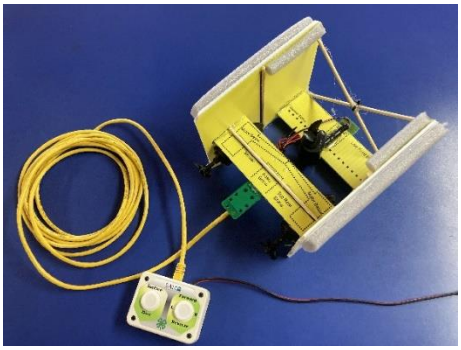
# SAM

## 4-H Remotely Operated Vehicle (ROV)

Assembly Guide Rev 2.0 9/24/2023

Available at: www.gearsinc.org/sam



## Contents


1 Scope ..... 1

2 Components ..... 2

3 Assembly stages ..... 3

3.1 SAM Overview ..... 3

3.2 Assembling the ROV Frame (chassis) ..... 3

3.3 Waterproofing the Electronics ..... 4

3.4 Adding Thrusters and X Stiffeners ..... 5

3.5 Mounting the Tether Termination ..... 5

3.6 Adding flotation and collection magnet ..... 6

3.7 Hookup and Test ..... 6

3.8 Buoyancy and Trim ..... 7


## 1 Scope

This manual is written for camp or activity leaders. It depends on a series of short videos to illustrate how to assemble the new 4-H Underwater robot, called SAM. Please view the videos before attempting to construct the ROV.

In the underwater industry, a tethered robot is typically called a “Remotely Operated Vehicle” (or ROV). We will use the term “ROV” extensively in this document. The SAM ROV is a minimal design, created to introduce youth to the fundamentals of underwater robotics through a hands-on construction project and follow-on activities.

The kit components have been designed to be as low cost as possible, while still achieving a realistic and functional underwater robot. The skills required to assemble SAM consist mainly of 1) following instructions and 2) the liberal use of a hot glue gun.

Watch Videos >

SAM can be used in various bodies of water, including tubs and tanks, small above ground pools, larger in-ground pools, ponds, and lakes. SAM isn't suitable for flowing rivers as it is subject to water currents.

## 2 Components

A standard SAM ROV kit contains enough parts to construct **two** ROV's and a **shared** controller with power supply. This approach of sharing the more expensive elements means that a club can more easily afford to have multiple ROVs.

The SAM kit is shipped as two boxes. Box 1 (left) contains the shared electronics elements and a Hot Glue gun. Box 2 (right) contains the chassis components for two (2) ROV's. Any additional bonus activities are also included in box 1.


The individual box contents are as follows:

Box 1 (Shared Elements)

- 12V Sealed Battery
- Battery Charger
- ROV Control Box with power cable
- Hot Glue gun.
- Magnetic Bingo Chips

- Buoyancy & Propulsion Activity x 2

Box 2 (Chassis components x 2)

- Coroplast Chassis. Two 6"x7", two 6"x2"
- Stiffening Skewers
- Buoyancy Foam
- Thruster Motors x 3
- Tether termination
- Magnet
- Tether (Ethernet cable)
- Hot Glue Sticks x 8
- Zip Ties 4" x 10

Watch Videos >

# 3 Assembly stages

The full assembly procedure is shown in a series of short "Step" videos located on the SAM ROV Site:

www.gearsinc.org/sam These steps are:

1. SAM Overview (1-ROV-per-kit version).
2. Assembling the ROV frame
3. Waterproofing the electronics
4. Adding thrusters & stiffeners
5. Mounting the tether termination
6. Adding flotation and collection magnet
7. Hookup and test
8. Buoyancy and Trim


These stages are described briefly below. These written descriptions are not intended to be stand-alone, instead they are useful as initial introductions, or as refreshers once the full videos have been watched.

## 3.1 SAM Overview

The SAM ROV is tethered to the surface using a lightweight ethernet cable. Power is provided at the surface by a rechargeable 12V Gel-Cell battery, and the pilot operates the ROV remotely using a small control box. The cable is required to provide power and control because the ROV must be lightweight and radio signals do not operate well through water.

SAM uses a traditional 3-thruster configuration to provide horizontal and vertical maneuverability. The frame (or chassis) is constructed from 4mm Coroplast sheet, which is assembled using Hot-Melt glue which is waterproof, adheres well to plastic, and is non-toxic.

The illustrated frame design is just one possible configuration, but it is a good choice to provide stable flight, and neutral buoyancy (neither strongly floating or sinking).

## 3.2 Assembling the ROV Frame (chassis)

The chassis assembly has several steps which are best understood by watching the video. Most steps require using liberal amounts of Hot Glue. To get the best results, the following tips can help:

- Hot glue is stickiest when it's hot, so make sure that the glue is still hot when you attach to parts together. This means be ready to attach the parts before you start applying the glue, and make sure you apply enough glue, so it stays hot for longer. It also means

using a glue gun which has sufficient wattage to get the glue to a high temperature. Small "kiddy safe" glue guns may not be sufficient.

- Make sure you have enough remaining glue-stick in the gun before starting each application. Running out of glue and having to take the time to load a new stick will allow time for the glue to cool before you get around to attaching the part.
- Hot glue isn't strong until it's cooled down, so make sure you hold pieces in place until the glue has gotten cold. If you are attaching the edge of one piece to another, the glue may take quite a while to cool down, so be prepared to wait. If you need a piece to be at a certain angle (like 90 deg) have a square edge handy to make sure your angles are right.

The chassis assembly process is as follows:

1) Lay the chassis pieces out on a flat surface and identify the correct orientation of each joint. Note that each joint has a letter A, B, C or D that appears on both pieces.
2) Glue a 6" skewer to each of the four chassis pieces between the lines that say "skewer". Note: three skewers go on the printed sides, and one goes on the underside (shown with dotted lines)
3) Glue the two cross-braces to one side panel. Glue A-A and C-C. Brace the sides upright at 90 degrees while cooling.


4) Glue the other side panel to the two cross-braces to make a rigid frame. Glue B-B and D-D. Hold in place while cooling.

## 3.3 Waterproofing the Electronics

Electronics (and exposed wiring) must be kept dry to function reliably. Even though pure water is not conductive, it will still cause metal pieces to rust over time. So, keeping the ROV running means keeping water away from electronics, and making sure that it's dried thoroughly after every use.

Watch Videos >

We can keep water away from most components by putting them in sealed containers, or covering them with plastic or glue, but thrusters are a problem because they must spin, which means you can't seal them 100%

The thrusters we use in SAM have a simple waterproof seal around the propellor shaft which will keep out most water, but they also have an opening where the cables come out, and we need to block this opening completely. Hot Glue is a great sealer if it's applied well, so follow the video to see how to keep water out of our thrusters.

The ROV also has several open electrical connections for the tether and thrusters, and these must be protected from electrolysis. For this we use a Dielectric Gel, that can be spread on all the exposed metal parts. Since we want to provide as much protection as possible, feel free to apply this gel liberally, and make sure you cover any "shiny" parts , or open connector holes.

## 3.4 Adding Thrusters and X Stiffeners

Thrusters are probably the most important, and most unique parts of an ROV. They are essential for achieving flight (yes, we call moving around underwater "flying") and so it's important to spend the time to get their placement and alignment correct.

Thrusters are basically propellors attached to a motor. We use simple DC motors on SAM. The motor turns the propellor, which causes "thrust" by pushing against the water.

Watch the video to see how two thrusters are placed horizontally on the rear cross brace, and one is placed vertically on the front brace. Take care to keep the thrusters aligned correctly as the glue cools, and make sure nothing is touching the propellors.

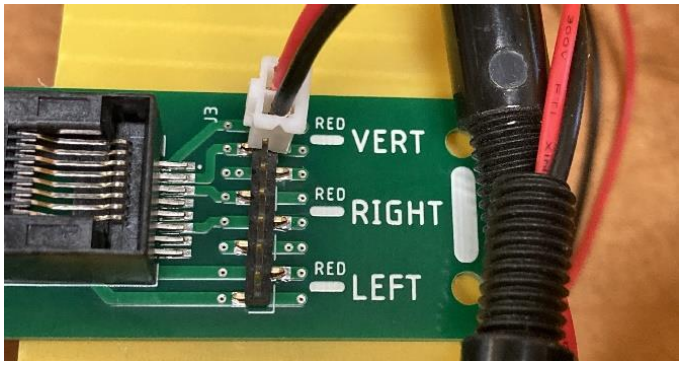
After attaching the thrusters, two of the longer skewers are added to the front of the ROV in an X pattern, to increase the stiffness of the frame.

## 3.5 Mounting the Tether Termination

The tether (cable) is attached to the ROV via a socket on a small circuit board. This board is called the Tether Termination. The termination board also has pins for the thruster cables to plug into. The termination will typically attach at the back of a ROV to enable the tether to stream behind as the ROV flies forward. It's also important to put it in the center of the chassis so it doesn't pull the ROV left or right as it flies forward.

Watch Videos >

Once the termination is mounted, the thruster plugs can also be inserted. It is VERY important for the correct thruster to be plugged into the correct connector, and that each plug is inserted with the red wires on the same/correct side. If any of the cables are inserted incorrectly, the ROV will not move as expected. It may turn when you expect it to go straight or go up when you want it to go down.




Watch the video to see how to complete these steps:

1) Attach the termination to the rear of the ROV.
2) Insert each thruster connector into the pins on the Tether Termination.
3) Add Zip Ties to prevent the cables from getting tangled in the propellors.

Before permanently attaching the thruster cables (with glue) you should test the thrusters with the control box to ensure they are correctly connected. See section 3.7.

## 3.6 Adding flotation and collection magnet

To have some fun with your ROV, you'll add a magnet to the front so you can collect metallic bingo chips. And finally, ROVs like to be "trimmed neutrally buoyant" which means that when they are submerged, they neither sink, nor float. A small amount of positive buoyancy (floaty-ness) is OK, because that means they will float to the surface slowly if the power goes out. Since your ROV will sink in its current condition, you need to add flotation in the form of foam rod.

Follow the steps in the video to:

1) Attach the magnet to the underside of the front cross brace.
2) Attach flotation to the top of the chassis sides. You will add more than you need, and then you'll trim off any excess in the final "trimming" step.

## 3.7 Hookup and Test

To set up the ROV for testing, or for actual use, the electrical system needs to be fully connected. Although this only requires inserting a couple of connectors, it's still important to get them right.

The power for the SAM ROV comes from a rechargeable 12V Gel-Cell battery. These batteries have been in use for many years and are very safe and reliable. The kit comes with a small battery charger which is used to ensure the battery is ready to run your ROV.

Watch Videos >

SAFETY WARNING

It is VERY important to never short-circuit the two battery terminals together with a wire or other metal component (like a screwdriver or metal table). This may result in sparks, hot wires and will probably damage the battery.

Since batteries supply DC (Direct Current) power, we always need to maintain correct voltage polarity. The SAM kit uses the standard polarity color-code of RED for +12v and BLACK for -12V. SO, it is VERY important to always connect red-to-red and black-to-black. Reversing the polarity will prevent the ROV from operating, and probably cause damage.

The video shows how to connect the control box to the ROV and then test the thrusters for correct function and direction.

Once you know your thruster connections are correct, feel free to use some zip ties (or hot glue) to organize any loose wires. Make sure there is no way they can get tangled on a propellor or the ground as the ROV moves across the bottom.

## 3.8 Buoyancy and Trim

As mentioned earlier, the final step is to take the ROV to a body of water and adjust the Buoyancy and Trim. Buoyancy is adjusted by adding ballast or floatation to an ROV. In our case the SAM ROV should now float when it's placed in the water. We can adjust the buoyancy to neutral and ensure the ROV sits trim (level) by selectively removing flotation.

Watch the final video to see how this is done.

Now go and have fun with your ROV. Challenge a buddy to see who can pick up the most bingo chips in 60 seconds or build a floating obstacle course in a pool and create your own test of flying skills.