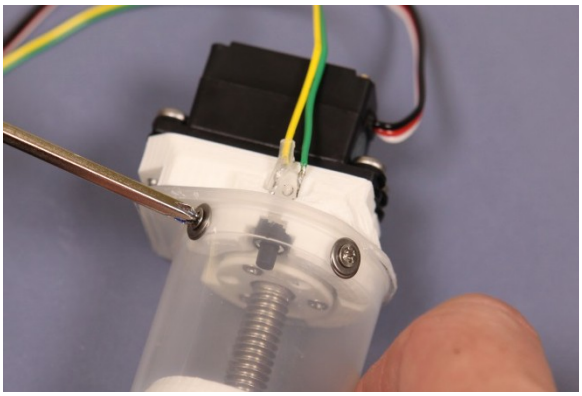


The servo assembly must smoothly fit back into the syringe. If there is excess glue, wait for it to cool and then cut it away with a sharp knife.

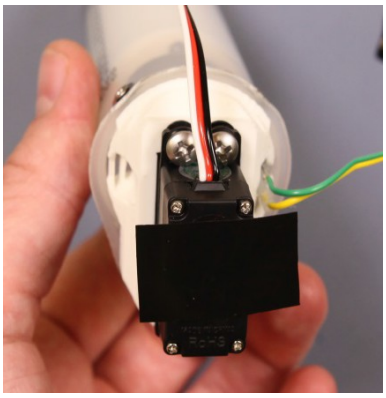
Fit Servo Assembly back into Syringe

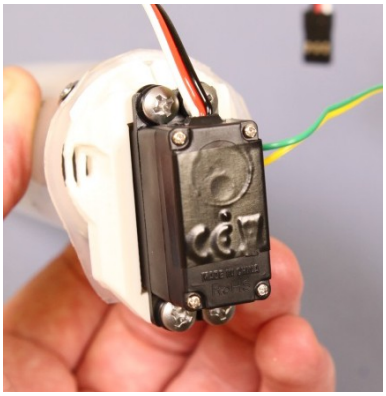


Secure in place with Four Screws each with Two Washers



Cover the Hole in the back of the Servo with Electrical Tape

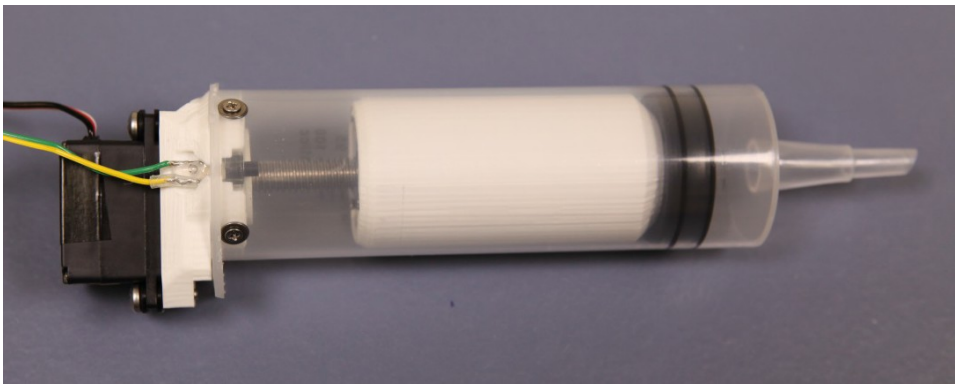




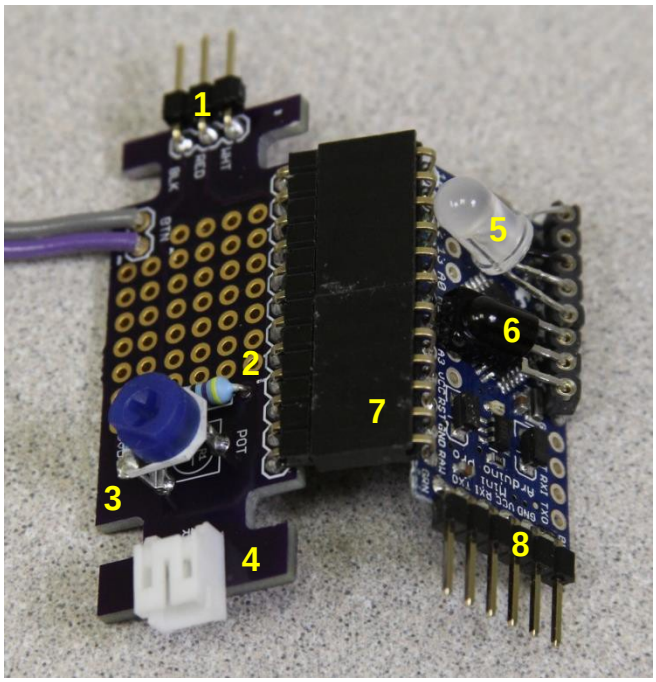
This makes the servo more water resistant in case of leaks.

VOILÀ!

Completed Buoyancy Engine – Congratulations!



3. Circuit Board



The Buoyancy Engine Controller manages the servo motor on the buoyancy engine and directs it when to drawn in water and when to expel it. It consists of two main parts: The **Circuit Board** on the left and the **Arduino Pro Mini** microcontroller on the right. These are connected by sets of header pins in the middle.

The main components of the **Circuit Board** are:

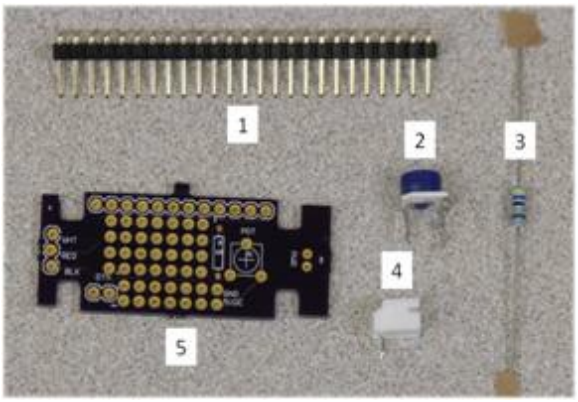
1. THREE-PIN HEADER - Connects to the buoyancy engine servo motor.
2. RESISTOR – Reduces the voltage on the servo.
3. POTENTIOMETER - Controls the pause time between buoyancy engine cycles and thus the length of the dive glide and rise glide.
4. POWER SUPPLY JACK – Is the plug-in location for the battery power supply.

The main parts of the **Arduino Pro Mini** microcontroller are:

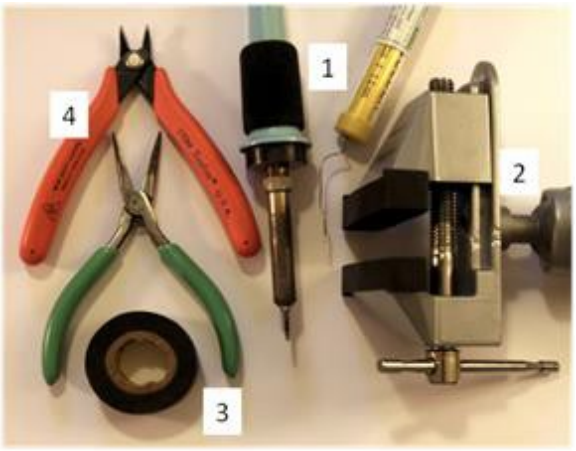
5. RGB LED – Indicates glider's descent or ascent by color changes.
6. IR Receiver – Picks up signals from Mini IR Remote to start and stop the buoyancy engine.
7. HEADER PINS (12) along length - Connects the circuit board to the Pro Mini.
8. HEADER PINS (6) along width - Enables connection to the FTDI breakout board for programming.

To create the Buoyancy Engine Controller, follow the **Circuit Board** build and **Arduino Pro Mini** build instructions then join these two components together as illustrated in the directions.

Circuit Board Build

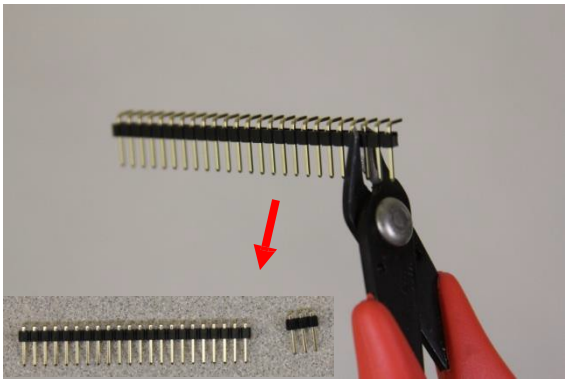


1. The circuit board build includes a male right angle header 24-pin set (1), a 10k Ohm trim potentiometer (2), a 2.7-ohm resistor (3), a 2-pin JST power jack (4), and a custom printed circuit board (PCB) (5).

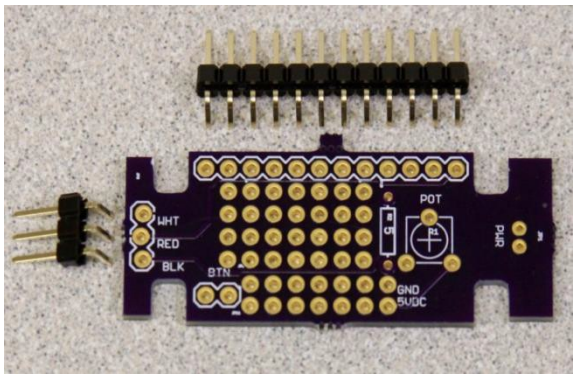


2. Tools and supplies needed are soldering iron with solder (1), small vise (2), electrical tape (3), and flush cutters and needle nose pliers (4).

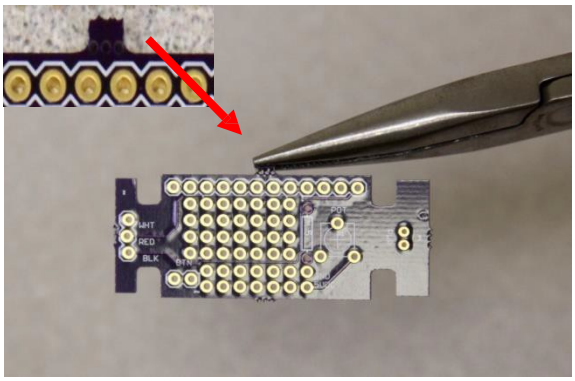
Safety Glasses/Goggles Required



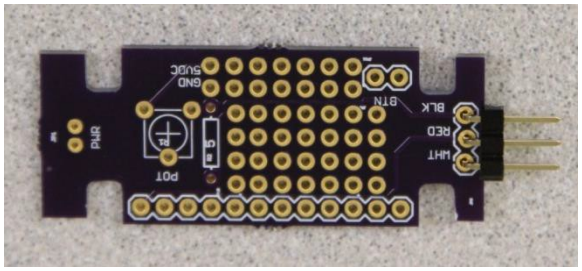
3. Use flush cutters to carefully remove a 3-pin section of male right angle header pins.



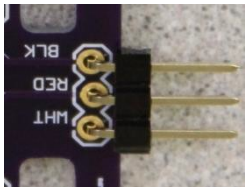
4. Also separate off a 12-pin section. **SAVE THE REST OF THE HEADER PINS** for the Arduino Pro Mini Build in the next set of instructions.

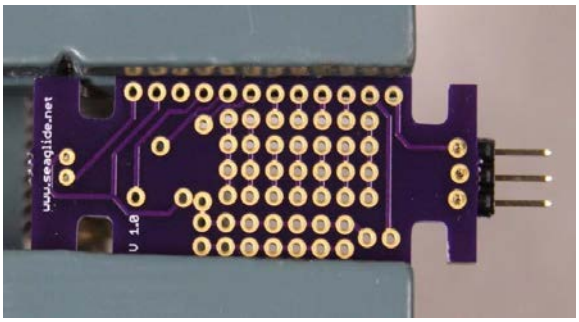


5. If remnant nubs from the PCB manufacture process remain on the board, snap these off with pliers.

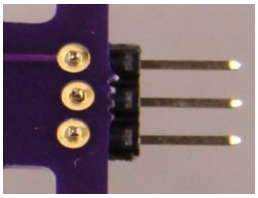


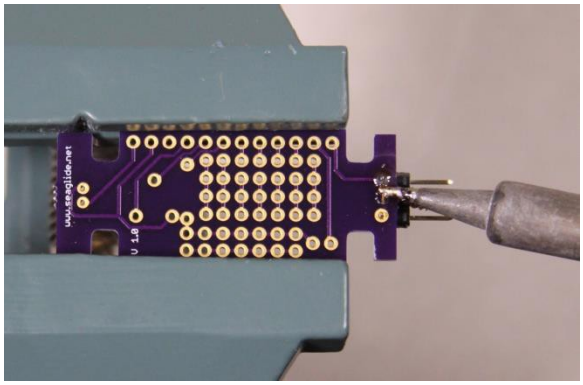
6. Place 3-pin header in PCB as shown.



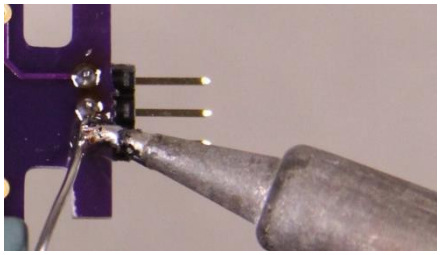


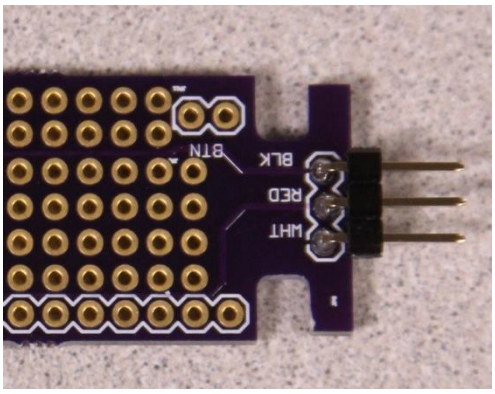
7. Flip the PCB over and secure it in a small vise.



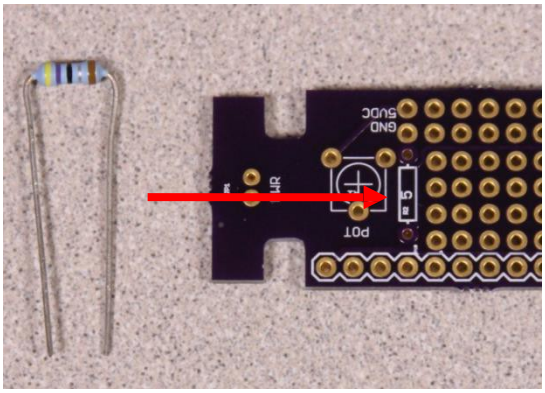


8. Solder pins in place.

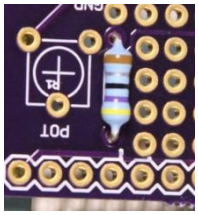




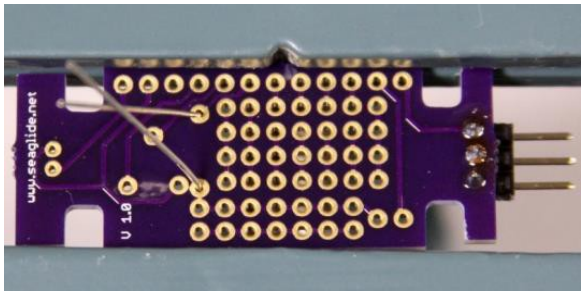
9. This 3-pin header is where the servo motor wire harness will attach. Notice the wire orientation that is labeled on the PCB: WHT for white, RED for red, and BLK for black.



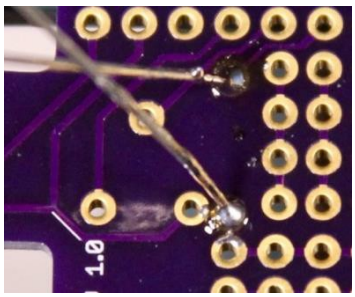
10. Locate the 2.7-ohm resistor, bend the wires as shown, and fit it in the outline labeled "R2 5 or 4.7Ω."



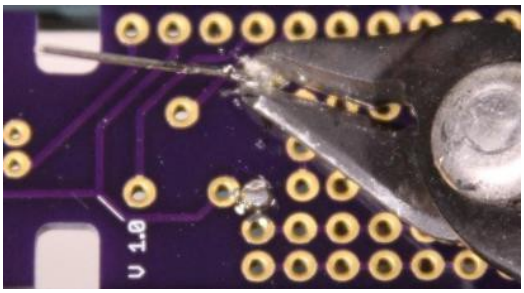
It can be installed in either direction.



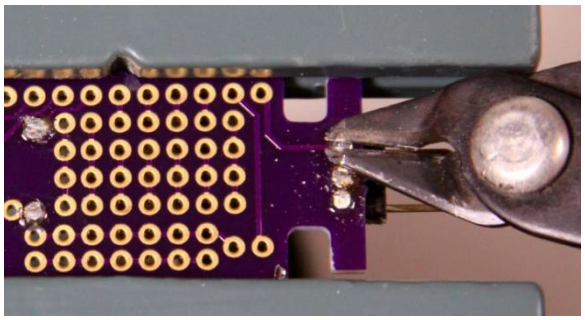
11. Flip the PCB over and bend the resistor wires to hold the resistor in a low profile position. Then secure the PCB with resistor in a small vise for soldering.



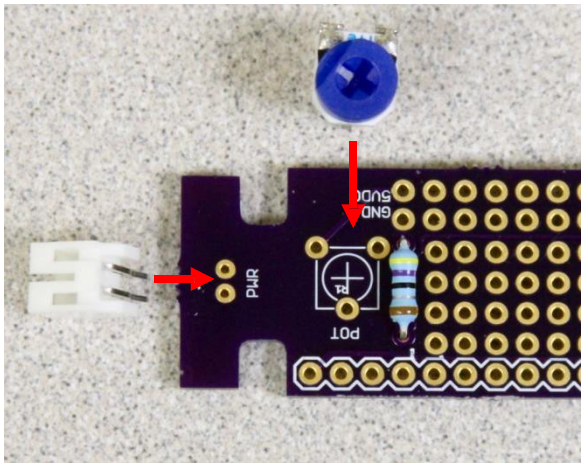
Solder Resistor Wires



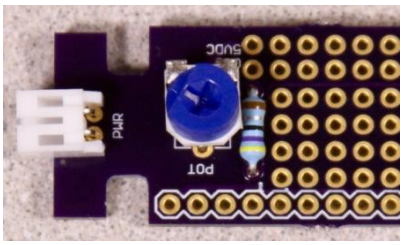
Trim Excess Wire with Flush Cutters

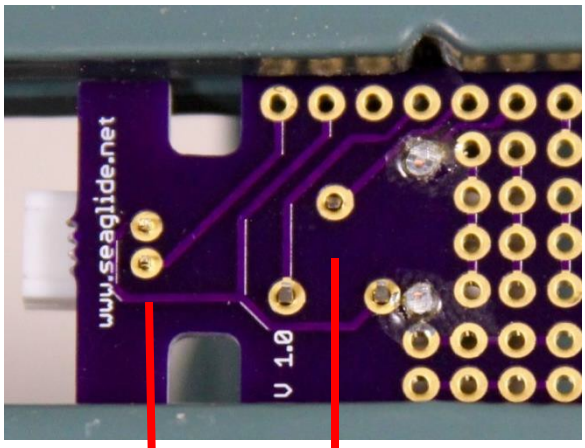


12. Also, trim the 3-pin header pins protruding from the PCB. It's okay to trim off the top of solder joints. A low-profile board will fit on the buoyancy engine later.
    WARNING: *Flush cutters will send clippings flying. Please wear safety glasses/goggles and clip into a trashcan.*

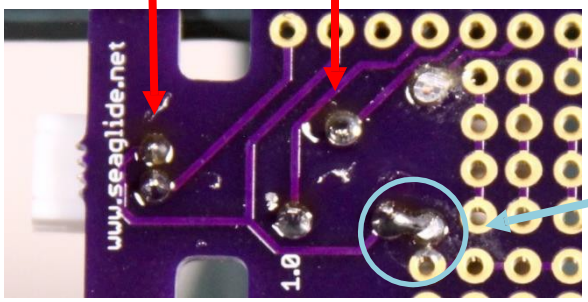


13. Locate the 10k Ohm potentiometer (POT) and 2-pin JST power jack (PWR). Fit these into their outlined positions as shown.

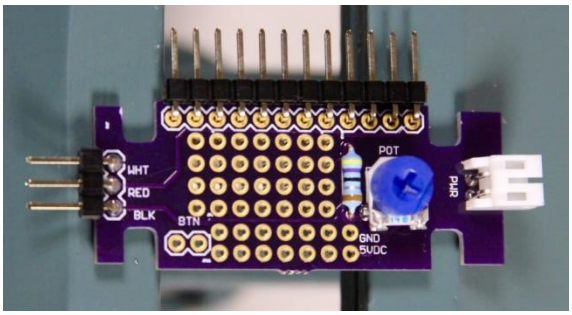




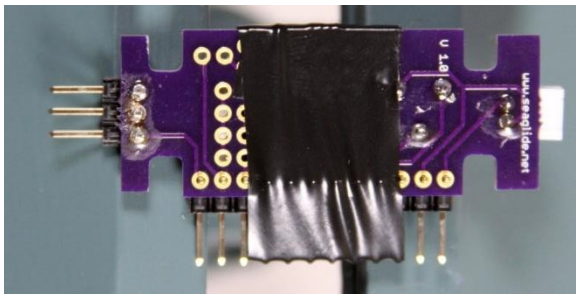
14. Flip the PCB with components over and secure the board in a vise for soldering.



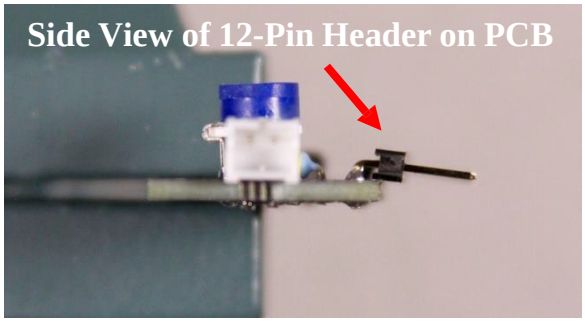
15. Solder the 10k-trim potentiometer (3-pins) and the JST power jack (2-pins) in place.
    Solder bridges in the circled area are okay, because these paths are already connected electrically.



16. Locate the 12-pin section of header pins from instruction #4. Fit it onto the PCB as shown.

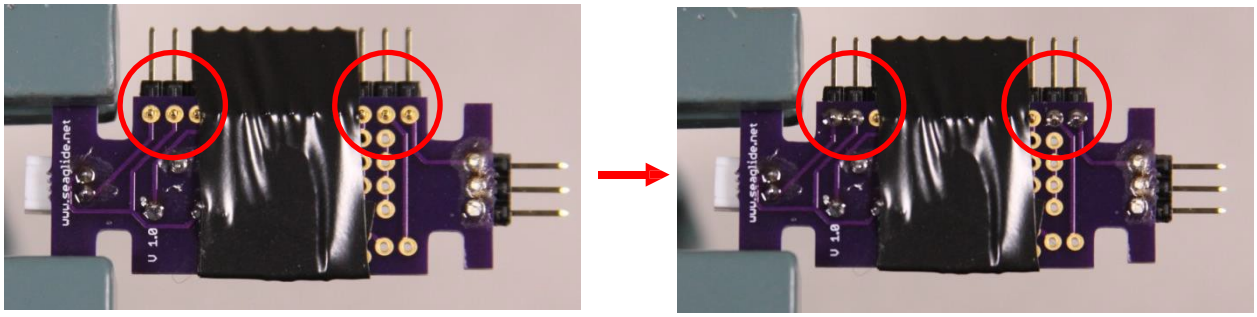


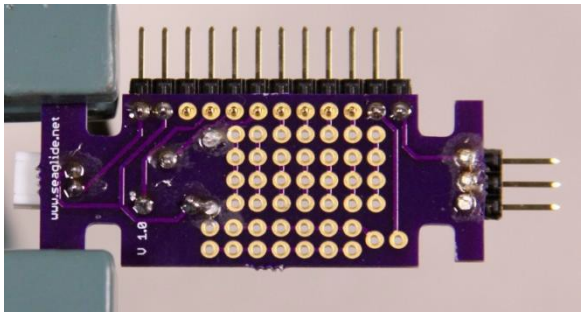
17. Flip the board over and tape the pins into position with electrical tape. Wrap the tape tightly enough to hold the pins at slight angle downward – towards the bottom of the PCB.

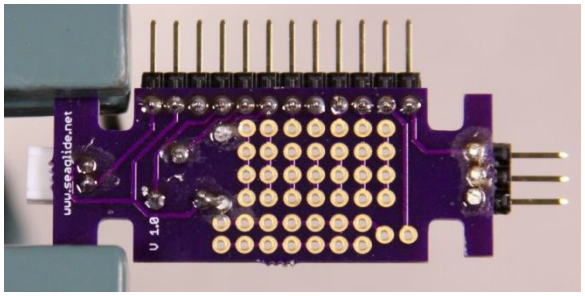


18. This slight angle will be helpful later for fitting the controller over the rounded cylinder of the buoyancy engine.

Secure PCB in vise and solder the exposed pins on either side of tape.





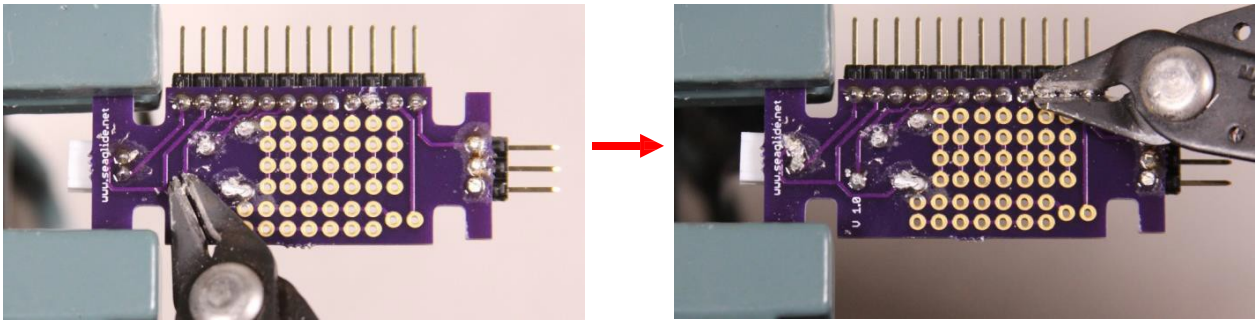


19. Remove electrical tape and finish soldering the rest of the 12-pin header.

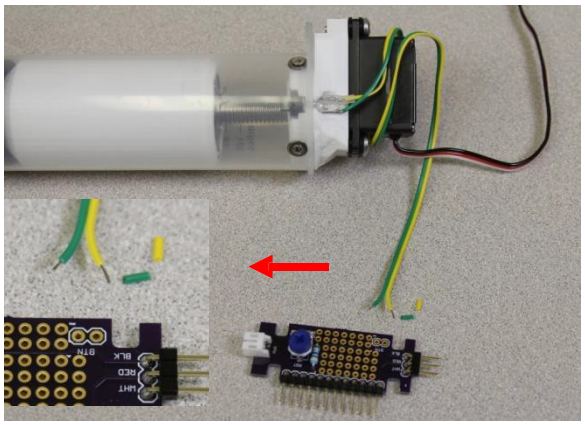
20. Check all solder joints. Use flush cutters to trim protruding pins and solder.

    WARNING: *Flush cutters will send clippings flying. Please wear safety glasses/goggles and clip into a trashcan.*

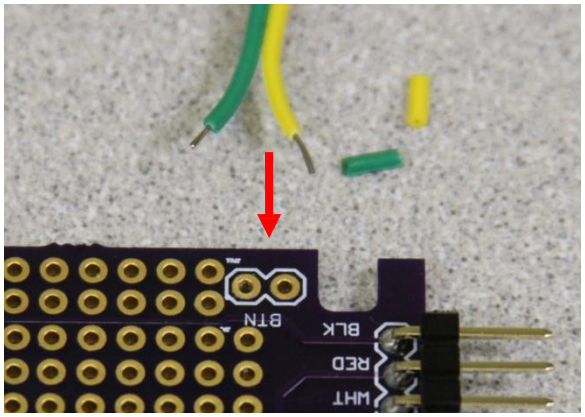
Use flush cutters to cut back pins and solder joints.



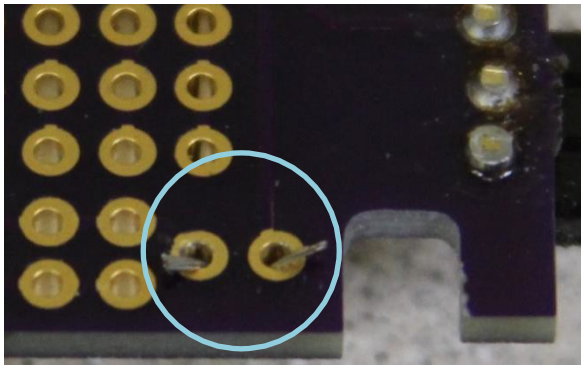
One last thing… the pushbutton switch needs to be soldered to the circuit board.



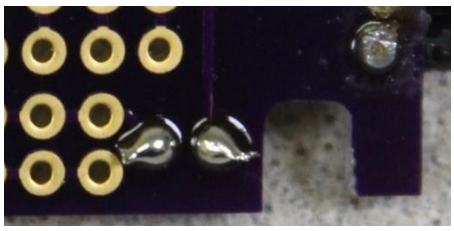
21. Locate the pushbutton switch that is attached to the buoyancy engine. Strip ~ ¼” of plastic insulation from ends of the two wires.

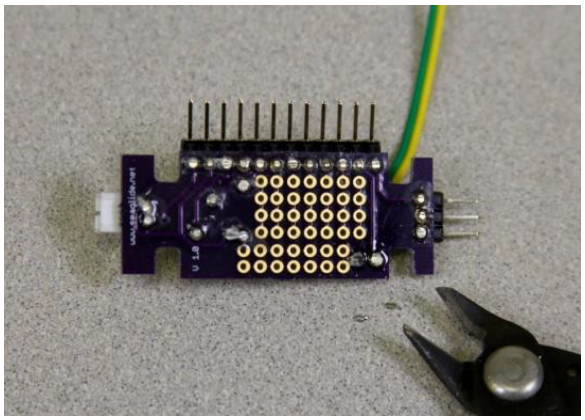


22. Fit the two wires (in any order) into outlined position marked BTN for button. Bend the wires to either side to hold them in place.



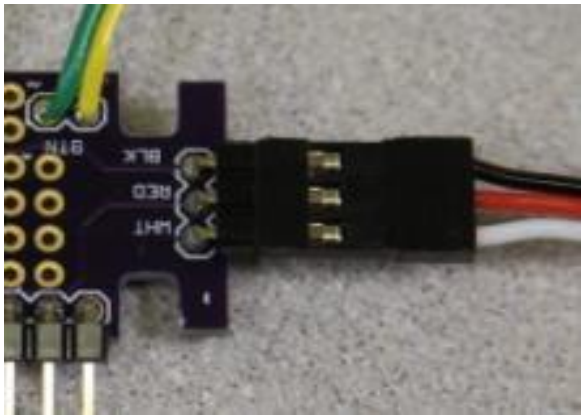
23. Flip the circuit board over and solder the two wires in place.





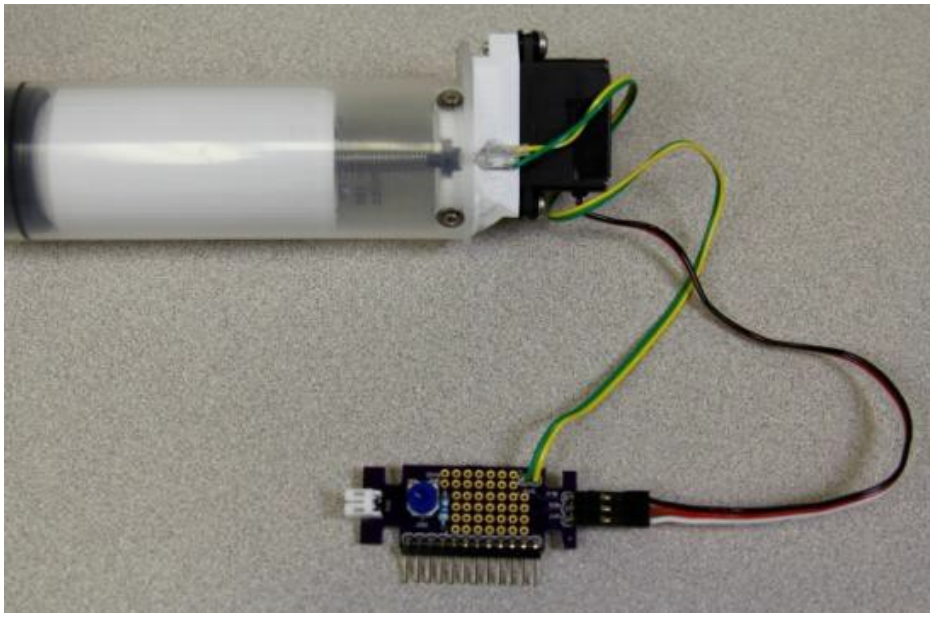
24. Check all solder joints. Use flush cutters to trim protruding pins and solder.

    WARNING: *Flush cutters will send clippings flying. Please wear safety glasses/goggles and clip into a trashcan.*

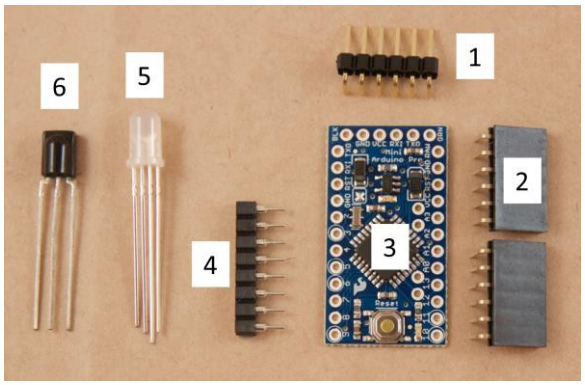


25. Flip the PCB over and attach the buoyancy engine servo harness to the circuit board. The ORDER of the color coded wires is IMPORTANT. Attached the harness so that the white wire aligns with the WHT pin, the red wire with the RED pin, and the black wire with BLK pin.

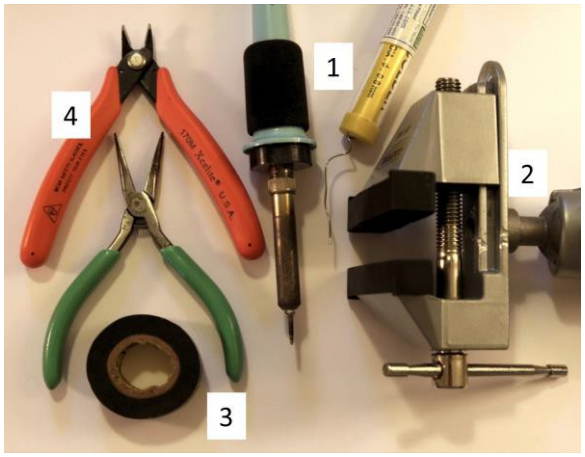
Buoyancy Engine with attached Circuit Board



4. Arduino Pro Mini

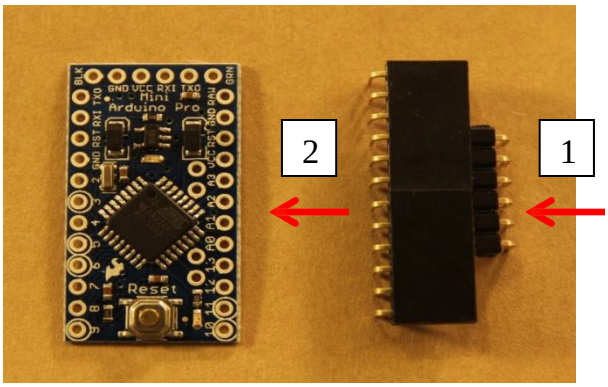


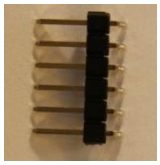
1. The Arduino build kit includes one set of male right angle header pins (1), two sets of female right angle header pins (2), an Arduino Pro Mini Board (3), a set of socket pins (4), an RGB (tri-color) LED (5), and an IR Receiver (6).



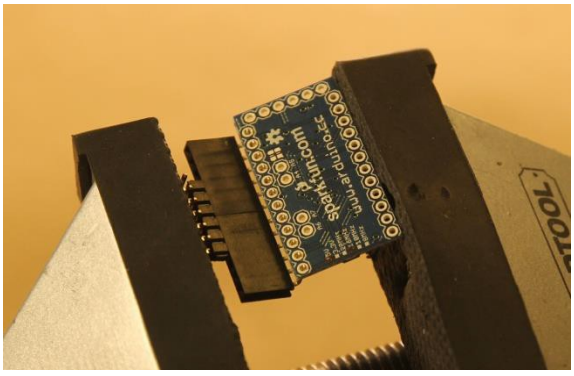
2. The tools and supplies needed are a soldering iron with solder (1), small vise (2), electrical tape (3), and flush cutters & needle nose pliers (4).

Safety Glasses/Goggles Required



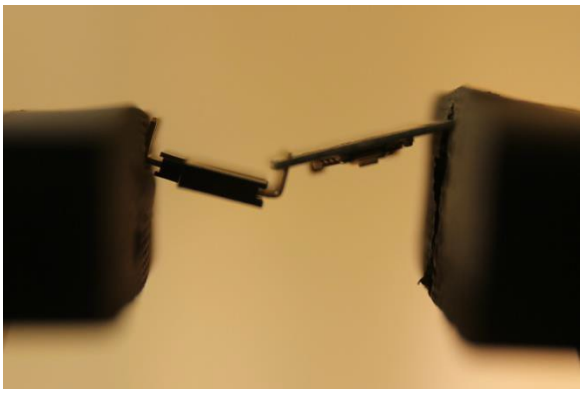


3. Use male header pins to connect and align the two sets of female header pins (1). Fit female header pins into pin holes on Pro Mini with a one-to-one alignment as shown (2).*

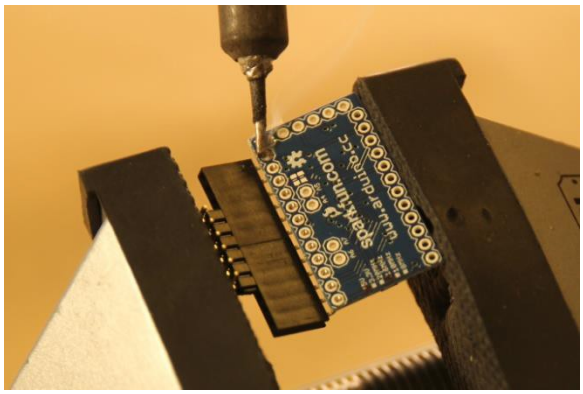


4. Flip the Pro Mini Board over while maintaining the connections between the pins and board. Secure in vise.

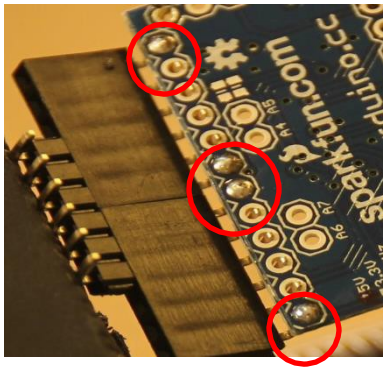
*Alignment is critical. The bottom pin aligns with hole (via) 10 and the top pin with RAW.



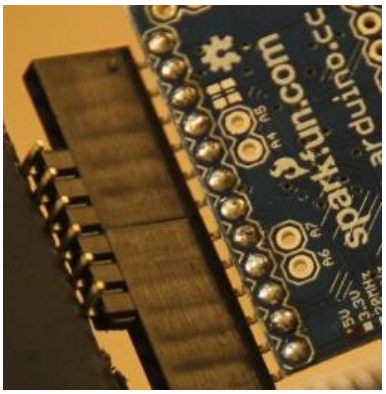
5. Be sure that the female header pins are at an angle in relationship to the plane of the Pro Mini. (This angle helps the Pro Mini conform to the shape of the buoyancy engine allowing it to more easily fit inside the glider's access opening.)



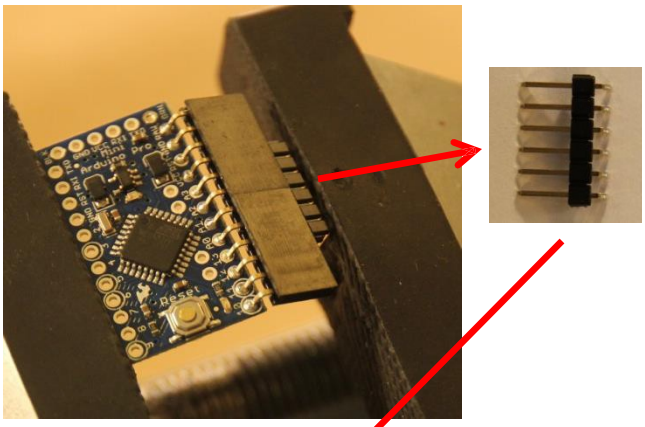
6. Solder connections…



7. First solder the ends and two middle pins to secure the two female header pin sets…

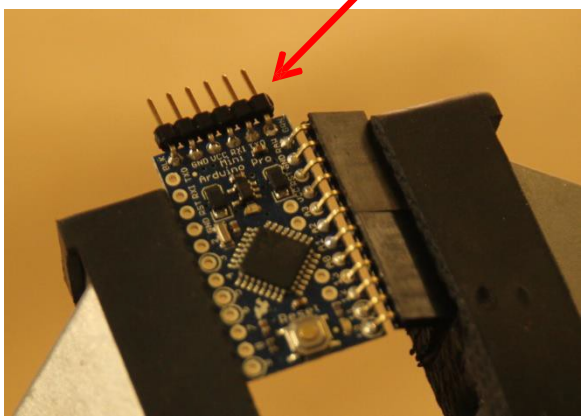


8. Then finish soldering the other joints.

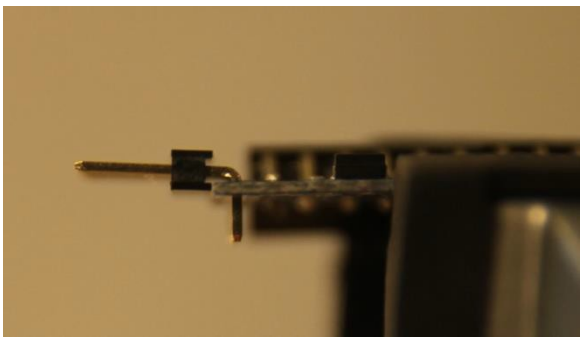


9. Flip over the Pro Mini Board with newly soldered female header pins and check the solder joints.

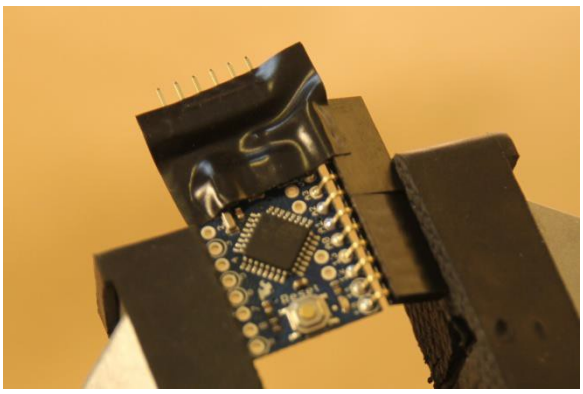
   Remove the male header pins that were used to align the female header pins.



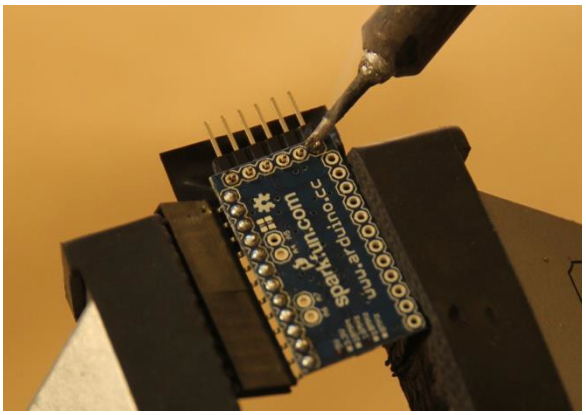
10. These will be soldered to the end of the Pro Mini Board adjacent to the female header pins as shown.



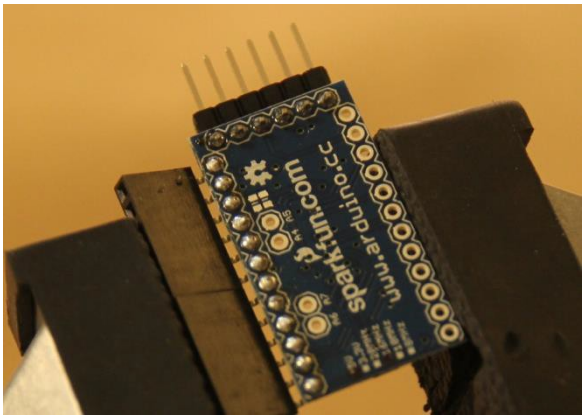
11. The six longer pins should stick straight out and be parallel to the Pro Mini Board. Shown here viewed from the side.



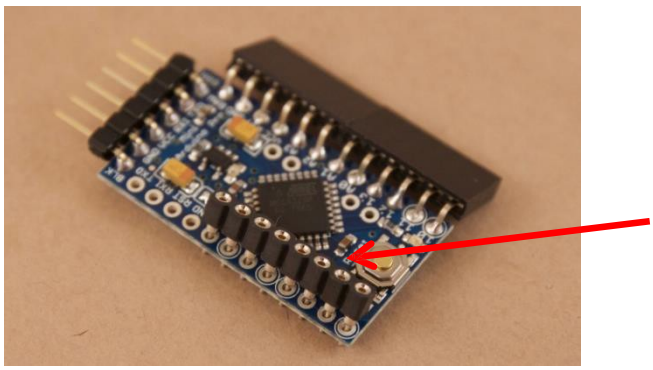
12. Tape male header pins in the position described above.



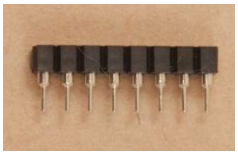
13. Flip the board over and solder the pins in place.

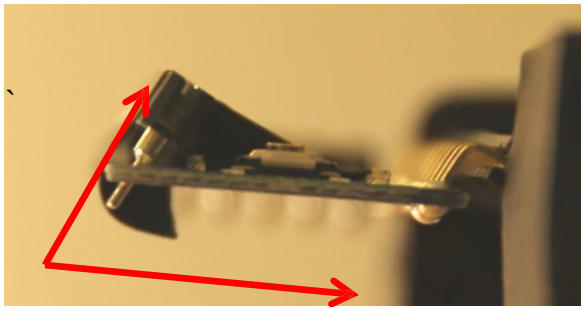


14. Check all solder joints.

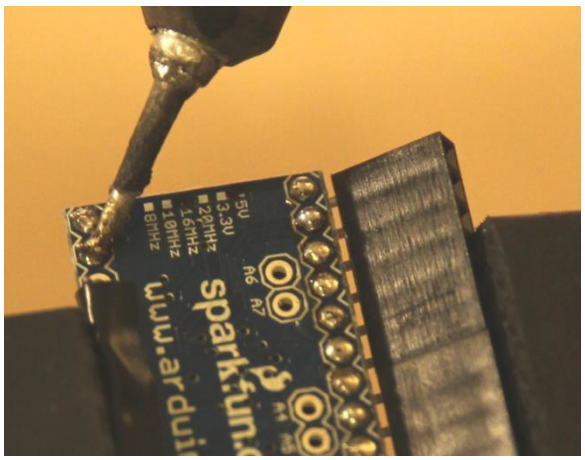


15. Remove the board from vise and position the socket pin set on Pro Mini as shown.

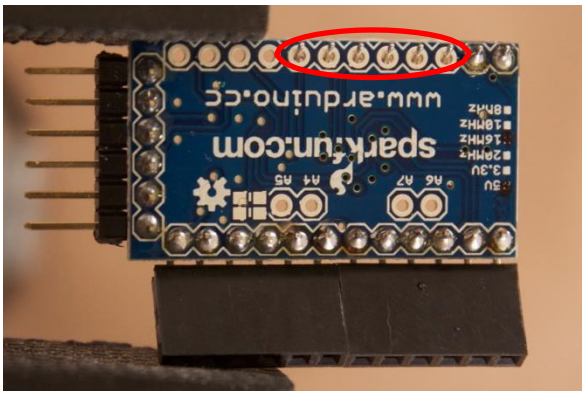




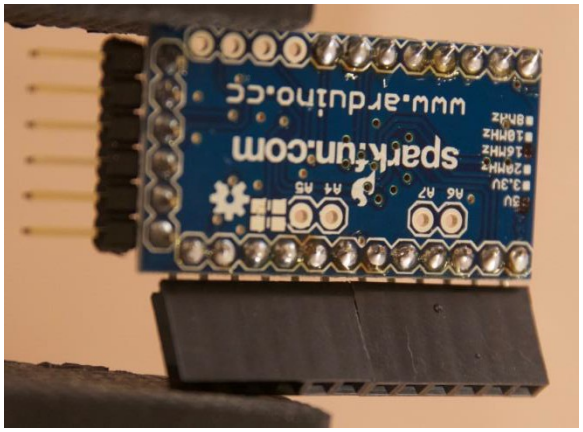
16. Tape the socket pins at an inward (acute) angle in relationship to the Pro Mini Board to secure them for soldering.



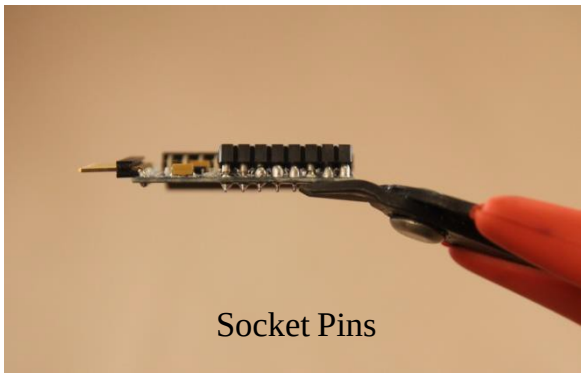
17. Place the board in a vise and solder the exposed socket pins.



18. Remove the tape and solder the remaining pins.

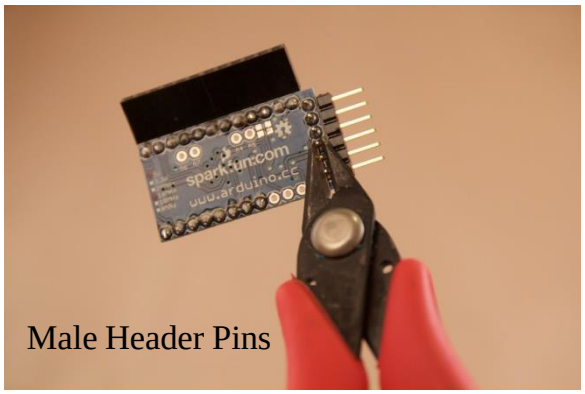


19. Check all solder joints.

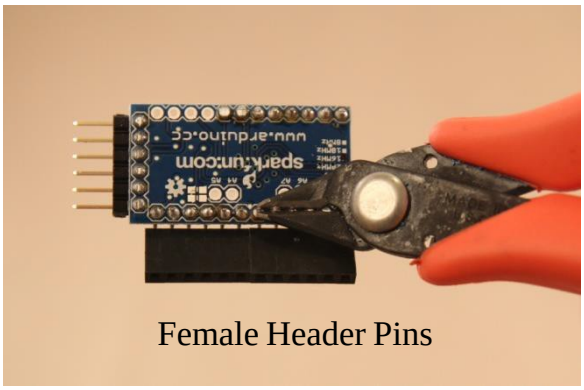


Socket Pins

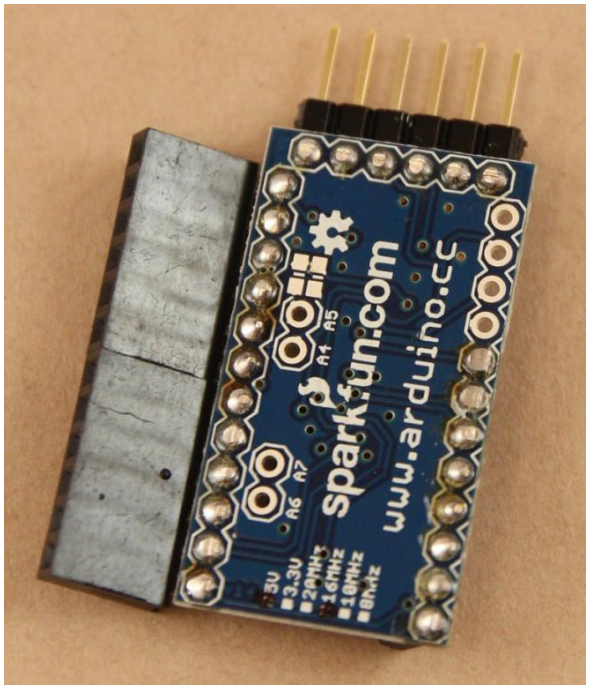
20. Use flush cutters to trim any excess pin material from the underside of all the solder joints. This allows the Pro Mini to more easily fit the contours of the buoyancy engine.



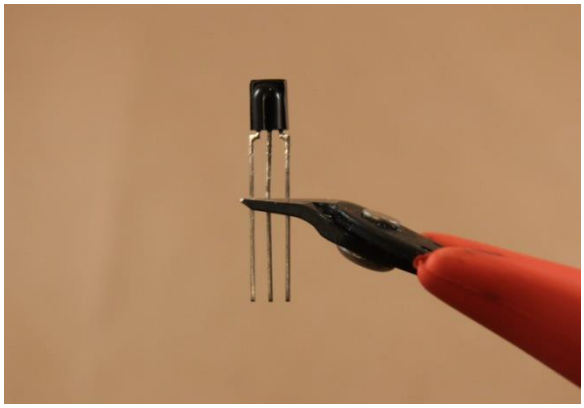
Male Header Pins



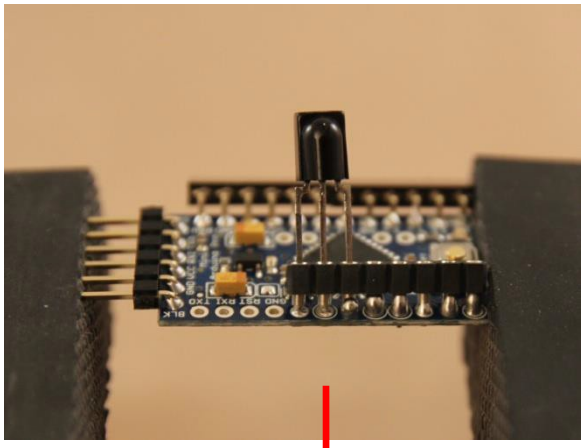
Female Header Pins



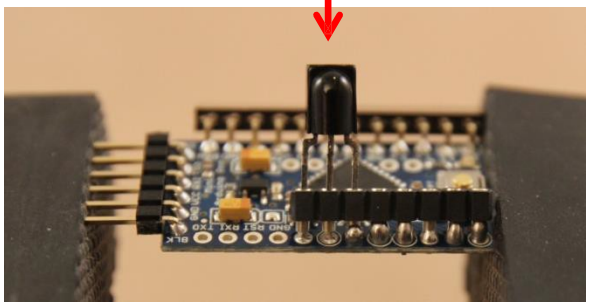
Trimmed Solder Joints



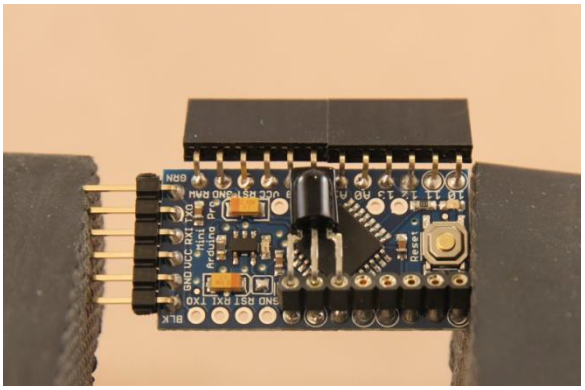
21. Prepare the IR Receiver for attachment to the Pro Mini Board by cutting the leads in half.



22. With the board secured upright, orient the IR Receiver with the photo detector “bump” outward and the leads aligned with the first three sockets in the socket pin row as shown.



23. Press the IR Receiver firmly in place.

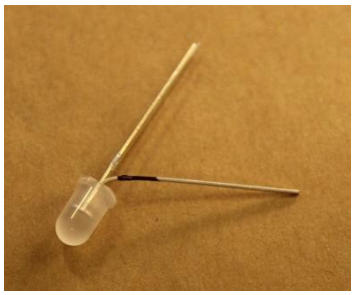


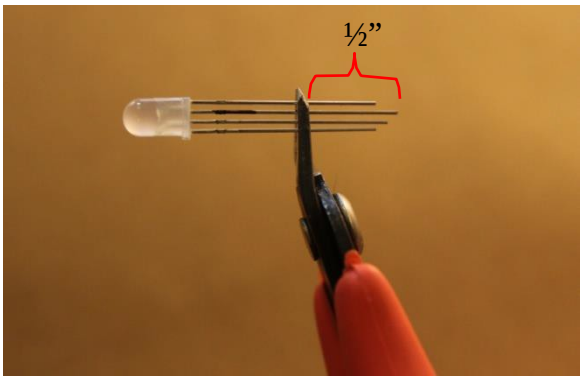
24. Bend the IR Receiver nearly flat against the Pro Mini Board. Done!

Next: The RGB LED.

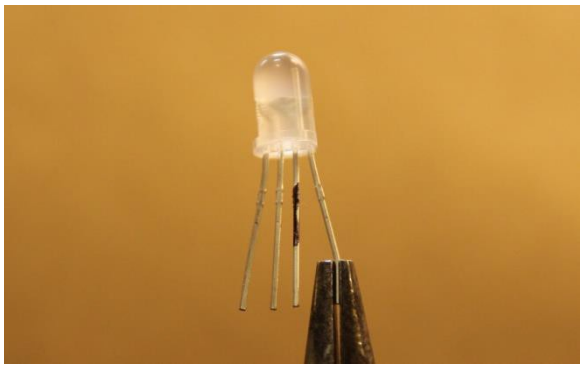
25. Locate the RGB (tri-color) LED and identify the longest lead which will be the common ground for the LED.

26. Bend this lead away from the others and mark it with a black marker.

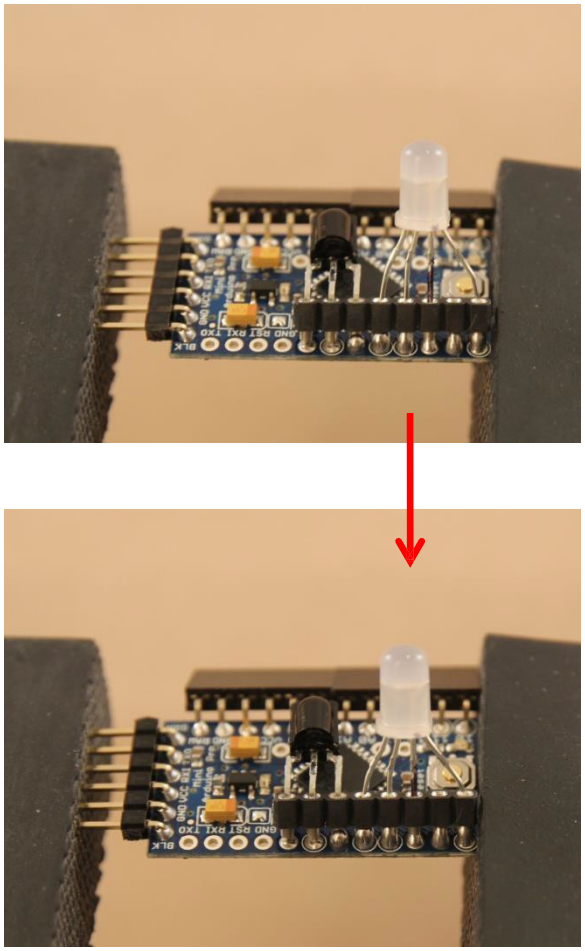




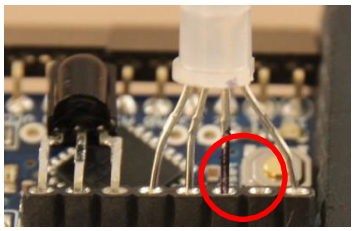
27. Clip all leads approximately 1/2” as measured from the longest pin.



28. Separate the leads and use needle nose pliers to bend the outer most wire (adjacent to marked lead) as shown. The tips of leads should roughly be parallel to one another.

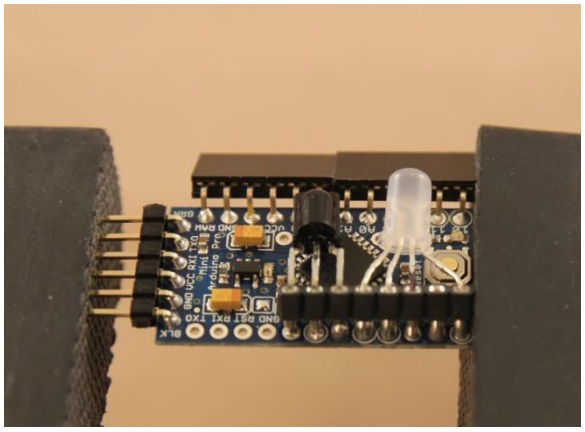


29. Fit RGB LED into the open socket pins next to the IR Receiver as shown. Notice that the socket that is second from the right is unoccupied.

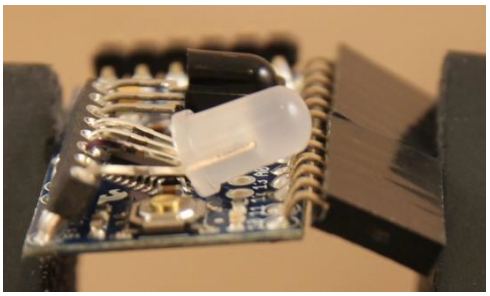


The marked lead should be at socket #7 (as marked on the Arduino) adjacent to this empty opening.

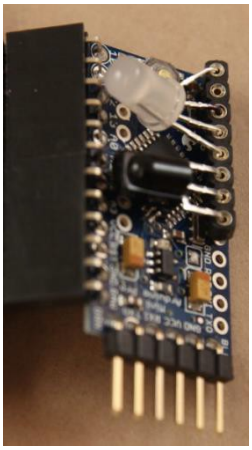
When the LED is aligned and matches the photos, press it firmly into place.



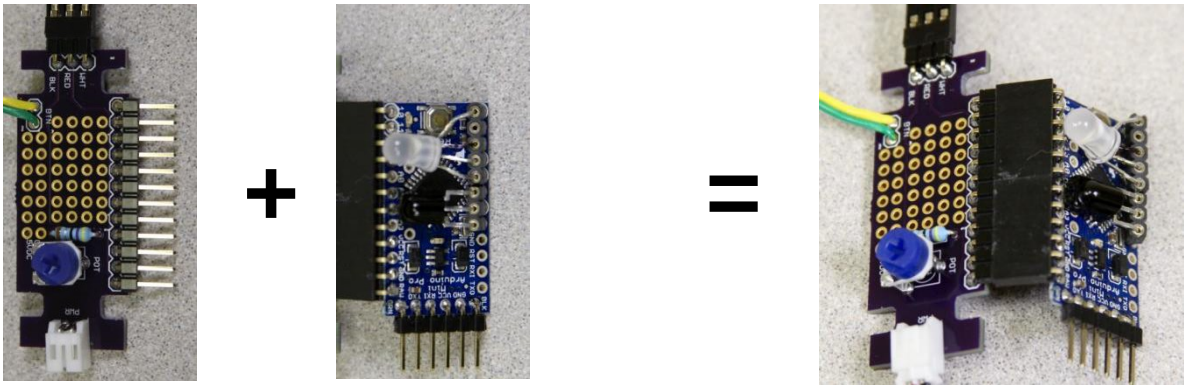
30. Bend the RGB LED so that the bulb nearly touches the Pro Mini board as shown.



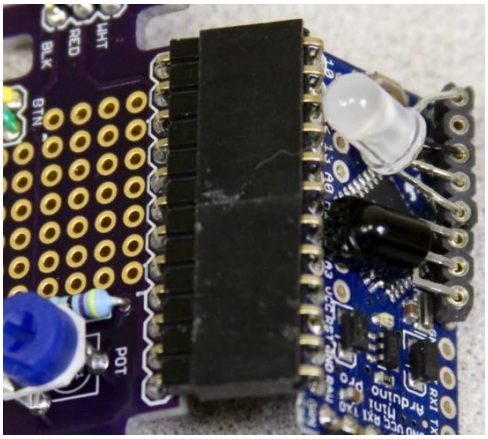
Done with the Pro Mini Board Build!



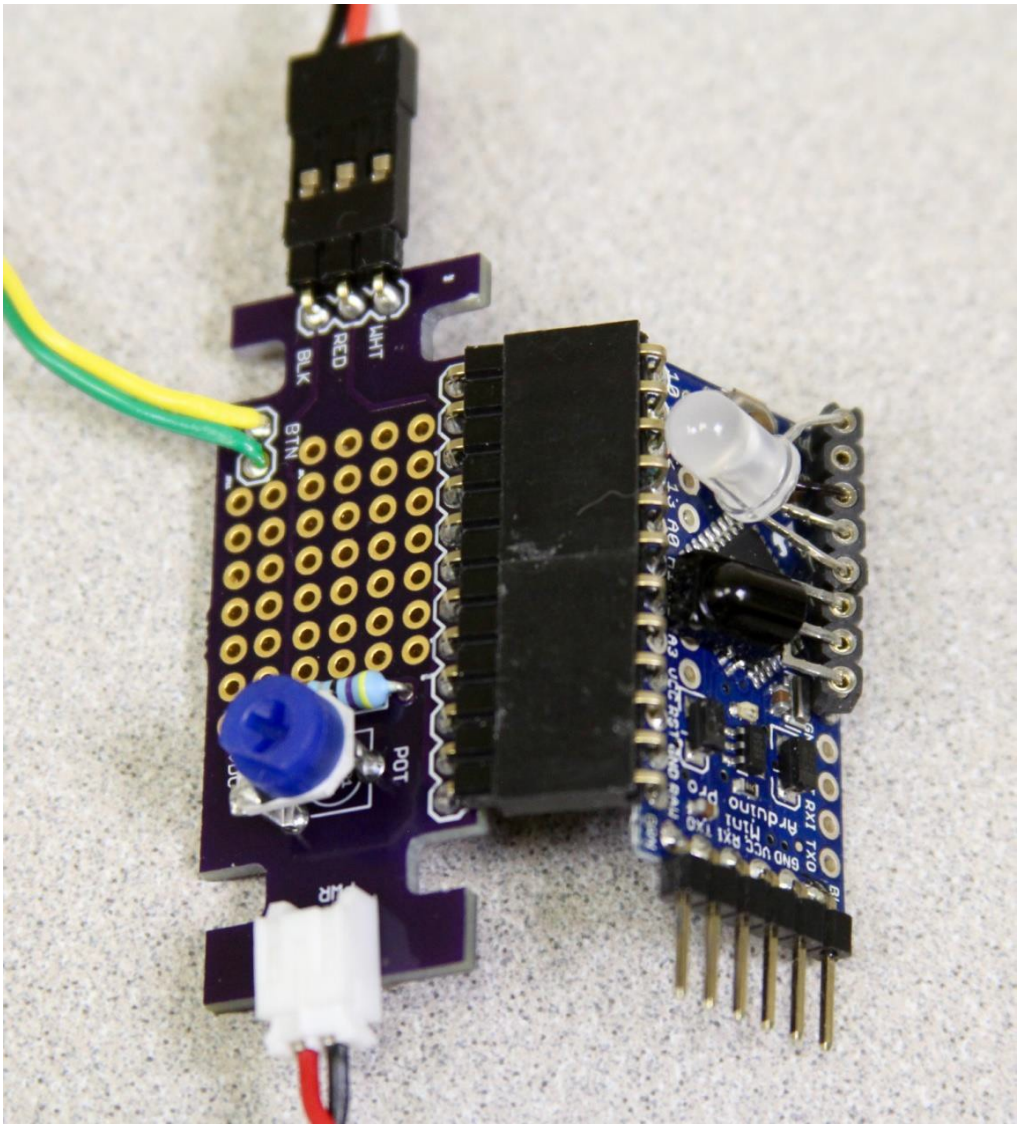
To assemble the final buoyancy engine controller, connect the Printed Circuit Board from instruction #4 to the female header pins on the Pro Mini Board Build.



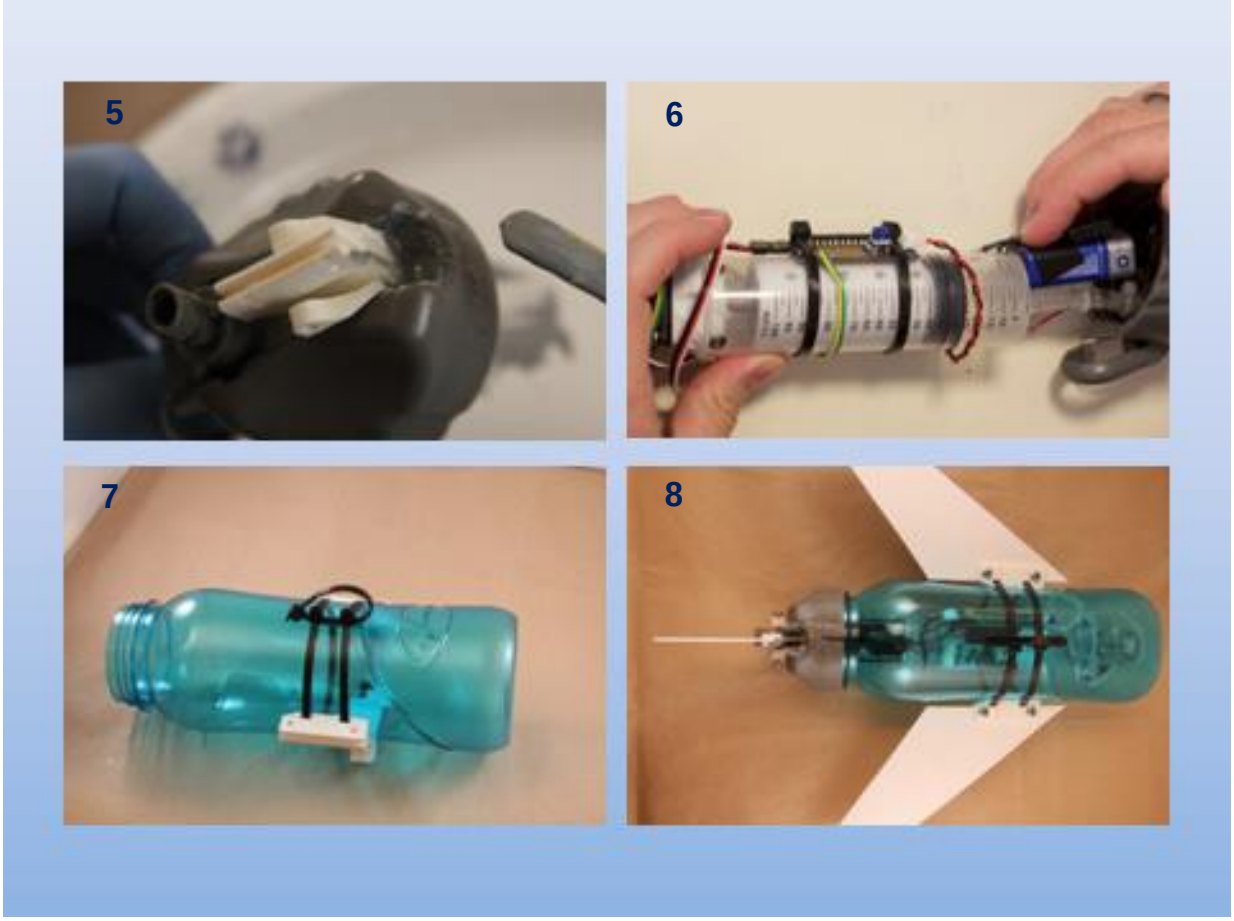
Make sure no power is connected and that the header pins align one-to-one in the orientation shown. Then press them firmly together.
WARNING: Mal-alignment can COOK your electronics.



Finished Buoyancy Engine Controller!

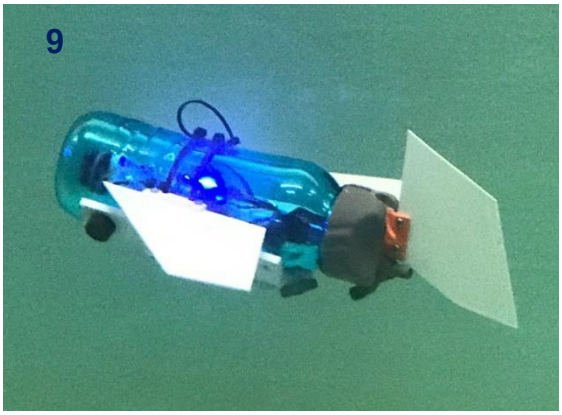


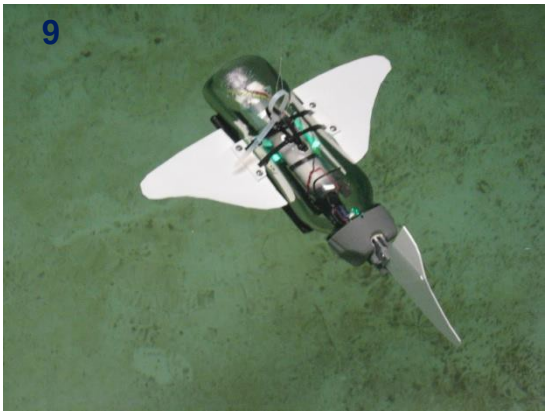
5-9 Bottle Prep & Ballast Overview



The Bottle Prep & Ballast instruction set is divided into five subsections:

5. Bottle Cap Preparation – Epoxy rudder mount to the bottle cap
6. Buoyancy Engine (BE) Assembly – Create a BE – Power Supply – Cap Assembly
7. Bottle Prep – Attach wing yoke to the bottle and insert Buoyancy Engine Assembly
8. Wing & Rudder Design – Create and attach wings and rudder
9. Ballast and Fly – Add ballast and fly glider

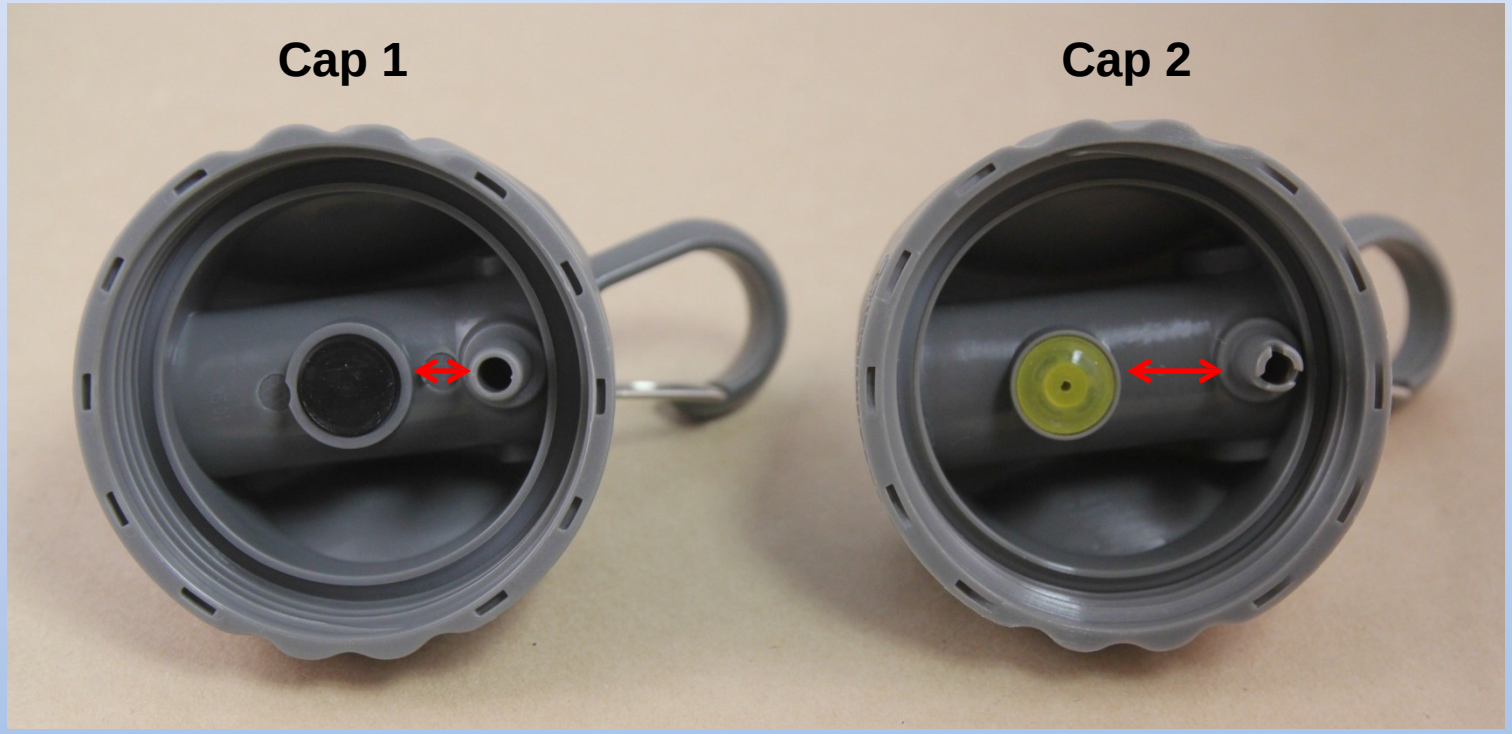




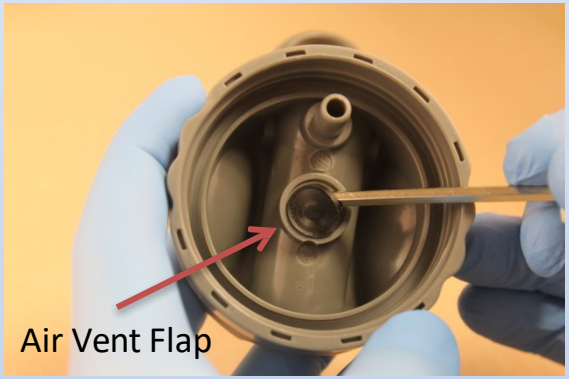
Rudder Mount

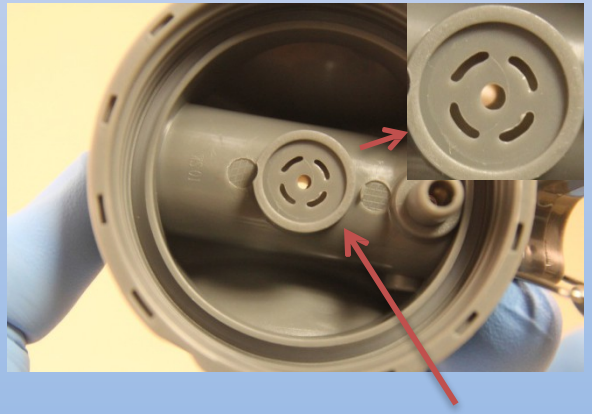
#6 Screw

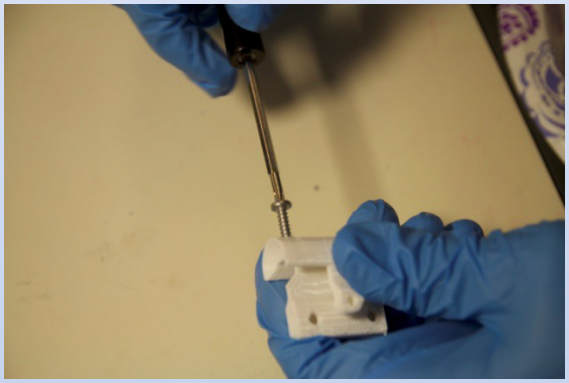
EPOXY

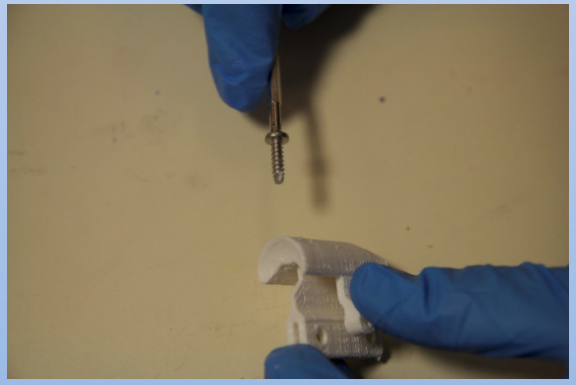


RED


Air Vent Flap

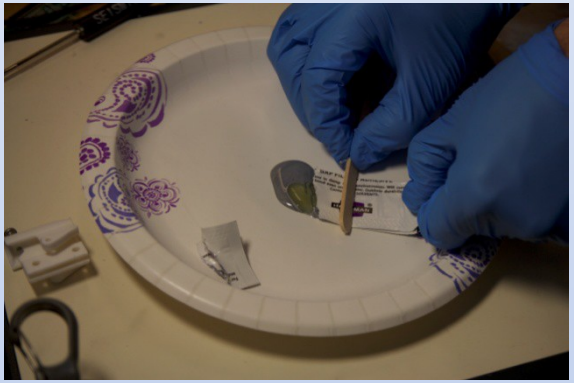




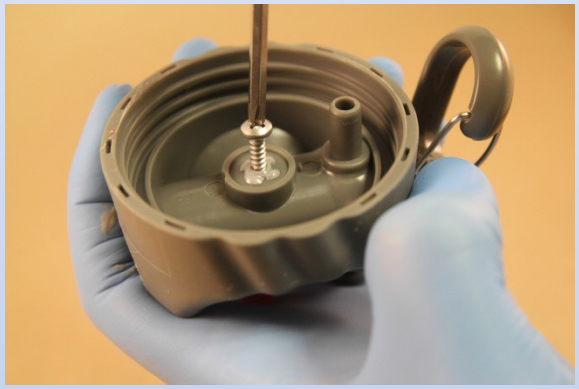


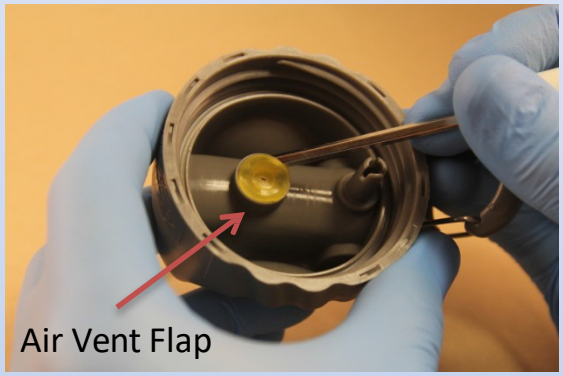
DOUBLE/BUBBLE®
EPOXY
WET SURFACE PATCHING
GAP FILLING ADHESIVE
HARDMAN

GAP FILLING ADHESIVE

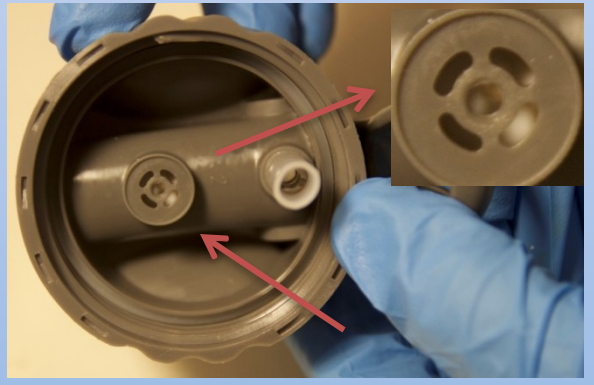


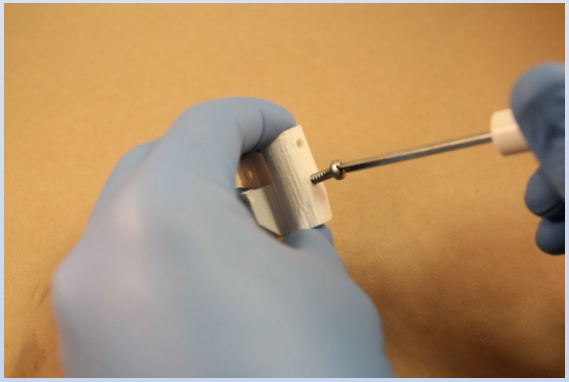
All REAGENTS

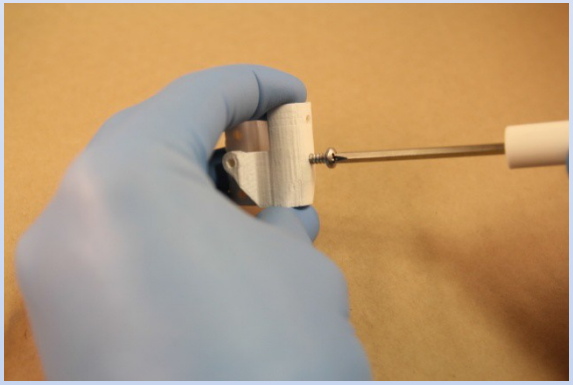


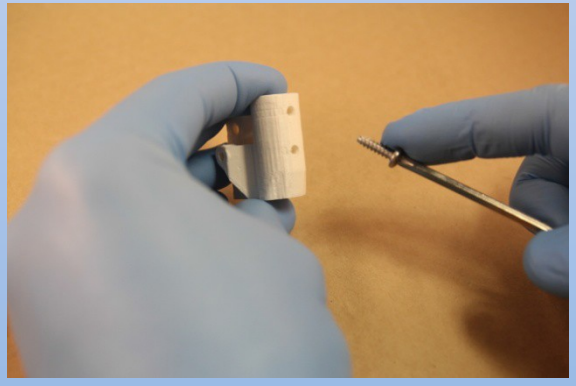

Air Vent Flap

Correct Screw Hole









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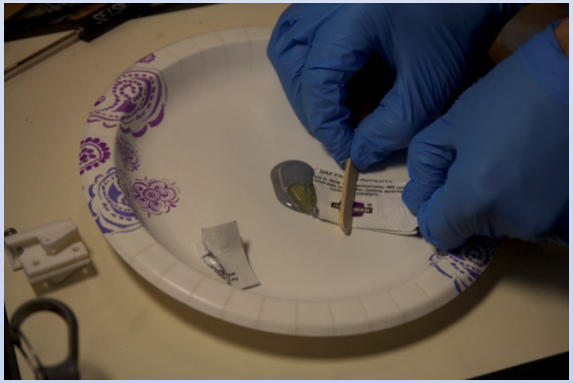
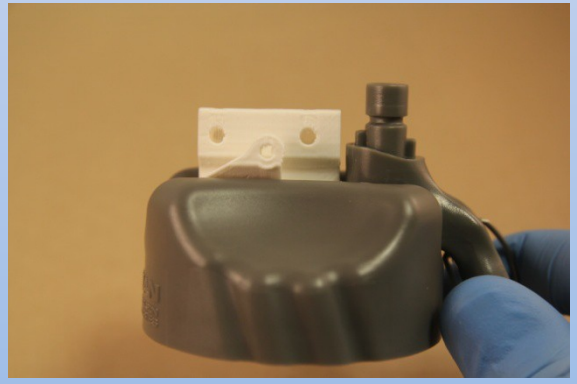
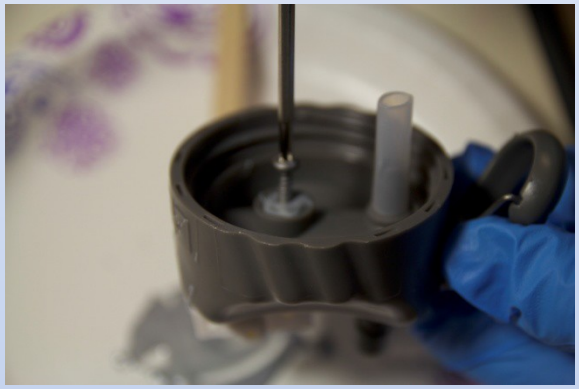
HARDMAN

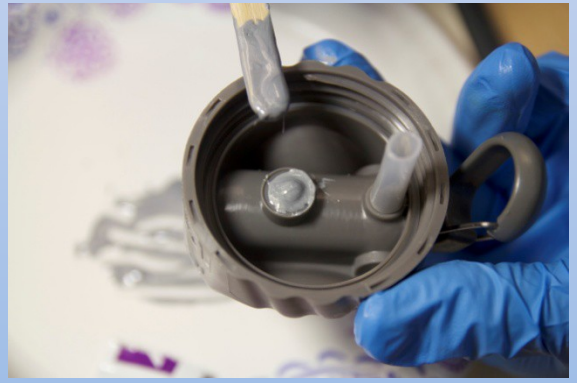
GAP FILLING ADHESIVE



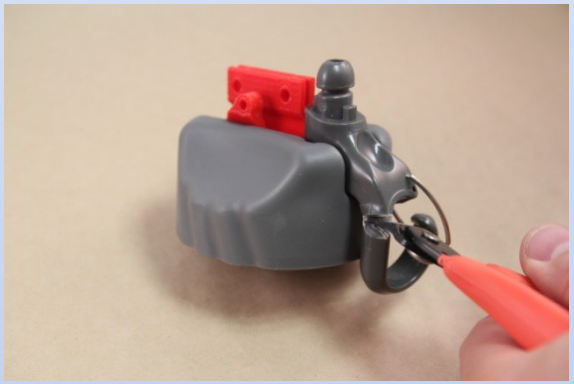
All REAGENTS

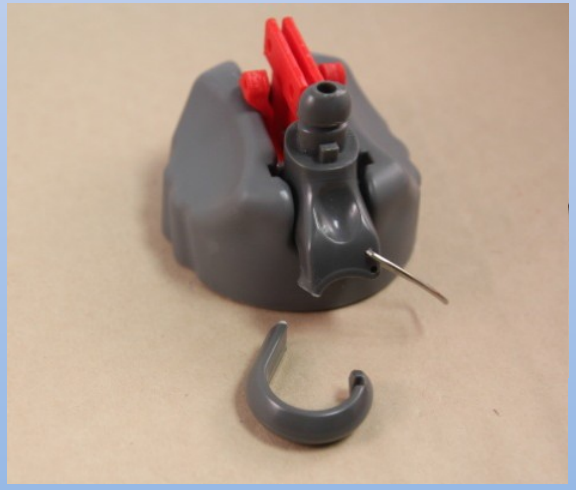


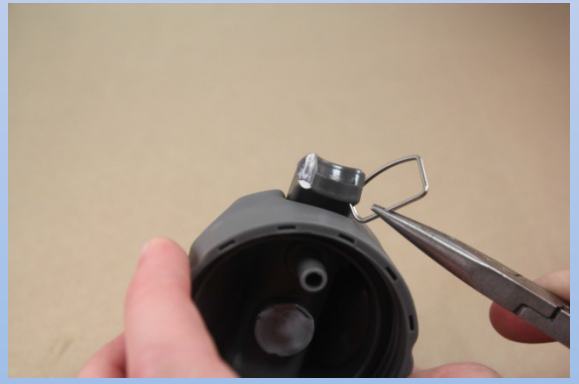


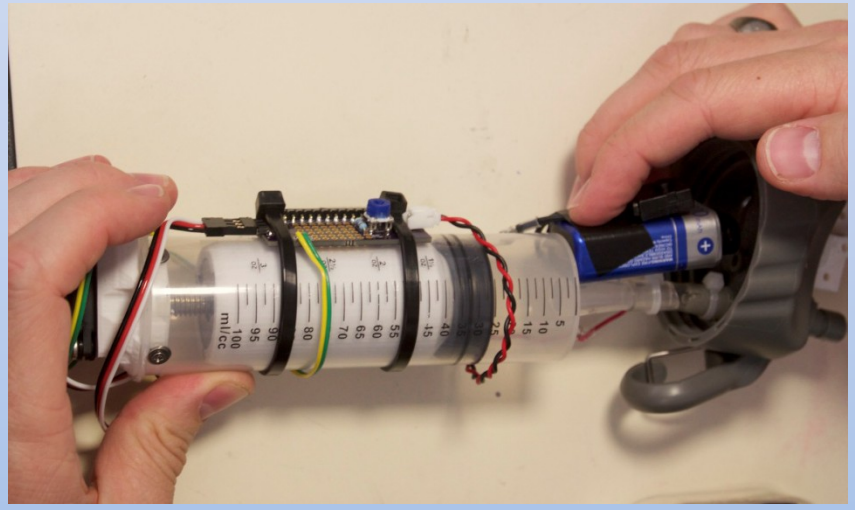


Safety goggles





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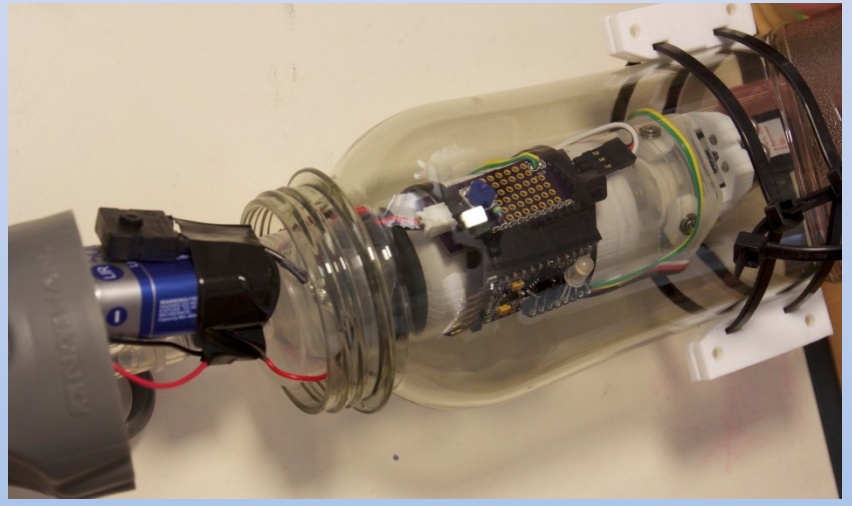

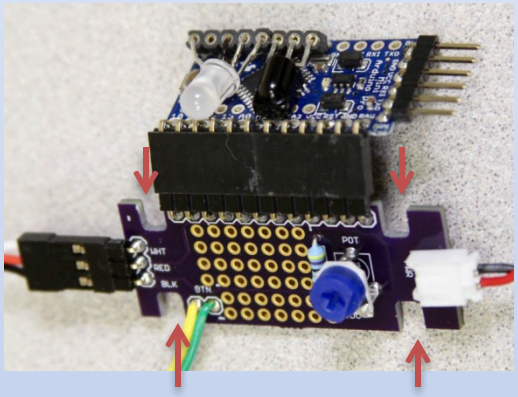

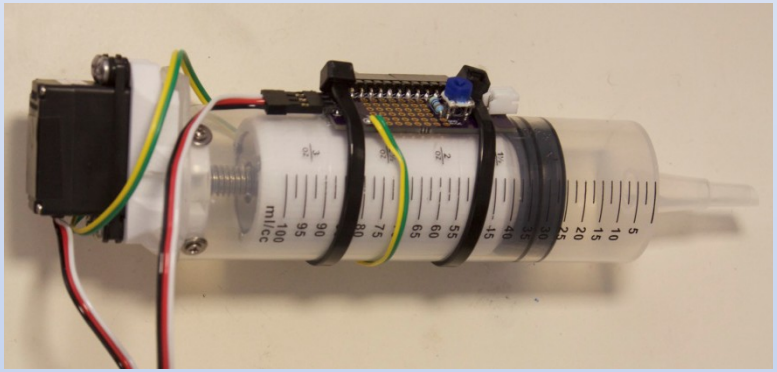

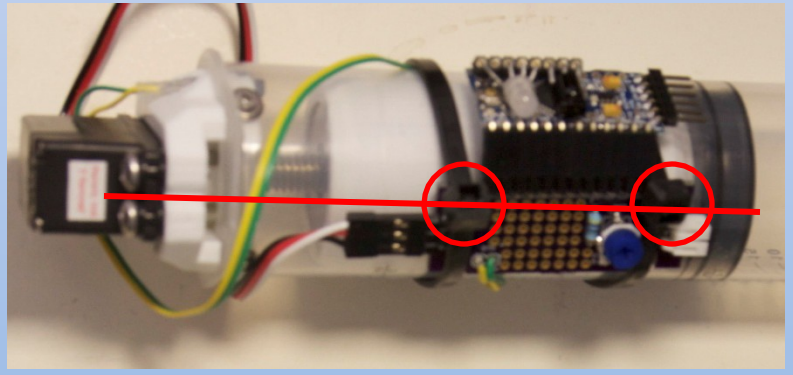

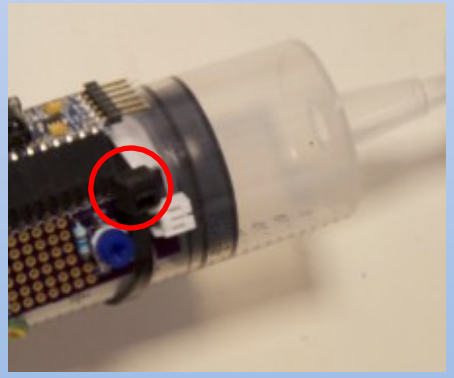

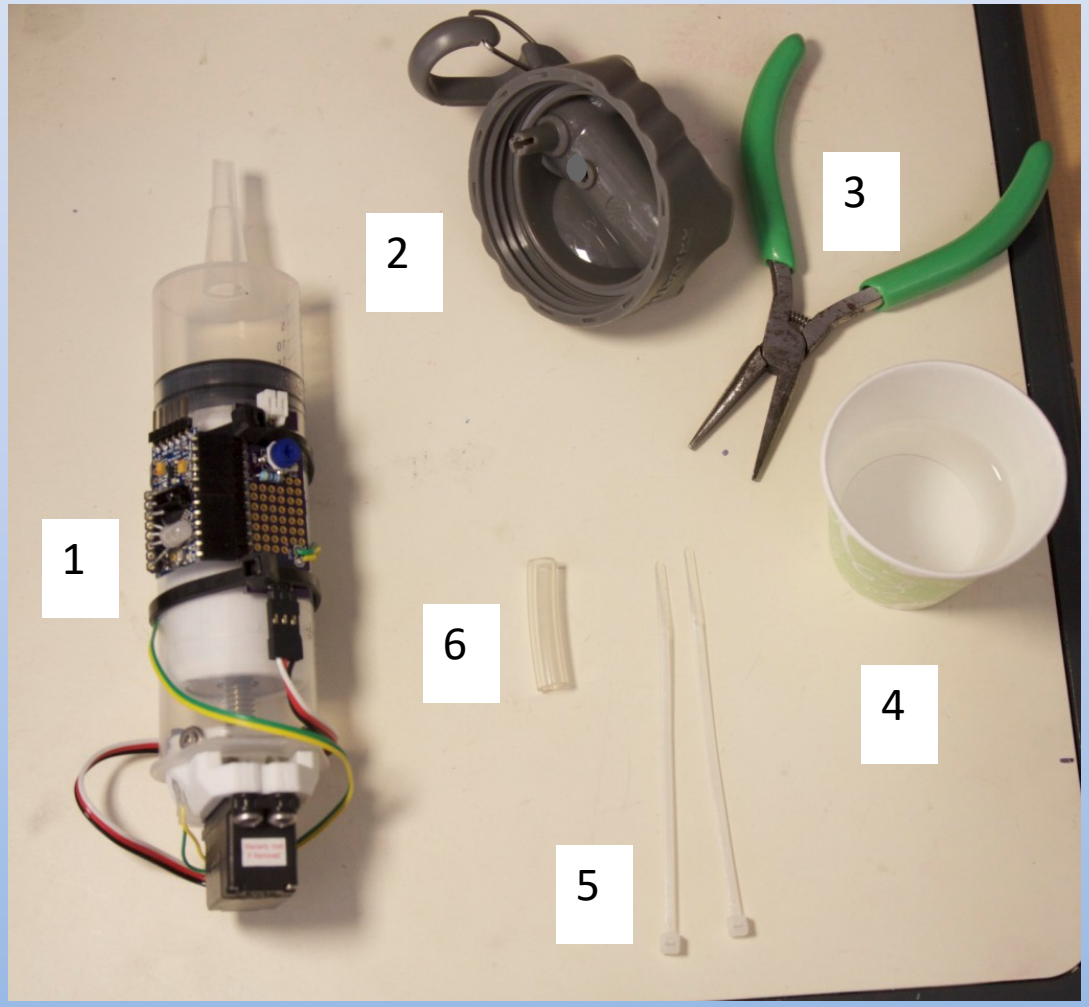
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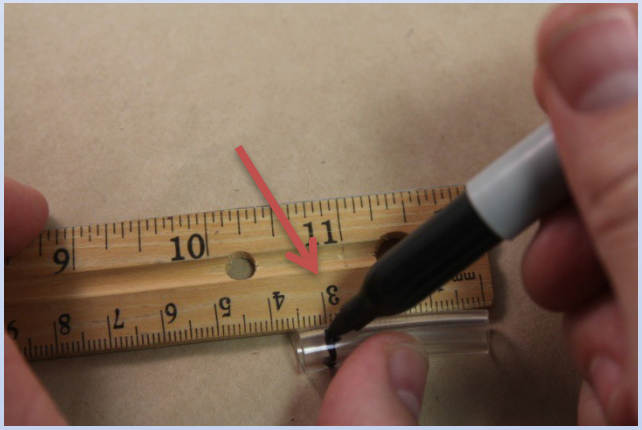
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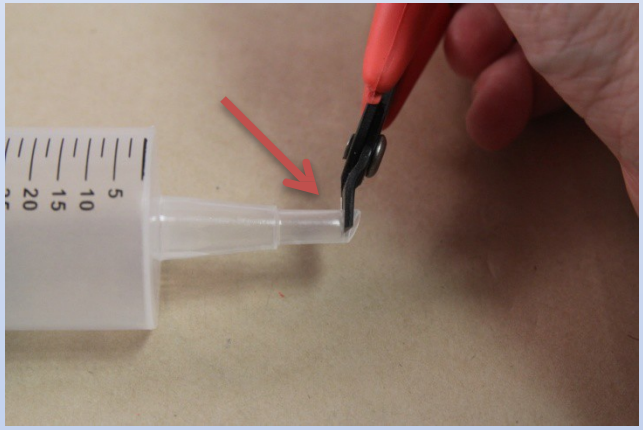

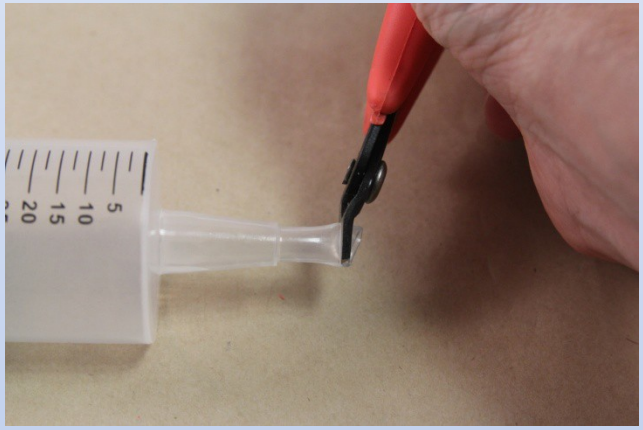

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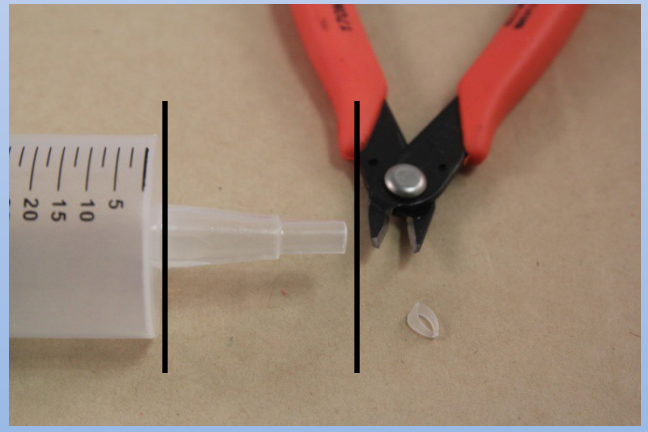
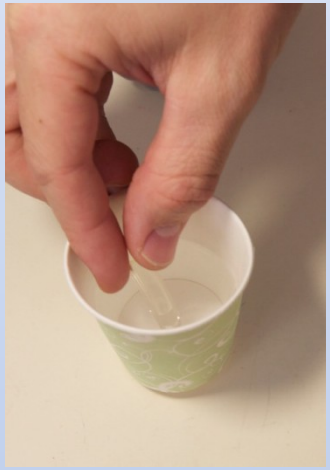
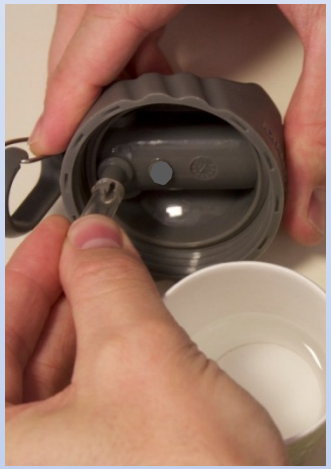
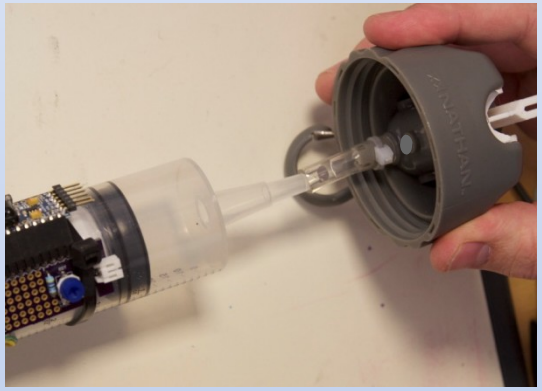
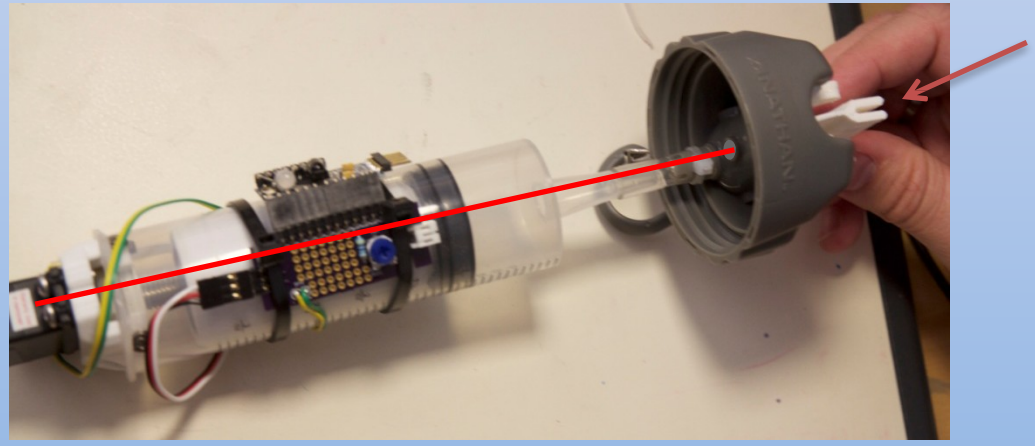
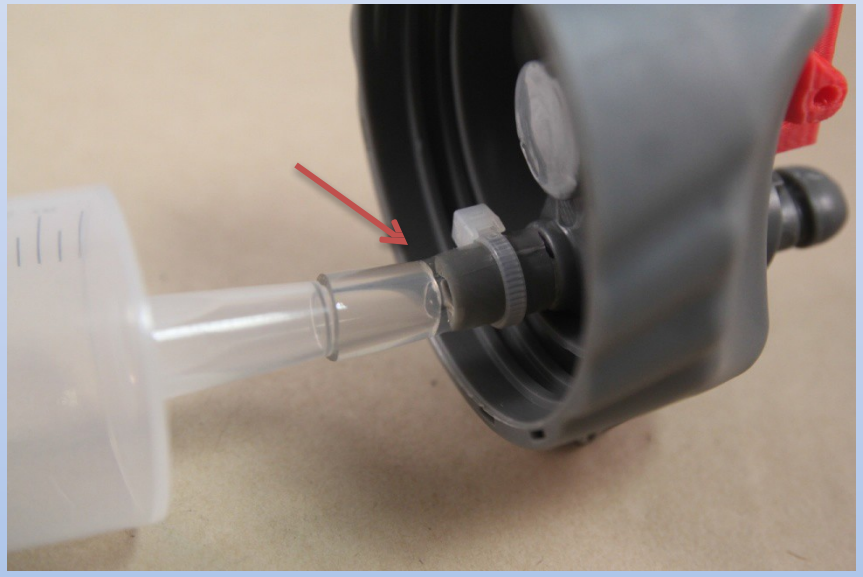


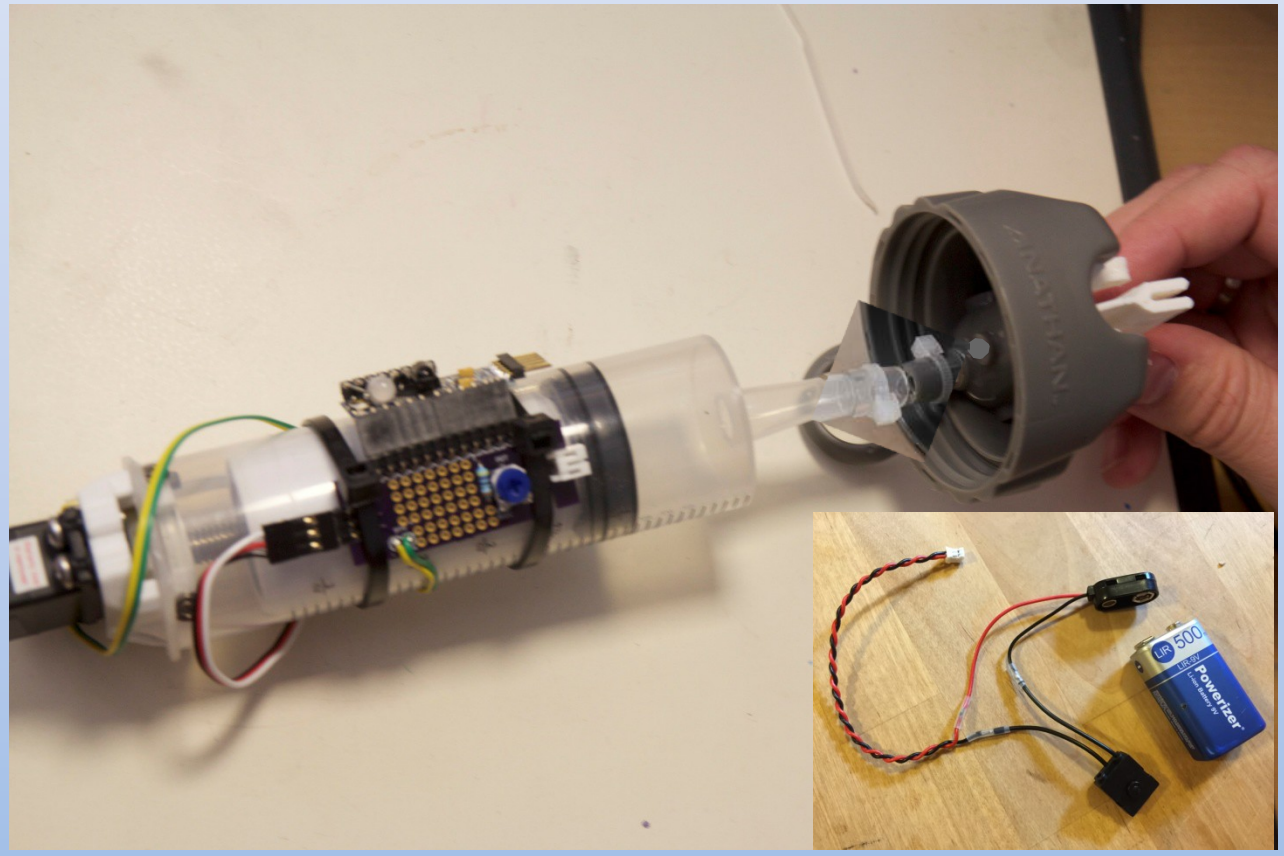




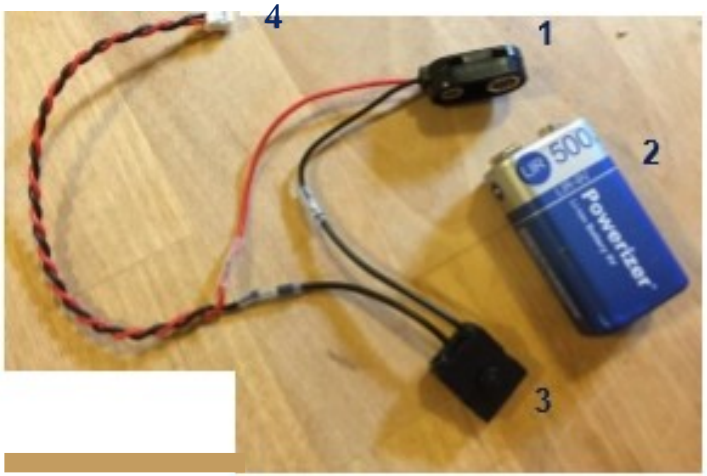







Powerizer

Po\ver Supply Review



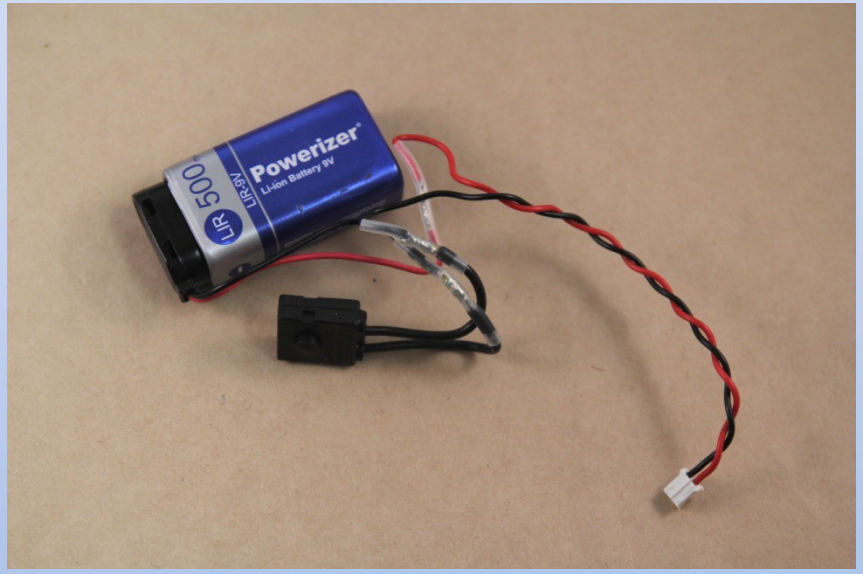
The power supply provides 8.4 volts of direct current to the buoyancy engine **controller v..rhere the \roltage** is reduced to approximately 7 **volts by a resistor. The pov.er supply includes a snap connector, a 9 volt** rechargeable Lithium battery, **and a pushbutton S\vitch** which is the ON/OFF control **for the circuit.**

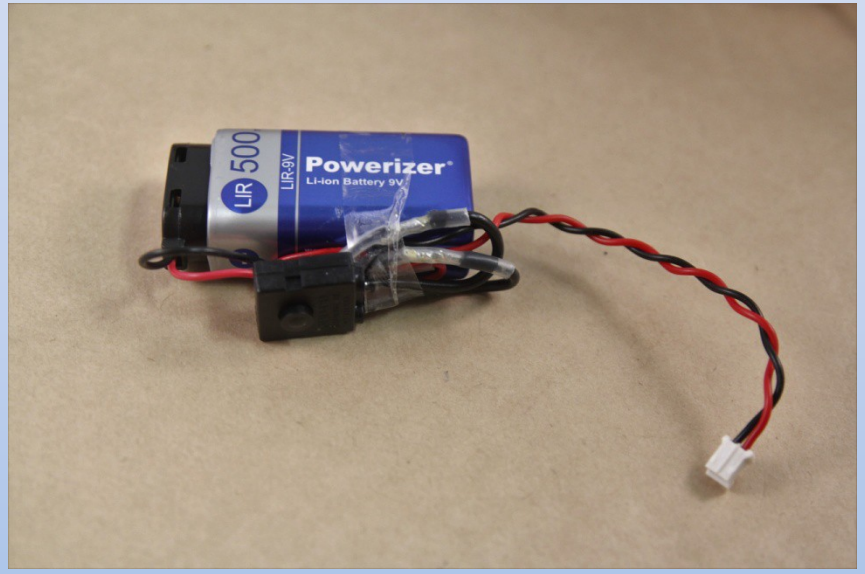
The power supply also includes a plug that connects to the buoyancy engine controller by sliding into the power supply jack on controller's circuit board.

The main components of the pov.er supply are:

1. BATTERY SNAP CONNECTOR - Connects battery to power supply circuit.
2. LITHIUM BATTERY -Provides 8.4 volts of rechargeable power.
3. PUSHBUTTON SWITCH -The ON/OFF **control for the circuit.**
4. POWER SUPPLY PLUG-Provides **po\ver to the buoyanc}'engine controller** by plugging into the power supply jack.

Buoyancy Engine Controller


LIR 500
LIR-9V
Powerizer
Li-ion Battery 9V


LIR 500
LIR-9V
Powerizer
Li-ion Battery 9V

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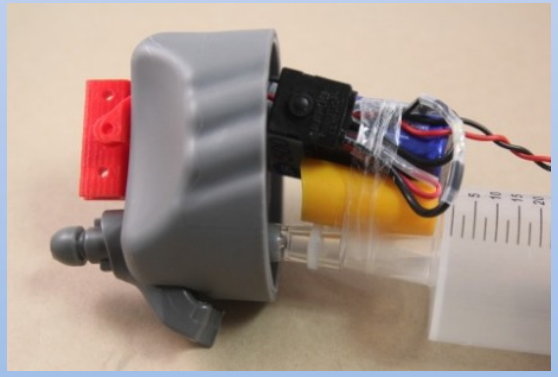
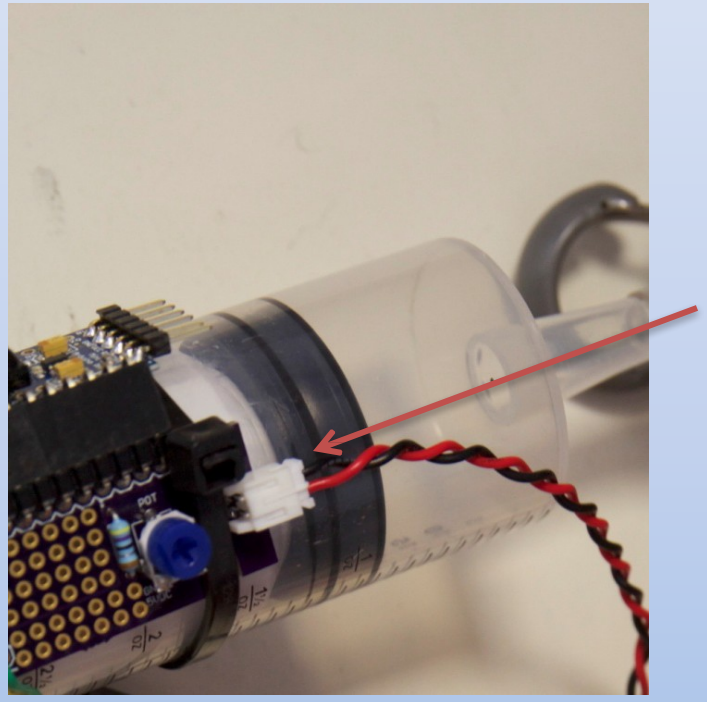
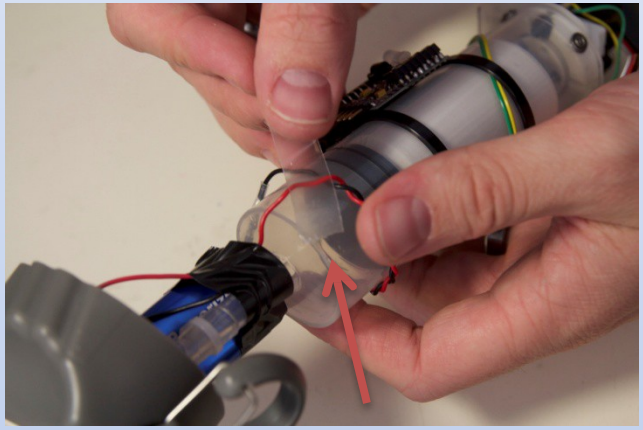
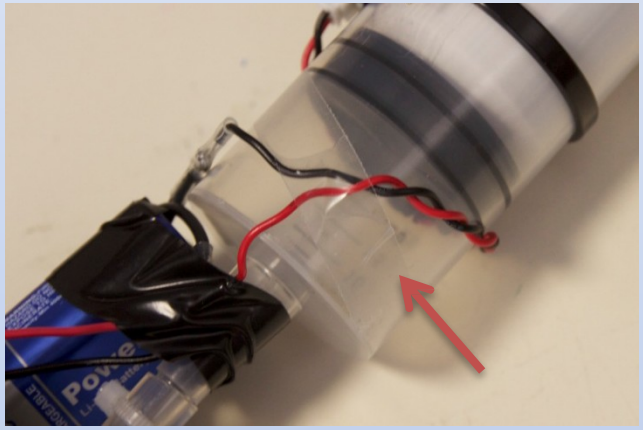
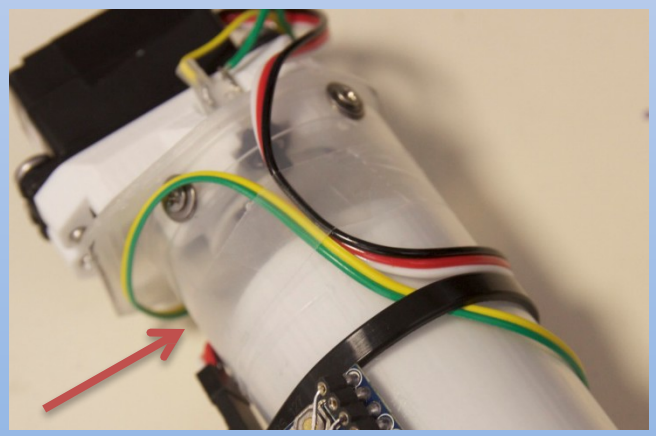


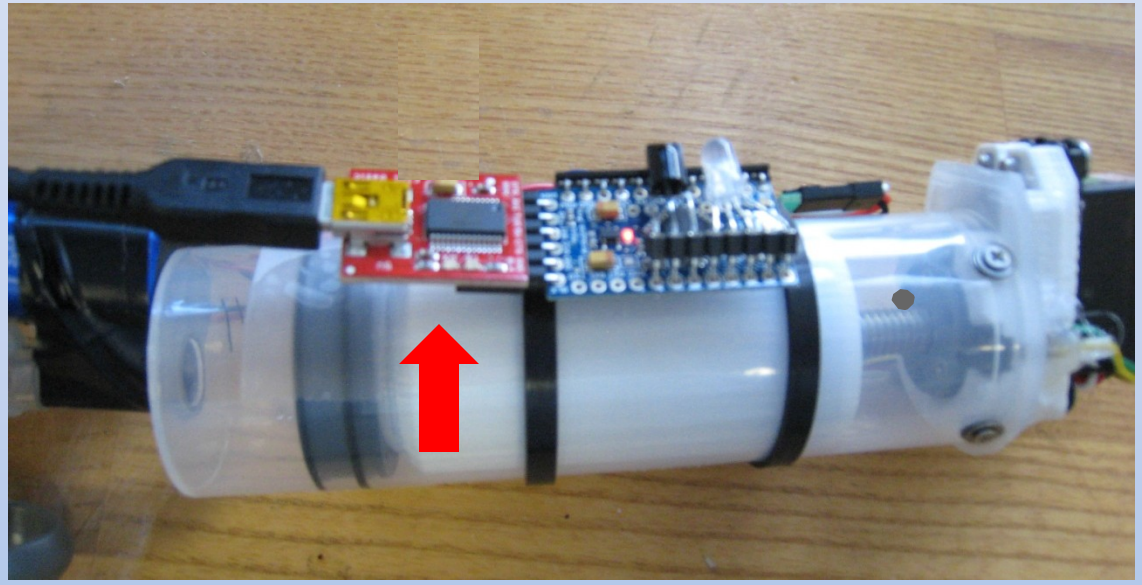
LIR

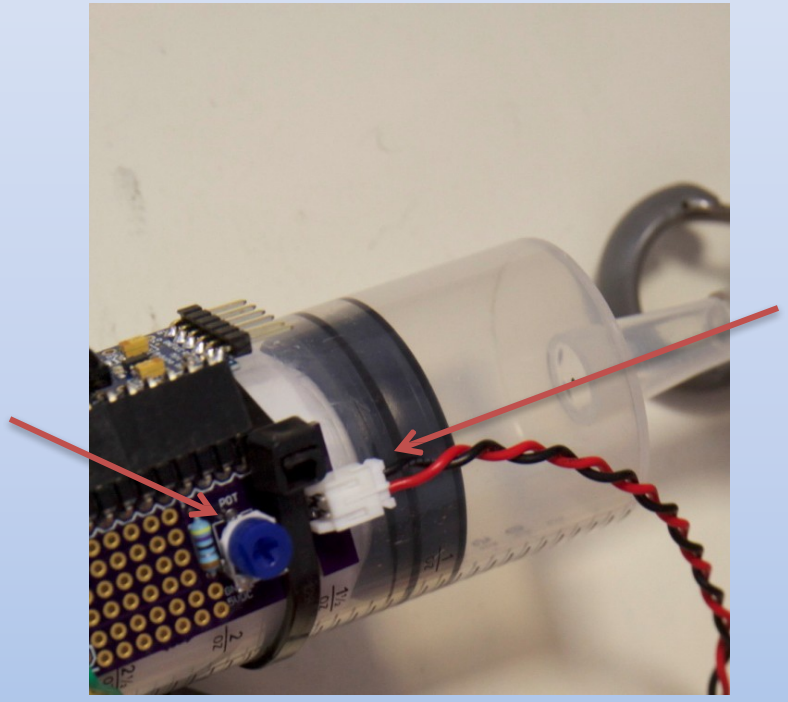


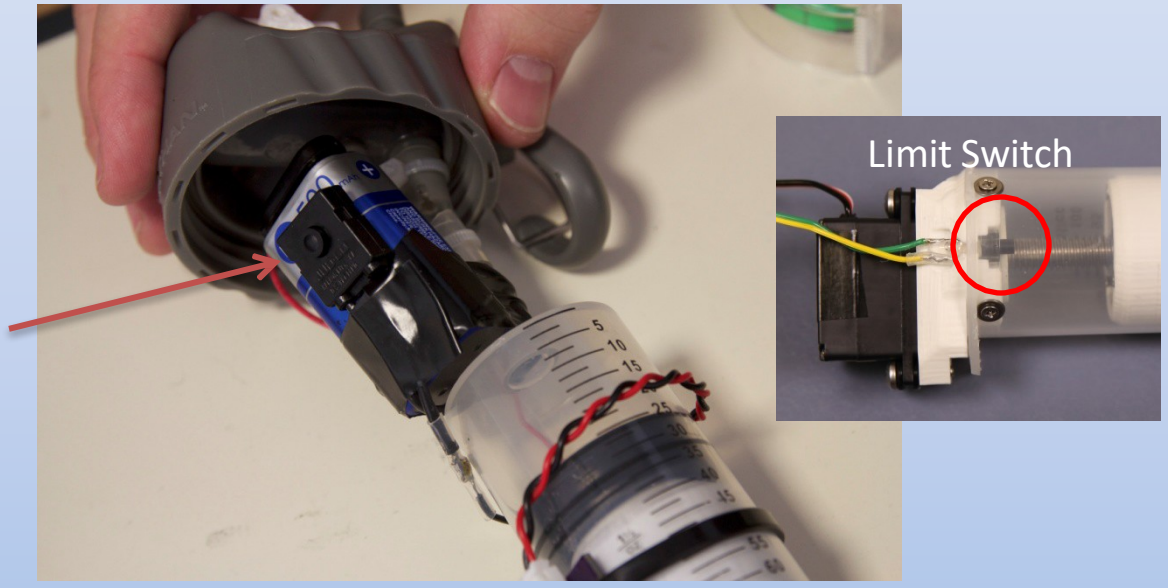




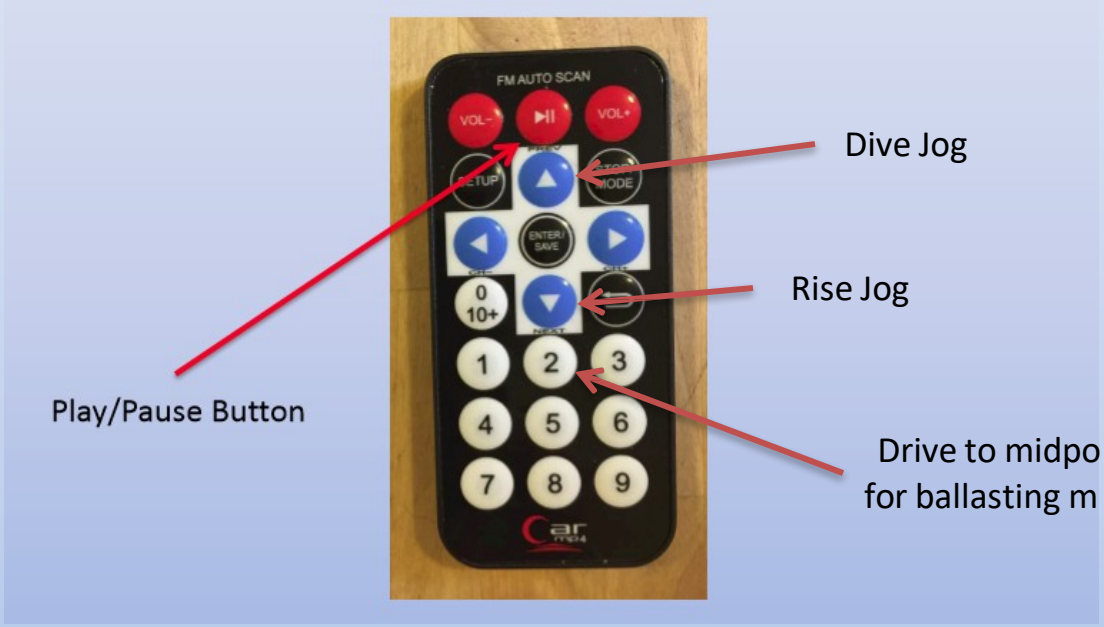


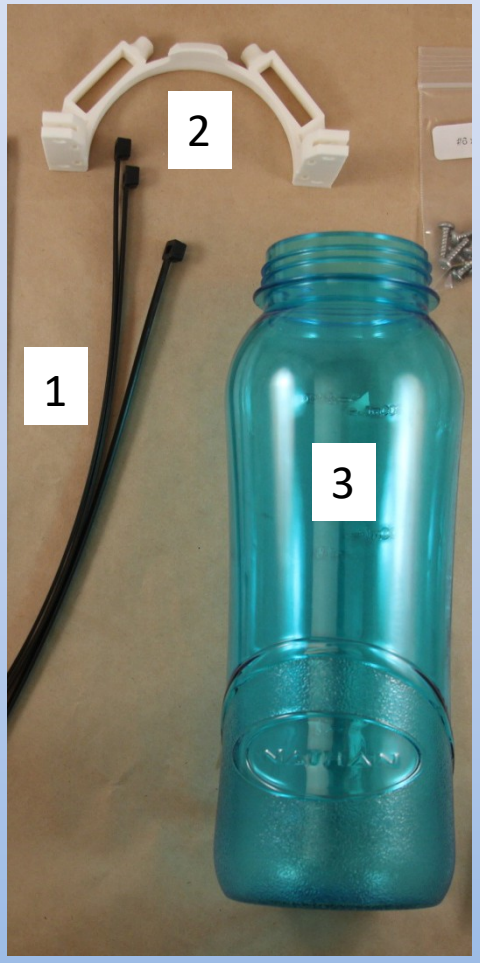



POT



READ


FM AUTO SCAN
VOL-
VOL+
SETUP
MODE
ENTER SAVE
0 10+
1
2
3
4
5
6
7
8
9
Play/Pause Button
Dive Jog
Rise Jog
Drive to midpo
for ballasting m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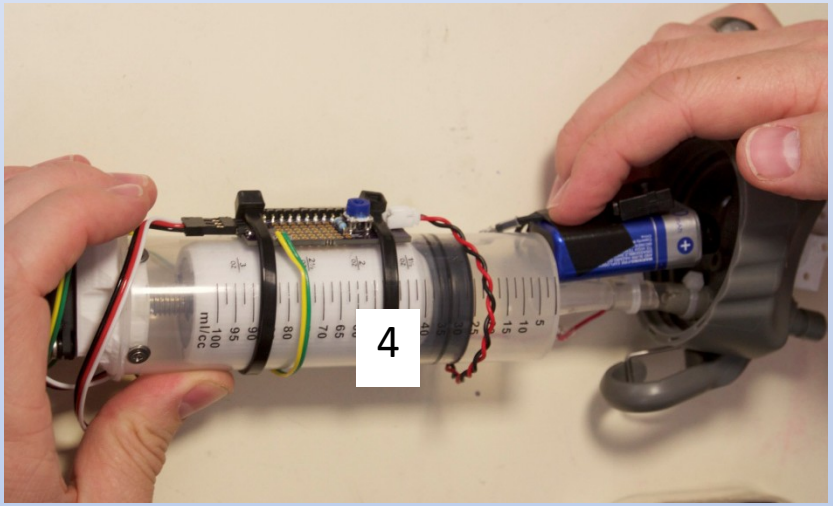
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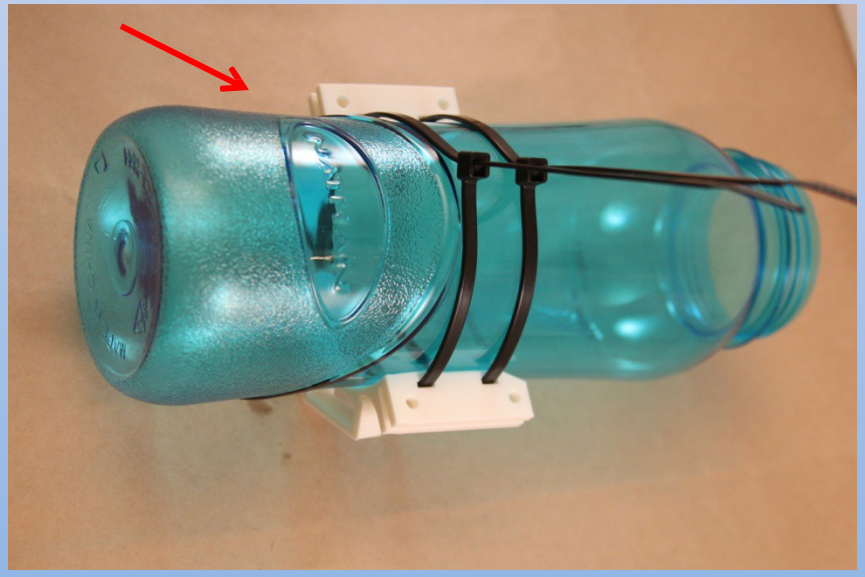
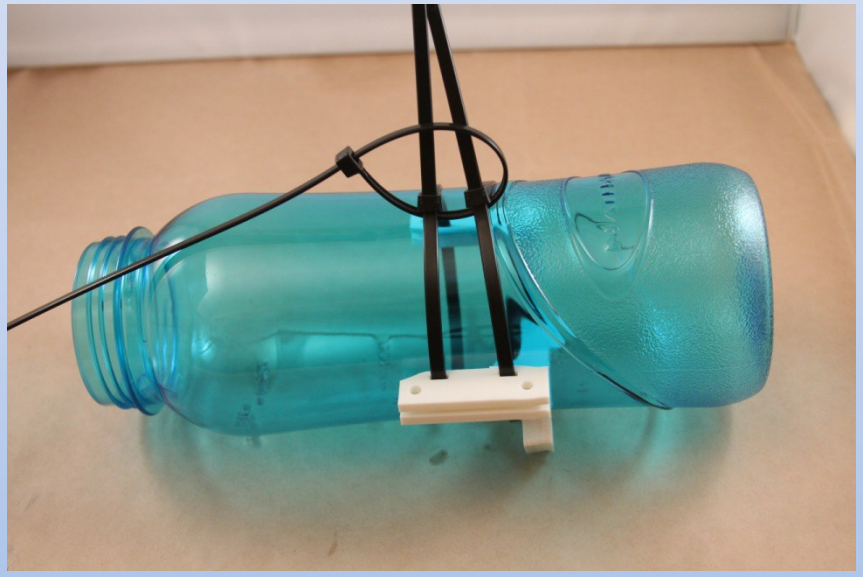
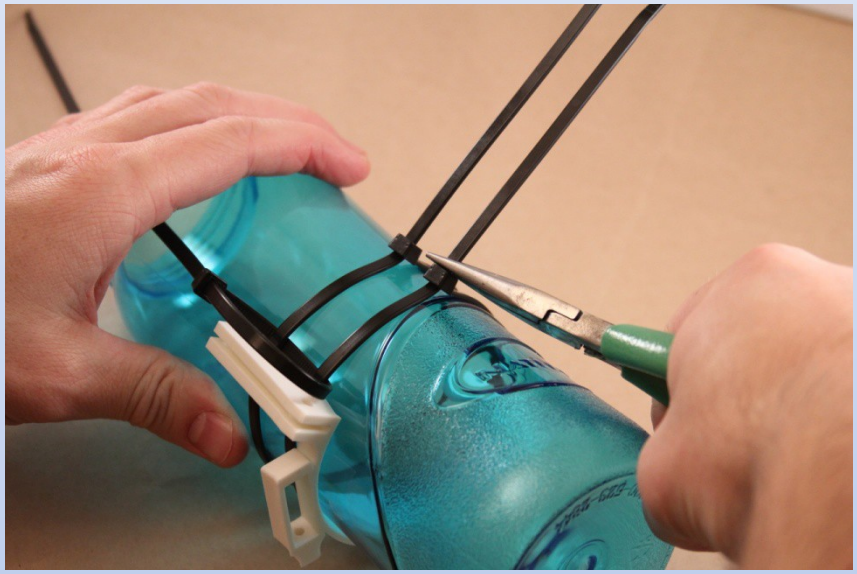
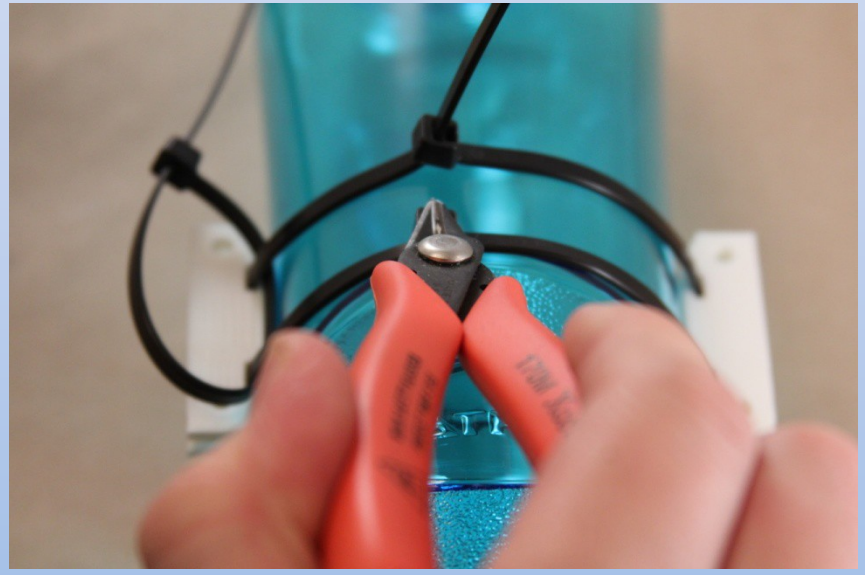
Zip Tie Teeth Facing In





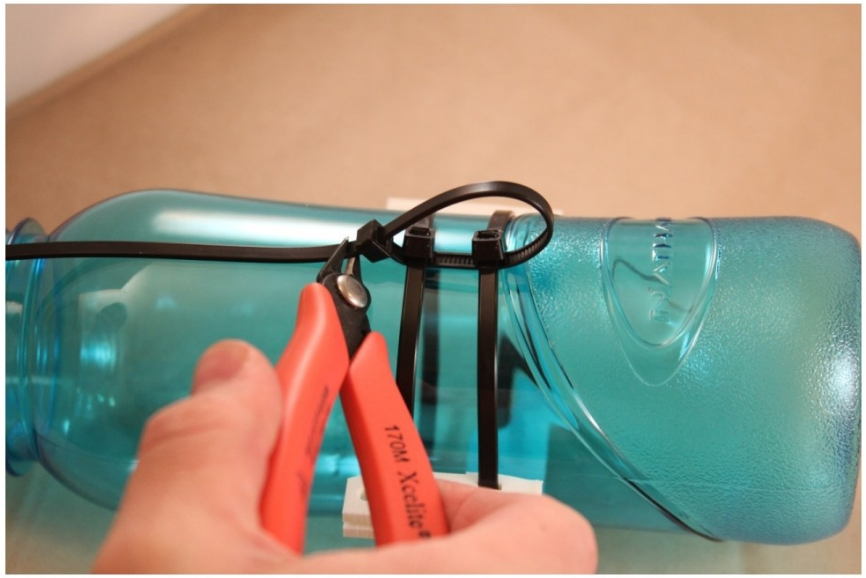
NATHAN

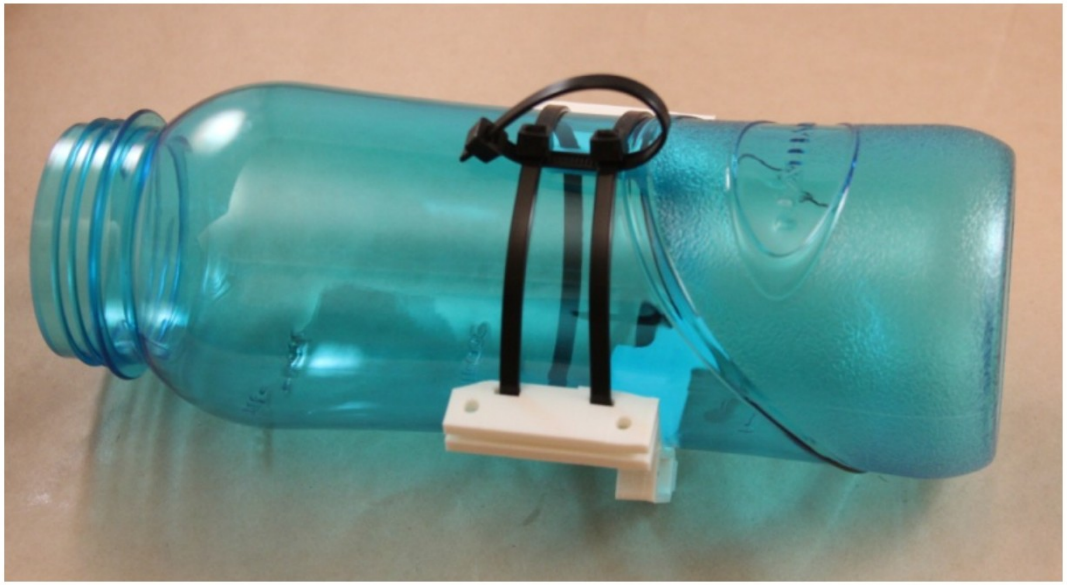


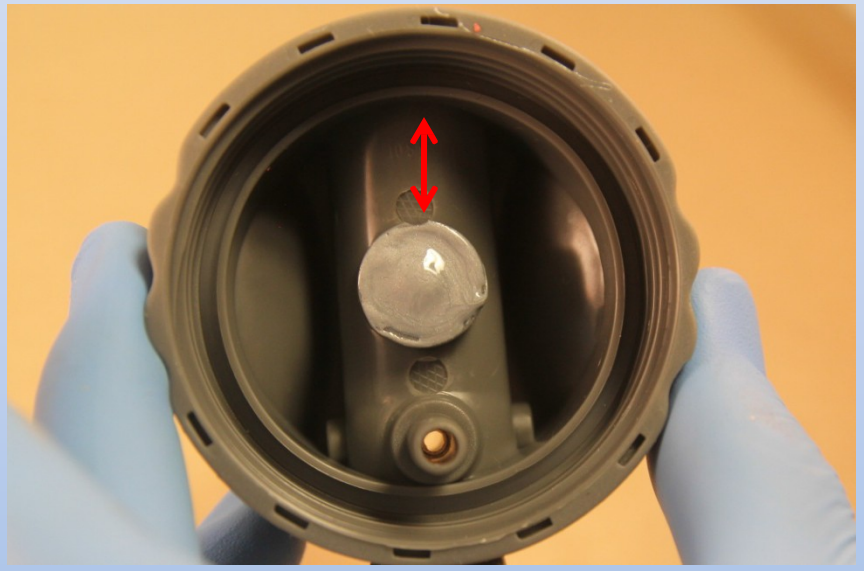


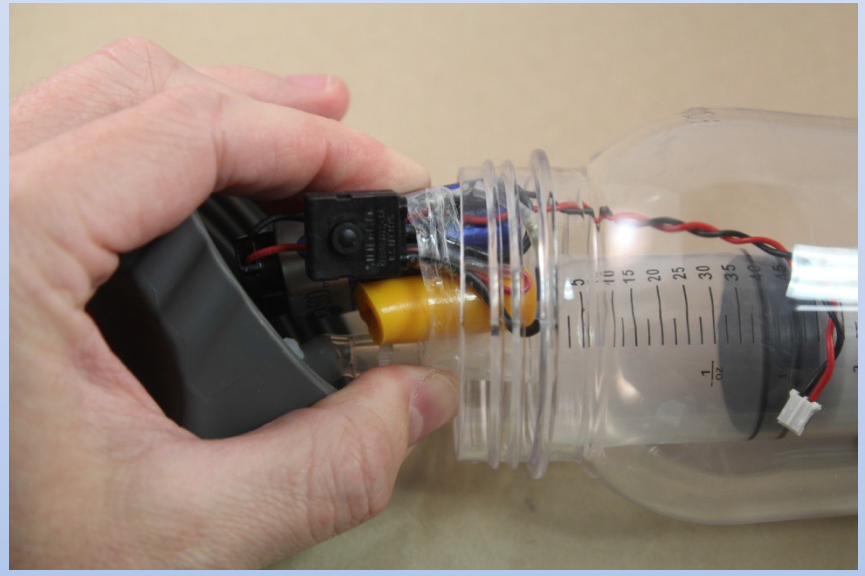
WEAR SAFETY GLASSES
PROTECT YOUR EYES

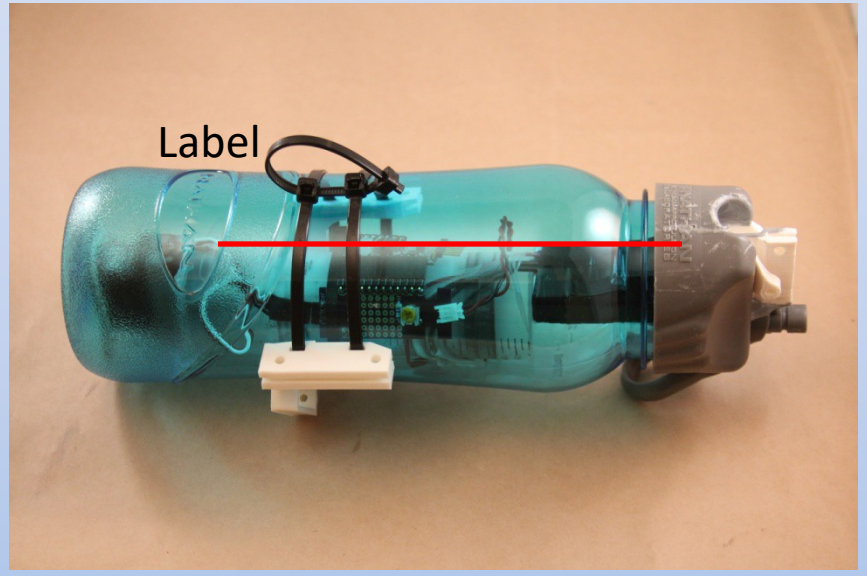
Slide Tether Loop to Top and Trim







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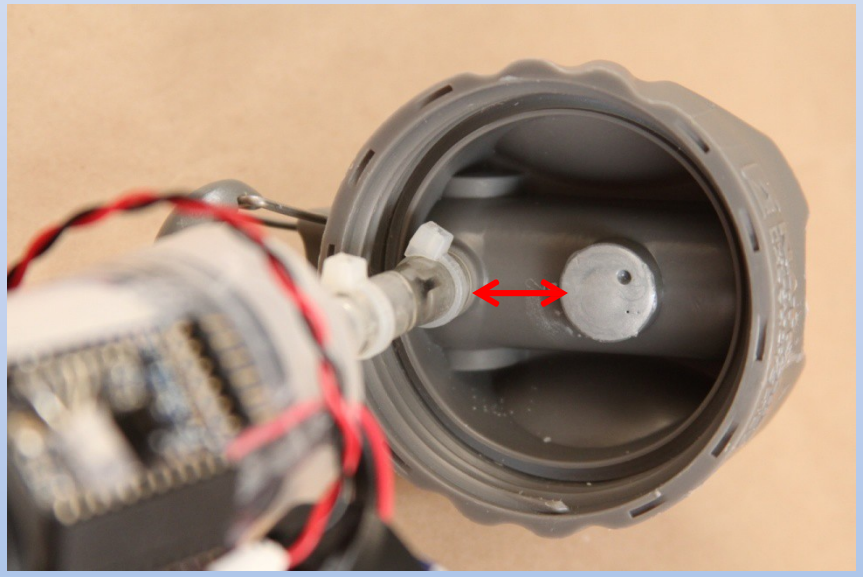
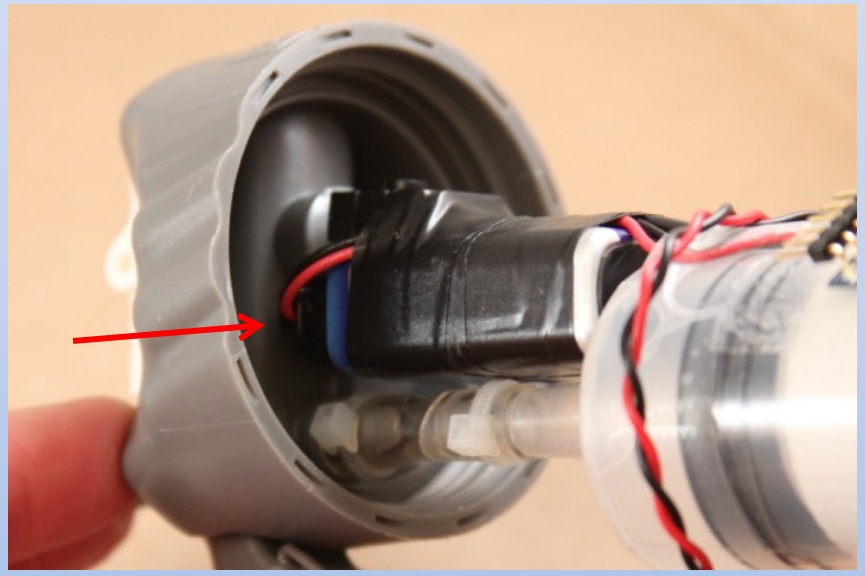
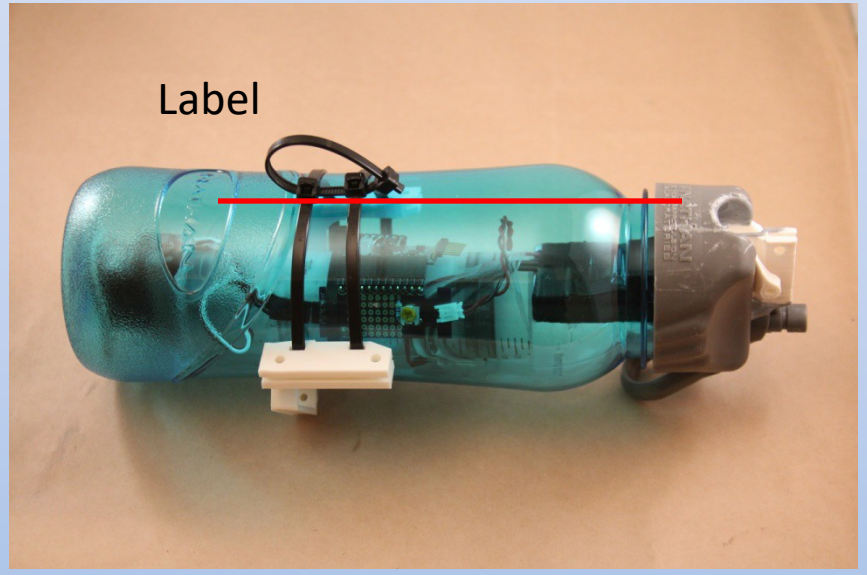


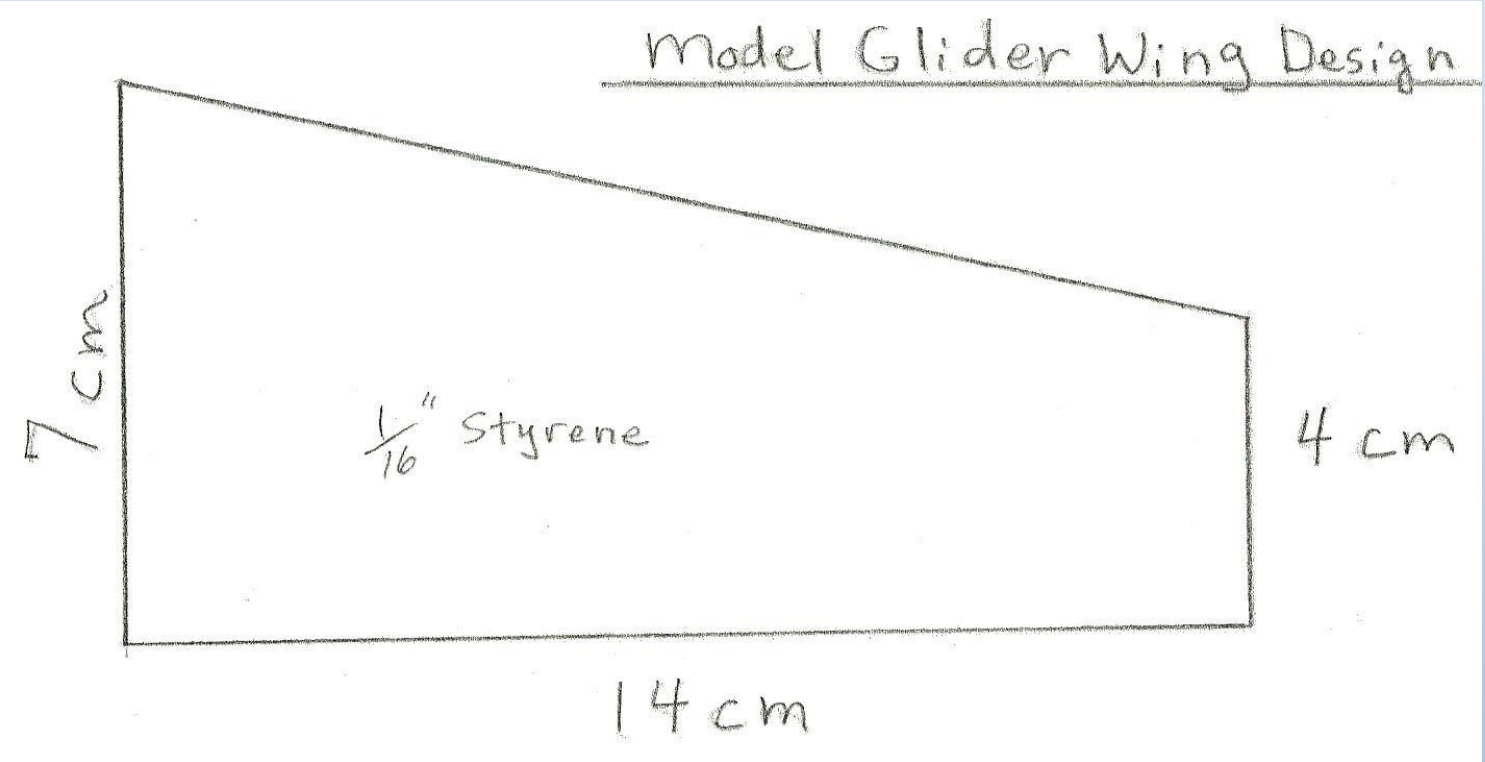



Label

Wing and Rudder Design

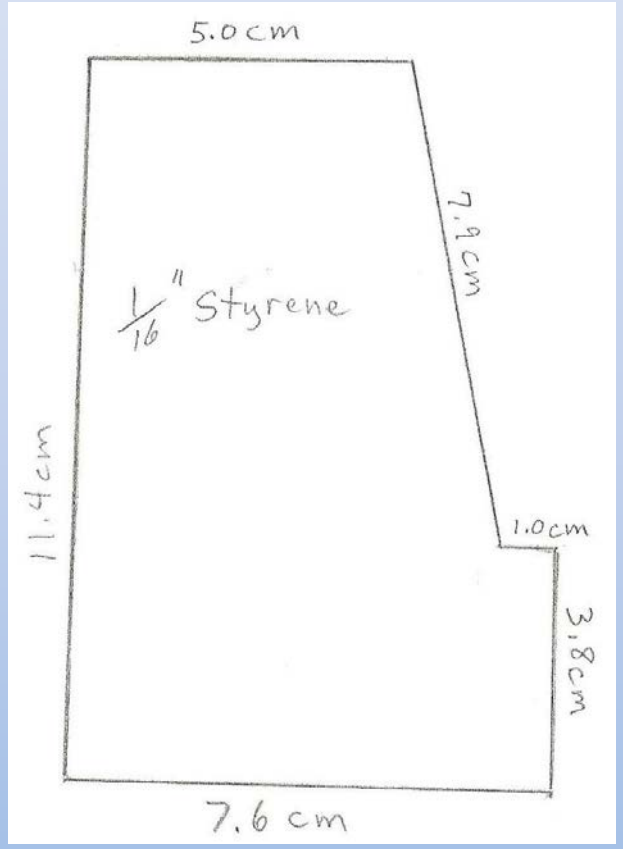
The following are instructions for basic wings and rudder (training wheels). It's more fun to do some research and create your own design, there's a good chance it'll fly better too. For inspiration see: www.SeaGlide.net/resources > Lessons > Animals That Glide (pdf)

Basic Wing Design



In the bottom of your kit box is a polystyrene sheet to make wings and rudders. Heavy duty scissors such as medical trauma scissors work well for cutting styrene. A utility knife may also be used. Remember to wear safety glasses or goggles.

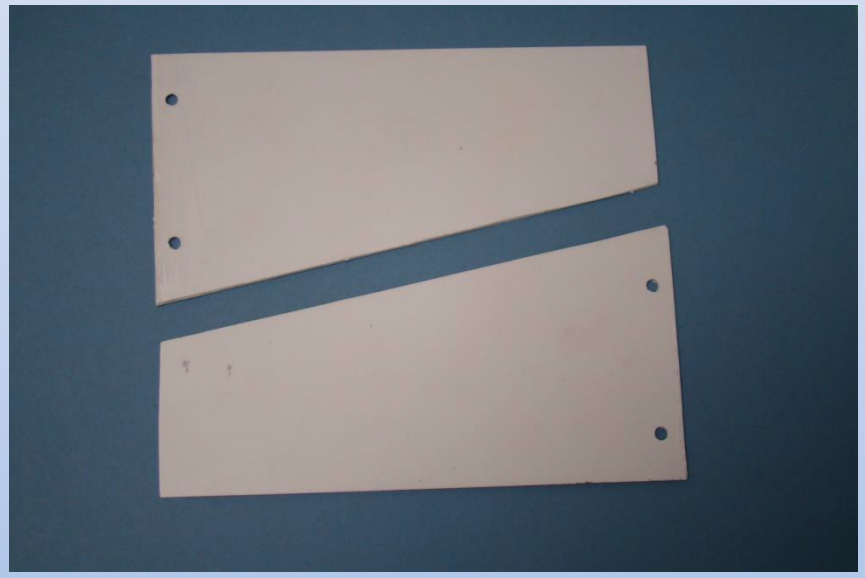
Basic Rudder Design



Copy this if you must, but it's a lot more fun to do some flight research and create your own wing and rudder designs.

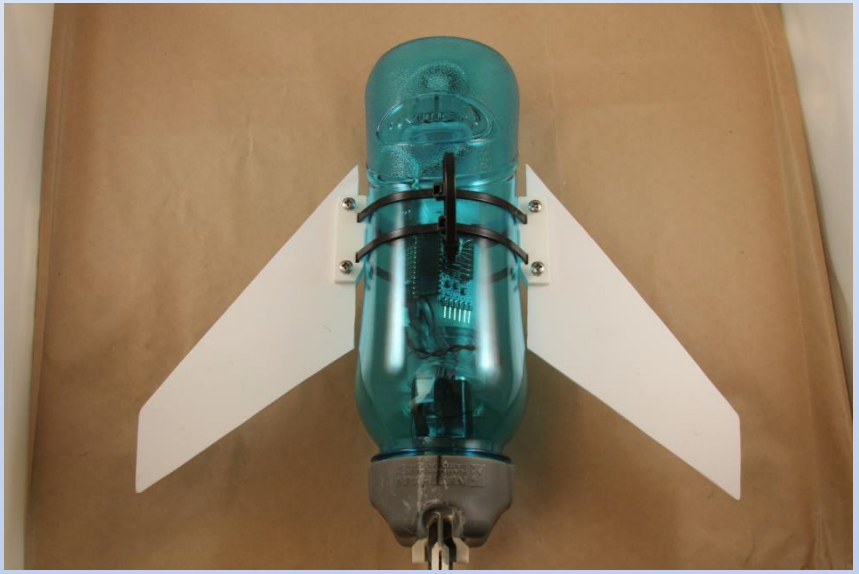
Design your wings and rudder by drawing them on graph paper. Then cut them out and fit-check on your glider.

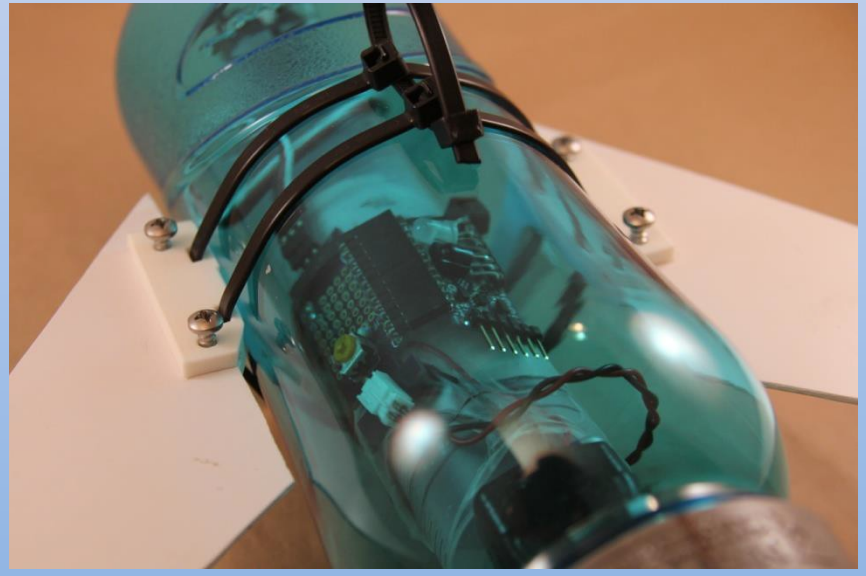
Drill Wing and Rudder Mounting Holes

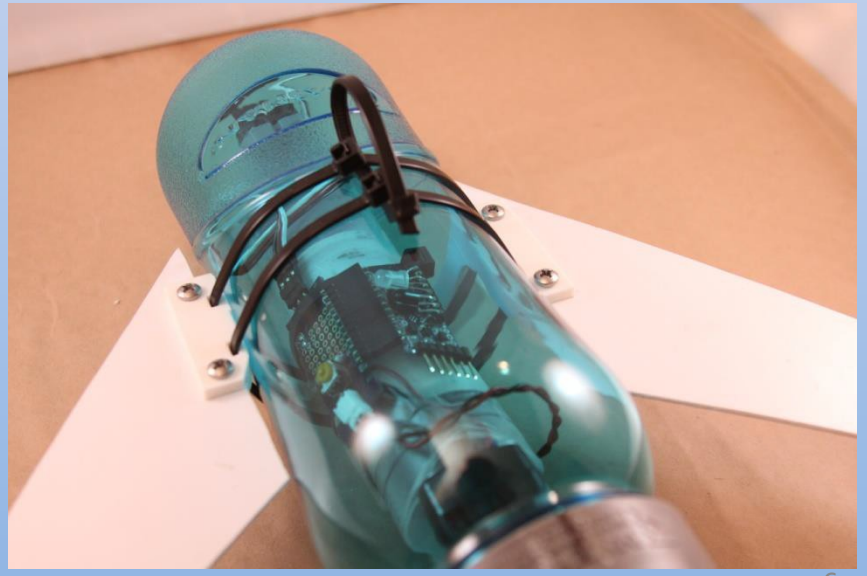


Place wings in wing yoke and use 3/32” drill bit from Tools bag to drill holes. You can mark the spot to drill with a pencil. Use a similar procedure for the rudder and rudder mount.
Secure wings and rudder in place with #6 screws from the Buoyancy Engine bag. The rudder mount will require two more screws to control the rudder angle. See “Attach Rudder” photos below.

Attach Wings

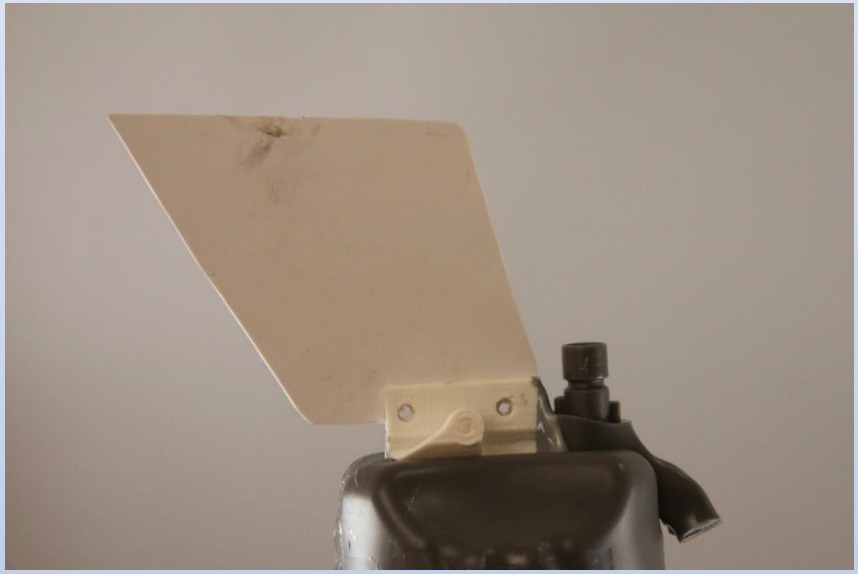


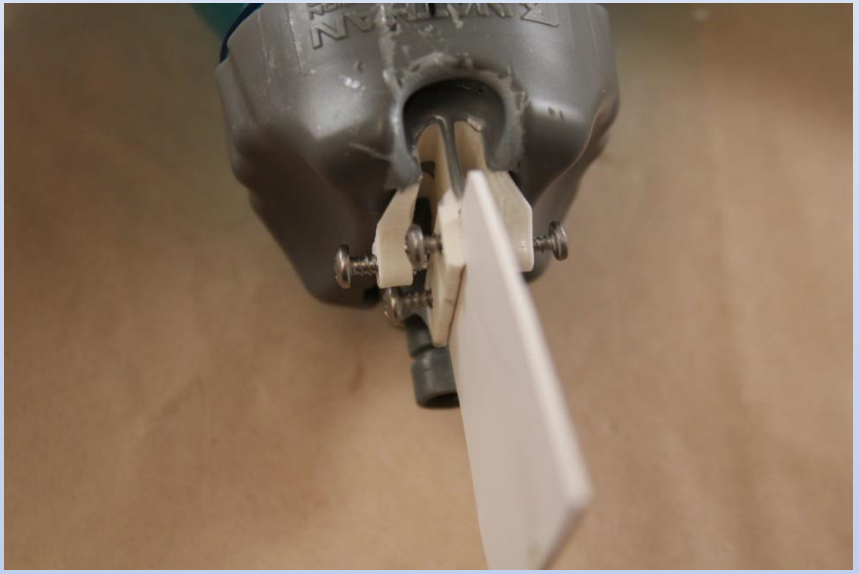


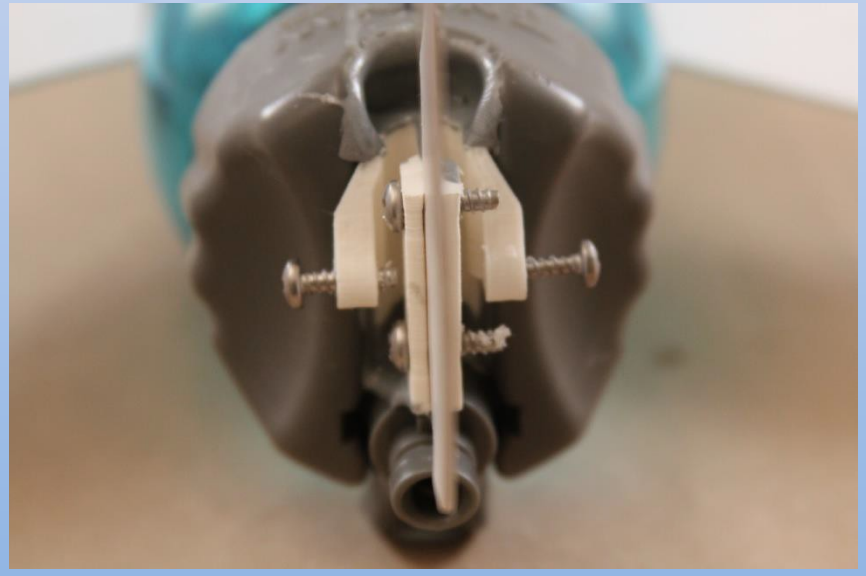


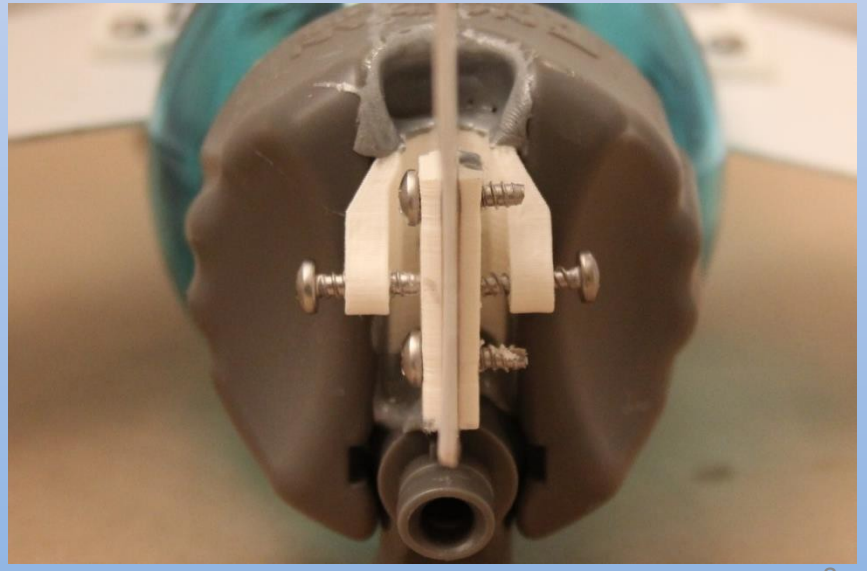
Remove Spring Clip from Cap

Attach Rudder









Ballast and Flight Principles

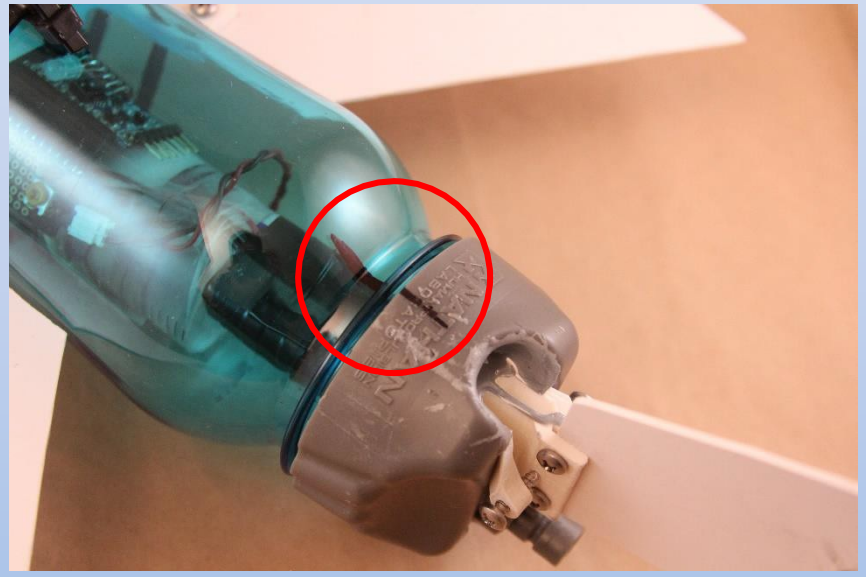
1

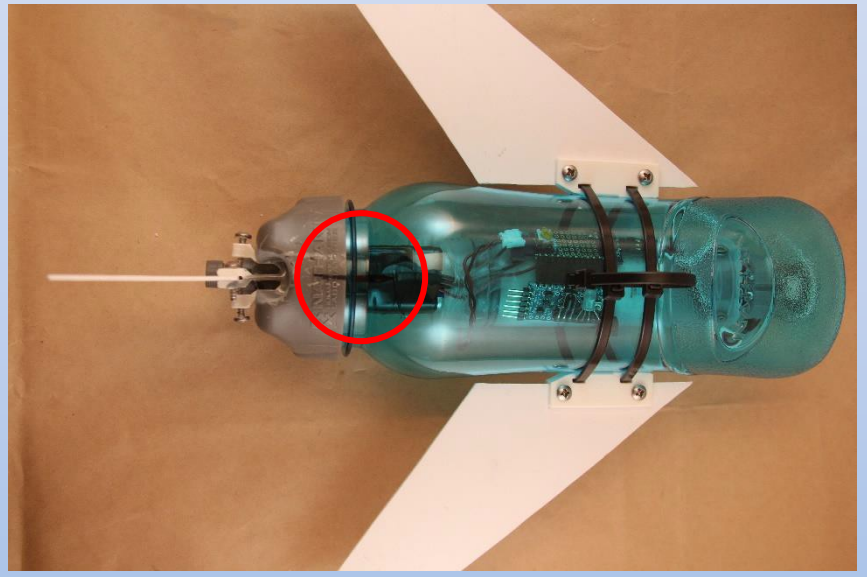
2

3

From the Bottle Prep & Ballast bag, you'll need the steel bars: Two 6"-long and one short bar (1), Dura-Lock "Velcro" (2), and eight round ballast magnets (3) as well as your glider.

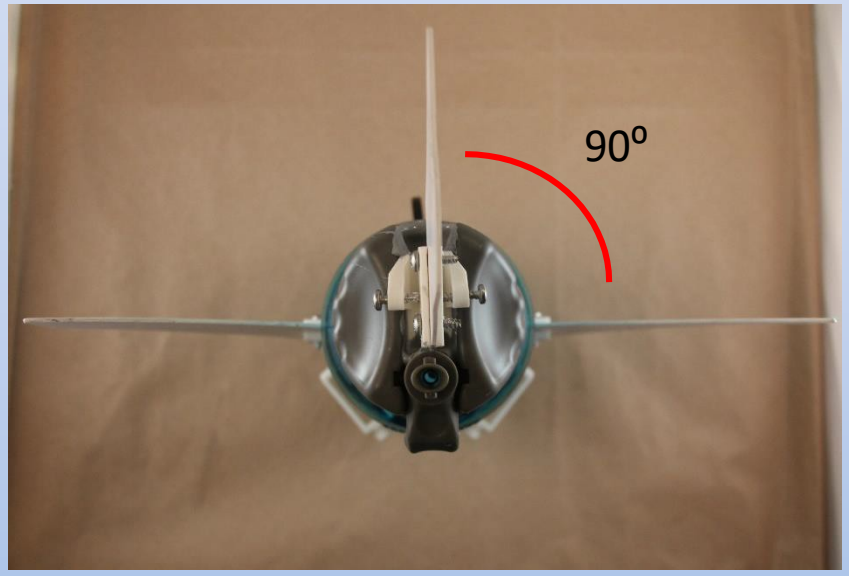
Tighten Cap and Mark Position





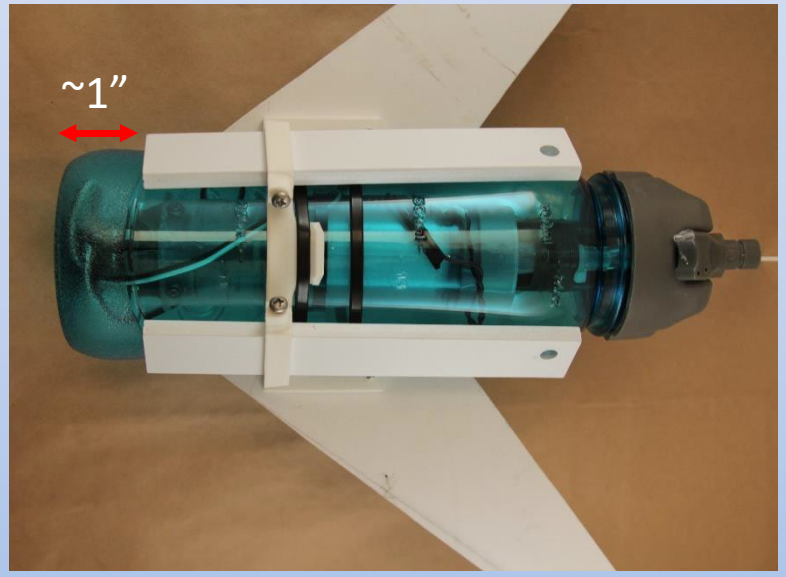
With the cap installed securely, mark the position on both the bottle and cap with a marker. If you match these witness-marks each time you close the bottle, you can ensure that your rudder is perpendicular to your wings every time. This will help your glider fly straight.

Align Rudder Perpendicular to Wings



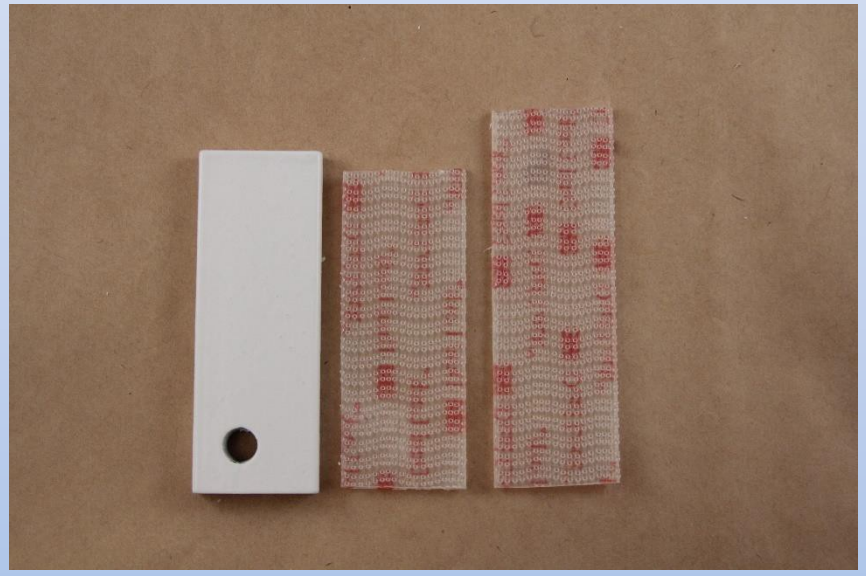
To avoid unwanted turning due to malalignment of the wings and rudder, rotate the wing yoke and wings so that they are at a 90º angle to the rudder.

Fit 6 Inch Bars into Wing Yoke



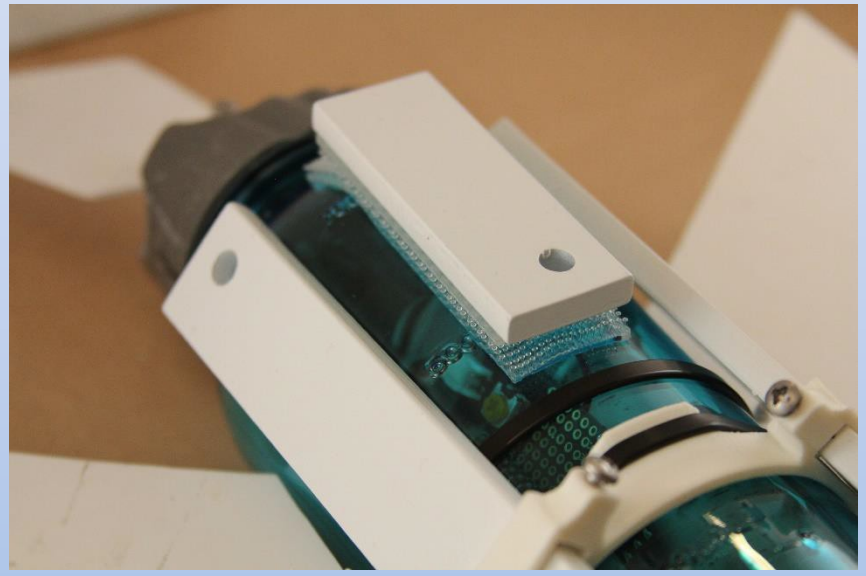
The two 6” bars fit in slots of the wing yoke on the underside of the glider. (The opposite side of the NATHAN label.) Slide one bar into each slot about 1” from the nose of the glider. Secure the bars in place with #6 screws from the Buoyancy Engine bag.

Prepare and Position Small Bar

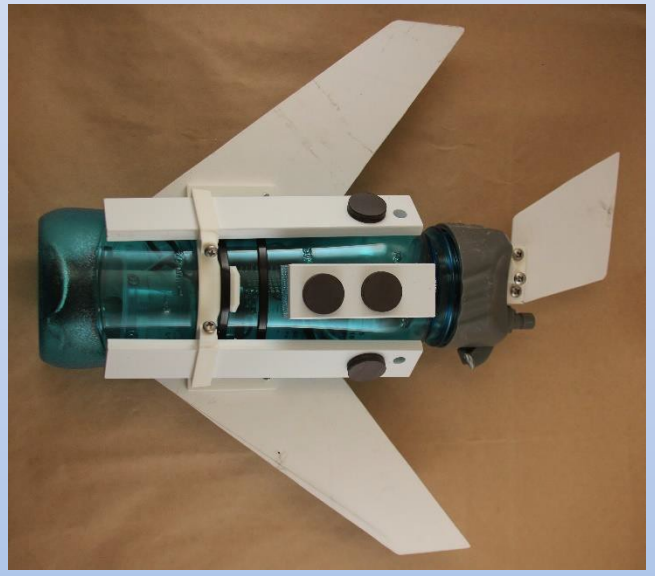


Cut a Dura-Lock strip to the length of the small bar. Remove the backing and stick it to the bar. Cut another Dura-Lock length to fit in space between the two long bars and the wing yoke and cap. Remove the backing and secure midway between the bars as shown.

Attach Small Bar & Add Magnets



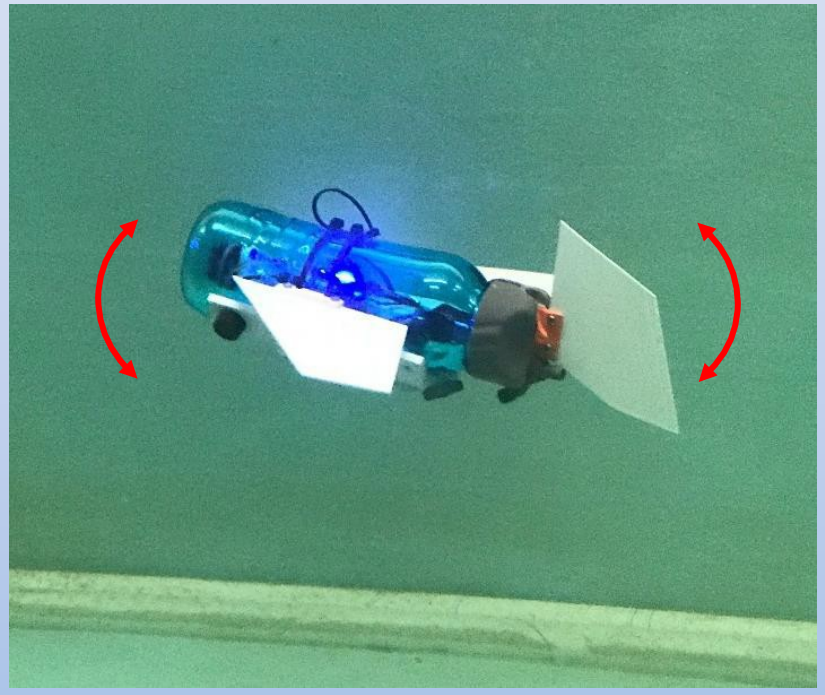
Matchup the Dural-Lock strips and press the small bar into position between the two larger bars.



Stick small magnets on the steel bars for additional ballast.

Flying the Glider: Basic Principles

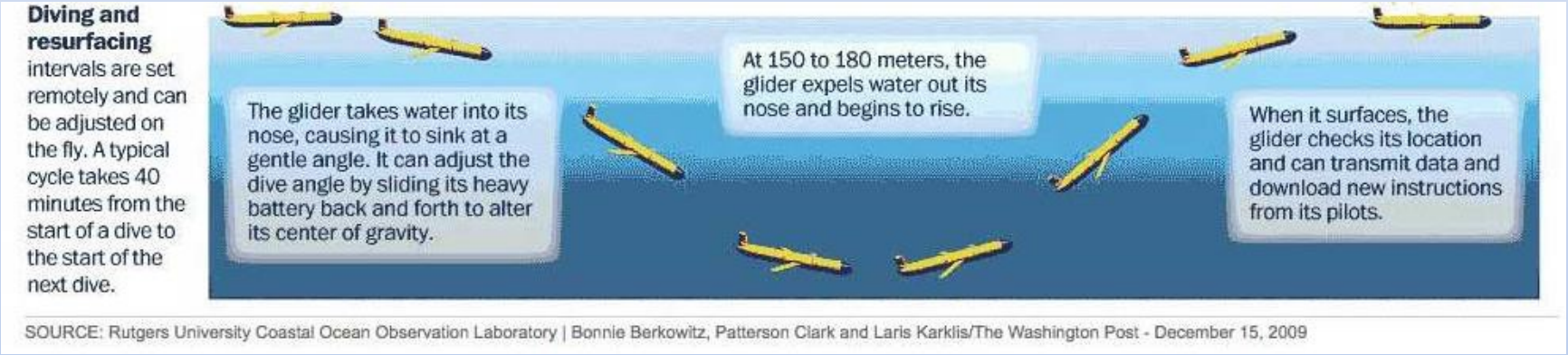
Pitch



Use Position of Weights to Control Pitch

Your first goal for your glider is to make forward progress underwater in a straight line as it dives *and* rises. (See "Sample One-Yo Glide video" at www.seaglide.net). To achieve this, the pitch of the glider has to be balanced and the roll and yaw may also need to be adjusted.

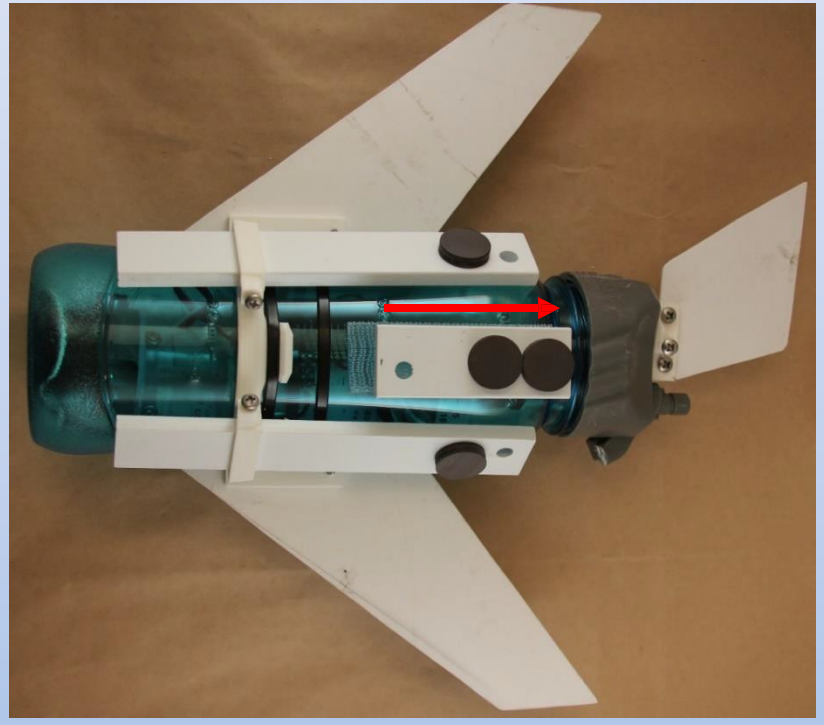
Dive Cycle of Commercial Glider



The graphic above shows an ideal cycle or yo for a commercial ocean-going glider. Good forward progress is achieved on both dive and rise cycles. SeaGlide works the same way; it must sink & pitch down on the dives and float & pitch up on the rises.

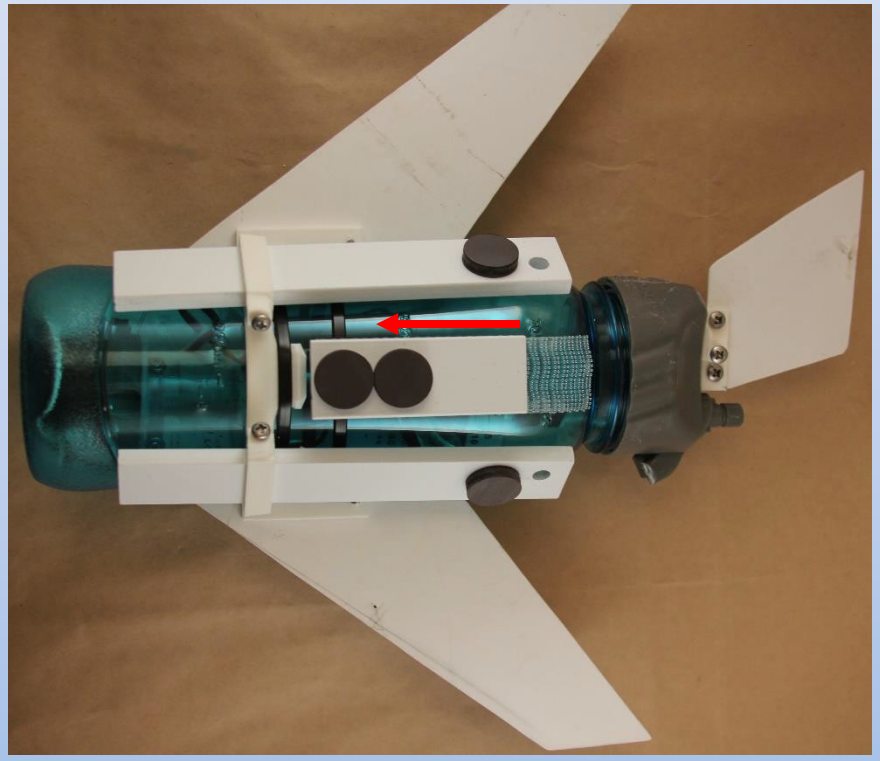
Move Weight to Adjust Pitch for Rise

Underside of Glider



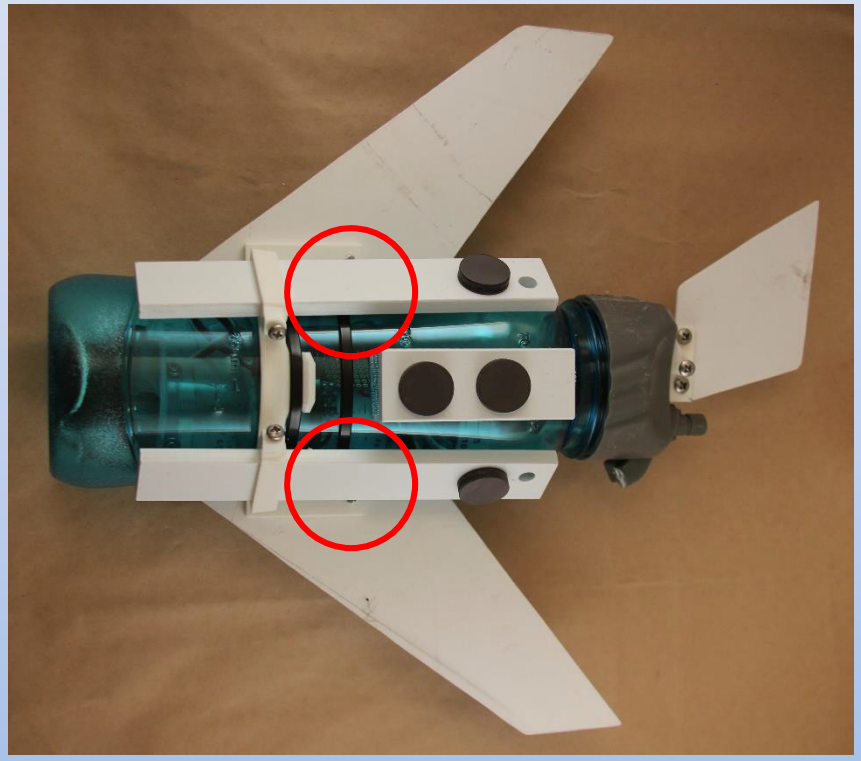
Often a glider flies well when diving, but does not pitch up in the rise cycle. It may float straight up with no forward progress, or even go backwards. To correct this, move magnets and/or small bar backwards towards the tail. If ballasting is way off, you may need to move the two large bars back. This may be required if you attach an action camera to the front of the glider.

Move Weight to Adjust Pitch for Dive



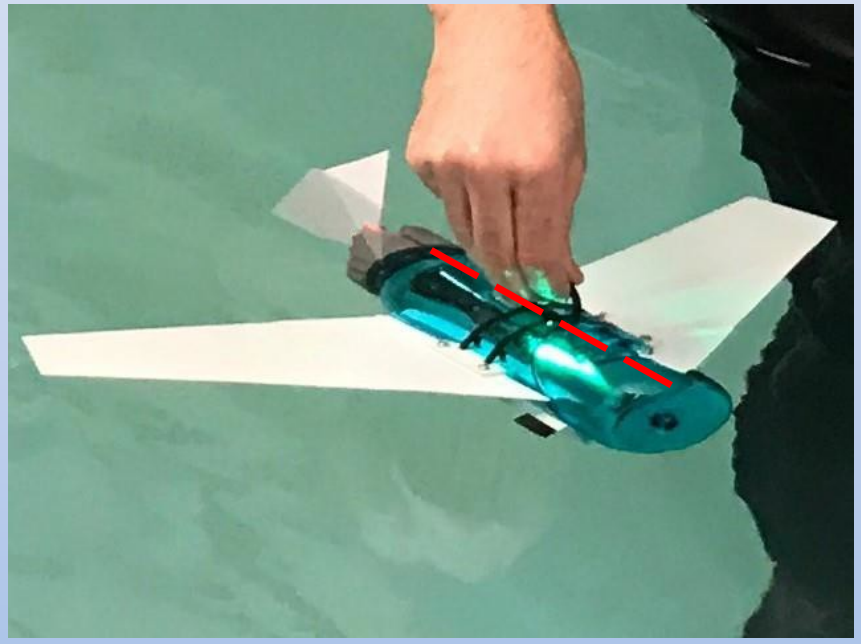
If the glider is not pitching down and diving well, you can move magnets and/or the small bar forward towards the nose of the glider. Usually it's not necessary to move the large ballast bars.

Add More Weight to Sink



Sometimes the pitch is fine and ballast is needed just to sink the glider when the buoyancy engine draws in water. More magnets can then be added symmetrically to a pitch neutral location, usually under the wings.

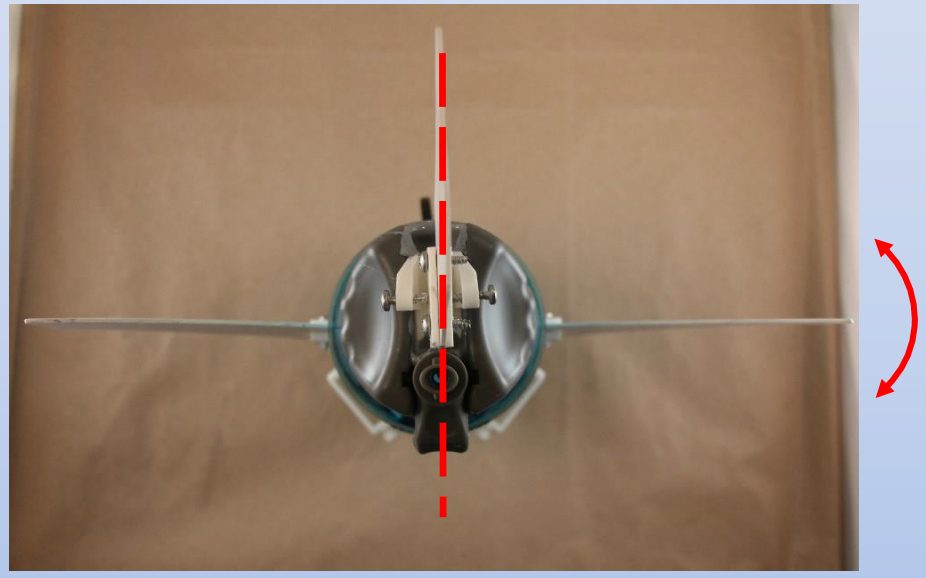
Ideal Ballasting



With the buoyancy engine plunger centered and the syringe full of water, the glider should barely float and be level or a little nose up in the water. Only a ~½”-wide strip at the top of the bottle should protrude above the waterline.

Flying the Glider: Basic Principles

Roll

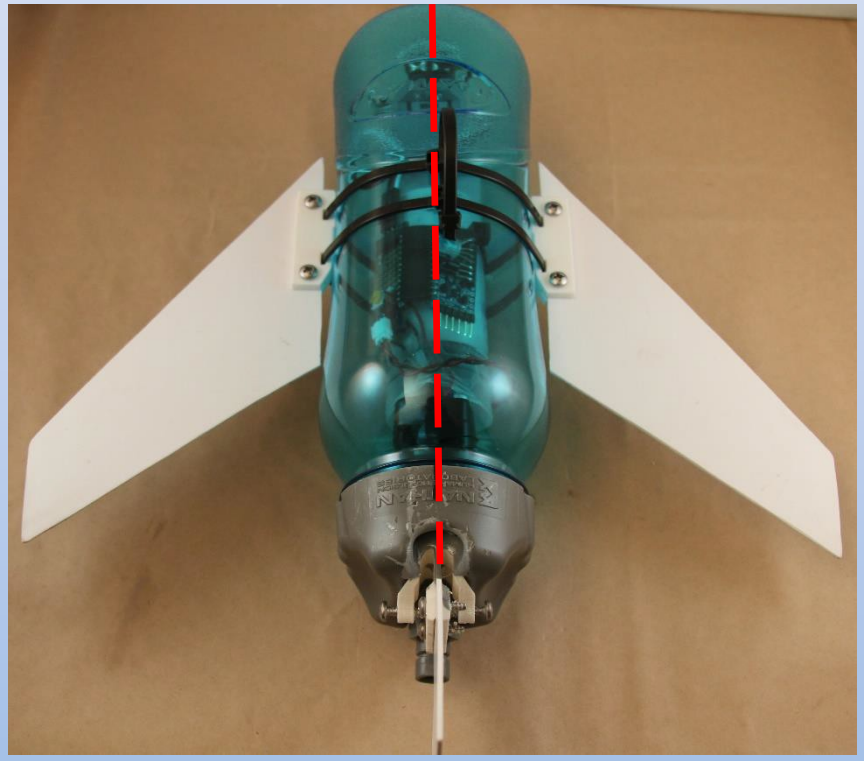


Balance Weight to Control Roll

A weight difference between the two halves of the glider can cause roll and a wing to dip, leading to an unwanted turn. Make sure the buoyancy engine is centered in the bottle. If the servo end is off to one side at the nose of the glider, thump the opposite side with the heal of your hand to center it.

Roll: Balance the Glider

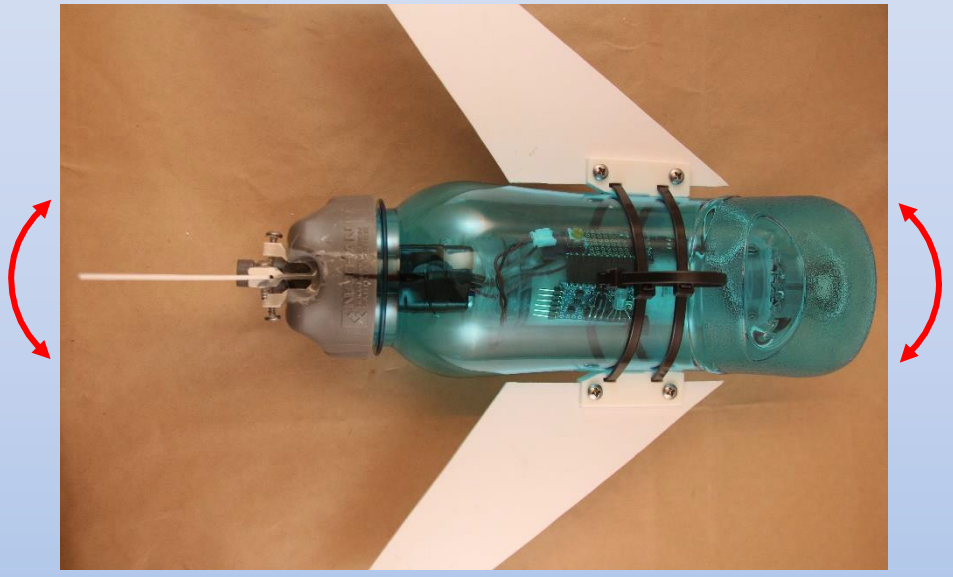
Wings should be Identical



Battery, Controller and Servo should be Centered

Flying the Glider: Basic Principles

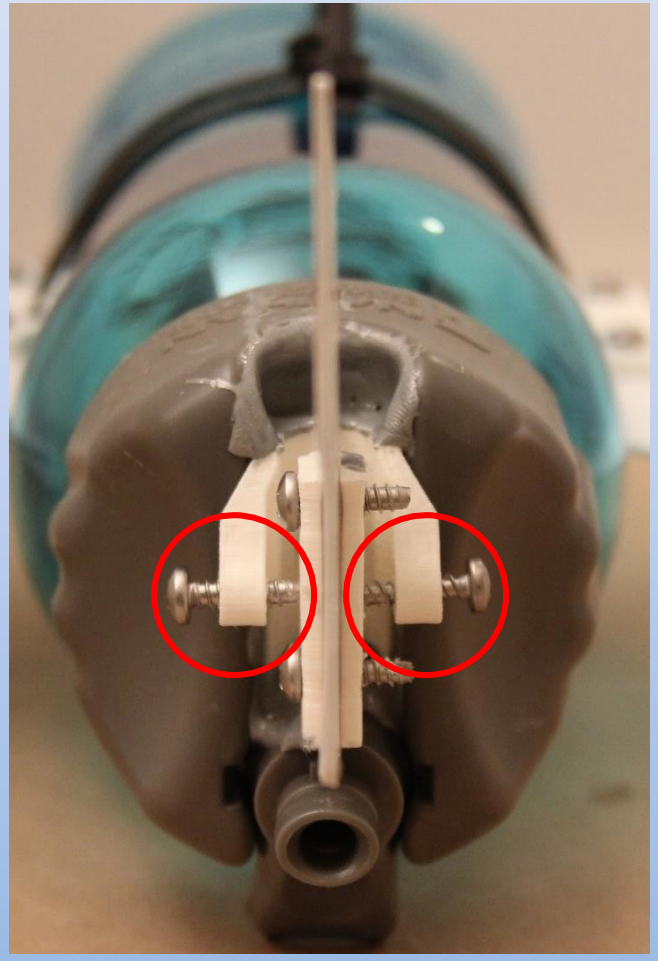
Yaw

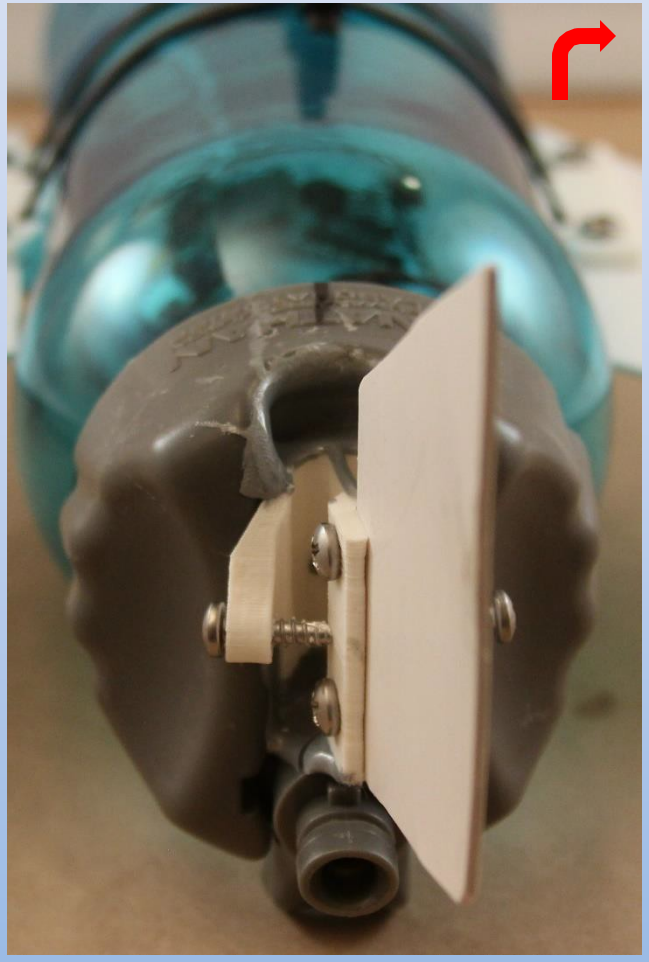


Use Rudder to Control Yaw

The manual rudder on SeaGlide can be used to help direct the glider straight or to turn left or right. It enables the glider to fly in circles or around objects such as a buoy marker.

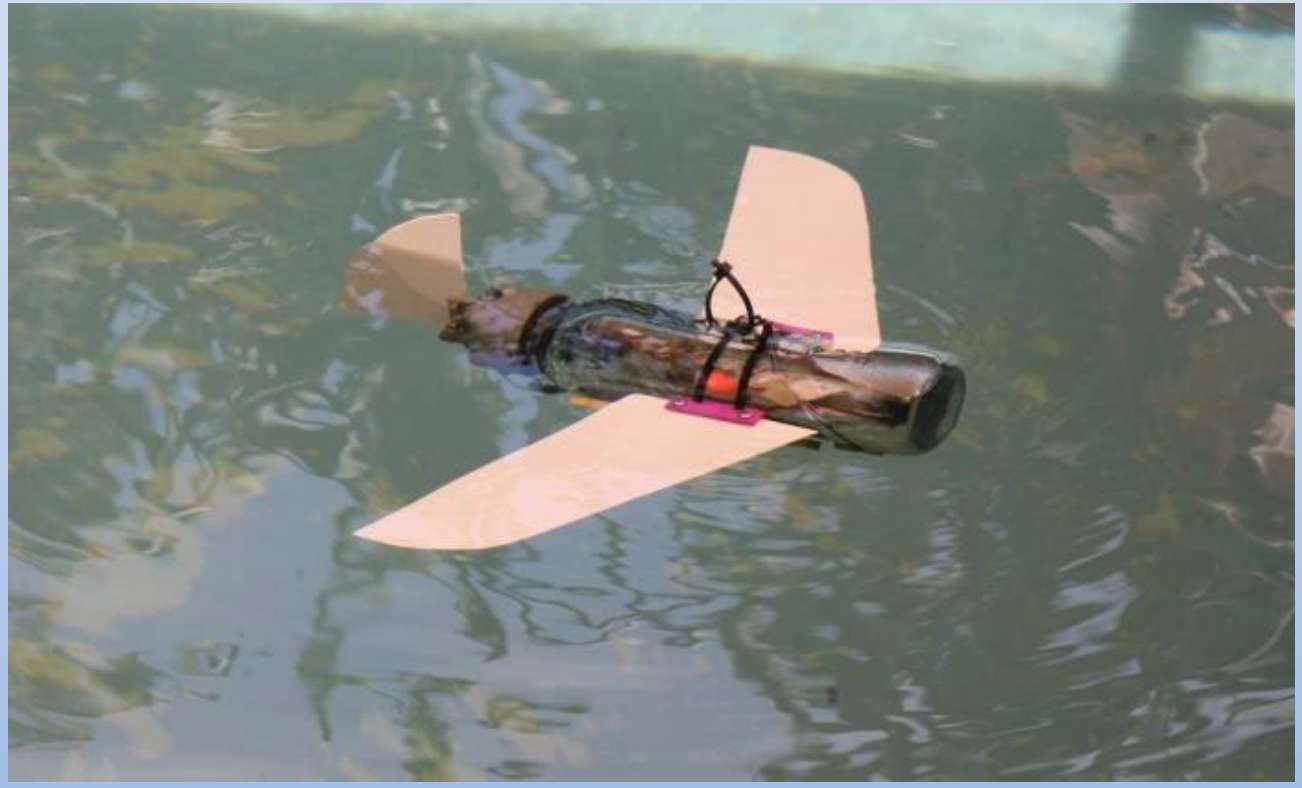
Yaw: Move Rudder to Turn





Adjust set screws, loosen one and tighten the other, to move the rudder.

Pre-Flight Checklist



Before Flight

- ❑Fully charge two battery.
- ❑Download program onto Arduino Pro Mini board and test buoyancy engine
- ❑Adjust “risedrivetime” in program for maximum syringe water capacity.
- ❑ Adjust the potentiometer for the depth you wish to dive: Counter-clockwise for shallower and clockwise for deeper.

Before Flight 2

- ❑ Start and center moving mass in buoyancy engine (BE), then pause it before closing bottle.
- ❑ Ensure there are no wires or other obstacles obstructing the cap closure.
- ❑ Back cap off threads ½ to ¾ turn and slide over first set of threads – then tighten cap.
- ❑ Make sure the rudder is perpendicular to the wings.

Before Flight 3

- ❑Rudder mount should have four screws: Two to secure rudder and two to adjust the rudder's position.
- ❑ Make sure the servo is centered at the bottom of the bottle.
- ❑Remove rear plastic clip from bottle cap to allow more space for outside ballast adjustments.
- ❑ Understand how to adjust for pitch, roll, and yaw as well as how to ballast to near neutral buoyancy.

Flight

- ❑ Attach safety tether to center cable-tie loop.
- ❑ Burp your bottle: Run the BE a couple of cycles holding the glider vertically underwater.
- ❑Check for leaks: Excess bubbles leaving cap seal or moisture/condensation inside the bottle.
- ❑ Test fly: Adjust ballast as necessary to achieve nearly equal forward progress for both the dive and rise cycles.
- ❑Feed out tether line freely so that the glider's forward progress is not impeded.

After Flight

- ❑ Turn off master power switch.
- ❑Check for leaks and dry as necessary.
- ❑ Leave cap open to further dry and avoid any pressure build up. Store in a cool dry place.
- ❑Battery can be recharged in place.
- ❑ With power off, snap cap can be left on battery to cover terminals.
- ❑Discard any damaged or soaked batteries according to manufacturers recommendations.