

MEET YOUR GUIDE VETRA



MECHANICAL REEF



04

THE ISLAND OF MACHINES AND MOVING PARTS!



As you sail away from Captain's Cove, strange shapes rise from the waves—giant wheels turning, ropes hanging from tall masts, gears spinning, and pulleys swinging in the breeze! Ahoy, Captain! Welcome to Mechanical Reef!" "This is the place where sailors, engineers, and inventors work together to build clever machines that make hard jobs easier!" "At Mechanical Reef, you'll explore how simple machines—like pulleys, levers, gears, and winches—are used on a sailboat to lift heavy sails, steer the rudder, or pull up an anchor." "You'll build, test, and discover how machines help sailors use less force to move big things. You'll even get to be an inventor yourself!"



"Ah, Mechanical Reef—my favorite island for tinkering! Gears, ropes, levers... it's like a sailor's playground! Get ready to build and test machines that make tough tasks easier. And don't forget to follow my blue square messages—they're packed with ideas to help you think like an inventor!"



MISSION 1 : DISCOVER SIMPLE MACHINES

Did you know that sailors use simple machines every day to make their work easier?

Machines like levers, pulleys, and winches help us lift heavy sails, steer big rudders, and pull up anchors without needing giant muscles!"

"Today at Mechanical Reef, you'll discover how simple machines work—and test how they make hard jobs easier!"

Your Challenge:

- Explore simple machines used on a sailboat
- Test how a lever works to lift heavy things
- Learn how machines help balance and reduce force

"Every time you see a rope, pulley, wheel, or stick on a boat—it's probably a simple machine helping the crew!"

Step 1: Learn About Simple Machines

A simple machine is something that helps you do a job with less effort. Here are some machines you might see on a sailboat:

- Lever – like a plank on a rock; you push one end to lift something on the other end
- Pulley – a wheel with a rope that helps you pull something up
- Winch – a crank with gears to wind up a rope
- Rudder – a flat piece that steers the boat by pushing water

"Even simple machines use big ideas from physics—like force, balance, and movement!"

Step 2: Test the Lever

Set up your lever:

- Place the plank over a block or rock (like a seesaw)
- Put a heavy object (like a book or stone) on one end
- Try lifting it by pushing down on the other end. "Was it easy or hard?"
- Now move the heavy object closer to the center of the lever. Try again.
- Move the heavy object farther from the center. Try again.

✎ Write what you noticed:

"It was easier to lift the object when it was _____."

Step 3: Reflect and Discuss

"Why did the lever work better when the heavy object was closer to the center?"

✎ Write or discuss:

"I think the lever helped because _____."

"Do you remember playing on a seesaw at the park? That's a lever too!" "Captain, you've discovered the first secret of Mechanical Reef: simple machines help sailors work smarter, not harder!"

MISSION N 2: EXPLORE PULLEYS AND BLOCKS

Today at Mechanical Reef, you'll test how pulleys and block systems help sailors lift and move heavy loads more easily.

Your Challenge:

- Discover how pulleys make lifting easier
- Try different pulley systems (1:1, 1:2, 1:4)
- Feel the difference in force needed with each system

"The more pulleys you use, the easier it gets—but you have to pull more rope!"

What You'll Need:

- Rope or string
- Toy pulleys or wheels
- A wooden frame (or chair or table) to hang the pulley
- Weights (like a bucket, books, or small bag)

Step 1: Learn About Pulleys and Blocks

- "A pulley is a wheel with a rope that changes the direction of the force."
- "A block is a pulley inside a frame."
- "When we use more pulleys together, we call it a block and tackle system."

There are three kinds of pulleys we use on a boat:

- **Fixed Pulley** – helps change direction, but doesn't reduce effort
- **Movable Pulley** – moves with the load, reduces effort
- **Compound Pulley** – combines both to make it even easier!

"On a sailboat, pulleys are used to raise sails, control ropes, or even pull up an anchor!"

Step 2: Try Lifting with Different Pulleys!

First, try a 1:1 system (just one pulley):

- Tie the rope to a bucket
- Run it through the pulley at the top
- Pull straight down to lift the bucket

Next, try a 1:2 system:

- Add a second pulley under the bucket
- Run the rope through both pulleys
- Pull again

Finally, try a 1:4 system if you can:

- Add more pulleys to create more loops
- Pull again

Observe how it feels each time:

- Is it easier or harder?
- Do you have to pull more rope?

Step 3: Reflect and Discuss

"Why do sailors use more than one pulley when they lift something heavy?"

✎ Write or say your answer:

"I think they use more pulleys because _____."

"The more pulleys in the system, the less force you need—but the longer the rope you have to pull. Sailors use block and tackle systems to hoist big sails, lift heavy equipment, and adjust ropes safely in strong winds."

MISSION 3 : STEERING THE BOAT WITH A RUDDER

Today at Mechanical Reef, you'll discover how the rudder works and why turning it changes the boat's direction

Your Challenge:

- Explore how the rudder steers a boat
- Test how the rudder's angle changes the boat's path
- Understand how the water pushes against the rudder to turn the boat

"The rudder doesn't push the boat—it pushes the water! And the water pushes back to turn the boat."

What You'll Need:

- A small plastic container or toy boat
- A piece of cardboard or ruler to use as the rudder
- A water tub or basin
- Tape or glue

Step 1: Learn About the Rudder

- "A rudder is a flat piece that turns left or right to steer the boat."
- "When you turn the rudder, it pushes water to the side."
- "And when water gets pushed one way, it pushes the boat the other way."

"The farther the rudder is from the middle of the boat, the bigger the turning force—it's called torque!"

Step 2: Build Your Rudder Boat

- Tape or glue a small ruler or flat cardboard onto the back of your plastic boat to be the rudder
- Fill your tub or basin with water
- Put your boat in the water
- Try turning the rudder left (30° , 45° , 60° , 90°) and right
- Gently push the boat forward or use your hand/fan to make “water flow”

Watch which way the boat turns!

✎ Write or say your answer:

“When I turned the rudder left, the boat went _____.”

“When I turned the rudder right, the boat went _____.”

“The more I turned the rudder, the _____ the boat turned.”

“The rudder doesn’t pull the boat—it redirects the water! When you push water one way, the water pushes the boat the other way—just like paddling a canoe on one side.”

BONUS MISSION : BUILD A WORKING WINCH

Welcome back to Mechanical Reef, sailor-in-training! Today you'll become an engineer and build a real winch—just like the ones sailors use to hoist sails, lift anchors, or tighten ropes in wild winds!

Your Challenge:

- Discover how winches help sailors do heavy work
- Build your own working winch system
- Try out different gear setups and test your design!

"Every time you turn a handle to move a rope, you're using a winch! The secret is in the gears—small turns can move big things!"

What You'll Need:

- Gears, shafts, cranks (Lego Technic pieces, wooden gears, or similar)
- String or rope
- Plastic base with holes (or use a box/cardboard to mount the winch)
- Optional: Two syringes (10ml and 5ml) + clear plastic tubing for a hydraulic winch experiment

Step 1: Learn How a Compass Works

- "A winch is a machine that winds rope to lift or pull heavy things."
- "It uses gears to increase power and a crank to turn the drum."
- "The secret? A big gear turns slower—but with more strength!"

"Try different gear sizes and feel how the effort changes. That's the gear ratio in action!"

Step 2: Build Your Winch!

1. Choose two gears (one big, one small)
2. Place them on shafts and mount the shafts onto a sturdy base
3. Attach a crank handle to one shaft
4. On the second shaft, add a drum and wrap a rope around it

☛ Turn the crank and watch the drum spin and pull the rope!

Step 3: Test It Out!

- Attach a small weight to the end of the rope
- Try turning the crank and lifting the weight
- Was it easy or hard?

Now change the setup:

- Swap the big and small gears
- Try again—what changed?

☛ Write or say what you noticed:

"When the big gear was first, it felt _____. When I reversed it, it felt _____."

Step 4: Reflect and Discuss

- "Why do you think some gear combinations made it easier or harder?"
- "When would sailors need a strong winch the most?"
- "How does a winch make sailing safer?"

☛ "I think winches help because _____."

BONUS MISSION : BUILD A WORKING WINCH

Bonus Mission: Try a Hydraulic Winch! Ready to level up your engineering skills? In this Bonus Mission, you'll use water power to control your winch—just like real machines that use hydraulic systems!

What You'll Need:

- 2 plastic syringes (one 10ml, one 5ml or both 10ml)
- 1 clear plastic tube (fits tightly over syringe tips)
- A small crank and drum setup (Lego, cardboard, or wood)
- Rope or string
- Water

Step-by-Step: Build Your Hydraulic Winch

1. **Fill the system:** Fill both syringes and the tube with water. No air bubbles allowed—it works best with only water!
2. **Connect the system:** Push the plastic tube tightly onto the tip of each syringe. One syringe is your “pump,” and the other is your “motor.”
3. **Build your winch setup:** Attach a simple winch (drum + string) to the second syringe's plunger using tape, glue, or Lego parts. 🏗️ When this syringe moves, it should turn the winch and lift something small!
4. **Control the winch with water power:** Gently push the plunger on the first syringe. Watch how the second syringe moves by itself—and powers the winch!

“This is how hydraulics work: You push water through a tube, and it sends force to another part of the machine—no electricity needed!”

Explore Further:

Try different sizes of syringes.

- What happens when the pump is bigger than the motor?
- Can you lift more weight or move faster?
- How could sailors use hydraulic systems on big ships?