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WELCOME, FORCES & MOTION ENGINEER!

ARE YOU READY TO ENGINEER MOTION?

Plan → Build → Test → Measure → Improve



Motion is happening all around you. Cars roll along roads. Air pushes against objects. Gliders travel through the sky. Boats move across water. Machines rotate, lift, and transport materials.

But what makes an object begin moving? Why does it speed up, slow down, turn, or stop? How can air pressure produce a powerful push? How can a glider remain stable in the air? Can an invisible force move a boat? How can rotation lift water upward? These are the kinds of questions that engineers investigate.

In this book, you will not simply read about forces and motion. You will build working systems that allow you to see, test, and control motion. You will:

- 🚙 Build a car powered by escaping air.
- 🫧 Create a classroom air cannon that uses air pressure.
- ✈️ Design and test a stable glider.
- ⛵ Move a boat using an invisible force at the water's surface.
- 💧 Build a rotating mechanical system that lifts water.

Each project begins with a challenge. You will build a first design, test its performance, collect evidence, and decide how it can be improved.

YOUR FORCES & MOTION ENGINEERING MISSION

Complete all five engineering projects and discover how engineers create, control, balance, and transfer motion. During your mission, you will:

1. Create Motion

Build a balloon-powered car and investigate how escaping air can produce a force that moves the car forward.

2. Use Air Pressure

Build a classroom air cannon and explore how compressed air can store energy and release it as motion.

3. Balance Forces

Design a glider and investigate how its shape, mass, and balance affect the way it travels through the air.

🚀 Build a Balloon-Powered Car



Get ready to **think like an engineer** and build your own moving car! In this activity, you will design and build a **balloon-powered car** using simple materials. Instead of using a motor or batteries, your car will move using **air power**!

When air rushes backward out of the balloon, the car is pushed forward in the opposite direction — similar to how rockets and jet engines create thrust. **But engineers don't just build once…**

👉 **You will**: ⊙ build your car ⊙ test how it moves ⊙ fix problems ⊙ improve your design

By the end, you'll create a better, faster, and smarter moving system!

❓ What problem are we solving?

Engineers often need to move objects from one place to another. But what if we don't have: an engine or electricity?

💡 **Challenge:** How can we design a balloon-powered car that travels farther, straighter, and more efficiently using only air?

🌎 Where do we see this in real life?

The same idea is used in real engineering systems:

🚀 Rockets move by pushing gas backward
✈️ Jet engines push air to move forward
🚙 Some vehicles use air or pressure systems

👉 In all these systems: **Air moves one way → the object moves the opposite way**

> 💡 **Engineer Insight:**
> *Push air backward → move forward!*

🛠️ Build Your System

Now it's time to build your **balloon-powered car**. Follow the steps carefully. Engineers build step by step, test their ideas, and improve their designs.

🏹 Launch a High-Pressure Air Cannon



Get ready to think like an engineer and build your own **air-powered launcher!**

In this activity, you will design and build a **high-pressure air cannon** using simple materials. Instead of using electricity or motors, your system will use **compressed air** to launch objects. When you stretch and release the balloon, air is pushed forward very quickly, creating a strong force that can move objects over a distance!

👉 **You will**: ⊙ build your air cannon ⊙ test how it launches objects ⊙ identify problems ⊙ improve your design

Engineering Goal: Build an air cannon that launches a lightweight object **farther, straighter, and more consistently**

❓ What problem are we solving?

Engineers often need to launch or move objects using force. But what if we don't have: engines, electricity, or fuel?

💡 **Challenge**: Can you build a launcher that moves an object using only a burst of air?

🌎 Where do we see this in real life?

🚀 Rockets launch by pushing gases at high pressure
💨 Air cannons and launchers use compressed air
⚙️ Machines use pressure systems to move objects
🔧 Tools use air pressure to generate force
👉 In all these systems: **Stored air pressure → released → creates force → moves objects**

🛠️ Build Your System

Now it's time to build your **high-pressure air cannon!** Follow the steps carefully. Engineers build step by step, test their ideas, and improve their designs.

Main Activity Results

Trial	Pull-Back Distance	Launch Distance	Moved Straight?	Hit Target Zone?
1	_____ cm	_____ cm	Yes / No	Yes / No
2	_____ cm	_____ cm	Yes / No	Yes / No
3	_____ cm	_____ cm	Yes / No	Yes / No

Average Launch Distance

Average distance = (Trial 1 + Trial 2 + Trial 3) ÷ 3

⊙ Average launch distance: _____ cm

Consistency Check

⊙ Longest distance: _____ cm
⊙ Shortest distance: _____ cm

Range = Longest distance – Shortest distance

⊙ Range: _____ cm

A smaller range means your air cannon is more consistent.

Think About Your Results

Which trial launched the object farthest?

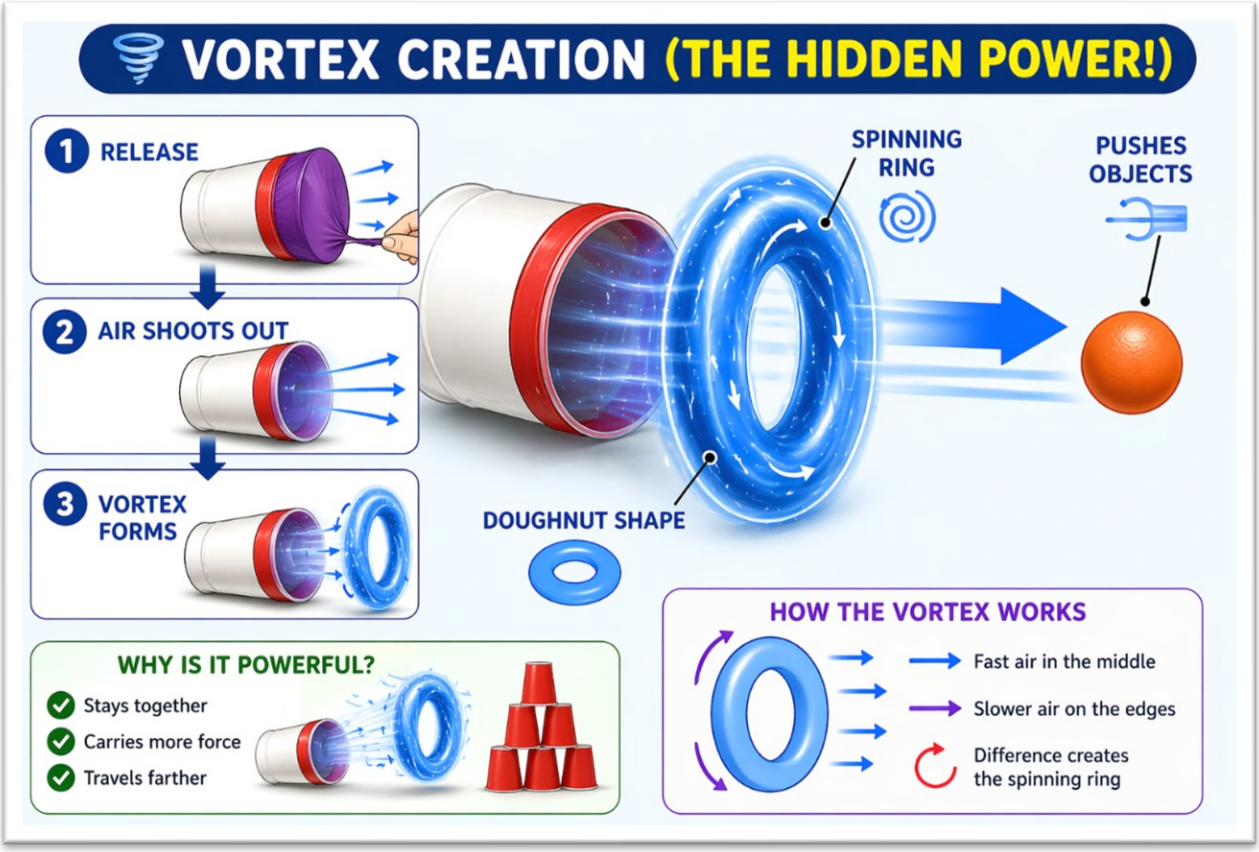
Which trial was most controlled?

Was the farthest launch also the straightest launch? Why or why not?

How It Works (Science Background)

Now that you have tested your air cannon, let's understand **what is really happening inside!**

✓ Air at the **edges slows down due to friction**



⚡ Energy Transformation

During this process: **Potential Energy (stored in balloon)** → becomes → **Kinetic Energy (moving air and objects)**

👉 Kinetic energy is the energy of motion

🚀 What Moves the Object?

The fast-moving vortex:

→ pushes on the air around it

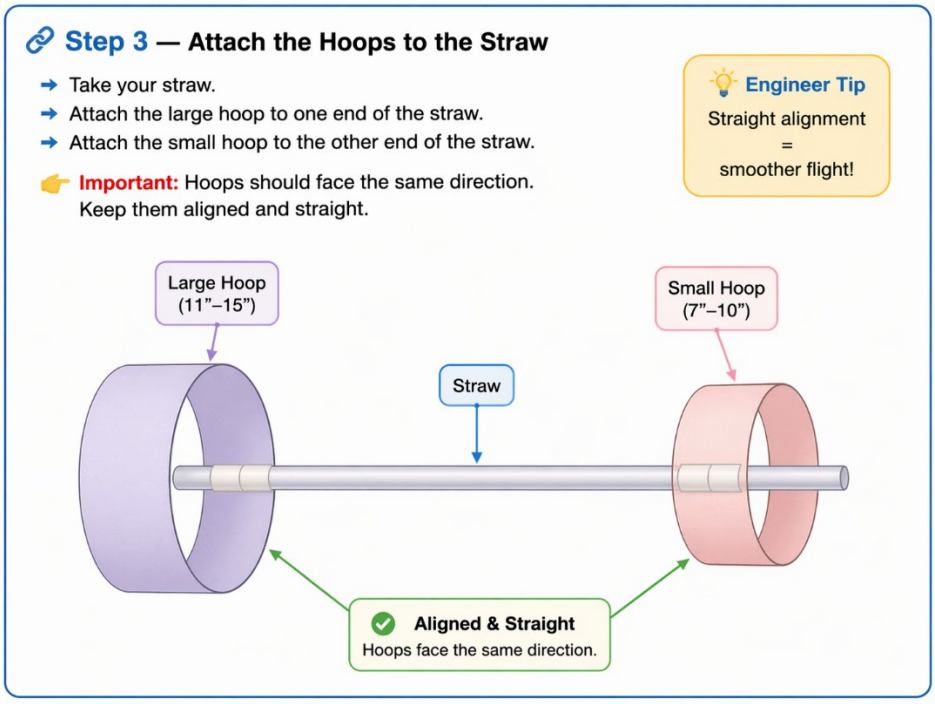
→ transfers force to nearby objects

👉 This force makes objects move forward

🛠️ Improve Your Design

Engineers improve pressure systems by changing one feature, testing again, and comparing the results with evidence. Choose one level — or complete all three.

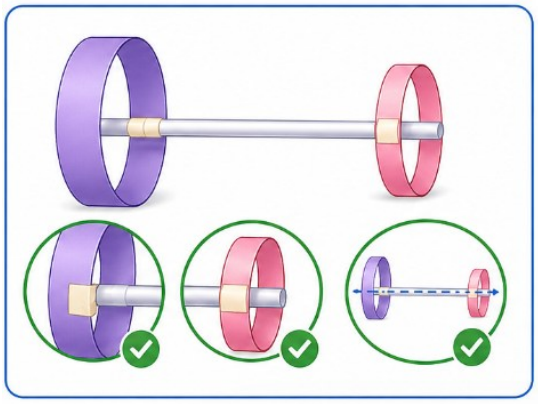
Keep your test fair by changing only one variable at a time.



🔧 Step 4 — Secure the Structure

→ Use tape or glue to hold both hoops firmly
→ Optional: Use paper clips instead of tape

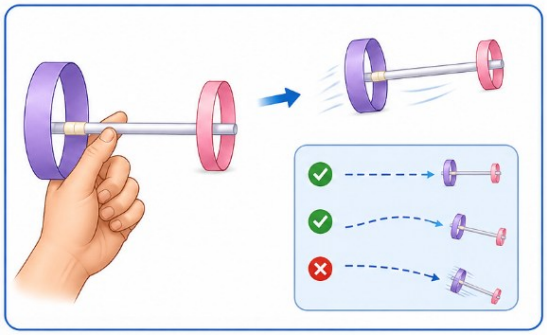
👉 Make sure:
✓ Hoops are not loose
✓ Straw is straight
✓ Everything is balanced



🚀 Step 5 — Launch Your Glider

→ Hold the glider by the straw
→ Aim forward
→ Throw it gently like a dart

👉 Observe:
☑ Does it fly straight?
☑ Does it glide smoothly?
☑ Does it fall quickly or stay in the air?



👀 Build Check

Before testing again, make sure:

✓ Large hoop is bigger than small hoop
✓ Hoops are aligned in the same direction

🛠️ Improve Your Design

Engineers improve flying systems by changing one feature, testing again, and comparing results with evidence. Choose one level — or complete all three.

🟢 LEVEL 1 — CHANGE THE LAUNCH ANGLE

🔧 **Challenge**: Test how launch angle affects flight distance, flight time, speed, and stability. Try three launch angles:

✓ straight forward ✓ slightly upward ✓ higher upward angle

Keep the same glider, launch line, launch force, and testing space.

🧪 Test and Measure

Launch Angle	Flight Distance	Flight Time	Speed Estimate	Flight Path	Stability Score
Straight forward	_____ cm	_____ s	_____ cm/s	Straight / Curved / Dropped	___ / 5
Slightly upward	_____ cm	_____ s	_____ cm/s	Straight / Curved / Dropped	___ / 5
Higher upward angle	_____ cm	_____ s	_____ cm/s	Straight / Curved / Dropped	___ / 5

⊙ **Best launch angle**: _____

⊙ **Why did it work better?**

🧠 What's Happening?

Launch angle changes the glider's path through the air. A straight launch gives more forward motion, but the glider may not stay in the air as long. A slightly upward launch can give the glider more time to glide, but if the angle is too steep, the glider may lose forward speed and drop quickly. Engineers must balance:

forward motion → time in air → stability → distance

🟡 LEVEL 2 — CHANGE THE STRAW LENGTH

🔧 **Challenge**: Test how straw length affects balance, speed, distance, and stability. Try two designs: ✓ shorter straw ✓ longer straw

Keep the same hoop sizes, paper type, launch angle, launch force, and testing space.

🧠 Final Engineer Reflection

The best turbo glider is not simply the one that flies far once.

The best design is the one that:

✓ travels farther
✓ stays in the air longer
✓ flies smoothly
✓ stays stable
✓ improves after testing

My best design was: _____

It worked best because: _____

Next time, I would improve: _____

🔧 Troubleshooting

🚧 Problem (Fault)	🔧 What You Can Do (Solution)
1. The glider drops quickly (does not glide)	✓ Throw gently — not too hard ✓ Check that hoops are aligned straight ✓ Make sure the small hoop is at the front and the large hoop trails behind ✓ Use a lighter paper if needed
2. The glider spins or wobbles in the air	✓ Check that both hoops face the same direction ✓ Make sure the straw is straight (not bent) ✓ Ensure hoops are centered on the straw ✓ Fix any loose connections
3. The glider turns to one side	✓ Check if one hoop is heavier than the other ✓ Make sure both sides are balanced ✓ Adjust the position of the hoops slightly ✓ Ensure the straw is not tilted
4. The glider does not fly straight	✓ Launch it straight forward (not sideways) ✓ Check alignment of hoops and straw ✓ Make sure the glider is balanced evenly ✓ Avoid throwing too hard

REFLECT & EXPLAIN

① System Pathway: Which pathway best describes the turbo glider system?

☐ A. Launch Force → Forward Motion → Airflow Around Glider → Balanced Forces → Glider Flight
☐ B. Gravity → Tape → Straw → No Motion → Glider Flight
☐ C. Hoop Size → Paper Color → Energy Disappears → Glider Stops
☐ D. Airflow → Glider Becomes Heavier → Gravity Stops Working

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② Balanced Forces: Why does a good turbo glider fly smoothly?

☐ A. Its forces work together so it can move forward, stay stable, and glide.
☐ B. Gravity disappears while it is flying.
☐ C. Drag pushes the glider upward forever.
☐ D. The straw creates electricity that keeps it moving.

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③ Forces in Flight: Which force slows the glider down as it moves through the air?

☐ A. Lift ☐ B. Drag ☐ C. Gravity ☐ D. Thrust

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④ Match Each Part to Its Function: Write the correct letter beside each part.

Part	Answer	Function
1. Large back hoop	___	A. Keeps the hoops aligned and spreads the forces across the glider
2. Small front hoop	___	B. Adds weight to adjust balance, if needed
3. Straw body	___	C. Creates more drag and helps stabilize the back of the glider
4. Paper clip	___	D. Helps guide the direction of flight

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⑤ A student's turbo glider traveled 150 cm in 5 seconds. What was its speed?

☐ A. 15 cm/s ☐ B. 25 cm/s ☐ C. 30 cm/s ☐ D. 155 cm/s

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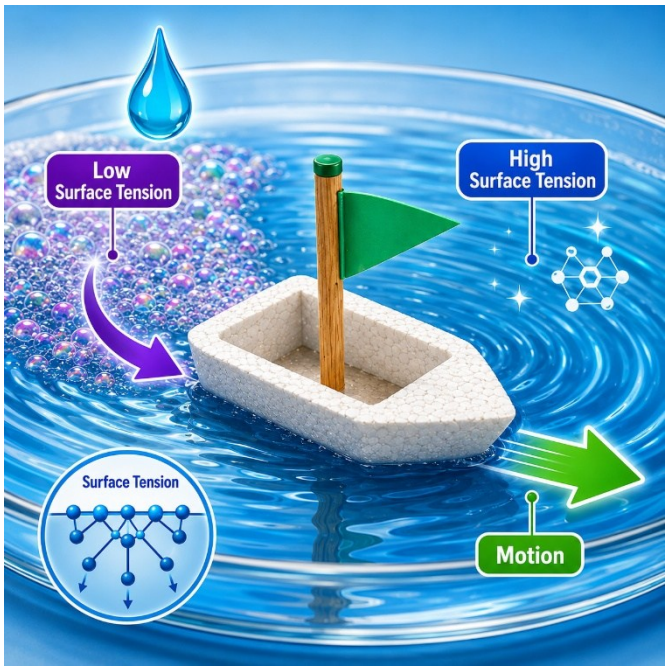
⑥ Analyze the Test Results

Trial	Flight Distance	Flight Time	Speed	Flight Path	Stability Score
Trial 1	120 cm	5 s	24 cm/s	Straight	3/5
Trial 2	160 cm	6 s	26.7 cm/s	Straight	5/5
Trial 3	140 cm	4 s	35 cm/s	Curved	2/5

🚤 Build a Soap-Powered Boat

Get ready to think like an engineer and build a boat that moves in a surprising way! In this activity, you will design and build a soap-powered boat using simple materials. But here's the twist...

🚫 No motor
🚫 No pushing
🚫 No pulling



Instead, your boat will move because of changes in the water itself! When you add soap behind the boat, it changes how the water behaves, creating a force that makes your boat move forward. 👉 You will:

☑ build your boat
☑ test how it moves
☑ observe what happens in the water
☑ improve your design

By the end, you'll create a faster, smoother, and more efficient boat!

❓ What problem are we solving?

Engineers often need to move objects through liquids...

But what if we don't use: 🚫 motors, 🚫 engines, or 🚫 pushing forces

💡 **Challenge**: How can we design a soap-powered boat that travels farther, moves straighter, and performs more consistently using only water, soap, and surface tension?

🌎 Where do we see this in real life?

The same idea is used in real systems:

🚢 Ships interact with water forces
🧪 Micro-systems move fluids without pumps
🧬 Biology uses surface forces in cells
⚙️ Engineers design systems using fluid behavior

👉 In all these systems: **Changing the liquid → creates motion**

The Motion Effect (Marangoni Effect)

Now something powerful happens:

👉 Water with **higher surface tension (in front)** pulls harder
👉 Water with **lower surface tension (behind)** pulls less

✓ The stronger pull in front **drags the boat forward**

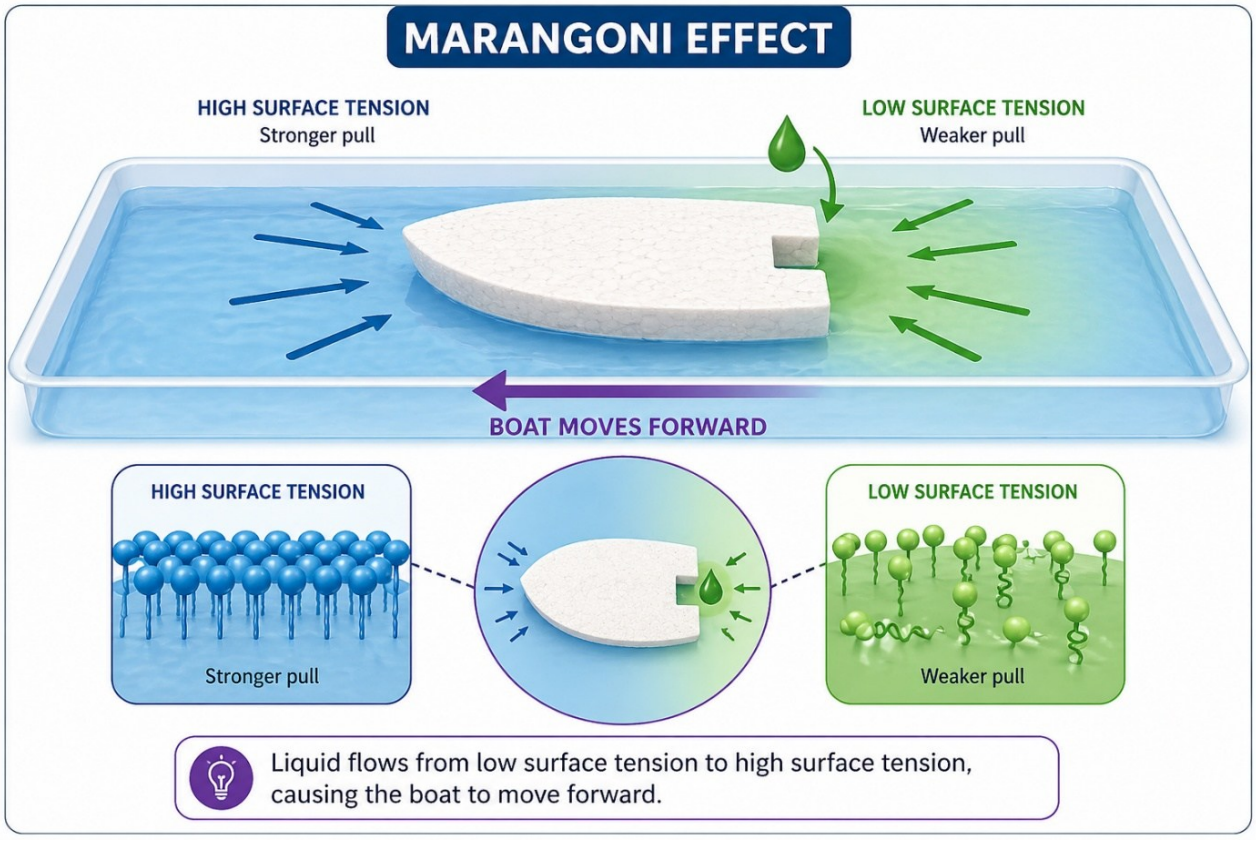
💡 This movement is called the **Marangoni Effect** → Motion caused by differences in surface tension

Why the Boat Moves

✓ Soap lowers surface tension behind the boat
✓ Water in front pulls more strongly
✓ This creates a **forward force**

👉 The boat moves without pushing or pulling directly!

💡 No motor • No wind • No pushing
👉 Just **science creating motion**



Soap Spreading in Water

⚙️ Engineer a Water Lifting System

Get ready to think like an engineer and build a system that can move water upward! In this activity, you will design and build a Water Lifting System (**Egyptian screw pump)** using simple materials. Instead of using electricity or a motor, your pump will use **rotation** to lift water from a lower bowl to a higher bowl. When you turn the bottle, water enters the spiral tube and moves step by step upward until it reaches the top and pours into the empty bowl.



👉 You will:

✓ build your screw pump
✓ test how well it lifts water
✓ observe how rotation and slope affect water movement
✓ improve your design

By the end, you'll create a working water-lifting system like a real engineer!

❓ What problem are we solving?

Engineers often need to move water from one place to another. But what if the water needs to move: 🚫 without electricity 🚫 without a motor 🚫 from a lower place to a higher place

💡 **Challenge:** How can we lift water upward using only rotation and a simple machine?

🌎 Where do we see this in real life?

The same idea is used in real engineering systems:

💧 Irrigation systems move water to crops
⚙️ Pumps move liquids in buildings and factories
🌊 Water treatment systems transport water through pipes
🏛️ Ancient engineers used screw pumps to move water for farming

👉 In all these systems: **Turn the system → move the water → solve a problem**