MATE ROV COMPETITION

IBM

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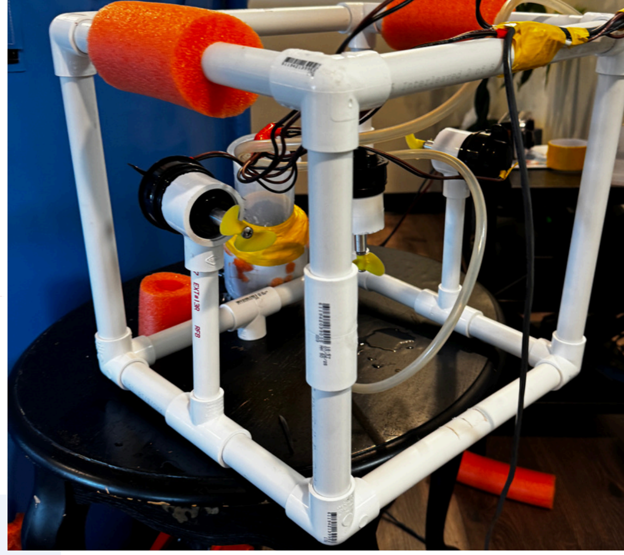

SEA MASTERS

ROVER A.I. & RESEARCH • MARINE STEM ED CLUB •
MATE ROV TEAM
SEA MASTERS
CHALLENGING THE FUTURE

MATE ROV 2026: SCOUT ENGINEERING PRESENTATION

Team of 4 students from St. Thomas Episcopal and Kids Robotic Academy: Imaad Memon, Jack Donewar, Mingzha Du, Shazil Baig

"CHALLENGING THE FUTURE"

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2026

COMPANY INTRODUCTION

SEA MASTERS ROV COMPANY
“CHALLENGING THE FUTURE”

Team Introduction

Sea Masters is a rookie underwater robotics engineering team focused on developing affordable, functional, and safe ROV systems using accessible materials and innovative engineering practices.

Team Roles

- CEO / Team Lead: Imaad Memon / Mingzha Du
- Pilot: Imaad Memon
- Co-Pilot: Shazil Baig
- Safety Officer:Mingzha Du
- Mechanical Engineer: Jack Donewar
- Systems Engineer: Jack / Shazil / Imaad
- Documentation & Presentation Lead: Imaad Memon
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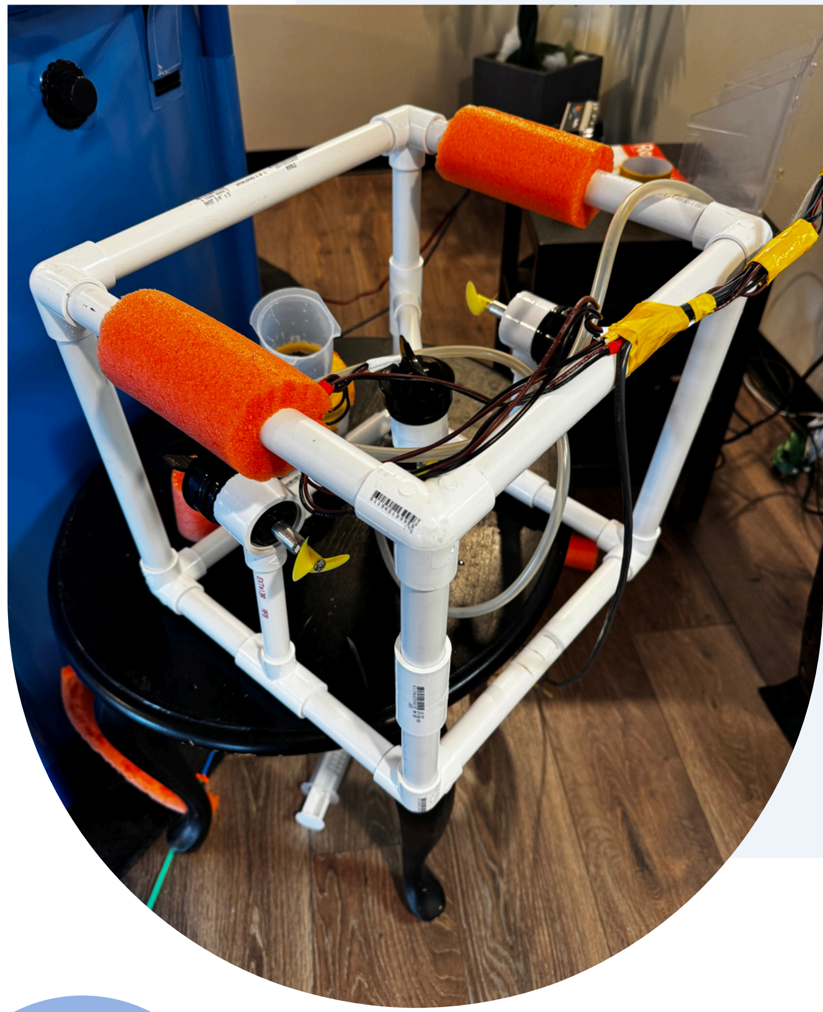
Mission Statement

“Our mission is to design and build an underwater robotic vehicle capable of solving engineering challenges through creativity, teamwork, and iterative problem solving.”

MISSION OBJECTIVES & DESIGN CONSTRAINTS



Team Sea Masters was challenged to design and build a safe, stable, and affordable underwater ROV capable of completing mission tasks while operating within SCOUT class limitations. As a rookie team, we focused on solving real engineering problems involving buoyancy, maneuverability, structural stability, and underwater manipulation using accessible materials and iterative design methods.

PRIMARY OBJECTIVES

Our ROV was designed to:

- Navigate underwater safely and efficiently
- Maintain neutral and controlled buoyancy
- Manipulate underwater objects
- Demonstrate reliable propulsion and control
- Operate within SCOUT class size limitations

DESIGN CONSTRAINTS

As a rookie team, we faced several engineering limitations:

- Limited budget
- Limited fabrication equipment
- First-year experience with underwater robotics
- Need for lightweight and repairable construction
- Safety requirements for underwater electrical systems

ENGINEERING PRIORITIES

- Safety
- Stability
- Buoyancy Control
- Maneuverability
- Reliability
- Affordability

KEY ENGINEERING CONCEPTS

- Center of Mass
- Center of Buoyancy
- Fluid Displacement
- Stability Optimization
- Thrust Vectoring

ENGINEERING DESIGN PROCESS STEPS

Our engineering process involved researching underwater robotics concepts, brainstorming multiple design ideas, building and testing prototypes, and continuously improving the robot through observation and redesign. Each stage of testing helped our team better understand buoyancy, propulsion, and underwater stability while strengthening our problem-solving and teamwork skills.

STEP 1: RESEARCH & PLANNING

We researched:

- Underwater ROV systems
- Buoyancy principles
- PVC frame structures
- Thruster placement
- Hydraulic and pneumatic systems

STEP 2: BRAINSTORMING & SKETCHING

The team created multiple concepts for:

- Frame geometry
- Thruster positioning
- Buoyancy systems
- Manipulator claw mechanisms

STEP 3: PROTOTYPE DEVELOPMENT

We developed early prototypes to test:

- Flotation
- Structural strength
- Stability underwater
- Claw movement
- Thruster efficiency

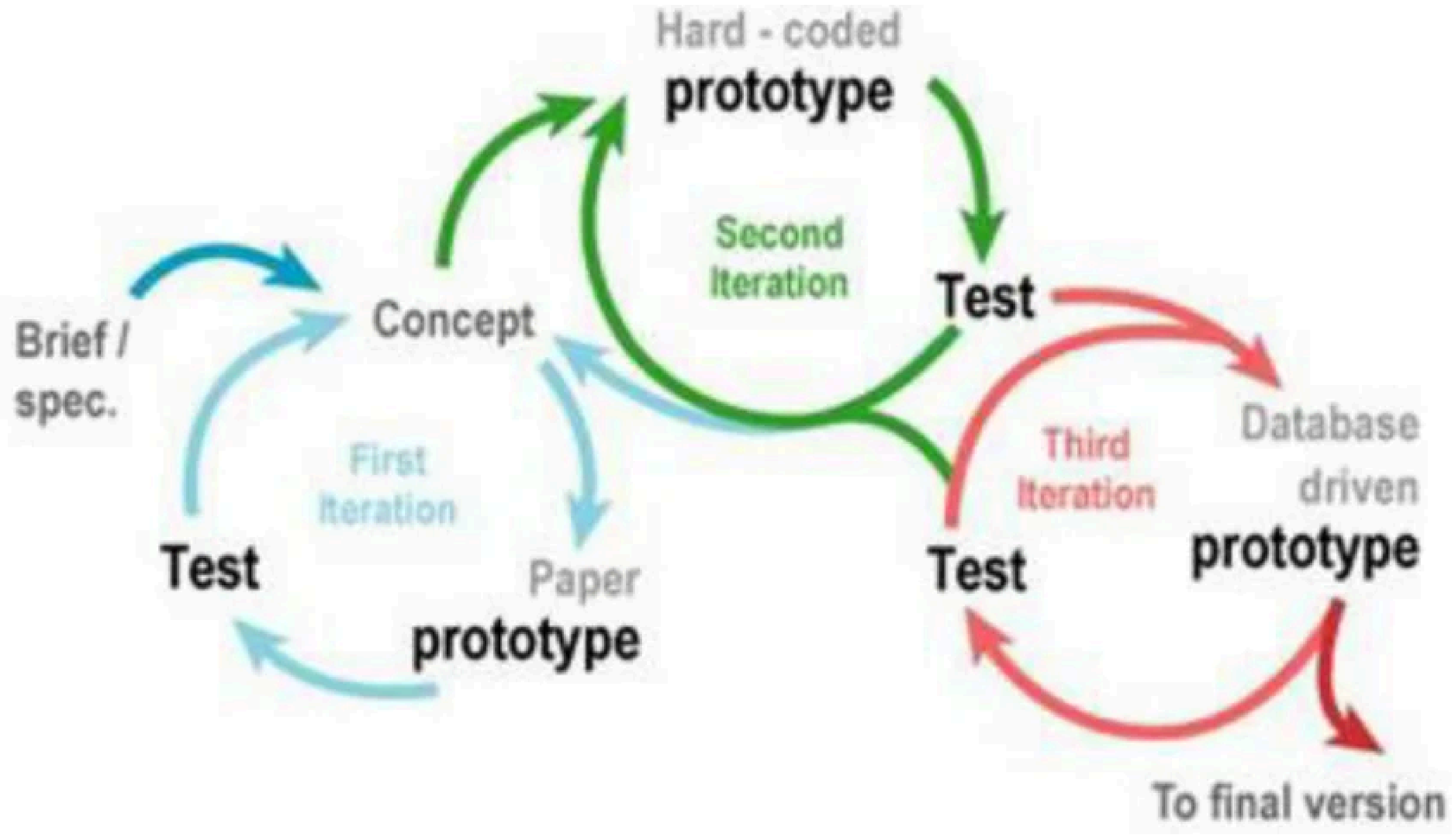
STEP 4: TESTING & ITERATION

We developed early prototypes to test:

- Flotation
- Structural strength
- Stability underwater
- Claw movement
- Thruster efficiency

Engineering Lesson

"Engineering success is achieved through testing, failure analysis, redesign, and continuous improvement."

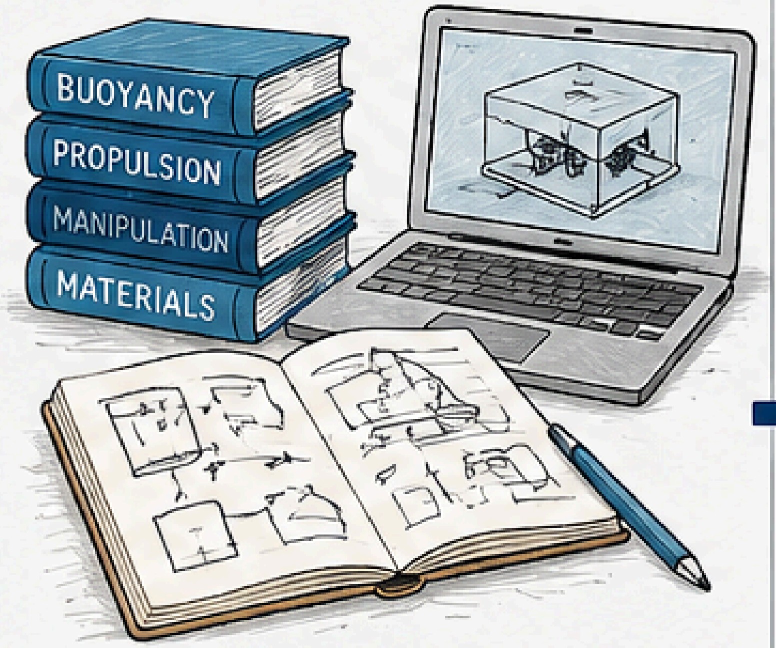


ENGINEERING DESIGN PROCESS

Our journey from idea to a functional ROV

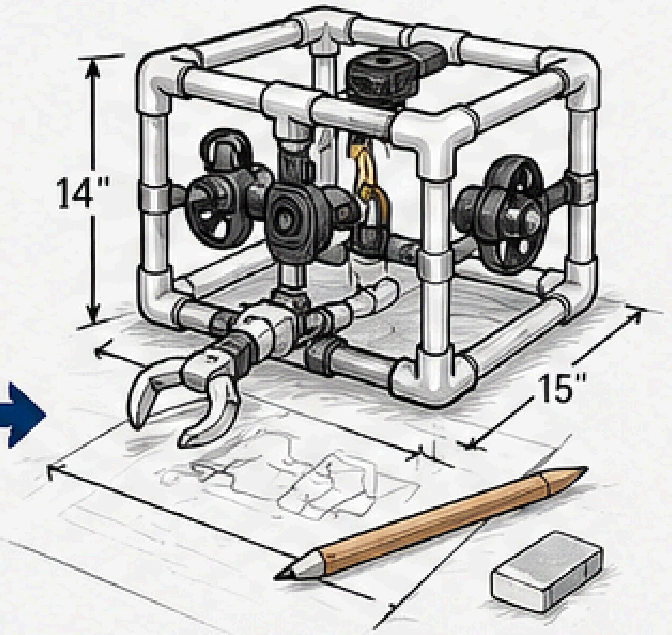
We followed a structured engineering process to design, build, and test our ROV.

1 RESEARCH



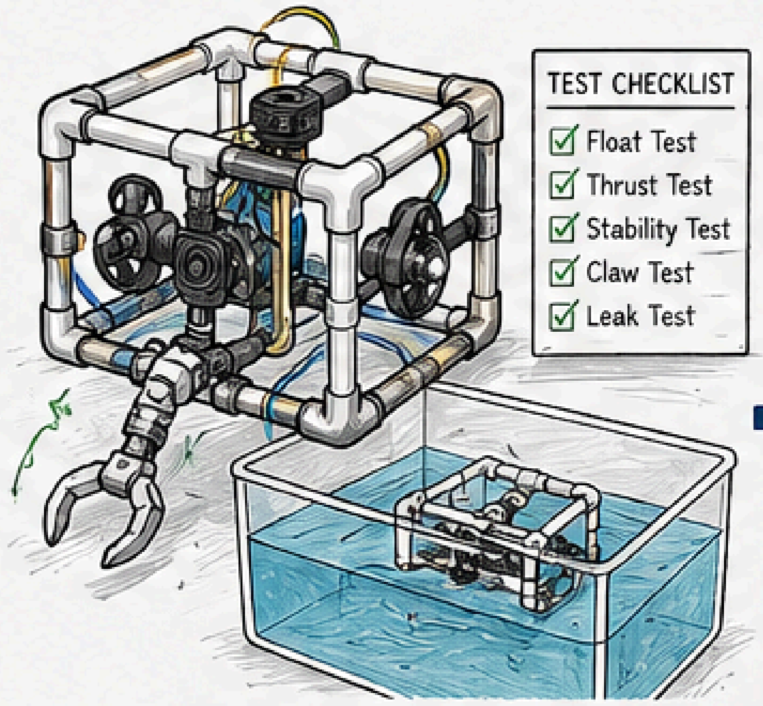
- Researched underwater robotics and mission tasks
- Studied buoyancy principles, thruster configurations, and manipulator systems
- Analyzed SCOUT class rules and constraints
- Created initial design goals and requirements

2 DESIGN & PLAN



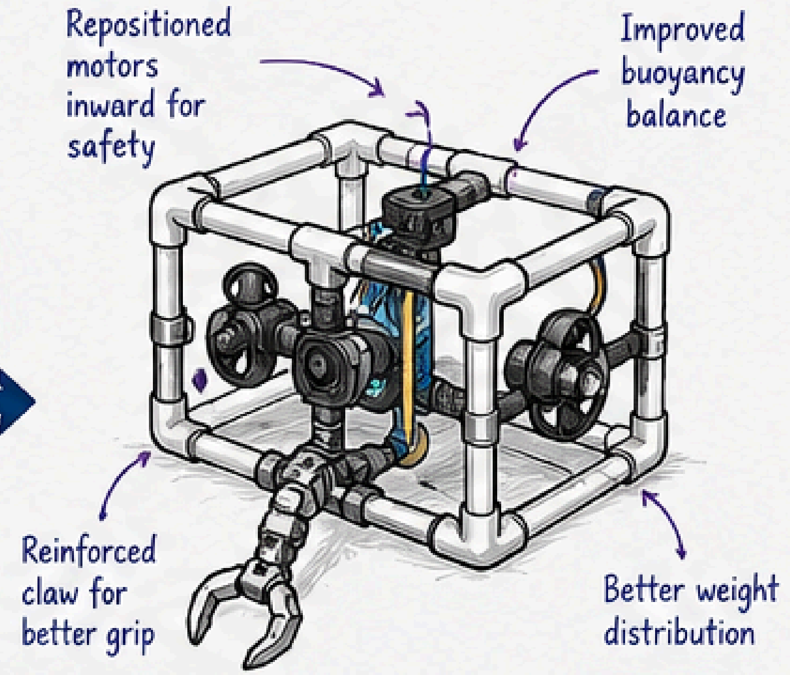
- Brainstormed multiple design concepts
- Selected a 14" x 15" cube PVC frame for stability
- Planned 3-motor configuration and pneumatic buoyancy system
- Designed syringe-operated claw mechanism
- Created detailed sketches and system layout

3 BUILD & TEST



- Built the ROV using PVC and home materials
- Conducted multiple tests: float, thrust, stability, claw and leak tests
- Collected data and observed performance
- Identified issues and areas for improvement

4 ITERATE & IMPROVE



- Refined design based on test results
- Adjusted buoyancy and weight distribution
- Improved claw strength and control
- Re-tested and optimized for mission performance

ENGINEERING IS AN ITERATIVE JOURNEY

We learned that every test, mistake, and improvement brings us one step closer to a better ROV.

MECHANICAL DESIGN & STRUCTURE

Team Sea Masters designed a compact 14″ × 15″ cube-shaped ROV using lightweight PVC materials to create a stable, affordable, and repairable underwater vehicle. The open-frame structure improved balance and reduced underwater drag while allowing easy access for maintenance and upgrades. Motors were intentionally inverted inward toward the frame to improve safety, protect the propellers from impacts, and reduce the risk of entanglement during operation. This design demonstrates our understanding of structural integrity, weight distribution, modularity, and safe engineering practices.

Vehicle Structure

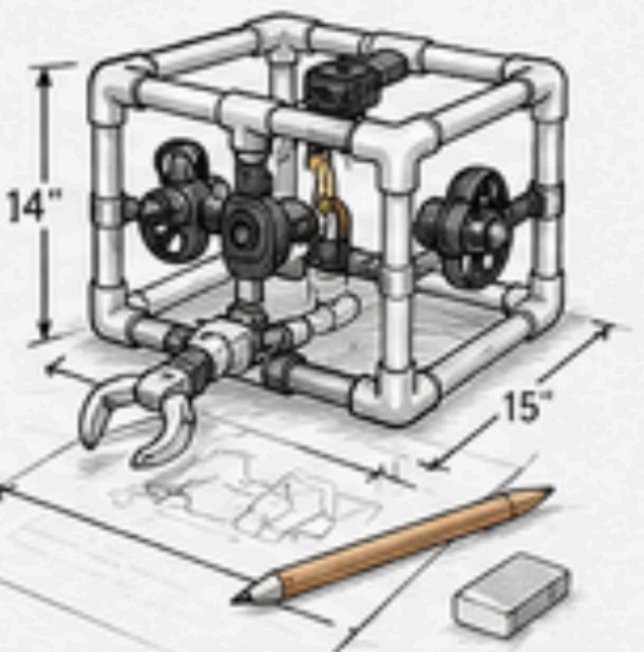
Robot Specifications

- Dimensions: 14″ × 15″ Cube
- Lightweight PVC structural frame
- Open modular design
- Home-built construction materials

Why PVC?

PVC was selected because it is:

- Lightweight
- Corrosion resistant
- Affordable
- Easy to modify and repair
- Readily available



Structural Design Features

- Cube geometry improves balance and stability
- Open-frame structure reduces drag underwater
- Modular sections simplify repairs and upgrades

Safety Engineering

To improve safety and durability:

- Motors were inverted inward toward the body
- Propellers were protected from external impacts
- Wiring was organized to reduce entanglement risks

Engineering Vocabulary

- Structural Integrity
- Modularity
- Hydrodynamic Considerations
- Weight Distribution
- Impact Protection

PROPULSION & MANEUVERABILITY SYSTEM

Our ROV uses a three-motor propulsion system consisting of two horizontal thrusters for movement and turning and one vertical thruster for depth control. The propulsion system was carefully designed to provide stable underwater navigation while maintaining maneuverability and efficiency. During testing, the team encountered issues with drifting and instability, which led to improvements in motor alignment and weight distribution. Through iterative testing and redesign, we optimized thrust control and improved the overall stability and performance of the vehicle.

Three-Motor Thruster Configuration

Propulsion Layout

Our ROV uses:

- Two horizontal thrusters for forward movement and turning
- One vertical thruster for depth control

Design Goals

The propulsion system was designed to:

- Provide stable navigation
- Allow directional control
- Maintain maneuverability underwater
- Minimize unnecessary drag

Engineering Challenges

We experienced:

- Uneven thrust
- Robot drifting
- Instability during turning

Solutions Implemented

- Repositioned motors for better balance
- Optimized thrust alignment
- Improved center of mass distribution

Why Inverted Motors?

The motors were intentionally angled inward to:

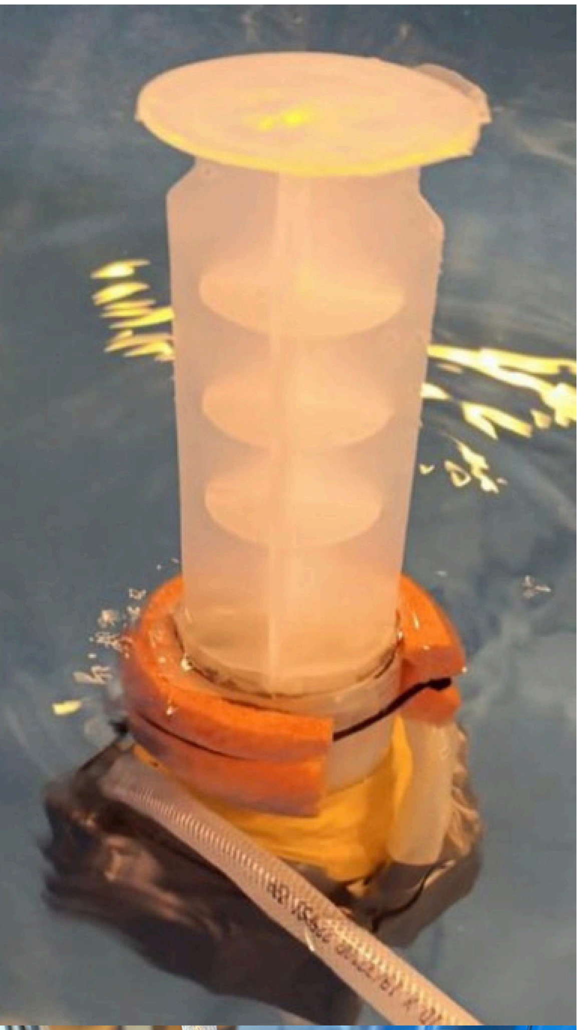
- Protect propellers
- Reduce accidental impacts
- Improve safety
- Prevent entanglement and mishaps

Engineering Concepts Applied

- Thrust Vectoring
- Directional Stability
- Drag Reduction
- Mechanical Safety Optimization

PNEUMATIC BUOYANCY CONTROL SYSTEM

One of the most innovative features of our ROV is the pneumatic buoyancy control system, which helps the robot maintain balance and controlled movement underwater. The system works by managing air and water displacement to improve flotation and stability. Through multiple rounds of float testing, sink rate analysis, and balance adjustments, the team gained a deeper understanding of Archimedes' Principle, fluid displacement, and center of buoyancy. Small modifications in flotation placement and weight distribution resulted in major improvements in underwater performance and stability.



Buoyancy Engineering System

Innovation Highlight

One of our major engineering achievements was developing a pneumatic pump system to help control buoyancy.

System Purpose

The system helps the ROV:

- Float more efficiently
- Control depth changes
- Maintain underwater balance
- Reduce tipping and instability

How the System Works

The pneumatic system adjusts buoyancy by:

- Managing air and water displacement
- Controlling flotation characteristics
- Assisting with depth stabilization

Scientific Principles Applied

- Archimedes' Principle
- Fluid Displacement
- Density Control
- Center of Buoyancy

Testing Procedures

The team conducted:

- Float tests
- Sink rate tests
- Stability trials
- Balance adjustment experiments

Improvements Made

- Reduced air leakage
- Improved flotation positioning
- Optimized weight distribution

Engineering Reflection

"Small adjustments in buoyancy created major improvements in underwater stability and vehicle performance."

MANIPULATOR CLAW SYSTEM

The Sea Masters manipulator claw was built using VEX components and controlled through a syringe-operated hydraulic and pneumatic system. The claw was designed to pick up and manipulate underwater objects while remaining lightweight and easy to repair. During development, the team faced challenges with gripping strength and underwater control, which were improved by reinforcing the claw structure and reducing friction in the moving joints. This system helped the team better understand real-world hydraulic mechanisms used in underwater robotics and industrial engineering applications.

Syringe-Controlled Claw Mechanism

Claw Construction

The manipulator claw was built using:

- VEX structural components
- Syringe-operated hydraulic/pneumatic motion
- Lightweight custom attachments

Purpose of the Claw

The claw was designed to:

- Pick up underwater objects
- Manipulate mission components
- Demonstrate controlled underwater movement

Why This Design?

This system was selected because it is:

- Affordable
- Lightweight
- Educational
- Easy to understand mechanically
- Easy to repair and modify

Engineering Challenges

We faced challenges including:

- Weak gripping force
- Mechanical friction
- Limited underwater control

Engineering Solutions

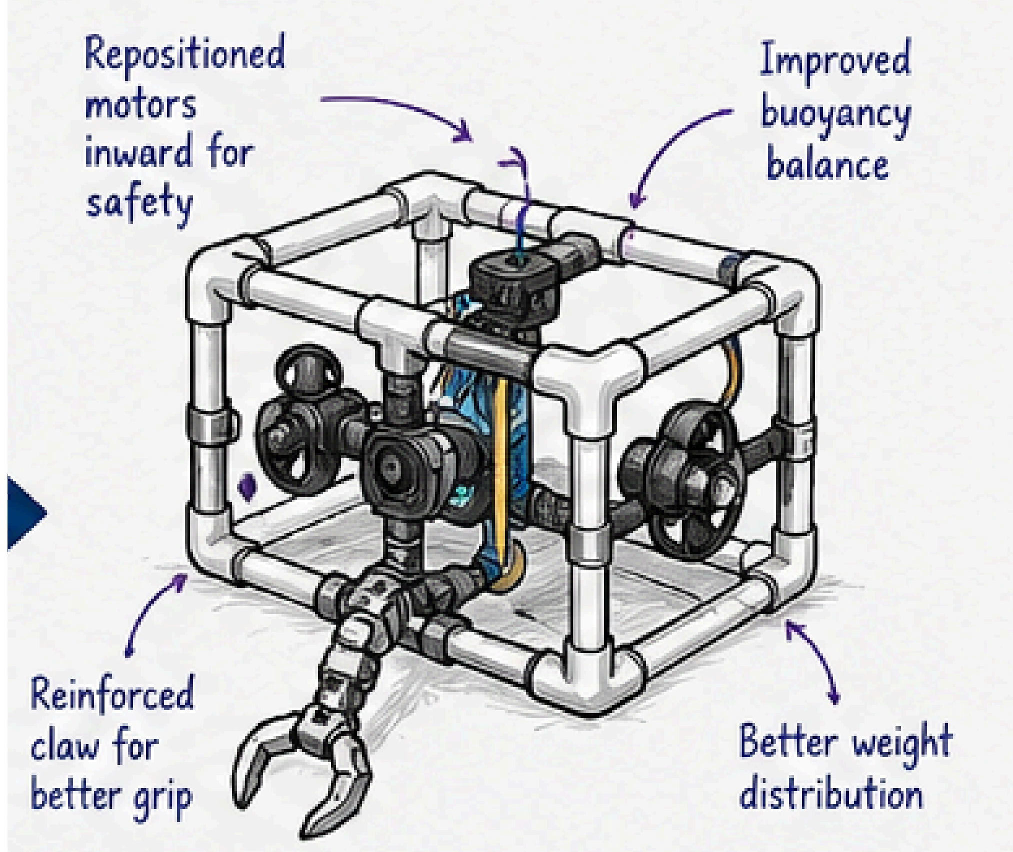
To improve performance we:

- Reinforced claw joints
- Increased syringe efficiency
- Reduced friction in moving parts

Real-World Engineering Connection

Hydraulic and pneumatic systems are used in:

- Industrial robotic arms
- Excavators
- Underwater manipulators
- Heavy equipment systems



ENGINEERING INNOVATION THROUGH SIMPLICITY

At Sea Masters, we believe engineering innovation does not depend on expensive materials or advanced manufacturing tools. By using PVC pipes, home improvement materials, VEX components, and syringe-based systems, our team demonstrated that creativity and problem solving are the foundation of engineering success. Our ROV showcases affordability, iterative design thinking, engineering fundamentals, and practical innovation. Through repeated testing and redesign, the team learned how small improvements can significantly improve performance and reliability.

Our Design Philosophy
At Sea Masters, we believe effective engineering does not always require expensive materials or advanced manufacturing tools.

Our ROV was intentionally designed using:
- PVC piping
- Home improvement materials
- VEX components
- Syringe-based control systems

Our Engineering System Demonstrates
- Creativity in solving underwater challenges
- Affordability using accessible materials
- Understanding of engineering fundamentals
- Iterative design thinking through repeated testing and redesign

Skills We Developed

By building this ROV, our team gained experience with:
- Buoyancy control
- Structural stability
- Propulsion systems
- Hydraulic and pneumatic systems
- Underwater vehicle optimization

Engineering Reflection
"Engineering is not defined by the cost of materials, but by the ability to solve problems effectively."

ELECTRICAL SYSTEMS & SAFETY

Safety was one of the highest priorities throughout the design and operation of our ROV. The team implemented organized wire management, waterproof electrical protection, and inward-facing motor placement to reduce potential hazards during underwater operation. Before every test session, the team conducted electrical inspections, dry tests, and safety checks to ensure reliable performance. This strong focus on safety helped us understand the importance of responsible engineering practices when working with electrical systems in underwater environments.

Safety First Engineering

Safety Features
Our ROV includes:

- Inverted motor placement
- Organized wire management
- Waterproof electrical sealing
- Protected moving components

Safety Procedures
Before every test:

- Electrical systems were inspected
- Motors were checked for damage
- Dry testing was completed
- Connections were verified

Importance of Safety
Underwater robotics combines:

- Water
- Electricity
- Rotating propellers

This makes safety a critical part of our engineering process.

Team Safety Culture

"Our team prioritized safety throughout the design, construction, testing, and operation of the ROV."

TESTING, DATA COLLECTION & VALIDATION

Testing played a critical role in the development of our ROV. The team conducted multiple float, thrust, stability, depth, and claw performance tests to evaluate the robot's functionality and reliability. Through testing, we identified weaknesses such as instability, uneven buoyancy, and claw inefficiency, which guided our redesign process. Data and observations collected during testing allowed us to optimize motor placement, improve balance, and strengthen the manipulator system. This process demonstrated the importance of engineering validation and iterative improvement.

Observations from Testing

The team observed:

- Improved balance after motor repositioning
- Better underwater stability after buoyancy adjustments
- Increased claw reliability after reinforcement
- Better recovery from tilt angles

Test	Purpose
Float Test	Verify balance and buoyancy
Stability Test	Prevent tipping
Thrust Test	Evaluate motor efficiency
Depth Test	Improve vertical control
Claw Test	Verify gripping functionality

Importance of Testing
Testing allowed us to:

- Identify weaknesses
- Improve reliability
- Optimize performance
- Validate engineering decisions

Engineering Reflection
"Testing revealed problems that could not be identified during initial design planning."

CHALLENGES & PROBLEM SOLVING

As a rookie team, we encountered many engineering challenges during the design and testing process. Our ROV initially experienced tipping, unstable turning, uneven buoyancy, and weak claw control. Instead of giving up, the team analyzed each issue, identified possible causes, and developed practical engineering solutions. By repositioning flotation, improving weight distribution, reinforcing the claw, and adjusting thruster orientation, we significantly improved the ROV’s performance. These experiences taught us that failure is an essential part of the engineering process and leads to stronger designs.

Failure Led to Improvement

Major Challenges Encountered

- Robot tipping underwater
- Uneven buoyancy distribution
- Weak claw performance
- Excessive drag
- Unstable turning movement

Engineering Solutions

The team solved these problems by:

- Rebalancing the frame
- Adjusting flotation placement
- Reinforcing the claw structure
- Repositioning thrusters
- Improving weight distribution

What We Learned

Every engineering failure became an opportunity to:

- Analyze performance
- Improve design
- Increase reliability
- Strengthen teamwork

Team Reflection

“As rookie engineers, we learned that problem solving and persistence are essential parts of engineering.”

FUTURE IMPROVEMENTS

The Sea Masters team plans to continue improving our ROV by adding advanced systems and improving overall efficiency. Future upgrades include camera integration, automated buoyancy control, improved waterproofing, enhanced hydrodynamic design, and electronic manipulator systems. Our long-term goal is to develop an advanced underwater robotic vehicle capable of performing scientific exploration, environmental monitoring, and real-world underwater inspection tasks. This project inspired our team to continue learning about engineering, robotics, and underwater technologies.

Next Generation Sea Masters ROV
Planned Upgrades

Future improvements include:

- Camera integration
- Automated buoyancy systems
- Improved waterproofing
- Electronic manipulator systems
- Enhanced hydrodynamic design
- Additional sensors and control systems

Long-Term Vision

Our long-term goal is to develop an advanced ROV capable of:

- Underwater inspections
- Scientific exploration
- Environmental monitoring
- Real-world engineering applications

Team Growth

This project inspired our team to continue learning:

- Engineering
- Robotics
- Programming
- Underwater technology

FINAL REFLECTION & CONCLUSION

Final Engineering Reflection

"Sea Masters demonstrated that engineering innovation is possible using accessible materials, teamwork, and iterative problem solving."

What We Learned

- Engineering requires persistence
- Testing is critical
- Safety must always come first
- Small improvements create major performance gains

QUESTIONS & THANK YOU

Team Sea Masters would like to thank our mentors, families, volunteers, and competition organizers for supporting our engineering journey. This experience allowed us to develop technical knowledge, teamwork skills, and confidence as future engineers and problem solvers. We are proud of how far we have come in our first year and excited to continue challenging the future through innovation and underwater robotics.

- *SCALING FOR IMPACT*
- *LEVERAGING COLLABORATION*
- *IDENTIFYING OPPORTUNITIES*