PERCY

Disaster Management

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The Problem

Floods are one of the most devastating natural disasters, affecting millions of people globally every year. In India alone, over **20 million individuals** face the dire consequences of flooding annually, including **loss of life**, **displacement**, and **damage to infrastructure**. As climate change accelerates, the frequency and intensity of floods are increasing, overwhelming rescue services and leaving many stranded without immediate assistance.

Despite the growing threat, there is a lack of accessible, affordable, and adaptable solutions for **personal vehicles** to navigate submerged roads safely. This gap in preparedness puts lives at risk and creates a heavy dependence on emergency response teams, which are often delayed or unavailable during crises.

There is an urgent need for a practical, scalable solution that empowers individuals and reduces reliance on external help during flood situations.

The Solution: Overview

PERCY is an **attachable kit** that can be mounted to work on any commercial car on the market. The kit that we will be providing will consist of **Air Tubes, Multiple Depth Sensors, and Big Air Pumps**. With this system, we can enable the car to float in the case of severe floods.

Our Objectives

1. Ensures Safety and Mobility
2. Reliable in Calamities
3. Affordable to the Public
4. Decreases Dependence on Emergency Vehicles

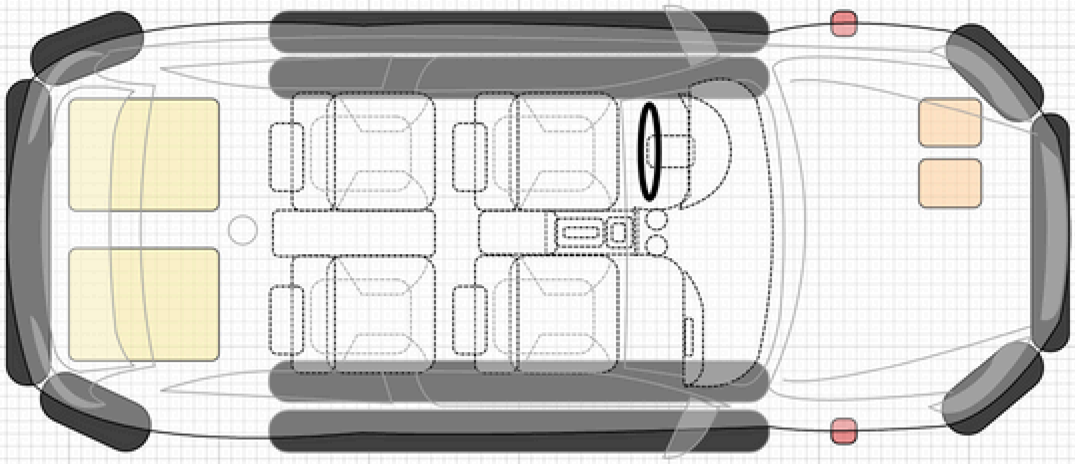
Working

- **Depth sensors** are strategically positioned around the vehicle, constantly monitoring water levels.
- When floodwaters rise above a critical threshold, PERCY activates its **Floatation Mechanism**.
- The **tubes inflate**, in order to provide essential buoyancy, allowing the car to float in this critical situation.
- We may also include customized **paddle-like spokes** to enable movement in water, mimicking the powerful strokes of a swimmer to push water backward and drive the vehicle forward.
- The driver will be able to manually deploy the floatation system, for redundancy.

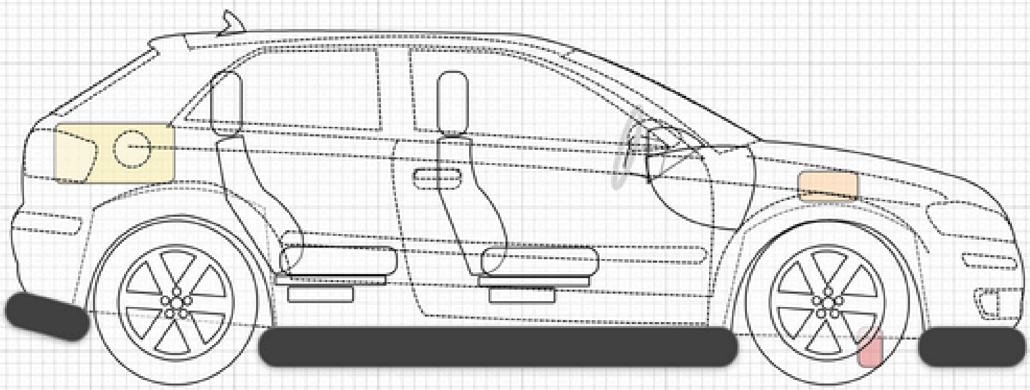
Advantages

- **Ensures Safety:** Prevents vehicle submersion, safeguarding passengers.
- **Universal Fit:** Compatible with most commercial vehicles.
- **Cost-Effective:** Affordable design for widespread accessibility
- **Reduces Dependence:** Minimizes reliance on emergency services.
- **Enhanced Mobility:** Optional paddles enable navigation in flooded areas.

CAD Engineering Drawings



PERCY Engineering Drawing	
Yellow Parts	Air Pumps
Orange Parts	Backup Air Pumps
Red Parts	Depth Sensors
Black Parts	Air Tubes

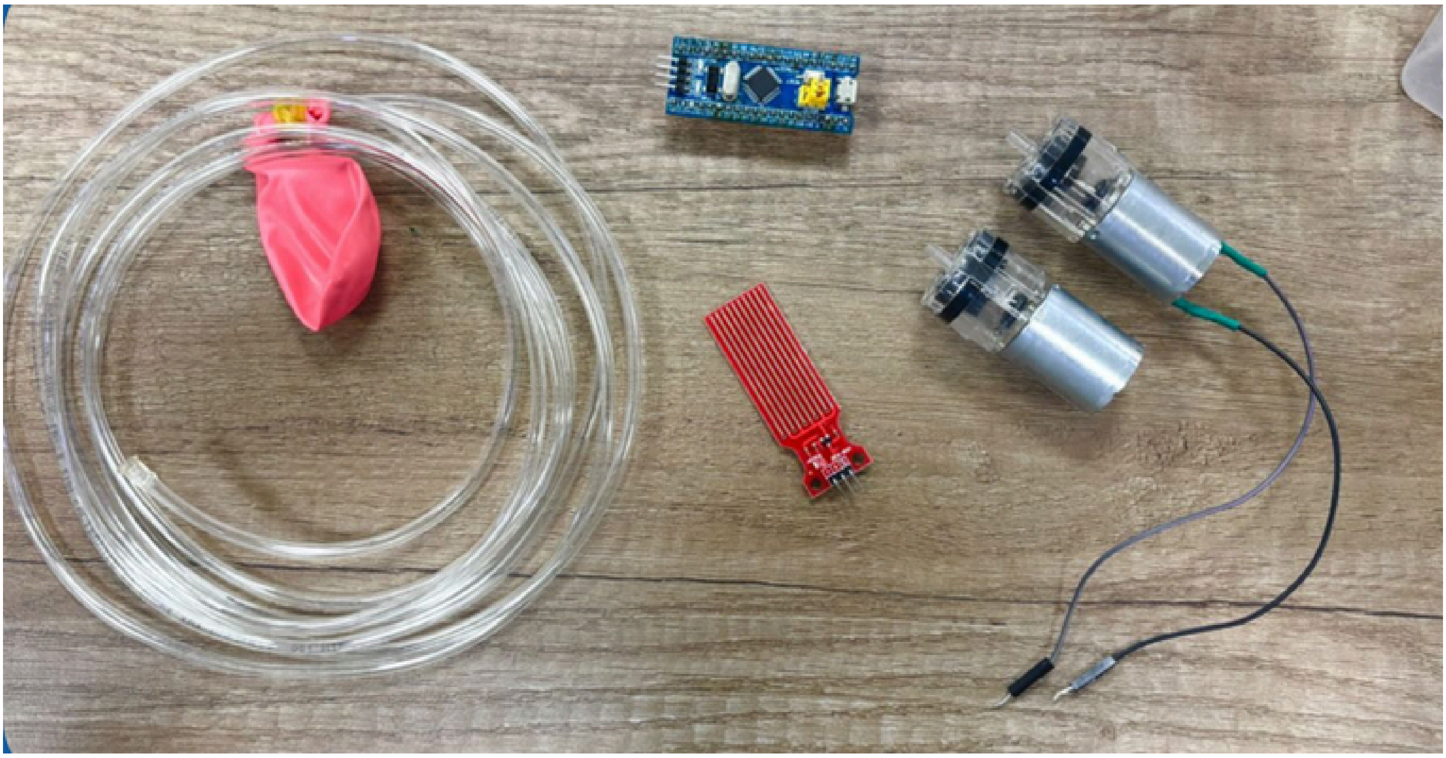


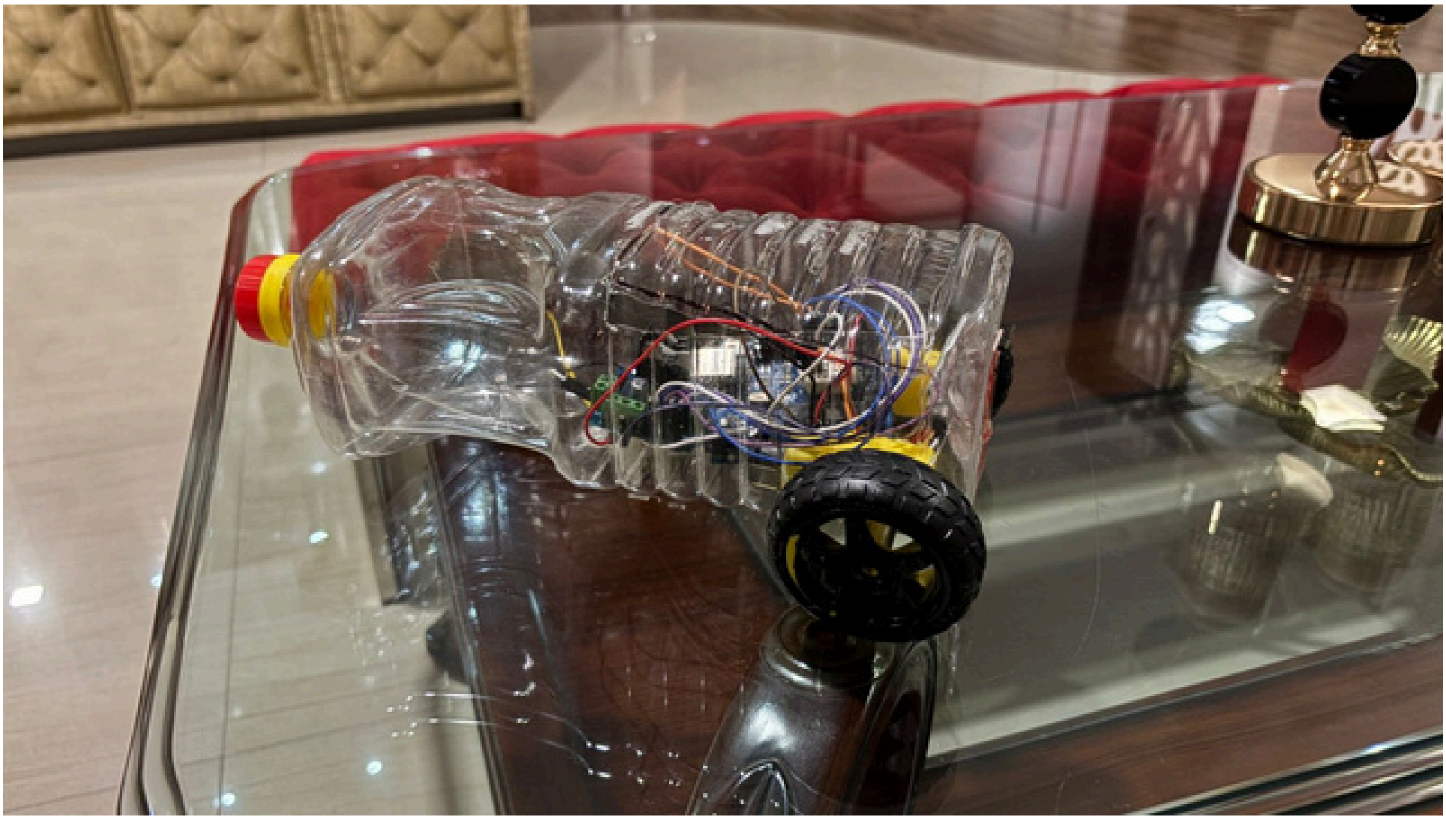
PERCY Engineering Drawing	
Yellow Parts	Air Pumps
Orange Parts	Backup Air Pumps
Red Parts	Depth Sensors
Black Parts	Air Tubes

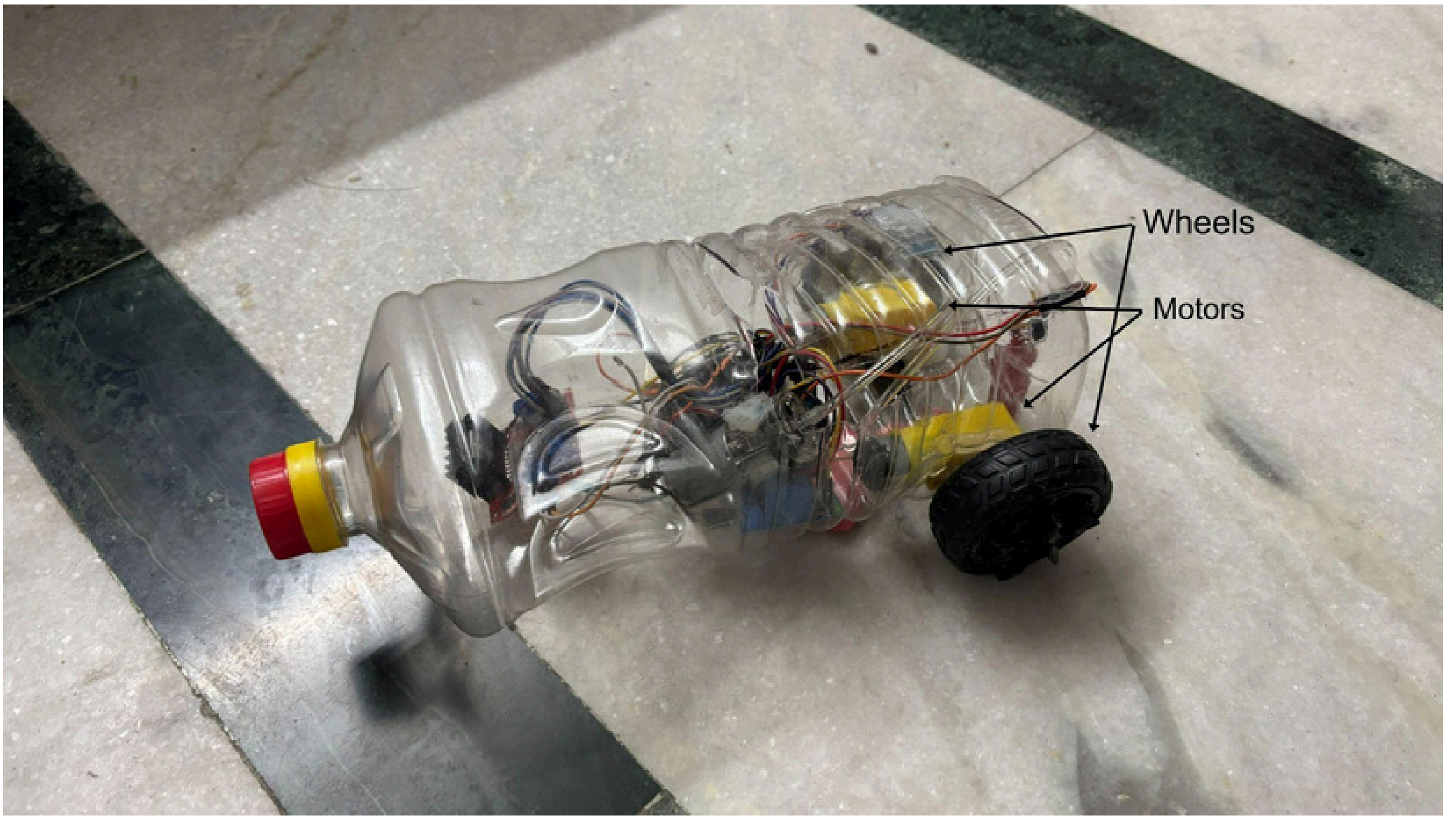
Our Mock-up Prototype

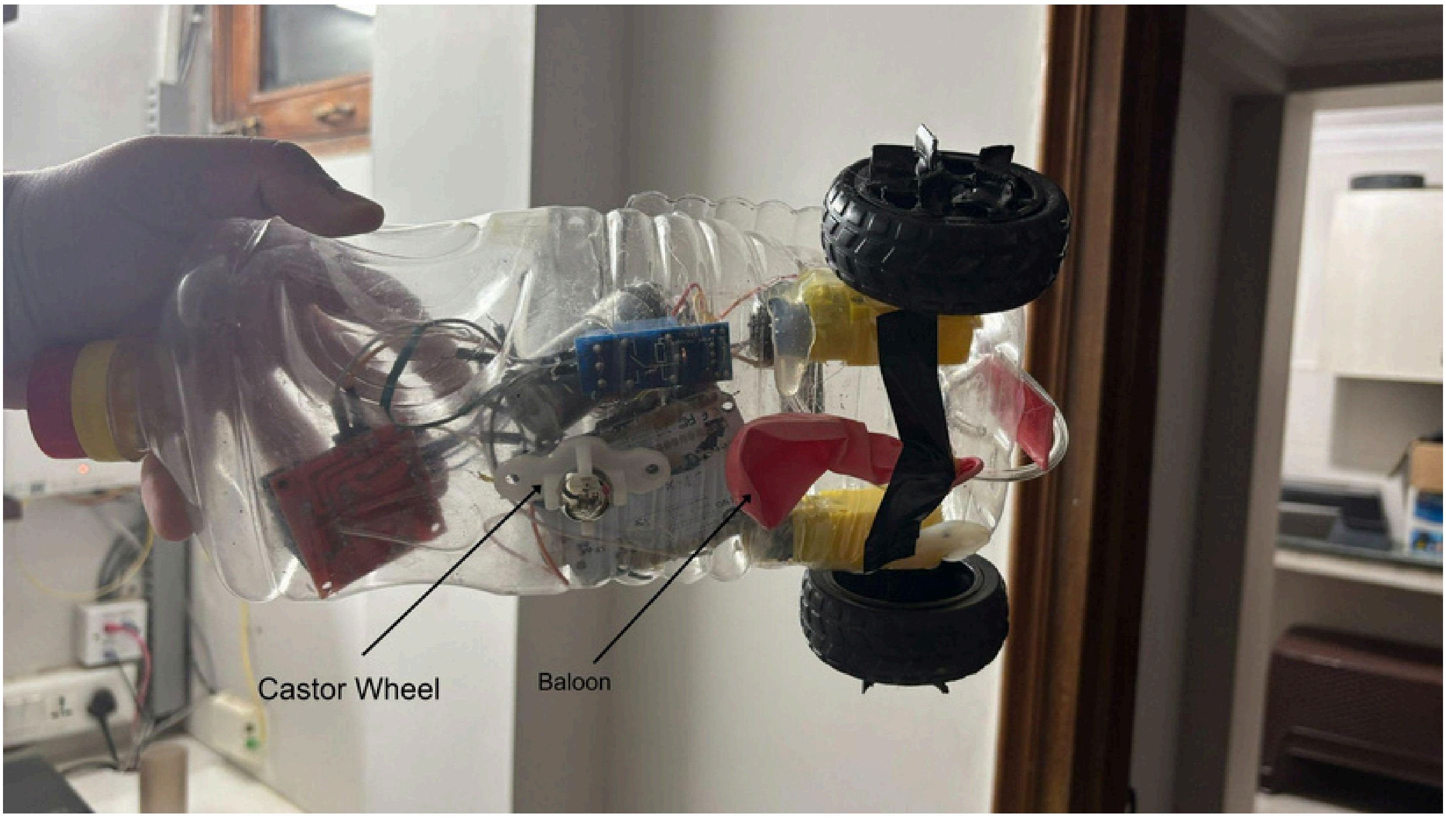
Name	Quantity	Cost
Depth Sensor Arduino	1	Rs. 25.00
Uno R3 Clone Board	1	Rs. 205.00
Mini Air Pump	1	Rs. 69.00
Relay Module	1	Rs. 29.00
12V Li-ion Battery	1	Rs. 109.00
BO Motors	2	Rs. 112.00
Wheels for BO Motors	2	Rs. 24.00
Motor Driver	1	Rs. 70.00
HM-10 BLE	1	Rs. 109.00
Miscellaneous Parts (Includes Bottle, Glue, etc.)	1	Rs. 50.00
Total		Rs. 802.00

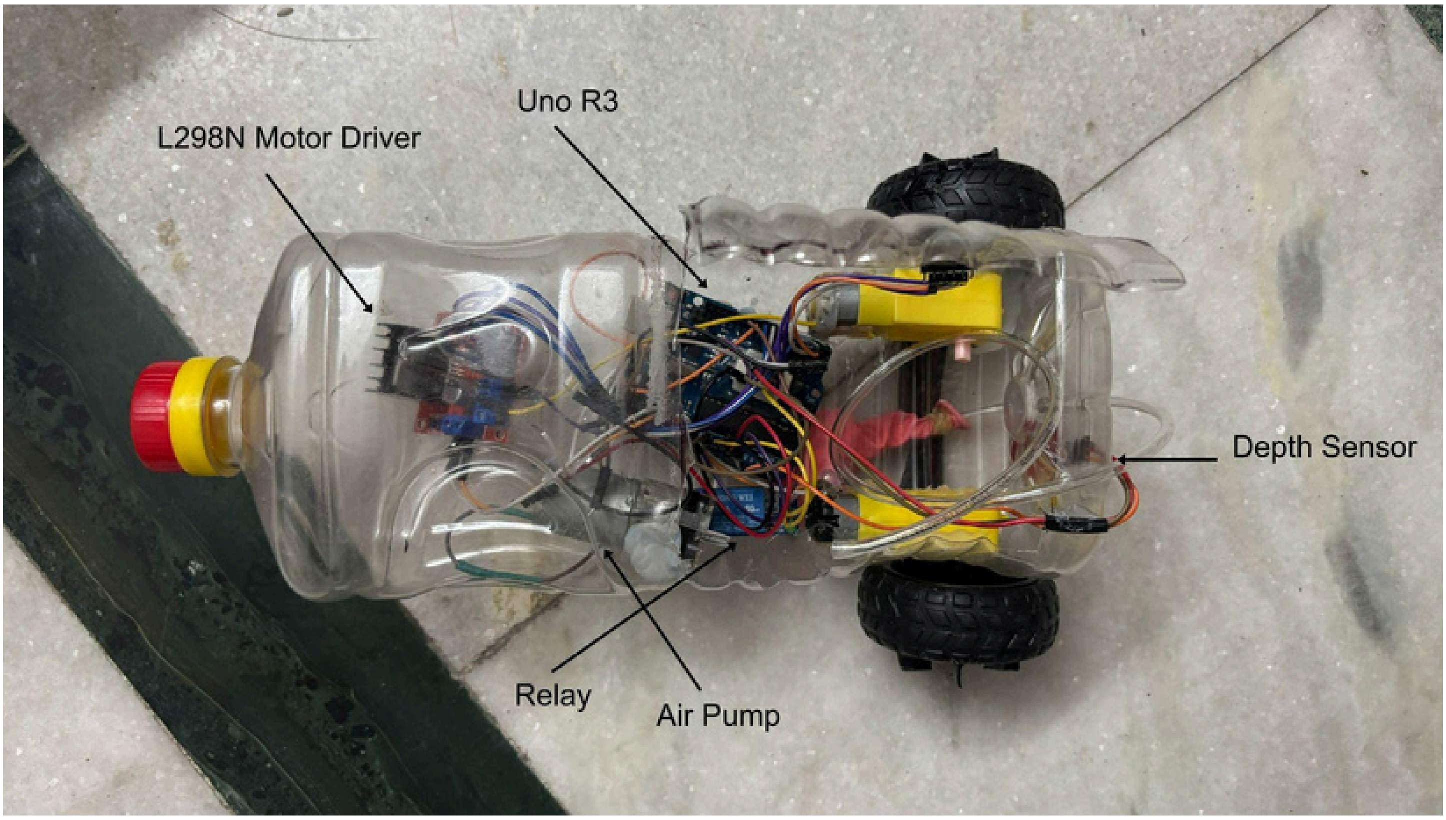
Images






Wheels
Motors


Castor Wheel
Baloon



Potential Future Developments

- **Integrated Anchor System (IAS):** Designed to stabilize and secure the vehicle during floods. This provides users with the ability to fix their vehicle in place when needed. The anchor system ensures safety in strong currents and prevents drifting, offering greater control and peace of mind in extreme flood conditions.
- **GPS module with an SOS button**: This feature will enable users to transmit their real-time location to rescue teams or emergency contacts during floods, ensuring timely assistance in critical situations.
- **Load Averaging:** We will be using a specialized micro computer to take water level data from multiple depth sensors simultaneously, making the system even more safe and secure.

Buoyancy Calculations

Assumptions

1. **Car Weight (Unloaded):** 1,025 kg
2. **Weight of Passengers (5 people):** 100 kg/person × 5 = 500 kg
3. **Weight of Trunk Load:** 70 kg
4. **Weight of Pumps (2 units):** 4.5 kg × 2 = 9 kg
5. **Volume Submerged:** 1/6th of the car's volume is submerged in water, meaning buoyancy offsets 1/6th of the car's weight.

Volume Submerged

Buoyancy Offset (from Archimedes' Principle)

- **Density of Water:** 1,000 kg/m^3
- **Submerged Volume:** (1/6) × (Car Weight (Unloaded) / Density of Water)
- Submerged Volume = (1/6) × (1,025 / 1,000) = 0.1708 m^3
- **Buoyancy Offset:** Buoyancy Offset = Submerged Volume × Density of Water × Gravity
- Buoyancy Offset = 0.1708 × 1,000 × 9.8 = 1,673.84 N

Total Weight After Buoyancy Offset

Total Mass Without Headroom

- **Total Weight Before Offset** = 1,025 kg + 500 kg + 70 kg + 9 kg = 1,604 kg
- **Weight After Buoyancy Offset:** = Total Weight Before Offset – (Buoyancy Offset / Gravity)
- Weight After Offset = 1,604 – (1,673.84 / 9.8) = 1,434.93 kg

Total Mass With 30% Headroom

- **Headroom** = 0.3 × Total Weight After Offset = 0.3 × 1,434.93 = 430.48 kg
- **Final Total Weight** = Total Weight After Offset + Headroom = 1,434.93 + 430.48 = 1,865.41 k

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Buoyant Force Required

- **Buoyant Force:** Total Weight × Gravity
- Buoyant Force = 1,865.41 × 9.8 = 18,283.02 N

Updated Buoyancy Calculations

Total Volume of Tubes Required

- **Volume Displaced** = Buoyant Force / (Density of Water × Gravity)
- Volume Displaced = 18,283.02 / (1,000 × 9.8) = 1.864 m^3

Tube Volume Calculation

- **Volume per Tube (2 tubes):** Volume per Tube = Total Volume / 2 = 1.864 / 2 = 0.932 m^3
- **Radius of Tube (Length = 4 m):** Radius = $\sqrt{(\text{Volume} / (\pi \times \text{Length}))}$ Radius = $\sqrt{(0.932 / (\pi \times 4))}$ = 0.273 m
- **Diameter of Tubes:** = 2 × Radius = 2 × 0.273 = 0.546 m (54.6 cm)

Pump Specifications and Fill Time

Air Pump Details

- **Capacity per Pump:** 110 L/min = 0.11 m^3/min
- **Total Capacity (2 pumps):** Total Capacity = 0.11 m^3/min × 2 = 0.22 m^3/min

Time to Fill the Tubes

- **Fill Time** = Total Volume / Total Pump Capacity
- Fill Time = 1.864 / 0.22 = 8.47 minutes

Pressure Requirements

At a Depth of 1 Meter

- **Pressure Required** = Density of Water × Gravity × Depth
- Pressure Required = 1,000 × 9.8 × 1 = 9,800 Pa (9.8 kPa)
- **Design Pressure (30% Headroom):** = 1.3 × Pressure Required
- Design Pressure = 1.3 × 9,800 = 12,740 Pa (12.74 kPa

Material Selection

The material for the tubes must:

1. Handle internal pressure of 12.74 kPa with a safety margin.
2. Be lightweight to minimize load.
3. Be corrosion-resistant for underwater use.

Candidate Materials

1. **High-Density Polyethylene (HDPE):**
   a. Tensile Strength: 25 MPa
   b. Density: 950 kg/m^3
   c. Advantages: Cost-effective, corrosion-resistant, lightweight.
2. **Aluminum Alloy (6061):**
   a. Tensile Strength: 275 MPa
   b. Density: 2,700 kg/m^3
   c. Advantages: Strong and lightweight, higher cost.
3. **Fiber-Reinforced Polymer (FRP):**
   a. Tensile Strength: 300 MPa
   b. Density: 1,800 kg/m^3
   c. Advantages: Excellent strength-to-weight ratio.

Wall Thickness Calculation

Using the hoop stress formula for cylindrical pressure vessels:

Wall Thickness = (Pressure × Radius) / Tensile Strength

For Each Material:

1. **HDPE:** Wall Thickness = (12,740 × 0.273) / (25 × 10^6) = 0.00014 m (0.14 mm)
2. **Aluminum:** Wall Thickness = (12,740 × 0.273) / (275 × 10^6) = 0.000013 m (0.013 mm)
3. **FRP:** Wall Thickness = (12,740 × 0.273) / (300 × 10^6) = 0.000012 m (0.012 mm)

Final

1. **Material Choice:**
   a. HDPE is sufficient for cost-effectiveness and corrosion resistance.
   b. Aluminum or FRP can be used for higher durability.
2. **Wall Thickness:**
   a. Minimum of **0.14 mm** for HDPE, including a 30% safety margin.
3. **Pump Selection:**
   a. Use **2 Hailea ACO-009 pumps**, providing a fill time of approximately **8.47 minutes**.
4. **Design Considerations:**
   a. Ensure pressure tolerance up to **12.74 kPa** with provisions for dynamic forces.