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Underwater Robot

Project Report

Technical details for the proposed robot

1. **Type of Robot:**

Submarine or underwater robot (remote-controlled and autonomous).

2. **Robot assembly design:**

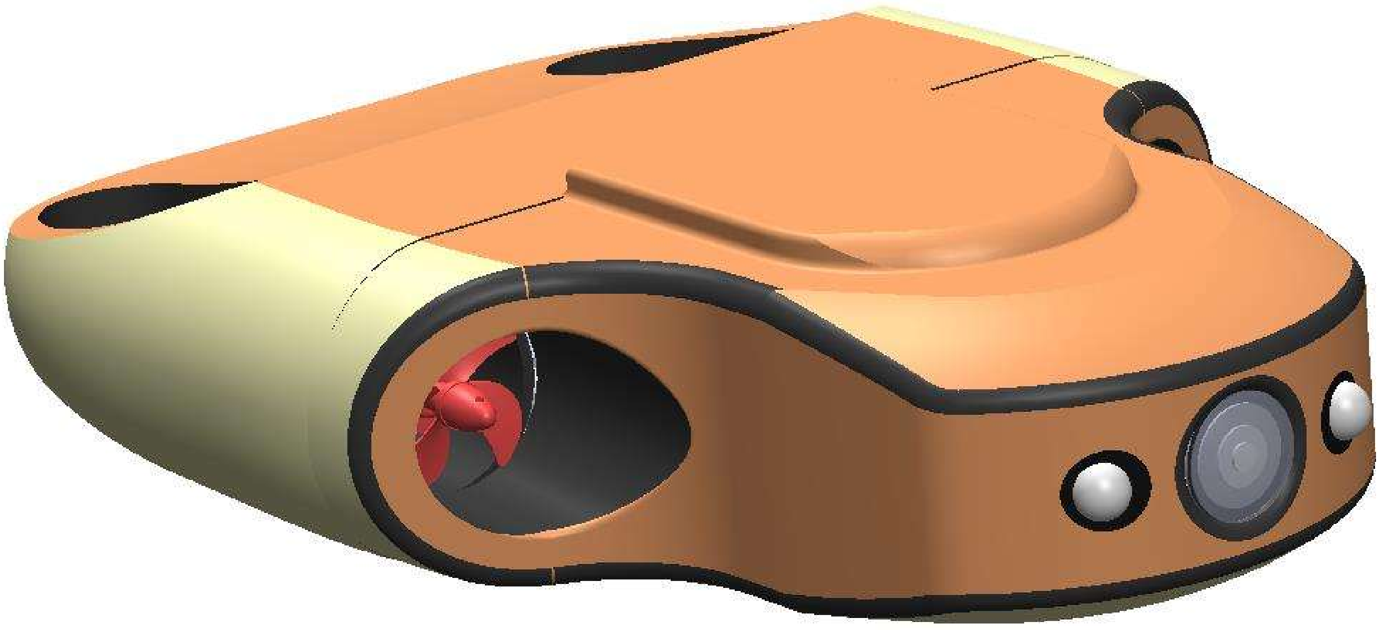


Figure 1 Isometric view

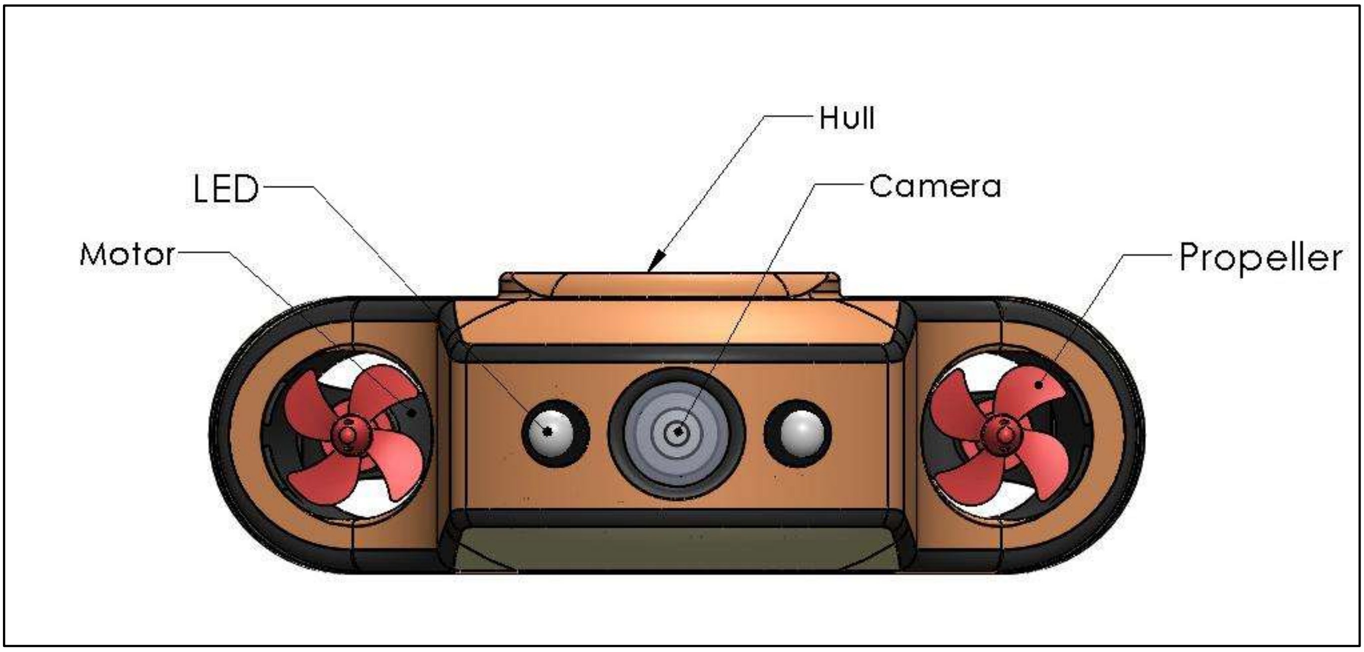


Figure 2 Front view

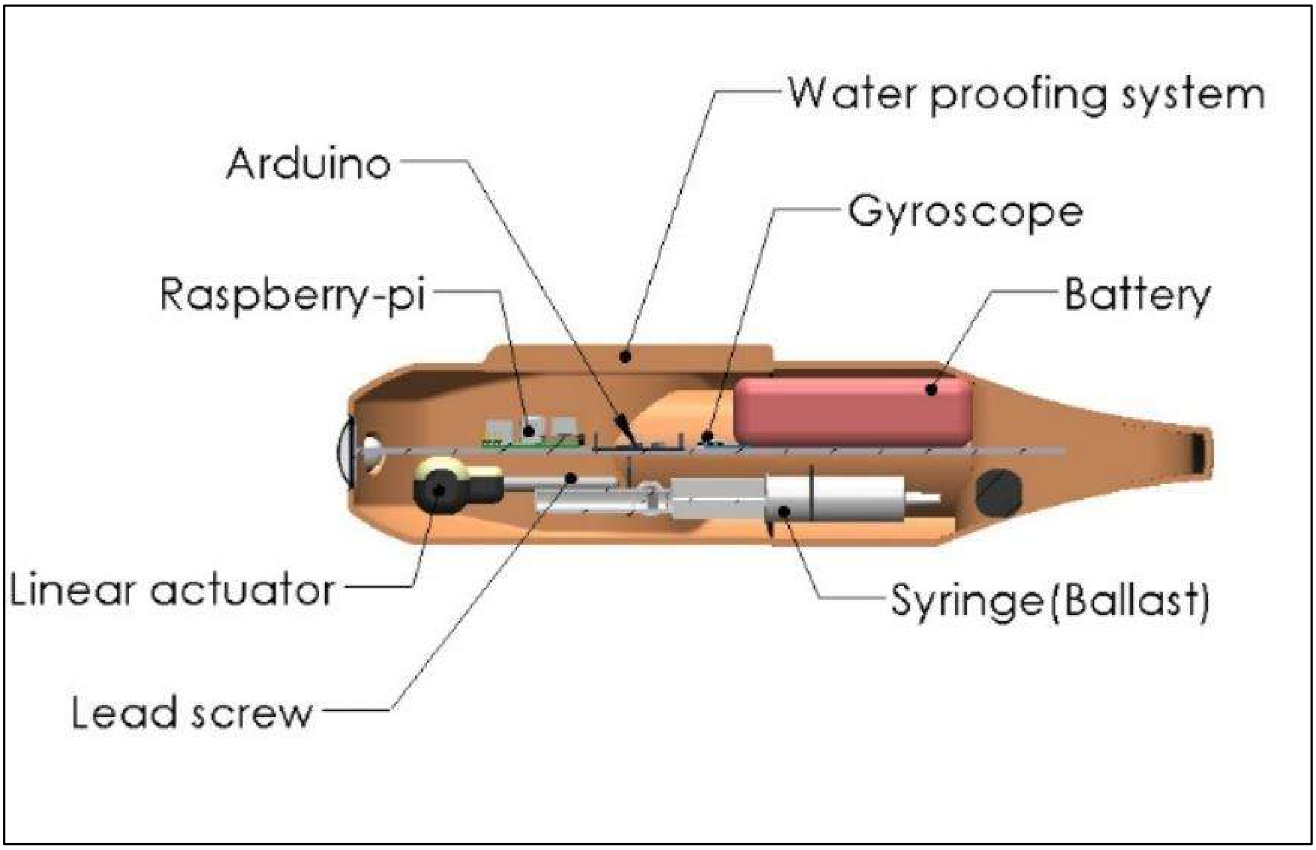


Figure 3 Side cross section view

Dimensions of robot:

Front view

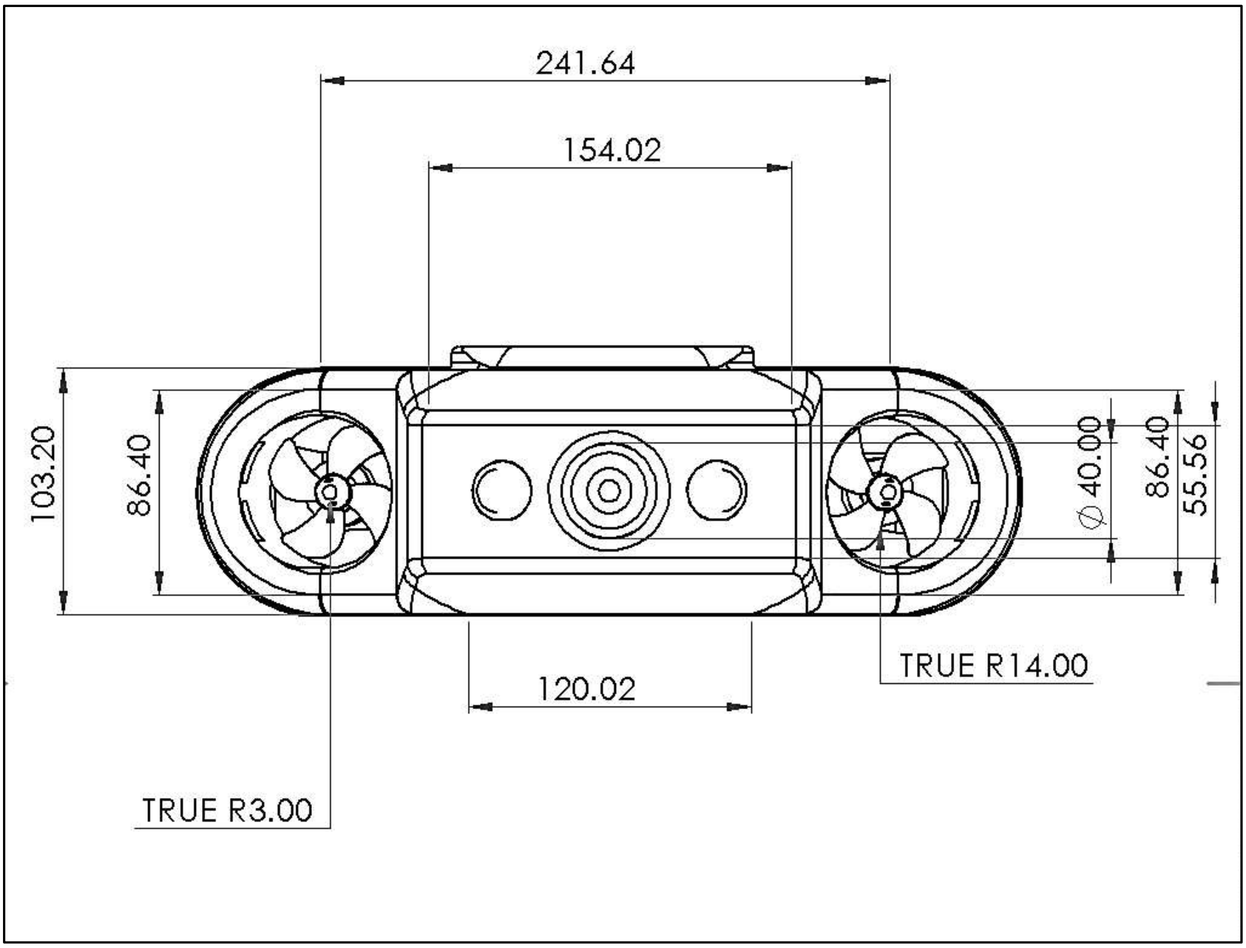
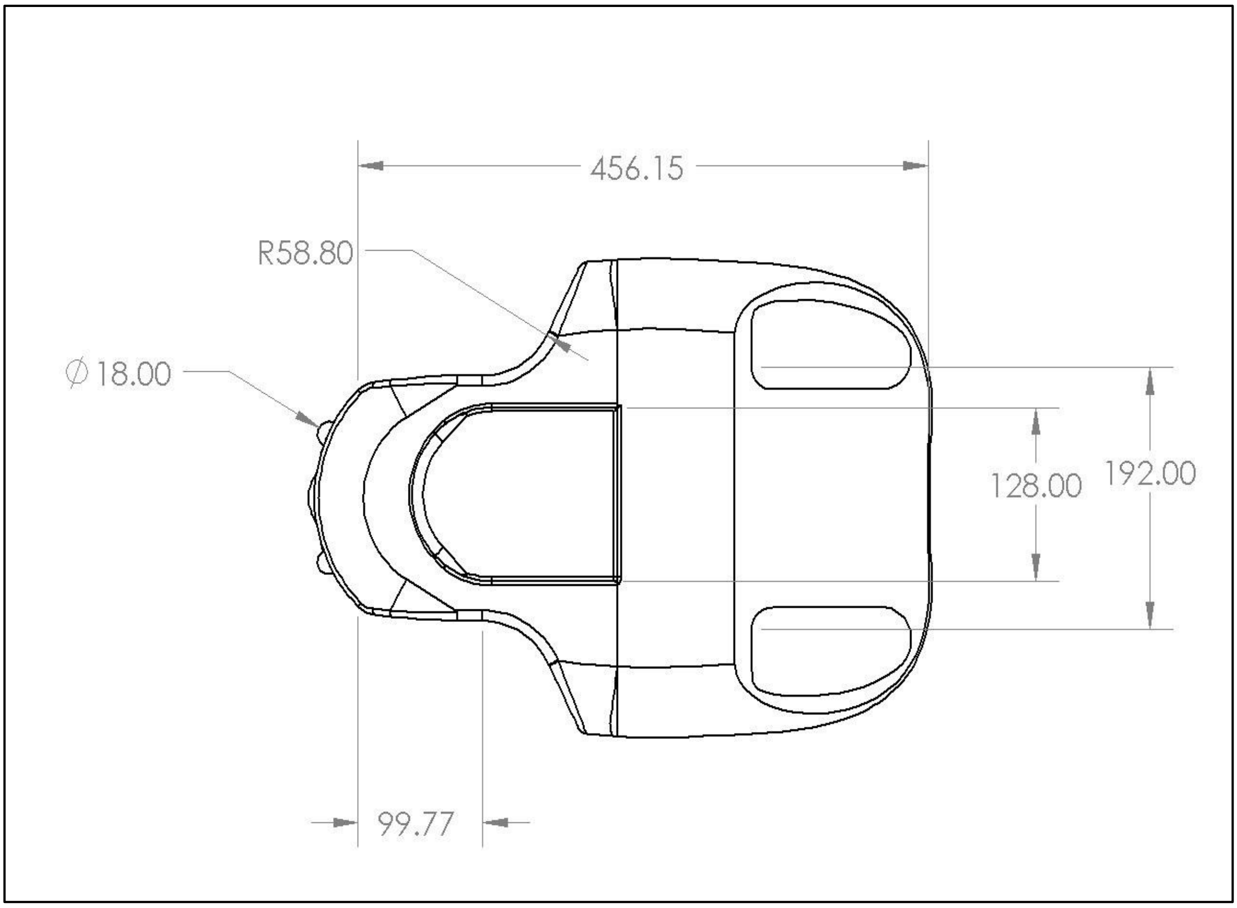


Figure 4



Top View

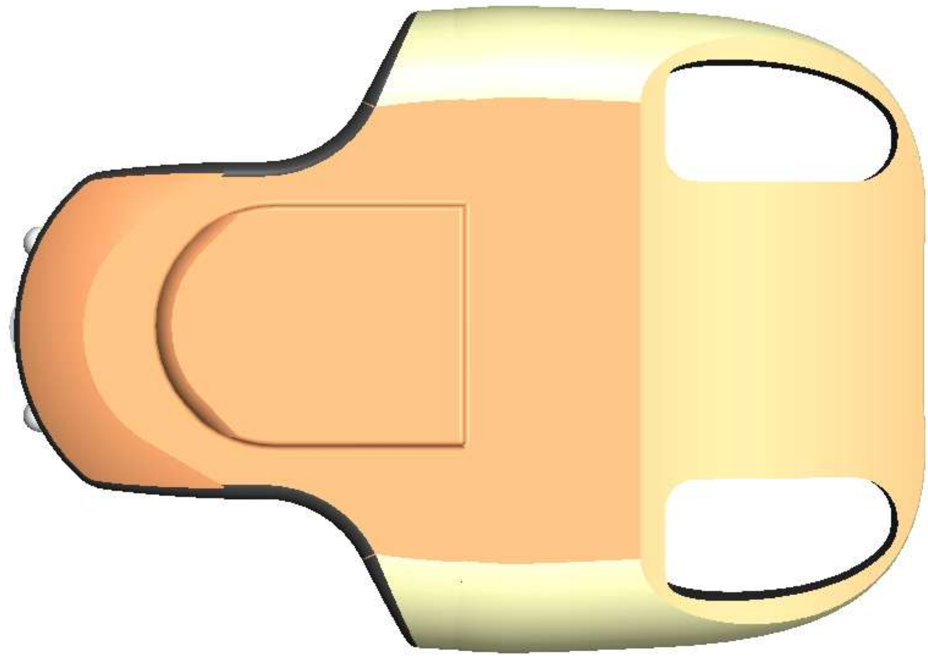
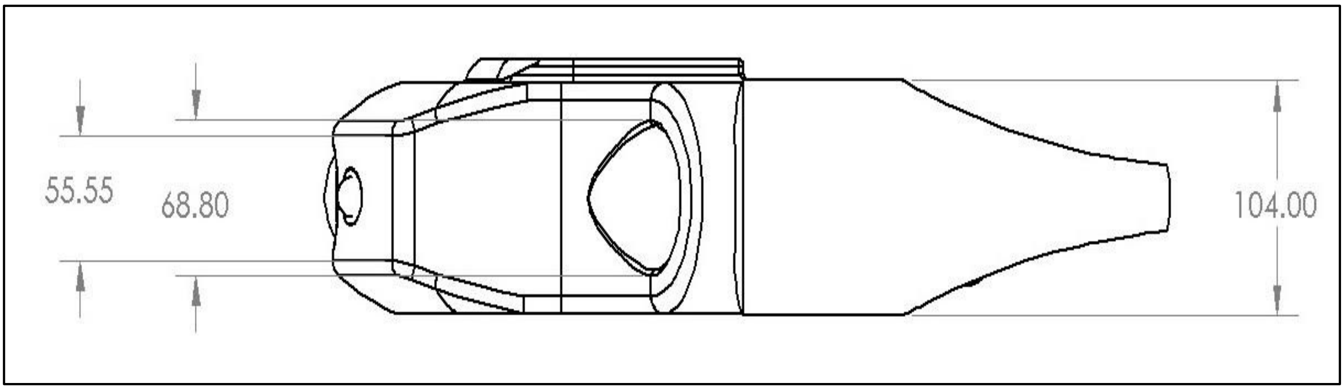


Figure 5

Side view



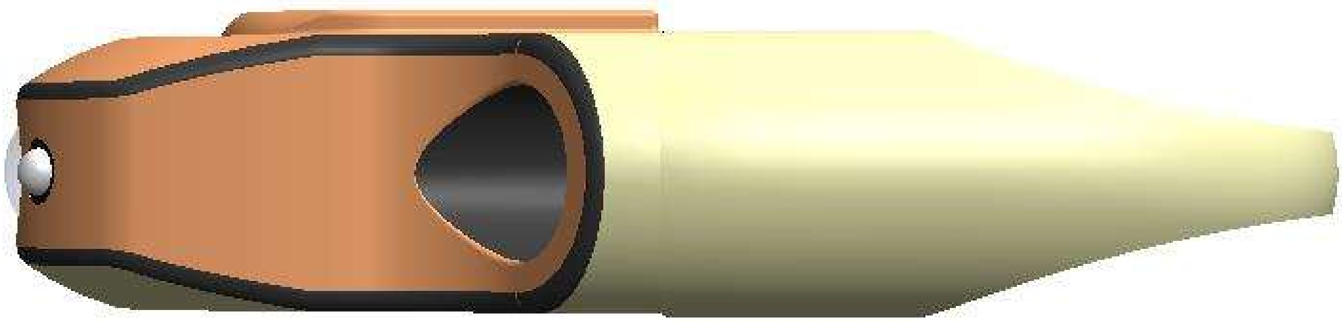
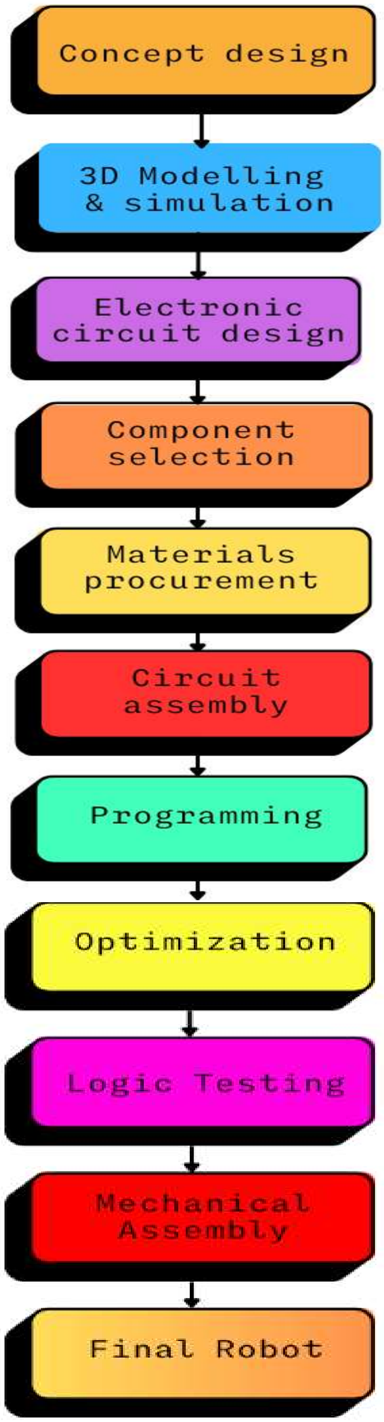


Figure 6

4. Methodology of the Robot



4.1 Technical specification

Table 3 Technical specifications

Dimensions of the robot(in mm)	Length: 500 Width:350 Height:104
Processing units	1)Raspberry-pi 4 2)Arduino UNO
Power supply:	12V 10000 mAh (2 batteries in parallel)
Features:	1) It's able to measure the pressure at a particular point in the water. 2) Automated buoyancy adjustment for stable underwater positioning.
Additional Functionalities	Automatic switch to manual mode or surface recovery in case of extremely low battery or critical error.
Software	We are utilizing **ROS (Robot Operating System)** in our underwater robot, with a configuration of multiple nodes to manage different tasks efficiently

4.2 Bouyancy Control (3 degrees of freedom)

To float any object on the surface of the water, its density (ρ) must be equal to and inferior to the density of the water (1024 kg/m3).

1) Initial density calculation:-

$$(\textit{Density})\rho 1 = \text{mass/volume(V1)}$$
$$\rho 1 = 3/0.00320$$
$$\rho 1 = 813.008 \text{ kg/m3}$$

Density of our robot is 813.008 kg/m3, less than density of water, so that our robot floats initially.

As the robot descends into the water, the pressure acting on it increases continuously. This pressure can be calculated using the formula (P =mgh) *in this case g=9.81*. Our robot is capable of diving up to 2 meters, where the pressure reaches 20,070.4 pascals. This increased pressure affects the robot's density. To maintain its initial density, we adjust the robot's volume accordingly.

2) Pressure calculation at 2 meters depth:-

$$P = \rho gh \qquad \textit{(h=2 meters)}$$
$$P = ((1024)^* \ (9.8)^*(2))$$
$$P = 20070.4 \text{ pa}$$

3) Volume Adjustment Calculation:

$$V2 = mgh/P$$
$$V2 = ((3) \cdot (9.8) \cdot (2))/20070.4V$$
$$V2 = 0.002929 \text{ m3}$$
$$V = V2\text{- } V1$$
$$V = 0.002929\text{-}0.00320$$
$$V = (-0.000271) \text{ m3} \qquad \textit{(Value is negative)}$$
$$V = 0.27L = 270 \text{ ml}$$

As the value is negative our robot’s volume should be decreased by 260 ml i.e ballast should take in 260 ml of water.

4) Motion Control:-

(a) Forward and Backward Motion:

-When the propellers rotate in the clockwise direction, the robot moves forward.

-When the propellers rotate in the counterclockwise direction, the robot moves backward.

(b)Left and Right Movements:

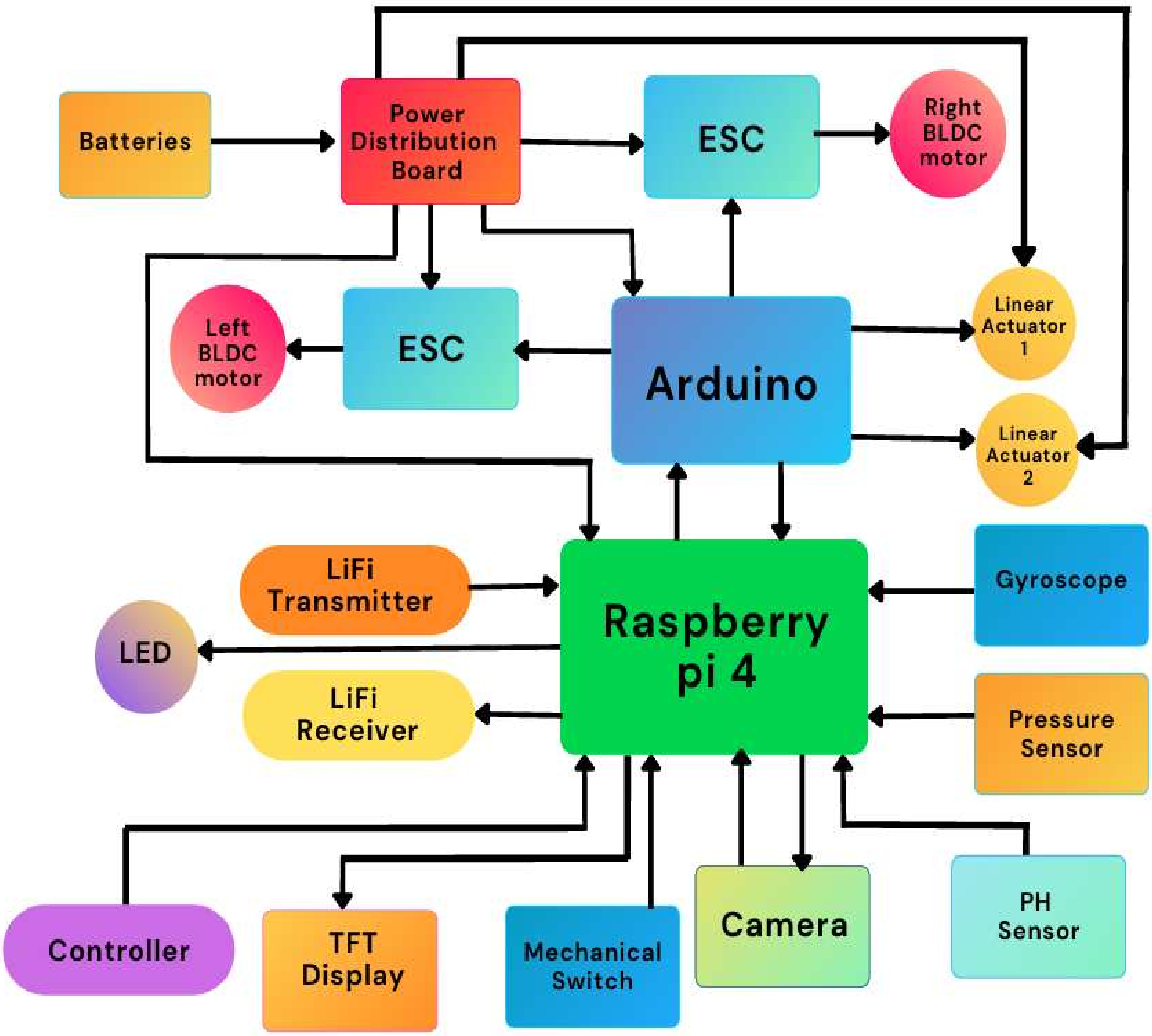
-For left movement, one propeller rotates at full speed while the other rotates at half speed, causing the robot to turn towards the faster rotating propeller.

-Reversing the speeds allows the robot to turn in the opposite direction.

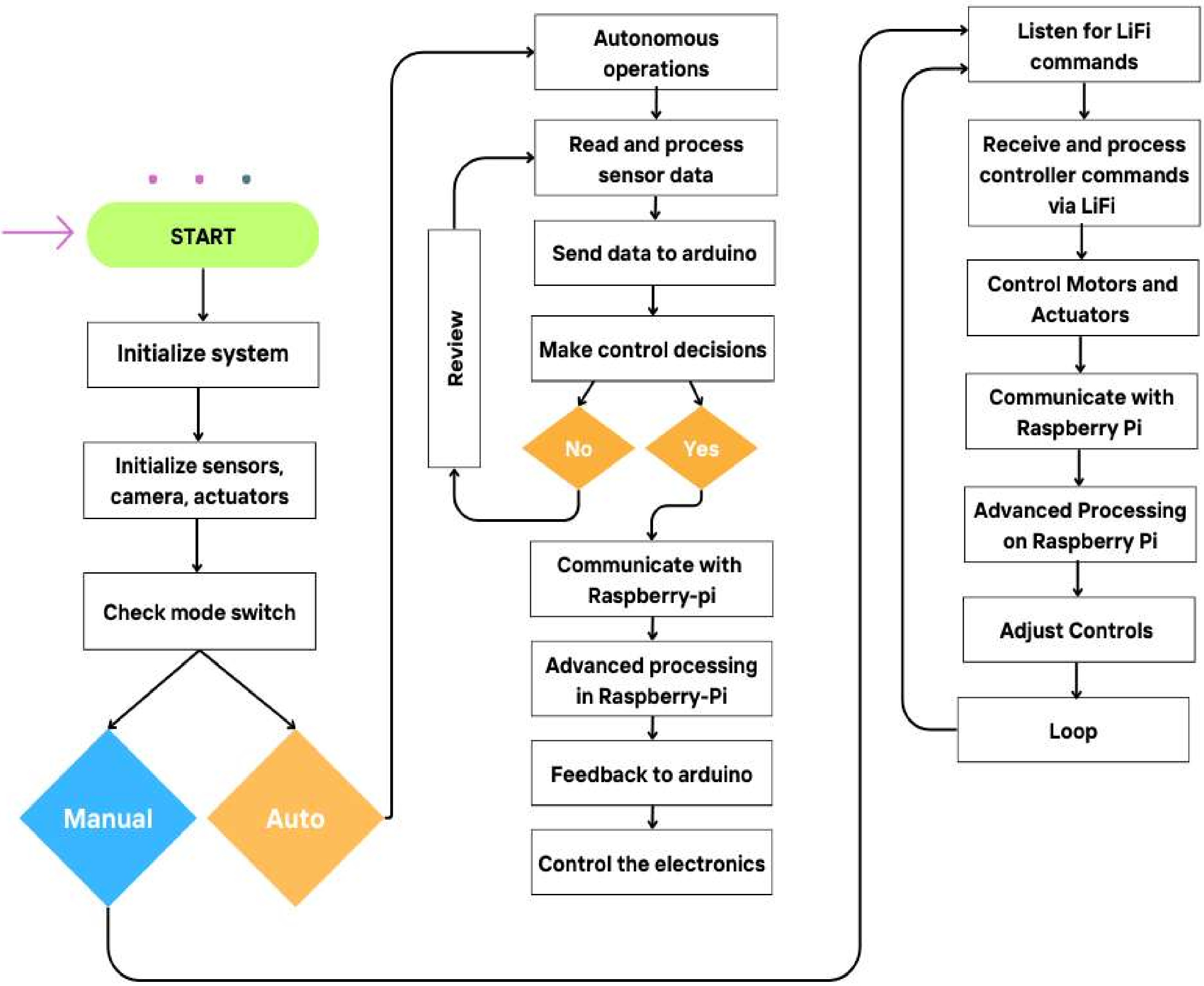
4.3 Mechanism of the robot

The underwater robot is designed for autonomous and manual operation. In autonomous mode, a gyroscope maintains stability, and uses camera for real-time obstacle avoidance, collecting pressure, temperature, and depth data. In manual mode, robot communicates surface controller, allowing direct control and real-time video feedback. Raspberry Pi handles core processing and interfaces with the camera, LiFi module, and sensors, while an Arduino manages motor drivers and sensor inputs. Key sensors include pressure, temperature, and proximity sensors. The robust mechanical structure, equipped with thrusters and actuators, ensures precise control.

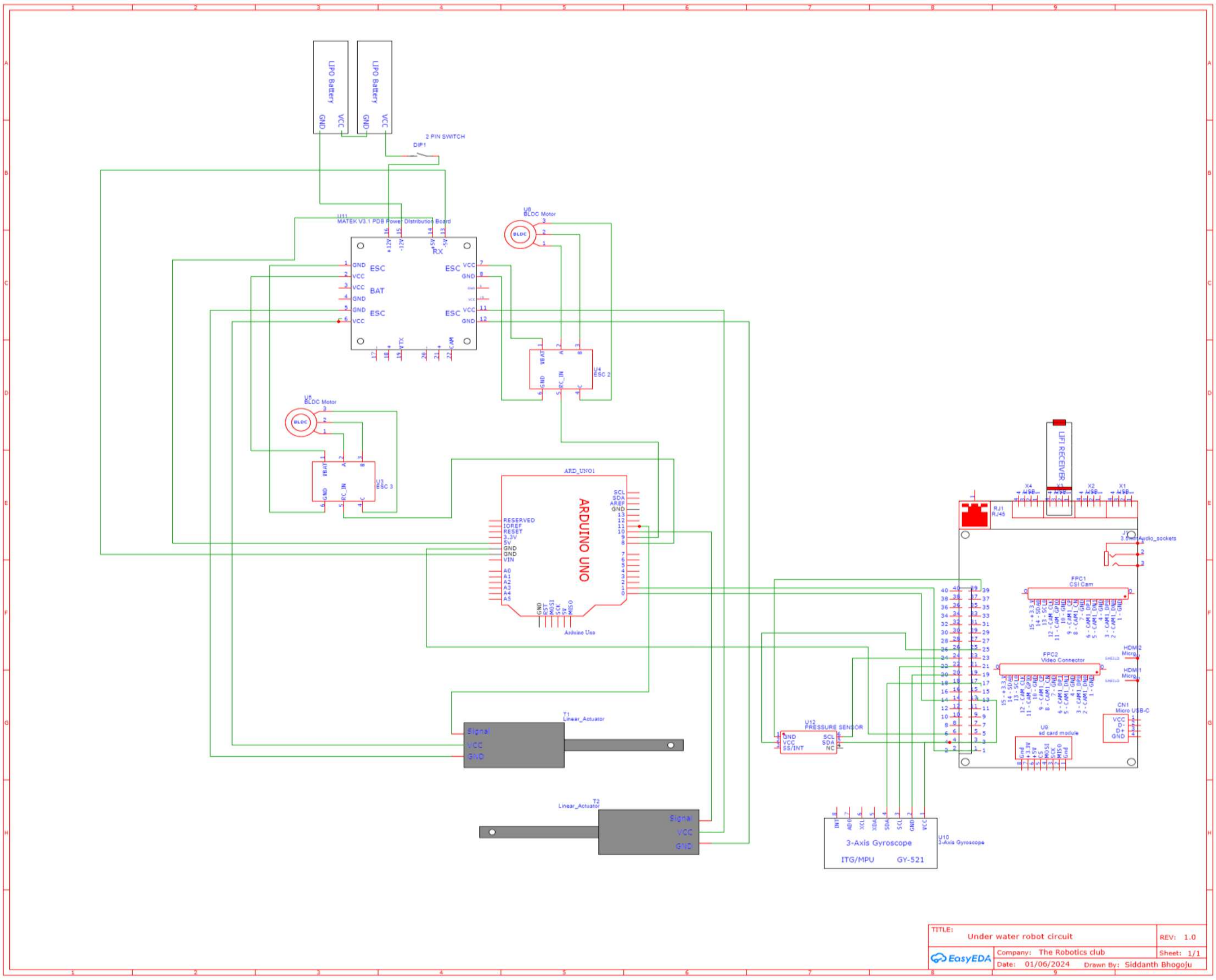
4.4 Block diagram of the robot



4.5 Logic flow of the robot



4.6 Circuit diagram of the robot



The above circuit diagram is created in an application called as EasyEDA EasyEDA is popularly known for its user-friendly interface, making circuit design accessible to both novices and experts. By seamlessly integrating schematic capture, we were able to create a circuit in a cloud-based platform, EasyEDA enhances workflow efficiency and reduces design time. It also enhances collaboration among users, enabling real-time project sharing and teamwork. Overall, EasyEDA offers a comprehensive solution for electronic design, catering to diverse needs from hobbyists to professional engineers.

4.7 Working of Electronic components:

1. **LiFi Nano- V2 Module:**

   In deep water,wireless protocols such as WiFi and RC struggle with communication. To overcome this, we employ a Nano-V2 module that can communicate at depths of 6-12 feet. The transmitter uses a fox light to send signals, which are then detected by a receiving module at the water's surface. With a high baud rate of 38600, this system efficiently broadcasts the pictures and videos captured by our cameras.

2. **Camera Module(OV5647):**

   The Camera Module (OV5647) is used in underwater robots to take clear pictures and videos. It helps the robot see where it is going, check things underwater, and collect information for research. It can also help find objects, watch marine life, and record underwater conditions live.

3. **Gyroscopic Sensor:**

   The gyroscopic sensor is used to balance our robot in the water. Whenever the robot tilts in any direction, the sensor adjusts the pressure opposite to the direction of the tilt, this continuous adjustment ensures the robot remains stable and correctly oriented in underwater environments.

4. **Pressure Sensor:**

   As the robot descends deeper underwater, the pressure it experiences increases, with the pressure sensor providing real-time pressure readings. These values are continuously analyzed to accurately determine the robot's true depth.

5. **BLDC Motor:**

   They are often encapsulated in waterproof housings to prevent water ingress. Corrosion-resistant materials are used to withstand the harsh conditions of underwater use. special attention is given to the seals and bearings to ensure water-tightness and longevity. The motor controller and power supply are also designed to be waterproof.

6. **Electronic speed controller**

   It receives input signals for motor speed and direction, and regulate power to the motor using drive circuitry and PWM control. Components are corrosion-resistant, and some include feedback mechanisms. They're powered by waterproof battery packs, ensuring reliable motor control in submerged conditions.

7. **Linear actuator**

   The two linear actuators are connected to two syringes, enabling precise control of fluid movement. Each actuator moves its respective syringe plunger, allowing for accurate manipulation of fluid pressure and volume, which can be used to creating suction and dispensing liquid.

8. **Power distribution board**

   Its important component that manages and distributes electrical power to various parts of the underwater robot. It ensures that each component receives the appropriate voltage and current, enabling the smooth operation of electronic components.

4.8 Manufacturing and Material Selection

We have determined all essential parameters, such as the pressure on the robot at the surface and at a depth of 2 meters, as well as the robot's density and buoyancy force. Given that we will produce all components in our institute's 3D printing lab, ABS material is the optimal choice for our robot. ABS is easy to manufacture and possesses the high density required by our calculations.

4.8.1 Acrylonitrile Butadiene Styrene (ABS)

ABS is used in underwater robots for its strength, chemical resistance, and ease of fabrication. It is ideal for structural components, watertight enclosures, and buoyancy control, ensuring durability and protection for sensitive electronics.

5. Application of proposed Robot in a societal context:

The underwater robot has several applications:

1. **Marine Research:**
   Collecting data on marine life, water quality, and ecosystems.

2. **Underwater Inspection and Maintenance:**
   Inspecting structures like pipelines, oil rigs, and ship hulls;performing maintenance tasks in hazardous or inaccessible environments.

3. **Military and Defense:**
   Inspecting and clearing underwater mines and hazards.

4. **Archaeology:**
   Exploring and documenting archaeological sites and shipwrecks. Mapping submerged artifacts and structures.

5. **Environmental Monitoring:**
   Measuring water quality parameters like temperature, salinity, and pollution. Tracking environmental changes due to climate change or human activity.

6. **Fishing Industry:**
   Assisting fishermen in locating shoals of fish, enhancing catch efficiency and reducing time spent searching.

9.Proposed outline (photography)

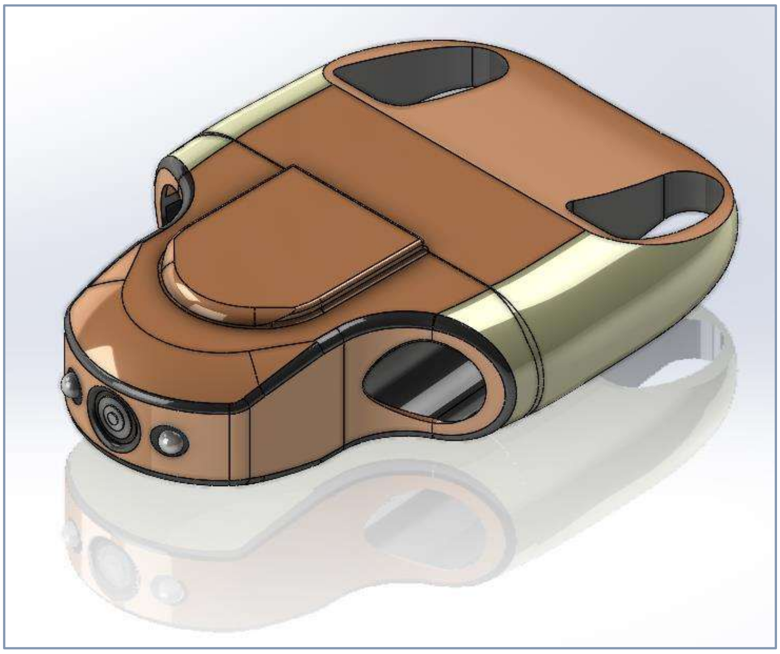


Figure 7: Underwater Robot-Isometric View

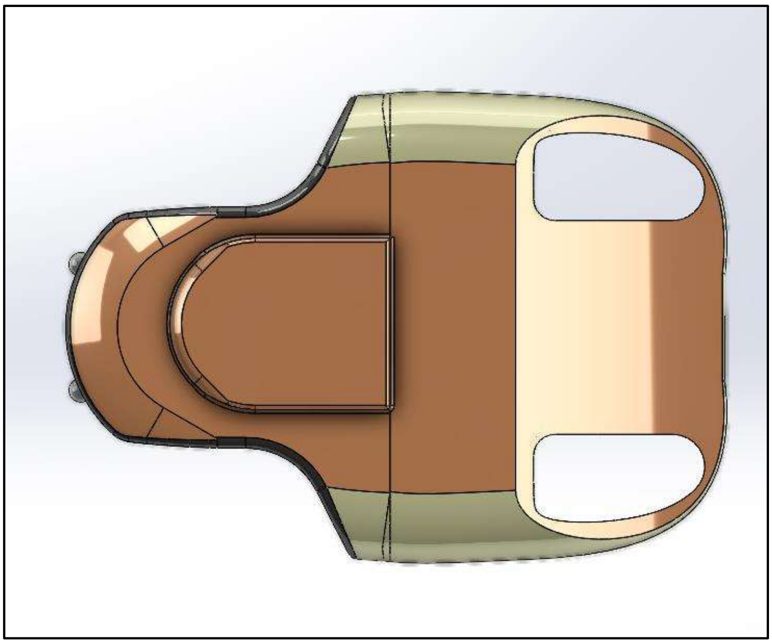


Figure 8: Top View of The Robot

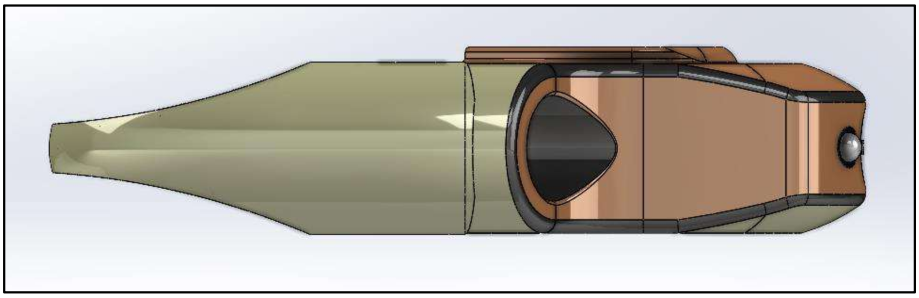


Figure 9: Side-View of The Robot

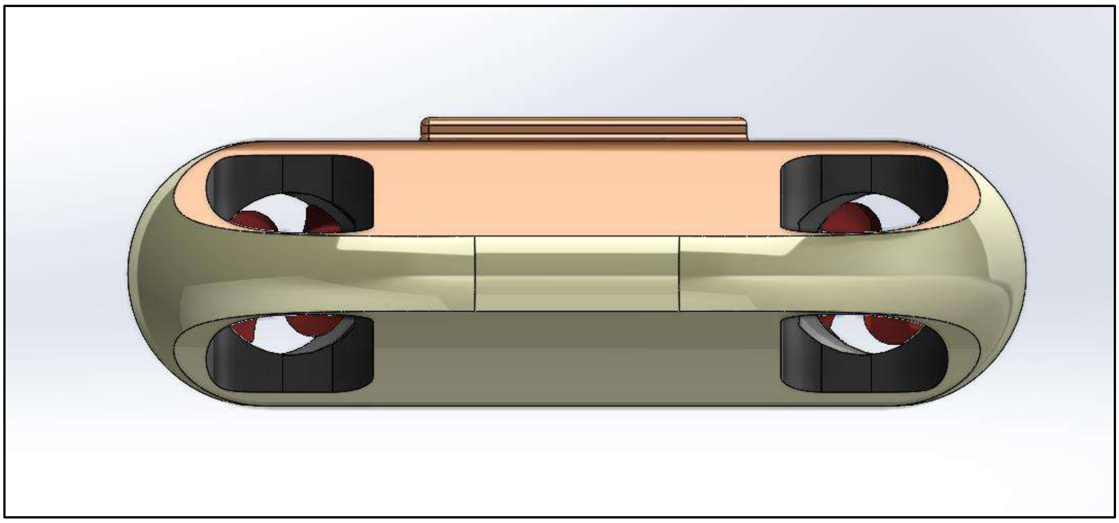


Figure 10: Back view of the robot

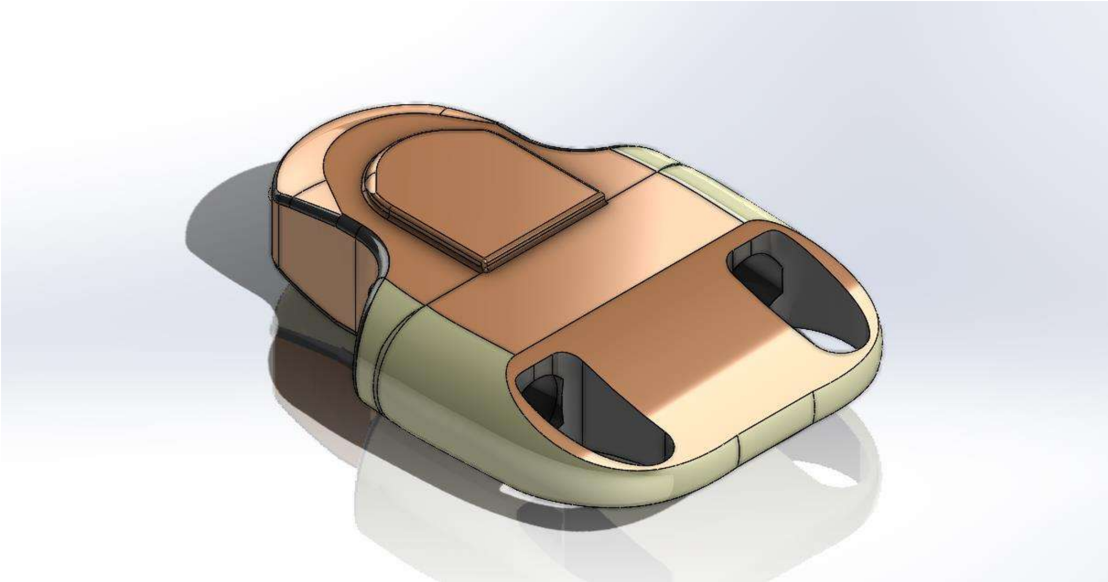


Figure 11: Back-right view of the robot

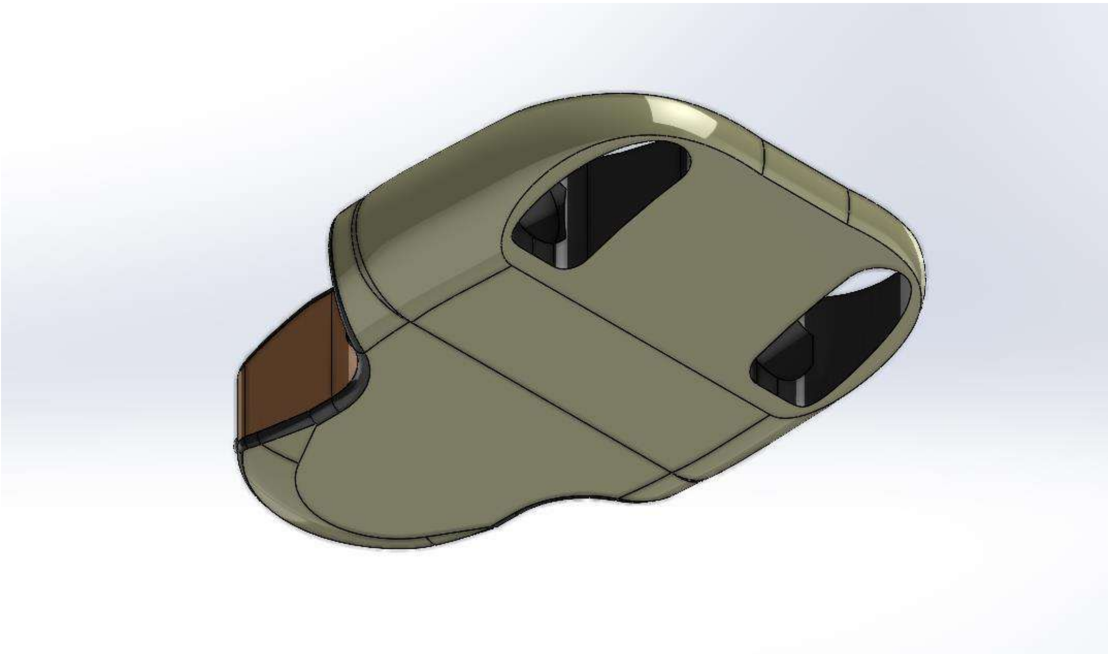


Figure 12: Bottom-left view of the robot