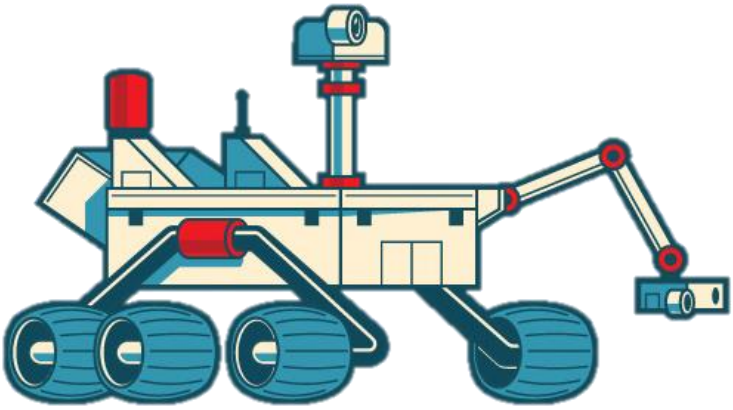
What Makes a Rover?

WHAT MAKES A ROVER? HOW DO SCIENTISTS USE THEM TO DISCOVER FAR AWAY PLACES?

Use this activity guide to explore rovers that humans have built, then design one of your own to explore a location in the solar system!

HOW DOES IT WORK?

Complete the activities in this guide to research, design, build, and test your own rovers! Use the instructions on the following pages to guide your research and design process. Directions for each activity are on the following pages: **Rover Research** (pages 2-3), **Design Challenge: Rovers** (pages 4-5), **Rover Races** (page 6).



WHAT'S A ROVER?

When humans want to learn about other planets or objects in the solar system, they can use tools like telescopes, satellites, and rovers. A **rover** is a small, mobile robot that scientists send to moons and planets to land on their surfaces and explore. Rovers can take pictures and collect information about the planet by taking temperature readings, rock, and soil samples. The rovers then send this information back to scientists on earth through radio signals. Rovers can help scientists learn about faraway places without having to send people to space, which can be tricky!

SKILLS

- Asking Questions
- Developing and Using Models
- Planning and Carrying out Investigations
- Analyzing and Interpreting Data
- Obtaining, Evaluating, and Communicating Information

CONCEPTS

- Cause and Effect
- Structure and Function

STANDARDS

More information regarding the NGSS standards of this activity is available at the end of this guide (page 9).

Stay Connected!

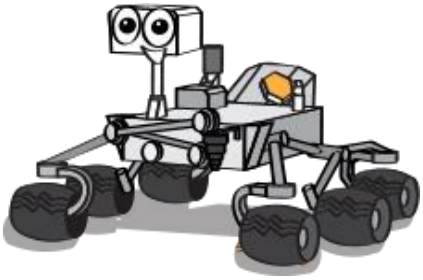
Be sure to share your research, designs, and prototypes with us online by tagging @chabotspace, or using the hashtags #ChabotRovers and #LearningLaunchpad

ROVER RESEARCH

NASA uses rovers to explore other places in our solar system. Research some of NASA's past missions to learn about what rovers have in common, and how they can be different. Is NASA planning to send any rovers to space in the future?

MATERIALS NEEDED

- A computer with internet access OR a few books about NASA rovers
- **TIP!** Check out your local library in person or online to see what books they have about rovers! Some suggested resources are listed below.
- Pen or pencil
- Research Log (page 7), or piece of paper



INSTRUCTIONS

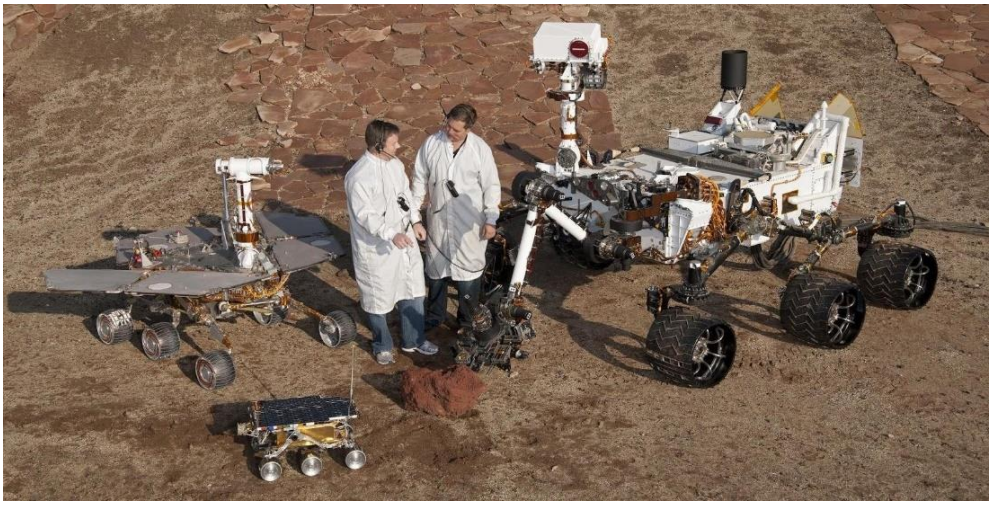
1. Get online! Open a web browser.
2. Check out some of the following websites:
    - **NASA's Space Place: Rovers** (https://spaceplace.nasa.gov/mars-rovers/en/)
    - **NASA Science: Mars Exploration Program** (https://mars.nasa.gov/#)
3. Pull out some books! Some titles are recommended below:
    - ***Curiosity: The Story of a Mars Rover*** Markus Motum
    - ***The Mighty Mars Rovers: The Incredible Adventures of Spirit & Opportunity*** Elizabeth Rusch
    - ***Exploring Space: From Galileo to the Mars Rovers and Beyond*** Martin Jenkins & Stephen Bietsy
    - ***Red Rover: Curiosity on Mars*** Richard Ho & Katherine Roy
4. Use the books and websites above to help you answer the questions in your research log. **TIP!** The resources listed are great to get you started, but feel free to use other books and websites too.

FOR GROWN UPS – ROVER CHEAT SHEET

NASA has sent rovers to many different places in the solar system. The first rovers NASA used were the **Apollo Lunar Roving Vehicles.** The first astronauts used these rovers to explore the surface of the moon. The astronauts drove the rovers around like a car, which allowed them to explore even more of the moon. These rovers were also nicknamed **"Moon Buggies!"**

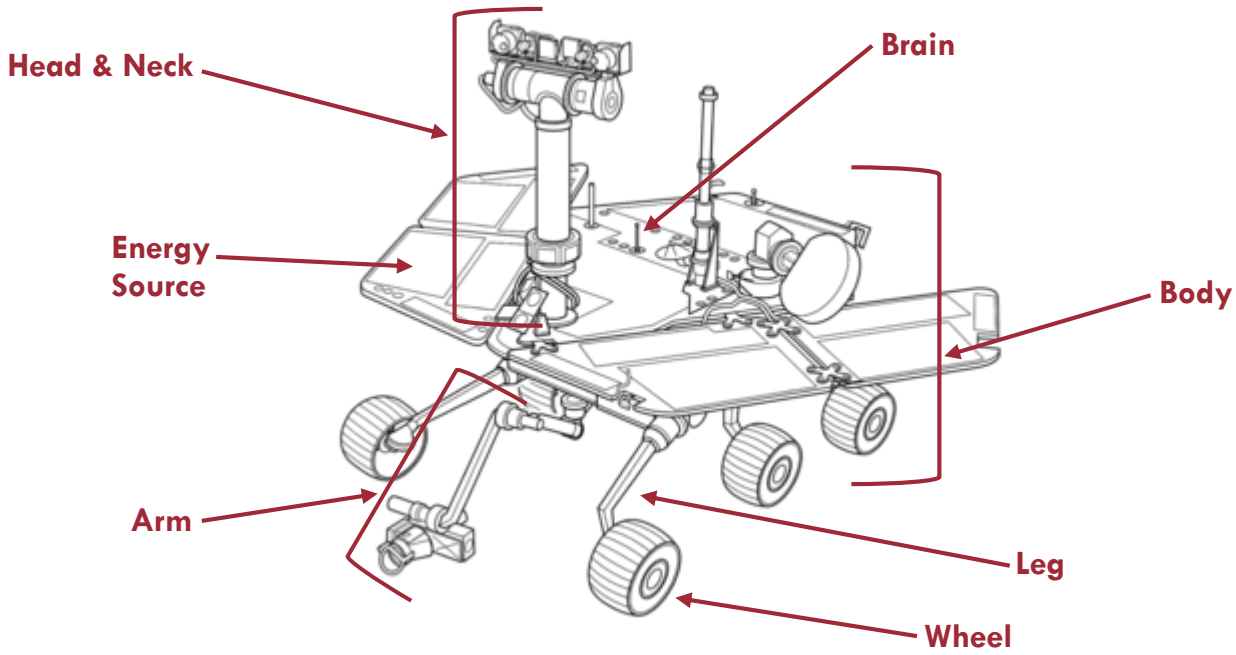
NASA has also sent **four** different rovers to explore Mars (Left). The first rover was named **Sojourner,** and was sent to mars in 1997. Sojourner was expected to explore mars for about a week, but ended up lasting for almost three months! She took over 500 pictures of the surface of Mars, and collected data about Martian wind and weather Patterns. The second and third rovers sent to Mars were **Spirit** and **Opportunity**. These **twin rovers** were launched around the same time in 2004, and explored opposite sides of the red planet. Spirit was active for 6 years, and opportunity for 14! The only rover that is active

on Mars today is the **Curiosity** rover, which launched in 2011. It's collecting data on rocks, dust, and oxygen in the Martian atmosphere.



NASA is also planning to launch a 5th rover to explore Mars in the future! This rover is named **Perseverance**, and will investigate Martian soil, rocks, and atmosphere to see if there is any evidence of past life forms on the red planet.

Most of NASA's modern rovers have similar parts and pieces. The main part of a rover, which houses all the vital systems is called the **body** of the rover. Similar to our own bodies, the body of a rover is the base, holding all the other parts together. The body also supports solar panels, which the rover uses to collect **energy** from the sun. The rover can store this energy in **batteries**, and use it to power its systems. Rovers also have a complex computer system, called the **brain**, The brain processes data, and helps transmit information back to Earth. A rover is able to move around on its **wheels** and **legs**. The wheels typically have thick treads, to help the rover move more easily along uneven surfaces. Rovers also have **arms** to extend their reach, which can have cameras or other tools used to collect data. Finally, rovers have a **neck** and **head**, which holds the main camera systems higher above the ground, to give the rover a better view.



DESIGN CHALLENGE: ROVERS

If you could design your own rover, where would you want it to go? What would it look like? Complete the challenge below to sketch, label, then design your own rover!

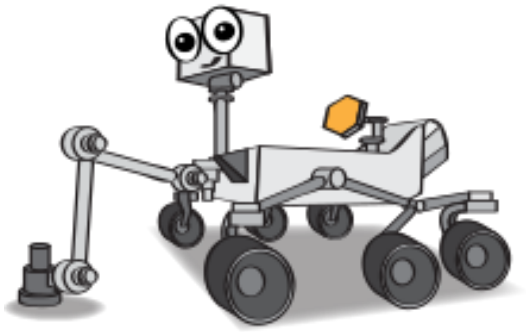
MATERIALS NEEDED

- Research Log (optional, page 7)
- Pencil or Pen
- Design Sheet (page 8)
- Scissors
- Tape or Glue
- Markers or Crayons (to decorate)
- **TIP**! Suggested materials are listed to the right, but feel free to substitute what you have! There are many different ways to build your rover

- Reusable Materials:
- Cardboard
- Construction Paper
- Paper cups
- Toothpicks
- Foil
- Straws
- Pipe Cleaners
- Popsicle Sticks
- Egg Cartons
- Toilet Paper or Paper Towel Rolls

INSTRUCTIONS

1. Get ready to brainstorm! Use your rover research and your imagination to answer the questions on the design sheet.
2. On the back of your design sheet, sketch what you'd like your rover to look like.



Optional Extension: Build a Prototype

1. Build the body of your rover.
    a) **TIP!** You can use a variety of materials for the body, but it should be something sturdy that you can attach other materials too.
2. Decorate the base! You can paint, color, or wrap your body however you'd like.
3. Build the wheels and legs of your rover. For help making a rover that rolls, follow steps (4-9) below.
    a) **TIP!** Materials that are round, and can roll make great wheels.
    b) **TIP!** Straws are a helpful material if you'd like to build a rover that rolls.
4. Tape a straw, or cylinder of paper horizontally across the bottom of your rover.
5. Repeat with one, two, or three more straws/paper cylinders. Try to make them equally spaced out on your rover.
6. Identify the materials you will be using as wheels, and as **axles**. The axel will hold your two wheels together.
    a) **TIP!** You will need the same number of axles as paper cylinders or straws, and twice the amount of wheels.

7. Thread your axle material through the straws or paper cylinders underneath your rover.
8. Use tape or glue to attach the center of your wheel to one end of an axle. Make sure the axel is still threaded through the straws on your rover!
9. Repeat so that each axle has two wheels attached to it, and is suspending on the bottom of your rover.
10. Add the arms, neck, and head to your rover. Use glue, tape, or poke them through the body of your rover to hold them in place.
    a) **TIP!** Strong, skinny materials that can stand up make good arms or necks.
    b) **TIP!** Get creative! You can add different tools to the ends of your rover arms too.
11. Add a brain, and an energy source to your rover. You can make them out of paper, cardboard, whatever material you think works best.
12. Decorate! You can add logos, a flag, even passengers to your rover.
13. Encourage others to build their own rover too. Can they use different materials than you to build their rover?
14. Share your rovers with us online! Tag @chabotspace on any social platform, and use the hashtags #ChabotRovers and #LearningLaunchpad

FOR GROWN UPS – MATERIALS TIPS

There are a variety of different materials you can use to build your own rover. For the body of a rover, cardboard, old boxes, even tin cans work well. Anything that's sturdy and can be attached to other pieces are great places to start while building your rovers.

For making a rover that rolls, the steps are listed above with some suggested materials, but there's more than one way to make wheels that spin. The key is to attach the axle of the wheels to the rover while still allowing the axle to spin freely. A common way to do this is to use a **bearing**, which is a hollow support that you can slip the axle through, then use the wheels or extra attachment to the axle to prevent it from falling out. Straws are a great material to use as a bearing, but you can also make your own out of paper or other materials. The bearing just needs to be wide enough for the axle to slip through. Rods, skewers, and toothpicks make great axels - basically anything that is long and skinny and will fit through the bearing. For wheels, anything that's round or circular will work, like toilet paper rolls, jar lids, ping pong balls, CDs - you can even make your own out of cardboard!

To make the arms, neck, and head of your rover, popsicle sticks, skewers, straws, pipe cleaners, or anything that's long, sturdy, and can stand under its own weight is recommended. You can make attachments like robot arms, sensors, or cameras to add to your rover too out of foil, construction paper, and other materials you might have around the house.

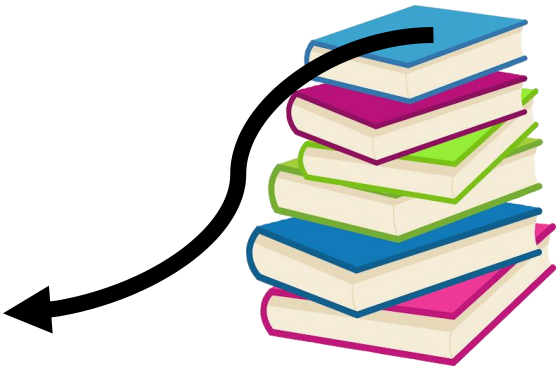
The above materials are recommendations to get you started, but there are many different ways of designing a rover, so be creative with the items that you have available!

ROVER RACES

Now that you've learned about and built your own rovers, it's time to race! Use the instructions and prompts below to build your own rover race tracks.

MATERIALS NEEDED

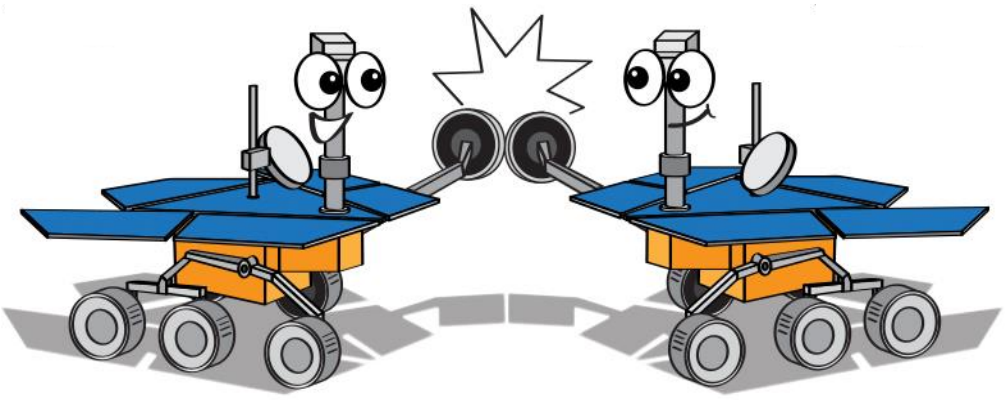
- (At least) one rover
- Large, flat piece of cardboard
- A stack of books
- Stopwatch or timer



INSTRUCTIONS

1. Place your stack of books on an open, flat surface.
2. Lean your piece of cardboard up against the stack of books, so that it's slanting towards the ground.
3. Stack one more book on top of the cardboard, sandwiching it in place.
4. Race your rovers!
    - Who's faster?
    - Can you make adjustments to improve your speed?
5. If you only have one rover, grab a timer! Time your rover as it rolls down the ramp.
    - How long did it take?
    - Can you make adjustments to make your rover faster or slower?
6. Investigate what happens when you change the number of books in your stack, making your ramp steeper or more flat.
    - Does the speed of your rover change too?

TIP! Cardboard works great for ramps, but you can also substitute other materials too. Large, flat hardcover books work well, as do the lids of storage bins, anything that's sturdy and flat!



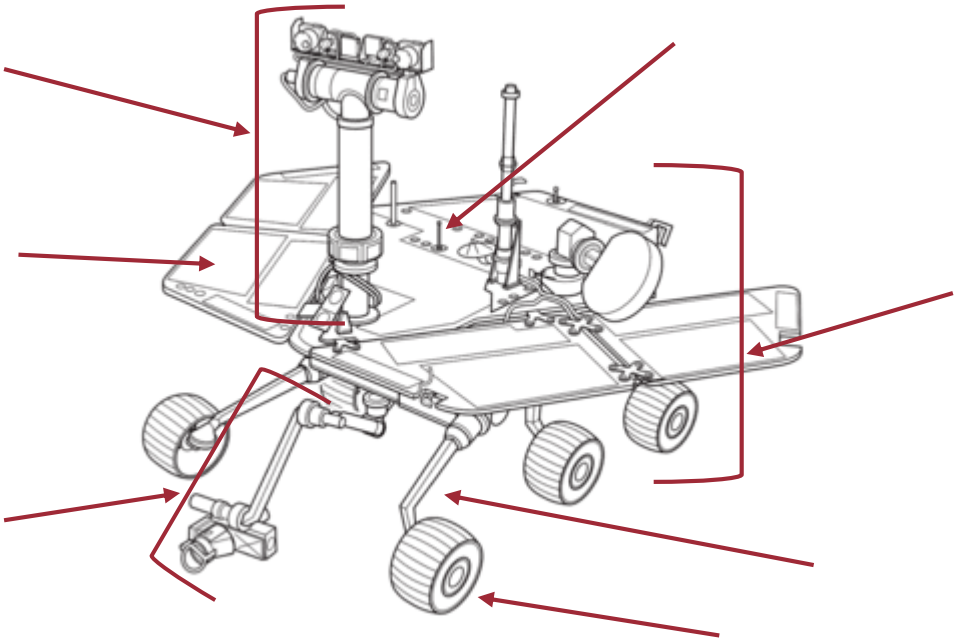
ROVER RESEARCH LOG

Answer the questions below to learn more about rovers.

NASA has sent 4 rovers to Mars. Can you figure out their names, and when they were launched?

What's the name of the next rover NASA wants to send to Mars? What do scientists hope to learn from this new rover?

Can you label all the parts of the rover in the image below?



CHALLENGE! Can you find an example of a rover that did not go to Mars? It might be a rover from the past!

ROVER DESIGN SHEET

Use this sheet to help you plan and design your very own rover!

Where in the solar system do you want your rover to explore? Pick your location, and write down three questions you have about this place that you'd want your rovers help answering.

What tools would you need to give your rover to help you answer the questions above?

Sketch your rover in the space below. Be sure to label all the parts!

BODY BRAIN LEGS WHEELS ARMS HEAD & NECK ENERGY SOURCE

Scavenger hunt! Look around the house to find materials you could use to build your rover.

- ☐ BODY
- ☐ BRAIN
- ☐ LEGS
- ☐ WHEELS
- ☐ ARMS
- ☐ TOOLS
- ☐ ENERGY SOURCE
- ☐ HEAD & NECK
- ☐ DECORATIONS

NGSS STANDARDS, SKILLS, CONCEPTS

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Completing these activities will satisfy the following NGSS standards:

- **K-PS2-1:** Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.
- **2-PS1-1:** Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
- **2-PS1-3:** Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.
- **K-2-ETS1-2:** Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- **K-2-ETS1-3:** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.
- **3-PS2-2:** Make observations and measurements of an objects motion to provide evidence that a pattern can be used to predict future motion.
- **3-5-ETS1-2:** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- **3-5-ETS1-3:** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

NGSS: PRACTICES FOR K-12 CLASSROOMS

Through these activities, learners of all ages will practice skills such as:

- Asking Questions
- Developing and Using Models
- Planning and Carrying out Investigations
- Analyzing and Interpreting Data
- Obtaining, Evaluating, and Communicating Information

NGSS: CROSS CUTTING CONCEPTS

Completing these activities will help learners understand the following about cross cutting concepts:

- **Cause and Effect:** cause and effect relationships are routinely identified and used to explain change that events have causes that generate observable patterns.
- **Structure and Function:** the shape and stability of structures of natural and designed objects are related to their function(s).

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