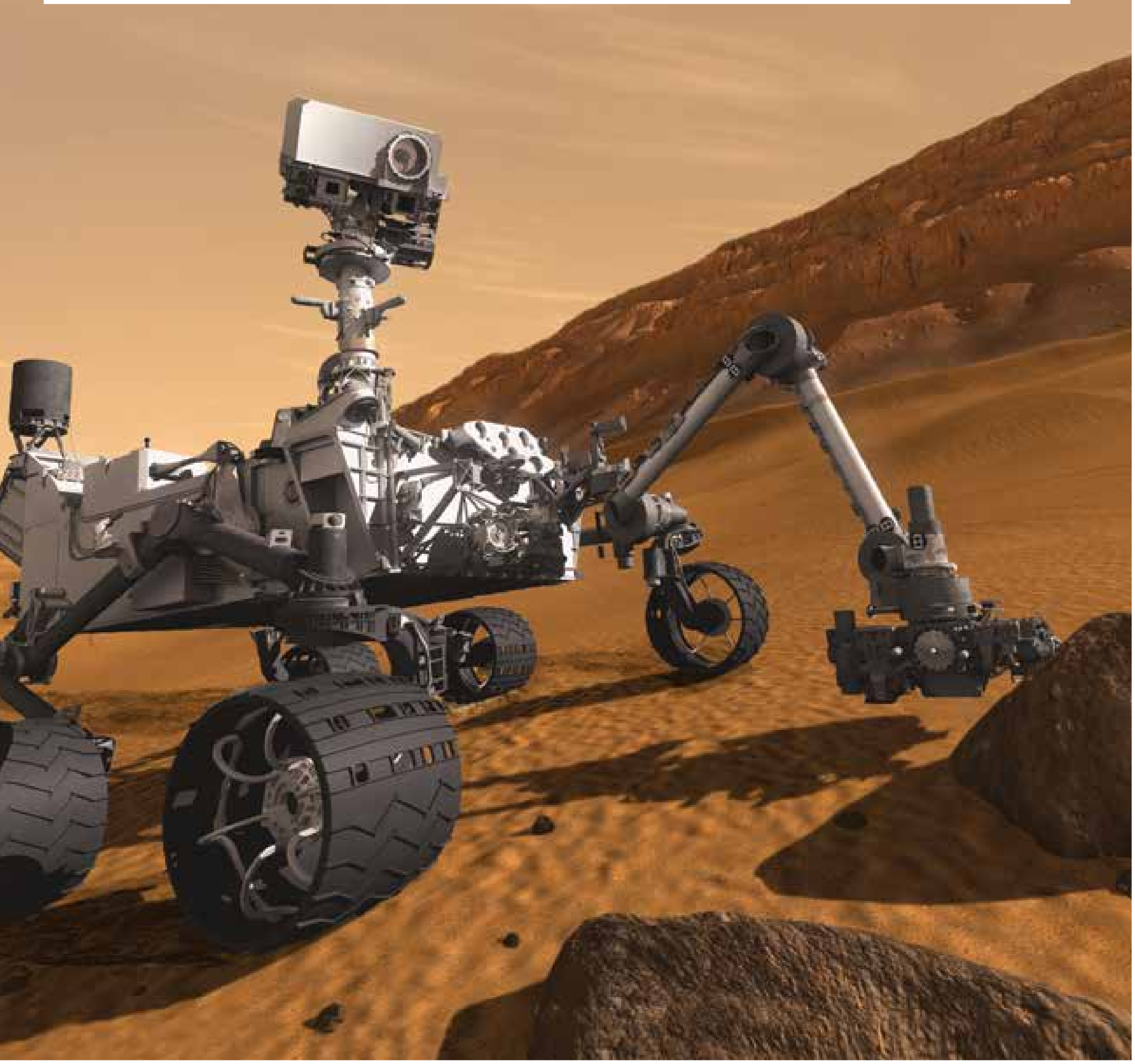
MISSION: SOLAR SYSTEM

NASA AND DESIGN SQUAD NATION TEAM UP TO INSPIRE A NEW GENERATION OF ENGINEERS



DESIGN squad Nation

in collaboration with the National Aeronautics and Space Administration

NASA

SPACE-BASED ENGINEERING CHALLENGES FOR SCHOOL AND AFTERSCHOOL PROGRAMS GRADES 4–8

National Aeronautics and
Space Administration

Headquarters
Washington, DC 20546-0001

Dear Educators:

Highly capable rovers, sophisticated sensors, and nimble spacecraft make this an especially exciting era in space exploration. Between October 2010 and August 2012, a fleet of NASA spacecraft made visits to many of our celestial neighbors. Their accomplishments include gathering clues about the evolution of the solar system, understanding the potential of Mars to support life now or in the past, and providing insights into the development of our own planet. So much exploration took place during these 23 months (the length of a single Martian year) that the Science Directorate gave the effort a special name—the Year of the Solar System. The Year of the Solar System missions have set the stage for future explorations. These and NASA's future missions have bold ambitions and are equipped with advanced technologies, helping NASA continue to broaden what we know about the solar system.

As NASA prepares for the future of exploration, we recognize that the young people of today are the engineers, scientists, and astronauts of tomorrow. Creativity, curiosity, and analytical thinking are the trusted tools of NASA's engineering toolkit, and we continually direct our educational efforts to create experiences that allow young people to develop these skills as they investigate and solve challenging problems.

NASA is proud to partner with *Design Squad® Nation*, Public Broadcasting Service's (PBS's) National Science Foundation-funded multimedia program for kids that includes television episodes, an interactive website, and hands-on engineering activities. Central to this partnership is our belief that science, technology, engineering, and mathematics education will play a vital role in solving the problems of the twenty-first century. *Mission: Solar System* is part of our long, proud tradition of showcasing how engineering fuels space exploration. By structuring the activities around real-world engineering applications, it is our hope that you will find the *Mission: Solar System* activities to be effective, innovative ways to engage your students in the engineering design process, encourage their interest in space exploration, and inspire them to pursue a career in engineering.

NASA supports people like you who play a key role in preparing the minds that will strengthen the nation's future. Use this guide to bring the possibilities of engineering to life for young people and to inspire them to solve challenging problems. Engage their creativity, foster their curiosity, and teach them to strive for excellence.

Sincerely,

John M. Grunsfeld
Associate Administrator for
Science Mission Directorate

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Launch your kids into space exploration! In *Mission: Solar System,* NASA and *Design Squad® Nation* bring kids fun, hands-on ways to think like NASA engineers. The guide's hands-on activities and videos let kids apply science, technology, engineering, and math (STEM) skills to solve design challenges. Use this resource in school and afterschool settings to engage kids in engineering and in NASA's exploration of our solar system.

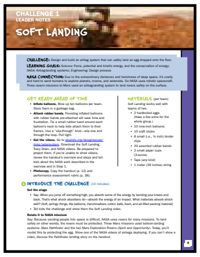
INTRODUCTION

ENGINEERING DESIGN CHALLENGES (Leader Notes and Handouts)

APPENDIX

PROJECT COMPONENTS

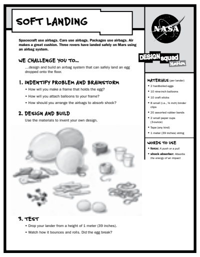
The standards-based challenges use readily available materials, give kids many ways to succeed, can be done in an hour, and work well with both large and small groups. The challenges have the following components and are downloadable at: pbskids.org/designsquad/links/solarsystem.



The Leader Notes give you all you need to run a challenge with kids.

Leader Notes

The leader notes include: an overview of the challenge and its connection to NASA; tips to help you prepare for, introduce, run, and wrap up the activity; discussion questions that explore the science, engineering, and space-related themes; and ways to make curriculum connections.



The Handouts help kids build and troubleshoot their projects.

Kids' Handout

These reproducible handouts step kids through each challenge, providing them questions to brainstorm, building tips, illustrations, and interesting stories about NASA missions related to the challenge.

The DIY Videos show kids having fun doing the challenge, using the design process, and applying science concepts.

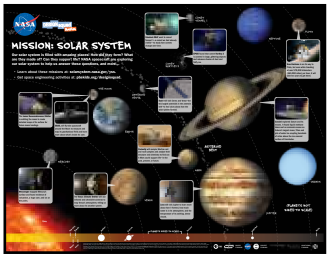
Do-It-Yourself (DIY) Videos

Each *Mission: Solar System* challenge has its own three-minute DIY video that shows kids doing the activity and talking about its science and engineering and its connection to NASA missions. Used as an introduction, the videos give kids a sense of the design possibilities and get them excited about doing some creative problem solving. Used as a wrap-up, the videos give you a way to reinforce the challenge's science, engineering, and NASA connection.

The Video Profiles feature NASA engineers and help kids relate the work they do in a challenge to real-world engineering.

Video Profiles of NASA Engineers

These three-minute videos feature young, dynamic engineers who tackle interesting problems related to NASA's solar system missions. They put a human face on engineering, showing engineers as well-rounded people with interesting work and personal lives. The connections to the activities are general—the primary goal is to break down engineer stereotypes and showcase engineering as a rewarding career. Each video has a sheet with discussion points and follow-up ideas to help kids make full use of the videos.



Wall Poster

This full-color poster gives kids a dramatic visual guide to NASA's Year of the Solar System missions. Post it so kids can easily read the fun mission facts, learn about solar-system destinations, and see images of the spacecraft.

RUNNING A CHALLENGE—START TO FINISH

Designed for kids in schools and afterschool programs, *Mission: Solar System's* five hands-on challenges bring to life NASA's Year of the Solar System missions. Each challenge provides an engaging way to integrate science and engineering into your science, technology, engineering, and mathematics (STEM) program.

BEFORE THE CHALLENGE

1. **Choose a challenge.** Consider your curricular goals and consult the activity overviews to choose a challenge that works for you.
2. **Read the Leader Notes.** Find out what to prepare ahead of time, the materials you'll need, and how to lead kids' exploration, troubleshoot potential issues, and wrap up the session.
3. **Try the challenge.** A practice run will help you figure out the best way to introduce the activity, anticipate potential questions and issues your kids may have, and identify modifications you may want to make.
4. **Get ready.** Use this section to determine what you'll need to prepare. You'll also want to download and preview the videos listed here. Get them at: pbskids.org/designsquad/links/solarsystem.
5. **Copy the Handout and Assessment Rubric (page 39)**. The black-and-white pages are designed to reproduce well on a photocopier.

DURING THE CHALLENGE

1. **Introduce the challenge.** Kick things off with the provided discussion prompts and everyday examples. Then show the DIY and NASA videos. Your kids will be inspired by seeing other kids tackling the challenge and will understand how the activity relates to NASA's exploration of the solar system. If you're unable to show videos, tell kids about the NASA connections described in the challenge overview and in the "Relate it to the NASA missions" section. Also review the handout's overview, steps, and stories.
2. **Identify the problem, brainstorm, and design.** Use the discussion prompts to get kids thinking about different ways to meet a challenge. Since an open-ended challenge offers kids many ways of succeeding, this section jump-starts their thinking about various possibilities and approaches.
3. **Build, test, evaluate, and redesign.** Use the strategies in this section of the Leader Notes to assist kids when issues arise as they work through a challenge. To help teams build and work effectively, give them the assessment rubric (page 39) and discuss its four performance criteria.
4. **Discuss what happened.** Use the questions (and answers) in the wrap-up section of the Leader Notes to review the challenge's science and engineering concepts, help kids reflect on how they used the design process (see page 4), and highlight how the challenge relates to NASA's solar system explorations.
5. **Show the NASA engineer profile.** These videos show young, dynamic NASA engineers tackling interesting problems related to NASA's missions and highlight how exciting engineering can be. Download the companion sheet with discussion prompts and follow-up ideas.

FOLLOWING UP THE CHALLENGE

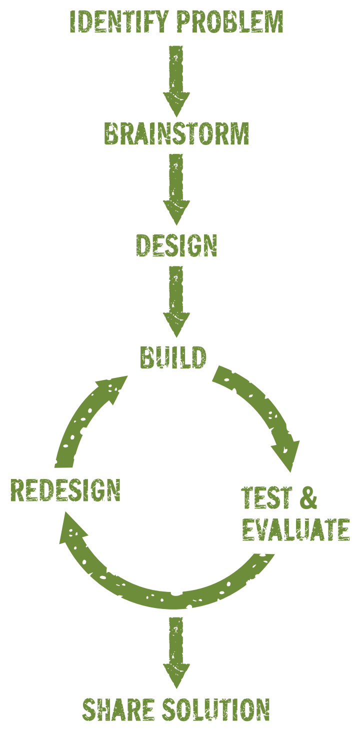
1. **Extend the challenge.** This section of the Leader Notes presents a few quick, fun ways that build on the experiences kids have had in a challenge and further their exploration.
2. **Curriculum connections.** This section of the Leader Notes offers suggestions for how to tie kids' challenge experiences to concepts commonly covered in science, math, and technology curricula.

INTRODUCING THE DESIGN PROCESS

When NASA engineers try to solve a problem, they try different ideas, learn from their mistakes, and try again. The series of steps engineers use to arrive at a solution is called the ***design process***.

Different versions of the design process exist. Yet, they all describe an iterative process for developing effective solutions to problems. *Design Squad Nation's* design process (graphic on the right) is available as a poster on page 38 of this Teacher's Guide.

As kids work through a challenge, use questions such as the ones below to talk about their work and tie what they are doing to specific steps of the design process.



BRAINSTORM

- What are some different ways to tackle today's challenge?
- Off-the-wall suggestions often spark GREAT ideas. How creative can you be?

DESIGN

- Which brainstormed ideas are really possible, given your time, tools, and materials?
- What are some problems you need to solve as you build your project?
- How can a sketch help clarify your design?

BUILD

- What materials will you need?
- What can you learn by looking at other kids' projects?

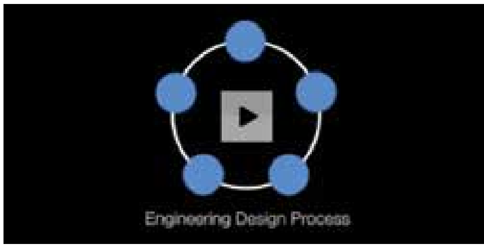
TEST, EVALUATE, AND REDESIGN

- Why is it a good idea to keep testing a design?
- What specific goal are you trying to achieve, and how will you know if you've been successful?
- How does the design meet the criteria for success presented in the challenge?

SHARE SOLUTIONS

- What's the best feature of your design? Why?
- What was the hardest problem to solve?
- What were the different steps you did to get your project to work?
- If you had more time, how would you improve your project?

As kids work through a challenge, they'll see that the steps of the design process encourage them to think creatively to solve a problem and produce a successful result.



This NASA video introduces kids to one version of the engineering design process and the methods engineers use to approach and solve problems. Get it at: www.nasa.gov/audience/foreducators/best/edp.html.

Tips for Facilitating Open-Ended Challenges

Emphasize creativity. There are multiple ways to successfully tackle a challenge, and one successful solution is as good as another. Help kids see that the challenges are not competitions. Instead, they're opportunities to unleash an individual's ingenuity and creativity.

Tap the power of brainstorming. Have kids come up with several ways to solve a problem before they move ahead with an idea.

See problems as opportunities. When something's not going as desired, encourage kids to try again. Problems are opportunities for learning and creative thinking.

Use questions to guide kids. When kids feel stuck, have them explain why they think they got the results they did. Then ask questions to get kids back on track rather than telling them what to do. For example, ask: "Why do you think this is happening?" or "What would happen if…?" or "What is another thing you could try?"

If a design doesn't work as planned, encourage kids to try again. Setbacks often lead to design improvements and to ultimate success.

Fit the Guide's Challenges into Any Program

Classrooms, afterschools, clubs, and other ongoing programs

Mission: Solar System challenges provide fun ways for kids to apply the design process and core science concepts. Each activity is distinct, offering kids variety, letting them unleash their creativity, and helping them practice important skills, such as problem solving, teamwork, and critical thinking.

Events and other one-time occasions

Take *Mission: Solar System* activities to a museum, library, mall, or university and spark kids' interest and confidence in engineering with a lively, fun-filled event. The *Inspector Detector* challenge is especially good for events like science and engineering days—it uses simple, readily available materials, and is open ended, with multiple solutions that engage a wide variety of ages and ability levels.

WHY HAVE NASA AND DESIGN SQUAD NATION TEAMED UP?

It's a natural! NASA is one of the biggest employers of engineers in the world—over 90,000 between its own employees and its corporate partners. Clearly, NASA's work depends on engineers. Not surprisingly, NASA is deeply committed to getting kids excited about engineering and inspiring them to become engineers.

And *Design Squad Nation* is all about engaging kids in engineering. Its award-winning TV program, website, and hands-on challenges highlight the fun, excitement, and rewards of engineering. Kids see that engineering not only can unleash their creativity, it can also offer an approach to challenges that enables people to make a real difference and change the world.

By teaming up to bring you the *Mission: Solar System* set of resources, NASA and *Design Squad Nation* put fun, hands-on challenges in the hands of educators whose goal is to make engineering and the adventure of space exploration real and relatable for kids.

NASA'S EXPERTISE IS EXPLORING SPACE

What's out in space? What will we find? What can we learn just by trying to get there, that will make life better here on Earth? NASA has been working for over 50 years to answer these questions. Its mission? To pioneer the future in space exploration, scientific discovery, and aeronautics research.

NASA scientists and engineers work in laboratories, on airfields, in wind tunnels, and in control rooms at NASA's ten centers around the country and even in different countries. NASA's work is divided into four main areas:

- ***Aeronautics:*** pioneers and tests new flight technologies that have practical applications on Earth and improve our ability to explore space.
- ***Exploration Systems:*** creates new capabilities and spacecraft for affordable, sustainable human and robotic exploration.
- ***Science:*** explores Earth, the moon, Mars, and beyond; charts the best route of discovery; and reaps the benefits of Earth and space exploration for society.
- ***Space Operations:*** provides technologies through the International Space Station, the Orion space capsule, the Space Launch System rocket, and flight support.

"NASA's engineers do some of the most amazing things ever undertaken by mankind." David E. Steitz, NASA

DESIGN SQUAD NATION'S EXPERTISE IS ENGAGING KIDS IN ENGINEERING

Design Squad Nation is a powerful multimedia way to open kids' eyes to the exciting world of engineering. The award-winning website gives kids a forum to brainstorm, submit project ideas, and respond to other kids' ideas. It also provides parents and educators with resources that bring engineering to life for kids and empower them to use their ingenuity to solve problems. Its Emmy and Peabody Award-winning television series lets kids see teens working on amazing, sometimes wacky projects that showcase the fun and creativity involved in engineering. Pages 7 and 37 list *Design Squad Nation* resources that get kids excited about engineering.

Imagination fuels innovation. To explore the frontiers of Earth, the solar system, and the universe, NASA engineers work on the coolest stuff, find solutions to extraordinary challenges, and turn dreams into realities.

RESOURCES FROM NASA AND DESIGN SQUAD NATION

FROM NASA

NASA offers many ways to enhance kids' explorations of the solar system. The websites below will quickly connect you to a host of resources.

NASA's education program (K–12). Find a variety of resources for students and educators. You can identify teaching materials by keyword, grade level, or subject at this NASA education hub. nasa.gov/audience/foreducators/index.html

Year of the Solar System (K–14). Get a host of activities and related resources (e.g., images, animations, videos, interactives, and podcasts) related to the 11 Year of the Solar System missions, organized by grade and searchable by topic. solarsystem.nasa.gov/yss

NASA Wavelength (K–16). Explore this peer-reviewed collection of digital Earth and space-science resources for formal and informal educators. The site's social media features even let you share your favorites with others. nasawavelength.org

NASA Solar System Exploration (K–16). Access resources for planets, missions, news, and education at this one-stop-shopping website devoted to solar system exploration. solarsystem.nasa.gov

NASA Robotics Education (K–12). Innovation, creativity, problem solving—the world of robotics at NASA is all of these things. Visit this site to see if robotics might be in your future. nasa.gov/education/robotics

Eyes on the Solar System interactive (5–8). Download this visualization tool to explore the solar system in 3-D using real mission data. Control your experience and see planets up close, hop on an asteroid, watch the solar system move in real time, and fly a spacecraft. eyes.nasa.gov

FROM DESIGN SQUAD NATION

Design Squad Nation is a diverse program designed to inspire the next generation of engineers. Check out the following resources in the website's Parents and Educators area: pbskids.org/designsquad/parentseducators.

Engineering-design challenges. Like the hands-on challenges in this guide? There are 60 more, covering such topics as electricity, force and energy, and technology and materials.

Scientist and engineer profiles. Like the *Mission: Solar System* engineers video profiles? We've got dozens more of engaging, young engineers tackling interesting problems and showing that engineering is a rewarding career that helps make the world a better place.

Online games. Kids can use their problem-solving and engineering skills in the multiplayer game *DESIGNit, BUILDit, FIDGiT;* and can compose music playing the *String Thing* interactive.

Interactive community. Kids can submit photos and sketches of their designs and projects and see what other kids have made. Educators can get project ideas for their own students.

TALKING WITH KIDS ABOUT ENGINEERING

Few kids can say what engineering is or what an engineer does. Yet once they find out, many are hooked! You can be the one to help a young person discover just how cool engineering can be. As you work with kids, use the information below to talk with them about engineering.

WHAT'S AN ENGINEER?

Engineers dream up creative, practical solutions and work with other smart, inspiring people to invent, design, and build things that matter. They are changing the world all the time.

WHAT DO ENGINEERS DO?

- **Think creatively.** Engineering is an ideal outlet for imagination and creative problem solving—an ideal field for independent thinkers.
- **Work with great people.** Engineering takes teamwork. As an engineer, you'll be surrounded by smart, creative, inspiring people.
- **Solve problems and design things that matter.** Engineers improve peoples' lives by tackling problems, improving current designs, and coming up with solutions no one else has thought of.
- **Change the world and make a difference.** Among many other pursuits, engineers develop systems that save lives, prevent disease, reduce poverty, and protect our planet.

You can be the one to help a young person discover just how cool engineering is.

HOW DO ENGINEERS IMPROVE PEOPLE'S LIVES AND MAKE THE WORLD A BETTER PLACE?

- Build spacecraft that travel to the moon
- Develop state-of-the-art cell phones
- Create more fuel-efficient cars
- Invent artificial retinas for the blind
- Design lighter bike frames
- Construct tall skyscrapers and high bridges
- Build systems that purify water and process waste
- Design clothing that repels mosquitoes
- Create satellites that detect drought around the world
- Develop a feather-light laptop

WHAT'S ENGINEERING?

"Engineers get to imagine the future and design for it."
Marisa Wolsky, *Design Squad* Executive Producer

"Engineering is about thinking through problems, finding solutions, and helping people."
Daniele Lantagne, environmental engineer

"The best part of being an engineer is the creativity that's involved and the satisfaction that comes from solving hard problems."
Jananda Hill, computer-science engineer

"Every day I see things that could be made better by just applying some good engineering know-how."
Jessica Miller, biomedical engineer

Photo credit: NASA/JPL

CHALLENGE 1
SOFT LANDING
LEADER NOTES

CHALLENGE: Design and build an airbag system that can safely land an egg dropped onto the floor.

LEARNING GOALS: *Science:* Force, potential and kinetic energy, and the conservation of energy; *NASA:* Airbag-landing systems; *Engineering:* Design process

NASA CONNECTION: Due to the extraordinary distances and harshness of deep space, it's costly and hard to send humans to explore planets, moons, and asteroids. So NASA uses robotic spacecraft. Three recent missions to Mars used an airbag-landing system to land rovers safely on the surface.

GET READY AHEAD OF TIME

- **Inflate balloons.** Blow up ten balloons per team. Store them in a garbage bag.
- **Attach rubber bands.** Providing inflated balloons with rubber bands pre-attached will save time and frustration. Tie a small rubber band around each balloon's neck to help kids attach them to their frames. Use a "slip-through" knot—slip one end through the loop. Pull tight.
- **Get the videos.** Go to pbskids.org/designsquad/links/solarsystem. Download the *Soft Landing,* Erick Ordoñez, and NASA videos. Be prepared to project them. If you're unable to show videos, review the handout's overview and steps and tell kids about the NASA work described in the overview and in Step 1.
- **Photocopy.** Copy the handout and performance assessment rubric (page 39).

MATERIALS (per lander)

Soft Landing works well with teams of two.

- 2 hardboiled eggs (Have a few extra for the whole group.)
- 10 nine-inch balloons
- 10 craft sticks
- 8 small (i.e., ¾ inch) binder clips
- 20 assorted rubber bands
- 2 small paper cups (3-ounce)
- Tape (any kind)
- 1 meter (39 inches) string

1 INTRODUCE THE CHALLENGE (10 minutes)

Set the stage

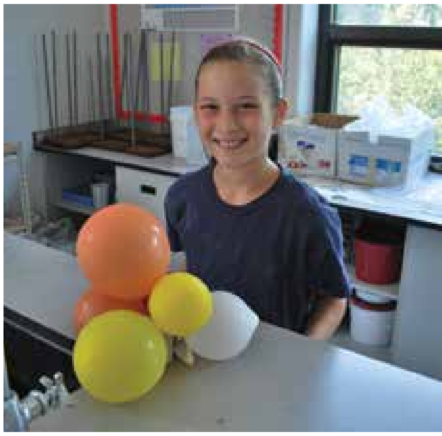
- Say: When you jump off something high, you absorb some of the energy by bending your knees and back. That's what shock absorbers do—absorb the energy of an impact. What materials absorb shock well? *(Soft, springy things, like balloons, marshmallows, cotton balls, foam, and air-filled packing material)*
- Tell kids the challenge and show them the *Soft Landing* video.

Relate it to NASA missions

Say: Because sending people into space is difficult, NASA uses rovers for many missions. To land safely on other worlds, the rovers must be protected. Three Mars missions used balloon-landing systems: *Mars Pathfinder* and the two Mars Exploration Rovers (*Spirit* and *Opportunity*). Today, you'll model this by protecting the egg. Show one of the NASA videos of airbags deploying. If you can't show a video, discuss the *Pathfinder* landing story on the handout.

2 BRAINSTORM AND DESIGN (10 minutes)

- **Identify the problem.** Have kids state the problem in their own words (e.g., keep the egg from breaking when it's dropped).
- **Show different kinds of frames.** Ask: How will you construct a frame to hold the egg firmly? Demonstrate how to connect the craft sticks with binder clips or with rubber bands.
- **Discuss the balloons.** Ask: How many balloons do you need to cushion the egg? (*Eight to ten work well.*) Show kids how the rubber bands can help them attach the balloons to the frame.



In ***Soft Landing,*** kids model three Mars missions that used airbag-landing systems.

3 BUILD, TEST, EVALUATE, AND REDESIGN (30 minutes)

If any of these issues come up, ask questions to get kids thinking about how they might solve them.

- **If balloons pop…** Have kids see if there are any sharp edges on their frames that need to be covered or eliminated. Check if they taped their balloons together. Tape is so inflexible that it can rip a balloon as it stretches upon impact. Have them remove some tape.
- **If balloons fall off the frame…** Point out the different materials kids can use to attach balloons (e.g., string, tape, and rubber bands).
- **If their egg breaks…** Have kids analyze why and improve the lander's ability to absorb shock.

Kids use the engineering design process to build landers that will protect an egg dropped onto the floor.

4 DISCUSS WHAT HAPPENED (10 minutes)

Emphasize key elements in today's challenge by asking:

- **Engineering:** How did testing help you decide what changes to make to your lander? (*Point out that kids followed the engineering design process: they brainstormed an initial design, built an early version [i.e., a prototype], and then revised it based on testing.*)
- **Engineering:** What design features did today's successful landers have? (*Typically, they have an effective way to absorb shock, stay intact upon impact, and protect the egg on all sides.*)
- **Science:** Why is it more likely for an egg to break when you drop it from a greater height? (*Due to the acceleration of gravity, a lander gains more energy when released from a greater height than from a lower height. The greater the energy, the greater the force of impact.*)
- **NASA:** What are some advantages of an airbag-cushioned landing? (*It can land in a variety of terrains and is lighter compared to a controlled landing, which requires fuel, engines, and a control system.*)
- **Career:** Show kids the engineer profile featuring Erick Ordoñez. As a materials engineer, he makes sure that the materials that go into space do the job and won't cause problems, like catching fire or failing at a crucial moment like during an airbag landing. Download the profile sheet for fun facts, discussion prompts, and extension ideas.

EXTEND THE CHALLENGE

- **Go higher.** Drop the landers from bleachers, balconies, windows in a building, etc.
- **Go lighter.** It costs $25,000 to send 0.5 kilos (1 pound) of material into space. That's why NASA engineers build the lightest spacecraft possible. Have teams optimize for weight. Divide the drop height by the weight. The successful mission with the lowest ratio of weight to drop height wins.
- **Rolling test.** Go bowling! Whose lander can protect the egg as it rolls across the floor?

CURRICULUM CONNECTIONS

Use *Soft Landing* to engage, explain, and extend student understanding of the following topics:

- **Force.** The airbags absorb energy from the collision between the ground and lander. The increased pressure in the airbag exerts a force in the opposite direction of the "push" from the ground (Newton's 3rd Law). Since heavy objects hit the ground with more force than lighter ones, you can discuss Newton's 2nd Law (force = mass x acceleration). Air also exerts a force on the lander as it falls.
- **Potential, kinetic, and mechanical energy.** Kids increase the potential (stored) energy of their landers when they lift them up. Once they let go, this potential energy changes to kinetic (motion) energy. When a lander hits the surface, some of its kinetic energy changes into mechanical energy (i.e., it does work by exerting a force on the airbag over a distance). Some of it also changes back into potential energy, as the air pressure inside the airbag increases. Ask kids to identify all the places one kind of energy changes into another kind.
- **Conservation of energy.** Drop a ball to the floor. Ask kids how high it bounces each time. (The ball bounces highest on the first bounce, getting successively lower with each additional bounce.) The law of conservation of energy says that energy cannot be lost or gained in a system. Ask kids why the ball doesn't bounce to the same height each time. (Each time the ball bounces, it loses energy to the work involved in compressing the ball and to friction with the ground and air. The cycle repeats until the ball—and lander—ultimately distributes its energy and stops.)

SOFT LANDING

Spacecraft use airbags. Cars use airbags. Packages use airbags. Air makes a great cushion. Three rovers have landed safely on Mars using an airbag system.

WE CHALLENGE YOU TO...

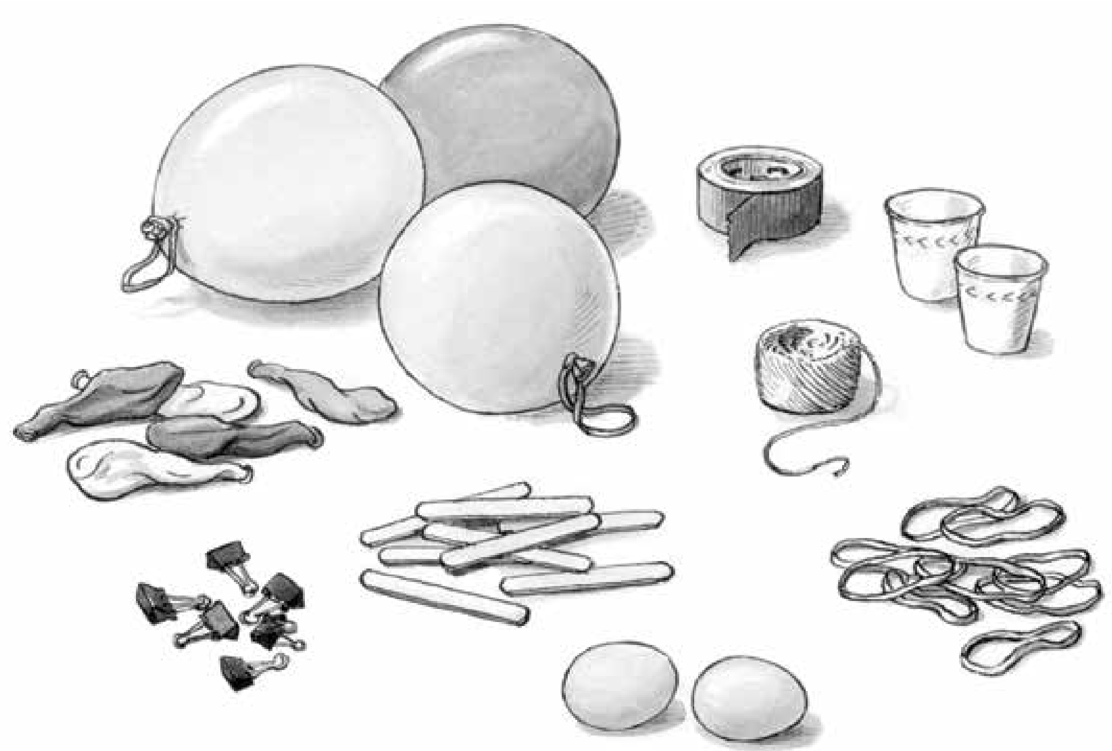
...design and build an airbag system that can safely land an egg dropped onto the floor.

1. IDENTIFY THE PROBLEM AND BRAINSTORM

- How will you make a frame that holds the egg?
- How will you attach balloons to your frame?
- How should you arrange the airbags to absorb shock?

2. DESIGN AND BUILD

Use the materials to invent your own design.



3. TEST

- Drop your lander from a height of 1 meter (39 inches).
- Watch how it bounces and rolls. Did the egg break?

MATERIALS (per lander)

- 2 hardboiled eggs
- 10 nine-inch balloons
- 10 craft sticks
- 8 small (i.e., ¾ inch) binder clips
- 20 assorted rubber bands
- 2 small paper cups (3-ounce)
- Tape (any kind)
- 1 meter (39 inches) string

WORDS TO USE

- **force:** *A push or a pull*
- **shock absorber:** *Absorbs the energy of an impact*

4. EVALUATE AND REDESIGN

- How well did the egg stay in the frame?
- How well do the balloons stay together to protect the egg on all sides?

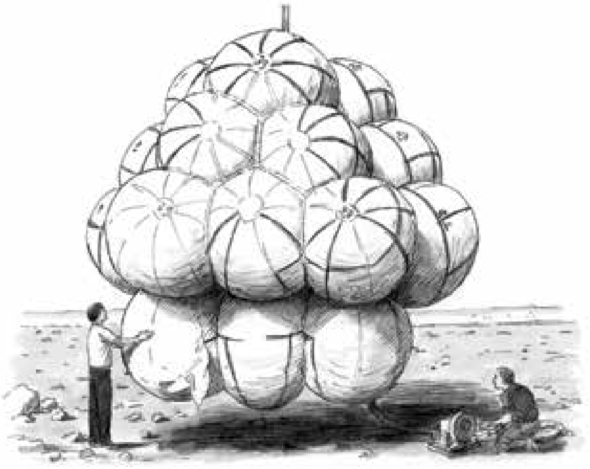
5. TRY THIS NEXT!

- Drop the lander from 2 meters (78 inches). How high can you go?
- Add a parachute or other system to slow the lander before it hits the ground.

Check out NASA's missions at nasa.gov

NASA EXPLORES SPACE

This picture shows NASA engineers testing an airbag-landing system on Earth. Three rovers have used this system to land safely on Mars. As they approach Mars, they're going about 20,000 kilometers (12,000 miles) per hour. Thanks to a parachute, heat shield, and rockets, the airbag-wrapped rovers hit the surface going about 80 kilometers (50 miles) per hour. One bounced as high as a five-story building. Then after 15 bounces, it stopped rolling, the airbags deflated, and the mission began.



The *Curiosity* rover is on Mars, studying the Martian climate and geology and looking for substances associated with life. *Curiosity* is the size of a small car. It is so big and heavy—about five times larger than earlier rovers—that it couldn't use an airbag-landing system. Instead, it used a rocket-propelled sky-crane that lowered it gently to the surface.

Visit the *Design Squad Nation* website at pbskids.org/designsquad.

MAJOR FUNDING PROJECT FUNDING ADDITIONAL FUNDING

Design Squad Nation is produced by WGBH Boston. Major funding is provided by the National Science Foundation. Project funding is provided by Northrop Grumman Foundation and S.D. Bechtel, Jr. Foundation. Additional funding is provided by United Engineering Foundation (ASCE, ASME, AIChE, IEEE, AIME). This *Design Squad Nation* material is based upon work supported by the National Science Foundation under Grant No. EEC-1129342. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. This NASA/Design Squad Nation challenge was produced through the support of the National Aeronautics and Space Administration under Grant No. <NNX12AB47G> issued through the Science Mission Directorate.


Photo credit: NASA/JPL

CHALLENGE 2
LEADER NOTES
ROBO ARM

CHALLENGE: Design and build a robotic arm that can lift a cup off a table.

LEARNING GOALS: *Science:* Levers, tension, and compression; *NASA:* Robotic arms; *Engineering:* Design process

NASA CONNECTION: To explore the surface of a planet, moon, or asteroid, rovers use robotic mechanical arms to do such things as collect samples, take pictures, and monitor the environment.

GET READY AHEAD OF TIME

- **Make the cardboard strips.** The long strips should be 15–20 centimeters (6–8 inches). For short strips, cut some long strips in half. The corrugation must run the length of the strip, not across it. Otherwise, it will bend and crimp easily. Punching cardboard is hard for kids. Punch one hole in the corner of each strip.
- **Make guides for the string.** Pre-cut the straws into 2.5-centimeter (1-inch) lengths. (Six per arm)
- **Get the videos.** Go to pbskids.org/designsquad/links/solarsystem. Download the *Robo Arm,* Sandeep Yayathi, and NASA videos. Be prepared to project them. If you're unable to show videos, review the handout's overview and steps and tell kids about the NASA work described in the overview and in Step 1.
- **Photocopy.** Copy the handout and performance assessment rubric (page 39).

MATERIALS (per arm)

- 1 large strip of corrugated cardboard (about 5 x 20 centimeters [2 x 8 inches]) with a hole punched in one corner
- 1 small strip of corrugated cardboard (Cut a large strip in half.) Punch a hole in one corner.
- 1 medium (i.e., 1-inch) brass fastener
- 1 straw, cut into 2.5-centimeter (1-inch) lengths
- 100 centimeters (39 inches) of smooth string (e.g., kite string)
- 2 large paper clips
- 2 paper cups (3-ounce)
- Tape (any kind)

1 INTRODUCE THE CHALLENGE (10 minutes)

Set the stage

- Robotic and human arms have similarities. Both use flexible parts (string or muscle) to move rigid parts (cardboard or bone). The string's or muscle's pull is directed by a guide (straw or tendons), and the guide's position affects the arm's efficiency. Finally, the brass fasteners mirror our joints. Make the "strings" (tendons) in the hand visible by having kids lift their fingers up and back.
- Tell kids the challenge and show them the *Robo Arm* video.

Give the NASA context

- Show one of the NASA videos that lets kids see a robotic arm in action.

2 BUILD A TWO-SECTION ARM (25 minutes)

Identify the problem

In Step 2, kids build a two-section arm and use it to play "Kick the Cup," a game where they keep their Robo Arms flat on the table. Step 2 lets kids focus on getting the sections to pivot properly and on using the string and guides to move the "hand." Mastering these elements ensures success in Step 3.

Brainstorm and design (5 minutes)

In *Robo Arm,* kids substitute a mechanical system for bones, joints, and muscles. Liken the cardboard to bones, string to muscles and tendons, and pivots to the joints in the hand and arm. Point out the system's lever arms and pivots. Ask:

- How will you connect the cardboard strips so they move freely? *(Insert a brass fastener loosely enough so the sections move easily.)*
- Where will you attach the string to the cardboard so that the sections move the way you want? *(Different attachment points will yield different results in terms of the pull required and the distance the arm moves.)*
- How will you use the straws as guides for the string? *(Decide how to make the joint work and THEN tape the guides in place so the string pulls as intended.)*

A *Robo Arm* is a lever system with sections pivoting around a fulcrum.

Build (15 minutes)

If any of these issues come up, ask questions to get kids thinking about how they might solve them.

- **If the sections don't move freely…** Loosen the brass fasteners. There's a lot of friction when the joint is tight, which keeps the "hand" from moving easily.
- **If the hand doesn't move in the direction it should…** Check that the end of the string is taped to an appropriate spot on the cardboard. Also check that the guide(s) are positioned so the string pulls efficiently.

Test, evaluate, and redesign (5 minutes)

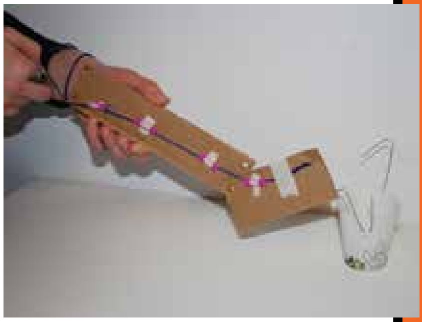
Play "Kick the Cup." Kids set paper cups near the end of their Robo Arms. They pull the string quickly and try to kick the cup across the table. Once they do, they're ready for Step 3.

3 ADD A HOOK TO THE ROBO ARM (10 minutes)

Identify the problem

In Step 3, kids unbend paper clips to form hooks and poke them into one of the arm's corrugation tubes. They tape a second paper-clip hook to a cup and use their Robo Arms to hook this "target" cup. Gather kids around a big table.

- Have a few kids demonstrate how their Robo Arms kick a cup.
- Show them how to fashion a hook out of a paper clip and insert it into a corrugation tube.
- Have kids make hooks and use their Robo Arms to lift target cups.



A two-section *Robo Arm* about to hook a Target Cup.

Build, test, evaluate, and redesign

Have kids play these two games:

- **Round Robin.** Everyone stands around a table, holding his or her Robo Arms. There is one target cup. The first kid lifts the target cup and sets it in front of the person to the right. This action repeats until the cup ends back at the first person. Can you do it faster?
- **Relay Race.** Form two teams. Have half of each team stand against one wall and the other half against the opposite wall. Using a Robo Arm, the first kid in line picks up a target cup, races across the room, and sets it down. The kid at the head of that line uses his or her Robo Arm to pick it up and carry it back across the room. The first team to cycle through wins.

4 DISCUSS WHAT HAPPENED (10 minutes)

Emphasize key elements in today's challenge by asking:

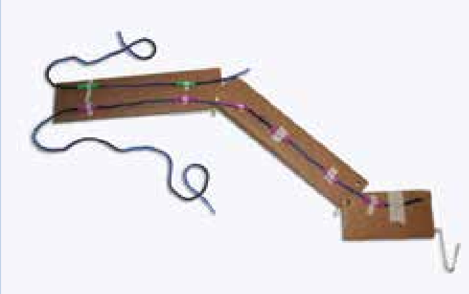
- **Engineering:** Basing a design on an existing object is called "reverse engineering." How is making a Robo Arm an example of reverse engineering? *(By starting with a known [i.e., their hands and arms] and building a mechanical version, kids are reverse engineering.)*
- **Science:** A Robo Arm is a lever system. What part is the fulcrum? The lever arm? What's the effect of moving a fulcrum, changing the length of a lever arm, or changing the string's attachment point? *(The brass fastener is the fulcrum and the cardboard is the lever arm. Changes will alter the force required to move the lever.)*
- **NASA:** What are some advantages of using robotic arms? (*Mechanical arms can be much stronger and more adaptable than human arms. Plus, robotic arms can be remotely operated, even over millions of miles.)*
- **Career:** Show kids the engineer profile featuring Sandeep Yayathi. As a robotics engineer, he designs and builds humanoid robots to work alongside astronauts. His robots have a lot of dexterity, strength, and intelligence. Download the profile sheet for fun facts, discussion prompts, and extension ideas.

Kids unbend paper clips to form hooks and poke them into one of the Robo Arm's corrugation tubes.

Kids use their Robo Arms to play games.

EXTEND THE CHALLENGE

- Add a third section to the arm, like a person's upper arm.
- Figure out a way for the hand to grip and pick up an object.



CURRICULUM CONNECTIONS

Use *Robo Arm* to engage, explain, and extend student understanding of the following topics:

- **Simple machines.** Levers convert a little effort into a lot of force (like a paper cutter or hammer) or convert a little movement into a large movement (like a broom or baseball bat). Ask kids to identify the lever systems in the arm. Then have them describe the effect of repositioning the fulcrum or changing the length of a section or the string's attachment point.
- **Tension and compression.** Tension is a pulling, stretching force. String is good in tension, making it an effective control cable. Compression is a pushing, squeezing force. Cardboard is good in compression, making it an effective lever arm. Have kids point out the places on the arm that are in tension and in compression and how the materials were selected to withstand these forces.

ROBO ARM

NASA sends spacecraft equipped with robotic arms to explore places humans can't yet visit, like Mars and asteroids. These arms are strong and adaptable and are where a lot of work gets done—it's where many of the Mars rovers' tools live.

WE CHALLENGE YOU TO...

...design and build a Robo Arm that you can use to lift a cup off a table.

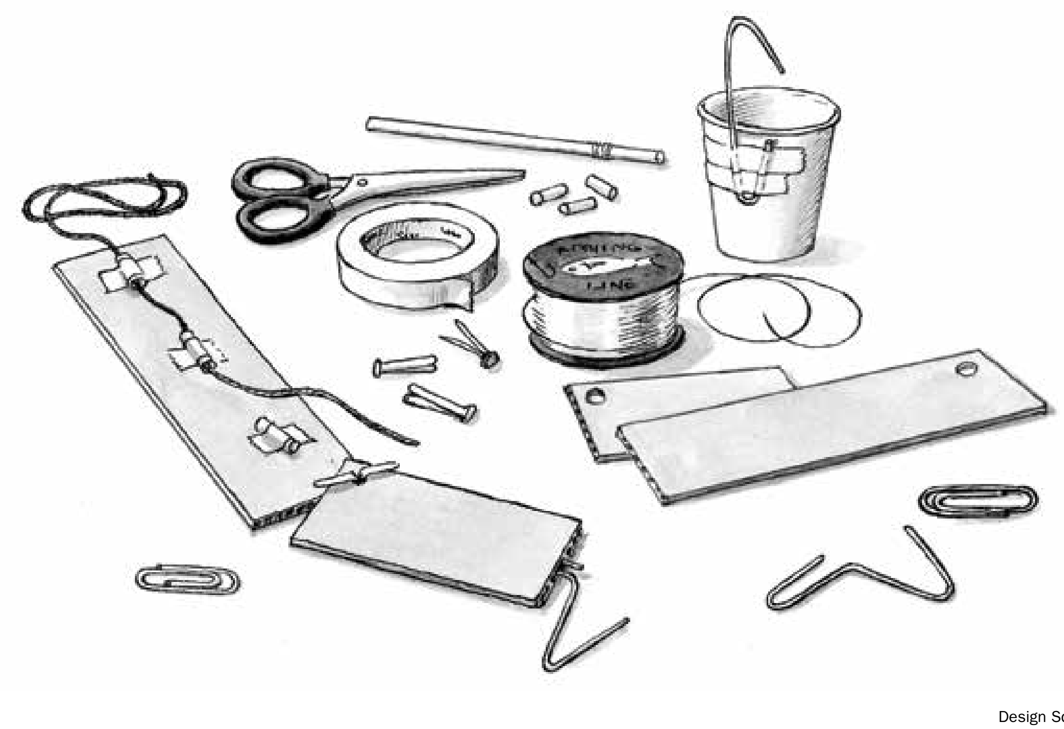
1. IDENTIFY THE PROBLEM AND BRAINSTORM

- How will you connect the cardboard strips so they pivot efficiently?
- Where will you tape the end of the string so that the "hand" moves the way you want it to?
- How can you use the straws as guides for the string?

2. DESIGN AND BUILD

Below are some Robo Arm ideas. Invent your own design or improve on one of these.

- **If the sections don't move freely...** Loosen the brass fasteners to reduce friction.
- **If the hand doesn't move in the direction it should...** Check where you taped the end of the string to the cardboard. Also check that the guides make the string pull in the right direction.



MATERIALS

- 1 large strip of corrugated cardboard (about 5 x 20 centimeters [2 x 8 inches]) Punch a hole in one corner.
- 1 small strip of cardboard (Cut a large strip in half.) Punch a hole in one corner.
- 1 medium (i.e., 1-inch) brass fastener
- 1 straw, cut into 2.5 centimeter (1-inch) lengths
- 100 centimeters (39 inches) of smooth string (e.g., fishing line)
- 2 large paper clips
- 2 paper cups (3-ounce)
- Tape (any kind)

WORDS TO USE

- **lever:** *A rigid bar attached to a pivot used to transmit force*
- **tension:** *A pulling, stretching force*
- **compression:** *A pushing, squeezing force*
- **friction:** *A force that resists motion*

3. TEST, EVALUATE, AND REDESIGN

- **Play Kick the Cup.** Lay your Robo Arm flat on the table. Put a paper cup by your arm's "hand." Pull the string quickly. How far you can kick the cup?
- **Pick up a target cup.** Add a hook to the end of your Robo Arm. Can you pick up the target cup?
- **Play Round Robin.** Have a few kids stand around a table. Use the Robo Arms to pass a cup all the way around. Can you do it faster?

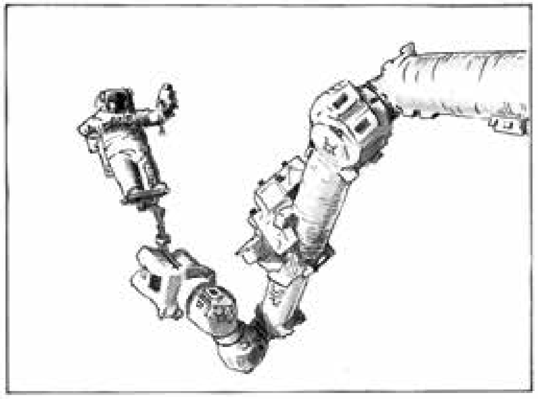
Check out NASA's missions at nasa.gov

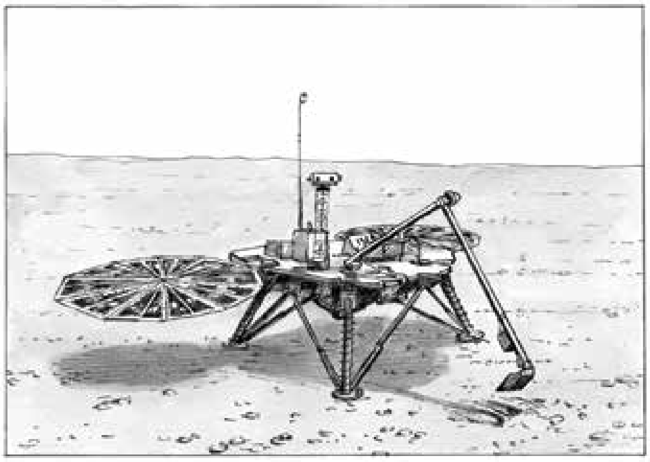
4. TRY THIS NEXT!

- Add a third section to the arm, like a person's upper arm.

NASA EXPLORES SPACE

The International Space Station has a robotic arm. It is 18 meters (58 feet) when fully extended and weighs 1800 kilograms (4,000 lbs). It moves equipment and supplies around the station, supports astronauts working in space, and services things like instruments. Because robotic arms are so versatile, many spacecraft use them, but they are much smaller than the one on the space station.





The Phoenix spacecraft reached Mars in 2008. It has a 2.4-meter (7.7-foot) robotic arm that dug into the soil to uncover a layer of ice. The arm dropped soil samples into instruments that checked for water and carbon-based chemicals—essential elements for life.

Visit the *Design Squad Nation* website at pbskids.org/designsquad.

MAJOR FUNDING PROJECT FUNDING ADDITIONAL FUNDING

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CHALLENGE 3
LEADER NOTES
DOWN TO THE CORE

Photo credit: NASA

CHALLENGE: Design and build a device that can take a core sample from a potato.

LEARNING GOALS: *Science:* Potential and kinetic energy, force (i.e., Newton's 2nd Law); *NASA:* Tools that sample the composition of planets, moons, and asteroids; *Engineering*: Design process

NASA CONNECTION: Many NASA spacecraft collect rock and soil samples to learn about a planet's, moon's, or asteroid's chemistry, potential to support life, and geologic history.

GET READY AHEAD OF TIME

- If possible, make a few different kinds of corers to stimulate kids' thinking.
- **Cut potato slices.** Slice potatoes for kids' testing. Slices should be 1 centimeter (½ inch) thick.
- **Get the videos.** Go to pbskids.org/designsquad/links/solarsystem. Download the *Down to the Core,* Allison Bolinger, and NASA videos. Be prepared to project them. If you're unable to show videos, review the handout's overview and steps and tell kids about the NASA work described in the overview and in Step 1.
- **Photocopy.** Copy the handout and performance assessment rubric (page 39).

MATERIALS (per corer)

- 12 craft sticks
- 4 flexible plastic straws
- 6 small (i.e., ¾-inch) or 4 medium (i.e., 1-inch) binder clips
- 8 rubber bands
- 2 potato slices (1 cm [½ inch] thick)
- Tape (any kind)
- Optional: 1 paper cup (6-ounce or larger)
- Optional: 1 sharp pencil for poking holes in the cup
- Optional: a wide straw that the flexible straw fits into

In *Down to the Core*, kids design and build a device that drives a straw into a potato to take a core sample.

1 INTRODUCE THE CHALLENGE (10 minutes)

Set the stage

- Ask: What are some examples of people taking samples? (*Cooks sample the food they prepare. Scientists studying what the climate was like in the past take cores from ice and trees. Doctors sample human tissue to detect diseases like cancer. Geologists sample rock to locate oil and mineral deposits.)*
- Tell kids the challenge and show them the *Down to the Core* video.

Relate it to NASA missions

Show the *Curiosity* rover animation. Point out the rover's sampling and analysis techniques. Tell kids that rock and soil samples reveal a lot about a planet's, moon's, or asteroid's chemistry, potential to support life, and geologic history.

Kids can add binder clips to the plunger. When pulled back against the rubber bands, the added weight (i.e., mass) gives the plunger more potential energy, enabling it to do more work.

2 BRAINSTORM AND DESIGN (10 minutes)

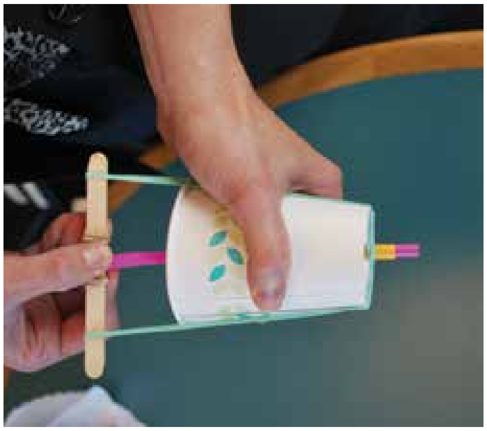
Identify the problem. Have kids state the problem in their own words (e.g., build a tool that can cut out a piece of potato).

Demonstrate the activity's sampling technique. Pick up a slice of potato and drive a straw through it. Show kids how the straw cut a sample out of the potato. Tell them that when NASA can't send a person into space to collect samples, it has to be done mechanically.

Show kids different kinds of coring devices. If you made sample corers, show kids your collection. This will give them ideas for frames (cup, craft sticks, cardboard), ways to hold the frame together (rubber bands, tape, binder clips), ways to connect the straw and crosspiece (tape, rubber bands, clamping), and how to connect the plunger (i.e., the straw connected to the crosspiece) to the frame. If you don't have samples, review the ideas on the handout.

Review the corer's key components

- What does the potato slice represent? *(The surface of a planet, moon, or asteroid)*
- What part will do the cutting? *(The straw)*
- What will you use to drive the straw into the potato? *(Rubber bands)*
- How will you hold the rubber bands and plunger? *(With a frame)*



Kids can use a wide straw as an outer casing to stabilize the thin straw sliding up and down inside. This is similar to how the outer casing in a push-pop ice cream treat stabilizes the flimsy ice cream.

3 BUILD, TEST, EVALUATE, AND REDESIGN (30 minutes)

If any of these issues come up, ask questions to get kids thinking about how they might solve them.

- **If the straw tip bends or breaks…** Have kids snip off the deformed end or use a new straw.
- **If the straw won't penetrate the slice…** Tell kids to add rubber bands to increase the force of the plunger. Or suggest that they add some binder clips to the plunger to increase its weight (i.e., mass). With more weight there is more potential energy when the plunger is pulled back against the rubber bands, enabling the straw to do more work.
- **If the straw bounces off the potato…** Have kids make a guide for the straw. For example, kids can run the straw through a hole poked in the bottom of a paper cup, similar to how the barrel of a clickable ballpoint pen keeps the tip steady. (See photos.)

When kids stretch the rubber bands, they build up potential energy. When they release the plunger, this potential energy changes to kinetic energy. When the straw hits the potato, the kinetic energy changes to mechanical energy and does work.

4 DISCUSS WHAT HAPPENED (10 minutes)

Emphasize key elements in today's challenge by asking:

- **Engineering:** What features helped your coring tool be effective? (*Answers will vary.*)
- **Science:** Your coring tool turns potential (stored) energy into kinetic (motion) energy. Explain how it does this. (*When kids stretch the rubber bands, they build up potential [stored] energy. When they release the rubber bands, the potential energy changes to kinetic [motion] energy. When the straw hits the potato, the kinetic energy changes to mechanical energy and does work. With more potential energy, the straw can penetrate more deeply and do more work.*)
- **NASA:** Why are NASA scientists interested in sampling planets, moons, and asteroids? (*Rock and soil samples reveal a lot about a planet's, moon's, or asteroid's chemistry, potential to support life, and geologic history. NOTE: Surface materials can change when they are exposed to wind and water or can mix with other materials [e.g., soil]. For the most reliable analysis, scientists want to get samples from below the surface.*)
- **Career:** Show kids the engineer profile featuring Allison Bolinger. One day, astronauts will visit asteroids and other planets and moons. As a spacewalk flight controller and trainer, Allison gets astronauts ready to work outside a spacecraft. They need to know how to use their tools while floating weightlessly in a bulky spacesuit. Download the profile sheet for fun facts, discussion prompts, and extension ideas.

EXTEND THE CHALLENGE

- **Build a spaceship.** Have kids add space-related components to their coring tools. For example, duct tape can represent solar panels. Kids can add rockets, fins, radio dishes, and other instruments to represent spacecraft components.
- **Add a way to easily remove the sample from the straw.** Have kids figure out how to push or blow a sample out of the straw.

CURRICULUM CONNECTIONS

Use *Down to the Core* to engage, explain, and extend student understanding of the following topics:

- **Potential, kinetic, and mechanical energy.** In this challenge, kids store energy (called potential energy) by stretching rubber bands. When they release the straw, this potential energy turns into motion (kinetic) energy and moves the straw forward. The straw's kinetic energy is then converted to mechanical energy when the straw penetrates the potato.
- **Newton's 2nd Law.** Adding weight (i.e., mass) to the plunger gives it more potential energy when you pull the plunger back against the rubber bands. More potential energy enables the plunger to do more work. This demonstrates Newton's 2nd Law—force equals mass times acceleration. Since acceleration is roughly the same for each trial, force is directly related to mass.

DOWN TO THE CORE

To find water, interesting minerals, or even life, you have to dig into a planet, moon, or asteroid. When NASA can't send a person to collect samples, they send spacecraft with tools that can take samples.

WE CHALLENGE YOU TO...

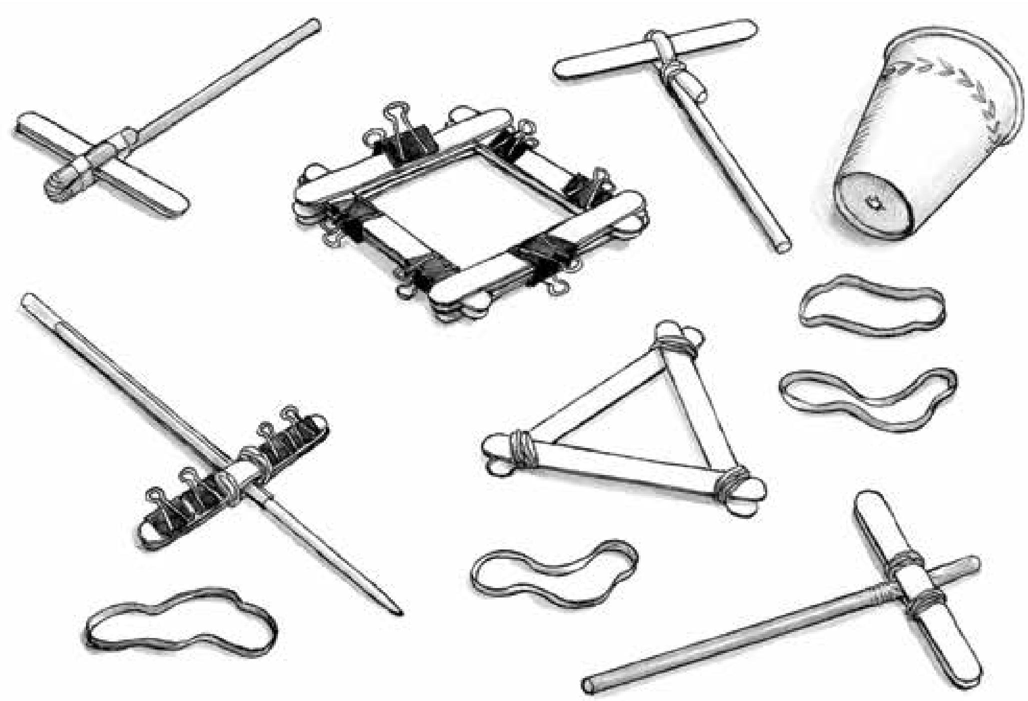
...design and build a tool that can take a core sample from a potato.

1. IDENTIFY THE PROBLEM AND BRAINSTORM

- What will you use to drive the straw into the potato (i.e., the "asteroid")?
- What kind of frame can you make to hold the rubber bands and straw?

2. DESIGN AND BUILD

Below are some ideas for coring tools. Invent your own design or improve on one of these.



MATERIALS (per corer)

- 12 craft sticks
- 4 flexible plastic straws
- 6 small (i.e., ¾-inch) binder clips
- 8 rubber bands
- 2 potato slices (1 centimeter [½-inch] thick)
- Tape (any kind)
- Optional: a wide straw that the flexible straw can fit into
- Optional: 1 paper cup (6-ounce or larger)
- Optional: 1 sharp pencil

WORDS TO USE

- **potential energy:** *Stored energy*
- **kinetic energy:** *Motion energy*
- **asteroid:** *One of the many small, rocky bodies that orbit the sun and lie between Mars and Jupiter. They range in size from less than a kilometer (half a mile) to nearly 800 kilometers (500 miles).*

3. TEST, EVALUATE, AND REDESIGN

- **If the straw tip bends or breaks…** Snip off the broken end or use a new straw.
- **If the straw doesn't go into the potato…** Try adding more rubber bands. Also, boost the plunger's force by adding weight, such as binder clips.
- **If the straw bounces off the potato…** Make a guide for the straw.

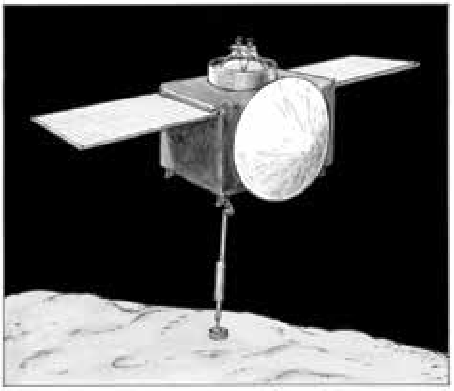
Check out NASA's missions at nasa.gov

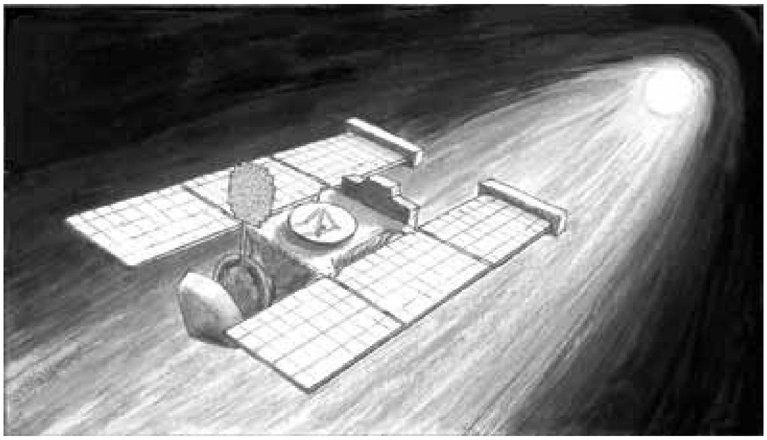
4. TRY THIS NEXT!

- Invent an easy way to remove the sample from the straw.
- Make your coring tool into a spaceship. Add rockets, fins, solar panels, radio dishes, and other spaceship components.

NASA EXPLORES SPACE

Osiris Rex will collect samples from asteroids. It uses a tool similar to your corer. Scientists study asteroids to learn about what the solar system was like when it formed five billion years ago. *Osiris Rex* will launch in 2016, with samples returning to Earth in 2023. Think about becoming a NASA scientist, and you could do research with these samples!





The *Stardust* spacecraft collected dust grains from the gases coming off a comet called Wild 2. *Stardust* then returned to Earth, delivering thousands of comet grains.

Visit the *Design Squad Nation* website at pbskids.org/designsquad.

MAJOR FUNDING PROJECT FUNDING ADDITIONAL FUNDING

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CHALLENGE 4
LEADER NOTES
INSPECTOR DETECTOR

Photo credit: NASA/JPL

CHALLENGE: Design and build a device that can pass above a surface and detect magnetic fields.

LEARNING GOALS: *Science*: Magnetism, inverse square law; *NASA*: Magnetometers; *Engineering*: Design process

NASA CONNECTION: Many NASA spacecraft carry instruments to study magnetic fields. If a planet or moon has a magnetic field, it might have a molten core. Magnetic fields also deflect the damaging radiation of the sun and cosmic rays, so they could be important for protecting future astronauts.

GET READY AHEAD OF TIME

- **Tape the magnets.** Tape five to ten magnets to a sheet of newspaper. Make one of these "planetscapes" per four or five kids.
- **Draw the grid.** On a full sheet of newspaper, use a black marker to draw a 10 x 10 grid. Label the top 1–10 and the side A–J. Make an answer key, noting where the magnets are. Then lay the grid on the newspaper with the magnets.
- **Make the metal shards.** (Use scissors you don't care about.) Cut #3 (coarse) steel wool in small pieces, between an eighth and a quarter of an inch long.
- **Get the videos.** Go to pbskids.org/designsquad/links/solarsystem. Download the *Inspector Detector,* Tracy Drain, and NASA videos. Be prepared to project them. If you're unable to show videos, review the handout's overview and steps and tell kids about the NASA work described in the overview and in Step 1.
- **Photocopy.** Copy the handout and performance assessment rubric (page 39).

MATERIALS (per magnetometer)

- 1 grid map (page 29)
- Pieces of cardboard or small cardboard box
- 1–2 paper cups (6- to 8-ounce)
- 1 piece copier paper
- A small pile of metal shards (cut off a pad of coarse [i.e., #3 or 4] steel wool)
- String (50 centimeters [20 inches])
- Tape (clear or masking)
- 1 small magnet for testing
- Scissors
- 6–10 full sheets of newspaper per planetscape
- Black marker
- 8–10 strong magnets per planetscape (available at dollar, toy, office supply, and craft stores)

1 INTRODUCE THE CHALLENGE (10 minutes)

Set the stage

- Tell kids that today they'll be doing a different kind of treasure hunt—searching for something invisible. Ask: What kinds of invisible forces and energy can your body detect? *(Your senses can detect things like heat, sound, pressure, etc. Your sense of balance can detect gravity.)*
- Name some devices that deal with invisible energy. *(Cell phones, radios, GPS, thermometers, compass, metal detectors, airport screening devices, medical imaging devices, etc.)*
- Tell kids the challenge and show them the *Inspector Detector* video.

Relate it to NASA missions

Magnetism is one invisible force NASA is interested in because it can tell scientists a lot about how a planet or moon formed and has changed. Planets and moons with huge amounts of fluids circulating (e.g., a molten core) can produce a magnetic field. NASA's *Juno* and *Lunar Prospector* missions use magnetometers, devices that detect magnetic fields. Show one or both of the NASA video clips.

- **Juno** will orbit Jupiter, going just above the planet's cloud tops. Its magnetometers will measure the strength and direction of Jupiter's magnetic field.
- **Lunar Prospector** measured the strength of the moon's magnetic fields. Its magnetometer provided data about the location of minerals and helped determine the size and composition of the lunar core.

2 BRAINSTORM AND DESIGN (10 minutes)

Show kids a magnetic field. Sprinkle some metal shards onto a piece of white copier paper. Pass it over a magnet. Have kids describe how the magnetic field affects the shards. Is there a pattern?

Identify the problem. Have kids state the problem in their own words (e.g., build a tool that can find hidden magnets).

Explain how to use the grid's numbers and letters to mark the location of a magnet.

Offer final tips

- **Relate the planetscape to the map.** Explain how to use the grid's numbers and letters to mark the location of a magnet (similar to the game Battleship®). Point out that their map (page 29) has the same grid. Tell them to mark their maps, not the newspaper. That way, other groups can use the planetscape.
- **Distributing shards.** Once kids have made a detector, tell them to call you over to sprinkle some shards on its window. Cover it lightly. It doesn't take a lot of shards to work effectively.
- **Keep shards away from magnets.** Cleaning them off a magnet is a nuisance.
- **Set up the room.** Have kids build in one area and test with the planetscapes in another area.

3 BUILD, TEST, EVALUATE, AND REDESIGN (30 minutes)

If any of these issues come up, ask questions to get kids thinking about how they might solve them.

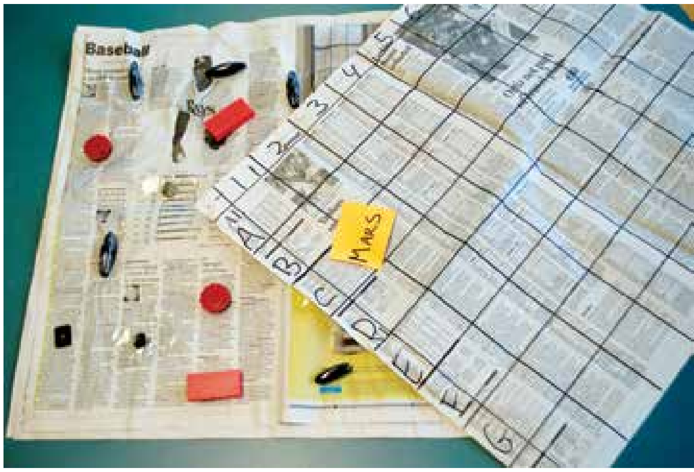
- **If a detector doesn't respond…** Tell kids to hold the detector closer to the planetscape. Check that there are enough shards, that the cardboard isn't too thick, and that nothing is interfering with how the shards move. Have kids test their detectors with a small magnet.
- **If it's hard to see the shards move…** Design a window or remove parts that block the view.
- **If there's a spill…** Use a plastic bag with some magnets inside. To clean up an area, swish the bag over any loose shards. To dump the shards, hold the bag over a piece of paper and lift out the magnets. The shards will fall onto the paper.

There are many designs that can contain the shards and let kids pass it over the grid. The simplest is a plain paper cup!

4 DISCUSS WHAT HAPPENED (10 minutes)

Emphasize key elements in today's challenge by asking:

- **Math:** Gather kids around one of the planetscapes. Use a detector to locate each magnet. Have kids check off the ones they got. Point out the power of a grid system. Maps, touch screens, mouse pads, and interactive white boards use grid systems to keep track of a point.
- **Science:** Why are NASA scientists interested in magnetic fields? *(Magnetic fields are indicators of a planet's interior structure, which is important in learning if there is an active core and how the planet formed and evolved. Magnetic fields also deflect damaging radiation from solar wind and cosmic rays, so could help protect future astronauts.)*



A planetscape has two parts: a sheet of newspaper with magnets taped to it that's covered by a second sheet of newspaper with a grid drawn on it.

- **NASA:** What kinds of missions use magnetometers? *(Magnetometers are typically used on spacecraft that fly past or orbit a planet or moon. It can take more than a thousand orbits to develop a comprehensive map of a magnetic field.)*
- **Career:** Show kids the engineer profile featuring Tracy Drain. As a flight systems engineer, Tracy makes sure a spacecraft's parts, instruments, and systems all work as intended. If even just one part fails, it can be catastrophic. Download the profile sheet for fun facts, discussion prompts, and extension ideas.

EXTEND THE CHALLENGE

- **Sensitivity test.** Make two or more planetscapes with magnets of different strengths. Whose detector can accurately locate the magnets AND determine their strength?
- **Go on a treasure hunt.** Houses and schools are loaded with magnets. For example, electric motors, speakers, telephones, door-closers, TVs, etc. all have magnets. Use the detector to go prospecting for magnets and see how many invisible magnetic fields are around you.

CURRICULUM CONNECTIONS

Use *Inspector Detector* to engage, explain, and extend student understanding of the following topics:

- **Magnetism.** This activity uses permanent magnets. As with all materials, a magnet's atoms have electrons orbiting a nucleus. In an iron-rich material, when many electron orbits are aligned (i.e., spin in the same direction), these aligned spins produce a magnetic field.
- **Inverse square law.** Gravity, electric charges, light, and sound are all governed by an inverse-square relationship. Let's use light as an example. As you move away from a light source, it gets dimmer. But how much dimmer? If you double your distance from the source, the light you see will be ¼ as bright as before, not ½ as bright (i.e., ½ squared = ¼). Because the intensity of the light varies as the square of the distance, this relationship is called the inverse square law. With magnets, the drop in the magnetic force is even more extreme—it changes as the cube of the distance!

INSPECTOR DETECTOR

When huge amounts of fluids circulate in a planet or moon, such as a molten core, it can produce a magnetic field. Scientists can tell a lot about how the planet or moon formed and has changed by studying its magnetic field.

WE CHALLENGE YOU TO...

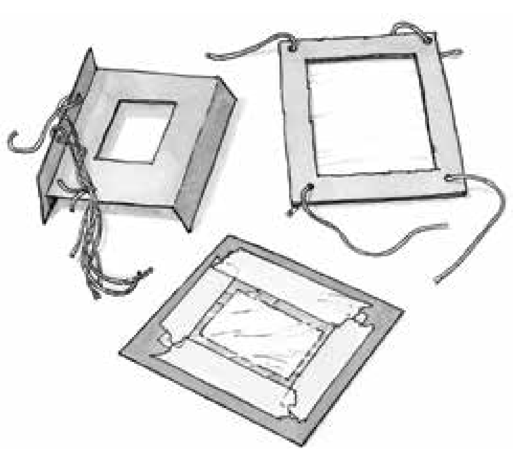
...build a device that you can pass above a surface to detect magnetic fields.

1. IDENTIFY THE PROBLEM AND BRAINSTORM

- How can you make sure that the metal shards stay in your detector and don't fall off?
- How can you make it easy to see when the metal shards move?
- How will you hold the detector as you move it above the surface?

2. DESIGN AND BUILD

Below are some ideas for detectors. Invent your own design or improve on one of these.



3. TEST

- **Try out your detector.** Use the small magnet to test how well your detector works.
- **Find the hidden magnets.** Slowly pass your detector over the grid, one section at a time.
- **Map the magnets.** Use the grid lines to identify the locations. Mark each magnet with a dot on your map (NOT on the newspaper).

MATERIALS

- Pieces of cardboard or a small box
- 1–2 paper cups (6- to 8-ounce)
- 1 piece copier paper
- A small pile of metal shards (cut off a pad of coarse [# 3] steel wool)
- 1 small magnet for testing
- 8–10 strong magnets per planetscape
- Tape (clear or masking)
- String (50 centimeters [20 inches])
- Scissors
- 1 grid map

WORDS TO USE

- **magnetic field:** *The area around a magnet where a magnetic force can be detected*
- **magnetometer:** *A device that detects magnetic fields*

4. EVALUATE AND REDESIGN

- **If it's hard to see the shards move…** Design a window or remove parts that block your view.
- **If your detector doesn't respond…** Check that you have enough metal shards and that nothing blocks how they move. Also check that you're not holding it too far above the surface.

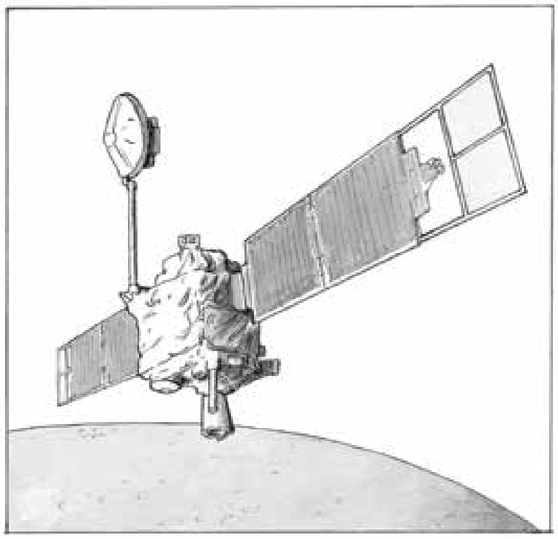
Check out NASA's missions at nasa.gov

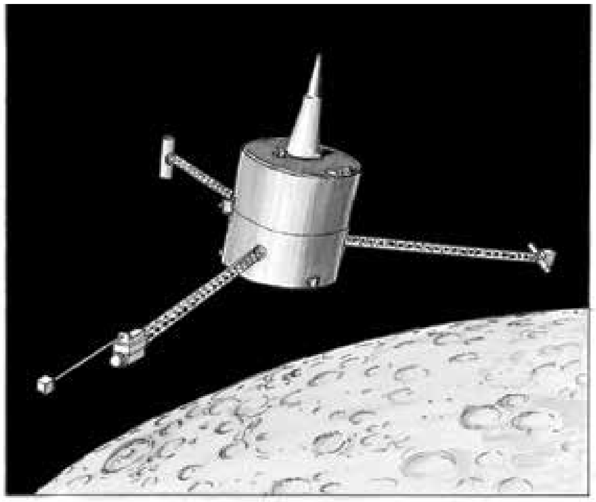
5. TRY THIS NEXT!

- **Magnet treasure hunt.** Use your detector and see how many invisible fields you can find. Check things like door closers, speakers, electric motors, and microphones.

NASA EXPLORES SPACE

NASA's *Mars Global Surveyor* carries magnetometers on the ends of its solar panels. The mission determined that Mars no longer has a strong magnetic field, meaning that its interior has cooled.





NASA's *Lunar Prospector* measured the strength of the moon's magnetic fields. The mission also used magnetometers to find the location of minerals and to determine the size and makeup of the moon's core.

Visit the ***Design Squad Nation*** website at **pbskids.org/designsquad.**

MAJOR FUNDING NSF PROJECT FUNDING NORTHROP GRUMMAN Foundation S. D. BECHTEL, JR. FOUNDATION STEPHEN BECHTEL FUND ADDITIONAL FUNDING

Design Squad Nation is produced by WGBH Boston. Major funding is provided by the National Science Foundation. Project funding is provided by Northrop Grumman Foundation and S.D. Bechtel, Jr. Foundation. Additional funding is provided by United Engineering Foundation (ASCE, ASME, AIChE, IEEE, AIME). This *Design Squad Nation* material is based upon work supported by the National Science Foundation under Grant No. EEC-1129342. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. This NASA/Design Squad Nation challenge was produced through the support of the National Aeronautics and Space Administration under Grant No. <NNX12AB47G> issued through the Science Mission Directorate.

MAP OF THE MAGNET LOCATIONS

Put an “X” where you think there is a magnet. (A big “X” = Strong and a small “x” = Weak.)

	1	2	3	4	5	6	7	8	9	10
A										
B										
C										
D										
E										
F										
G										
H										
I										
J										

Check the planet you mapped: ___Earth ___Mars ___Venus Team Members: ________________

Photo credit: NASA/JPL

CHALLENGE 5

LEADER NOTES

INVISIBLE FORCE

CHALLENGE: Design a setup so that when a steel ball rolls past a magnet, it changes direction and hits a target that's off to the side.

LEARNING GOALS: *Science:* Magnetism, inverse square law; *NASA*: Gravity-assisted travel; *Engineering*: Design process

NASA CONNECTION: Many spacecraft fly close by a planet or moon to use its gravitational pull to change speed and direction. This "gravity assist" also greatly reduces the fuel required to navigate a spacecraft.

GET READY AHEAD OF TIME

- **Magnets**. The best magnets for this activity are the silver, three-inch-long, oblong magnets sometimes called "cow" or "snake-egg" magnets. If you use disc magnets, kids may need to stack a few to produce a strong magnetic field.
- **Steel balls.** Bike stores sell the 60-millimeter (quarter-inch) ball bearings used in this activity. Slingshot ammo is 80 millimeters (5⁄16 inch) and is also an option. Balls larger than this build up so much momentum that they don't respond well to weak magnetic fields.
- **Make a physical guide.** In Step 2, kids use a rope to guide the ball's motion. Cut a 30-centimeter (12-inch) length of clothesline per team. Wrap the ends with tape to keep the rope from unraveling and forming a flare that interferes with the ball traveling smoothly along the rope.
- **Get the videos.** Go to pbskids.org/designsquad/links/solarsystem. Download the *Invisible Force,* Victoria Garcia, and NASA videos. Be prepared to project them. If you're unable to show videos, review the handout's overview and steps and tell kids about the NASA work described in the overview and in Step 1.
- **Photocopy.** Copy the handout and performance assessment rubric (page 39).

MATERIALS (per team)

Invisible Force works well with teams of two.

- Paper cup (6- to 8-ounce)
- Strip of index card (2.5 x 12.5 centimeters [1 X 5 inches])
- 30-centimeter (12-inch) length of flexible rope (e.g., clothesline)
- 1 steel ball (e.g., 60-millimeter [quarter-inch] ball bearing)*
- 1 strong magnet**
- 1 target (e.g., "X" of tape on the table or object to hit [e.g., a glass, coin, cup, etc.])
- Tape (any kind)

**** Available at bike stores. Slingshot ammo from sporting-goods stores works, too.***

***** Available at toy, dollar, craft, and office supply stores.***

1 INTRODUCE THE CHALLENGE (10 minutes)

Set the stage and give the NASA context

- Explain that gravity is a force present in all things and that planets and moons exert a gravitational pull on spacecraft that pass close by.

- Spacecraft use small onboard rockets to make minor course corrections. Big corrections require a lot of fuel, which is heavy to carry. Instead of using rockets, NASA engineers use a planet's or moon's gravity to increase a spacecraft's speed and "steer" it by changing its direction. This process is called a "gravity assist."
- Tell kids that today they will do something similar to what NASA does, but instead of using gravity to steer a ball, they'll use a magnetic force. Then show kids the *Invisible Force* video.

Kids roll a ball down a ramp and use a ROPE to guide it over to a target.

2 STEER THE BALL USING A PHYSICAL GUIDE (10 minutes)

- Get a ramp, piece of rope, and steel ball. Place a target right in front of the ramp. Ask: What will happen when I roll this ball down the ramp? *(The ball will hit the target.)*
- Next, place the target 15 centimeters (6 inches) to the right of the ramp. Ask: What will happen now? *(The ball will roll past the target.)*
- Ask: How can I use this rope so the ball hits the target? *(Curve the rope from the end of the ramp over to the target.)* Follow kids' suggestions to hit the target with the ball.
- Emphasize that kids can change the ball's speed—it goes faster when released from the top and slower when released from the bottom. Release the ball from different points on the ramp to show that a ball needs a certain amount of energy to make it to the target.
- Challenge kids to put the target in "wacky" locations around the ramp and use the rope to guide the ball to the target. By trying different speeds and rope shapes, how creative can they get?

3 DISCUSS THE GAME'S KEY POINTS (5 minutes)

Stop kids' play by asking them to stick the ball to the magnet and come over to a demo area.

- **Path shape.** Without a guide, how will the ball travel once it leaves the ramp? *(Straight)*
- **Off-center positions.** What were the "wackiest" target positions that your ball hit?
- **Speed and energy.** How was the ball's speed affected by where you released it? Why is the ball's speed important? *(The greater the speed, the greater the momentum. Momentum gives the ball energy to roll to the target.)*
- **Consistent results.** It's helpful to tape the ramp in place and release the ball cleanly (e.g., hold it back with the tip of a sharp pencil).

Set the ball on the magnet. It will move to the pole—the strongest part of the magnetic field. Make a loop of duct tape and stick it at 90 degrees from the pole. Have kids tape their magnets to the table so the pole is in the same plane as the rolling ball.

4 STEER THE BALL USING A MAGNET (5 minutes)

Tell kids that their new challenge is to replace the rope with a magnet that will guide the ball. Set the rope aside. Tape down a strong magnet.

- Ask: How does this system compare to the one with the rope? *(The magnet replaces the rope. Its magnetic force will change the path of the ball. Otherwise, the setup is similar.)*
- Ask: How big is the zone around the magnet that can affect the ball? *(Small)*
- Ask: How are the ball's speed and distance from the magnet related? *(A slowly moving ball has less energy than a fast-moving one, and the magnet can capture it more easily. A faster ball can travel closer to the magnet without crashing.)*
- How is this small zone like the Goldilocks story? *(Too close and you crash. Too far and you get lost. Just right and the ball curves and hits the target.)*

5 BRAINSTORM AND DESIGN (5 minutes)

- How will you control how fast the "spacecraft" travels? *(Change the release point on the ramp.)*
- What will you do if the spacecraft always crashes into the "planet?" *(Aim farther from the magnet.)*
- What will you do if the spacecraft zips right by the planet? *(Aim closer to the magnet.)*

Kids roll a ball down a ramp and use a MAGNET to guide it over to a target.

6 BUILD, TEST, EVALUATE, AND REDESIGN (15 minutes)

If any of these issues come up, ask questions to get kids thinking about how they might solve them.

- **If kids can't consistently launch a ball…** Stabilize the ramp by taping it to the table. Also tape the ramp to the cup.
- **If kids can't find the "zone" around the magnet…** Tell them that a magnet's strength drops off quickly with distance. Also have them experiment with the ball's speed.

7 DISCUSS WHAT HAPPENED (10 minutes)

Emphasize key elements in today's challenge by asking:

- **Engineering:** How did testing help you decide how to change to your setup? *(Answers will vary.)*
- **Science:** Why did your ball change direction? What did you have to do to get it to change direction? *(The ball passed through a magnetic field. To change the path, the ball has to pass close enough to the magnet so the magnetic force affects the path of the ball.)*
- **NASA:** What part of the model represents the launch pad, spacecraft, gravity, and the planet or moon? Is the rope or magnet a better model of how spacecraft travel? *(There are no physical guides in space, but there are invisible forces. The magnetic field is a stand-in for gravity.)*
- **Career:** Show kids the engineer profile featuring Victoria Garcia. As an aerospace engineer, she uses virtual-reality tools to design effective spaces for astronauts living and working on a spacecraft. Download the profile sheet for fun facts, discussion prompts, and extension ideas.

EXTEND THE CHALLENGE

- **Sharpest turn**. Which team can consistently achieve the largest change in direction of the launch path? Can anyone do better than a 90° bend? Which team can consistently hit the target?
- **Go longer.** Find a large, level area. Challenge teams to hit a target that is at least 30 centimeters (1 foot) away. Next try 60 centimeters (2 feet) away.

CURRICULUM CONNECTIONS

Use *Invisible Force* to engage, explain, and extend student understanding of the following topics:

- **Inverse square law.** Gravity, electric charges, light, and sound are all governed by an inverse-square relationship. Let's use light as an example. As you move away from a light source, it gets dimmer. But how much dimmer? If you double your distance from the source, the light you see will be ¼ as bright as before, not ½ as bright (i.e., ½ squared = ¼). Because the intensity of the light varies as the square of the distance, this relationship is called the inverse square law. With magnets, the drop in the magnetic force is even more extreme—it changes as the cube of the distance!
- **Newton's 1st Law.** Unless acted upon by an outside force, objects in motion tend to stay in motion, and objects at rest tend to stay at rest. This law is key to understanding how spacecraft move and navigate from Earth to their targets billions of miles away. Newton's 1st law says that a spacecraft will travel in a straight line and at the same speed forever unless an outside force acts on it. NASA often uses gravity assists to supply the force necessary for changing a spacecraft's direction and speed.
- **Newton's 2nd Law.** As with the magnet, the closer the spacecraft passes to the planet or moon, the more force will be exerted. As more force is applied to spacecraft, its acceleration—its speed and/or direction—changes. There is a direct proportion between the two quantities.

INVISIBLE FORCE

To make changes in a spacecraft's speed and direction, NASA often uses gravity. To get what's called a "gravity assist," NASA passes a spacecraft close to a planet or moon. The strong gravity changes the spacecraft's speed and direction.

DESIGN squad Nation

CHALLENGE 1

Roll a ball down a ramp and use a ROPE to guide it to a target that's set off to the side.

1. BRAINSTORM AND DESIGN

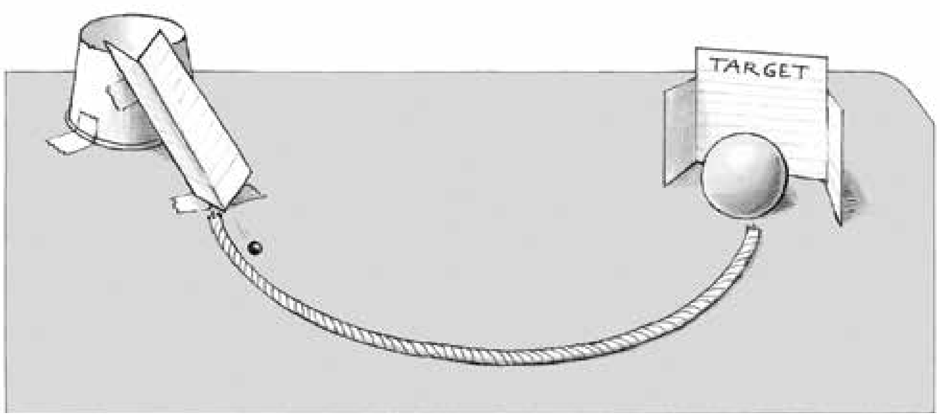
- How should you line up the rope with the end of the ramp so the rope can guide the ball?

2. BUILD AND TEST

- Taping the ramp in place is very helpful for consistent results.
- You can change the ball's speed by launching from different places on the ramp.

3. EVALUATE, REDESIGN, AND RETEST

- What were the "wackiest" target positions that you could hit with your ball?



MATERIALS

- Paper cup (6- to 8-ounce)
- Strip of index card (2.5 x 12.5 centimeters [1 X 5 inches])
- 30-centimeter (12-inch) length of flexible rope (e.g., clothesline)
- 1 steel ball (e.g., 60-millimeter [quarter-inch] ball bearing)
- 1 strong magnet
- 1 target (e.g., "X" of tape on the table or an object to hit)
- Tape (any kind)

WORDS TO USE

- **magnetic field:** *The area around a magnet where a magnetic force can be detected*
- **gravity assist:** *Using a planet's or moon's gravity to change a spacecraft's direction and speed*

CHALLENGE 2

Roll a ball down a ramp and use a MAGNET to guide it to a target that's set off to the side.

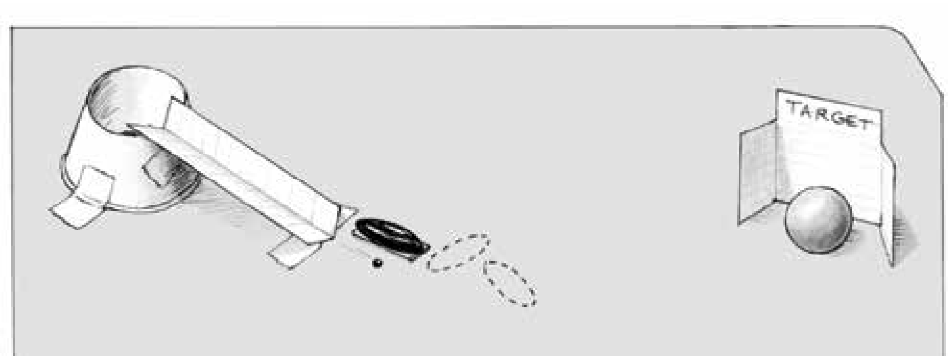
Check out NASA's missions at nasa.gov

1. BRAINSTORM AND DESIGN

- Where should you tape the magnet so the ball's path curves?

2. BUILD AND TEST

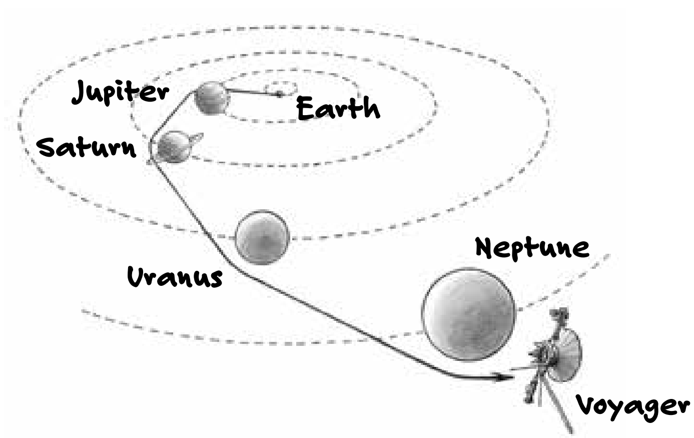
- Find the right speed and distance from the magnet so the ball curves over to the target.



3. EVALUATE, REDESIGN, AND RETEST

- How extreme a turn can your ball make?
- How many times in a row can you get the ball to hit the target?

NASA EXPLORES SPACE



For most NASA missions, engineers pass a spacecraft close to a planet or moon. This lets them use the strong gravity to change the spacecraft's direction and increase its speed. For example, NASA's Voyager mission got a gravity assist from five planets to help it on its way!

Visit the *Design Squad Nation* website at pbskids.org/designsquad.

MAJOR FUNDING PROJECT FUNDING ADDITIONAL FUNDING

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DESIGN CHALLENGE PERFORMANCE ASSESSMENT RUBRIC

Challenge name: ______________________

Names of team members: ______________________

____

Identifying the problem(s) and brainstorming solutions	Showed a clear understanding of the problem(s) to solve. Independently brainstormed solutions.	Needed some teacher direction to define the problem(s) and brainstorm possible solutions.	Needed lots of teacher direction to define the problem(s). Little if any independent brainstorming.	**Points:**
Working as a team member	Worked well together. All team members participated and stayed on task.	Some team members were occasionally off task.	Most team members were often off task and not cooperating or participating fully.	**Points:**
Using the de-sign process	Team brainstormed many design ideas and tested and improved the design. Final design complete or nearly complete and shows creative problem solving.	Some team members were occasionally off task.	Team brainstormed few design ideas and did little testing or redesigning. Final design lacks clear design idea(s).	**Points:**
Processing the science and engineering	Team gave a strong presentation of its solution to the challenge and showed clear understanding of the science concepts and design process.	Team gave a basic presentation of its solution to the challenge and showed basic understanding of the science concepts and design process.	Team gave a weak presentation of its solution to the challenge and showed little understanding of the science concepts and design process.	**Points:**
				Total Points:

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EDUCATION STANDARDS

NEXT GENERATION SCIENCE STANDARDS

PRACTICES

1. Asking questions, defining problems **(ALL CHALLENGES)**
2. Developing and using models **(ALL CHALLENGES)**
3. Planning and carrying out investigations **(ALL CHALLENGES)**
4. Analyzing and interpreting data (**CHALLENGE 4)**
5. Using math and computational thinking (**CHALLENGE 5)**
6. Constructing explanations **(ALL CHALLENGES)**
8. Obtaining, evaluating, and communicating information **(ALL CHALLENGES)**

CROSSCUTTING CONCEPTS

1. Patterns (**CHALLENGE 5)**
2. Cause and effect **(ALL CHALLENGES)**
4. Systems and system models (**CHALLENGE 3 and 5)**
5. Energy and matter **(ALL CHALLENGES)**
6. Structure and function (**CHALLENGES 1–4)**

CORE AND COMPONENT IDEAS

Physical Science

PS2: Motion and Stability

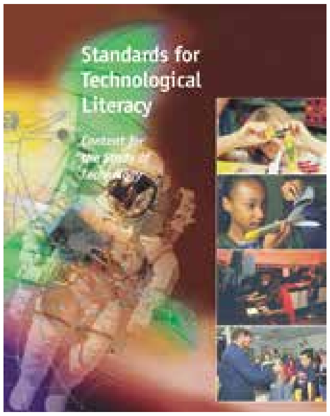
PS2.A: Forces and motion **(ALL CHALLENGES)**
PS2.B: Types of interactions **(ALL CHALLENGES)**

PS3: Energy

PS3.A: Definitions of energy (**CHALLENGE 4)**
PS3.B: Conservation of energy and energy transfer (**CHALLENGE 3)**
PS3.C: Relationship between energy and forces (**CHALLENGE 4)**

Engineering Design

ETS1.A: Defining and delimiting an engineering problem **(ALL CHALLENGES)**
ETS1.B: Developing possible solutions **(ALL CHALLENGES)**
ETS1.C: Optimizing the design solution **(ALL CHALLENGES)**



INTERNATIONAL TECHNOLOGY EDUCATION ASSOCIATION CONTENT STANDARDS

DESIGN

- Standard 8: Attributes of design **(ALL CHALLENGES)**
- Standard 9: Engineering design **(ALL CHALLENGES)**
- Standard 10: Role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving **(ALL CHALLENGES)**

ABILITIES FOR A TECHNOLOGICAL WORLD

- Standard 11: Applying the design process **(ALL CHALLENGES)**
- Standard 12: Using and maintaining technological products and systems **(ALL CHALLENGES)**
- Standard 13: Assessing the impact of products and systems **(ALL CHALLENGES)**

THE DESIGNED WORLD

- Standard 16: Selecting and using energy and power technologies **(CHALLENGES 1, 3, 4)**

MASSACHUSETTS SCIENCE AND TECHNOLOGY/ENGINEERING STANDARDS

PHYSICAL SCIENCES GRADES 3–5

- Properties of Objects and Materials **(ALL CHALLENGES)**
- Forms of Energy **(CHALLENGES 1, 2, 3, 5)**
- Magnetic Energy **(CHALLENGE 5)**

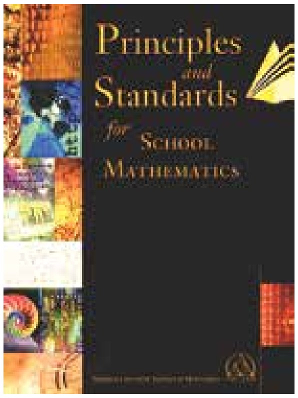
PHYSICAL SCIENCES GRADES 6–8

- Forms of Energy **(CHALLENGES 1, 3, 5)**
- Motion of Objects **(CHALLENGES 1, 5)**

TECHNOLOGY/ENGINEERING

- Materials and Tools **(ALL CHALLENGES)**
- Engineering Design **(ALL CHALLENGES)**

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS STANDARDS



CONTENT

- Measurement—Grades 6–8 (Understand metric and customary systems of measurement) **(ALL CHALLENGES)**
- Data Analysis—Grades 3–5 (Design investigations to address a question and consider how data collection methods affect the nature of the data set; collect data using observations, surveys, and experiments; represent data using tables and graphs) **(ALL CHALLENGES)**
- Algebra—Grades 6–8 (Represent, analyze, and generalize a variety of patterns with tables, graphs, words, and when possible, symbolic rules) **(CHALLENGE 4)**

PROCESS

- Problem Solving—Grades K–12 (Apply and adapt appropriate strategies to solve problems; solve problems that arise in mathematics and other contexts) **(ALL CHALLENGES)**

PROFESSIONAL DEVELOPMENT RESOURCES FROM DESIGN SQUAD NATION

Looking for ways to integrate the design process into your lessons? New to leading hands-on challenges? Want to get kids excited about engineering? *Design Squad Nation* offers a suite of free, online professional-development resources. Check them out by clicking the "Training" link at: pbskids.org/designsquad/parentseducators.

MISSION: SOLAR SYSTEM TRAINING VIDEO

See the *Mission: Solar System* resources in action in this five-minute video. Watch how an educator creates a rich, multi-faceted learning experience for kids by integrating the DIY, Engineer-Profile, and NASA videos into a hands-on design challenge.

LEADING HANDS-ON ENGINEERING ACTIVITIES ONLINE WORKSHOP

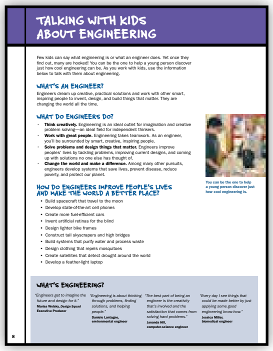
Use this free, 75-minute, self-paced tutorial to help you build skills and confidence in leading hands-on, open-ended engineering design challenges with kids.

TRAINING OTHERS

Train volunteers, parents, and mentors how to lead engineering activities with kids. This one-hour slide show comes with talking points, printable handouts, and preparation tips.

HOW-TO SHEETS

Find helpful *How-To* sheets in the front section of each guide. Topics covered include: *Introducing the Design Process*, *Talking to Kids about Engineering and Invention, Setting up an Engineering/Invention Club*, *Hosting an Event*, and *Working With Kids.*

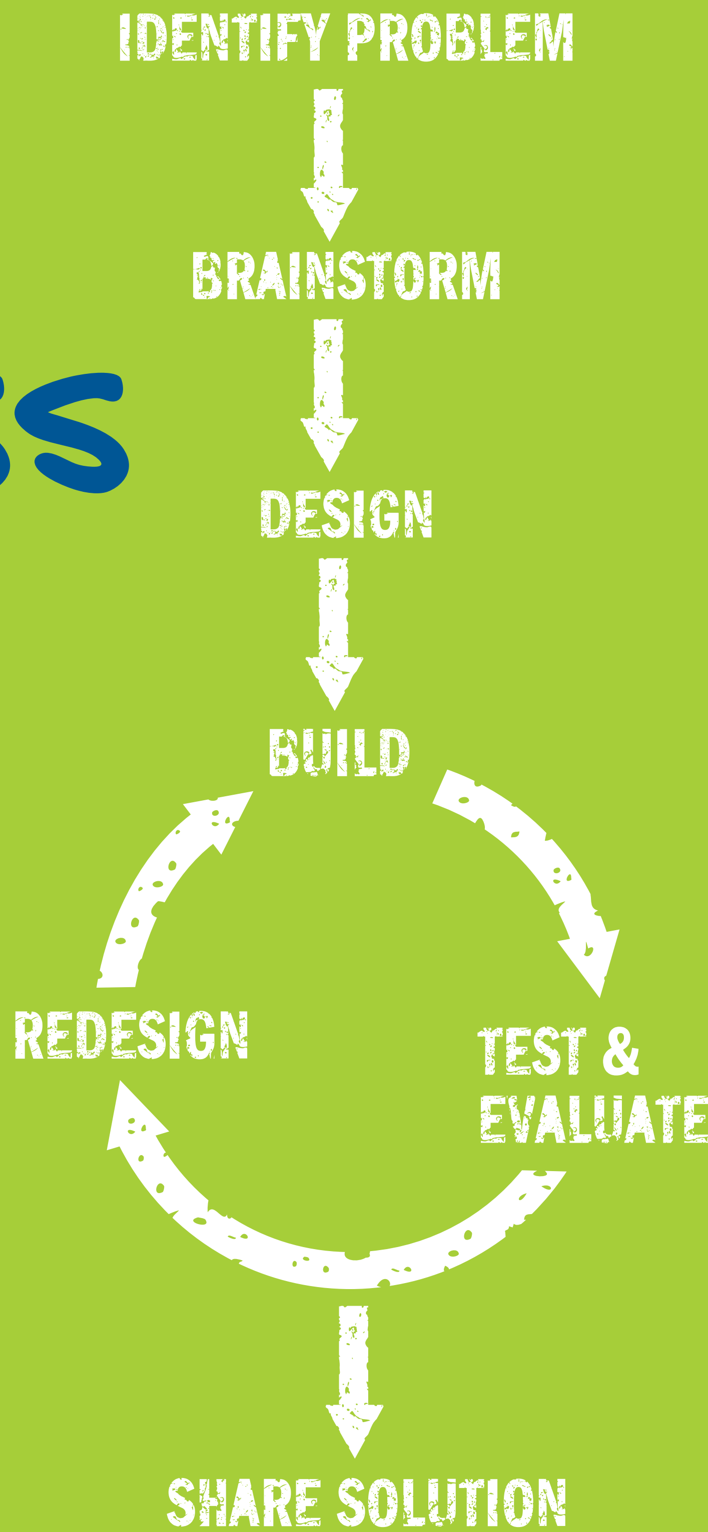


SOCIAL MEDIA CONNECTION

Get the latest news about *Design Squad Nation* and engineering education. Subscribe to our **newsletter**, follow us on **Twitter**, and friend us on **Facebook**. We've got an Educator page just for you at: facebook.com/DesignSquadEducators.

THE DESIGN PROCESS

USED BY BOTH INVENTORS AND ENGINEERS, THE DESIGN PROCESS HELPS PEOPLE THINK CREATIVELY ABOUT A PROBLEM AND PRODUCE A SUCCESSFUL RESULT. THE DESIGN PROCESS IS A GREAT WAY TO TACKLE ALMOST ANY TASK.



DESIGN squad Nation

PBS pbskids.org/designsquad

NASA

nasa.gov

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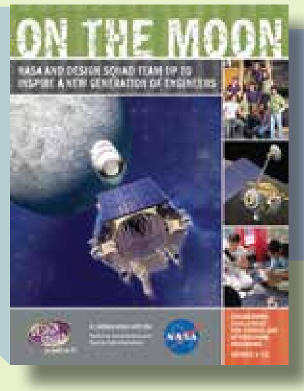
BRING ENGINEERING TO LIFE FOR KIDS

PBS's *Design Squad Nation* combines real-world engineering problems with readily accessible materials so kids can unleash their ingenuity and think like engineers.



***Mission: Solar System's* companion guide *On the Moon* has six engineering challenges that spotlight NASA's moon missions.**

LIKE THESE CHALLENGES?

There are over 60 more! Each one has leader notes, handouts, and related TV episodes, animations, and engineer-profile videos.

Visit: pbskids.org/designsquad.

Check out these NASA resources on PBS LearningMedia

The *NASA Physics and Engineering Collection* brings you videos and interactives exploring real-world applications of these subjects.

The *NASA Planetary Science Collection* brings you videos and interactives of what NASA missions have discovered about the planets, moons, and other objects in the solar system.

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