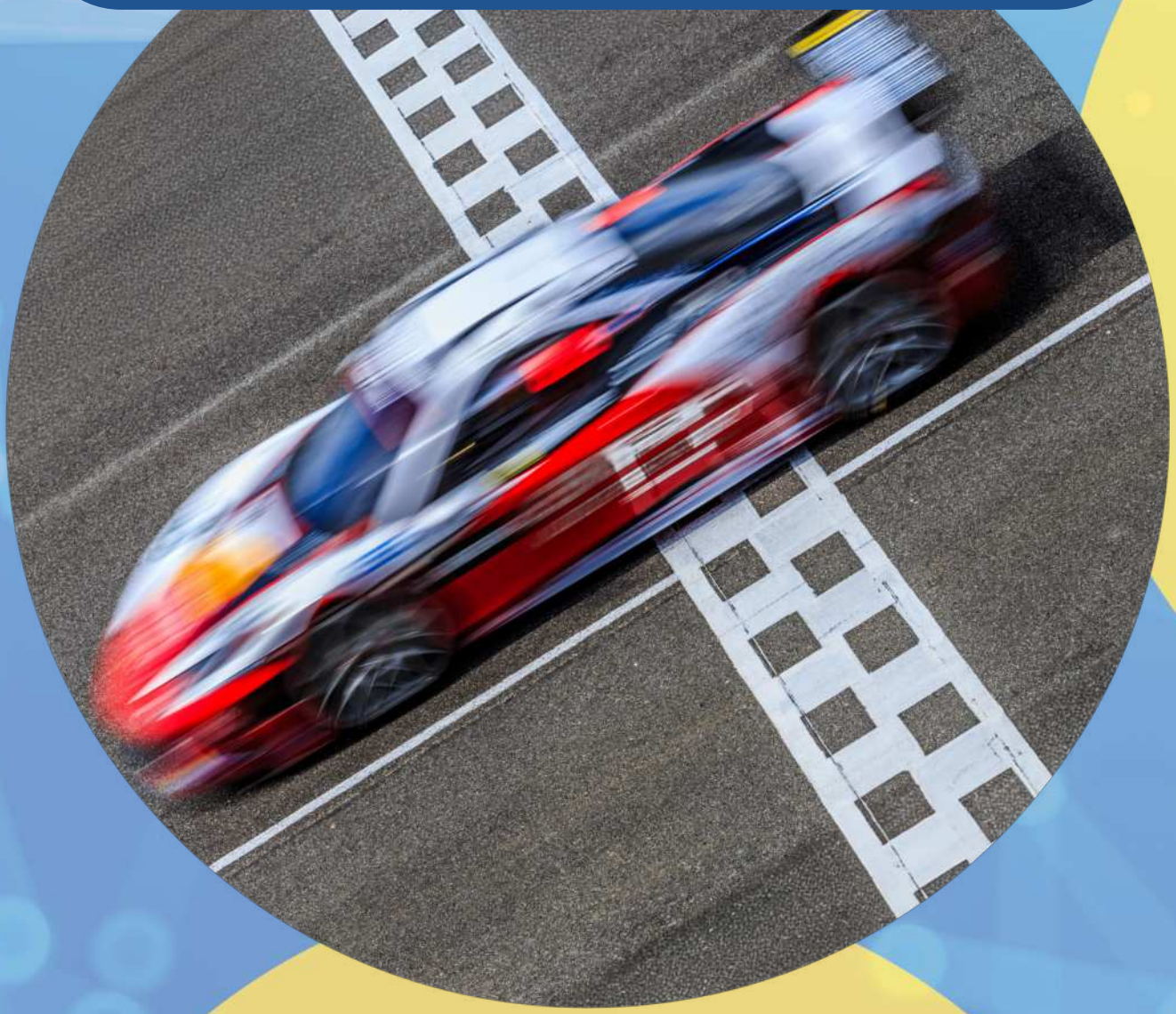
Gravity Games!

A Racing Science Adventure



the Shoebox Lab

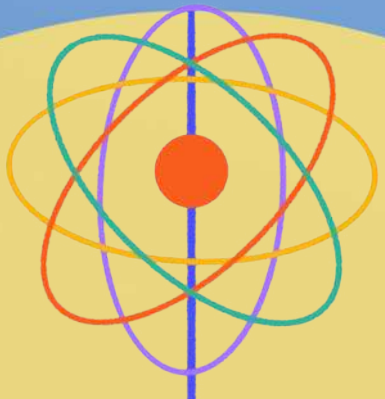
What Will You Learn?

You will learn...

- What gravity is — and how it moves your car
- The difference between stored energy and motion energy
- How ramp angle, weight, and wheel size change how far a car rolls
- How to collect data and use it to make real design choices

Your Activities at a Glance

	You will explore ...
#1. Build & Roll - Ramp Angle Test	Does ramp height change distance?
#2. Load It Up - The Weight Test	Does car weight change distance?
History Spotlight - Ramps Long Ago	Explore ramps in history & today
#3. Size It Up - Wheel Size Test	Does wheel size change distance?
Science Spotlight - Gravity & Energy	Learn the why!
Challenge - Build the Best Car	Let's put it all together!



Scan for this kit's videos!
shoeboxlab.org/gg

Meet Your Kit

Welcome to Gravity Games — your racing science lab! You'll build your own cars. You'll send them flying down ramps. And you'll find out why some cars zoom farther than others. You're the engineer, the driver, and the scientist — all at once!

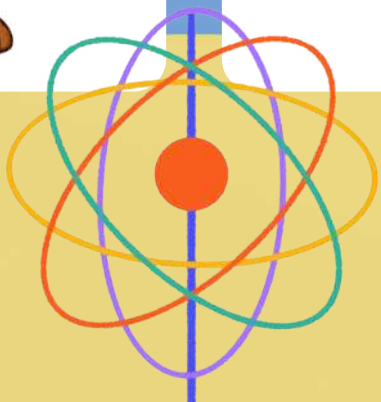
Meet Bolt, Your Racing Buddy!

Hi there! I'm Bolt the Bear, your science partner for this adventure! I love going fast, experiments, and learning new skills — just like you! I'll pop up all through this book to cheer you on and share tips. Ready to race? Let's go!

What's in Your Kit?

- Building bricks (including wheels, axles, body bricks)
- 2 weighted blocks
- 1 ramp board (foamboard)
- Measuring tape
- This workbook + a pencil

You will also need a few large, heavy books from home. Encyclopedias or textbooks work — any big stack will do!



ACTIVITY 1
BUILD & ROLL - THE RAMP ANGLE TEST

WHAT IS THIS ACTIVITY ABOUT? You're going to build a car. Then you'll set up a ramp and test it. A higher ramp makes a steeper angle. Does steeper send your car farther? Let's find out!

MY LEARNING GOAL

I will find out how the ramp's steepness changes how far my car rolls

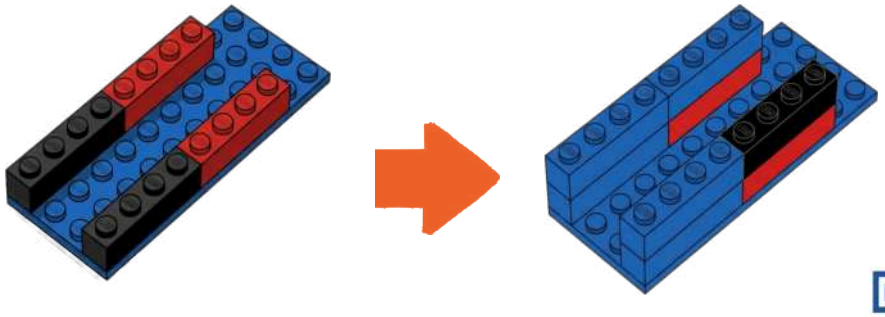
WHAT YOU NEED

- Building bricks (including wheels, axles, body bricks)
- The ramp board (foamboard)
- 3 to 5 large, heavy books
- Measuring tape
- This workbook + a pencil

Your bricks may be different colors — that's fine!

BUILD IT!

STEP 1. Build the car base



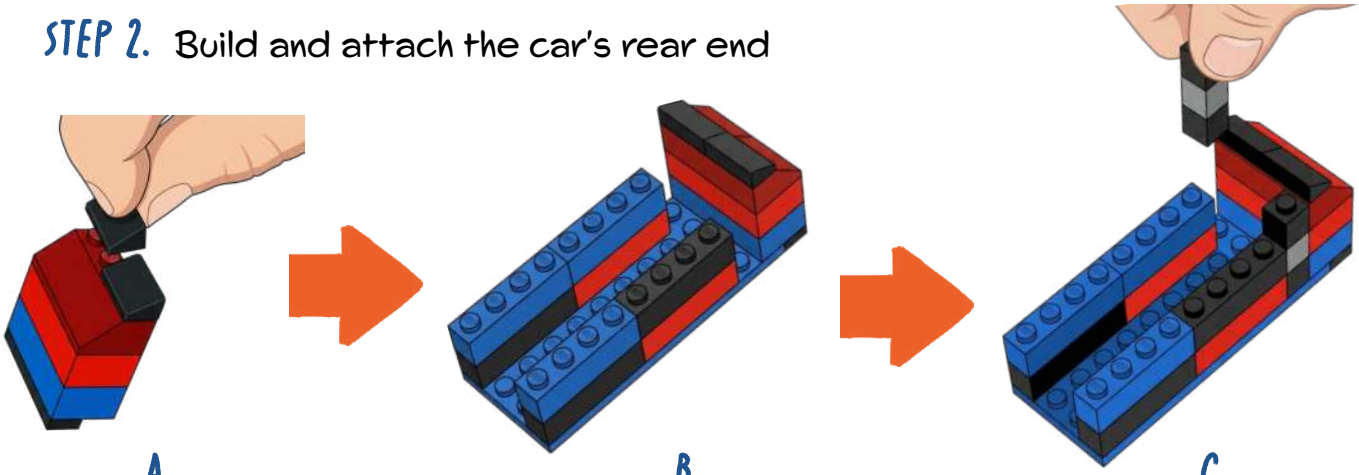
A B

GG • ACTIVITY 1
shoeboxlab.org/gg1

BUILD & ROLL - THE RAMP ANGLE TEST

BUILD IT! (CONTINUED)

STEP 2. Build and attach the car's rear end



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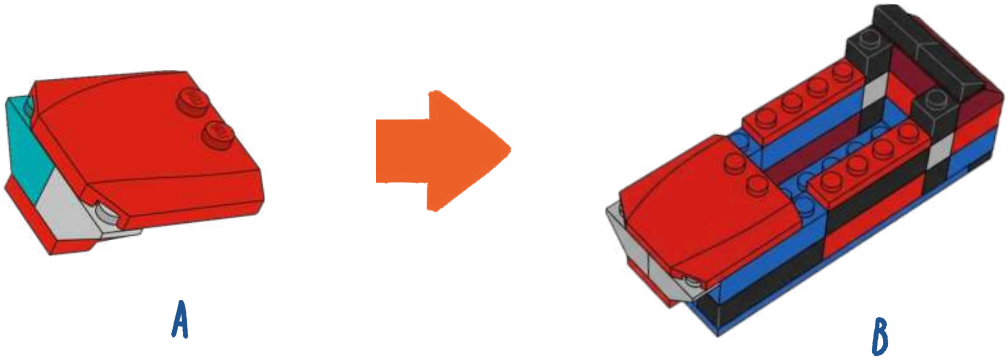
STEP 3. Build and attach the car's hood



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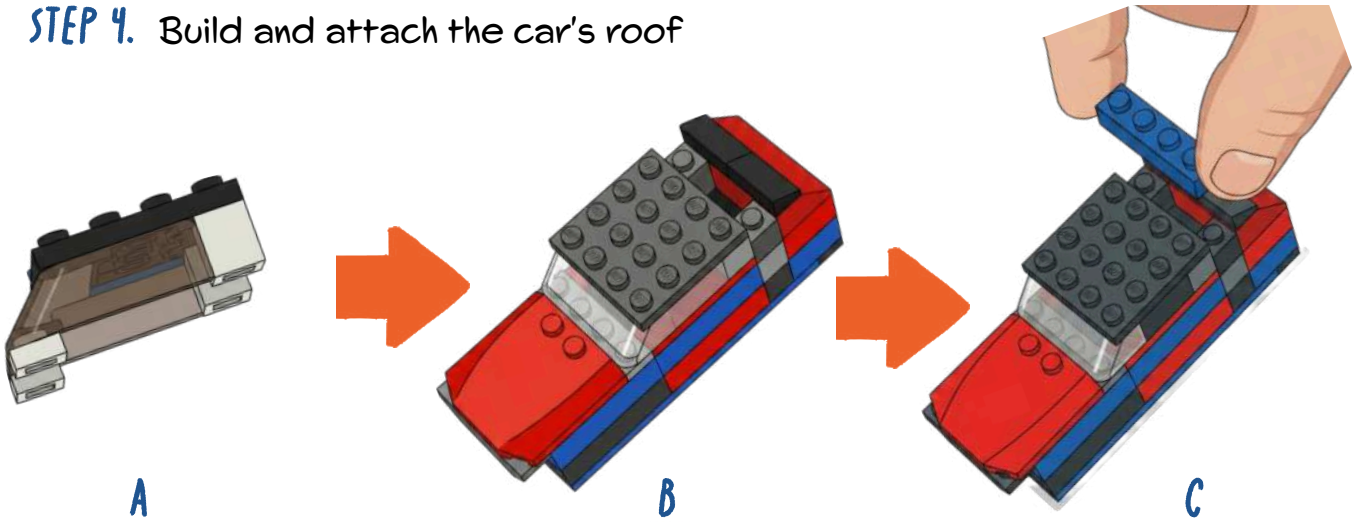
STEP 4. Build and attach the car's roof



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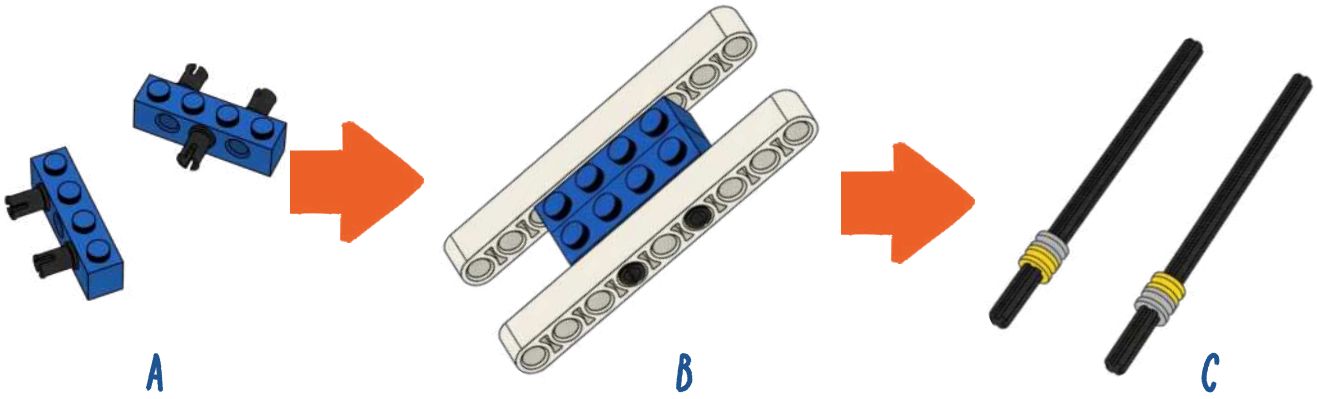
Activity 1
Build & Roll - The Ramp Angle Test

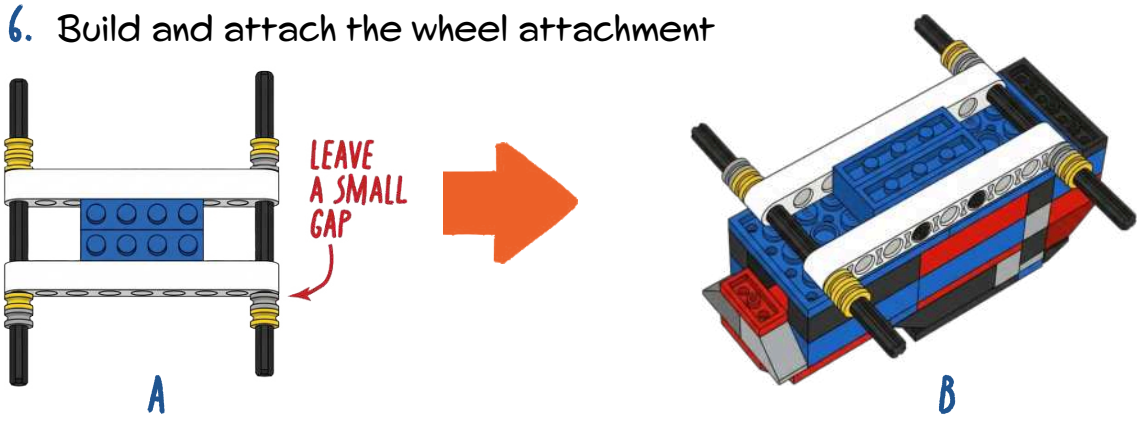
Build It! (continued)

Step 5. Build the wheel attachment parts



A B C

Step 6. Build and attach the wheel attachment



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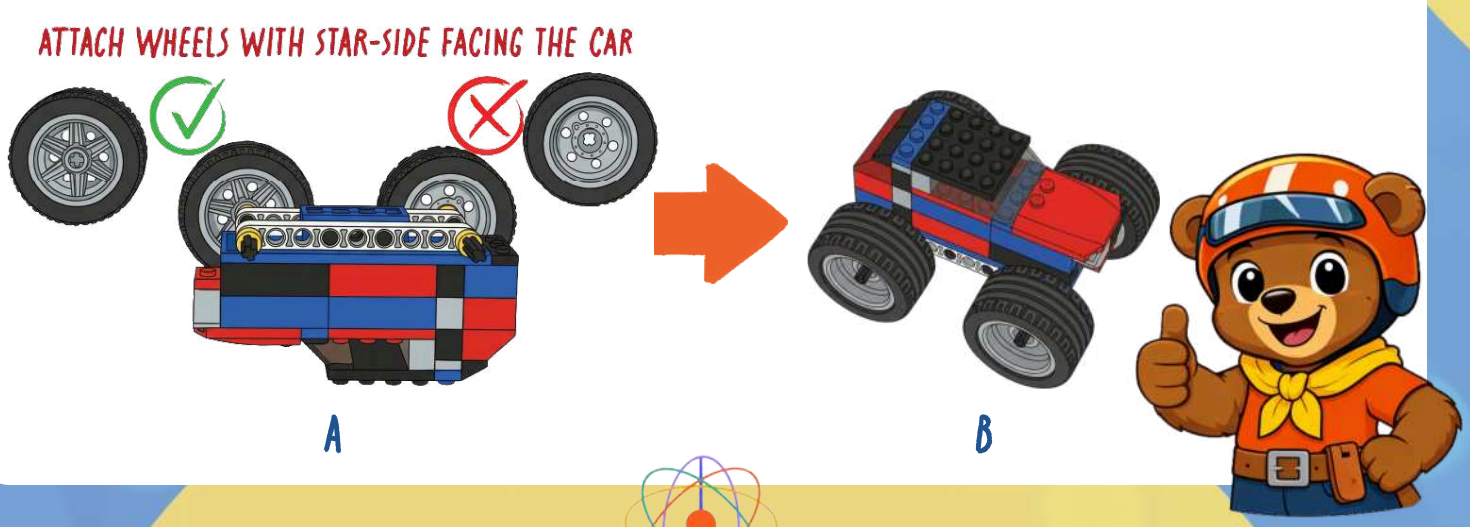
Step 7. Attach the wheels



A B

Activity 1
Build & Roll - The Ramp Angle Test

Build It! (continued)

Step 8.
Unfold and tape the ramp.
Mark the start line with tape.

Step 9.
Set up your ramp on books.
Now, you are ready to investigate!

Investigate!
Run your experiment!

Step 10.
Place your car at the very TOP of the ramp — don't push, just let go!

Step 11.
Measure from the bottom of the ramp to the front of the car.

Step 12.
Write that distance in the table below.

Step 13.
Repeat 2 more times for that same height.

Step 14.
Add another book or two to raise the ramp.
Then do all three trials again.

Bolt says

Why three trials? One run can go wrong — maybe the car bumped something. Three trials let you check. The best scientists always test more than once!

Activity 1
Build & Roll - The Ramp Angle Test

My Data

Run #	Ramp Height (Number of Books)	Trial 1	Trial 2	Trial 3	Best Run
1	1 book				
2	2 books				
3	3 books				
4	5 books				

Reflect

1. How did the distance change as you added more books under your ramp?

2. Which ramp height made the car go farthest?

3. ✏✨ Challenge: Imagine adding 10 books. Would the car keep rolling farther? Why or why not?

Activity 2
Load It Up – The Weight Test

What is this activity about? Now you'll test the WEIGHT of your car. The ramp stays at the same height for every run. Only one thing changes: how many weights ride on the car. Changing just one thing at a time — that's the secret to a fair experiment!

My Learning Goal

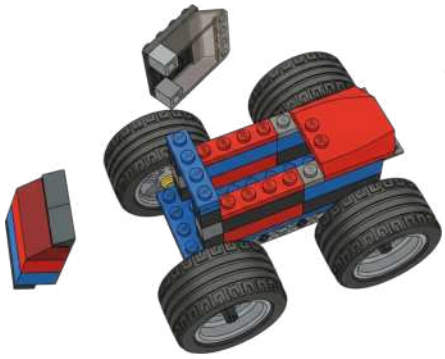
I will find out how the weight of my car changes how far it rolls

What You Need

- Your car from Activity 1
- The weight blocks
- The ramp board
- 3 large, heavy books (the same as before)

WEIGHT BLOCKS

- Measuring tape
- This workbook + a pencil



Investigate!

Run your experiment!

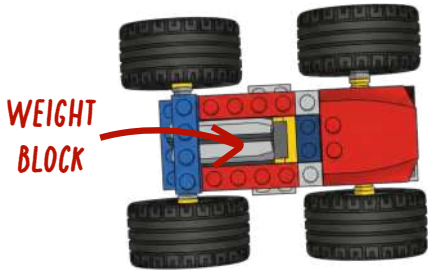
Step 1.

First, run the car three times with NO weights.
Write down those runs.
Then take off the car's roof and rear end.

Word Watch

OBSERVE - To observe means to notice something carefully with your senses — eyes, ears, even touch. Scientists observe what happens so they can learn from it.

Try it: After each run, observe exactly where the car stops. Write down what you notice.



Step 2.

Add one (1) weight and one small yellow brick. Put the roof back on.

Only one weight for now!

GG • ACTIVITY 2
shoeboxlab.org/gg2

Activity 2
Load It Up – The Weight Test

Investigate! (continued)

Step 3.
Place your car at the very TOP of the ramp — don't push, just let go!

Step 4.
Measure from the bottom of the ramp to the front of the car.

Step 5. Write that distance in the table below.

Step 6. Repeat 2 more times for that same weight.

Step 7.
Take off the small yellow brick. Add another weight to your car. Then do all three trials again.

Bolt says Use the SAME ramp height for every run in this activity. The only thing you change is the number of weights on the car.

My Data

Run #	Car Weight (Number of Weights)	Trial 1	Trial 2	Trial 3	Best Run
1	NO weights				
2	1 weight				
3	2 weights				

Activity 2
Load It Up – The Weight Test

WORD WATCH

FORCE - A force is a push or a pull. Forces can make things start moving, stop moving, speed up, or slow down.

TRY IT: Name the force that pulls your car down the ramp.

Reflect

1. Which car traveled farthest?
   The lightest car (no weights)? Medium? Or the heaviest car (two weights)?

2. Were you surprised by the result? What did you expect to happen?

3. ✏✨ Challenge: What if you added THREE weights?
   What do you predict would happen?

WORD WATCH

MASS - Mass is the amount of matter (stuff) in an object. An object with more mass is heavier. The weighted brick adds mass to your car.

TRY IT: Does more mass mean your car rolls farther? Check your data!

Ramps Throughout History

One of the World's Oldest Simple Machines

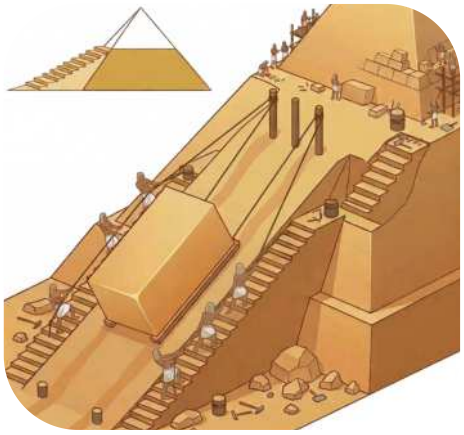
Ramps in Ancient Civilizations

Your ramp isn't just a toy. It's one of the oldest and most powerful tools in human history! Long before cars — even before wheels — people learned that a sloped surface can do amazing things. Scientists call it an inclined plane.

Word Watch

Simple Machine - A simple machine is a basic tool with few or no moving parts. It makes work easier by changing a force's direction or size. The inclined plane is one of six simple machines.

Try It: You built one — your ramp!



The Egyptian Pyramids (Around 2600 BC)

The Great Pyramid of Giza has over two million stone blocks. Each one weighs as much as a pickup truck! Workers could not lift them straight up. So builders likely made long dirt ramps that zigzagged up the pyramid's side. Teams pulled the stones up on sleds and ropes.

Stonehenge (Around 2600-2400 BC)

Stonehenge in England has huge stones lying across the tops of standing stones. How did they get up there? Scientists believe workers built dirt ramps around the standing stones. Then they slid the top stones into place. When the work was done, the ramps were cleared away. That's why we don't see them today.

The Diolkos (Ancient Greece, Around 600 BC)

The ancient Greeks built a stone ramp-road almost 6 kilometers long. Whole ships rolled across it on log rollers — some ships weighed 20 tons! Why? It saved sailors weeks of sailing around dangerous coasts.

GG • History Spotlight
shoeboxlab.org/gg6

Ramps Today

THE RAMP HASN'T GONE ANYWHERE – IT JUST LOOKS DIFFERENT NOW

WORD WATCH

INCLINED PLANE - An inclined plane is a flat surface tilted at an angle — a ramp! It lets you move things up or down with less force than lifting. The trade: you move them a longer distance.

TRY IT: Spot two inclined planes in your neighborhood

WHEELCHAIR RAMPS

Ramps let people using wheelchairs or strollers enter buildings without steps.

ESCALATORS

Moving staircases are inclined planes with steps. They carry people between floors using the same idea.

AIRCRAFT CARRIERS

Jets zoom off a ski-jump ramp at the front of some aircraft carriers. The ramp helps them take off in less space.

SLEDDING HILLS

Hills are nature's inclined planes. Sleds and skis speed up going down — just like your car on the ramp!

PLAYGROUND SLIDES

A slide is an inclined plane! Gravity pulls you down the slope — exactly like your car on the ramp.

LOADING DOCKS

Trucks use ramps to load and unload heavy cargo — the same idea the Egyptians used thousands of years ago!

BOLT SAYS

Pretty cool, right? Your ramp is the same tool the Egyptians used to build the pyramids. You're doing age-old engineering!

Activity 3
Size It Up – The Wheel Size Test

What is this activity about? You've tested ramp angle. You've tested weight. Now: do the WHEELS matter? Does a smaller wheel roll farther? What about a taller one? Time to investigate!

My Learning Goal

I will find out whether wheel size changes how far my car rolls

What You Need

- Your car from Activity 2
- Wheel Pack 3
- The ramp board
- 3 large, heavy books (the same ones you used before)
- Measuring tape
- This workbook + a pencil

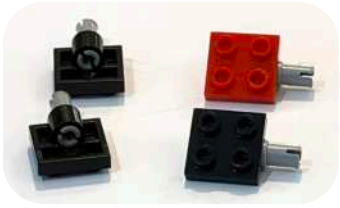
Word Watch

DISTANCE - Distance is how far something travels from one place to another. In your tests, you are measuring distance.

Try it: Every number in your data tables is a distance.

Investigate!

Run your experiment!



Step 1.

First, run the car 3 times with its original wheels. Write down those runs.

Step 2.

Take off the car's wheels. Put on the smaller wheels.

GG • Activity 3
shoeboxlab.org/gg3

Activity 3
Size It Up – The Wheel Size Test

Investigate! (continued)

Step 3.
Place your car at the very TOP of the ramp — don't push, just let go!

Step 4.
Measure from the bottom of the ramp to the front of the car.

Step 5. Write that distance in the table below.

Step 6. Repeat 2 more times for the same wheels.

Step 7.
Put on another type of wheels. Then do all three trials again.

Bolt says Use the SAME ramp height for every run in this activity. The only thing you change is the type of wheels on the car.

My Data

Run #	Wheel Type	Trial 1	Trial 2	Trial 3	Best Run
1	Original Wheels				
2	Small Wheels				
3	Large Wheels				

Activity 3
Size It Up – The Wheel Size Test

WORD WATCH

DESIGN - Design means making a plan for how something will be built. A good design uses the goal, the materials, and what you've already learned.

TRY IT: Your next design gets to use everything you've tested!

Reflect

1. Which car traveled farthest? The one with the original wheels? The small wheels? The large wheels?

2. Were you surprised by the result? What did you expect to happen?

3. ✏✨ Challenge: What car design would travel the farthest? (In the Grand Challenge, you'll get to test your idea!)

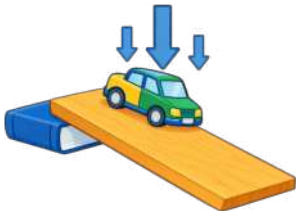
WORD WATCH

VARIABLE - A variable is the one thing you choose to change in an experiment. Everything else stays the same, so you can tell what made the difference.

TRY IT: Here, the variable is wheel size. Ramp height and car weight stay the same.

Science Spotlight

YOU ALREADY TESTED WHAT HAPPENED. NOW LET'S LEARN WHY IT HAPPENED.



The Big Idea: Gravity

Have you ever wondered WHY your car rolls down the ramp on its own? It needs no push! Something invisible pulls it. That invisible force is called gravity.

WORD WATCH

GRAVITY - Gravity is the invisible force that pulls things toward Earth. It keeps you on the ground and makes things fall. It's why your car rolled down the ramp instead of sitting still.

TRY IT: Drop a pen and a shoe. Gravity pulls both!

The Big Surprise: Stored Energy

Here's something amazing. Lift your car to the TOP of the ramp — you just stored energy inside it! It's like charging a battery. This stored energy is called potential energy.

Two things change how much energy your car stores:

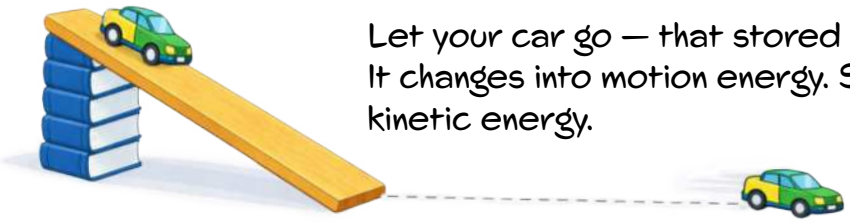
- HEIGHT — The higher the car starts, the more energy it stores.
- MASS (weight) — The heavier the car, the more energy it stores.

That's exactly what you tested in Activities 1 and 2!

FUN FACT

The scientist Sir Isaac Newton began figuring out gravity over 300 years ago. Legend says a falling apple gave him the idea.

The Big Result: Motion Energy



Let your car go — that stored energy doesn't disappear! It changes into motion energy. Scientists call motion energy kinetic energy.

WORD WATCH

ENERGY - Energy makes things move or change. It gets a car rolling. It makes a fire hot and bright. It even sends a dog's bark across the yard!

GG • SCIENCE SPOTLIGHT
shoeboxlab.org/gg5

Science Spotlight (Continued)

You already tested what happened. Now let's learn why it happened.

Fun Fact

Why does your car stop? A force called friction—the rubbing between the wheels and floor—turns motion energy into heat until the car runs out of go.

Word Watch

Potential Energy - Potential energy is energy that is stored and waiting to be used. An object has more potential energy when it is higher up or heavier. Let the car go — that stored energy changes into motion.

Try it: Which has more potential energy — your car on a 5-book ramp, or on a 1-book ramp?

Kinetic Energy - Kinetic energy is the energy of motion. Anything that moves has kinetic energy. Let the car go — its potential energy turns into kinetic energy as it rolls.

Try it: The car speeds up as it rolls down. Its kinetic energy is growing. Where did that energy come from?

Check Your Understanding

1. What force pulls your car down the ramp?
   - A) Electricity
   - B) Gravity
   - C) Magnetism
   - D) Wind

2. Which car has MORE potential energy at the top of the ramp?
   - A) Light car on a low ramp
   - B) Heavy car on a high ramp
   - C) Light car on a high ramp
   - D) They are all the same

3. In your own words: what is potential energy? Give a real-life example!

Bolt Says

You just learned real physics! Engineers who design ski jumps, cars, and spacecraft all think about potential and kinetic energy. That makes you pretty much a rocket scientist!

Grand Challenge
Design Your Best Car!

What is this activity about?

You've done three experiments. You know how ramp angle, weight, and wheel size change distance. Now use ALL of it. Engineer the ULTIMATE car — the car that rolls the farthest!

Bolt says

Real engineers use data to make smart design choices — just like you! Look back at your three data tables. What did you learn? Use it now!

Plan Your Design

1. How many books will you use for the ramp?
   (Look at your Activity 1 data for a clue!)

2. Will you use weights? How many?
   Why or why not?

3. What size wheel will you use?
   Why those wheels?

Word Watch

HYPOTHESIS - A hypothesis is your best guess about what will happen in an experiment. A good hypothesis uses what you already know from earlier tests.

4. My hypothesis:
   I think my car will travel _____
   because _____.

GG • GRAND CHALLENGE
shoeboxlab.org/gg4

Grand Challenge
Design Your Best Car!

Design Sketch

Draw your planned car. Label all the important parts before you build!

DRAW YOUR GRAND CHALLENGE CAR DESIGN HERE!

Investigate!

Build your car. Then race it THREE times to see how it does.

Run #	Design	Trial 1	Trial 2	Trial 3	Best Run
1	Best Plan				
2	Modified #1				
3	Modified #2				

Word Watch

DATA - Data is information collected during an experiment — often numbers, or things you observed. Your data tables are full of data

TRY IT: Point to the single best run in all your data.

Grand Challenge
Design Your Best Car!

Word Watch

PROTOTYPE - A prototype is a first working version of a design. Engineers build it and test it to see if it works. Then they make it better, using the test results.

TRY IT: Your Best Plan car is a prototype!

Final Reflection

1. Compare your best Grand Challenge run to your very first run in Activity 1. Longer? Shorter?

2. Which design choices made the biggest difference in distance?

3. ✎✨ Challenge: If you could test one more change to make your car go even farther, what would you test?

Outstanding Work!

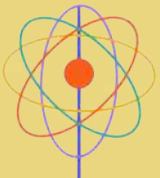
You explored gravity. You learned about stored (potential) and motion (kinetic) energy. You ran real experiments with three trials each. And you used data to engineer a champion racing car. That's real engineering!

"Keep asking questions – every great discovery started with curiosity!" – Bolt the Bear

GLOSSARY

HERE ARE ALL THE SCIENCE AND ENGINEERING WORDS YOU USED IN THIS WORKBOOK.
THESE ARE REAL WORDS THAT SCIENTISTS AND ENGINEERS USE EVERY DAY!

WORD	DEFINITION
DATA (NOUN)	Information you collect and write down — often numbers. Your data tables are full of data!
DESIGN (NOUN / VERB)	A plan for how something will be built. To design means to make that plan. Good designs use what you learned from testing.
DISTANCE (NOUN)	How far something travels from one point to another. In this kit, you measure from the ramp's bottom to where the car stops.
ENERGY (NOUN)	What it takes to make things move or change. Energy comes in many forms — heat, light, sound, and motion.
FORCE (NOUN)	A push or a pull. Forces make things start moving, stop, speed up, or slow down. Gravity is a force.
FRICTION (NOUN)	A force that slows things down when two surfaces rub together. A rough surface makes more friction than a smooth one.
GRAVITY (NOUN)	An invisible force that pulls everything toward Earth. Gravity is why your car rolls down the ramp.
HYPOTHESIS (NOUN)	Your best guess about what will happen in a test, using what you already know. Scientists make a hypothesis before they test.
INCLINED PLANE (NOUN)	A flat surface tilted at an angle — a ramp. One of the six simple machines. It makes moving heavy things easier.
KINETIC ENERGY (NOUN)	The energy of motion. Anything that moves has kinetic energy. The faster it moves, the more it has.
MASS (NOUN)	The amount of matter (stuff) in an object. More mass means heavier. The weighted brick adds mass to your car.
OBSERVE (VERB)	To notice something carefully with your senses. Scientists observe what happens so they can learn from it.
POTENTIAL ENERGY (NOUN)	Stored energy, ready to be used. Higher up or heavier means more potential energy. Your car stores it at the top of the ramp.
PROTOTYPE (NOUN)	A first working version of a design. Engineers build it, test it, and make it better.



GLOSSARY

HERE ARE ALL THE SCIENCE AND ENGINEERING WORDS YOU USED IN THIS WORKBOOK.
THESE ARE REAL WORDS THAT SCIENTISTS AND ENGINEERS USE EVERY DAY!

WORD	DEFINITION
SIMPLE MACHINE (NOUN)	A basic tool with few or no moving parts that makes work easier. There are six — the inclined plane is one of them.
SPEED (NOUN)	How fast something moves — how much distance it covers in a certain time. A higher ramp gives the car more speed at the bottom.
VARIABLE (NOUN)	The one thing you change in an experiment. Everything else stays the same, so you can tell what caused the difference.

This STEM kit was designed and tested by Randolph Kirchain, III, as part of earning the Eagle Scout rank at Troop 313 in Arlington, Massachusetts, Spirit of Adventure Council. The kits were assembled and distributed by the Scouts and community members of Troop 313.

Eagle Scout is the highest rank in Scouting America — and one of the most demanding achievements for youth anywhere. Fewer than 4% of Scouts go on to earn Eagle Scout. Those who do must demonstrate sustained leadership and plan and execute a significant community service project of their own design. This kit is the result of one of those projects. It was created for families at The Root Cellar, a refugee and immigrant transition center in Lewiston, Maine, with the hope that kits like these will find their way to similar programs and communities across the country.

For more than a century, Scouting America has prepared young people for lives of impact and purpose — building character, leadership, and personal fitness through hands-on adventure and real-world challenges. What is less widely known is that Scouting also cultivates curiosity about science, technology, engineering, and math. With merit badges spanning topics from astronomy to artificial intelligence and from robotics to environmental science, Scouts explore the world around them in ways far beyond the trailhead. Scouting America is open to all young people, boys and girls, from kindergarten through high school.

To learn more about Scouting or find a troop near you, visit www.scouting.org

THE MOST WORTHWHILE THING IS TO TRY TO PUT HAPPINESS INTO THE LIVES OF OTHERS - ROBERT BADEN POWELL (SCOUTING'S FOUNDER)

the Shoebox Lab

GRAVITY GAMES! A RACING SCIENCE ADVENTURE

a the **Shoebox Lab** kit

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