

KINDERGARTEN ENGINEERING & PHYSICS

First edition

8 units

32 lessons + Toy Lab

A video for every lesson

FIRST EDITION

COURSE GUIDE

This first engineering course is written for a parent to read aloud to a five- or six-year-old. It follows the same eight strands as every grade in the series: pushes, pulls and machines; bridges; houses and towers; magnets and batteries; water and lights at home; boats; flight; and robots and inventors. Each lesson begins with a short true story, such as the Romans building the Pont du Gard, John Smeaton's lighthouse on a rock in the sea, Joseph Bazalgette's sewers, Noah's ark, or the Wright brothers' first flight on December 17, 1903.

Then come two simple questions: **Why does it work?** and **How do builders use it?** Last, your child does a small build and tests it: rolling cars down ramps, loading paper bridges with pennies, testing houses against a fan "wolf," lighting a bulb with a battery, floating foil boats, flying paper airplanes and kites. Each test has a guess first, a fair test that changes only one thing, a count or measurement, and a second try to make it better. An optional bonus unit, the Toy Lab, looks at the science of tops, bouncing balls, pinwheels and building blocks.

God made an orderly world that we can test and count on, and He made people in His image to be makers. Building something that is safe and useful is a way of loving our neighbors. The old Latin saying *Fabricando fit faber*, "by making, one becomes a maker," is the heart of this course.

Most videos come from trusted children's science channels and museums: SciShow Kids, Free School, Homeschool Pop, Science Buddies, Mystery Science, CBC Kids, the Children's Museum of Houston and others, chosen lesson by lesson and previewed for content. Each is between two and ten minutes long. Some end with an invitation to subscribe or a short advertisement; you can stop when the teaching ends. Watch together, and pause when the lesson says to guess what will happen next.

WHO IT IS FOR

For kindergarten children, about ages 5–6, with a parent or teacher reading aloud and helping with every build. No reading or writing is required of the child; the grown-up writes the numbers and the child draws. Lessons are two 30-minute sessions a week. No kits are required: every build uses household or inexpensive craft-store materials. A few optional kits are listed for families who want them.

HOW TO USE THIS COURSE

1. **The weekly rhythm.** The year has 32 lessons, one a week. Session 1 (about 30 minutes) is the warm-up, the story, the video and the picture study. Session 2 (about 30 minutes) is the build and the engineer's notebook. In the last week of each unit, add a short third session for the unit review and the portfolio build.
2. **Reading aloud.** The core ideas are written in short sentences for you to read aloud. Each lesson begins with a true story ("Long ago..."), then "Why does it work?" and "How do builders use it?" After each paragraph, ask your child to tell it back in his or her own words, or to show it with hands or toys.
3. **Picture study.** Each lesson has one old painting, photograph, drawing or print. Look at it quietly together for a minute or two. Then put it away and ask your child to tell everything he or she remembers. Bring it back and use the "look for" items and questions, which point to the science and engineering in the picture.
4. **The engineer's notebook.** Use a large sketchbook or a composition book for the whole year. Before each test, your child makes a guess. You write the numbers as your child counts or measures. Your child draws what happened. Date every page. Honest records matter more than winning results: "a just weight is his delight" (Proverbs 11:1).
5. **Fair tests and trying again.** Most builds change only one thing at a time and test it more than once. Every build ends with a "make it better" round. When something fails, celebrate it: now we know something new, and we can fix it.
6. **Optional kits.** Some units list kits such as KEVA planks, Magna-Tiles, LEGO DUPLO, a Bee-Bot floor robot or Snap Circuits. They are extras. Every lesson can be done without them.

7. **Unit review and portfolio.** Each unit ends with a short oral review with no points. Ask the questions aloud and let your child answer by telling, pointing, building or drawing. Then do the portfolio build and keep its notebook page and a photo in a folder for the year.
8. **Safety.** Read the safety note before each build. Electricity in this course comes only from small AA, C or D batteries, never from the outlets in the wall. A grown-up handles scissors for tough cutting, pins and anything sharp, and stays beside every water build. Fly kites only in open fields, far from power lines.
9. **The family invention fair.** In the last week, set out the best build from each unit with its notebook page, and let your child show them to family and guests. Explaining your work to someone else is part of being an engineer.
10. **The Toy Lab (optional).** Unit 9 is a bonus unit of four toy lessons: spinning tops, bouncing balls, pinwheels, and building blocks from Froebel to LEGO. Use it after the fair, over the summer, or any week that needs something fun.

SCOPE AND SEQUENCE

UNIT 1 • WEEKS 1–4

Push and Pull

Pushes and pulls; ramps and rolling; how wheels make work easier; and building the tallest block tower that stands, with the Tower of Babel as a warning against showing off.

- 1.1 Pushes and Pulls
- 1.2 Ramps and Rolling
- 1.3 Wheels Make Work Easier
- 1.4 The Tallest Block Tower That Stands

UNIT 2 • WEEKS 5–8

Bridges

A log across a creek; how folding makes paper strong, as in the Britannia Bridge; the Roman arch of the Pont du Gard; and the Golden Gate Bridge hanging from its cables.

- 2.1 A Log Across a Creek
- 2.2 Folding Paper Makes It Strong
- 2.3 The Strong Arch
- 2.4 The Golden Gate Bridge

UNIT 3 • WEEKS 9–12

Houses and Towers

Testing straw, sticks and bricks; why triangles are strong, from the Eiffel Tower; a tall cup tower and the Empire State Building; and the wise man who built his house upon the rock, with Smeaton's lighthouse.

- 3.1 Straw, Sticks or Bricks?
- 3.2 Triangles Are Strong
- 3.3 The Tall Cup Tower
- 3.4 The Wise Man Built His House upon the Rock

UNIT 5 • WEEKS 17–20

Water and Lights at Home

Where tap water comes from, with the Croton Aqueduct; where it goes, with Bazalgette's sewers; how power lines bring electricity from Niagara Falls to the city; and thanking the workers who keep it all running.

- 5.1 Where Tap Water Comes From
- 5.2 Where the Water Goes
- 5.3 Power Lines Bring Electricity
- 5.4 Thank You, Workers!

UNIT 4 • WEEKS 13–16

Magnets and Batteries

Magnets that pull and push, with William Gilbert; sorting what magnets pick up; lighting a bulb with a battery, from Volta's first battery; and the rule never to touch the outlets.

- 4.1 Magnets Pull
- 4.2 What Do Magnets Pick Up?
- 4.3 A Battery Lights a Flashlight
- 4.4 Never Touch the Outlets

UNIT 6 • WEEKS 21–24

Boats

Sink or float; a foil boat that carries pennies, like the iron ship *Great Britain*; sails that catch the wind; and Noah's ark, its measurements and its steady shape.

- 6.1 Sink or Float?
- 6.2 A Foil Boat Holds Pennies
- 6.3 Sails Catch the Wind
- 6.4 Noah's Ark

UNIT 7 • WEEKS 25–28

Flight

How birds fly, from Leonardo’s notebook; paper airplanes and Lilienthal’s gliders; kites and the Wrights’ kite tests; and the Wright brothers’ first flight.

- 7.1 How Birds Fly
- 7.2 Paper Airplanes
- 7.3 Kites Ride the Wind
- 7.4 The Wright Brothers’ First Flight

UNIT 9 • WEEKS 33–36

Toy Lab

Optional Toy Lab: spinning tops; which ball bounces highest; pinwheels and windmills; and building blocks, from Froebel’s first kindergarten to LEGO bricks.

- 9.1 Spinning Tops
- 9.2 Which Ball Bounces Highest?
- 9.3 Pinwheels
- 9.4 Building Blocks, from Froebel to LEGO

UNIT 8 • WEEKS 29–32

Robots and Inventors

What a robot is, from Sojourner on Mars; step-by-step instructions, from Jacquard’s loom; a cardboard grabber like the Canadarm; and the family invention fair.

- 8.1 What Is a Robot?
- 8.2 Step-by-Step Instructions for a Grown-Up Robot
- 8.3 A Cardboard Grabber
- 8.4 Our Invention Fair

WEEKLY PACING CALENDAR

WEEK	PLAN
1	- Session 1: Lesson 1.1 Pushes and Pulls: warm-up, video, teaching and picture study - Session 2: Lesson 1.1 build project and engineer’s notebook <i>Two sessions a week is the usual rhythm. Younger children can split a long session in two; older students can do both sessions in one sitting.</i>
2	- Session 1: Lesson 1.2 Ramps and Rolling: warm-up, video, teaching and picture study - Session 2: Lesson 1.2 build project and engineer’s notebook

WEEK	PLAN
3	• Session 1: Lesson 1.3 Wheels Make Work Easier: warm-up, video, teaching and picture study • Session 2: Lesson 1.3 build project and engineer's notebook
4	• Session 1: Lesson 1.4 The Tallest Block Tower That Stands: warm-up, video, teaching and picture study • Session 2: Lesson 1.4 build project and engineer's notebook • Session 3: Unit 1 review and portfolio project
5	• Session 1: Lesson 2.1 A Log Across a Creek: warm-up, video, teaching and picture study • Session 2: Lesson 2.1 build project and engineer's notebook
6	• Session 1: Lesson 2.2 Folding Paper Makes It Strong: warm-up, video, teaching and picture study • Session 2: Lesson 2.2 build project and engineer's notebook
7	• Session 1: Lesson 2.3 The Strong Arch: warm-up, video, teaching and picture study • Session 2: Lesson 2.3 build project and engineer's notebook
8	• Session 1: Lesson 2.4 The Golden Gate Bridge: warm-up, video, teaching and picture study • Session 2: Lesson 2.4 build project and engineer's notebook • Session 3: Unit 2 review and portfolio project
9	• Session 1: Lesson 3.1 Straw, Sticks or Bricks?: warm-up, video, teaching and picture study • Session 2: Lesson 3.1 build project and engineer's notebook
10	• Session 1: Lesson 3.2 Triangles Are Strong: warm-up, video, teaching and picture study • Session 2: Lesson 3.2 build project and engineer's notebook
11	• Session 1: Lesson 3.3 The Tall Cup Tower: warm-up, video, teaching and picture study • Session 2: Lesson 3.3 build project and engineer's notebook
12	• Session 1: Lesson 3.4 The Wise Man Built His House upon the Rock: warm-up, video, teaching and picture study • Session 2: Lesson 3.4 build project and engineer's notebook • Session 3: Unit 3 review and portfolio project

WEEK	PLAN
13	• Session 1: Lesson 4.1 Magnets Pull: warm-up, video, teaching and picture study • Session 2: Lesson 4.1 build project and engineer's notebook
14	• Session 1: Lesson 4.2 What Do Magnets Pick Up?: warm-up, video, teaching and picture study • Session 2: Lesson 4.2 build project and engineer's notebook
15	• Session 1: Lesson 4.3 A Battery Lights a Flashlight: warm-up, video, teaching and picture study • Session 2: Lesson 4.3 build project and engineer's notebook
16	• Session 1: Lesson 4.4 Never Touch the Outlets: warm-up, video, teaching and picture study • Session 2: Lesson 4.4 build project and engineer's notebook • Session 3: Unit 4 review and portfolio project
17	• Session 1: Lesson 5.1 Where Tap Water Comes From: warm-up, video, teaching and picture study • Session 2: Lesson 5.1 build project and engineer's notebook
18	• Session 1: Lesson 5.2 Where the Water Goes: warm-up, video, teaching and picture study • Session 2: Lesson 5.2 build project and engineer's notebook
19	• Session 1: Lesson 5.3 Power Lines Bring Electricity: warm-up, video, teaching and picture study • Session 2: Lesson 5.3 build project and engineer's notebook
20	• Session 1: Lesson 5.4 Thank You, Workers!: warm-up, video, teaching and picture study • Session 2: Lesson 5.4 build project and engineer's notebook • Session 3: Unit 5 review and portfolio project
21	• Session 1: Lesson 6.1 Sink or Float?: warm-up, video, teaching and picture study • Session 2: Lesson 6.1 build project and engineer's notebook
22	• Session 1: Lesson 6.2 A Foil Boat Holds Pennies: warm-up, video, teaching and picture study • Session 2: Lesson 6.2 build project and engineer's notebook

WEEK	PLAN
23	• Session 1: Lesson 6.3 Sails Catch the Wind: warm-up, video, teaching and picture study • Session 2: Lesson 6.3 build project and engineer's notebook
24	• Session 1: Lesson 6.4 Noah's Ark: warm-up, video, teaching and picture study • Session 2: Lesson 6.4 build project and engineer's notebook • Session 3: Unit 6 review and portfolio project
25	• Session 1: Lesson 7.1 How Birds Fly: warm-up, video, teaching and picture study • Session 2: Lesson 7.1 build project and engineer's notebook
26	• Session 1: Lesson 7.2 Paper Airplanes: warm-up, video, teaching and picture study • Session 2: Lesson 7.2 build project and engineer's notebook
27	• Session 1: Lesson 7.3 Kites Ride the Wind: warm-up, video, teaching and picture study • Session 2: Lesson 7.3 build project and engineer's notebook
28	• Session 1: Lesson 7.4 The Wright Brothers' First Flight: warm-up, video, teaching and picture study • Session 2: Lesson 7.4 build project and engineer's notebook • Session 3: Unit 7 review and portfolio project
29	• Session 1: Lesson 8.1 What Is a Robot?: warm-up, video, teaching and picture study • Session 2: Lesson 8.1 build project and engineer's notebook
30	• Session 1: Lesson 8.2 Step-by-Step Instructions for a Grown-Up Robot: warm-up, video, teaching and picture study • Session 2: Lesson 8.2 build project and engineer's notebook
31	• Session 1: Lesson 8.3 A Cardboard Grabber: warm-up, video, teaching and picture study • Session 2: Lesson 8.3 build project and engineer's notebook
32	• Session 1: Lesson 8.4 Our Invention Fair: warm-up, video, teaching and picture study • Session 2: Lesson 8.4 build project and engineer's notebook • Session 3: Unit 8 review and portfolio project <i>Last week. Hold a family engineering fair: set out the best build from each unit with its notebook pages, and let the student show guests how one of them works.</i>
33	• Session 1: Lesson 9.1 Spinning Tops: warm-up, video, teaching and picture study

WEEK	PLAN
	Session 2: Lesson 9.1 build project and engineer's notebook <i>Optional bonus unit: Toy Lab. Do it after the fair, over the summer, or slip a lesson in whenever a week needs something fun.</i>
34	- Session 1: Lesson 9.2 Which Ball Bounces Highest?: warm-up, video, teaching and picture study - Session 2: Lesson 9.2 build project and engineer's notebook
35	- Session 1: Lesson 9.3 Pinwheels: warm-up, video, teaching and picture study - Session 2: Lesson 9.3 build project and engineer's notebook
36	- Session 1: Lesson 9.4 Building Blocks, from Froebel to LEGO: warm-up, video, teaching and picture study - Session 2: Lesson 9.4 build project and engineer's notebook - Session 3: Unit 9 review and portfolio project

MATERIALS

Engineer's notebook (a large sketchbook or composition book) and crayons

One for the whole year: guesses, drawings and the numbers a grown-up writes down.

A tape measure, a ruler and a yardstick

For measuring how far cars roll, towers stand and airplanes fly.

A smartphone stopwatch or kitchen timer

For counting seconds in the drop, spin and sailboat tests.

Wooden blocks, paper cups (about 30) and toy cars

For ramps, towers and wheel tests in Units 1 and 3.

Cardboard, card stock, paper, masking tape, clear tape and glue

The main building materials all year.

Straws, craft sticks, pipe cleaners, string, rubber bands and brass paper fasteners

For triangles, kites, grabbers and the bucket truck.

About 100 pennies

Standard weights for bridge and boat tests. Keep them away from babies.

Two or three magnets and a box of steel paper clips

For Unit 4. Use large magnets only; tiny magnets are dangerous if swallowed.

A D-cell battery (or two AA cells) in a holder, a small flashlight bulb in a holder, and four to six alligator clip wires

For Units 4 and 5. Batteries only, never the outlets in the wall.

Aluminum foil, modeling clay and a tub or sink of water

For the boat builds in Unit 6, with a grown-up beside the water.

A box fan

The “wolf” for house tests and the wind for kites and pinwheels.

Two plastic bottles, paper towel tubes and a baking pan

For the water tower and pipe slope tests in Unit 5.

Four different balls (a bouncy ball, a tennis ball, a ping-pong ball and a soft ball)

For the optional Toy Lab.

Optional: one kit, such as KEVA planks, Magna-Tiles, LEGO DUPLO, a Bee-Bot or Snap Circuits

Never required. See the kits listed in each unit.

GRADING

Kindergarten engineering is not graded with letters or points. The goal is a child who guesses, tests, counts, tells what happened and tries again.

Scale: No letter grades. Use short notes such as “beginning,” “growing” and “strong” if you want a record.

- After each build, write one or two sentences in the notebook about what your child did well and what he or she tried again. For example: “Guessed the high ramp would win and counted the blocks carefully.”
- Notice the habits that matter most: making a guess first, testing fairly, counting honestly and trying again after a failure.
- The unit reviews are oral and have no points. Use them to see what to review, not to score.
- Keep a portfolio folder with one notebook page and one photo from each unit. It makes a lovely record of the year and the centerpiece of the family invention fair.

A NOTE TO PARENTS

You do not need to be an engineer to teach this course. Read the story aloud, watch the video together, and then be your child’s helper at the build: hold the ruler, write

down the numbers, and ask two questions over and over: “What do you think will happen?” and “Why do you think that happened?” Those two questions are most of what a good engineering teacher does.

Expect things to fall down, sink and flop. That is the point. The Wright brothers crashed gliders for three summers before they flew. Praise careful testing and honest counting more than a winning result, and let your child see you try again too.

Fabricando fit faber: by making, one becomes a maker.

A few stories touch on hard things, such as a great fire, a smelly river or a storm. They are told gently and briefly, with the focus on what the builders learned and how they made things safer for others.

UNIT 1

PUSH AND PULL

Everything that moves needs a push or a pull. In this unit your child will feel pushes and pulls, roll toy cars down ramps, find out why wheels make work easier, and build the tallest block tower that will stand. Each lesson starts with a short “Long ago” story, then asks “Why does it work?” and “How do builders use it?”

Every build is a small test. Your child will guess first, try it, count or measure, and then try to make it better. That is what engineers do. God made a world where things move in ways we can count on, so we can learn how they work and use them to help people.

PREREQUISITES

- Can count to 10 (counting to 20 is a bonus)
- Can stack blocks and roll a ball
- Can sit for a short story and a short video

MASTERY CHECKLIST

- ☐ I can show a push and a pull.
- ☐ I can tell that a harder push makes a thing go farther.
- ☐ I can show that a higher ramp makes a car roll faster and farther.
- ☐ I can tell why wheels make heavy things easier to move.
- ☐ I can build a tower with a wide bottom so it stands.

OPTIONAL KITS FOR THIS UNIT

- **KEVA Planks**: Plain maple planks, all the same size, for towers, ramps and bridges. Good for young builders with a grown-up nearby. Fits Lesson 1.4 and Units 2 and 3.
- **Magna-Tiles**: Flat magnetic shapes that click together into walls and towers. Easy for small hands. Fits Lesson 1.4 and Unit 3.

Not required. Every project in this unit can be built with household materials. School Launch has no ties to these companies.

LESSONS IN THIS UNIT

1.1 Pushes and Pulls

2 sessions of 30 minutes

1.2 Ramps and Rolling

2 sessions of 30 minutes

1.3 Wheels Make Work Easier

2 sessions of 30 minutes

1.4 The Tallest Block Tower That Stands

2 sessions of 30 minutes

UNIT 1 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. Show me a push. Now show me a pull.
2. Which makes a toy car go farther: a gentle push or a strong push?
3. Build a quick ramp with a book. Where should the car start so it rolls the farthest: on a low ramp or a high ramp?
4. Why is it easier to move a heavy box on a wagon than to drag it?
5. Point to a wheel and an axle on a toy or a bike.
6. Build a tower that will not tip over easily. What did you do?

ANSWER KEY

1. The child pushes something away (a door, a ball) and pulls something toward himself or herself (a drawer, a wagon).
2. A strong push.
3. On a high (steeper) ramp.
4. The wheels roll instead of rubbing on the floor.
5. The wheel is the round part; the axle is the rod in its middle.
6. Made a wide base, put big blocks at the bottom and stacked them straight.

PORTFOLIO PIECE: MY RAMP AND TOWER SHOW

Set up a ramp and roll a car down from a low and a high height, then build your best wide-based tower. Show a family member how they work and tell what you learned. Keep the notebook pages and a photo of your best tower in your portfolio folder.

LOOK FOR	WHAT IT MEANS
Guessed first	Made a guess before each test.
Fair test	Let the car go the same way each time and changed only the height.
Counted or measured	Counted blocks or footsteps, with a grown-up writing the numbers down.
Tried again	Built the tower again after it fell and made it better.

1.1 PUSHES AND PULLS

OBJECTIVES

- Show a push and a pull with your hands.
- Tell that a push moves a thing away from you and a pull brings it toward you.
- Test how a gentle push and a strong push move a toy car, and count the result.

Warm-up. Play “Push or Pull?” Say an action, and your child acts it out and calls out the answer: open a drawer (pull), close a door (push), kick a ball (push), tug a wagon (pull), ring a doorbell (push), take a tissue from the box (pull). Then ask: How does a ball start to roll?

WATCH

Push and Pull for Kids | Forces in Science

Homeschool Pop · 5:28

<https://www.youtube.com/watch?v=ZLDUrPaLQWE>

WHEN TO WATCH

After the story. Each time the video shows something moving, stop and let your child shout “push” or “pull” first.

BACKUP VIDEO

Swings, Slides, and Science | Physics for Kids

SciShow Kids · 3:38

<https://www.youtube.com/watch?v=JvSClZ3vHOI>

Later in the week, before a trip to the playground.

KEY TERMS

push

Moving something away from you.

pull

Moving something toward you.

force

A push or a pull. A force can start something moving, stop it, or turn it.

CORE IDEAS

Long ago. Long ago there were no tractors. Farmers needed help to dig up their fields. So they hitched big, strong oxen to a plow. The oxen **pulled**. The plow dug the dirt into long rows. Then the farmer could plant seeds.

Why does it work? Nothing moves by itself. A ball sits still until someone kicks it. A wagon sits still until someone tugs it. A **push** moves a thing away from you. A **pull** moves a thing toward you. A push or a pull is called a **force**.

Big and small. A small push makes a car roll a little way. A big push makes it roll a long way. A push can also stop a rolling ball, or turn it to a new path. God made the world this way every day, so we can count on it.

How do builders use it? Builders push and pull all day. A crane pulls heavy beams up high. A bulldozer pushes dirt to make a flat place for a house. Engineers are people who plan and build things. They think hard about how big a push or a pull each job needs.

PICTURE STUDY



Ploughing in the Nivernais, Rosa Bonheur, 1849 · Oil on canvas · Musée d'Orsay, Paris

Image: [Wikimedia Commons](#), public domain

Rosa Bonheur loved to paint animals. Here two teams of oxen pull plows up a hill in France. The farmers are getting the field ready for planting.

Look closely

- Find the oxen. Are they pushing or pulling?
- Find the plow behind them. What is it doing to the dirt?
- Find the long bar on the oxen's necks. That is a yoke. It lets two oxen pull together.
- Find the farmer. How is he helping?

Talk about it

1. Why do you think the farmers used so many oxen for one plow?
2. What machine pulls a plow on a farm today?

BUILD

The Push Test

You will push a toy car gently and then strongly, and measure how far it goes each time. Then you will try a pull with a string.

You will need

- A toy car that rolls well
- Masking tape for a start line
- A smooth floor (not thick carpet)
- Building blocks or a tape measure for measuring
- A small box and a piece of string about as long as your arm
- Engineer's notebook and crayons

Steps

1. Put a strip of tape on the floor. This is the start line.
2. **Guess.** Ask: Will a gentle push or a strong push make the car go farther?
Draw a small car and a big car in the notebook and circle your guess.
3. Give the car a gentle push from the start line. Where it stops, lay blocks end to end back to the line. Count the blocks. A grown-up writes the number.
4. Now give it a strong push from the same line. Count the blocks again.
5. **Fair test.** Use the same car and the same start line each time. Only the push changes. Do each push two times.
6. Tie the string to the box. Pull the box across the floor. Then push it back. Is it easier to pull or push this box?
7. **Make it better.** Can you make the car stop right on a piece of tape your grown-up puts down? Try a little push, then a bit more, until it stops on the tape.

Tips

- If you do not have blocks, count the grown-up's footsteps, heel to toe.
- Keep a tally: one mark for each block counted.

Check your work

- ☐ I can show a push and a pull.
- ☐ I can tell which push made the car go farther, and I have the numbers to show it.

ENGINEER'S NOTEBOOK

1. Draw yourself pushing something and pulling something. Your grown-up writes “push” and “pull” under them.
2. Make a two-row chart: “gentle push” and “strong push.” Color one square for each block the car went.

From history. Oxen were used for plowing for thousands of years, and in some places they still are. Rosa Bonheur studied real animals on farms and at markets so she could paint their muscles and movement correctly.

COMMON MISTAKES

- Starting the car from a different place each time. Use the tape line.
- Thinking the car moves by itself. Something always gives it a push.

Make it a game • Push or Pull Statues. Stand across from your parent. When your parent calls push or pull, act it out with your hands on a pretend heavy box. Then you call, and your parent acts, but sometimes does the wrong one on purpose. Shout Stop! and show the right motion. Catch three mistakes to win. Say what a push does and what a pull does.

1.2 RAMPS AND ROLLING

OBJECTIVES

- Tell what a ramp is and find one at home or in town.
- Show that a higher ramp makes a car roll faster and farther.
- Run a fair test with one book, two books and three books.

Warm-up. Hold a toy car on a flat table. Does it roll by itself? Now tip one end of a cutting board or a big book and set the car at the top. What happens? Talk about slides at the playground. Why do you slide down but not up?

WATCH

Ramps: A Super, Simple Machine! - #sciencegoals

SciShow Kids · 4:09

<https://www.youtube.com/watch?v=3COvm0TtxWg>

WHEN TO WATCH

After the first two core ideas, before the build.

KEY TERMS

ramp

A flat board or path with one end higher than the other.

slope

How steep a ramp is. A steep ramp is high at one end.

gravity

The pull that makes things fall down and roll downhill.

CORE IDEAS

Long ago. Long ago people built with giant stones. A stone that big is too heavy to lift by hand. Many people think the builders made long dirt **ramps**. Then many workers pulled the stones up a little at a time.

Why does it work? Things fall down. That pull is called **gravity**. God made gravity to hold us on the ground. On a ramp, gravity pulls a car down the hill. A higher ramp is steeper. On a steep ramp the car rolls faster and goes farther.

Up is easier, too. Lifting a heavy box straight up is hard. Pushing it up a long, gentle ramp is easier. It takes more steps, but each step is a smaller push.

How do builders use it? Ramps are all around us. A wheelchair ramp helps people go into a building. A loading ramp helps workers roll boxes into a truck. Roads in the mountains wind back and forth so the hill is not too steep for cars.

PICTURE STUDY



Girls Playing on a Slide, Webster & Stevens, About 1910 · Photograph · Museum of History & Industry, Seattle

Image: [Wikimedia Commons](#), public domain

This photograph was taken more than one hundred years ago at a playground in Seattle. A slide is a ramp made for fun.

Look closely

- Find the top of the slide and the bottom. Which end is higher?
- Find the ladder. How do the children get to the top?
- Look at how steep the slide is. Would a steeper slide be faster or slower?
- Find the sides of the slide. Why are they there?

Talk about it

1. What pulls the children down the slide?
2. Why is it hard to walk up a slide but easy to slide down?

BUILD

The Ramp Test

You will make a ramp from a board and a stack of books. You will roll a car down it from one, two and three books high and measure how far it rolls.

You will need

- A stiff board, a large piece of cardboard or a baking sheet
- Three or four thick books of the same size
- A toy car
- Masking tape
- Blocks, footsteps or a tape measure for measuring
- Engineer's notebook and crayons

Steps

1. Lay the board with one end on one book. Put tape on the floor where the ramp ends.
2. **Guess.** Will the car go farther from one book or from three books? Draw your guess.
3. Set the car at the top of the ramp. Let go. Do not push! Count blocks or footsteps from the end of the ramp to the car.
4. Add a second book. Let the car go again and count.
5. Add a third book. Let it go again and count.
6. **Fair test.** Use the same car and let go the same way each time. Only the height changes. Do each height two times.
7. Color a bar chart: one bar for each height.
8. **Make it better.** Lay a towel on the floor at the end. Does the car go as far? Try a smooth floor again. Which floor helps the car roll?

Tips

- Let go; never push. A push would change the test.
- If the car falls off the side, tape two rulers along the edges as rails.

Check your work

- ☐ I can make a ramp and tell which end is high.
- ☐ I can tell which ramp made the car go farthest, and I have the numbers.

ENGINEER'S NOTEBOOK

1. Draw the ramp at one, two and three books. Draw where the car stopped each time.
2. Draw a ramp you have seen in town or at church.

From history. A ramp is one of the six simple machines. The others are the lever, the wheel and axle, the pulley, the wedge and the screw. You will meet more of them in later grades.

COMMON MISTAKES

- Pushing the car instead of letting it go.
- Using a different car for different tests.

Make it a game • Ramp Roll Guess. Lean a book against the couch to make a ramp and set a toy car at the top. Before each roll, point to where you think it will stop. Roll it, and mark the spot with a sock. Then stack one more book and guess again. Say which ramp sent the car farther, and say the word gravity.

1.3 WHEELS MAKE WORK EASIER

OBJECTIVES

- Find the wheels and axles on a wagon, a bike or a toy car.
- Feel that a box on wheels is easier to pull than a box sliding on the floor.
- Measure the pull with a rubber band and a ruler.

Warm-up. Go on a wheel hunt around the house and yard. Count all the wheels you can find: on a chair, a bike, a stroller, a car, a wagon, a toy. Make a tally mark for each one. How many did you find?

WATCH

Let's Get Rolling! | Physics for Kids

[SciShow Kids](https://www.youtube.com/watch?v=YIV9IUHqW3A) · 3:18

<https://www.youtube.com/watch?v=YIV9IUHqW3A>

WHEN TO WATCH

After the story, before the build.

BACKUP VIDEO

Simple Machines: The Wheel & Axle

[funsciencedemos](https://www.youtube.com/watch?v=vYoWCn5r3rQ) · 6:04

<https://www.youtube.com/watch?v=vYoWCn5r3rQ>

For a grown-up to watch first. It shows rollers and then wheels with a pull scale, almost the same test as our build.

KEY TERMS

wheel

A round part that turns so a thing can roll.

axle

The rod in the middle of a wheel. The wheel turns around it.

rub

When two things slide against each other. Rubbing slows things down and makes them hard to drag.

CORE IDEAS

Long ago. Long ago people had to drag heavy loads on the ground. It was slow, hard work. Then people learned to put round logs under a load and roll it. Later they made **wheels** with an **axle** through the middle. Now a horse could pull a whole wagon full of hay.

Why does it work? When you drag a box, its bottom rubs on the floor. Rubbing makes it hard to move. A wheel does not drag. It rolls. Only a tiny part of the wheel touches the ground at a time. So a heavy load on wheels is much easier to pull.

How do builders use it? Wheels are everywhere. Cars, trains, bikes, wagons, carts and wheelbarrows all roll on wheels. Workers use dollies with wheels to move heavy boxes. Engineers choose big wheels for bumpy ground and small wheels for smooth floors.

PICTURE STUDY



The Hay Wain, John Constable, 1821 · Oil on canvas · The National Gallery, London

Image: [Wikimedia Commons](#), public domain

A “wain” is an old word for a farm wagon. John Constable painted this wagon crossing a shallow river near his home in England.

Look closely

- Find the wagon’s big wheels. How many can you see?
- Find the horses. Are they pushing or pulling the wagon?
- Find the water. Why might the farmer drive the wagon through a shallow river?
- Find the little dog on the bank.

Talk about it

1. Why does a hay wagon need big wheels?
2. How would the farmer move the hay if the wagon had no wheels?

BUILD

The Rubber-Band Pull Test

You will pull a box of blocks three ways: sliding on the floor, rolling on pencils, and riding on a toy truck or wagon. A rubber band will show how hard you pull. The more it stretches, the harder the pull.

You will need

- A small shoebox with a few blocks or cans inside
- A thick rubber band and a piece of string
- Six round pencils or markers (all the same)
- A toy truck, wagon or skateboard the box can sit on
- A ruler
- Engineer's notebook

Steps

1. A grown-up pokes a small hole in one end of the box, ties the string through it, and ties the rubber band to the string.
2. **Guess.** Which way will be easiest: sliding, rollers or wheels? Draw a star by your guess.
3. **Slide.** Hold the end of the rubber band and pull the box slowly along the floor. A grown-up holds a ruler beside the rubber band and reads how long it stretches.
4. **Rollers.** Lay the pencils in a row like a little road. Set the box on them and pull again. Measure the rubber band.
5. **Wheels.** Set the box on the toy truck or wagon and pull again. Measure the rubber band.
6. **Fair test.** Keep the same box with the same things inside. Pull slowly each time. Only the way it moves changes.
7. Write the three numbers in the notebook. Which pull stretched the band the least?
8. **Make it better.** Try the wheels on a rug and on a smooth floor. Which floor is easier?

Tips

- Pull slowly and steadily, not with a jerk.
- When the box rolls off the back pencil, move that pencil to the front, just as people did long ago.

Check your work

- ☐ I can point to a wheel and an axle.
- ☐ I can tell which way of moving the box was easiest, and show my numbers.

ENGINEER'S NOTEBOOK

1. Draw the box three ways: sliding, on rollers and on wheels. Your grown-up writes how far the rubber band stretched under each one.
2. Draw a wagon and color its wheels and axle.

From history. People have used wheels for a very long time. Old pictures and carvings show wagons and chariots with solid wooden wheels. Later, wheels with spokes were made, because they were lighter and still strong.

COMMON MISTAKES

- Yanking the string. A quick yank stretches the band more than a slow pull.
- Thinking a wheel is just a circle. It needs an axle to turn around.

Make it a game • Wheel Hunt Race. Set a timer for two minutes and hunt through the house for things with wheels and axles. Touch each one and say its name. Your parent counts them on fingers. Then pull a box across the floor, and again with toy cars under it. Tell which was easier, and beat your count next time.

1.4 THE TALLEST BLOCK TOWER THAT STANDS

OBJECTIVES

- Build a block tower and measure how tall it is.
- Show that a wide bottom helps a tower stand.
- Try again to make a taller tower that still stands.

Warm-up. Stand on one foot with your feet close together, and have a grown-up give a gentle push on your shoulder. Now stand with your feet wide apart. Which way is it easier to stay up? Talk about why.

WATCH

How High Can You Stack? | Engineering for Kids

SciShow Kids · 4:05

<https://www.youtube.com/watch?v=eR2OR3coiX4>

WHEN TO WATCH

Before the build. Pause when Jessi starts a new tower, and guess whether it will stand.

KEY TERMS

tower

A building that is much taller than it is wide.

base

The bottom part that holds everything up.

stable

Steady. Hard to tip over.

CORE IDEAS

Long ago. The Bible tells of people in a land called Shinar. They made bricks and said, “Let us build a tower whose top may reach to heaven.” They wanted to make a big name for themselves. God stopped the tower. Their problem was not the bricks. It was a proud heart.

Why does it work? A tall tower wants to tip. A tower with a narrow **base** tips over easily. A tower with a wide base is **stable**. Its weight is spread out over more ground. That is why a mountain is wide at the bottom and narrow at the top.

How do builders use it? Engineers make tall towers wide and heavy at the bottom. They make them lighter near the top. They also stack each piece straight, right over the one below. A tower that leans is more likely to fall.

Try it. Engineers almost never get it right the first time. They build, test, and try again. When your tower falls, you have learned something. Build it again, better.

PICTURE STUDY



The Tower of Babel, Pieter Bruegel the Elder, 1563 · Oil on wood panel · Kunsthistorisches Museum, Vienna

Image: [Wikimedia Commons](#), public domain

Pieter Bruegel painted the Tower of Babel as if it were being built in his own day. He filled it with tiny workers, ladders and cranes. Look closely; there is a lot to find.

Look closely

- Look at the tower's bottom and its top. Which is wider?
- Find the arches all the way around. Arches help hold up the heavy stone.
- Find a crane with a big wheel. People walked inside the wheel to lift stones.
- Find the boats in the harbor. What might they be bringing?
- Does the tower look finished?

Talk about it

1. Why did Bruegel paint the tower so wide at the bottom?
2. Why do you think the tower was never finished?

Safety first. Build on the floor, not on a table. Stand back when a tall tower starts to sway, and never climb on a chair to reach the top.

BUILD

The Tallest Tower That Stands

You will build a skinny tower and a wide tower, measure them, and test which one stands up to a little “wind.” Then you will try to build your tallest steady tower.

You will need

- Wooden blocks, LEGO DUPLO bricks or plastic cups
- A tape measure or yardstick
- A piece of paper to fan as “wind”
- Engineer’s notebook

Steps

1. **Skinny tower.** Stack blocks one on top of another, one block wide, until it falls. Count how many blocks it had before it fell.
2. **Wide tower.** Now make a wide base of four or more blocks. Build up, making each layer a little smaller. Count the blocks.
3. A grown-up measures each tower with the tape measure before it falls.
4. **Guess.** Which tower will stand when we make wind? Point to it.
5. **Wind test.** A grown-up fans a sheet of paper three times at each tower from the same spot. Which one stands?
6. **Fair test.** Fan both towers the same way and from the same distance.
7. **Make it better.** Build the tallest tower you can that still stands up to the wind test. Measure it. Try one more time to beat your number.

Tips

- Line each block up straight over the one below it.
- Put the biggest, heaviest blocks at the bottom.

Check your work

- ☐ I can show why a wide base makes a tower stable.
- ☐ I can tell how tall my best tower was.

ENGINEER'S NOTEBOOK

1. Draw your skinny tower and your wide tower side by side. Your grown-up writes how tall each one was.
2. Draw the tallest tower you made, and color the base.

From history. Bruegel painted two pictures of the Tower of Babel. This large one is in Vienna, and a smaller one is in Rotterdam. He painted the cranes and scaffolding the way builders of his own time used them.

COMMON MISTAKES

- Building fast and crooked. Slow and straight builds taller.
- Giving up after the first fall. Engineers try again.

Make it a game • Wide Base Wobble. Build one block tower with a tiny bottom and one with a wide bottom, both the same height. Gently wiggle the table. Which one falls first? Now play Tower Doctor: your parent builds a wobbly tower and you fix it, saying the word base each time you add a wide piece underneath.

Scripture. “let us build us a city and a tower, whose top may reach unto heaven; and let us make us a name” (Genesis 11:4, KJV)

The people of Babel built to show off. We build to help others and to thank God for the good minds He gave us.

UNIT 1

PUSH AND PULL

Everything that moves needs a push or a pull. In this unit your child will feel pushes and pulls, roll toy cars down ramps, find out why wheels make work easier, and build the tallest block tower that will stand. Each lesson starts with a short “Long ago” story, then asks “Why does it work?” and “How do builders use it?”

Every build is a small test. Your child will guess first, try it, count or measure, and then try to make it better. That is what engineers do. God made a world where things move in ways we can count on, so we can learn how they work and use them to help people.

PREREQUISITES

- Can count to 10 (counting to 20 is a bonus)
- Can stack blocks and roll a ball
- Can sit for a short story and a short video

MASTERY CHECKLIST

- ☐ I can show a push and a pull.
- ☐ I can tell that a harder push makes a thing go farther.
- ☐ I can show that a higher ramp makes a car roll faster and farther.
- ☐ I can tell why wheels make heavy things easier to move.
- ☐ I can build a tower with a wide bottom so it stands.

OPTIONAL KITS FOR THIS UNIT

- **KEVA Planks**: Plain maple planks, all the same size, for towers, ramps and bridges. Good for young builders with a grown-up nearby. Fits Lesson 1.4 and Units 2 and 3.
- **Magna-Tiles**: Flat magnetic shapes that click together into walls and towers. Easy for small hands. Fits Lesson 1.4 and Unit 3.

Not required. Every project in this unit can be built with household materials. School Launch has no ties to these companies.

LESSONS IN THIS UNIT

1.1 Pushes and Pulls

2 sessions of 30 minutes

1.2 Ramps and Rolling

2 sessions of 30 minutes

1.3 Wheels Make Work Easier

2 sessions of 30 minutes

1.4 The Tallest Block Tower That Stands

2 sessions of 30 minutes

UNIT 1 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. Show me a push. Now show me a pull.
2. Which makes a toy car go farther: a gentle push or a strong push?
3. Build a quick ramp with a book. Where should the car start so it rolls the farthest: on a low ramp or a high ramp?
4. Why is it easier to move a heavy box on a wagon than to drag it?
5. Point to a wheel and an axle on a toy or a bike.
6. Build a tower that will not tip over easily. What did you do?

ANSWER KEY

1. The child pushes something away (a door, a ball) and pulls something toward himself or herself (a drawer, a wagon).
2. A strong push.
3. On a high (steeper) ramp.
4. The wheels roll instead of rubbing on the floor.
5. The wheel is the round part; the axle is the rod in its middle.
6. Made a wide base, put big blocks at the bottom and stacked them straight.

PORTFOLIO PIECE: MY RAMP AND TOWER SHOW

Set up a ramp and roll a car down from a low and a high height, then build your best wide-based tower. Show a family member how they work and tell what you learned. Keep the notebook pages and a photo of your best tower in your portfolio folder.

LOOK FOR	WHAT IT MEANS
Guessed first	Made a guess before each test.
Fair test	Let the car go the same way each time and changed only the height.
Counted or measured	Counted blocks or footsteps, with a grown-up writing the numbers down.
Tried again	Built the tower again after it fell and made it better.

UNIT 2

BRIDGES

A bridge lets people cross over water or a deep valley. In this unit your child will start with the very first kind of bridge, a log across a creek, and then find out three big secrets of bridge builders: folding makes paper strong, an arch pushes its load down into the ground, and strong cables can hold up a long road in the air, as on the Golden Gate Bridge.

Each build is a bridge between two stacks of books, tested with pennies. Your child will guess how many pennies it will hold, count them in one at a time, write the number down, and then make the bridge stronger. A bridge that stays up is a way of loving our neighbors, because people trust it to carry them safely.

PREREQUISITES

- Can count to 20 with help
- Knows a push and a pull (Unit 1)
- Can fold a piece of paper in half

MASTERY CHECKLIST

- ☐ I can tell what a bridge is for.
- ☐ I can show that a short bridge holds more than a long one.
- ☐ I can fold paper to make a stronger bridge.
- ☐ I can build an arch and show how it holds weight.
- ☐ I can tell how the Golden Gate Bridge hangs from its cables.

OPTIONAL KITS FOR THIS UNIT

- **KEVA Planks:** Plain wooden planks that make good beam bridges and, with a grown-up's help, simple arches. Fits Lessons 2.1 and 2.3.

Not required. Every project in this unit can be built with household materials. School Launch has no ties to these companies.

LESSONS IN THIS UNIT

2.1 A Log Across a Creek

2 sessions of 30 minutes

2.2 Folding Paper Makes It Strong

2 sessions of 30 minutes

2.3 The Strong Arch

2 sessions of 30 minutes

UNIT 2 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. What is a bridge for?
2. Here are two paper strips over a gap: one over a short gap, one over a long gap. Which will hold more pennies?
3. Show me how to make a flat paper bridge stronger without adding any paper.
4. Make an arch with your hands and a grown-up's hands. What does an arch need at its feet?
5. Point to the towers, cables and road in a picture of the Golden Gate Bridge. What holds up the road?
6. Why do bridge builders test their bridges?

ANSWER KEY

1. To carry people, cars or trains over water, a road or a valley.
2. The one over the short gap.
3. Fold it: fold the sides up or fold it like a fan.
4. Strong, steady ground that will not slide apart.
5. The cables hold up the road, and the towers hold up the cables.
6. So people can cross safely; testing shows how much a bridge can hold.

PORTFOLIO PIECE: MY STRONGEST BRIDGE

Choose your favorite kind of bridge from this unit: folded, arch or hanging. Build it between two stacks of books or two chairs, test it with pennies, and then make it stronger. Show it to your family, tell them how many pennies it held, and keep the notebook page and a photo in your portfolio folder.

LOOK FOR	WHAT IT MEANS
Guessed first	Guessed how many pennies before testing.
Counted carefully	Added pennies one at a time and counted out loud.
Made it better	Changed the bridge after the first test and tested it again.
Told about it	Explained to someone why the bridge shape made it strong.

2.1 A LOG ACROSS A CREEK

OBJECTIVES

- Tell what a bridge is and why people build them.
- Build a beam bridge between two stacks of books.
- Show that a short bridge holds more pennies than a long one.

Warm-up. Lay two jump ropes or towels on the floor as the banks of a “river.” How could you get across without getting wet? Try laying a board or a long book across the gap and stepping over on it (keep it low and safe). Talk about bridges you have crossed in the car or on foot.

WATCH

What Makes Bridges So Strong? | Engineering for Kids | STEAM | SciShow Kids

SciShow Kids · 3:45

<https://www.youtube.com/watch?v=oVOnRPefcno>

WHEN TO WATCH

After the story. Pause when Jessi builds her block bridge and guess if it will hold.

Note: This video is also used in the Grade 5 course; it is the clearest short bridge video for young children.

KEY TERMS

bridge

Something built to carry people or cars over water, a road or a valley.

beam

A long, straight piece, like a log or a board, that lies across a gap.

span

How far a bridge reaches from one side to the other.

CORE IDEAS

Long ago. Long ago a man came to a creek. The water was too deep and cold to wade. Then he saw a tree that had fallen right across it. He walked across on the log! That

was one of the first **bridges**. People still cut logs to cross creeks in the woods.

Why does it work? A log is a **beam**. Each end rests on solid ground. When you stand in the middle, the log bends down a little. A thick log bends less than a thin one. A short log bends less than a long one.

How do builders use it? Many bridges on our roads are beam bridges. They are long beams of concrete or steel. Engineers rest them on strong posts so the **span** between posts is short. Short spans are strong spans.

PICTURE STUDY



Crossing Ketchikan Creek on Logs, William Howard Case, About 1900–1908 · Photograph · University of Washington Libraries, Special Collections

Image: [Wikimedia Commons](#), public domain

This photograph was taken in Alaska more than one hundred years ago. The men are crossing a creek on logs, just like the first bridge builders.

Look closely

- Find the logs. Where do their ends rest?
- Find the water under the logs. Is it calm or rushing?
- Count the people crossing.
- Look at the middle of the log. Is it the strongest part or the weakest part?

Talk about it

1. Why do you think the men walk one at a time?
2. How could you make this bridge safer?

BUILD

The Beam Bridge Penny Test

You will lay a strip of card across a gap between two stacks of books. You will add pennies until it sags and falls. Then you will make the gap shorter and test again.

You will need

- Two stacks of books the same height
- A strip of card stock or a file folder, about as long as your forearm and as wide as your hand
- A small paper cup
- A jar of pennies
- A ruler
- Engineer's notebook

Steps

1. Set the two book stacks apart so the gap is a little shorter than your strip. A grown-up measures the gap with a ruler.
2. Lay the strip across. Put the paper cup in the middle.
3. **Guess.** How many pennies will it hold? A grown-up writes your guess.
4. Drop in pennies one at a time and count out loud. Stop when the bridge sags so far that the cup touches the table or falls. Write the number.
5. Now push the books closer together so the gap is shorter. Test again with the same strip.
6. **Fair test.** Use the same strip, the same cup, and put the cup in the middle each time. Only the gap changes.
7. **Make it better.** Lay two strips on top of each other. Does a thicker beam hold more?

Tips

- Drop pennies gently. A hard drop is like a jump on the bridge.
- Count in groups of five or ten to keep track.

Check your work

- ☐ I can build a beam bridge.
- ☐ I can tell whether a short or long bridge held more pennies.

ENGINEER'S NOTEBOOK

1. Draw your bridge between the books. Draw the cup of pennies in the middle.
2. Make a picture chart: the long bridge and the short bridge, with the number of pennies each held.

COMMON MISTAKES

- Moving the cup closer to one end. The middle is the hardest test, so keep it there.
- Using a new strip for one test. A bent strip is weaker, so use a fresh strip for each round if the old one creased.

Make it a game • Bridge Builder Charades. Act out a bridge with your body: stretch your arms across two chairs and be the beam. Your parent pretends to be a tiny car and crosses you carefully. Then switch. Next, say why people build bridges, and name three things that might cross one, like a truck, a bike or a horse. Wave when it gets across.

2.2 FOLDING PAPER MAKES IT STRONG

OBJECTIVES

- Show that a flat paper bridge is weak.
- Fold paper into new shapes and test which holds the most pennies.
- Tell how engineers made a strong bridge from flat iron plates.

Warm-up. Hold a flat sheet of paper by one edge. It flops down. Now fold it back and forth like a fan and hold it the same way. What happened? Look at the edge of a cardboard box. What do you see inside?

WATCH

Paper Bridges STEM Activity

Science Buddies • 2:05

<https://www.youtube.com/watch?v=CqYGVW2Eu6Y>

WHEN TO WATCH

Before the build. The video has words on the screen and no talking, so read them aloud.

KEY TERMS

fold

To bend paper over and press it flat in a line.

shape

The form something has. The same paper in a new shape can be much stronger.

test

Trying something to find out how well it works.

CORE IDEAS

Long ago. About 175 years ago, engineers in Wales needed a railroad bridge over the sea. A man named Robert Stephenson planned it. He wanted to use flat iron plates. But flat plates bend, just like paper.

How they figured it out. Stephenson and his helper William Fairbairn made small model tubes. Some were round, some were oval and some were shaped like a box.

They tested each one with weights until it broke. The box shape was the strongest! So they built giant iron boxes, and the trains rode right through them.

Why does it work? A flat sheet bends easily. When you fold it, the folds stand up tall. Tall edges are hard to bend. A fan fold has many tall edges, so it is very stiff.

How do builders use it? The inside of a cardboard box has a wavy, folded layer. That makes it strong but light. Metal roofs and many steel bridge beams have folds or tall edges for the same reason.

PICTURE STUDY



Floating a Tube of the Britannia Bridge, George Hawkins, 1849–1850 · Lithograph · Published in Great Britain; digital copy from the Digital Public Library of America

Image: [Wikimedia Commons](#), public domain

This print shows the Britannia Bridge in Wales being built in 1849. One of the giant iron tubes has been floated out on the water. Next it will be lifted up, little by little, between the stone towers. Trains would run inside it.

Look closely

- Find the long iron tube on the water. What shape is it?
- Find the tall stone towers. The tube will be lifted up between them.
- Find a tube that is already up high between two towers.
- Find the crowd watching from the shore, and the little boats helping.

Talk about it

1. Why did the engineers make the bridge a box and not a flat sheet?
2. How is the box like your folded paper bridge?

BUILD

Flat, Folded and Fan-Folded

You will test three paper bridges between two stacks of books: a flat sheet, a sheet with its sides folded up, and a sheet folded like a fan. Then you will invent a stronger shape.

You will need

- Two stacks of books the same height, set about a hand's width apart
- Several sheets of printer paper
- A small paper cup
- Pennies
- Tape
- Engineer's notebook

Steps

1. **Flat.** Lay a flat sheet across the gap. Set the cup in the middle and add pennies one at a time. Count until it falls. A grown-up writes the number.
2. **Folded sides.** Take a new sheet. Fold up each long side, like a rain gutter. Tape the corners so it keeps its shape. Test it the same way.
3. **Guess.** Will a fan fold hold more or less? Point to your guess.
4. **Fan fold.** Fold a new sheet back and forth like a fan. Lay it across the gap with the folds running from bank to bank. Lay a flat sheet on top as a road. Test it.
5. **Fair test.** Use the same size paper, the same gap and the same cup each time. Only the shape changes.
6. Make a bar chart with three bars.
7. **Make it better.** Invent your own shape: roll it into a tube, or make a box. Can you beat the fan?

Tips

- Crease each fold hard with a thumbnail.
- Keep the gap the same by marking the book places with tape.

Check your work

- ☐ I can show that folding paper makes it stronger.
- ☐ I can tell which shape held the most pennies.

ENGINEER'S NOTEBOOK

1. Draw the end of each bridge: flat, folded sides and fan. Your grown-up writes how many pennies each held.
2. Draw the shape you invented.

From history. The Britannia Bridge carried trains for more than one hundred years. The iron tubes were later replaced, but some of the original stone towers and the large stone lions still stand.

COMMON MISTAKES

- Laying the fan fold the wrong way, with the folds running across the gap. The folds must run from one book to the other.
- Reusing a sheet that is already creased in the middle.

Make it a game • Fold It Stronger. Bridge makers need strong paper. Lay a flat sheet across two cups and add pennies or buttons one at a time, counting out loud. Then fold the same sheet into a fan and try again. Guess before each test: will it hold more or fewer? Tell your parent which shape won and the word fold.

2.3 THE STRONG ARCH

OBJECTIVES

- Find the arch shape in bridges, doors and windows.
- Build a paper arch and show that it holds more than a flat bridge.
- Tell how the Romans built strong stone arches long ago.

Warm-up. Stand facing a grown-up, a step apart. Put your hands together up high and lean in toward each other. You made an arch! Can you hold each other up? Now look for arches around the house and church: doorways, windows, the top of a chair.

WATCH

Why are arched bridges so strong?

Canal & River Trust • 2:16

<https://www.youtube.com/watch?v=Zu6LE0pZP5E>

WHEN TO WATCH

After the story. Watch the children build a wooden arch and stand on it.

KEY TERMS

arch

A curved shape that goes up and over, like a rainbow.

keystone

The stone at the very top of an arch. It locks the other stones in place.

Romans

People who lived long ago in a great empire around the city of Rome. They were famous builders.

CORE IDEAS

Long ago. Long ago the **Romans** needed to carry water across a deep valley in France. They built the Pont du Gard. It has three rows of stone **arches**, one on top of the other. They cut the big stones so well that they fit with no glue at all. The bridge has stood for about two thousand years!

Why does it work? Each stone in an arch leans on the next one. When weight presses on top, the stones push each other tight. The push goes around the curve and down

into the ground. The stone at the top is the **keystone**. It locks the arch together.

How do builders use it? An arch needs strong feet on each side, so it cannot spread out. While builders work, they hold the stones up on a wooden frame. When the keystone goes in, they take the frame away, and the arch holds itself up. Arches are used in bridges, doors, windows and churches.

PICTURE STUDY



The Pont du Gard, Hubert Robert, 1786 · Oil on canvas · Musée du Louvre, Paris

Image: [Wikimedia Commons](#), public domain

Hubert Robert loved to paint old Roman buildings. Here he painted the Pont du Gard, a Roman bridge that carried water in a channel on its top.

Look closely

- Count the rows of arches. Which row has the biggest arches?
- Find the stone at the top of one arch. That is the keystone.
- Find the river under the bridge.
- Find the tiny people. How big is the bridge next to them?

Talk about it

1. Why do you think the arches at the bottom are the biggest?
2. How have the arches stayed up for so long?

BUILD

Flat Bridge, Arch Bridge

You will test a flat paper bridge, then add a paper arch under it, and count how many more pennies it holds.

You will need

- Two stacks of books about a hand's width apart
- Two sheets of card stock or a file folder cut in half
- A small paper cup and pennies
- Tape
- Engineer's notebook

Steps

1. **Flat.** Lay one card across the gap. Set the cup in the middle and add pennies, counting, until it sags to the table. A grown-up writes the number.
2. **Arch.** Bend the second card into a curve. Tuck its two ends against the bottom of each book stack, so the books are its strong feet.
3. Lay a new flat card on top of the books and arch, as the road.
4. **Guess.** How many pennies will it hold now?
5. Set the cup in the middle and add pennies one at a time. Count.
6. **Fair test.** Use the same gap, the same cup and the same kind of card. Only the arch is new.
7. **Make it better.** Pull one book stack away a little. What happens to the arch? Push it back. Why does an arch need strong feet?

Tips

- A taller, rounder arch is usually stronger than a flat one.
- Hold the book stacks steady; they are the ground the arch pushes against.

Check your work

- ☐ I can build an arch and point to its feet.
- ☐ I can tell how many more pennies the arch bridge held.

ENGINEER'S NOTEBOOK

1. Draw your flat bridge and your arch bridge. Write the penny numbers under each.
2. Draw an arch you found at home or at church.

From history. The Pont du Gard was part of a long water channel that carried spring water to the Roman city of Nîmes. The channel sloped down very gently the whole way, so the water flowed by itself.

COMMON MISTAKES

- Letting the arch's feet slide out. The arch is only strong if its feet cannot move.
- Thinking the curve alone is strong. The stones (or card) push on each other and on the ground.

Make it a game • Arch Hunt Parade. March through the house like an arch-spotting parade. Whenever you spot a curved arch shape, such as a doorway, a window top or a handle, stop and trace it in the air with your whole arm. Your parent keeps score. Find five arches. Then bend a paper into an arch and say why a curve helps it hold.

Scripture. “a tried stone, a precious corner stone, a sure foundation” (Isaiah 28:16, KJV)

A “tried” stone is a tested stone. Builders test their stones, and God gives us Jesus as the sure foundation we can trust.

2.4 THE GOLDEN GATE BRIDGE

OBJECTIVES

- Tell where the Golden Gate Bridge is and when it opened.
- Point to the towers, cables and road of a suspension bridge.
- Build a string bridge and test how many pennies it holds.

Warm-up. Hold a jump rope or a long string at both ends with a grown-up, and let it hang in a smile shape. Hang a small toy from the middle with a paper clip. Now pull the rope tight. What happens to the toy?

WATCH

The Golden Gate Bridge for Kids: Famous Landmarks for Children - FreeSchool

Free School · 3:43

<https://www.youtube.com/watch?v=WKphjf3VZhA>

WHEN TO WATCH

After the story, to see the real bridge.

BACKUP VIDEO

Golden Gate Bridge for Kids

Homeschool Pop · 4:08

<https://www.youtube.com/watch?v=bPBTx97pMDs>

Later in the week, for more about how it was built.

KEY TERMS

suspension bridge

A bridge whose road hangs from big cables.

cable

A very strong rope made of many steel wires twisted or bundled together.

tower

The tall posts that hold up a suspension bridge's cables.

CORE IDEAS

Long ago. Not so long ago, people in San Francisco had to ride a ferry boat across the water called the Golden Gate. Many said a bridge there could never be built. The water was deep and windy, and fog rolled in. But an engineer named Joseph Strauss and his team said it could be done. The Golden Gate Bridge opened in 1937.

How they figured it out. The gap was too long for a beam or an arch. So they built a **suspension bridge**. They set two very tall **towers** in the water. They hung two huge **cables** over the towers. Each cable is made of more than 27,000 thin steel wires bundled together. Then they hung the road from the cables.

Why does it work? The cables pull. The weight of the road pulls down on the cables. The cables pull on the towers and on giant blocks of concrete in the ground at each end. Many thin wires together are much stronger than one thick bar.

How do builders use it? Safety came first. Strauss made the workers wear hard hats, and he hung a big net under the bridge to catch anyone who slipped. Today painters keep painting the bridge its orange color, called International Orange, so the steel does not rust.

PICTURE STUDY



Building the Golden Gate Bridge, Unknown photographer, May 19, 1936 · Aerial photograph · U.S. National Archives

Image: [Wikimedia Commons](#), public domain

This photograph was taken from an airplane while the bridge was being built. The towers and cables are up, and the workers are adding the road.

Look closely

- Find the two tall towers.
- Find the big cables. What shape do they make between the towers?
- Find the parts of the road that are already hung. Are there gaps?
- Find the land at each end, where the cables are held down.

Talk about it

1. Why did the workers build the towers and cables before the road?
2. Why do you think the bridge is painted orange and not gray?

BUILD

A String Suspension Bridge

You will make a little suspension bridge between two chairs. The road will hang from strings. You will test it with pennies, then add more strings to make it stronger.

You will need

- Two chairs with tall backs
- Strong string or yarn
- A strip of card stock about as long as your arm, for the road
- A hole punch or a pencil to poke holes
- A small paper cup and pennies
- Masking tape
- Engineer's notebook

Steps

1. Set the chairs back to back, a little closer than the road strip is long. Lay the road strip between the seats. Set the cup in the middle and add pennies until it sags to the floor. Write the number.
2. Now tie two long strings from the top of one chair back to the top of the other, letting them hang in a smile. These are your cables.
3. A grown-up punches two holes near each end and in the middle of the road strip. Tie short strings from the holes up to the cables. These are the hangers.
4. **Guess.** How many pennies will the hanging road hold?
5. Set the cup in the middle and add pennies. Count.
6. **Fair test.** Use the same road strip, the same cup and the same spot.
7. **Make it better.** Add more hangers, closer together. Test again. Do more hangers make it stronger?

Tips

- Tape the cable strings well to the chair backs so they do not slide.
- Keep the chairs from sliding together; put a heavy book on each seat.

Check your work

- ☐ I can point to the towers, cables and hangers on my bridge.
- ☐ I can tell how many more pennies the hanging bridge held.

ENGINEER'S NOTEBOOK

1. Draw the Golden Gate Bridge with two towers, two cables and the road. Color it orange.
2. Draw your chair bridge and write how many pennies it held before and after the hangers.

From history. When the Golden Gate Bridge opened in 1937, its middle span of 4,200 feet was the longest of any suspension bridge in the world. On the first day, people walked across before any cars were allowed.

COMMON MISTAKES

- Thinking the road holds up the cables. The cables hold up the road.
- Pulling the cables so tight that the chairs tip toward each other.

Make it a game • Cable and Tower Pose. Make a suspension bridge with your body. Stand with your feet apart and your arms curved down like a cable, while your parent holds a scarf as the road. Say tower, cable and road as you point to each part. Then trade places. Finish by telling where the Golden Gate Bridge is.

UNIT 2

BRIDGES

A bridge lets people cross over water or a deep valley. In this unit your child will start with the very first kind of bridge, a log across a creek, and then find out three big secrets of bridge builders: folding makes paper strong, an arch pushes its load down into the ground, and strong cables can hold up a long road in the air, as on the Golden Gate Bridge.

Each build is a bridge between two stacks of books, tested with pennies. Your child will guess how many pennies it will hold, count them in one at a time, write the number down, and then make the bridge stronger. A bridge that stays up is a way of loving our neighbors, because people trust it to carry them safely.

PREREQUISITES

- Can count to 20 with help
- Knows a push and a pull (Unit 1)
- Can fold a piece of paper in half

MASTERY CHECKLIST

- ☐ I can tell what a bridge is for.
- ☐ I can show that a short bridge holds more than a long one.
- ☐ I can fold paper to make a stronger bridge.
- ☐ I can build an arch and show how it holds weight.
- ☐ I can tell how the Golden Gate Bridge hangs from its cables.

OPTIONAL KITS FOR THIS UNIT

- **KEVA Planks:** Plain wooden planks that make good beam bridges and, with a grown-up's help, simple arches. Fits Lessons 2.1 and 2.3.

Not required. Every project in this unit can be built with household materials. School Launch has no ties to these companies.

LESSONS IN THIS UNIT

2.1 A Log Across a Creek

2 sessions of 30 minutes

2.2 Folding Paper Makes It Strong

2 sessions of 30 minutes

2.3 The Strong Arch

2 sessions of 30 minutes

UNIT 2 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. What is a bridge for?
2. Here are two paper strips over a gap: one over a short gap, one over a long gap. Which will hold more pennies?
3. Show me how to make a flat paper bridge stronger without adding any paper.
4. Make an arch with your hands and a grown-up's hands. What does an arch need at its feet?
5. Point to the towers, cables and road in a picture of the Golden Gate Bridge. What holds up the road?
6. Why do bridge builders test their bridges?

ANSWER KEY

1. To carry people, cars or trains over water, a road or a valley.
2. The one over the short gap.
3. Fold it: fold the sides up or fold it like a fan.
4. Strong, steady ground that will not slide apart.
5. The cables hold up the road, and the towers hold up the cables.
6. So people can cross safely; testing shows how much a bridge can hold.

PORTFOLIO PIECE: MY STRONGEST BRIDGE

Choose your favorite kind of bridge from this unit: folded, arch or hanging. Build it between two stacks of books or two chairs, test it with pennies, and then make it stronger. Show it to your family, tell them how many pennies it held, and keep the notebook page and a photo in your portfolio folder.

LOOK FOR	WHAT IT MEANS
Guessed first	Guessed how many pennies before testing.
Counted carefully	Added pennies one at a time and counted out loud.
Made it better	Changed the bridge after the first test and tested it again.
Told about it	Explained to someone why the bridge shape made it strong.

UNIT 3

HOUSES AND TOWERS

People need safe homes, and towns need tall buildings. In this unit your child will test building materials the way the three little pigs should have, find out why triangles are the strongest shape, build a tall tower of paper cups, and learn from Jesus' story of the wise man who built his house upon the rock. Along the way we meet real builders: the people who rebuilt London in brick, Gustave Eiffel and his iron tower, the workers on the Empire State Building, and John Smeaton, who built a lighthouse on a rock in the sea.

Each build is a test: a wind test with a fan, a push test on a shape, a height test with a tape measure, and a water test on sand and rock. Your child will guess, test, count and try again. "Through wisdom is an house builded," says Proverbs 24:3.

PREREQUISITES

- Knows that a wide base helps a tower stand (Lesson 1.4)
- Can count to 20 with help
- Knows the shapes circle, square and triangle

MASTERY CHECKLIST

- ☐ I can tell why builders choose strong materials like brick and stone.
- ☐ I can show that a triangle does not squash but a square does.
- ☐ I can build a tall cup tower and measure it.
- ☐ I can tell why a house needs a strong foundation, like the wise man's house on the rock.

OPTIONAL KITS FOR THIS UNIT

- **Magna-Tiles:** Flat magnetic squares and triangles. Children can feel for themselves that a box of triangles is stiffer than a box of squares. Fits Lessons 3.2 and 3.3.
- **LEGO DUPLO:** Large bricks for small hands, good for the "brick house" in Lesson 3.1 and for towers. Many families already have some.

Not required. Every project in this unit can be built with household materials. School Launch has no ties to these companies.

LESSONS IN THIS UNIT

3.1 Straw, Sticks or Bricks?	2 sessions of 30 minutes
3.2 Triangles Are Strong	2 sessions of 30 minutes
3.3 The Tall Cup Tower	2 sessions of 30 minutes
3.4 The Wise Man Built His House upon the Rock	2 sessions of 30 minutes

UNIT 3 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. Name two materials that houses are made of. Which would stand best in a big wind?
2. Make a square and a triangle from straws or craft sticks. Push on each one. What happens?
3. How can you make a square frame strong?
4. Build a cup tower. What helps it go higher and stay up?
5. Tell the story of the wise and foolish builders. Why did the wise man's house stand?
6. What is a foundation?

ANSWER KEY

1. Any two of wood, brick, stone, concrete, glass, straw. Brick or stone stands best.
2. The square leans over and squashes; the triangle keeps its shape.
3. Add a brace from corner to corner, making two triangles.
4. A wide bottom, careful straight stacking, and card floors between layers.
5. He built on the rock; rock does not wash away like sand.
6. The strong bottom of a building that holds it up.

PORTFOLIO PIECE: A HOUSE THAT STANDS

Build a small house or tower from the material you think is best. Give it a strong foundation, use triangles or braces to make it stiff, and test it with the fan and with a little water. Show your family, tell them why it stood, and keep a photo and your notebook page in your portfolio folder.

LOOK FOR	WHAT IT MEANS
Chose a strong material	Picked a material and could tell why.
Used triangles or braces	Added at least one triangle or brace to make the frame stiff.
Tested it	Did the wind and water tests the same way each time.
Tried again	Fixed a weak spot after the first test and tested again.

3.1 STRAW, STICKS OR BRICKS?

OBJECTIVES

- Name some materials houses are made of: wood, brick, stone.
- Build three little houses from different materials.
- Test them with a fan “wolf” and tell which was strongest.

Warm-up. Tell or read the story of the three little pigs. Then walk around the house or down the street. What is your house made of? Knock gently on a wall, a window and a door. Do they sound and feel the same?

WATCH

Engineering for the Three Little Pigs

Teach Engineering · 2:50

<https://www.youtube.com/watch?v=zrlRunvUI3A>

WHEN TO WATCH

After the story. The video has words on the screen and no talking; read them aloud. Pause before each test and guess which brick will hold.

Note: From TeachEngineering, a free engineering curriculum from university engineering schools. It mixes sand and glue to make test bricks; children should not copy the cooking spray step without help.

KEY TERMS

material

What something is made of, like wood, brick, stone or glass.

brick

A block of clay baked hard in a hot oven, called a kiln.

strong

Able to hold weight and stand up to wind and rain without breaking.

CORE IDEAS

Long ago. Long ago, in the year 1666, a great fire burned much of the city of London. Many houses there were made of wood, and they were packed close together. The

fire spread from house to house. When the people built their city again, they made a rule: new houses must be made of brick and stone.

Why does it work? Different **materials** are good at different jobs. Straw is light and keeps out the cold, but it blows away. Wood is strong and easy to cut, but it can burn and rot. **Bricks** and stone are heavy and hard. Wind cannot blow them away, and fire cannot burn them.

How do builders use it? Builders choose the right material for each part. They use stone or concrete for the bottom, wood or steel for the frame, glass for windows, and shingles on the roof to keep out the rain. A good builder thinks about wind, rain and fire before choosing.

PICTURE STUDY



The Little Street, Johannes Vermeer, About 1658 · Oil on canvas · Rijksmuseum, Amsterdam

Image: [Wikimedia Commons](#), public domain

Johannes Vermeer painted this quiet street in his hometown of Delft, in the Netherlands. The houses are made of red brick. Some of them were already old when he painted them.

Look closely

- Find the bricks. Can you see the lines of white mortar between them?
- Find a place where the white paint has worn off the bricks.
- Find the windows. What are they made of?
- Find the people. What is each one doing?
- Find the roof. What shape is it?

Talk about it

1. Why do you think the people of Delft built with brick?
2. Do you think these houses would stand in a big wind? Why?

Safety first. A grown-up runs the fan or hair dryer. Use only the cool setting on a hair dryer, and keep fingers and hair away from the fan.

BUILD

The Big Bad Fan Test

You will build three little houses the same size, one of paper straws or paper, one of craft sticks and one of blocks. A fan will be the wolf. Which house will stand?

You will need

- Paper drinking straws or strips of paper (the “straw” house)
- Craft sticks and tape (the “stick” house)
- Wooden blocks or LEGO DUPLO bricks (the “brick” house)
- A box fan or a hair dryer on cool
- A tape measure
- Engineer’s notebook

Steps

1. Build three small houses about the same size: as tall as your hand. Use tape to hold the straw and stick houses together.
2. **Guess.** Which house will stand when the wolf blows? Draw a star by it.
3. Put the first house on the floor. A grown-up sets the fan one big step away and turns it on **low**. Does it stand? Then try **medium** and **high**.
4. Test the other two houses the same way.
5. **Fair test.** The fan must be the same distance away and on the same settings for each house. Only the material changes.
6. Make a chart with three rows. Color a box for each fan speed each house stood up to.
7. **Make it better.** Choose the weakest house. Change one thing to make it stand: a wider base, more tape, or a heavy book inside. Test it again.

Tips

- Use the same amount of tape on the straw and stick houses.
- Measure the distance with the tape measure so it stays the same.

Check your work

- ☐ I can tell which material made the strongest house.
- ☐ I can tell one way I made the weakest house better.

ENGINEER'S NOTEBOOK

1. Draw your three houses. Draw a big wind arrow and show which ones stood and which ones fell.
2. Draw your own house and color what it is made of.

From history. After the Great Fire of London, Sir Christopher Wren designed more than fifty new churches for the city, including St Paul's Cathedral with its great dome. They were built of stone.

COMMON MISTAKES

- Moving the fan closer for one house. Keep it the same distance every time.
- Thinking heavy is always best. Builders also need materials that are easy to carry and cut, so they use each one where it is best.

Make it a game • Three Little Houses. Make three little houses from a pillow, a blanket and a tower of blocks, with a toy person inside each. Take a big breath and be the wind. Blow on each house, and say which one stays up. Say what each house is made of. Tell your parent which material you would pick, and why.

3.2 TRIANGLES ARE STRONG

OBJECTIVES

- Build a square and a triangle from straws and push on them.
- Show that a triangle keeps its shape and a square squashes.
- Find triangles in the Eiffel Tower and in bridges and roofs.

Warm-up. Play “I spy a triangle” around the house and outside. Look at the roof, a swing set, a ladder leaning on a wall, a bike frame, a clothes hanger. How many triangles can you find?

WATCH

Let's Build a TOWER! | Let's Find Out | Science Experiments for Kids | RTÉjr

RTÉ KIDSjr · 2:10

<https://www.youtube.com/watch?v=guiPKY9PING>

WHEN TO WATCH

Before the build. Watch the children test cubes and triangles made of sticks and putty.

BACKUP VIDEO

Paper Bridge Challenge | Science of Strong Shapes

Science Lab ANU · 2:45

<https://www.youtube.com/watch?v=gdQO3mIGJA8>

For a grown-up, or with the child: a clear demonstration with a square and a triangle frame.

KEY TERMS

triangle

A shape with three straight sides and three corners.

square

A shape with four equal sides and four corners.

brace

A piece added across a shape to keep it from squashing.

CORE IDEAS

Long ago. About 135 years ago, a man named Gustave Eiffel built a tower in Paris, France. It was taller than any building in the world. It was made of more than 18,000 iron pieces held together with millions of rivets. Look closely at the Eiffel Tower, and you will see triangles everywhere!

Why does it work? Push on the corner of a square made of sticks. It leans over into a squashed shape. Now push on a **triangle**. It stays a triangle! Its three sides hold each other in place. That is why the triangle is the builder's strongest shape.

How do builders use it? When builders want a square frame to stay square, they add a stick from one corner to the other. This is called a **brace**. It turns one square into two triangles. You can see braces in roofs, bridges, towers, cranes and even bicycle frames.

PICTURE STUDY



The Eiffel Tower Under Construction, Louis-Émile Durandelle, November 23, 1888 · Photograph · Musée d'Orsay, Paris

Image: [Wikimedia Commons](#), public domain

This photograph was taken while the Eiffel Tower was being built. The bottom is done, and the workers are building the middle. It is not yet half as tall as it will be.

Look closely

- Find the four big legs. Are they close together or spread wide?
- Look closely at the iron. Find the triangles.
- Find the cranes at the top. What are they lifting?
- Find the arches between the legs.

Talk about it

1. Why do you think the legs are so far apart at the bottom?
2. Why did Eiffel use thin iron pieces in triangles instead of solid walls?

BUILD

Squares, Triangles and a Straw Tower

You will make a square and a triangle from straws and push on them. Then you will brace the square and build a tower of triangles.

You will need

- Plastic or paper drinking straws
- Pipe cleaners cut into short pieces, or tape
- Scissors (for the grown-up)
- A tape measure
- A sheet of paper to fan as “wind”
- Engineer’s notebook

Steps

1. Join four straws at the corners with pipe cleaners pushed into the ends to make a square. Join three straws to make a triangle.
2. **Guess.** Which one will squash when you push on a corner?
3. Push gently on one corner of the square. What happens? Now push the triangle. Write or draw what happened.
4. Add one more straw across the square, corner to corner. Push again. Did the brace help?
5. Build a tower from triangles: make a triangle on the table, then stand three straws up from its corners and join them at the top like a tent. Add more layers if you can.
6. Measure your tower with the tape measure. Give it a wind test with the paper fan.
7. **Make it better.** Add more braces where the tower wobbles. Measure and test again.

Tips

- Bend the pipe cleaner pieces into a V shape to make good corners.
- Wide at the bottom, narrow at the top, just like Lesson 1.4.

Check your work

- ☐ I can show that a triangle keeps its shape.
- ☐ I can add a brace to make a square strong.

ENGINEER'S NOTEBOOK

1. Draw your square before and after you pushed it. Then draw the square with a brace.
2. Draw the Eiffel Tower and color in three triangles you can find.

From history. The Eiffel Tower was built for a great world's fair in Paris in 1889. Some people at first thought it was ugly, but it soon became the best-loved sight in France. It was the tallest structure in the world for about forty years.

COMMON MISTAKES

- Pushing so hard that the straw bends. A gentle push shows the shape change.
- Thinking a square made of thicker sticks will not squash. Without a brace, any square frame can lean over.

Make it a game • Shape Squish Test. Build a square and a triangle from craft sticks or straws and tape. Press gently on the corner of each. Which one squishes? Say Triangle stays strong, in your best announcer voice. Then hunt for triangles in the house, like a roof, a sign or a ladder, and count how many you find in one minute.

3.3 THE TALL CUP TOWER

OBJECTIVES

- Tell how the Empire State Building was built very fast and very tall.
- Build a tall tower from paper cups and cards, and measure it.
- Change one thing and try to build it taller.

Warm-up. Look out the window or at a picture of a big city. Which is the tallest building you have ever seen? How do you think workers get the steel up so high? Stack five cups in a single column, then in a pyramid. Which stands better?

WATCH

How are skyscrapers built? Cool facts! Skyscrapers explained with LEGO bricks | Activities for home

LEGO • 9:24

<https://www.youtube.com/watch?v=ewNkuacMtkw>

WHEN TO WATCH

In two parts if your child is restless: the first half before the build, the rest during a snack.

BACKUP VIDEO

How tall is the Empire State Building?

Jared Owen • 4:26

<https://www.youtube.com/watch?v=PDL0ImZjeQc>

After the story, to see the Empire State Building drawn in 3D.

KEY TERMS

skyscraper

A very tall building with many floors.

floor

One level of a building. A skyscraper has floors stacked one on top of another.

frame

The strong steel bones inside a building that holds it up. In a skyscraper it is made of steel.

CORE IDEAS

Long ago. About 95 years ago, workers in New York City built the Empire State Building. It has 102 **floors**. They built it in just over one year! Sometimes they added four floors in one week. For about forty years it was the tallest building in the world.

How did they do it? First they dug down to solid rock and built a strong foundation. Then they bolted and riveted a steel **frame**, like a giant jungle gym. Trucks brought steel beams every day, and cranes lifted them up. Workers called ironworkers walked on the beams high in the sky to join them together.

Why does it work? Each floor sits on the one below. The frame carries the weight of every floor down to the ground. A **skyscraper** is wider at the bottom and steps in near the top, so it stays steady.

Try it. When you build your cup tower, a flat card between each layer acts like a floor. It spreads the weight and lets you build higher.

PICTURE STUDY



A Workman on the Empire State Building, Lewis Hine, 1930–1931 · Photograph · U.S. National Archives

Image: [Wikimedia Commons](#), public domain

Lewis Hine climbed up the Empire State Building with the workers to take their pictures. He wanted people to see how brave and skillful they were.

Look closely

- Find the steel beams. Are they straight or bent?
- Find the bolts or rivets that hold the beams together.
- Find the city far below. Can you find the pointed top of the Chrysler Building?
- What is the worker holding or doing?

Talk about it

1. Why does a tall building need a steel frame?
2. What would you need to be a good ironworker?

BUILD

The Tallest Cup Tower

You will build a tower from paper cups, first without floors and then with card “floors” between the layers. You will measure each tower and try to beat your best.

You will need

- About 30 paper or plastic cups, all the same
- Index cards or squares of card stock (the floors)
- A tape measure
- Engineer’s notebook

Steps

1. **Tower 1.** Build the tallest tower you can in five minutes with cups only. Measure it. Count the cups.
2. **Guess.** Will cards between the layers help you build higher?
3. **Tower 2.** Build again, but lay a card on top of each layer of cups before you start the next layer. Measure it and count the cups.
4. **Fair test.** Use the same cups and the same time for each tower. Only the floors change.
5. Write both heights in the notebook. Color a bar for each.
6. **Make it better.** Try a wider bottom layer, or turn some cups upside down. Can you beat your best height?

Tips

- Set each cup gently and straight.
- If you run out of cups, see how tall you can build with the same 20 cups.

Check your work

- ☐ I can tell how tall my best tower was.
- ☐ I can tell what the card floors did.

ENGINEER’S NOTEBOOK

1. Draw your two towers side by side and write how tall each was.

2. Draw a skyscraper with a steel frame inside, like a jungle gym.

From history. The Empire State Building opened on May 1, 1931. Lewis Hine took hundreds of photographs of its construction, some of them while hanging out over the edge in a basket held by a crane.

COMMON MISTAKES

- Building fast. Careful, straight stacking goes higher.
- Thinking only height matters. A tall tower must also stand steady.

Make it a game • Tallest Cup Tower. Stack paper cups into a tower and set a one-minute timer. Count aloud how many cups are in the tower when time is up, then lay a string next to it to measure how tall it is. Say the word floor for every cup layer. Try again, and see if you can beat your own score.

3.4 THE WISE MAN BUILT HIS HOUSE UPON THE ROCK

OBJECTIVES

- Tell Jesus' story of the wise and foolish builders.
- Test a house on sand and a house on rock with water.
- Tell why every building needs a strong foundation.

Warm-up. Stand on a pillow, then on the floor. Which is steadier? Then go outside or to a sandbox and press your hand into the sand, then onto a rock or the sidewalk. Which one moves?

WATCH

Object Lesson: Build on the Rock or Sand?

Kids' Bible History · 2:36

https://www.youtube.com/watch?v=4DhbJWem_Zg

WHEN TO WATCH

After reading Matthew 7:24-27. It shows the same test you will do.

Note: A small children's ministry channel, chosen because it shows the sand-and-rock test simply and well.

KEY TERMS

foundation

The strong bottom of a building that rests on the ground and holds it up.

rock

Hard stone in the ground that does not wash away.

lighthouse

A tower with a bright light that warns ships away from rocks.

CORE IDEAS

Jesus' story. Jesus told about two builders. The wise man built his house upon the **rock**. The rain came down, the floods came up, and the wind blew, but the house did not fall. The foolish man built on the sand. When the storm came, his house fell flat. Jesus said that people who hear His words and do them are like the wise man.

Long ago. About 265 years ago, an engineer named John Smeaton was asked to build a **lighthouse** on a rock out in the sea near England. Storms and fire had already ruined two lighthouses there. Smeaton made his lighthouse of stone. He cut each stone to lock into the next one like puzzle pieces, and he locked the bottom stones into the rock itself. He made it wide at the bottom, like the trunk of an oak tree. His lighthouse stood strong for more than one hundred years.

Why does it work? Sand moves. Water washes it away, and a heavy house sinks into it. Rock stays put. A house on rock cannot slide or sink.

How do builders use it? Before builders put up a house, they dig down and make a **foundation** of concrete. For very big buildings they dig all the way down to rock, or drive long posts deep into the ground. The part you cannot see holds up the part you can.

PICTURE STUDY



The Eddystone Lighthouse in a Storm, Unknown artist, for The Penny Magazine, 1832 · Wood engraving ·
The Penny Magazine, London
Image: [Wikimedia Commons](#), public domain

This picture shows John Smeaton's lighthouse on the Eddystone rocks in a storm. Huge waves crash against it, but it stands firm on its rock.

Look closely

- Find the rock the lighthouse stands on.
- Find the waves. How high do they splash?
- Look at the shape of the lighthouse. Where is it widest?
- Find the light room at the top.

Talk about it

1. Why did Smeaton build his lighthouse on rock and not on sand?
2. How is the lighthouse like the wise man's house?

Safety first. Do the water test outdoors or in a large tub or baking pan, and wipe up spills so no one slips.

BUILD

Sand or Rock? The Flood Test

You will build two little houses, one on a pile of sand and one on a flat rock or brick. Then you will make it “rain” and see which house stands.

You will need

- A large baking pan or plastic tub
- Sand (or loose soil)
- A flat rock, a brick or a piece of wood (the rock)
- Blocks or LEGO DUPLO bricks for two small houses
- A watering can or a cup of water
- Engineer’s notebook

Steps

1. At one end of the pan, make a hill of sand. At the other end, set the flat rock.
2. Build two houses that are the same: the same blocks and the same size. Put one on the sand and one on the rock.
3. **Guess.** Which house will stand in the flood?
4. Pour one cup of water slowly over each house, the same way. Count to ten. Did it stand? Pour a second cup and a third.
5. **Fair test.** Same houses, same water, poured the same way. Only the foundation changes.
6. Draw what happened to each house after each cup.
7. **Make it better.** Can you make the sand house stand? Try pressing a flat piece of wood into the sand first as a foundation, or digging down to the bottom of the pan. Test again.

Tips

- Pour slowly like rain, then faster like a flood.
- Count cups out loud so your test is fair.

Check your work

- ☐ I can tell Jesus’ story of the two builders.

- ☐ I can tell why the house on the rock stood.

ENGINEER'S NOTEBOOK

1. Draw the two houses after the flood. Write “sand” and “rock” under them.
2. Draw a lighthouse on a rock in the sea, with a bright light at the top.

From history. In the 1870s, the sea began to wear away the rock under Smeaton's lighthouse, though the tower itself was still sound. A new lighthouse was built on a nearby rock, and the top of Smeaton's tower was taken apart and built again on land in Plymouth, where people can still climb it today.

COMMON MISTAKES

- Pouring more water on one house than the other.
- Thinking the house walls are what matter most. The foundation underneath matters just as much.

Make it a game · Sand or Rock Story. Tell the story of the wise and foolish builders using two blocks and a tray, one with sand and one with a flat rock. Your parent pretends to be the rain and wind. Which house stood? You must say the word foundation when the house stays standing. Then switch jobs and tell it again.

Scripture. “Therefore whosoever heareth these sayings of mine, and doeth them, I will liken him unto a wise man, which built his house upon a rock: And the rain descended, and the floods came, and the winds blew, and beat upon that house; and it fell not: for it was founded upon a rock.” (Matthew 7:24-25, KJV)

A good builder digs down to rock. A wise child builds his life on Jesus' words.

UNIT 3

HOUSES AND TOWERS

People need safe homes, and towns need tall buildings. In this unit your child will test building materials the way the three little pigs should have, find out why triangles are the strongest shape, build a tall tower of paper cups, and learn from Jesus' story of the wise man who built his house upon the rock. Along the way we meet real builders: the people who rebuilt London in brick, Gustave Eiffel and his iron tower, the workers on the Empire State Building, and John Smeaton, who built a lighthouse on a rock in the sea.

Each build is a test: a wind test with a fan, a push test on a shape, a height test with a tape measure, and a water test on sand and rock. Your child will guess, test, count and try again. "Through wisdom is an house builded," says Proverbs 24:3.

PREREQUISITES

- Knows that a wide base helps a tower stand (Lesson 1.4)
- Can count to 20 with help
- Knows the shapes circle, square and triangle

MASTERY CHECKLIST

- ☐ I can tell why builders choose strong materials like brick and stone.
- ☐ I can show that a triangle does not squash but a square does.
- ☐ I can build a tall cup tower and measure it.
- ☐ I can tell why a house needs a strong foundation, like the wise man's house on the rock.

OPTIONAL KITS FOR THIS UNIT

- **Magna-Tiles**: Flat magnetic squares and triangles. Children can feel for themselves that a box of triangles is stiffer than a box of squares. Fits Lessons 3.2 and 3.3.
- **LEGO DUPLO**: Large bricks for small hands, good for the "brick house" in Lesson 3.1 and for towers. Many families already have some.

Not required. Every project in this unit can be built with household materials. School Launch has no ties to these companies.

LESSONS IN THIS UNIT

3.1 Straw, Sticks or Bricks?	2 sessions of 30 minutes
3.2 Triangles Are Strong	2 sessions of 30 minutes
3.3 The Tall Cup Tower	2 sessions of 30 minutes
3.4 The Wise Man Built His House upon the Rock	2 sessions of 30 minutes

UNIT 3 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. Name two materials that houses are made of. Which would stand best in a big wind?
2. Make a square and a triangle from straws or craft sticks. Push on each one. What happens?
3. How can you make a square frame strong?
4. Build a cup tower. What helps it go higher and stay up?
5. Tell the story of the wise and foolish builders. Why did the wise man's house stand?
6. What is a foundation?

ANSWER KEY

1. Any two of wood, brick, stone, concrete, glass, straw. Brick or stone stands best.
2. The square leans over and squashes; the triangle keeps its shape.
3. Add a brace from corner to corner, making two triangles.
4. A wide bottom, careful straight stacking, and card floors between layers.
5. He built on the rock; rock does not wash away like sand.
6. The strong bottom of a building that holds it up.

PORTFOLIO PIECE: A HOUSE THAT STANDS

Build a small house or tower from the material you think is best. Give it a strong foundation, use triangles or braces to make it stiff, and test it with the fan and with a little water. Show your family, tell them why it stood, and keep a photo and your notebook page in your portfolio folder.

LOOK FOR	WHAT IT MEANS
Chose a strong material	Picked a material and could tell why.
Used triangles or braces	Added at least one triangle or brace to make the frame stiff.
Tested it	Did the wind and water tests the same way each time.
Tried again	Fixed a weak spot after the first test and tested again.

UNIT 4

MAGNETS AND BATTERIES

Magnets pull without touching, and batteries make a flashlight shine. In this unit your child will test how strong a magnet is, sort things into “magnet pulls it” and “magnet does not,” build a real battery-and-bulb circuit with a grown-up’s help, and learn the most important electricity rule of all: never touch the outlets in the wall.

We meet William Gilbert, who studied magnets with careful tests more than four hundred years ago, Alessandro Volta, who made the first battery, and Thomas Edison, who brought electric light into homes. The builds use only small batteries (AA, C or D cells), which are safe for children to handle with a grown-up nearby.

PREREQUISITES

- Can sort things into two groups
- Can count to 20
- Knows what a push and a pull are (Unit 1)

MASTERY CHECKLIST

- ☐ I can show a magnet pulling and pushing.
- ☐ I can test things and sort them into “magnet pulls it” and “magnet does not.”
- ☐ I can make a bulb light with a battery and wires, and tell why it needs a full loop.
- ☐ I know never to touch or poke anything into an outlet in the wall.

OPTIONAL KITS FOR THIS UNIT

- **Snap Circuits:** Electronics pieces that snap together on a plastic board, powered by AA batteries, with no wires to strip. The Snap Circuits Beginner set is made for ages 5 and up; the larger sets are for older children. Fits Lessons 4.3 and 4.4, with a grown-up.

Not required. Every project in this unit can be built with household materials. School Launch has no ties to these companies.

LESSONS IN THIS UNIT

4.1 Magnets Pull

2 sessions of 30 minutes

4.2 What Do Magnets Pick Up?

2 sessions of 30 minutes

UNIT 4 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. Show me a magnet pulling a paper clip. Can it pull through a sheet of paper?
2. Here are a nail, a penny, a crayon and a paper clip. Which will the magnet pick up? Test them.
3. Hold two magnets close together. Show me them pulling together and pushing apart.
4. Make the bulb light with the battery and wires. Why does it go out when you unclip a wire?
5. What is the rule about outlets in the wall?
6. Who made the first battery?

ANSWER KEY

1. Yes; a magnet can pull through paper without touching the clip.
2. The nail and the paper clip (iron or steel). Not the penny or the crayon.
3. The child turns one magnet around to change from attract to repel.
4. The loop (circuit) is broken; electricity must go all the way around.
5. Never touch them or poke anything into them; outlet electricity is strong and dangerous.
6. Alessandro Volta.

PORTFOLIO PIECE: MY LIGHT WITH A SWITCH

Build your battery light with a clothespin switch, and set a magnet beside it with a chain of paper clips. Show a family member how to turn the light on and off, explain why it needs a full loop, and tell them the outlet rule. Keep a photo and your notebook pages in your portfolio folder.

LOOK FOR	WHAT IT MEANS
It works	The light turns on and off with the switch.
Can explain	Told why the light needs a full loop.
Safe	Used only batteries and said the outlet rule.
Tested and fixed	Tested the switch many times and fixed it if it did not work every time.

4.1 MAGNETS PULL

OBJECTIVES

- Show that a magnet pulls some things without touching them.
- Show that two magnets can pull together or push apart.
- Measure a magnet's strength by counting paper clips.

Warm-up. Hold a refrigerator magnet a little way from the fridge door and slowly bring it closer. When do you feel the pull? Then try to stick the magnet to a wooden door, a window and a metal pan. Where does it stick?

WATCH

Fun with Magnets!

SciShow Kids · 5:01

<https://www.youtube.com/watch?v=s236Q1nuWXg>

WHEN TO WATCH

After the story. Pause when Jessi tries each new thing and guess first.

KEY TERMS

magnet

A piece of metal or stone that pulls on iron and steel.

attract

To pull toward. A magnet attracts a paper clip.

repel

To push away. Two magnets turned the wrong way repel each other.

compass

A tool with a magnet needle that always points north.

CORE IDEAS

Long ago. Long ago people found a strange dark rock. It pulled little bits of iron to itself! They called it a lodestone. Later, sailors hung a thin magnet needle so it could turn. It always pointed north. That was the first **compass**, and it helped ships find their way.

How they figured it out. More than four hundred years ago, an English doctor named William Gilbert wanted to know how magnets really work. He did not just guess. He

tested magnets over and over and wrote down what happened. He found that the whole earth is like a giant magnet. That is why a compass points north.

Why does it work? A **magnet** pulls, or **attracts**, things made of iron and steel. It can pull without touching, even through paper! Every magnet has two ends, called poles. Two magnets can pull together. Turn one around, and they push apart, or **repel**.

How do builders use it? Magnets are hidden all around us. They hold the refrigerator door shut. They help speakers make sound. Big magnets in factories lift heavy steel. God made the magnet's pull, and engineers put it to work.

PICTURE STUDY



A Smithy, from On the Magnet, From William Gilbert's De Magnete, 1600 · Woodcut · De Magnete (London, 1600)

Image: [Wikimedia Commons](#), public domain

This picture is from William Gilbert's book about magnets, printed in 1600. It shows a blacksmith hammering a bar of iron. Gilbert found that an iron bar hammered while it points north and south becomes a little magnet.

Look closely

- Find the blacksmith and his hammer.
- Find the anvil, the heavy block he hammers on.
- Find the letters on each side. They show north and south.
- Find the window and the tools in the workshop.

Talk about it

1. Why do you think Gilbert put this picture in his book?
2. How could you test whether the iron bar became a magnet?

Safety first. Use only large magnets. Very small magnets and magnet balls are dangerous if swallowed; keep them away from little brothers and sisters.

BUILD

How Strong Is My Magnet?

You will measure how strong a magnet is in two ways: by how many paper clips it can hold in a chain, and by how many sheets of paper it can pull through.

You will need

- Two or three different magnets (fridge magnet, bar or horseshoe magnet)
- A box of steel paper clips
- A stack of printer paper
- Engineer's notebook

Steps

1. **Guess.** Which magnet do you think is strongest? Draw a star by it.
2. **Chain test.** Touch a paper clip to the end of a magnet. Touch another clip to the bottom of that one. Keep adding clips, one at a time, until the chain will not hold another. Count the clips.
3. Do the chain test with each magnet. A grown-up writes the numbers.
4. **Paper test.** Put a paper clip on the table. Lay one sheet of paper over it. Can the magnet pull the clip up through the paper? Add one sheet at a time and count how many sheets it can pull through.
5. **Fair test.** Use the same kind of paper clips and the same paper for each magnet.
6. **Push and pull.** Hold two magnets close together. Turn one around. Feel them pull together and then push apart.
7. **Make it better.** Stack two magnets together and do the chain test again. Is a double magnet stronger?

Tips

- Hold the magnet still while you add clips.
- If your magnets will not stack, try turning one over.

Check your work

- ☐ I can show a magnet attract and repel.

- I can tell which of my magnets was strongest, and show my numbers.

ENGINEER'S NOTEBOOK

1. Draw each magnet and its paper clip chain. Write how many clips each one held.
2. Draw two magnets pulling together, and two magnets pushing apart, with arrows.

From history. William Gilbert was a doctor to Queen Elizabeth I. His book *De Magnete* (“On the Magnet”) was one of the first science books built on careful experiments instead of old stories.

COMMON MISTAKES

- Thinking a magnet pulls all metal. It pulls iron and steel, but not aluminum foil, copper or most coins.
- Thinking the biggest magnet is always the strongest. Test it!

Make it a game • Magnet Pull Detectives. Take a magnet on a quick detective hunt. Find three things in the house that it pulls, and one thing that it does not. Say attract when it pulls. Then hold two magnets close together, and tell your parent whether they pull together or push apart. Say the word repel when they push away.

4.2 WHAT DO MAGNETS PICK UP?

OBJECTIVES

- Guess whether a magnet will pick up each thing, then test it.
- Sort things into two groups and make a chart.
- Tell how a giant magnet helps sort steel in a scrap yard.

Warm-up. Gather a basket of twelve small things from around the house: a spoon, a penny, a key, a crayon, foil, a paper clip, a bottle cap, a button, a nail, a coin, a toy car and a sock. Hold each one up. Does it look like metal?

WATCH

Is it magnetic or non-magnetic?

Next Generation Science • 3:28

<https://www.youtube.com/watch?v=yorUUI5oCIE>

WHEN TO WATCH

Before the build. Pause before each object is tested and let your child guess.

KEY TERMS

magnetic

Pulled by a magnet. Iron and steel things are magnetic.

sort

To put things into groups that are alike.

steel

A strong metal made mostly of iron. Nails, paper clips and many tools are steel.

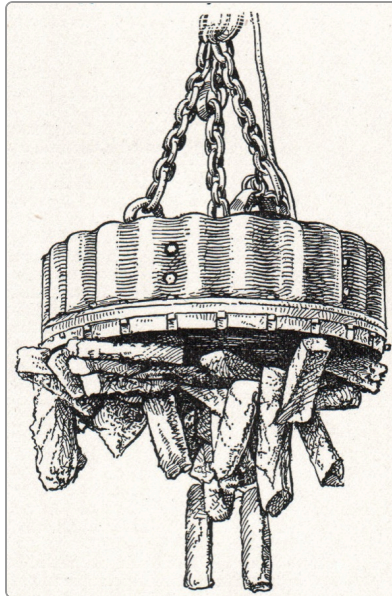
CORE IDEAS

Why does it work? A magnet does not pull everything. It does not pull wood, plastic, glass or cloth. It does not even pull every metal! It pulls things made of iron and steel. We call those things **magnetic**.

Surprises. A penny is metal, but a magnet will not pick it up. Aluminum foil is metal, but it will not stick either. Some spoons stick and some do not. That is why scientists test instead of just guessing.

How do builders use it? At a scrap yard, a crane holds a giant magnet. It swings over a big pile of old metal. The magnet picks up the iron and steel and leaves the other metals behind. At recycling centers, magnets pull steel cans out of the mixed bins. Then the steel can be melted and used again.

PICTURE STUDY



A Magnet Lifting Pig Iron, Unknown artist, for *The New Student's Reference Work*, 1914 · Drawing · The New Student's Reference Work (Chicago, 1914)

Image: [Wikimedia Commons](#), public domain

This drawing is more than one hundred years old. A huge round magnet hangs from a crane. It is lifting heavy bars of iron called pig iron, all at once, with no hooks or ropes.

Look closely

- Find the round magnet.
- Find the iron bars stuck to the bottom of the magnet.
- Find the chain that holds the magnet up.
- How many bars can you count?

Talk about it

1. Why is a magnet a quick way to lift iron?
2. Would this magnet pick up a pile of wood? Why not?

BUILD

The Magnet Sorting Test

You will guess which things a magnet will pick up, then test each one and sort them on a chart.

You will need

- A strong magnet
- A basket of about twelve small, safe things (see the warm-up)
- Two paper plates labeled with a picture of a magnet and a magnet with an X
- Engineer's notebook

Steps

1. A grown-up draws a chart with three columns: the thing, "my guess," and "what happened."
2. **Guess.** For each thing, guess yes or no. Draw a smile for yes and an X for no in the guess column.
3. **Test.** Touch the magnet to each thing. Put it on the "yes" plate or the "no" plate.
4. Mark what happened on the chart.
5. Count: how many guesses were right? How many surprised you?
6. **Fair test.** Use the same magnet for everything, and touch it right to the thing each time.
7. **Make it better.** Hunt around the house for five more things to test. Which room has the most magnetic things?

Tips

- Test both ends of a thing like a pencil: the metal part and the wood part.
- Keep magnets away from phones, tablets and computers.

Check your work

- ☐ I can sort things into magnetic and not magnetic.
- ☐ I can tell one thing that surprised me.

ENGINEER'S NOTEBOOK

1. Draw the two plates and the things on each one.
2. Draw a crane with a giant magnet lifting steel.

From history. Big lifting magnets are electromagnets. They are magnets only when electricity flows through them, so the crane operator can drop the load by turning the electricity off. You will make an electromagnet in a later grade.

COMMON MISTAKES

- Thinking all shiny things are magnetic. Test them.
- Forgetting to guess before testing. The guess is part of the science.

Make it a game • Yes or No Magnet Guess. Collect ten small things from around the house, like a spoon, a button, a paper clip and a crayon. Hold up each one and guess out loud: yes or no, will the magnet grab it? Then test it. Sort them into a yes pile and a no pile. Count which pile is bigger.

4.3 A BATTERY LIGHTS A FLASHLIGHT

OBJECTIVES

- Find the battery, bulb and switch in a flashlight.
- Light a bulb with a battery and wires, with a grown-up's help.
- Show that the bulb lights only when the loop is complete.

Warm-up. With a grown-up, unscrew a flashlight and look inside. Find the batteries, the little bulb or light, and the switch. Put it back together and turn it on and off. Where does the light's power come from?

WATCH

The Power of Circuits! | Technology for Kids | SciShow Kids

SciShow Kids · 4:42

<https://www.youtube.com/watch?v=HOFp8bHTN30>

WHEN TO WATCH

After the story, before the build.

Note: The makers note that a few animations show the electricity flowing the wrong way around the loop. That detail does not matter at this age; the big idea, a complete loop, is right.

BACKUP VIDEO

How Batteries Work for Kids || What is a Battery? || Science for Kids

Socratica Kids · 6:17

<https://www.youtube.com/watch?v=RWWLfUliMAw>

Later in the week. A puppet show about the many sizes of batteries.

KEY TERMS

battery

A small can that stores electricity to use later.

circuit

A full loop that electricity travels around: from the battery, through the bulb and back.

switch

A part that opens or closes the loop to turn something off or on.

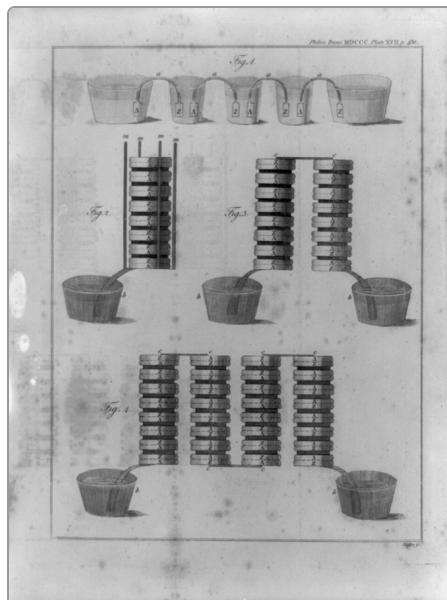
CORE IDEAS

Long ago. More than two hundred years ago, in Italy, Alessandro Volta stacked up little round plates of two kinds of metal. Between them he put pieces of cardboard soaked in salty water. The stack made electricity, steady and strong! It was the first **battery**.

Why does it work? Electricity must travel in a full loop. It goes out one end of the battery, through a wire to the bulb, through the bulb, and back to the other end of the battery. That loop is called a **circuit**. If there is a gap anywhere in the loop, the light goes out.

How do builders use it? A flashlight is a circuit inside a tube. When you push the **switch**, it closes the gap, and the light shines. When you push it again, it opens the gap, and the light goes out. Engineers put batteries in flashlights, toys, clocks and phones so we can carry electricity with us.

PICTURE STUDY



Volta's First Battery, James Basire, engraver, after Alessandro Volta, 1800 · Engraving · Philosophical Transactions of the Royal Society, London; Library of Congress

Image: [Wikimedia Commons](#), public domain

Alessandro Volta sent these drawings to scientists in London in the year 1800 to show his new invention. It was printed so that others could build it and test it too.

Look closely

- Find the tall stacks of round plates. That is Volta's pile.
- Count the plates in one stack.
- Find the row of cups. Volta made another kind of battery with cups of salty water.
- Find the bent metal strips that join the cups.

Talk about it

1. Why do you think Volta drew his battery so carefully?
2. How is Volta's pile like the batteries in your flashlight?

Safety first. Use only AA, C or D batteries. Never connect a wire straight from one end of a battery to the other without the bulb; it gets hot and wastes the battery. Keep coin and button batteries away from small children, because they are very dangerous if swallowed.

BUILD

Light the Bulb

With a grown-up, you will make a bulb light up with a battery and two wires. Then you will make a gap in the loop and test what can close it.

You will need

- One D-cell battery in a battery holder (or two AA cells in a holder)
- A small flashlight bulb in a bulb holder, made for the same voltage as the batteries
- Two or three alligator clip wires
- Test things: a strip of aluminum foil, a paper clip, a piece of string, a craft stick, a coin
- Engineer's notebook

Steps

1. A grown-up clips one wire from the battery holder to one side of the bulb holder.
2. **Guess.** Will the bulb light now? Look.
3. Clip a second wire from the other side of the bulb holder back to the battery holder. Did it light? You made a full loop!
4. Unclip one end. The light goes out. Clip it back. It lights. You are the switch!
5. **Gap test.** Unclip the second wire from the bulb and add a third wire, so there are two loose clips. Touch both clips to each test thing: foil, paper clip, string, craft stick, coin.
6. Mark each one on a chart: did the bulb light, yes or no?
7. **Fair test.** Use the same battery, bulb and wires for each thing. Only the thing in the gap changes.
8. **Make it better.** Make a switch from a clothespin with foil on its two jaws. Pinch it closed to turn on the light.

Tips

- If the bulb does not light, check that the bulb is screwed in tight and the clips are on the metal parts.
- Things that let electricity through are usually metal.

Check your work

- ☐ I can make a bulb light with a battery and wires.
- ☐ I can tell why a gap makes the light go out.

ENGINEER'S NOTEBOOK

1. Draw your circuit: battery, wires and glowing bulb. Trace the loop with your finger, then with a crayon.
2. Draw the things you put in the gap, with a light bulb by the ones that worked.

From history. Volta's battery was a stack, or "pile," of metal discs, so the French called a battery a *pile*, and they still do. The word "volt," which you see printed on every battery, is named after Volta.

COMMON MISTAKES

- Leaving a clip off. Every part of the loop must be joined.
- Using a bulb made for a much bigger battery. It will not glow brightly.

Make it a game • Flashlight Parts Hunt. With a grown-up, take apart a flashlight and lay out the pieces. Point to the battery, the bulb and the switch, and say each name three times in a whisper, a boom and a squeak. Then close your eyes while your parent hides one piece. Open your eyes and say which one is missing.

Scripture. "Neither do men light a candle, and put it under a bushel, but on a candlestick; and it giveth light unto all that are in the house." (Matthew 5:15, KJV)

A light is made to be seen. Jesus wants us to shine like a light, too, by doing good for others.

4.4 NEVER TOUCH THE OUTLETS

OBJECTIVES

- Tell why outlets in the wall are dangerous and batteries are safe for our builds.
- Find the outlets, cords and switches in your home and count them.
- Make a switch for your battery light.

Warm-up. Turn on a lamp with its switch. Where does that electricity come from? Look at the cord going into the outlet in the wall. Talk about it: Is this the same kind of electricity as the little battery? Which one is much stronger?

WATCH

Kids Safety

OG&E · 4:26

<https://www.youtube.com/watch?v=Pr9YntO7V1U>

WHEN TO WATCH

After the story. After each tip, have your child repeat the rule in his or her own words.

Note: Made by an electric company for children. It also covers power lines and the green boxes in yards, which we meet again in Unit 5.

BACKUP VIDEO

P.I. Plug's Home Safety Video

Electrical Safety Foundation International · 3:31

https://www.youtube.com/watch?v=Veyv2lFc_Fk

Later in the week, before the safety hunt.

KEY TERMS

outlet

The holes in the wall where cords plug in. Strong, dangerous electricity comes from them.

cord

The covered wire that carries electricity from the outlet to a lamp or machine.

electrician

A trained worker who safely puts in and fixes the wires in a building.

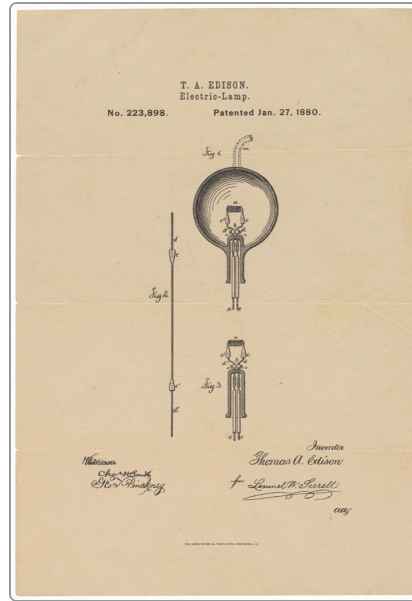
CORE IDEAS

Long ago. Not so long ago, houses had no electric lights. People used candles and oil lamps. Then Thomas Edison and his helpers tested thousands of materials to make a light bulb that would glow for a long time. In 1882 Edison built a power station in New York City. It sent electricity through wires under the streets to light homes and shops.

Why does it matter? The electricity in the **outlets** in the wall is much, much stronger than a battery. It can badly hurt a person. That is why the rule is: **never touch an outlet or poke anything into it.** Never pull a plug out by its **cord**. Keep water away from anything plugged in. Our builds use only small batteries, because they are safe.

How do builders use it? Engineers make electricity safe. The wires are hidden inside the walls. Plugs and cords are covered with rubber or plastic. Special breakers turn off the power if something goes wrong. Only a trained **electrician** opens up the wires in a house.

PICTURE STUDY



Edison's Drawing for an Electric Lamp, Thomas A. Edison, 1880 · Patent drawing · U.S. National Archives

Image: [Wikimedia Commons](#), public domain

Thomas Edison sent this drawing to the U.S. Patent Office to show how his light bulb was made. A patent protects an inventor's idea.

Look closely

- Find the glass bulb.
- Find the thin curly line inside. That is the filament that glows.
- Find the two wires at the bottom. Where do they go?
- Find Edison's name, written on the page.

Talk about it

1. Why does a bulb need two wires?
2. How did electric lights make homes better and safer than candles?

Safety first. This lesson is about safety. Children never touch outlets, plugs, or cords that are plugged in. A grown-up does the counting near outlets, and the child points from a step away. All builds use batteries only.

BUILD

Safety Detective and a Battery Switch

First you will be a safety detective and count the outlets, switches and cords in your home, pointing from a safe distance. Then you will make a switch for the battery light from Lesson 4.3.

You will need

- Engineer's notebook and a pencil
- Your battery, bulb and clip wires from Lesson 4.3
- A clothespin, aluminum foil and tape
- Optional: safety caps for unused outlets (a grown-up puts them in)

Steps

1. A grown-up makes a chart with each room in the house and three columns: outlets, light switches and cords.
2. Walk from room to room. Point to each outlet, switch and cord from a step away, and make a tally mark for each one.
3. **Count.** Which room has the most outlets? Which has the most cords?
4. Look for danger: a cord across a walkway, a plug near a sink, or a crowded outlet. Tell a grown-up.
5. **Battery switch.** Wrap a little foil around the tip of each jaw of a clothespin. Clip one wire to each jaw's foil. Squeeze the clothespin closed: the loop closes and the light turns on.
6. Turn your light on and off ten times. Does it work every time?
7. **Make it better.** If your switch does not work every time, add more foil or press the wires on tighter, and test ten more times.

Tips

- Point, don't touch.
- Count the switch tests with tally marks.

Check your work

- ☐ I can say the outlet rule: never touch it or poke anything into it.

- ☐ I can make a switch that turns my battery light on and off.

ENGINEER'S NOTEBOOK

1. Draw an outlet with a big red X over a finger. Write "Never touch!"
2. Draw your clothespin switch, open and closed. Draw the bulb dark and then glowing.

From history. Edison's Pearl Street Station opened on September 4, 1882. At first it lit about four hundred lamps. Within a few years, power stations were being built in cities all over the country.

COMMON MISTAKES

- Thinking a battery and an outlet are the same. The outlet is far stronger and can hurt you.
- Thinking it is safe to unplug something by yanking the cord. A grown-up pulls the plug itself.

Make it a game • Outlet Safety Detective. Be a safety detective. Walk through one room with your hands behind your back and spot every outlet, cord and switch. Point with your nose or elbow, never your fingers. Your parent tallies the count. Then say the rule out loud: we never touch outlets. Trade jobs and find a different room.

UNIT 4

MAGNETS AND BATTERIES

Magnets pull without touching, and batteries make a flashlight shine. In this unit your child will test how strong a magnet is, sort things into “magnet pulls it” and “magnet does not,” build a real battery-and-bulb circuit with a grown-up’s help, and learn the most important electricity rule of all: never touch the outlets in the wall.

We meet William Gilbert, who studied magnets with careful tests more than four hundred years ago, Alessandro Volta, who made the first battery, and Thomas Edison, who brought electric light into homes. The builds use only small batteries (AA, C or D cells), which are safe for children to handle with a grown-up nearby.

PREREQUISITES

- Can sort things into two groups
- Can count to 20
- Knows what a push and a pull are (Unit 1)

MASTERY CHECKLIST

- ☐ I can show a magnet pulling and pushing.
- ☐ I can test things and sort them into “magnet pulls it” and “magnet does not.”
- ☐ I can make a bulb light with a battery and wires, and tell why it needs a full loop.
- ☐ I know never to touch or poke anything into an outlet in the wall.

OPTIONAL KITS FOR THIS UNIT

- **Snap Circuits:** Electronics pieces that snap together on a plastic board, powered by AA batteries, with no wires to strip. The Snap Circuits Beginner set is made for ages 5 and up; the larger sets are for older children. Fits Lessons 4.3 and 4.4, with a grown-up.

Not required. Every project in this unit can be built with household materials. School Launch has no ties to these companies.

LESSONS IN THIS UNIT

4.1 Magnets Pull

2 sessions of 30 minutes

4.2 What Do Magnets Pick Up?

2 sessions of 30 minutes

UNIT 4 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. Show me a magnet pulling a paper clip. Can it pull through a sheet of paper?
2. Here are a nail, a penny, a crayon and a paper clip. Which will the magnet pick up? Test them.
3. Hold two magnets close together. Show me them pulling together and pushing apart.
4. Make the bulb light with the battery and wires. Why does it go out when you unclip a wire?
5. What is the rule about outlets in the wall?
6. Who made the first battery?

ANSWER KEY

1. Yes; a magnet can pull through paper without touching the clip.
2. The nail and the paper clip (iron or steel). Not the penny or the crayon.
3. The child turns one magnet around to change from attract to repel.
4. The loop (circuit) is broken; electricity must go all the way around.
5. Never touch them or poke anything into them; outlet electricity is strong and dangerous.
6. Alessandro Volta.

PORTFOLIO PIECE: MY LIGHT WITH A SWITCH

Build your battery light with a clothespin switch, and set a magnet beside it with a chain of paper clips. Show a family member how to turn the light on and off, explain why it needs a full loop, and tell them the outlet rule. Keep a photo and your notebook pages in your portfolio folder.

LOOK FOR	WHAT IT MEANS
It works	The light turns on and off with the switch.
Can explain	Told why the light needs a full loop.
Safe	Used only batteries and said the outlet rule.
Tested and fixed	Tested the switch many times and fixed it if it did not work every time.

UNIT 5

WATER AND LIGHTS AT HOME

When you turn on the tap, clean water comes out. When you flip a switch, the light comes on. In this unit your child will find out where tap water comes from, where it goes when it runs down the drain, and how electricity travels along power lines to the house. We meet real engineers: the builders of New York's Croton Aqueduct, Joseph Bazalgette, who built London's great sewers, and the engineers who first sent electricity from Niagara Falls to a faraway city.

Most of all, we say thank you. Water workers, sewer workers and lineworkers keep these hidden systems running day and night, in snow and storms. Their work is a way of loving their neighbors, and ours. The builds test how water pushes and flows and how electricity travels along a long wire, always with batteries only.

PREREQUISITES

- Knows the battery-and-bulb loop (Lesson 4.3)
- Knows the outlet rule (Lesson 4.4)
- Can pour water carefully

MASTERY CHECKLIST

- ☐ I can tell where tap water comes from and how it gets to my house.
- ☐ I can show that water in a high tank pushes harder.
- ☐ I can tell where water goes when it runs down the drain.
- ☐ I can tell how electricity gets from a power plant to my house.
- ☐ I know to stay far away from power lines and to thank the workers who keep them running.

LESSONS IN THIS UNIT

5.1 Where Tap Water Comes From

2 sessions of 30 minutes

5.2 Where the Water Goes

2 sessions of 30 minutes

5.3 Power Lines Bring Electricity

2 sessions of 30 minutes

5.4 Thank You, Workers!

2 sessions of 30 minutes

UNIT 5 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. Where does the water in your tap come from?
2. Why are water towers built up high?
3. Where does the water go when it runs down the drain?
4. Draw how electricity gets from the power plant to your lamp.
5. What do you do if you see a power line on the ground?
6. Name a worker who keeps our water or lights running. What would you say to them?

ANSWER KEY

1. From rain that fills rivers, lakes or wells; it is cleaned at a water plant and carried in pipes to the house.
2. Water up high pushes harder, so it can flow through the pipes into houses.
3. Into sewer pipes, then to a treatment plant where it is cleaned.
4. Power plant, power lines on towers and poles, the box near the house, wires in the walls, the lamp.
5. Stay far away and tell a grown-up right away.
6. A lineworker, water worker or sewer worker; “Thank you.”

PORTFOLIO PIECE: MY TOWN’S WATER AND LIGHTS MAP

On a big sheet of paper, draw a map of your town with a river, a water plant, a water tower, pipes, your house, the sewer, a treatment plant, a power plant and power lines. Add your bucket truck model or your bottle test results beside it. Show your family the path of the water and the path of the electricity, and keep the map and a photo in your portfolio folder.

LOOK FOR	WHAT IT MEANS
Water path	Showed water coming in through pipes and going out through the sewer.
Electricity path	Showed electricity coming from a power plant on power lines.
Safety	Can say the power line rule and the storm drain rule.
Thankful	Named a worker and made a thank-you card.

5.1 WHERE TAP WATER COMES FROM

OBJECTIVES

- Tell where tap water comes from: rain, rivers, lakes and wells.
- Tell how pipes and water towers bring water to the house.
- Test how water higher up pushes harder.

Warm-up. Turn on the kitchen tap and watch the water. Ask: Where was this water yesterday? Where was it last week? Then go on a hunt and count every tap in the house: kitchen, bathrooms, outside hose. How many did you find?

WATCH

How Does Water Get to Your House?

[SciShow Kids](https://www.youtube.com/watch?v=cGi4PugN4qY) · 3:36

<https://www.youtube.com/watch?v=cGi4PugN4qY>

WHEN TO WATCH

After the story, before the build.

KEY TERMS

pipe

A long tube that carries water from one place to another.

water tower

A big tank up high that holds water. Because it is high, the water pushes hard through the pipes.

aqueduct

A long channel or pipe that carries water from far away to a city.

CORE IDEAS

Long ago. Long ago, the people of New York City drank water from wells, and much of it was dirty. So engineers built the Croton **Aqueduct**. It carried clean water more than forty miles from a river in the hills to the city. In 1842 the water arrived, and the people had a great party to celebrate! The aqueduct even crossed a river on a bridge of stone arches called the High Bridge.

Why does it work? God made the rain to fall and the rivers to run. The water in your tap began as rain. It ran into rivers and lakes or soaked into the ground. At a water plant, workers clean it. Then **pipes** under the streets carry it to every house.

How do builders use it? Water needs a push to climb up into your house. So engineers pump it up into a **water tower** or a tank on a hill. Water up high pushes down hard. That push sends it through the pipes and out of your tap.

PICTURE STUDY



The High Bridge at Harlem, Unknown printmaker, 1849 · Hand-colored print · New York Public Library

Image: [Wikimedia Commons](#), public domain

This print shows the High Bridge in New York, built to carry the Croton Aqueduct's water pipes across the Harlem River. It looks like a bridge for people, but its real job was to carry water.

Look closely

- Find the arches. Count as many as you can.
- Find the river and the boats. Find the horse and carriage.
- Look at the top of the bridge. The water pipes ran inside it.
- Do the arches remind you of the Roman bridge in Lesson 2.3?

Talk about it

1. Why did the bridge need to be so high?
2. Why do you think people celebrated when clean water came to the city?

Safety first. Do the build outdoors or in a bathtub, with a grown-up nearby. A grown-up pokes the holes in the bottle.

BUILD

The Water Tower Push Test

You will fill a bottle that has three holes, one high, one in the middle and one low. You will measure which stream of water squirts the farthest. That shows where the water pushes hardest.

You will need

- A large plastic bottle (a 2-liter soda bottle works well)
- A nail or skewer (for the grown-up)
- Masking tape
- A pitcher of water
- A ruler or tape measure
- A baking pan or the bathtub
- Engineer's notebook

Steps

1. A grown-up pokes three small holes in a line up the side of the bottle: one near the bottom, one in the middle and one near the top. Cover each hole with a strip of tape.
2. Fill the bottle to the top with water. Stand it at the edge of the pan or tub.
3. **Guess.** Which hole will squirt the farthest: top, middle or bottom?
4. Pull off all three tapes at once. Watch the streams. A grown-up measures how far each one lands from the bottle.
5. Write the three numbers.
6. **Fair test.** Fill the bottle to the same line each time, and pull the tapes at the same time. Do it two times.
7. **Make it better.** Fill the bottle only halfway and try again. Does the bottom stream go as far? What does that tell you about a full water tower?

Tips

- The bottom stream has the most water above it pushing down.
- Put the tape back on to stop the water while you measure.

Check your work

- ☐ I can tell where tap water comes from.
- ☐ I can tell why water towers are built up high.

ENGINEER'S NOTEBOOK

1. Draw your bottle with three streams. Make the farthest stream the longest line.
2. Draw water's trip: rain, river, water plant, water tower, pipe, your tap.

From history. The High Bridge opened in 1848 and is the oldest bridge still standing in New York City. Today people can walk across it.

COMMON MISTAKES

- Thinking the top hole squirts farthest because it is higher. The bottom hole has the most water pushing on it.
- Thinking tap water is made at the tap. It travels a long way to get there.

Make it a game · Water Trip Story. Act out where tap water comes from. Wiggle fingers like rain, flow your arm like a river, then stand tall as a water tower and push a pretend flow down a pipe, which is your parent's arm. Tell the order: rain, river, tower, pipe, tap. Do it again, faster, with your parent's help only if you forget.

Scripture. "All the rivers run into the sea; yet the sea is not full; unto the place from whence the rivers come, thither they return again." (Ecclesiastes 1:7, KJV)

God made water go around and around, from the sea to the clouds to the rivers and back again. That is why there is water for our taps.

5.2 WHERE THE WATER GOES

OBJECTIVES

- Tell where water goes after it runs down the drain.
- Tell how Joseph Bazalgette’s sewers cleaned up London.
- Test how the slope of a pipe changes how fast water flows.

Warm-up. Pour a cup of water down the sink and listen. Where did it go? Look under the sink with a grown-up and find the bent pipe. Then look at the street for a storm drain grate (from the sidewalk, never in the street). Where do you think that water goes?

WATCH

Where does the water go? - Sewerage treatment

southeastwater · 6:47

<https://www.youtube.com/watch?v=wAcZrC1wnss>

WHEN TO WATCH

After the story. Watch in two parts if needed: the pipes first, then the treatment plant.

Note: Made by a water company in Australia, so a few words are different (a toilet is a “loo”).

BACKUP VIDEO

Keeping Our Water Clean! | SciShow Kids

SciShow Kids · 4:54

<https://www.youtube.com/watch?v=Npv47F3GK2w>

Later in the week, to learn about storm drains.

KEY TERMS

drain

A hole with a pipe where used water runs away.

sewer

Big pipes under the streets that carry used water away from houses.

slope

How much a pipe tilts downhill. Water in a sewer flows downhill.

CORE IDEAS

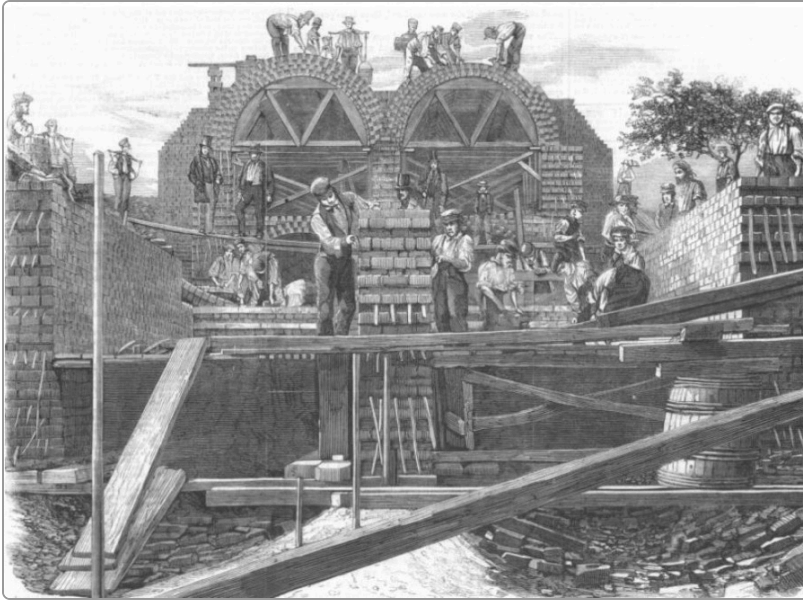
Long ago. Long ago, in London, the dirty water from houses ran straight into the River Thames. The river became so dirty that people got sick. One hot summer it smelled so bad that people called it “the Great Stink.” The city asked an engineer named Joseph Bazalgette to fix it.

How they figured it out. Bazalgette planned a giant set of brick **sewers**. Small pipes under every street ran into bigger pipes. The big pipes ran gently downhill, away from the city. Where the pipes were too low to flow downhill, huge pumps lifted the water up. Bazalgette even made his pipes twice as big as he thought they needed to be, in case the city grew. It did! His sewers still work today.

Why does it work? Water always runs downhill. A pipe with a gentle **slope** lets water and dirt flow away steadily. If the pipe is flat, the water sits still. That is why engineers plan every pipe to tilt just right.

How do builders use it? Today the used water from your sink, bath and toilet goes down the **drain** into the sewer. It flows to a treatment plant. There, workers and machines clean the water before it goes back to a river. Rain from the street goes into storm drains. That is why we never pour paint or trash into a storm drain.

PICTURE STUDY



Building London's Sewers at Old Ford, The Illustrated London News, August 27, 1859 · Wood engraving · The Illustrated London News

Image: [Wikimedia Commons](#), public domain

This picture was printed in a London newspaper while Bazalgette's sewers were being built. It shows the giant brick pipes in a deep trench before they were covered over.

Look closely

- Find the big rounded tunnels. How many can you count?
- Find the bricks. The sewers were made of millions of them.
- Find the curved wooden frames. They hold up the bricks until the arch is done, just like Lesson 2.3.
- Find the workers. What jobs are they doing?

Talk about it

1. Why are the pipes round?
2. Why did Bazalgette make the pipes bigger than he needed?

Safety first. Never go near open manholes or storm drains, and never play in them. Look at storm drains only from the sidewalk with a grown-up.

BUILD

The Pipe Slope Test

You will make a pipe from paper towel tubes or a cut pool noodle and test how fast water and little “dirt” pieces flow through it when the pipe is flat, a little tilted and very tilted.

You will need

- Three or four paper towel tubes taped end to end, with a strip of plastic wrap inside, or a pool noodle cut in half the long way (a grown-up cuts it), or a piece of rain gutter
- Books to raise one end
- A cup of water and ten pieces of round cereal or dried peas (the “dirt”)
- A bucket or bowl at the bottom end
- A stopwatch or a grown-up who counts seconds
- Engineer’s notebook

Steps

1. Do this outside or in the bathtub. Lay the pipe flat with the bowl at one end.
2. **Guess.** Will the water and cereal flow out if the pipe is flat?
3. Drop the ten cereal pieces into the top end. Pour the cup of water in. Count the seconds until the water stops coming out. Count how many cereal pieces reached the bowl.
4. Raise the top end on one book. Do it again.
5. Raise it on three books. Do it again.
6. **Fair test.** Use the same cup of water and ten cereal pieces each time. Only the slope changes.
7. Make a chart: slope, seconds, cereal pieces that made it.
8. **Make it better.** Make a bend in your pipe with tape. Does the cereal get stuck? How would you fix it?

Tips

- Pour the water the same way every time.

- Count “one-thousand-one, one-thousand-two” if you have no stopwatch.

Check your work

- ☐ I can tell where water goes after the drain.
- ☐ I can tell why sewer pipes slope downhill.

ENGINEER’S NOTEBOOK

1. Draw your pipe flat, a little tilted, and very tilted. Write how many cereal pieces reached the bowl each time.
2. Draw a house with a pipe going from the sink, under the ground, to the sewer.

From history. Bazalgette built about 1,100 miles of street sewers and 82 miles of large main sewers. He also built the Thames Embankment, a wide new riverside road with a main sewer and a railway tunnel hidden underneath it.

COMMON MISTAKES

- Thinking used water just disappears. It travels through sewers to be cleaned.
- Thinking the steepest pipe is always best. Too steep, and the water rushes away and leaves the dirt behind; engineers pick a steady slope.

Make it a game • Drain Journey Charades. Pretend to be a drop of water that goes down the sink. Slide down a pillow slope, which is your pipe, then travel along the floor to the sewer. Your parent guesses each stop. Say the word slope when you go downhill. Then tell why Joseph Bazalgette built his sewers in London.

5.3 POWER LINES BRING ELECTRICITY

OBJECTIVES

- Tell how electricity travels from a power plant to the house.
- Tell the story of the first power plant at Niagara Falls.
- Test whether a battery light still works with a long “power line.”

Warm-up. Go outside or look out the window and find power lines. Follow them with your eyes. Where do they go? Count the poles you can see on your street. Are there wires on the poles, or are they under the ground?

WATCH

How does electricity get into our homes?

[Fun Kids Learn](#) · 2:07

<https://www.youtube.com/watch?v=39DHRal-uzM>

WHEN TO WATCH

After the story. The narrator is British and says “pylons” for tall power-line towers.

KEY TERMS

power plant

A building where big machines called generators make electricity.

power line

Wires on tall poles or towers that carry electricity from the power plant.

generator

A machine that makes electricity when it spins.

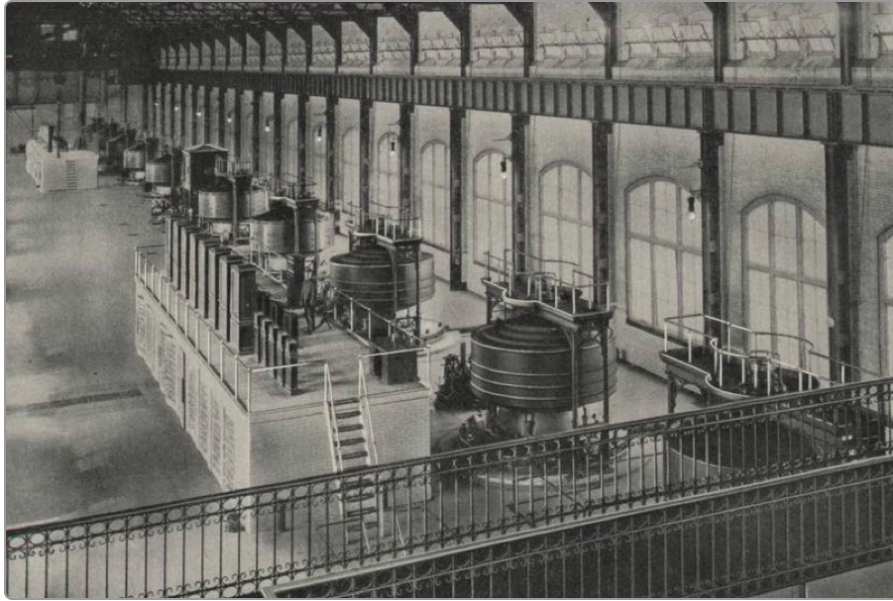
CORE IDEAS

Long ago. Niagara Falls is a huge waterfall. For years, people wondered whether all that falling water could make electricity. In 1895 engineers built a **power plant** there. The rushing water spun giant wheels, and the wheels spun **generators**. The next year, electricity from the falls traveled on wires all the way to the city of Buffalo, more than twenty miles away!

Why does it work? A generator makes electricity when it spins. Water, steam or wind can turn it. Then the electricity travels on **power lines**, over towers and poles, to the town. Near your house, a gray can on a pole or a green box in the yard makes the electricity just right for a home.

How do builders use it? Engineers plan the whole path, from the power plant to your light switch. They put the wires high on poles or deep under the ground, so people cannot touch them. That is why the rule is: **stay far away from power lines**, and never fly a kite near them. If you ever see a wire lying on the ground, stay away and tell a grown-up.

PICTURE STUDY



Generators at Niagara Falls, Westinghouse Electric & Manufacturing Company, 1904 · Photograph · Works of the Westinghouse Electric & Manufacturing Company (1904)

Image: [Wikimedia Commons](#), public domain

This photograph shows the great hall of the Niagara Falls power plant. Each big round machine is a generator, spun by water falling deep below the floor.

Look closely

- Count the generators.
- Find a person. How big is he next to a generator?
- Find the crane at the top of the hall. What might it lift?
- Look at the floor. Is the hall messy or neat?

Talk about it

1. Where is the water that spins these generators?
2. Why do you think the hall was kept so clean and neat?

Safety first. Never go near power lines, substations or the green metal boxes in yards. Never fly kites or climb trees near power lines. Our build uses batteries only.

BUILD

A Long Power Line

You will make a little town with paper-tube “poles” and see whether your battery can light a bulb at the far end of a long “power line” made of clip wires.

You will need

- Your battery, bulb and clip wires from Lesson 4.3
- Four or more extra alligator clip wires (or one long piece of wire, with a grown-up)
- Paper towel tubes for poles, stood up in lumps of clay
- A small box for the “power plant” and a small box for the “house”
- A tape measure
- Engineer’s notebook

Steps

1. Set the battery in the “power plant” box and the bulb in the “house” box.
2. Connect them with the short wires. Does the bulb light? Measure how far apart the boxes are.
3. **Guess.** If we make the line longer, will the bulb still light?
4. Clip two wires together end to end for each side of the loop. Move the house farther away. Measure. Does it light?
5. Add more wires and move the house farther again. Measure each time.
6. Lay the wires over the paper-tube poles like a real power line.
7. **Fair test.** Use the same battery and bulb each time. Only the length of the line changes.
8. **Make it better.** Can you make your power line go around a chair or under a table and still light the house?

Tips

- Remember: electricity needs a full loop, so there are two lines, one going and one coming back.
- Look closely: is the bulb as bright at the end of a very long line?

Check your work

- ☐ I can tell how electricity gets from the power plant to my house.
- ☐ I can say the power line rule.

ENGINEER'S NOTEBOOK

1. Draw the path of electricity: power plant, tall towers, poles, the house, your lamp.
2. Write or draw how far your longest power line reached and whether the bulb lit.

From history. The Niagara power plant used an idea called alternating current, worked out by the inventor Nikola Tesla and built by George Westinghouse's company. Alternating current can be sent long distances on wires, and it is still what comes to our homes today.

COMMON MISTAKES

- Thinking power lines are safe to touch because birds sit on them. Never touch or go near them.
- Using only one long wire. The loop needs a wire going and a wire coming back.

Make it a game • Power Line Relay. Make a human power line. Your parent is the power plant at one end of the room and you are the house at the other, and a string of pillows or toys is the line. Pass a pretend spark from toy to toy, saying power plant, power line and house. Race your own best time.

5.4 THANK YOU, WORKERS!

OBJECTIVES

- Name the workers who keep water and electricity coming to our homes.
- Tell how a lineworker's bucket truck lifts a worker safely.
- Build a model bucket lift and say thank you to a real worker.

Warm-up. Ask: What would happen if the water and the lights stopped working today? Who would come to fix them? Remember a storm when the power went out. Who came to turn it back on?

WATCH

What Does a Lineworker Do In Our Neighborhoods?

Meet the Helpers • 2:52

<https://www.youtube.com/watch?v=mpMP0bkO-S0>

WHEN TO WATCH

After the story. A real lineworker shows his tools and his bucket truck.

Note: A small channel that makes short videos about community helpers; chosen because a real lineworker explains his job simply.

BACKUP VIDEO

Kids Literacy Video - Lineman

Town of Bedford, Virginia • 3:43

<https://www.youtube.com/watch?v=iinMLtASr0c>

Later in the week. A town's electric workers read a short story and show their trucks.

KEY TERMS

lineworker

A worker who builds and fixes power lines, often high up on poles.

bucket truck

A truck with a long arm that lifts a worker in a bucket up to the wires.

service

Work that helps other people.

CORE IDEAS

Long ago. When power lines were first built, **lineworkers** climbed the wooden poles with sharp spikes on their boots and a strong belt around the pole. It was hard and careful work. Workers still climb poles sometimes, but now they often ride up in a **bucket truck**.

Why does it work? A bucket truck has a long, strong arm. The arm swings up and out to lift the worker high and close to the wires. The truck has legs that push down on the ground, so it will not tip over. A wide base keeps it steady, just like your tower in Lesson 1.4!

How do builders use it? Lineworkers wear thick rubber gloves, hard hats and special clothes. They follow safety rules every time. After a big storm, they work day and night until everyone's lights are back on. Water workers fix broken pipes, even in the freezing cold. Their work is **service**. They are loving their neighbors.

PICTURE STUDY



TVA Linemen at Work, Tennessee Valley Authority photographer, 1940s · Color photograph · Tennessee Valley Authority

Image: [Wikimedia Commons](#), public domain

This photograph shows lineworkers for the Tennessee Valley Authority, which brought electricity to many country farms and towns that had never had it before.

Look closely

- Find the two lineworkers. How do they stay on the pole?
- Find the crossarms, the bars across the pole, and the little glass knobs that hold the wires.
- Find the wires. How many can you count?
- How high up do you think they are?

Talk about it

1. What do lineworkers need to stay safe?
2. How did these workers help families who had no electricity?

Safety first. Children never climb poles or go near power lines. If you see a worker on a pole or a bucket truck, wave from a safe distance and stay out of the work zone marked by cones.

BUILD

A Cardboard Bucket Lift

You will build a model bucket truck arm from cardboard. A string will lift a little paper-cup bucket with a toy worker inside. Then you will make a thank-you card for a real worker.

You will need

- A shoebox or small cardboard box (the truck)
- A long strip of stiff cardboard about as long as your arm (the boom)
- A pencil and a brass paper fastener
- A small paper cup and string
- A small toy person
- Coins or a lump of clay for weight
- A ruler
- Card stock and crayons for a thank-you card

Steps

1. A grown-up pokes a hole near one end of the cardboard strip and through the side of the box, and joins them with the paper fastener so the strip can swing up and down.
2. Hang the paper cup from the far end of the strip with a short string. Put the toy worker inside.
3. Tie a long string to the middle of the strip. Pull the string to lift the boom.
4. **Guess.** Will the truck tip over when the boom is up?
5. Lift the boom and measure how high the bucket goes with the ruler.
6. If the truck tips, put coins or clay inside the box on the other side. These are like the truck's legs. How many coins does it need to stay steady? Count them.
7. **Make it better.** Make the boom reach higher or farther and test it again.
8. Now make a thank-you card for a lineworker, water worker or garbage collector. A grown-up can help you mail it or hand it to them.

Tips

- Lift slowly; a jerk makes the truck tip.
- Many electric companies and water departments are glad to receive cards from children.

Check your work

- ☐ I can tell what a lineworker does.
- ☐ I can tell how I kept my bucket truck from tipping over.

ENGINEER'S NOTEBOOK

1. Draw a lineworker in a bucket truck, with a hard hat and gloves.
2. Write or draw how high your bucket lifted and how many coins kept the truck steady.

From history. Before the 1930s, many farms in America had no electricity at all. Groups like the Tennessee Valley Authority and local electric cooperatives built thousands of miles of power lines into the countryside, and lineworkers strung them pole by pole.

COMMON MISTAKES

- Thinking the lights turn back on by themselves after a storm. People work hard to fix them.
- Putting the weight on the same side as the boom. The weight goes on the other side to balance it.

Make it a game • Thank You Worker Quiz. Today you are a radio host thanking workers. Name every worker who brings water and electricity to your house, like the plumber, the lineworker and the water-plant worker. Say what each one does in one sentence. Your parent claps for each right answer. Then draw a bucket truck and tell what it lifts.

Scripture. “In every thing give thanks: for this is the will of God in Christ Jesus concerning you.” (1 Thessalonians 5:18, KJV)

We thank God for clean water and light, and we thank the people who work hard to bring them to us.

UNIT 5

WATER AND LIGHTS AT HOME

When you turn on the tap, clean water comes out. When you flip a switch, the light comes on. In this unit your child will find out where tap water comes from, where it goes when it runs down the drain, and how electricity travels along power lines to the house. We meet real engineers: the builders of New York's Croton Aqueduct, Joseph Bazalgette, who built London's great sewers, and the engineers who first sent electricity from Niagara Falls to a faraway city.

Most of all, we say thank you. Water workers, sewer workers and lineworkers keep these hidden systems running day and night, in snow and storms. Their work is a way of loving their neighbors, and ours. The builds test how water pushes and flows and how electricity travels along a long wire, always with batteries only.

PREREQUISITES

- Knows the battery-and-bulb loop (Lesson 4.3)
- Knows the outlet rule (Lesson 4.4)
- Can pour water carefully

MASTERY CHECKLIST

- ☐ I can tell where tap water comes from and how it gets to my house.
- ☐ I can show that water in a high tank pushes harder.
- ☐ I can tell where water goes when it runs down the drain.
- ☐ I can tell how electricity gets from a power plant to my house.
- ☐ I know to stay far away from power lines and to thank the workers who keep them running.

LESSONS IN THIS UNIT

5.1 Where Tap Water Comes From

2 sessions of 30 minutes

5.2 Where the Water Goes

2 sessions of 30 minutes

5.3 Power Lines Bring Electricity

2 sessions of 30 minutes

5.4 Thank You, Workers!

2 sessions of 30 minutes

UNIT 5 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. Where does the water in your tap come from?
2. Why are water towers built up high?
3. Where does the water go when it runs down the drain?
4. Draw how electricity gets from the power plant to your lamp.
5. What do you do if you see a power line on the ground?
6. Name a worker who keeps our water or lights running. What would you say to them?

ANSWER KEY

1. From rain that fills rivers, lakes or wells; it is cleaned at a water plant and carried in pipes to the house.
2. Water up high pushes harder, so it can flow through the pipes into houses.
3. Into sewer pipes, then to a treatment plant where it is cleaned.
4. Power plant, power lines on towers and poles, the box near the house, wires in the walls, the lamp.
5. Stay far away and tell a grown-up right away.
6. A lineworker, water worker or sewer worker; “Thank you.”

PORTFOLIO PIECE: MY TOWN’S WATER AND LIGHTS MAP

On a big sheet of paper, draw a map of your town with a river, a water plant, a water tower, pipes, your house, the sewer, a treatment plant, a power plant and power lines. Add your bucket truck model or your bottle test results beside it. Show your family the path of the water and the path of the electricity, and keep the map and a photo in your portfolio folder.

LOOK FOR	WHAT IT MEANS
Water path	Showed water coming in through pipes and going out through the sewer.
Electricity path	Showed electricity coming from a power plant on power lines.
Safety	Can say the power line rule and the storm drain rule.
Thankful	Named a worker and made a thank-you card.

UNIT 6

BOATS

Why does a giant steel ship float, but a little pebble sinks? In this unit your child will test what sinks and what floats, shape a ball of foil into a boat that carries a load of pennies, make a little sailboat that catches the wind, and build a model of Noah's ark from the measurements God gave in Genesis.

We meet the iron steamship *Great Britain*, the sailors of long ago, and Noah, the first shipbuilder in the Bible. Every build happens in a tub or sink of water with a grown-up close by. "They that go down to the sea in ships ... these see the works of the LORD" (Psalm 107:23-24).

PREREQUISITES

- Can count to 20, and to 50 with help
- Can sort things into two groups (Lesson 4.2)
- Knows that a wide base is steady (Lesson 1.4)

MASTERY CHECKLIST

- ☐ I can guess and test whether things sink or float.
- ☐ I can shape foil into a boat and count how many pennies it carries.
- ☐ I can show that a bigger sail catches more wind.
- ☐ I can tell how big Noah's ark was and why its shape was steady.

LESSONS IN THIS UNIT

6.1 Sink or Float?

2 sessions of 30 minutes

6.2 A Foil Boat Holds Pennies

2 sessions of 30 minutes

6.3 Sails Catch the Wind

2 sessions of 30 minutes

6.4 Noah's Ark

2 sessions of 30 minutes

UNIT 6 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. Here are a cork, a coin and a crayon. Which will float? Test them.
2. How can you make a ball of clay or foil float?
3. Make a foil boat. Where should you put the pennies so it carries the most?
4. Which sail catches more wind: a big one or a small one?
5. How big was Noah's ark? What shape was it?
6. How can a big ship made of steel float?

ANSWER KEY

1. The cork and the crayon usually float; the coin sinks.
2. Shape it into a wide, hollow boat.
3. Spread out evenly over the bottom.
4. A big one.
5. 300 cubits long, 50 wide and 30 high; a long, wide box.
6. It is hollow and wide, so it pushes away lots of water, and the water pushes it up.

PORTFOLIO PIECE: MY BEST BOAT

Build your best boat: a foil penny boat, a sailboat or a model ark. Test it in the tub, count how many pennies or animals it carries, and then make it better. Show your family how it floats, and keep a photo and your notebook page in your portfolio folder.

LOOK FOR	WHAT IT MEANS
Guessed first	Made a guess before testing.
Counted carefully	Counted pennies or seconds out loud, with a grown-up writing the numbers.
Made it better	Changed the boat and tested again.
Can explain	Told why the boat floats or why its shape is steady.

6.1 SINK OR FLOAT?

OBJECTIVES

- Guess whether things will sink or float, then test them.
- Make a chart of what sank and what floated.
- Notice that the same stuff can sink or float depending on its shape.

Warm-up. In the bathtub or a sink, push a plastic cup or a ball down under the water and let go. What does the water do? Can you feel the water pushing up on your hand?

WATCH

Sink or Float?

[SciShow Kids](#) · 5:50

https://www.youtube.com/watch?v=eQuW8G2QV_Q

WHEN TO WATCH

After the core ideas. Pause before each thing goes in the water and make your guess.

BACKUP VIDEO

Float or Sink - Cool Science Experiment

[SpanglerScienceTV](#) · 3:25

<https://www.youtube.com/watch?v=MzsORE0ae10>

For a surprise: on a TV news set, a can of diet soda floats while a can of regular soda sinks. The sugar in the regular soda makes it heavier for its size.

KEY TERMS

float

To stay up on top of the water.

sink

To go down to the bottom of the water.

predict

To make a careful guess before you test.

CORE IDEAS

Long ago. Long ago, people saw that logs **float**. They tied logs together to make rafts. They hollowed out a big log to make a canoe. Later they built boats from wooden

boards. Today some ships are made of steel and are as long as three football fields!

Why does it work? When a thing goes into water, it pushes some water out of the way. The water pushes back up. If the water's push is strong enough, the thing floats. If not, it **sinks**. Light, puffy things like wood, corks and plastic foam float. Small, heavy, solid things like a rock or a key sink.

A surprise. Shape matters too! A ball of clay sinks. But if you press the same clay into a wide bowl shape, it can float. The wide shape pushes away lots of water, and the water pushes back up hard. That is the secret of every boat.

How do builders use it? Boat builders make boats hollow and wide. Inside a ship is mostly air. So even a ship made of heavy steel can float.

PICTURE STUDY



Boat Builders, Winslow Homer, 1873 · Oil on panel

Image: [Wikimedia Commons](#), public domain

Winslow Homer grew up near the sea and loved to paint boats and the people who sail them. Here two boys are building a little boat of their own on the beach.

Look closely

- Find the two boys. What is each one doing?
- Find the little boat. What is it made of?
- Find the real boats out on the water.
- What tool might the boys be using?

Talk about it

1. Why do you think the boys chose wood for their boat?
2. How will they test their boat when it is finished?

Safety first. A grown-up stays right beside the tub or sink the whole time. Empty the water when you are done.

BUILD

The Sink-or-Float Test

You will guess whether twelve things will sink or float, test them in a tub, and sort them on a chart. Then you will make clay sink and float.

You will need

- A tub, sink or large bowl of water
- Twelve small things: a cork, a coin, a crayon, a spoon, an apple, a grape, a leaf, a rock, a sponge, a key, a plastic lid, a toy block
- A lump of modeling clay about the size of a walnut
- A towel
- Engineer's notebook

Steps

1. A grown-up draws a chart with three columns: the thing, “my guess” and “what happened.”
2. **Predict.** Hold up each thing and guess: sink or float? Mark your guess.
3. **Test.** Set each thing gently on the water. Let go. Mark what happened.
4. **Count:** how many guesses were right?
5. **Fair test.** Set each thing on the water the same gentle way. Do not push it.
6. **Clay challenge.** Roll the clay into a ball and set it on the water. It sinks! Now press it into a wide, thin bowl with tall sides. Set it on the water. Can you make it float?
7. **Make it better.** If your clay bowl sinks, make it wider and thinner, and try again.

Tips

- Dry the things on the towel after each test.
- An apple floats but a grape sinks. That surprises many people!

Check your work

- ☐ I can predict and test sink or float.

- ☐ I can make clay float by changing its shape.

ENGINEER'S NOTEBOOK

1. Draw a line across the page for the water. Draw the things that floated above the line and the things that sank at the bottom.
2. Draw your clay ball and your clay boat.

From history. Some of the first boats people made were dugout canoes: one big log, hollowed out with tools and sometimes with careful burning. Very old dugout canoes have been found buried in mud near rivers and lakes.

COMMON MISTAKES

- Thinking big things always sink. A big log floats; a small key sinks.
- Pushing things under. Set them on the water gently.

Make it a game · Guess Then Splash. Fill a tub or sink. Before you drop in each object, say sink or float. Test it, and give yourself a point if you were right. Test ten things, like a spoon, a cork or a crayon. Your parent keeps a tally chart with a sinker column and a floater column. Try to beat ten points.

6.2 A FOIL BOAT HOLDS PENNIES

OBJECTIVES

- Tell how a heavy iron ship can float.
- Shape aluminum foil into a boat and count how many pennies it carries.
- Change the boat's shape to carry more.

Warm-up. Crumple a square of foil into a tight ball and drop it in water. Does it float or sink? Now take a flat square of foil and fold up the edges into a little tray. What happens when you set it on the water?

WATCH

Float a Boat! - #sciencegoals

SciShow Kids · 3:35

<https://www.youtube.com/watch?v=jj-vKtmtljw>

WHEN TO WATCH

Before the build. Two children build foil boats just like yours.

BACKUP VIDEO

Why Do Ships Float?

SciShow Kids · 3:52

<https://www.youtube.com/watch?v=CvWrkxzCiaY>

After the story, to learn the word “displacement.”

KEY TERMS

hull

The body of a boat, the part that sits in the water.

load

What a boat carries, like people, boxes or pennies.

iron

A strong, heavy metal. Steel is made mostly from iron.

CORE IDEAS

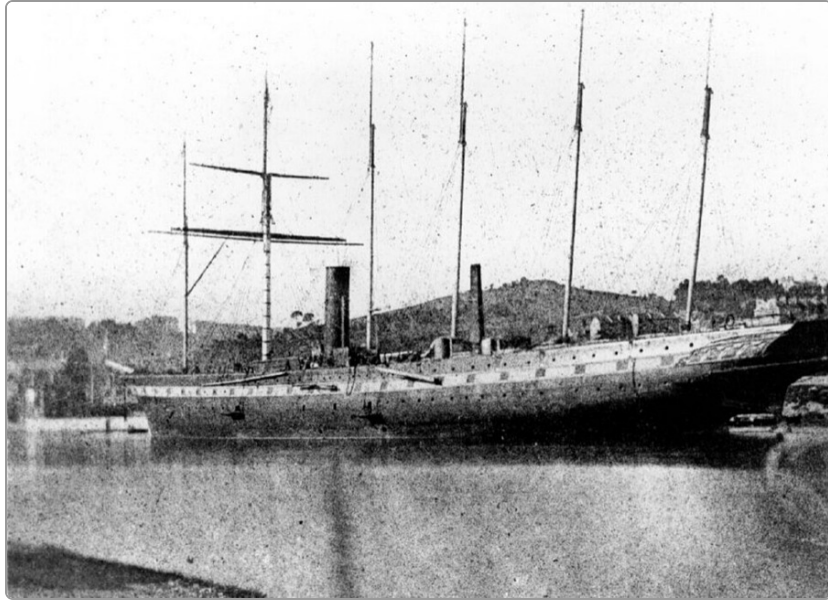
Long ago. For thousands of years ships were made of wood. Many people thought a ship made of **iron** would sink like a rock. But an engineer named Isambard Kingdom

Brunel built a giant iron steamship called the *Great Britain*. She was launched in 1843. She floated, and she sailed across the ocean to America!

Why does it work? A lump of iron sinks. But if you shape the iron into a big, hollow **hull**, it pushes away a lot of water. The water pushes back up, enough to hold up the ship and its whole **load**. Your foil boat works the same way.

How do builders use it? Engineers make cargo ships wide and flat-bottomed so they can carry heavy loads. They paint a line on the side of the ship. If the water comes up past that line, the ship is carrying too much.

PICTURE STUDY



The Great Britain in Bristol, William Henry Fox Talbot, April 1844 · Photograph (calotype) · Taken in Bristol, England

Image: [Wikimedia Commons](#), public domain

This is one of the first photographs ever taken of a ship. William Henry Fox Talbot, one of the inventors of photography, took it in 1844. It shows the iron ship *Great Britain* at the dock where she was built.

Look closely

- Find the ship's tall masts.
- Find the dark side of the hull. It is made of iron plates.
- Find the water line where the hull meets the water.
- Look closely for people or ropes on the dock.

Talk about it

1. How can a ship made of iron float?
2. Why do you think the photograph looks blurry and brown?

Safety first. A grown-up stays beside the water. Pennies go back in a jar right away so small children cannot put them in their mouths.

BUILD

The Penny Boat Challenge

You will shape a square of foil into a boat and add pennies one at a time until it sinks. Then you will change the shape and try to carry more.

You will need

- Aluminum foil cut into squares about the size of a sheet of paper
- A tub or sink of water
- About 100 pennies
- A towel
- Engineer's notebook

Steps

1. **Boat 1.** Fold up the sides of a foil square to make a boat. Set it on the water.
2. **Guess.** How many pennies will it hold?
3. Add pennies one at a time, counting out loud. Stop when water spills in and the boat sinks. A grown-up writes the number.
4. **Boat 2.** Take a new square the same size. Make a different shape: wider and flatter, or taller and narrower.
5. Test it the same way and count.
6. **Fair test.** Use the same size of foil each time, and set the pennies in gently, spread out over the bottom.
7. Make a bar chart for your boats.
8. **Make it better.** Look at your best boat. Make it even better and beat your record.

Tips

- Spread the pennies out. If they all pile on one side, the boat will tip.
- Low sides that are too short let water in. Make the sides tall enough.

Check your work

- ☐ I can tell how an iron ship floats.

- ☐ I can tell which boat shape carried the most pennies, and show my numbers.

ENGINEER'S NOTEBOOK

1. Draw each of your foil boats from the side. Write how many pennies it carried.
2. Draw a big ship with a line on its side showing how full it may be loaded.

From history. The *Great Britain* was the first big ocean ship with both an iron hull and a propeller. After a long life at sea she was brought back to Bristol in 1970, and today she sits in the same dry dock where she was built, as a museum.

COMMON MISTAKES

- Dropping pennies in one spot. Spread them out.
- Using different sizes of foil. A bigger square is not a fair test.

Make it a game · Penny Boat Duel. Make two foil boats, one flat and one with high sides. Guess which will hold more pennies. Then load each boat penny by penny while your parent counts out loud. The first boat to sink loses. Say the word hull for the boat's body. Fix the weaker boat, and race it again.

6.3 SAILS CATCH THE WIND

OBJECTIVES

- Tell how a sail uses the wind to move a boat.
- Build a little sailboat and time it across a tub.
- Test whether a big sail or a small sail goes faster.

Warm-up. Hold a sheet of paper in front of you and run across the yard. What do you feel? Now hold it flat and run again. Then blow on a paper napkin. Which way does it move?

WATCH

Learn About Sailing for Kids! | CBC Kids

CBC Kids • 2:56

<https://www.youtube.com/watch?v=BJQQ-bgD3QI>

WHEN TO WATCH

After the story. Watch the sails fill with wind.

BACKUP VIDEO

Toy Sailboat with Keel | STEM Activity

Science Buddies • 1:46

<https://www.youtube.com/watch?v=yOYGIMBjfCA>

Before the build, if you want to try a cork sailboat with a keel. Read the words on the screen aloud.

KEY TERMS

sail

A big sheet of cloth on a boat that catches the wind.

mast

The tall pole that holds up the sail.

wind

Moving air. We cannot see it, but we can feel its push.

CORE IDEAS

Long ago. Long ago, sailors had no engines. To cross the sea, they raised big cloth **sails** on tall **masts**. The wind filled the sails and pushed the ships along. Sailing ships

carried people and goods all over the world.

Why does it work? Wind is moving air. When it hits a sail, it pushes. A bigger sail catches more wind, so it gets a bigger push. Sailors can turn their sails to catch the wind just right.

How do builders use it? A sailboat needs more than a sail. Under the water it has a long fin called a keel. The keel keeps the boat from tipping over and from sliding sideways. Boat builders give each sailboat the right size of sail and the right size of keel.

PICTURE STUDY



Breezing Up (A Fair Wind), Winslow Homer, 1873–1876 · Oil on canvas · National Gallery of Art, Washington

Image: [Wikimedia Commons](#), public domain

Winslow Homer painted a man and three boys out sailing on a windy day. The boat is leaning over and moving fast.

Look closely

- Find the sail. Is it full of wind or floppy?
- Find the mast.
- Look at the boat. Is it sitting straight or leaning?
- Find the boy holding the rope. That rope controls the sail.
- Find the waves. Is it a calm day or a windy day?

Talk about it

1. Which way is the wind blowing? How can you tell?
2. Why do you think the people are sitting on the high side of the boat?

Safety first. A grown-up stays beside the water. If you use a fan for wind, a grown-up sets it up away from the water and keeps the cord dry.

BUILD

The Sail Test

You will make a little sailboat from a sponge or a plastic lid and send it across a tub by blowing through a straw. Then you will test a big sail and a small sail.

You will need

- A kitchen sponge or a plastic lid (the hull)
- A straw or a wooden skewer with the sharp tip cut off (the mast)
- Paper for sails: one big and one small
- Tape and a lump of clay
- A bathtub or a long plastic bin of water
- Straws for blowing
- A stopwatch or a grown-up to count seconds
- Engineer's notebook

Steps

1. Stick the mast into the sponge, or into a lump of clay on the lid.
2. Tape the small sail to the mast.
3. **Guess.** Will the big sail or the small sail go faster?
4. Set the boat at one end of the tub. Blow through a straw at the sail. A grown-up counts the seconds until the boat reaches the other end.
5. Change to the big sail. Test again and count.
6. **Fair test.** Use the same boat, start at the same place, and blow the same way. Only the sail changes. Test each sail two times.
7. **Make it better.** If your boat tips over, add a little clay underneath as a keel. If it spins, try a different sail shape. Test again.

Tips

- Blow at the sail, not at the water.
- Count “one-thousand-one, one-thousand-two” if you have no stopwatch.

Check your work

- ☐ I can tell how a sail makes a boat go.

- ☐ I can tell which sail was faster, and show my numbers.

ENGINEER'S NOTEBOOK

1. Draw your boat with its big sail and small sail. Write the number of seconds for each test.
2. Draw wind arrows pushing on a sail.

From history. Sailing ships carried goods across the oceans for thousands of years. In the 1800s steamships began to take over, but sailboats are still used today for fishing, for training sailors and for fun.

COMMON MISTAKES

- Blowing harder for one sail than the other.
- Making the sail so big that the boat tips over. A tall sail needs a keel.

Make it a game · Sail Blow Race. Make a tiny sailboat from foil, a straw mast and a paper sail. Float it at one end of a tub. Blow gently on the sail and time how long it takes to cross, counting aloud. Then try with no sail. Say which was faster and why the wind helps. Beat your own time.

Scripture. “They that go down to the sea in ships, that do business in great waters; These see the works of the LORD, and his wonders in the deep.” (Psalm 107:23-24, KJV)
Sailors see God’s wind and waves up close. The wind that fills a sail is one of His works.

6.4 NOAH'S ARK

OBJECTIVES

- Tell the story of Noah building the ark.
- Tell the ark's measurements and its long box shape.
- Build a model ark and test how steady it is in waves.

Warm-up. Read Genesis 6:14-16 together. Then measure out 30 steps in the yard or a long hallway, heel to toe, for the ark's length, and 5 steps across for its width. (Each step stands for 10 cubits.) How long and skinny is it?

WATCH

You Won't Believe How Big Noah's Ark Really Was!

Ark Encounter • 2:41

<https://www.youtube.com/watch?v=P20ClidpVFg>

WHEN TO WATCH

After the story. It shows a full-size model of the ark built in Kentucky and compares its size to trucks and houses.

Note: The Ark Encounter uses a “long cubit” of about 20 inches; other people use 18 inches. Either way, the ark was very big.

KEY TERMS

ark

The big wooden ship God told Noah to build.

cubit

An old way to measure: the length from a man's elbow to the tip of his fingers, about a foot and a half.

pitch

A thick, sticky coating that keeps water out of a wooden boat.

steady

Hard to tip over.

CORE IDEAS

The story. God told Noah that a great flood was coming. He told Noah to build an ark to keep his family and the animals safe. God gave Noah the plan: make it of

gopher wood, make rooms inside, and cover it inside and out with **pitch** to keep the water out.

The measurements. God told Noah exactly how big to make it: 300 **cubits** long, 50 cubits wide and 30 cubits high. That is longer than a football field! It was a long, wide box, about six times longer than it was wide.

Why does it work? The ark did not need to go fast. It needed to float and stay **steady** in big waves. A long, wide, low box is very hard to tip over. Engineers who study ship shapes have found that the ark's shape is a very good one for staying steady.

How do builders use it? Many big cargo ships today have a long, boxy shape too, because it holds a lot and floats steadily. Noah trusted God and followed the plan carefully. Good builders follow the plan, too.

PICTURE STUDY



Noah's Ark, Edward Hicks, 1846 · Oil on canvas · Philadelphia Museum of Art

Image: [Wikimedia Commons](#), public domain

Edward Hicks was an American painter who loved Bible stories. He painted the animals walking into the ark, two by two, just before the rain began.

Look closely

- Find the ark. What shape is it?
- Find the ramp. What does it help the animals do?
- Name all the animals you can find.
- Look at the sky. What is about to happen?

Talk about it

1. Why did the ark need to be so big?
2. Hicks painted the ark like a house on a boat. Is it the same shape as the ark in Genesis? How is it different?

Safety first. A grown-up stays beside the tub. Make gentle waves with your hand, not big splashes.

BUILD

A Model Ark Wave Test

You will build two foil boats from the same amount of foil: one long and wide like the ark, and one tall and narrow. You will load them with toy animals or pennies and make waves to see which stays steady.

You will need

- Aluminum foil or card stock and tape
- A ruler
- Small toy animals or pennies
- A tub of water
- Engineer's notebook

Steps

1. **Ark boat.** With a grown-up, make a box boat 6 inches long, 1 inch wide and almost 1 inch high (the ark's shape, six times longer than wide). Fold foil or tape card stock and cover it with foil to keep it dry.
2. **Tall boat.** Using the same amount of foil, make a short, tall, narrow boat.
3. **Guess.** Which boat will stay steady in waves?
4. Load each boat with the same number of toy animals or pennies, spread out.
5. Make waves by pushing your hand back and forth in the water five times.
Does each boat stay upright? Count how many waves before it tips.
6. **Fair test.** Same amount of foil, same load and the same waves. Only the shape changes.
7. **Make it better.** Add more load to the ark boat until it sinks. How many did it hold? Can you make it hold more without changing its shape?

Tips

- Put the heaviest things low and in the middle.
- Make waves the same way each time: five gentle pushes.

Check your work

- ☐ I can tell how big the ark was in cubits.

- ☐ I can tell why a long, wide box shape is steady.

ENGINEER'S NOTEBOOK

1. Draw the ark from the side and from the top. Write 300, 50 and 30 on its length, width and height.
2. Draw your two boats in the waves. Which one tipped?

From history. A full-size model of the ark, built to the measurements in Genesis, opened in Kentucky in 2016. Visitors can walk through its three decks and see how much room there was inside.

COMMON MISTAKES

- Thinking the ark was shaped like a little round bathtub boat. Genesis says it was long and boxy.
- Making the two test boats with different amounts of foil.

Make it a game • Noah's Ark Builder. Tell Noah's story with toy animals marching two by two into a long box. Your parent plays Noah and asks, how long is the ark? You answer with the measurements, with your parent helping on the numbers. Then rock the ark gently in a tub of water and say whether it stays steady.

Scripture. “Make thee an ark of gopher wood; rooms shalt thou make in the ark, and shalt pitch it within and without with pitch. And this is the fashion which thou shalt make it of: The length of the ark shall be three hundred cubits, the breadth of it fifty cubits, and the height of it thirty cubits.” (Genesis 6:14-15, KJV)

God gave Noah a careful plan with exact measurements, and Noah built it just as God said.

UNIT 6

BOATS

Why does a giant steel ship float, but a little pebble sinks? In this unit your child will test what sinks and what floats, shape a ball of foil into a boat that carries a load of pennies, make a little sailboat that catches the wind, and build a model of Noah's ark from the measurements God gave in Genesis.

We meet the iron steamship *Great Britain*, the sailors of long ago, and Noah, the first shipbuilder in the Bible. Every build happens in a tub or sink of water with a grown-up close by. "They that go down to the sea in ships ... these see the works of the LORD" (Psalm 107:23-24).

PREREQUISITES

- Can count to 20, and to 50 with help
- Can sort things into two groups (Lesson 4.2)
- Knows that a wide base is steady (Lesson 1.4)

MASTERY CHECKLIST

- ☐ I can guess and test whether things sink or float.
- ☐ I can shape foil into a boat and count how many pennies it carries.
- ☐ I can show that a bigger sail catches more wind.
- ☐ I can tell how big Noah's ark was and why its shape was steady.

LESSONS IN THIS UNIT

6.1 Sink or Float?

2 sessions of 30 minutes

6.2 A Foil Boat Holds Pennies

2 sessions of 30 minutes

6.3 Sails Catch the Wind

2 sessions of 30 minutes

6.4 Noah's Ark

2 sessions of 30 minutes

UNIT 6 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. Here are a cork, a coin and a crayon. Which will float? Test them.
2. How can you make a ball of clay or foil float?
3. Make a foil boat. Where should you put the pennies so it carries the most?
4. Which sail catches more wind: a big one or a small one?
5. How big was Noah's ark? What shape was it?
6. How can a big ship made of steel float?

ANSWER KEY

1. The cork and the crayon usually float; the coin sinks.
2. Shape it into a wide, hollow boat.
3. Spread out evenly over the bottom.
4. A big one.
5. 300 cubits long, 50 wide and 30 high; a long, wide box.
6. It is hollow and wide, so it pushes away lots of water, and the water pushes it up.

PORTFOLIO PIECE: MY BEST BOAT

Build your best boat: a foil penny boat, a sailboat or a model ark. Test it in the tub, count how many pennies or animals it carries, and then make it better. Show your family how it floats, and keep a photo and your notebook page in your portfolio folder.

LOOK FOR	WHAT IT MEANS
Guessed first	Made a guess before testing.
Counted carefully	Counted pennies or seconds out loud, with a grown-up writing the numbers.
Made it better	Changed the boat and tested again.
Can explain	Told why the boat floats or why its shape is steady.

UNIT 7

FLIGHT

People have always watched birds and wished they could fly. In this unit your child will look closely at how birds use their wings, fold and test paper airplanes, build a kite that rides the wind, and hear the true story of Wilbur and Orville Wright, two brothers who built the first airplane that really flew, on December 17, 1903.

Every build is a flight test: dropping, gliding, flying and measuring how far or how long. Your child will guess, test, measure with a tape measure or count seconds, and then make it fly better. That is exactly how the Wright brothers worked. “They shall mount up with wings as eagles” (Isaiah 40:31).

PREREQUISITES

- Can count to 20, and count seconds with help
- Knows that wind is moving air (Lesson 6.3)
- Can fold paper along a line

MASTERY CHECKLIST

- ☐ I can tell how birds use their wings to fly and glide.
- ☐ I can fold a paper airplane, measure how far it flies and make it fly farther.
- ☐ I can tell how a kite uses the wind, and I know never to fly one near power lines.
- ☐ I can tell the story of the Wright brothers’ first flight.

OPTIONAL KITS FOR THIS UNIT

- **KiwiCo Kiwi Crate**: A monthly box of hands-on science and building projects for ages 5–8, with picture instructions a young child can follow with help. Topics change from month to month. Optional for any unit.

Not required. Every project in this unit can be built with household materials. School Launch has no ties to these companies.

LESSONS IN THIS UNIT

7.1 How Birds Fly

2 sessions of 30 minutes

7.2 Paper Airplanes

2 sessions of 30 minutes

UNIT 7 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. Show me how a bird flaps and how it glides.
2. Fold a paper airplane. What can you change to make it fly better?
3. What holds a kite up in the sky?
4. Where should you never fly a kite?
5. Who made the first airplane flight? When and where?
6. How did the Wright brothers learn to fly?

ANSWER KEY

1. Flapping: arms pushing down and up. Gliding: arms held out wide and still.
2. Add a paper clip to the nose, make the folds even, bend up the back of the wings, or throw it more gently.
3. The wind pushing on the tilted kite while the string pulls.
4. Near power lines, roads or trees, or in a storm.
5. Wilbur and Orville Wright; December 17, 1903; at Kitty Hawk, North Carolina.
6. They tested kites, then gliders, then a wind tunnel, wrote everything down and kept improving.

PORTFOLIO PIECE: MY BEST FLYER

Choose your best paper airplane or kite. Fly it at least three times, measure each flight, and then make one change to make it better. Show your family how it flies, tell them about the Wright brothers, and keep your flight chart and a photo in your portfolio folder.

LOOK FOR	WHAT IT MEANS
Measured	Measured at least three flights with a grown-up’s help.
Changed one thing	Changed only one thing between tests.
Made it better	The new version flew farther or steadier, or the child can tell why it did not.
Told the story	Told who the Wright brothers were and what they did.

7.1 HOW BIRDS FLY

OBJECTIVES

- Watch birds and describe how they flap and glide.
- Find the parts of a wing and a feather.
- Test how wings slow a fall by dropping paper “birds” and counting seconds.

Warm-up. Go outside or look out a window and watch birds for three minutes. Do they flap all the time? Do some birds glide without flapping? Then flap your arms fast, then hold them out wide and still like a gliding bird.

WATCH

How Do Animal Wings Work? | The Science of Flight | SciShow Kids

SciShow Kids · 4:48

<https://www.youtube.com/watch?v=4Bp4MgmT0Co>

WHEN TO WATCH

After the story. Watch for the albatross, a bird that glides for hours.

BACKUP VIDEO

The Amazing Science of How Birds Fly | Wytham Woods

University of Oxford · 3:57

<https://www.youtube.com/watch?v=Zz-UwbLMoCY>

For a grown-up, or to watch real birds in slow motion together. The words are for older listeners.

KEY TERMS

wing

The part of a bird (or airplane) that helps it fly.

feather

The light covering on a bird. Long, stiff feathers on the wings push on the air.

glide

To fly smoothly without flapping.

CORE IDEAS

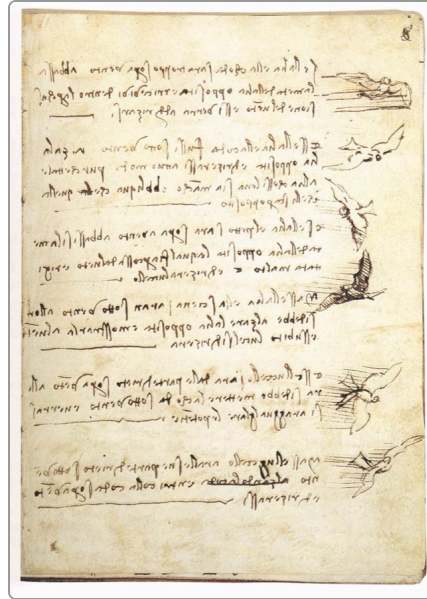
Long ago. More than five hundred years ago, a painter and inventor named Leonardo da Vinci wanted to know how birds fly. He watched them for hours. He filled a little notebook with drawings of birds turning, rising and gliding in the

wind. He even drew flying machines with wings. They never flew, but people kept studying birds.

Why does it work? A bird's **wings** push down on the air when it flaps. The air pushes back up, and the bird rises. A bird's bones are hollow and light. Its **feathers** are light but stiff. When a bird holds its wings out wide and still, it can **glide** on the air, slowly coming down.

How do builders use it? Airplane engineers learned from birds. An airplane has wide, still wings like a gliding bird. It has a tail to keep it steady, like a bird's tail. God made birds to fly, and people learned by watching them.

PICTURE STUDY



A Page from the Codex on the Flight of Birds, Leonardo da Vinci, About 1505 · Ink drawings in a notebook · Biblioteca Reale, Turin

Image: [Wikimedia Commons](#), public domain

This is a page from Leonardo da Vinci's notebook about how birds fly. He wrote backward, from right to left, so you need a mirror to read it!

Look closely

- Find the little drawings of birds. How many can you count?
- Look at their wings. Are they flapping or held out wide?
- Find the writing. Hold a mirror up to it. What happens?
- Do any birds look tilted, as if they are turning?

Talk about it

1. Why do you think Leonardo drew so many birds?
2. What could you learn by drawing birds in your own notebook?

BUILD

The Paper Bird Drop Test

You will drop a crumpled paper ball, a paper bird with small wings and a paper bird with big wings from the same height, and count how long each takes to land. Wings that catch the air fall slowly, like a gliding bird.

You will need

- Three sheets of paper the same size
- Scissors and tape
- A paper clip for each bird
- A stopwatch, or a grown-up who counts seconds
- A sturdy step stool, used with a grown-up, or just stand tall on the floor
- Engineer's notebook

Steps

1. Crumple one sheet into a tight ball.
2. Make a small-wing bird: fold a sheet into a narrow strip for a body, and tape a small paper wing across it. Put a paper clip on the front.
3. Make a big-wing bird the same way, but with wings twice as wide.
4. **Guess.** Which will take the longest to land?
5. Hold each one up as high as you can reach and let go. A grown-up counts the seconds until it lands. Write the number.
6. **Fair test.** Drop each one from the same height, three times each. Only the wings change.
7. Color a bar chart for the ball, the small wings and the big wings.
8. **Make it better.** Can you make a bird that glides across the room instead of falling straight down? Try bending the back edges of the wings up a little.

Tips

- Let go; do not throw. A throw changes the test.
- Move the paper clip forward or back until your bird flies smoothly.

Check your work

- ☐ I can tell how wings help a bird glide.
- ☐ I can tell which paper bird stayed in the air longest, and show my numbers.

ENGINEER'S NOTEBOOK

1. Draw a bird you watched, with its wings flapping and then gliding.
2. Draw your three paper birds. Write how many seconds each one took to land.

From history. Leonardo's little Codex on the Flight of Birds has only eighteen pages. It is kept in Turin, Italy. Leonardo also designed a parachute shaped like a pyramid; in the year 2000 a man built one and safely jumped with it.

COMMON MISTAKES

- Thinking birds fly by flapping only. Many birds glide a lot.
- Dropping from a different height each time.

Make it a game • Bird Flight Acting. Act like a bird. Flap your arms for flying, then hold them out steady to glide. Your parent calls out flap or glide, and you switch fast. Then point to the wing on a feather picture or on your own arm. Say wing and feather three times. Count how many glides you can do in one minute.

Scripture. "But they that wait upon the LORD shall renew their strength; they shall mount up with wings as eagles; they shall run, and not be weary; and they shall walk, and not faint." (Isaiah 40:31, KJV)

An eagle rises on the wind without getting tired. God gives strength to people who trust Him.

7.2 PAPER AIRPLANES

OBJECTIVES

- Fold a simple paper airplane.
- Measure how far it flies with a tape measure or footsteps.
- Change one thing and make it fly farther.

Warm-up. Toss a flat sheet of paper forward. Then toss a crumpled ball. Then a folded paper airplane, if you have one. Which goes farthest? Which floats? Talk about why.

WATCH

How to Make a Paper Airplane

SciShow Kids · 4:17

<https://www.youtube.com/watch?v=7KPaxKUDj6I>

WHEN TO WATCH

Before the build. Pause after each fold and do it together.

BACKUP VIDEO

How To Make A Paper Airplane | Science Max

Science Max - Scholastic · 3:03

<https://www.youtube.com/watch?v=pYzW1COVEtA>

For a second design to try in the “make it better” round.

KEY TERMS

glider

An aircraft with wings but no engine. A paper airplane is a glider.

lift

The push of air that holds a wing up.

nose

The front point of an airplane.

CORE IDEAS

Long ago. About 130 years ago, a German engineer named Otto Lilienthal built **gliders** with big curved wings like a bird’s. He ran down a hill, jumped, and glided

through the air! He made about two thousand glides. He wrote down what he learned so that others could learn too.

Why does it work? When you throw a paper airplane, its wings move through the air. The wings are tilted up a little at the front. They push air down, and the air pushes the wings up. That push is called **lift**. The airplane slowly glides down to the floor.

How do builders use it? A good glider is balanced. If the **nose** is too light, it swoops up and stalls. If the nose is too heavy, it dives. Airplane engineers test and change their designs until they fly smoothly. You can do it too: a paper clip on the nose changes the balance.

PICTURE STUDY



Otto Lilienthal in Flight, Richard Neuhauss, June 29, 1895 · Photograph

Image: [Wikimedia Commons](#), public domain

This photograph shows Otto Lilienthal gliding on wings he built himself. He hung under the wings and steered by swinging his legs.

Look closely

- Find Otto Lilienthal. Where is he hanging?
- Look at the wings. Are they flat or curved?
- What do the wings look like? A bird? A bat?
- Find the crowd of people watching.

Talk about it

1. How is Lilienthal's glider like your paper airplane?
2. Why do you think he wrote down what happened on each glide?

Safety first. Never throw a paper airplane at a person's face. Fly in a hallway, a big room or outside.

BUILD

The Paper Airplane Distance Test

You will fold a paper airplane, fly it three times and measure how far it goes. Then you will change one thing, a paper clip on the nose or bent-up wing tips, and see if it flies farther.

You will need

- Printer paper
- Paper clips
- Masking tape for a start line
- A tape measure
- Engineer's notebook

Steps

1. With a grown-up, fold a simple dart airplane, as in the video.
2. Put a strip of tape on the floor as the throwing line.
3. **Guess.** How far will it fly? Point to a spot.
4. Throw it gently and straight from the line, three times. A grown-up measures each flight with the tape measure. Write the numbers.
5. **Change one thing.** Add a paper clip to the nose. Fly it three more times and measure.
6. **Fair test.** Throw from the same line, the same way, with the same airplane. Only the paper clip changes.
7. Circle your longest flight.
8. **Make it better.** Try one more change: bend the back edges of the wings up a little, or fold a new plane with wider wings. Fly and measure.

Tips

- A gentle, level throw flies farther than a hard throw.
- Make your folds sharp and even on both sides.

Check your work

- ☐ I can fold a paper airplane and measure its flight.

- I can tell what change made my airplane fly farther.

ENGINEER'S NOTEBOOK

1. Draw your airplane from the top and from the side. Label the nose and the wings.
2. Make a chart of your flights: without a clip and with a clip.

From history. Otto Lilienthal's brother Gustav helped him build his gliders. The Wright brothers read Lilienthal's writings and used his measurements to begin their own work.

COMMON MISTAKES

- Throwing hard. Paper airplanes fly best with a smooth, gentle push.
- Changing two things at once. Change only one thing between tests.

Make it a game • Paper Plane Footsteps. Fold a paper airplane and fly it down the hall. Walk to where it landed using heel-to-toe steps, and count aloud. Guess first how many steps it will go, then compare. Make one change, like a bent nose or wing, and fly again. Who is closer to their guess, you or your parent?

7.3 KITES RIDE THE WIND

OBJECTIVES

- Tell how the wind holds up a kite.
- Build a simple paper kite with a tail.
- Test how the tail's length changes how steady the kite flies.

Warm-up. Hold a sheet of paper by one corner in front of a fan or out a car window (with a grown-up) or in the wind outside. Tilt it a little. What does the wind do? Now tie a string to a paper plate and run with it.

WATCH

Let's Make a Kite! | Science Project for Kids

SciShow Kids · 4:30

https://www.youtube.com/watch?v=mc3AUuuj9_I

WHEN TO WATCH

Before the build. Watch how Jessi makes her kite.

BACKUP VIDEO

How does a Kite work? 🦋 Maddie's Do You Know 🧑

Maddie's Do You Know? · 4:46

https://www.youtube.com/watch?v=ij_z3IJ_Ago

Later in the week, before flying your kite outside.

KEY TERMS

kite

A light frame covered with paper or cloth that flies on a string in the wind.

tail

A long strip on the bottom of a kite that keeps it steady.

string

The line that holds the kite. Its pull keeps the kite tilted into the wind.

CORE IDEAS

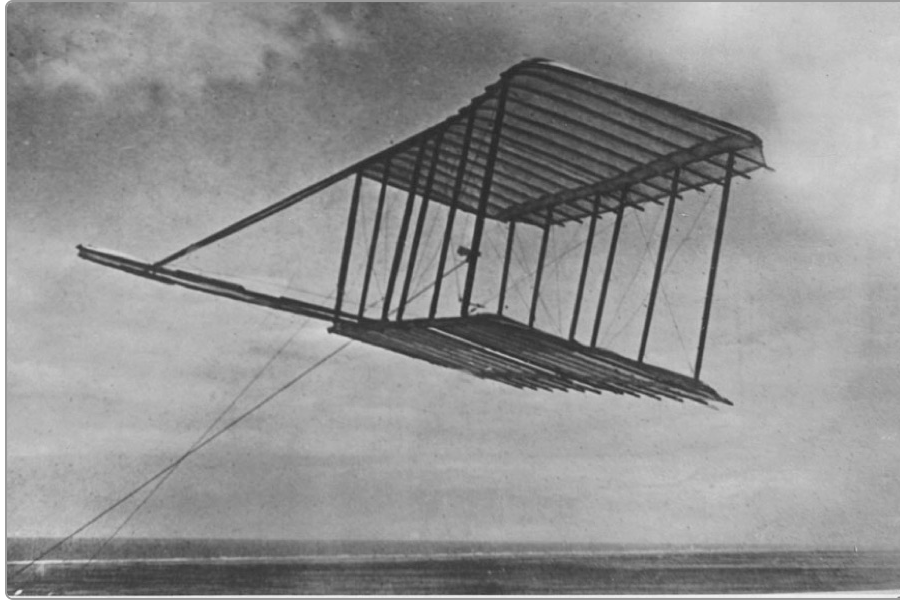
Long ago. People have flown kites for a very long time. In 1900, Wilbur and Orville Wright built a big glider with two wings. Before anyone rode on it, they flew it like a

kite on the windy sand hills of Kitty Hawk, North Carolina. They held strings and watched how it flew. They learned how to control it without anyone getting hurt.

Why does it work? A kite is tilted into the wind. The wind pushes on the kite. The **string** pulls back. Together they push the kite up and up. The **tail** hangs down and keeps the kite pointed the right way, so it does not spin.

How do builders use it? The Wrights tested on kites first because it was safe and cheap. Engineers still test new ideas on small models before building the big thing. A kite is also a good wind tester: when the kite flies high, the wind is strong.

PICTURE STUDY



The Wright Glider Flown as a Kite, Wilbur or Orville Wright, 1900 · Glass-plate photograph · Library of Congress, Wright Brothers Collection

Image: [Wikimedia Commons](#), public domain

The Wright brothers took this photograph at Kitty Hawk in 1900. Their glider is flying on strings like a kite. No one is riding it yet.

Look closely

- Find the two wings, one above the other.
- Find the strings. Where do they go?
- Find the sand. Why was sand a good place to test a glider?
- Is the glider flat or tilted?

Talk about it

1. Why did the Wrights fly their glider as a kite before riding on it?
2. What do you think they learned from this test?

Safety first. Fly kites only in a wide, open field or park, far from power lines, roads and trees. Never fly a kite in rain or when thunder can be heard. If a kite gets caught in a power line, let go of the string and tell a grown-up.

BUILD

A Paper Sled Kite and the Tail Test

You will build a simple paper kite and test it in front of a box fan or in the wind outside with no tail, a short tail and a long tail.

You will need

- A sheet of printer paper or a paper grocery bag
- Two straight drinking straws or thin wooden dowels
- Tape and a hole punch
- String (about 3 meters, or 10 feet) and a stick or cardboard tube to wind it on
- Crepe paper or ribbon for the tail
- A box fan (indoors) or a breezy day (outdoors)
- Engineer's notebook

Steps

1. With a grown-up, fold the paper and tape the two straws on it as the frame, as in the video.
2. Punch a hole near the front corner (with tape on it to make it strong) and tie on the string.
3. **Guess.** Will the kite fly better with no tail, a short tail or a long tail?
4. **No tail.** Hold the string and let the fan's wind (or the outside wind) catch the kite. Count how many seconds it flies before it spins or falls.
5. **Short tail.** Tape on a tail as long as your arm. Test again and count.
6. **Long tail.** Make the tail twice as long. Test again and count.
7. **Fair test.** Same kite, same fan speed and distance (or the same place outside). Only the tail changes.
8. **Make it better.** If the kite still spins, move the string hole or add a second tail. Then fly it outside in an open field.

Tips

- A grown-up holds the fan steady; keep fingers and string away from the blades.
- Outside, stand with your back to the wind and let the kite go up out of your hand.

Check your work

- ☐ I can tell how the wind and string hold up a kite.
- ☐ I can tell which tail made my kite steadiest, and I know the power line rule.

ENGINEER'S NOTEBOOK

1. Draw your kite in the sky with arrows for the wind and the string.
2. Draw the three tails and write how many seconds the kite flew with each.

From history. In 1899, before building their glider, Wilbur Wright flew a small kite with two wings, about five feet wide, to test his idea for twisting the wings to steer. It worked, and the brothers kept the idea for every airplane they built.

COMMON MISTAKES

- Running too fast with the kite. Let the wind do the work.
- Flying near trees or power lines. Always pick an open field.

Make it a game • Kite Tail Test. Fold a paper kite and run with it across the yard or hall. Fly it once with no tail, then once with a long tail. Tell your parent which flew steadier. Then play Kite Says, where your parent says kite up, kite down or kite dive, and you act it out with the kite.

7.4 THE WRIGHT BROTHERS' FIRST FLIGHT

OBJECTIVES

- Tell the story of the Wright brothers' first flight on December 17, 1903.
- Measure 120 feet and count 12 seconds to see how far and how long the first flight was.
- Fly a paper glider and compare it with the Wright Flyer.

Warm-up. Ask: Have you ever been on an airplane, or seen one in the sky? Who do you think made the very first airplane? Then count to twelve slowly together. That is how long the first airplane flight lasted.

WATCH

Biography of the Wright Brothers for Children: Orville and Wilbur Wright for Kids - FreeSchool

Free School · 7:28

<https://www.youtube.com/watch?v=Qt3pry6cWJM>

WHEN TO WATCH

After the story. It uses the Wrights' own photographs.

Note: This covers the brothers' whole lives, so it is a little long for a five-year-old; you may stop after the first flight.

KEY TERMS

airplane

A flying machine with wings and an engine.

engine

A machine that makes power to turn the propellers.

propeller

Spinning blades that push air back and pull the airplane forward.

CORE IDEAS

Long ago. Wilbur and Orville Wright were brothers from Dayton, Ohio. Their father was a bishop, and their home was full of books. When they were boys, their father brought home a little toy flying machine with a rubber band. They played with it

until it broke, and then they built their own. When they grew up, they ran a bicycle shop. But they kept dreaming of flying.

How they figured it out. The Wrights worked carefully, one step at a time. First they flew kites. Then they built gliders and flew them on the sand hills of Kitty Hawk. When their gliders did not lift as well as they expected, they built a wind tunnel, a box with a fan, and tested about two hundred little wings. Then they built an **engine** and **propellers**.

The first flight. On December 17, 1903, on a cold, windy morning, Orville lay on the wing of their **airplane**, the Flyer. The engine roared. The Flyer rolled along a wooden rail and rose into the air! It flew for 12 seconds and went 120 feet. That day they made four flights. The longest went 852 feet.

How do builders use it? Every airplane today has wings, an engine and a way to steer, just like the Flyer. Airplane engineers still test with models and wind tunnels, the way the Wrights did. The brothers never gave up, and they wrote down everything they learned.

PICTURE STUDY



The First Flight, John T. Daniels, December 17, 1903 · Glass-plate photograph · Library of Congress

Image: [Wikimedia Commons](#), public domain

This is one of the most famous photographs ever taken. A man named John Daniels from the nearby lifesaving station had never used a camera before. Orville set up the camera and asked him to squeeze the bulb if the Flyer took off. He did, just at the right moment!

Look closely

- Find Orville lying on the wing.
- Find Wilbur standing on the sand. What is he doing?
- Find the wooden rail the Flyer rolled along.
- Find the two wings, one above the other.
- Is the Flyer high up or low over the sand?

Talk about it

1. How do you think Wilbur felt as he watched?
2. Why do you think the brothers flew on a windy beach?

Safety first. Measure the 120 feet on a sidewalk, a park path or a field, not in a street.

BUILD

How Far Is 120 Feet?

You will measure 120 feet, the length of the first flight, and walk it while counting to 12. Then you will fly your best paper glider and see how its flight compares.

You will need

- A long tape measure (or a 10-foot string to measure with twelve times)
- Two cones, shoes or sticks for markers
- A stopwatch, or a grown-up who counts seconds
- Your best paper airplane from Lesson 7.2
- Engineer's notebook

Steps

1. Outside, put a marker at the start. A grown-up helps measure 120 feet with the tape measure (or 12 lengths of the 10-foot string). Put a marker at the end.
2. **Guess.** How many of your steps is 120 feet?
3. Walk from start to end and count your steps. Write the number.
4. Now walk it again while a grown-up counts 12 seconds. Can you walk it in 12 seconds, or do you need to jog? The Flyer went that far in 12 seconds!
5. Fly your paper airplane three times from the start marker. Measure each flight.
6. How many of your paper airplane flights would it take to cover 120 feet?
7. **Make it better.** Try to make your paper airplane fly even farther than last time. Measure and write it down.

Tips

- Count steps out loud together.
- Fly the paper airplane with the wind at your back.

Check your work

- ☐ I can tell the date, the time and the distance of the first flight.

- ☐ I can tell how far my paper airplane flew compared to the Flyer.

ENGINEER'S NOTEBOOK

1. Draw the Wright Flyer taking off, with Orville on the wing and Wilbur watching.
2. Write how many steps 120 feet was for you, and how far your best paper airplane flew.

From history. The 1903 Wright Flyer now hangs in the Smithsonian National Air and Space Museum in Washington, D.C. In 1969 Neil Armstrong carried a small piece of its wing fabric with him to the Moon.

COMMON MISTAKES

- Thinking the first flight was long and high. It was short and low, but it was the first time a machine with an engine flew with a pilot and landed safely.
- Thinking the Wrights got it right the first time. They tested and changed their designs for four years.

Make it a game • 120 Feet Wright Walk. Pretend to be Orville Wright. Use giant steps to measure 120 feet, which is about 40 big grown-up steps, and mark the end with a shoe. Then count 12 seconds out loud while you run forward with your arms out like wings. Say the date, the Wright brothers and the word propeller.

UNIT 7

FLIGHT

People have always watched birds and wished they could fly. In this unit your child will look closely at how birds use their wings, fold and test paper airplanes, build a kite that rides the wind, and hear the true story of Wilbur and Orville Wright, two brothers who built the first airplane that really flew, on December 17, 1903.

Every build is a flight test: dropping, gliding, flying and measuring how far or how long. Your child will guess, test, measure with a tape measure or count seconds, and then make it fly better. That is exactly how the Wright brothers worked. “They shall mount up with wings as eagles” (Isaiah 40:31).

PREREQUISITES

- Can count to 20, and count seconds with help
- Knows that wind is moving air (Lesson 6.3)
- Can fold paper along a line

MASTERY CHECKLIST

- ☐ I can tell how birds use their wings to fly and glide.
- ☐ I can fold a paper airplane, measure how far it flies and make it fly farther.
- ☐ I can tell how a kite uses the wind, and I know never to fly one near power lines.
- ☐ I can tell the story of the Wright brothers’ first flight.

OPTIONAL KITS FOR THIS UNIT

- **KiwiCo Kiwi Crate**: A monthly box of hands-on science and building projects for ages 5–8, with picture instructions a young child can follow with help. Topics change from month to month. Optional for any unit.

Not required. Every project in this unit can be built with household materials. School Launch has no ties to these companies.

LESSONS IN THIS UNIT

7.1 How Birds Fly

2 sessions of 30 minutes

7.2 Paper Airplanes

2 sessions of 30 minutes

UNIT 7 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. Show me how a bird flaps and how it glides.
2. Fold a paper airplane. What can you change to make it fly better?
3. What holds a kite up in the sky?
4. Where should you never fly a kite?
5. Who made the first airplane flight? When and where?
6. How did the Wright brothers learn to fly?

ANSWER KEY

1. Flapping: arms pushing down and up. Gliding: arms held out wide and still.
2. Add a paper clip to the nose, make the folds even, bend up the back of the wings, or throw it more gently.
3. The wind pushing on the tilted kite while the string pulls.
4. Near power lines, roads or trees, or in a storm.
5. Wilbur and Orville Wright; December 17, 1903; at Kitty Hawk, North Carolina.
6. They tested kites, then gliders, then a wind tunnel, wrote everything down and kept improving.

PORTFOLIO PIECE: MY BEST FLYER

Choose your best paper airplane or kite. Fly it at least three times, measure each flight, and then make one change to make it better. Show your family how it flies, tell them about the Wright brothers, and keep your flight chart and a photo in your portfolio folder.

LOOK FOR	WHAT IT MEANS
Measured	Measured at least three flights with a grown-up’s help.
Changed one thing	Changed only one thing between tests.
Made it better	The new version flew farther or steadier, or the child can tell why it did not.
Told the story	Told who the Wright brothers were and what they did.

UNIT 8

ROBOTS AND INVENTORS

A robot is a machine that can sense, think and act. In this unit your child will find out what makes a robot a robot, give a grown-up “robot” step-by-step instructions (the first step in learning to code), build a cardboard grabber like a robot arm, and finish the year with a family invention fair.

We meet the rover Sojourner on Mars, Joseph-Marie Jacquard’s loom that followed a program of punched cards, the Canadarm that worked in space, and Bezalel, the craftsman God filled with skill to build the tabernacle. The fair at the end is a time to show the best build from each unit, tell what was learned, and thank God for the good minds He gives.

PREREQUISITES

- Knows left and right (or can learn with a sticker on one hand)
- Has notebook pages and photos from Units 1–7 for the fair
- Can follow and give simple directions

MASTERY CHECKLIST

- ☐ I can tell what a robot is: a machine that senses, thinks and acts.
- ☐ I can give clear step-by-step directions and fix a mistake in them.
- ☐ I can build a grabber and test what it can pick up.
- ☐ I can plan, build, test and improve an invention and show it at the fair.

OPTIONAL KITS FOR THIS UNIT

- **Bee-Bot:** A small bee-shaped floor robot made by TTS for young children. You press arrow buttons to give it a list of steps, then press Go. Fits Lesson 8.2 very well.
- **KiwiCo Kiwi Crate:** Monthly hands-on building projects for ages 5–8. Some crates include simple machines and moving parts that fit Lessons 8.3 and 8.4.

Not required. Every project in this unit can be built with household materials. School Launch has no ties to these companies.

LESSONS IN THIS UNIT

8.1 What Is a Robot?

2 sessions of 30 minutes

8.2 Step-by-Step Instructions for a Grown-Up Robot

2 sessions of 30 minutes

8.3 A Cardboard Grabber

2 sessions of 30 minutes

8.4 Our Invention Fair

2 sessions of 30 minutes

UNIT 8 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. What three things does a robot do?
2. Name a robot that helps people.
3. Give me three arrow steps to walk to the door. (The parent follows them exactly.)
4. What is a bug in a program?
5. Show me your grabber. What did you do to make it grip better?
6. Tell the engineer's steps.

ANSWER KEY

1. It senses, thinks (decides) and acts.
2. Any good answer: a robot vacuum, a factory robot arm, a Mars rover, the Canadarm.
3. Any program that works; if it does not, the child finds the bug and fixes it.
4. A mistake in the steps.
5. For example, added rubber bands or tape to the jaws.
6. Ask, imagine, plan, build, test, improve.

PORTFOLIO PIECE: THE FAMILY INVENTION FAIR

Hold a family invention fair. Show your helper invention and your best build from each unit, with its notebook page. Explain to your guests how one of them works and what you changed to make it better. Keep a photo of the fair and your invention page as the last page of your portfolio folder.

LOOK FOR	WHAT IT MEANS
Used the steps	Asked, imagined, planned, built, tested and improved the invention.
Tested it	Counted how many times out of five it worked, before and after improving it.
Helps someone	Could tell who the invention helps and how.
Told about it	Explained at least one build clearly to a guest.

8.1 WHAT IS A ROBOT?

OBJECTIVES

- Tell the three things a robot does: sense, think and act.
- Name robots that help people, at home, in factories and on Mars.
- Play a robot game and count how many times the “robot” follows its rule.

Warm-up. Play a guessing game: Is it a robot? A toaster? A robot vacuum? A teddy bear? A car that parks itself? A wind-up toy? Talk about each one. Can it sense? Can it decide? Can it move?

WATCH

Real-Life Robots

[SciShow Kids](https://www.youtube.com/watch?v=8wHjLMnikU) · 4:08

<https://www.youtube.com/watch?v=8wHjLMnikU>

WHEN TO WATCH

After the core ideas. Watch for the rovers on Mars.

KEY TERMS

robot

A machine that can sense what is around it, decide what to do, and act by itself.

sensor

A part of a robot that notices things, like a camera that sees or a bumper that feels.

rover

A robot car that explores a faraway place, like Mars.

CORE IDEAS

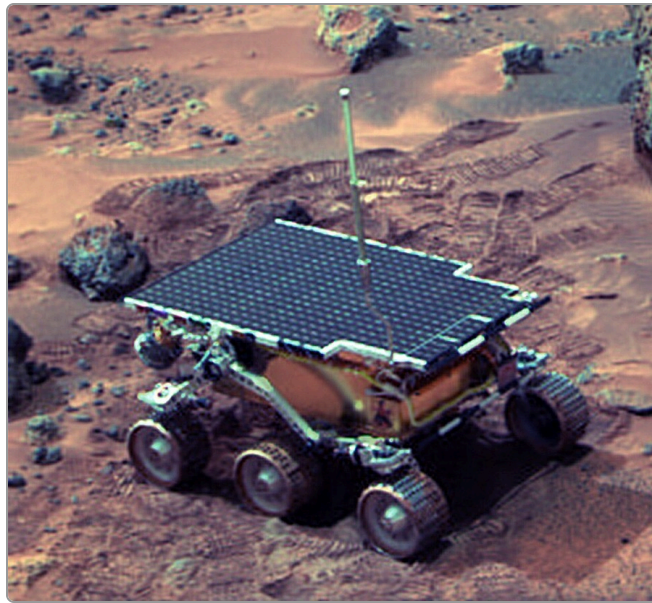
Long ago. In 1997 a little **rover** named Sojourner rolled off a spaceship onto the planet Mars. It was about the size of a toy wagon, with six wheels. It was the first rover ever to drive on Mars! It looked at rocks with its cameras and tested what they were made of.

How does a robot work? A **robot** does three things. It **senses**: cameras and **sensors** are like its eyes and ears. It **thinks**: a little computer inside follows rules that people

wrote. It **acts**: motors spin its wheels or move its arms.

How do builders use it? Engineers build robots to do jobs that are too hard, too boring or too far away for people. Robot vacuums clean floors. Robot arms build cars in factories. Rovers explore Mars. But robots only know what people teach them. God made people to think and create; robots only follow the rules we give them.

PICTURE STUDY



Sojourner on Mars, NASA / Jet Propulsion Laboratory, 1997 · Photograph from Mars · NASA
Image: [Wikimedia Commons](#), public domain

This picture was taken on Mars by the Pathfinder lander's camera. The little rover Sojourner has driven up to a rock to study it.

Look closely

- Find Sojourner. Count its wheels.
- Find the flat panel on top. It catches sunlight to make electricity.
- Find the rocks around it. What does Sojourner do with rocks?
- Find the wheel tracks in the dust.

Talk about it

1. Why did people send a robot to Mars instead of going themselves?
2. How does Sojourner sense, think and act?

BUILD

Be a Robot

You will build a cardboard “robot” costume or model with a sensor, a brain and movers. Then you will play a robot game: the robot must follow its rules exactly, and we will count how often it gets it right.

You will need

- A cardboard box (a cereal box or shoebox)
- Bottle caps, foil, paper tubes and tape
- Markers
- Red, green and yellow paper squares
- Engineer’s notebook

Steps

1. Build a robot from the box. Give it “sensors” (bottle-cap eyes), a “brain” (draw a little computer inside a flap) and “movers” (paper-tube arms or wheels).
2. Label the parts with your grown-up: sense, think, act.
3. **Robot game.** Now you are the robot! Your rules: green means walk, red means stop, yellow means turn around.
4. A grown-up holds up colors one at a time. You sense the color, think of the rule and act.
5. **Count.** Out of ten colors, how many did the robot get right? Write the number.
6. **Switch:** you hold up the colors and the grown-up is the robot.
7. **Make it better.** Add a new rule (for example, blue means clap). Play again. Did the robot still get ten out of ten?

Tips

- A good robot does exactly what the rule says, nothing more.
- Go slowly at first, then faster.

Check your work

- ☐ I can tell what sense, think and act mean.

- ☐ I can name a robot that helps people.

ENGINEER'S NOTEBOOK

1. Draw your robot and label its sensor, brain and movers.
2. Draw a robot you would like to invent. What job would it do?

From history. Sojourner was planned to work for about a week, but it kept going for nearly three months. Since then, larger rovers named Spirit, Opportunity, Curiosity and Perseverance have explored Mars.

COMMON MISTAKES

- Thinking any machine is a robot. A toaster acts, but it does not sense and decide by itself.
- Thinking robots are alive or can think like people. They follow rules that people wrote.

Make it a game • Be a Robot Game. You are the robot and your parent is the boss. A robot does three things: sense, think and act. Your parent claps, which you sense, then you stop and think, then you act by doing a silly move. Say each of the three words each round. Then name three robots that help people, even one on Mars.

8.2 STEP-BY-STEP INSTRUCTIONS FOR A GROWN-UP ROBOT

OBJECTIVES

- Tell what a program is: a list of steps in the right order.
- Give a grown-up “robot” step-by-step arrow directions to reach a treasure.
- Find and fix a mistake, called a bug.

Warm-up. Ask your child to tell you how to brush your teeth, one step at a time, while you do exactly what you are told and nothing more. (If they forget “put toothpaste on the brush,” brush with no toothpaste!) Laugh together, then talk: Why does the order of the steps matter?

WATCH

What is Sequence? | Coding for Kids | Kodable

Kodable · 2:48

https://www.youtube.com/watch?v=v_Pc3UnePZY

WHEN TO WATCH

After the warm-up. It shows hand-washing as a list of steps.

Note: Made by a company that sells a coding app; you do not need the app for this lesson.

KEY TERMS

program

A list of steps that tells a machine what to do, in order.

sequence

The order of the steps. First, next, then, last.

bug

A mistake in a program. Fixing it is called debugging.

CORE IDEAS

Long ago. More than two hundred years ago, in France, a weaver named Joseph-Marie Jacquard built a loom that could weave beautiful pictures into cloth all by itself. How did it know what to do? It followed a long chain of cards with holes

punched in them. Each card told the loom which threads to lift for one row. Change the cards, and the loom wove a new picture!

Why does it work? Jacquard's cards were a **program**: a list of steps in order. Robots and computers follow programs too. They do exactly what the steps say, in the **sequence** they are given. They cannot guess what you meant.

How do builders use it? People who write programs are called programmers. They write the steps very carefully. Then they test the program. If the robot does something wrong, there is a **bug** in the program. The programmer finds the wrong step and fixes it, then tests again.

PICTURE STUDY



A Portrait Woven by Jacquard's Loom, Woven by Michel-Marie Carquillat, after a painting by Claude Bonnefond, 1839 · Woven silk · Library of Congress

Image: [Wikimedia Commons](#), public domain

This picture looks like a drawing, but it is woven from silk thread on a Jacquard loom! The loom followed a program of thousands of punched cards, one card for each row of threads.

Look closely

- Find Jacquard. What is he holding in his hand?
- Find the papers and tools around him.
- Look closely at the tiny lines and shadows. Each one is made of threads.
- Find the words at the bottom. They say “In memory of J. M. Jacquard.”

Talk about it

1. How could a machine weave a picture this detailed?
2. What would happen if one card were put in the wrong order?

BUILD

Program the Grown-Up Robot

You will make a grid on the floor, hide a “treasure,” and write a program of arrow cards to guide a grown-up “robot” to it. Then you will find and fix the bugs.

You will need

- Masking tape to make a 5×5 grid of squares on the floor (each square about one big step)
- Index cards with arrows drawn on them: forward, turn left, turn right
- A small toy for the treasure
- Engineer’s notebook

Steps

1. With a grown-up, tape a grid of squares on the floor.
2. The grown-up robot stands in a corner square, facing forward. Put the treasure in another square.
3. **Plan.** Lay arrow cards in a line on the floor or table: one card for each step. Forward means one square forward. Turn left and turn right mean turn in place.
4. **Guess.** Will your program get the robot to the treasure?
5. **Test.** Read the cards one at a time. The robot does exactly what each card says.
6. If the robot misses, find the bug. Which card is wrong? Change it and test again. Count how many tries it took.
7. **Make it better.** Move the treasure and write a new program. Can you get it right on the first try? Can you do it with fewer cards?

Tips

- The grown-up robot should be silly and do exactly what is said, nothing more.
- Put a sticker on the child’s right hand to help with left and right.

Check your work

- ☐ I can write a program of arrow steps.
- ☐ I can find a bug and fix it.

ENGINEER'S NOTEBOOK

1. Draw the grid, the robot's start and the treasure. Draw your arrows on the path.
2. Write how many tries it took to get the program right.

From history. Jacquard showed his loom in 1801. Years later, an English inventor named Charles Babbage planned a calculating machine that would use punched cards like Jacquard's. He even owned one of these woven silk portraits.

COMMON MISTAKES

- Forgetting that a turn does not move the robot forward. Turn, then forward.
- Mixing up left and right. Try standing next to the robot and facing the same way.

Make it a game • Treasure Arrow Program. Hide a toy treasure and give your parent a list of arrow steps to find it: forward, turn, forward. Say the steps in the right order. Your parent walks only what you say. If the robot bumps a chair, it is a bug. Fix it by changing the steps, and try again.

8.3 A CARDBOARD GRABBER

OBJECTIVES

- Tell how a robot arm reaches and grabs things.
- Build a cardboard grabber that stretches out and closes.
- Test what it can pick up and make its grip better.

Warm-up. Pick up a cotton ball, a block and a spoon with your fingers. Now try with two spoons, then with kitchen tongs. Which tool works best for each one? Why?

WATCH

STEAM Handbook Extending Grabber! Science and Engineering Project Idea for Kids

STEM Inventions • 4:02

https://www.youtube.com/watch?v=aNUkqJ_xOq8

WHEN TO WATCH

Before the build. A grown-up may want to watch it first to see how the strips join.

Note: The video ends with a short advertisement for the presenter's book.

BACKUP VIDEO

Science Alive! Episode 1: The Canadarm

Canada Aviation and Space Museum • 3:54

<https://www.youtube.com/watch?v=zCc0OFsAhUc>

For a grown-up or an older brother or sister: a museum curator and an astronaut look at a real Canadarm.

KEY TERMS

robot arm

A machine arm with joints that can bend, reach and grab.

joint

A place where two parts are joined so they can bend or turn, like your elbow.

gripper

The “hand” at the end of a robot arm that holds things.

CORE IDEAS

Long ago. In 1981, the Space Shuttle Columbia flew into space with a new kind of **robot arm**, built by engineers in Canada. It was called the Canadarm. It was longer than a school bus. Astronauts inside the shuttle used it to reach out, grab satellites and move heavy things in space.

Why does it work? An arm needs **joints** so it can bend, like your shoulder, elbow and wrist. A grabber made of crossed strips works like a folding gate. When you squeeze the handles, all the X shapes open together and the grabber stretches far out. When you pull them apart, it pulls back.

How do builders use it? Engineers choose the right **gripper** for each job. A soft gripper picks up eggs. Strong claws lift heavy metal. Some grippers use suction cups. They test each gripper on many things and keep improving it.

PICTURE STUDY



Two Robot Arms Shake Hands in Space, NASA, April 28, 2001 · Photograph · NASA

Image: [Wikimedia Commons](#), public domain

In space, two robot arms worked together. The new arm on the Space Station handed a load to the arm on the Space Shuttle. Astronauts called it a robot handshake! Here you can see the arm holding the load.

Look closely

- Find the robot arm. Can you find the word “Canada” on it?
- Find the joints where the arm can bend.
- Find the load the arm is holding.
- Look at the background. Why is it black?

Talk about it

1. Why do astronauts use robot arms instead of carrying things by hand?
2. How is your grabber like these arms?

Safety first. A grown-up pokes the holes in the cardboard with a sharp pencil or a skewer. Point the grabber away from faces.

BUILD

The Grabber Test

You will build a stretching grabber from cardboard strips and paper fasteners, test it on five things and make its grip better.

You will need

- Six strips of stiff cardboard, each about as long as your forearm and two fingers wide
- About eight brass paper fasteners (brads)
- A sharp pencil or skewer (for the grown-up)
- Rubber bands, sandpaper or tape for grippy tips
- Five test objects: a cotton ball, a block, a paper cup, a sock and a spoon
- Engineer's notebook

Steps

1. A grown-up pokes a hole in the middle and at each end of every strip.
2. Cross two strips in an X and join them in the middle with a paper fastener. Make three X's.
3. Join the X's end to end with paper fasteners, as in the video. The first X's ends are the handles; the last X's ends are the jaws.
4. Squeeze the handles. Does it stretch out? Pull them apart. Does it pull back?
5. **Guess.** Which of the five things will it pick up?
6. **Test.** Try to pick up each thing and carry it to a bowl. Make a tally: yes or no.
7. **Fair test.** Put each thing the same distance away. Try each one three times.
8. **Make it better.** Wrap rubber bands or tape (sticky side out) around the jaws. Test again. Can it pick up more things now?

Tips

- Do not push the fasteners in too tight, or the strips will not move.
- If the jaws do not meet, trim the last two strips.

Check your work

- ☐ I can show the joints on my grabber.

- ☐ I can tell how I made my grabber pick up more things.

ENGINEER'S NOTEBOOK

1. Draw your grabber stretched out and pulled in.
2. Make a chart of the five things: yes or no, before and after you made the grip better.

From history. The Canadarm worked on 90 space shuttle flights over thirty years, from 1981 to 2011. Its larger cousin, Canadarm2, still works on the International Space Station today, catching cargo ships when they arrive.

COMMON MISTAKES

- Fastening the brads so tight that the X's cannot open and close.
- Changing the grabber and the objects at the same time. Change one thing.

Make it a game · Grabber Pickup Challenge. Use your cardboard grabber to pick up small things like a sock, a cup or a ball, and set a one-minute timer. Count how many it can move to a bowl. Then use your hand as a robot arm and say the words joint and gripper. Make one change to your grabber and beat your score.

8.4 OUR INVENTION FAIR

OBJECTIVES

- Use the engineer's steps: ask, imagine, plan, build, test and improve.
- Invent a simple machine that helps someone at home.
- Show your inventions and your best builds from the year at a family fair.

Warm-up. Spread out all your notebook pages and photos from the year. Look back together: the ramp, the bridges, the towers, the battery light, the boats, the paper airplanes, the grabber. Which build was your favorite? Which one did you have to fix the most?

WATCH

Think Like an Engineer: The BEST Solution! | SciShow Kids

SciShow Kids · 5:23

<https://www.youtube.com/watch?v=taOokuzR2EI>

WHEN TO WATCH

Before the build. The friends test rafts, compare them and choose the best one.

KEY TERMS

invention

Something new that someone made up to solve a problem.

inventor

A person who makes an invention.

improve

To make something better after testing it.

CORE IDEAS

Long ago. When God told Moses to build the tabernacle, He chose a man named Bezalel to lead the work. The Bible says God filled Bezalel with wisdom and skill in all kinds of work: gold, silver and brass, cutting stones and carving wood. God gives people good minds and skillful hands so we can make things that help others and honor Him.

How do inventors work? This year you learned the engineer's steps. **Ask:** what is the problem? **Imagine:** think of ideas. **Plan:** draw it. **Build** it. **Test** it. **Improve** it. Then test again! The Wright brothers, Bazalgette, Volta and the builders of the Golden Gate all worked this way.

Helping others. The best **inventions** help people. A ramp helps a person in a wheelchair. A bridge helps people cross a river. A light helps people see in the dark. When you invent, start by asking: Who could I help?

Show and tell. Engineers show their work to others and explain it. That is what you will do at your fair. *Fabricando fit faber:* by making, you become a maker.

PICTURE STUDY



A Philosopher Lecturing on the Orrery, Joseph Wright of Derby, About 1766 · Oil on canvas · Derby Museum and Art Gallery, England

Image: [Wikimedia Commons](#), public domain

An orrery is a machine that shows how the planets move around the sun. Here a teacher shows one to a group of children and grown-ups. The lamp in the middle stands for the sun. It is like a little science fair!

Look closely

- Find the orrery. What shapes do you see?
- Find the lamp in the middle. What does it stand for?
- Find the children. How do their faces look?
- Find the teacher. What is he doing with his hand?
- Find the man writing notes.

Talk about it

1. Why do you think everyone is so interested?
2. How will you show your inventions to your family at the fair?

BUILD

Invent a Helper and Hold a Fair

You will invent a simple machine that helps someone in your home, using the engineer's steps. Then you will set up a family invention fair with your invention and your best build from each unit.

You will need

- Boxes, paper tubes, string, tape, craft sticks, cups, rubber bands and other things from the year
- Your notebook pages and photos from Units 1–8
- A table and paper for signs
- Engineer's notebook

Steps

1. **Ask.** Interview someone in the family: What is a problem you have? (For example: "I can't reach the top shelf," "The dog's ball rolls under the couch," or "My keys get lost.")
2. **Imagine.** Think of three ideas. Draw them quickly.
3. **Plan.** Pick one. Draw it carefully and list what you need.
4. **Build.** Build your invention with a grown-up's help.
5. **Test.** Try it five times. Count how many times it works.
6. **Improve.** Change one thing and test it five more times. Did it work more often?
7. **The fair.** Set up a table with your invention and your best build from each unit, with a sign and a notebook page for each. Invite your family. Show them how each build works and tell what you learned.

Tips

- Keep the invention simple. A small idea that works is better than a big idea that does not.
- Practice telling about one build before the guests come.

Check your work

- ☐ I can tell the engineer's steps: ask, imagine, plan, build, test, improve.
- ☐ I can show my invention and tell how it helps someone.

ENGINEER'S NOTEBOOK

1. Draw your three ideas, and circle the one you built.
2. Draw your invention and write how many times out of five it worked, before and after you improved it.

From history. Joseph Wright painted many pictures of people doing science and building machines in England in the 1700s, at a time when new inventions such as steam engines and spinning machines were changing the way people worked.

COMMON MISTAKES

- Skipping the test. Every invention must be tested.
- Giving up when it does not work. Fix one thing and test again.

Make it a game • Invent a Helper Pitch. Be an inventor with a fair booth. Show your parent your invention, and use the six steps in order: ask, imagine, plan, build, test and improve. Your parent plays the customer and asks, how does it help? Answer in one sentence. Then name one change that would improve it, and tell it with a big smile.

Scripture. “And I have filled him with the spirit of God, in wisdom, and in understanding, and in knowledge, and in all manner of workmanship,” (Exodus 31:3, KJV)

God gave Bezalel skill to build. He gives us minds and hands to make good things that help others.

UNIT 8

ROBOTS AND INVENTORS

A robot is a machine that can sense, think and act. In this unit your child will find out what makes a robot a robot, give a grown-up “robot” step-by-step instructions (the first step in learning to code), build a cardboard grabber like a robot arm, and finish the year with a family invention fair.

We meet the rover Sojourner on Mars, Joseph-Marie Jacquard’s loom that followed a program of punched cards, the Canadarm that worked in space, and Bezalel, the craftsman God filled with skill to build the tabernacle. The fair at the end is a time to show the best build from each unit, tell what was learned, and thank God for the good minds He gives.

PREREQUISITES

- Knows left and right (or can learn with a sticker on one hand)
- Has notebook pages and photos from Units 1–7 for the fair
- Can follow and give simple directions

MASTERY CHECKLIST

- ☐ I can tell what a robot is: a machine that senses, thinks and acts.
- ☐ I can give clear step-by-step directions and fix a mistake in them.
- ☐ I can build a grabber and test what it can pick up.
- ☐ I can plan, build, test and improve an invention and show it at the fair.

OPTIONAL KITS FOR THIS UNIT

- **Bee-Bot:** A small bee-shaped floor robot made by TTS for young children. You press arrow buttons to give it a list of steps, then press Go. Fits Lesson 8.2 very well.
- **KiwiCo Kiwi Crate:** Monthly hands-on building projects for ages 5–8. Some crates include simple machines and moving parts that fit Lessons 8.3 and 8.4.

Not required. Every project in this unit can be built with household materials. School Launch has no ties to these companies.

LESSONS IN THIS UNIT

8.1 What Is a Robot?

2 sessions of 30 minutes

8.2 Step-by-Step Instructions for a Grown-Up Robot

2 sessions of 30 minutes

8.3 A Cardboard Grabber

2 sessions of 30 minutes

8.4 Our Invention Fair

2 sessions of 30 minutes

UNIT 8 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. What three things does a robot do?
2. Name a robot that helps people.
3. Give me three arrow steps to walk to the door. (The parent follows them exactly.)
4. What is a bug in a program?
5. Show me your grabber. What did you do to make it grip better?
6. Tell the engineer's steps.

ANSWER KEY

1. It senses, thinks (decides) and acts.
2. Any good answer: a robot vacuum, a factory robot arm, a Mars rover, the Canadarm.
3. Any program that works; if it does not, the child finds the bug and fixes it.
4. A mistake in the steps.
5. For example, added rubber bands or tape to the jaws.
6. Ask, imagine, plan, build, test, improve.

PORTFOLIO PIECE: THE FAMILY INVENTION FAIR

Hold a family invention fair. Show your helper invention and your best build from each unit, with its notebook page. Explain to your guests how one of them works and what you changed to make it better. Keep a photo of the fair and your invention page as the last page of your portfolio folder.

LOOK FOR	WHAT IT MEANS
Used the steps	Asked, imagined, planned, built, tested and improved the invention.
Tested it	Counted how many times out of five it worked, before and after improving it.
Helps someone	Could tell who the invention helps and how.
Told about it	Explained at least one build clearly to a guest.

TOY LAB

This is a bonus unit for after the fair, for the summer, or for any week that needs something fun. Your child will find the science hiding inside four favorite toys: the spinning top, the bouncing ball, the pinwheel and building blocks. We meet the people behind them, from Charles Goodyear, who learned how to make rubber stay bouncy, to Friedrich Froebel, who invented the kindergarten and its blocks, and the Danish carpenter who started LEGO.

Each lesson is a toy test. Your child will build or gather the toys, change one thing at a time, count or measure, and make the toy work better. Toy makers are engineers too: they think about how a toy works, how to make it strong and cheap, and how to keep small children safe. “The streets of the city shall be full of boys and girls playing” (Zechariah 8:5).

PREREQUISITES

- Has finished most of Units 1–8 (or does this unit any time with a grown-up)
- Can count seconds with help
- Can use a ruler or tape measure with help

MASTERY CHECKLIST

- ☐ I can make a top and find out what makes it spin longest.
- ☐ I can test which ball bounces highest and tell why balls bounce.
- ☐ I can make a pinwheel and show how wind turns it.
- ☐ I can tell how Froebel’s blocks and LEGO bricks began, and show why bricks that lock together stay up better.

OPTIONAL KITS FOR THIS UNIT

- **LEGO DUPLO:** Large interlocking bricks made for small hands, and safer for homes with toddlers than small bricks. Fits Lesson 9.4.
- **KEVA Planks:** Plain wooden planks that do not lock together, the opposite of LEGO bricks. Good for comparing the two kinds of building in Lesson 9.4.

Not required. Every project in this unit can be built with household materials. School Launch has no ties to these companies.

LESSONS IN THIS UNIT

9.1 Spinning Tops	2 sessions of 30 minutes
9.2 Which Ball Bounces Highest?	2 sessions of 30 minutes
9.3 Pinwheels	2 sessions of 30 minutes
9.4 Building Blocks, from Froebel to LEGO	2 sessions of 30 minutes

UNIT 9 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. Why does a top stay up only while it spins?
2. Show me how to make a top spin longer.
3. Why does a rubber ball bounce but a play-dough ball does not?
4. Blow on your pinwheel. Why does it turn?
5. What does “kindergarten” mean, and who started it?
6. Why should babies not play with small toys like tiny balls or bricks?

ANSWER KEY

1. A spinning thing keeps spinning the same way and stays upright; when it slows and stops, it falls.
2. Put the point in the center, add weight near the edge, spin on a smooth surface.
3. Rubber squashes and springs back; play dough squashes and stays flat.
4. The wind pushes the slanted blades sideways, around in a circle.
5. “Children’s garden”; Friedrich Froebel.
6. They could swallow them and choke.

PORTFOLIO PIECE: MY TOY LAB SHOW

Choose your favorite toy from this unit: your champion top, your pinwheel, the winning bouncy ball or your brick tower. Show your family how it works, tell them about your test and your numbers, and explain what you changed to make it better. Keep a photo and your notebook page in your portfolio folder.

LOOK FOR	WHAT IT MEANS
Guessed first	Made a guess before each test.
Fair test	Changed only one thing and tested each version more than once.
Counted or measured	Counted seconds, turns or taps, or measured a height, with a grown-up's help.
Toy safety	Can tell why small toys are kept away from babies.

9.1 SPINNING TOPS

OBJECTIVES

- Tell why a top stays up only while it spins.
- Make a top from a paper plate or cardboard and a pencil.
- Test what makes a top spin longest and count the seconds.

Warm-up. Try to stand a pencil on its point. It falls! Now spin a coin on its edge on the table. Watch it wobble and fall. If you have a toy top, spin it too. Why do spinning things stay up?

WATCH

O Wow Moment: Science is the Tops

Children's Museum Houston • 4:04

<https://www.youtube.com/watch?v=i9OmA0nNXco>

WHEN TO WATCH

Before the build. Children at the museum make cardboard tops like yours.

BACKUP VIDEO

Make-Your-Own Spinning Top

Lakeshore Learning • 6:15

https://www.youtube.com/watch?v=Gi0_xLcAPqk

For a second way to make a top, with a coin for weight.

KEY TERMS

top

A toy that spins on a point.

spin

To turn around and around very fast.

friction

The rubbing that slows things down.

balance

When the weight is spread evenly, so the toy does not tip to one side.

CORE IDEAS

The story. Tops are one of the oldest toys in the world. Long ago, children spun tops made of wood, clay or stone. Nobody knows who made the first one. Children in many lands have played with them for thousands of years, and they still do!

How they figured it out. Toy makers learned by trying. A top with its point off to one side wobbles and falls. A top with its point right in the middle spins smoothly. A top that is heavier around its edge spins longer. They carved and turned their tops on a lathe until they were round and even.

Why does it work? A **spinning** thing wants to keep spinning the same way. That is why a top stays standing up while it turns, but falls when it stops. Rubbing, called **friction**, slowly takes away its spin. A smooth, sharp point and a smooth floor mean less friction and a longer spin.

How do toy makers use it? Toy makers put the point exactly in the center so the top has good **balance**. They put extra weight near the outside edge. They make tops big enough that a baby cannot swallow them, because small toys can make little children choke.

PICTURE STUDY



Child with a Top, François-Bernard Lépicie, after Jean Siméon Chardin, 1742 · Engraving · The Metropolitan Museum of Art, New York
Image: [Wikimedia Commons](#), public domain

This engraving copies a painting by the French artist Chardin. A boy has stopped his schoolwork to watch his top spin.

Look closely

- Find the top. Is it spinning or still?
- Find the boy's eyes. Where is he looking?
- Find the books and pen. What was he doing before?
- Look at the top's shape. Where is it widest?

Talk about it

1. How long do you think the top will spin?
2. What is the boy learning by watching his top?

Safety first. A grown-up pokes the pencil hole. Keep small tops, coins and pennies away from babies and toddlers; they can cause choking.

BUILD

The Top Spin Test

You will make a top from a cardboard circle and a pencil and count how many seconds it spins. Then you will change one thing at a time to make it spin longer.

You will need

- Stiff cardboard or paper plates
- Something round to trace: a small cup and a big bowl
- A short, sharpened pencil
- Pennies and tape
- A stopwatch, or a grown-up who counts seconds
- A smooth table or floor
- Engineer's notebook

Steps

1. Trace a circle around the cup and cut it out. A grown-up pokes the pencil through the very center, point down, so a little point sticks out the bottom.
2. Spin the top three times. Count the seconds each time. Write the numbers.
3. **Guess.** Will a bigger circle spin longer or shorter?
4. Make a big circle from the bowl and test it the same way.
5. **Pennies.** Tape four pennies near the outside edge of the big top, spread evenly. Test it. Then move them close to the pencil and test again.
6. **Fair test.** Spin each top the same way, on the same table. Spin each three times. Only one thing changes each time.
7. Color a bar chart of your tops.
8. **Make it better.** Design your champion top and see if it can beat your best time.

Tips

- If the top wobbles, check that the pencil is straight and in the very center.
- Twist the pencil between your thumb and finger and let go.

Check your work

- ☐ I can tell why a top stays up while it spins.
- ☐ I can tell what made my top spin longest, and show my numbers.

ENGINEER'S NOTEBOOK

1. Draw your small top, big top and penny top. Write how many seconds each one spun.
2. Draw a top with curly lines to show it spinning.

From history. Old tops have been found in many places, from ancient Egypt to China to the Americas. Some tops are kept spinning by tapping them with a little whip; others are started by pulling a wound-up string. Children have played with both kinds for hundreds of years.

COMMON MISTAKES

- Putting the pencil off center. The top will wobble and fall.
- Spinning harder for one top than another. Spin each the same way.

Make it a game · Top Spin Stopwatch. Spin your cardboard top on a table and count out loud how many seconds it stays up. Your parent keeps score on paper. Then wobble it with your finger to make it stop, and say friction. Make the top flatter or lighter and spin again. Try to beat your best count, and say why it falls when it slows.

Scripture. “And the streets of the city shall be full of boys and girls playing in the streets thereof.” (Zechariah 8:5, KJV)

God loves to see children play. Playing with toys is a good gift, and it can teach us how His world works.

9.2 WHICH BALL BOUNCES HIGHEST?

OBJECTIVES

- Tell why a ball bounces: it squashes and springs back.
- Drop four kinds of balls from the same height and measure each bounce.
- Test how the floor changes the bounce.

Warm-up. Squeeze a soft rubber ball in your hand and let go. What does it do? Now squeeze a ball of play dough. Does it spring back? Drop each one on the floor. Which bounces?

WATCH

Why Some Balls Don't Bounce | A Moment of Science | PBS

A Moment of Science • 2:03

<https://www.youtube.com/watch?v=ewDXEpyT-tw>

WHEN TO WATCH

After the story. A science show from Indiana University and public television.

BACKUP VIDEO

Why Do Balls Bounce? | Sid the Science Kid | Jim Henson Company

The Jim Henson Company • 3:16

<https://www.youtube.com/watch?v=ABBV8nA0XGI>

For a younger listener: a cartoon class finds out why a play-dough ball will not bounce.

KEY TERMS

bounce

To hit the ground and spring back up.

rubber

A stretchy material that springs back after you squash it. Natural rubber comes from the sap of rubber trees.

elastic

Able to squash or stretch and then spring back to its shape.

CORE IDEAS

The story. Long ago, people in Central America made balls from the sap of rubber trees. When explorers from Spain first saw those balls bounce, they were amazed! But **rubber** had a problem. It got sticky when it was hot and cracked when it was cold. In 1839 an American named Charles Goodyear found that heating rubber with sulfur made it strong and bouncy in hot and cold weather. Later, in 1965, a chemist named Norman Stingley made a super-bouncy ball from a new kind of rubber.

How they figured it out. Goodyear tried and tried for years, mixing rubber with all kinds of things. Many of his tests failed. He kept going until he found the mix that worked.

Why does it work? When a ball hits the floor, it squashes a little. A rubber ball is **elastic**, so it springs back to its round shape and pushes off the floor. That push sends it back up. A play-dough ball squashes but does not spring back, so it does not **bounce**. No ball bounces all the way back to where you dropped it. A little of its push turns into heat and sound.

How do toy makers use it? Toy makers choose the material for each ball. Bouncy balls are made of springy rubber. A beach ball is light and full of air. A tennis ball has fuzz and air inside. Very small bouncy balls are not safe for babies, because they can choke on them.

PICTURE STUDY



Little Boy with a Coloured Ball, Miklós Barabás, 1800s · Oil painting · Hungary

Image: [Wikimedia Commons](#), public domain

Miklós Barabás was a Hungarian painter who painted many portraits. Here he painted a little boy with his favorite toy, a colorful ball.

Look closely

- Find the ball. What color is it?
- Find the racket. What game might it be for?
- Find the boy's straw hat.
- Look at the boy's clothes. Do children dress like this today?

Talk about it

1. Do you think this ball would bounce high? Why or why not?
2. What game might the boy play with his ball?

Safety first. Drop balls away from windows, lamps and faces. Keep small bouncy balls away from babies and toddlers.

BUILD

The Bounce Test

You will drop four different balls from the same height beside a wall and measure how high each one bounces. Then you will test different floors.

You will need

- Four different balls, such as a bouncy rubber ball, a tennis ball, a ping-pong ball and a soft foam or plush ball
- A yardstick or meter stick, taped upright to a wall, or a tape measure
- Masking tape
- A hard floor and a carpet or rug
- Engineer's notebook

Steps

1. Tape a yardstick upright against a wall, or put tape marks on the wall every 10 centimeters (or every 4 inches) up to about one meter.
2. **Guess.** Line up the balls from the one you think will bounce highest to the one that will bounce lowest.
3. A grown-up holds a ball at the top of the yardstick and lets go (no throwing!). You watch the wall and point to how high it bounced. Write the number.
4. Drop each ball three times. Write each number.
5. **Fair test.** Drop every ball from the same height, onto the same floor, by letting go. Only the ball changes.
6. Make a bar chart of the best bounce for each ball. Which won? Was your guess right?
7. **Floor test.** Drop the winning ball onto the carpet. Does it bounce as high? Try a pillow, a wooden floor or the sidewalk.
8. **Make it better.** Can you make a ball bounce higher? Try a warm ball and a cold ball (from the refrigerator), and test again.

Tips

- Get down low with your eyes at the height of the bounce.

- A phone video in slow motion can help you see the top of the bounce.

Check your work

- ☐ I can tell why a rubber ball bounces.
- ☐ I can tell which ball bounced highest, and show my numbers.

ENGINEER'S NOTEBOOK

1. Draw the four balls in a row, with a line showing how high each one bounced.
2. Draw a ball squashing on the floor and springing back.

From history. Charles Goodyear's process is called vulcanization. It is still used today to make car and bicycle tires strong and springy. The Goodyear tire company was named after him many years later, though he never worked for it.

COMMON MISTAKES

- Throwing the ball down. Just let go.
- Thinking bigger balls always bounce higher. Test it!

Make it a game • Bounce Height Duel. Gather four balls or soft things. Hold each one at the same height and drop it. Your parent marks the bounce with a finger on the wall. Before each drop, guess which bounce is highest. Say squash and spring back when the ball hits the floor. Tell which ball is the champion.

9.3 PINWHEELS

OBJECTIVES

- Make a paper pinwheel.
- Tell how the wind pushes on the slanted blades to turn it.
- Test how the distance from a fan changes how fast it spins.

Warm-up. Blow straight at a flat sheet of paper held up in front of you. It bends back. Now fold a little paper fan and blow on it from the side. Look outside: can you see anything that the wind turns, like a weather vane, a flag or a windmill?

WATCH

Test Different Pinwheel Designs | STEM Activity

Science Buddies • 5:19

<https://www.youtube.com/watch?v=Q7FXhuBYmxM>

WHEN TO WATCH

Before the build. The video has words on the screen and no talking, so read them aloud. Make the first design together.

BACKUP VIDEO

Wind Energy: Making & Testing Pinwheels to Model Wind Turbines

Teach Engineering • 1:59

https://www.youtube.com/watch?v=KvU_NFaeL3c

After the build, to see why a pinwheel must face the wind.

KEY TERMS

pinwheel

A toy with paper blades on a stick that spins in the wind.

blade

One of the slanted arms of a pinwheel or windmill that the wind pushes.

windmill

A building with big blades that the wind turns to do work, like grinding grain or pumping water.

CORE IDEAS

The story. Children have played with paper **pinwheels** for hundreds of years. Long before that, people built giant **windmills**. In the Netherlands, windmills pumped water off the low, wet land so farmers could grow crops there. Other windmills turned heavy stones that ground grain into flour.

How they figured it out. Windmill builders learned that flat sails pointing straight at the wind do not turn. The **blades** must be slanted, so the wind pushes them sideways. They turned the whole top of the windmill to face the wind.

Why does it work? Wind is moving air. When it hits a slanted blade, it pushes the blade to the side. All the blades are slanted the same way, so they all get pushed around in a circle. The stronger the wind, the faster the pinwheel spins.

How do toy makers use it? A pinwheel must turn easily on its pin, so the hole must not be too tight. The paper must be stiff enough to hold its shape. Toy makers also cover the sharp end of the pin so it cannot poke anyone.

PICTURE STUDY



The Windmill at Wijk bij Duurstede, Jacob van Ruisdael, About 1668–1670 · Oil on canvas ·

Rijksmuseum, Amsterdam

Image: [Wikimedia Commons](#), public domain

Jacob van Ruisdael painted this windmill beside a river in the Netherlands. It is like a giant pinwheel that does real work.

Look closely

- Find the four big sails, the windmill's blades.
- Look at the sky. Is it a windy day?
- Find the sailboat. What does its sail tell you about the wind?
- Find the people. How big are they next to the windmill?

Talk about it

1. How is the windmill like your pinwheel?
2. What work do you think this windmill did?

Safety first. A grown-up pushes the pin through the pinwheel and into the pencil eraser, and bends or covers any sharp tip. Keep fingers away from the fan blades.

BUILD

The Pinwheel Fan Test

You will make a paper pinwheel and test how fast it spins at different distances from a fan. You will mark one blade so you can count its turns.

You will need

- A square of stiff paper about 15 centimeters (6 inches) on each side
- Scissors, a ruler and a pencil with an eraser
- A pushpin or straight pin (for the grown-up), and a small bead if you have one
- A sticker or marker
- A box fan
- A stopwatch, or a grown-up who counts seconds
- Engineer's notebook

Steps

1. Make the pinwheel: draw lines from each corner toward the center, cut along them partway (stop before the middle), and fold every other point into the center. A grown-up pins the points and the center to the pencil eraser, with a bead behind for an easy spin.
2. Put a sticker on one blade.
3. **Guess.** Will the pinwheel spin faster close to the fan or far away?
4. Turn the fan on low. Hold the pinwheel one big step away, facing the fan. For ten seconds, count how many times the sticker passes the top.
5. Test again at two steps and at three steps.
6. **Fair test.** Same pinwheel, same fan speed, held facing the fan the same way. Only the distance changes.
7. Make a bar chart of turns at each distance.
8. **Make it better.** Turn the pinwheel so it faces sideways to the fan. Does it still spin? Then make a bigger pinwheel and test it at one step.

Tips

- If the pinwheel will not turn, loosen the pin a little.
- Counting is easier on the low fan setting.

Check your work

- ☐ I can make a pinwheel and tell how the wind turns it.
- ☐ I can tell where my pinwheel spun fastest, and show my numbers.

ENGINEER'S NOTEBOOK

1. Draw your pinwheel with arrows showing the wind and the way it spins.
2. Draw a windmill like Ruisdael's and color its sails.

From history. The Netherlands once had about ten thousand windmills. More than a thousand still stand today, and some still pump water and grind grain.

COMMON MISTAKES

- Pinning it too tight, so it cannot turn.
- Holding the pinwheel at a different angle each test.

Make it a game • Pinwheel Breeze Race. Hold your pinwheel in front of a fan or blow on it. Count how many turns in ten seconds, with your parent keeping time. Then tilt it and try again. Which way made it spin faster? Say wind pushes the blades like a cheer. Beat your own count, then pass the pinwheel to your parent.

9.4 BUILDING BLOCKS, FROM FROEBEL TO LEGO

OBJECTIVES

- Tell how Friedrich Froebel started the kindergarten with blocks and other “gifts.”
- Tell how LEGO bricks grip each other.
- Test whether a tower of plain blocks or locking bricks stands up longer to a shake.

Warm-up. Ask: Do you know what the word “kindergarten” means? It is German for “children’s garden.” Then build two little walls side by side: one of plain wooden blocks and one of LEGO or DUPLO bricks. Push each one gently. What happens?

WATCH

How were LEGO bricks invented?

Mystery Science · 8:29

<https://www.youtube.com/watch?v=Z9aKkM6vHfk>

WHEN TO WATCH

After the story. Pause halfway for a snack if needed.

Note: The end invites viewers to vote on the next question on the channel’s website; you can skip it.

BACKUP VIDEO

Froebel Kindergarten Gifts Early Childhood Education History of Toys

Froebel USA · 9:36

<https://www.youtube.com/watch?v=LNbzmCKLNdU>

For a grown-up: the history of Froebel’s blocks and gifts, with old photographs of the first kindergartens.

KEY TERMS

block

A plain, solid building piece, often made of wood.

brick

A building piece. LEGO bricks have bumps on top and tubes underneath so they lock together.

kindergarten

A German word that means “children’s garden.” It is the first year of school.

CORE IDEAS

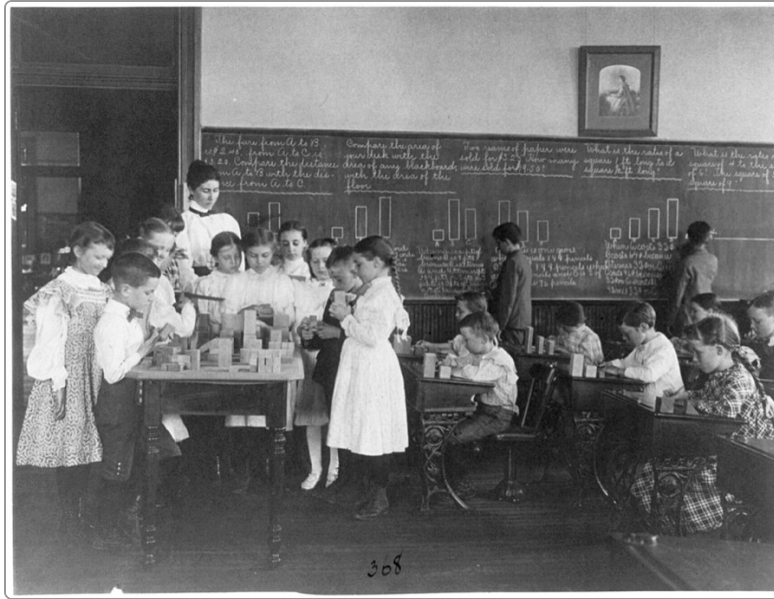
The story. Almost two hundred years ago, a German teacher named Friedrich Froebel started the first **kindergarten**. He wanted little children to learn by playing. He gave them special toys he called “gifts”: soft balls, a wooden ball, a cube, and wooden **blocks** in a box. Children built houses and bridges and learned about shapes and numbers.

More blocks. In 1932 a carpenter in Denmark named Ole Kirk Christiansen began making wooden toys. He named his company LEGO, from Danish words that mean “play well.” Later the company made plastic **bricks** with bumps on top.

How they figured it out. The first plastic bricks did not hold together very well. Towers fell apart. So in 1958 Ole’s son Godtfred and his team added round tubes inside the bottom of each brick. Now the bumps of one brick squeezed snugly between the tubes of the next. The bricks clicked together and stayed!

Why does it work? A plain block stays up only because it is heavy and stacked straight. A gentle shake can slide it off. Locking bricks hold on to each other. Their tight fit makes rubbing, called friction, that holds them together. Toy makers must make every brick the exact same size so they all fit. Small bricks are not safe for babies, so DUPLO bricks are made big.

PICTURE STUDY



Children Working with Blocks, Frances Benjamin Johnston, 1899 · Photograph · Library of Congress

Image: [Wikimedia Commons](#), public domain

Frances Benjamin Johnston photographed schools in Washington, D.C., in 1899. Here children learn numbers and shapes with small wooden blocks, much as Froebel had taught.

Look closely

- Find the blocks on the tables.
- What are the children making with them?
- Find the blackboard. What are those children doing?
- Find the teacher.

Talk about it

1. How could blocks help you learn to count?
2. How is this classroom like yours, and how is it different?

Safety first. Small bricks and blocks are choking hazards for children under three. Build at a table, and pick up every piece when you are done.

BUILD

The Block Shake Test

You will build two towers the same height, one of plain blocks and one of locking bricks. Then you will make an “earthquake” by tapping the table, and count how many taps each tower can stand.

You will need

- Plain wooden blocks (or KEVA planks, or small boxes)
- LEGO DUPLO or LEGO bricks
- A table
- A ruler
- Engineer’s notebook

Steps

1. Build a tower of plain blocks, ten blocks tall, one on top of the other.
2. Build a tower of locking bricks the same height. Measure both with the ruler.
3. **Guess.** Which tower will fall first when we shake the table?
4. A grown-up taps the table with a fist, gently and the same way each time.
Count the taps until the plain tower falls. Write the number.
5. Do the same for the brick tower.
6. **Fair test.** Same height, same table, same taps. Only the kind of block changes.
7. **Bridge test.** Build a bridge from each kind across a gap between two books.
Which one holds together when you press the middle?
8. **Make it better.** Can you make the plain block tower stand up to more taps without glue? Try a wide base, as in Lesson 1.4.

Tips

- Tap from the same spot each time.
- Stop at twenty taps if a tower never falls.

Check your work

- ☐ I can tell who Froebel was and what “kindergarten” means.

- ☐ I can tell why locking bricks stay together, and show my numbers.

ENGINEER'S NOTEBOOK

1. Draw the plain tower and the brick tower. Write how many taps each one stood.
2. Draw the bottom of a LEGO brick with its tubes, and the top with its bumps.

From history. Froebel opened his first play school in 1837 and named it a kindergarten in 1840. Kindertgartens soon spread to England and America. A famous American architect, Frank Lloyd Wright, later said that playing with Froebel blocks as a boy helped him learn to design buildings.

COMMON MISTAKES

- Tapping harder for one tower.
- Building the towers different heights.

Make it a game • Block Shake Test. Build two block creations, one with bricks pressed tight and one just stacked. Gently shake the table, and see which one stays together. Say the word brick every time one holds. Then tell your parent the story of Froebel and the first kindergarten, and name three shapes you can build with blocks.

TOY LAB

This is a bonus unit for after the fair, for the summer, or for any week that needs something fun. Your child will find the science hiding inside four favorite toys: the spinning top, the bouncing ball, the pinwheel and building blocks. We meet the people behind them, from Charles Goodyear, who learned how to make rubber stay bouncy, to Friedrich Froebel, who invented the kindergarten and its blocks, and the Danish carpenter who started LEGO.

Each lesson is a toy test. Your child will build or gather the toys, change one thing at a time, count or measure, and make the toy work better. Toy makers are engineers too: they think about how a toy works, how to make it strong and cheap, and how to keep small children safe. “The streets of the city shall be full of boys and girls playing” (Zechariah 8:5).

PREREQUISITES

- Has finished most of Units 1–8 (or does this unit any time with a grown-up)
- Can count seconds with help
- Can use a ruler or tape measure with help

MASTERY CHECKLIST

- ☐ I can make a top and find out what makes it spin longest.
- ☐ I can test which ball bounces highest and tell why balls bounce.
- ☐ I can make a pinwheel and show how wind turns it.
- ☐ I can tell how Froebel’s blocks and LEGO bricks began, and show why bricks that lock together stay up better.

OPTIONAL KITS FOR THIS UNIT

- **LEGO DUPLO:** Large interlocking bricks made for small hands, and safer for homes with toddlers than small bricks. Fits Lesson 9.4.
- **KEVA Planks:** Plain wooden planks that do not lock together, the opposite of LEGO bricks. Good for comparing the two kinds of building in Lesson 9.4.

Not required. Every project in this unit can be built with household materials. School Launch has no ties to these companies.

LESSONS IN THIS UNIT

9.1 Spinning Tops	2 sessions of 30 minutes
9.2 Which Ball Bounces Highest?	2 sessions of 30 minutes
9.3 Pinwheels	2 sessions of 30 minutes
9.4 Building Blocks, from Froebel to LEGO	2 sessions of 30 minutes

UNIT 9 REVIEW

A parent asks these questions aloud. Your child may answer by telling, pointing, building or drawing. There are no points; just notice what your child knows and what to review.

1. Why does a top stay up only while it spins?
2. Show me how to make a top spin longer.
3. Why does a rubber ball bounce but a play-dough ball does not?
4. Blow on your pinwheel. Why does it turn?
5. What does “kindergarten” mean, and who started it?
6. Why should babies not play with small toys like tiny balls or bricks?

ANSWER KEY

1. A spinning thing keeps spinning the same way and stays upright; when it slows and stops, it falls.
2. Put the point in the center, add weight near the edge, spin on a smooth surface.
3. Rubber squashes and springs back; play dough squashes and stays flat.
4. The wind pushes the slanted blades sideways, around in a circle.
5. “Children’s garden”; Friedrich Froebel.
6. They could swallow them and choke.

PORTFOLIO PIECE: MY TOY LAB SHOW

Choose your favorite toy from this unit: your champion top, your pinwheel, the winning bouncy ball or your brick tower. Show your family how it works, tell them about your test and your numbers, and explain what you changed to make it better. Keep a photo and your notebook page in your portfolio folder.

LOOK FOR	WHAT IT MEANS
Guessed first	Made a guess before each test.
Fair test	Changed only one thing and tested each version more than once.
Counted or measured	Counted seconds, turns or taps, or measured a height, with a grown-up's help.
Toy safety	Can tell why small toys are kept away from babies.