NASA and *Design Squad*® team up to bring kids in your school or afterschool program six hands-on challenges. These fun challenges will get your kids thinking like engineers and excited about NASA's missions to the moon.

Why Have NASA and *Design Squad* Teamed Up?  
Introducing the Design Process  
How to Use this Guide  
Going to the Moon with NASA  
Talking with Kids about Engineering  
Online Resources from NASA and *Design Squad*  

Challenges:  

**Launch It**  
Design an air-powered rocket that can hit a distant target.  

**Touchdown**  
Create a platform that can safely cushion “astronauts” when they land on a table near you.  

**Roving on the Moon**  
Build a rubber band powered rover that can scramble across the room.  

**Heavy Lifting**  
Build a cardboard crane and see how heavy a load it can lift.  

**On Target**  
Modify a paper cup so it can zip down a line and drop a marble onto a target.  

**Feel the Heat**  
Heat things up by building a solar hot water heater.  

Education Standards  
Credits  

Want More Challenges Like These?  
Get *Design Squad* challenges, activity guides, games, and much more at pbs.org/designsquad.
NASA is one of the biggest employers of engineers in the world—about 90,000 among its own employees and its corporate partners. So it’s not surprising that NASA wants kids to learn more about engineering, become interested in the things engineers do, and experience the world of engineering firsthand.

*Design Squad* is all about engaging kids in engineering by offering them opportunities to give it a try. Through its award-winning TV program, Web site, and hands-on challenges, *Design Squad* helps kids unleash their creativity, experience the fun and excitement of engineering, and see that engineers make an important difference in the world.

By teaming up to develop the *On the Moon* guide, NASA and *Design Squad* help you bring hands-on engineering and the adventure of space exploration to life for kids.

**NASA explores space**

What’s out there in space? How do we get there? What will we find? What can we discover there, or learn just by trying to get there, that will make life better here on Earth? NASA has been working on these questions for over 50 years, pioneering space exploration, scientific discovery, and aeronautics research.

NASA scientists and engineers work in a wide range of settings around the country, from laboratories to airfields to wind tunnels to control rooms. The main areas they work in are:

- **Aeronautics:** where they pioneer new flight technologies that have practical applications on Earth and improve our ability to explore space.
- **Exploration Systems:** where they create new technologies and spacecraft that make human and robotic exploration more affordable and sustainable.
- **Science:** where they explore Earth, the moon, Mars, and beyond; chart the best ways to learn about the universe; and help society reap the benefits of Earth and space exploration.
- **Space Operations:** where they manage the space shuttle and International Space Station and provide flight support.

**Design Squad engages kids in engineering**

*Design Squad* is an award-winning TV show that airs on PBS. It’s a powerful way to open kids’ eyes to the exciting world of engineering. On the show, two teams of teenagers take on a wide array of imaginative engineering challenges. The lively action and fun-filled challenges demonstrate for viewers the rich variety of problems that engineers tackle as they work to improve people’s lives and our society. *Design Squad’s* Web site and activity guides put a range of valuable resources into the hands of educators, parents, and kids. These materials engage and empower kids by having them use their ingenuity to solve problems and design and build interesting projects.
When NASA engineers try to solve a problem, their initial ideas rarely work out perfectly. Like all engineers, they try different ideas, learn from mistakes, and try again. The series of steps engineers use to arrive at a solution is called the **design process**.

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

**BRAINSTORMING**
- At this stage, all ideas are welcome, and criticism is not allowed.
- What are some different ways to start tackling today’s challenge?

**DESIGNING**
- Talk through the brainstormed ideas. What’s really possible given your time, tools, and materials?
- What specific goal are you trying to achieve, and how will you know if you’ve been successful?
- What are some problems you’ll need to solve as you build your project?

**BUILDING, TESTING, EVALUATING, AND REDESIGNING**
- Does your design meet the goal set out in the challenge?
- Why do you have to test something a few times before getting it to work the way you want?
- What can you learn from looking at other kids’ projects and discussing them?

**SHARING SOLUTIONS**
- What were the different steps you had to do to get your project to work the way you wanted?
- What do you think is the best feature of your design? Why?
- What are some things everyone’s designs have in common?
- If you had more time, how could you improve your design?

*The design process is built into each challenge. Over the course of doing a challenge, kids see that the steps of the design process let them think creatively about a problem and produce a successful result.*
This guide offers six hands-on challenges that bring engineering and NASA’s moon missions to life for kids in schools and afterschool programs. The challenges take an hour (except *Feel the Heat*, which takes 1½ to 2 hours), use readily available materials, give kids many ways to succeed, and can be done with large groups. The activities also meet many of the national science, technology, and mathematics standards.

**HOW TO GET STARTED**

**Choose a challenge.** You’ll want to consider the number of the kids in your group and their ages and ability levels. The chart below will help you find the right activities for your program’s age group. Also check the related Science, Math, and Technology Standards starting on page 37 to find challenges that are a good match for your curriculum.

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Events</th>
<th>Grades 3–5</th>
<th>Grades 6–8</th>
<th>Grades 9–12</th>
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<td>Launch It</td>
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<td>Feel the Heat</td>
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**Read the leader notes.** These notes will assist you in facilitating the challenges. They include suggestions to help you prepare for, introduce, and run the activity as well as discussion questions to help kids explore the activity’s science, engineering, and space-related themes.

**Try the activity yourself.** A practice run will help you figure out the best way to introduce the activity and anticipate potential problems your kids may run into.

**Print the challenge sheet.** This handout walks kids through a challenge, providing them with a materials list, questions to brainstorm, building tips, and interesting stories related to the challenge.

**Get kids excited about NASA’s moon missions.** By the year 2020, NASA plans to build an outpost on the moon and have teams of astronauts live there. Get your kids excited about what’s involved in living and working on the moon. On pages 5 and 6, you’ll find a brief description of NASA and two of its moon missions. Share this information with your kids.

**Decorate the room with space images.** You can motivate kids and help them visualize the moon and NASA’s moon missions by displaying space-related images. NASA has many excellent ones you can print out. (Visit [moon.msfc.nasa.gov](http://moon.msfc.nasa.gov).) To get the NASA images used in this guide, use the URL found below each image.
**LEADING A CHALLENGE**

Never led an engineering challenge before? Don’t worry! From getting started, to helping kids succeed, to wrapping up the activity, the leader notes give you all you need to facilitate a challenge with kids. The leader notes are divided into the following sections:

**Prepare ahead of time:** Lists things to do to get ready for the activity.

**Introduce the challenge:** Provides a script you can use to introduce the activity’s key ideas and show how the challenge relates to NASA’s goal of having people live on the moon.

**Brainstorm and design:** Helps kids think about different ways to meet a challenge. Since challenges offer kids many ways of succeeding, this section jump starts their thinking about various approaches and possibilities.

**Build, test, evaluate, and redesign:** Lists issues that might surface during a challenge and suggests strategies to use with kids who face these issues.

**Discuss what happened:** Provides questions (and answers) for reviewing the activity’s key concepts, helping kids reflect on how they used the design process (see page 2 for an overview of this process), and highlighting how the challenge relates to NASA’s moon-exploration efforts.

**Extend the challenge:** Presents short activities that kids can do to reinforce and expand the experiences they have had in a challenge.

**Curriculum Connections:** Lists the topics in a challenge that relate to concepts commonly covered in science, math, and technology curricula.

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**TIPS FOR FACILITATING OPEN-ENDED CHALLENGES**

- There are multiple ways to successfully tackle a challenge, so 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.
- When kids feel stuck, have them describe what they’re doing by explaining 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?”
- When something’s not going as desired, encourage kids to try again. Problems are opportunities for learning and creative thinking.
- Have kids come up with several ways to solve a problem before they move ahead with an idea.

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**If a design doesn’t work as planned, encourage kids to try again. Setbacks often lead to design improvements and success.**
Could people live on the moon for months at a time? Yes! By the year 2020, NASA plans to build a lunar outpost capable of housing teams of astronauts for six months or more. But there’s a lot to learn before this can happen. Between now and then, NASA will prepare by sending several robotic missions to:

- identify good landing sites. Orbiting spacecraft will image and map the surface and identify hazards, such as steep slopes, rough terrain, and other obstacles.
- measure temperature, lighting, dust, and radiation levels. NASA needs to know this to design materials and equipment that will work reliably on the moon and assure astronaut safety.
- look for useful resources, such as minerals and ice. Shipping things from Earth is costly—over $25,000 a pound! NASA needs astronauts to make as much as possible of what they need on site, using raw materials found on the moon, like calcium compounds to make cement and nitrogen compounds to fertilize crops.

The two missions featured in this guide—the Lunar Reconnaissance Orbiter and Lunar Crater Observation and Sensing Satellite—are the first two missions NASA is sending and are the first step in NASA’s effort to return to the moon.
THE LUNAR RECONNAISSANCE ORBITER (LRO)

LRO is an unmanned spacecraft that will orbit the moon for at least a year. It will help NASA select safe landing sites, study radiation levels on the moon, and identify lunar resources. LRO will use the following sensors to help NASA put together a comprehensive understanding of the moon’s features and resources:

- **Cosmic-ray Telescope:** Studies the effects of radiation and its potential impact on living things.
- **Diviner Lunar Radiometer:** Gives detailed information about surface and subsurface temperatures as well as landing hazards, such as rocks and rough terrain.
- **Lyman Alpha Mapper:** Maps the surface of the moon, searches for ice and frost at the surface, and images the moon’s permanently shadowed regions, such as at the bottom of deep craters.
- **Neutron Detector:** Maps the distribution of the element hydrogen, which is an indicator of possible water and ice. It also provides information about radiation on the moon.
- **Laser Altimeter:** Measures the steepness of slopes and surface roughness and generates a high-resolution, 3D map of the moon.
- **Camera:** Takes detailed pictures of the moon, capturing images of objects as small as one meter.
- **Radio Frequency Demonstration:** Searches for ice deposits beneath the surface of the moon.

THE LUNAR CRATER OBSERVATION AND SENSING SATELLITE (LCROSS)

LCROSS has a specific mission: search for ice. If astronauts are going to live on the moon for extended periods of time, finding water is essential. Astronauts need water to drink, and plants need it to grow. Water also can be broken down into oxygen, which can be used for breathing, and into hydrogen, which can be used for fuel for the return trip to Earth. Water is heavy, so sending all the water that a long-term mission needs from Earth would add considerable expense to the moon exploration budget.

LCROSS to the rescue! It’s helping NASA look for a source of water on the moon. LCROSS will test the theory that ancient ice exists in the permanently shadowed craters near the moon’s poles. Since no sunlight reaches the bottom of these deep craters, the dark, frigid conditions there are perfect for preserving possible ancient ice deposits. NASA is sending LCROSS’s two sections hurtling into a crater near the moon’s South Pole. Their impacts will make two deep pits in the crater floor, sending up a plume of dust and gas 6 miles (10 km) high. Instruments on the Lunar Reconnaissance Orbiter, the Hubble Space Telescope, and Earth will analyze the plume for the presence of water (ice and vapor), carbon compounds, and minerals that contain water.
Few kids can describe 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—the perfect field for innovative thinkers.
- **Work with great people.** Engineering takes teamwork. As an engineer, you’ll be surrounded by smart, creative people.
- **Solve problems and design things that matter.** Engineers improve people’s 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.

**HOW DO ENGINEERS MAKE THE WORLD A BETTER PLACE?**

Here are some things engineers do to help improve people’s lives.

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

**FIND OUT MORE**

Explore more about engineering. The following Web sites offer fun projects, videos of engineers doing innovative work, and videos of real-world STEM connections:

- NASA eClips at [nasa.gov/audience/foreducators/nasaeclips](nasa.gov/audience/foreducators/nasaeclips)
- Engineer Your Life at [engineeryourlife.org](engineeryourlife.org)
- Discover Engineering at [discoverengineering.org](discoverengineering.org)
- Design Squad at [pbs.org/designsquad](pbs.org/designsquad)
FROM NASA

Want more ways to extend and enrich your kids’ experiences of space exploration and living on the moon?

Tap NASA’s vast collection of moon-related animations, videos, interactives, and educator guides at NASA.gov.

- Engineering Design Challenges (Grades 5–12)
- Exploring the Moon Teacher’s Guide (Grades 4–12)
- Field Trip to the Moon Educator Guide (Grades 5–8)
- Field Trip to the Moon Companion Guide (Grades 5–8)
- Field Trip to the Moon Informal Educator Guide (informal settings)
- Lunar Nautics: Designing a Mission to Live and Work on the Moon Educator Guide (Grades 5–8)
- Lunar Plant Growth Chamber Educator Guide (Grades 9–12)
- Moon Munchies Educator Guide (Grades K–4)
- Packing Up for the Moon (Grades 5–8)

Also, get games, activities, and the Exploring the Moon Teacher’s Guide from the Lunar Reconnaissance Orbiter Web site at lro.gsfc.nasa.gov/education.html.

FROM DESIGN SQUAD

Extend and enrich your kids’ Design Squad experiences. Find the following resources at pbs.org/designsquard.

- Watch Design Squad—Get all the episodes online and view video clips of engineers who showcase diverse, creative career paths in engineering.
- Get more hands-on, open-ended engineering challenges—Each comes with leader notes and reproducible challenge sheets in English and Spanish.
- Host Design Squad clubs and events—Get the Event Guide to help you host fun-filled engineering events for kids and families. It contains five challenges with reproducible activity sheets in English and Spanish, a list of sources for materials, a planning checklist, and an evaluation form. The Web site also has downloadable signs, iron-on T-shirt transfers, and volunteer certificates.
- Stay informed—Sign up for an E-newsletter about the show, Web site, resources, events, and trainings.

FIT THE GUIDE’S CHALLENGES INTO ANY PROGRAM

Classrooms, afterschools, clubs, and other ongoing programs

On the Moon 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 On the Moon activities to a museum, library, mall, or university and spark kids’ interest and confidence in engineering with a lively, fun-filled event. The first two challenges are especially good for events like science and engineering days—they use simple, readily available materials, and are open ended, with multiple solutions that engage a wide variety of ages and ability levels.