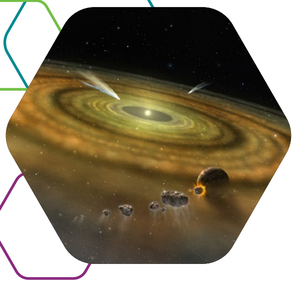


FACILITATOR GUIDE
Design, Build, Test

Learning objectives

- Scientists use spacecraft to explore Earth and space.
- Missions to space require large teams to design, build, and test spacecraft.
- Preparing to launch a spacecraft into space takes a lot of time.

Materials

- Foam pieces
- Printed plastic tool pieces
- Printed plastic solar panel pieces
- 1/2-inch PVC couplings
- 2 parts bins
- Lazy Susan/turntable contraption
- Shake test contraption
- 3M Command strips
- Build, Spin, and Shake placemats
- Dry-erase whiteboard
- Neon dry-erase markers
- Activity and facilitator guides
- Information sheets
- *Tips for Leading Hands-on Activities*

The Explore Science toolkit comes complete with all necessary materials for this activity. While some materials are also readily available online or at local retail stores to create or restock activity kits, many of the pieces in this activity are difficult to source. All the graphic files can be downloaded from *www.nisenet.org,* and if you don't have the physical materials you can adapt this activity, while still covering some of the same learning goals, by encouraging participants to draw their own spacecraft with markers and describe the purpose of the mission. Participants can even name their spacecraft and talk about how they might test different components.

Safety

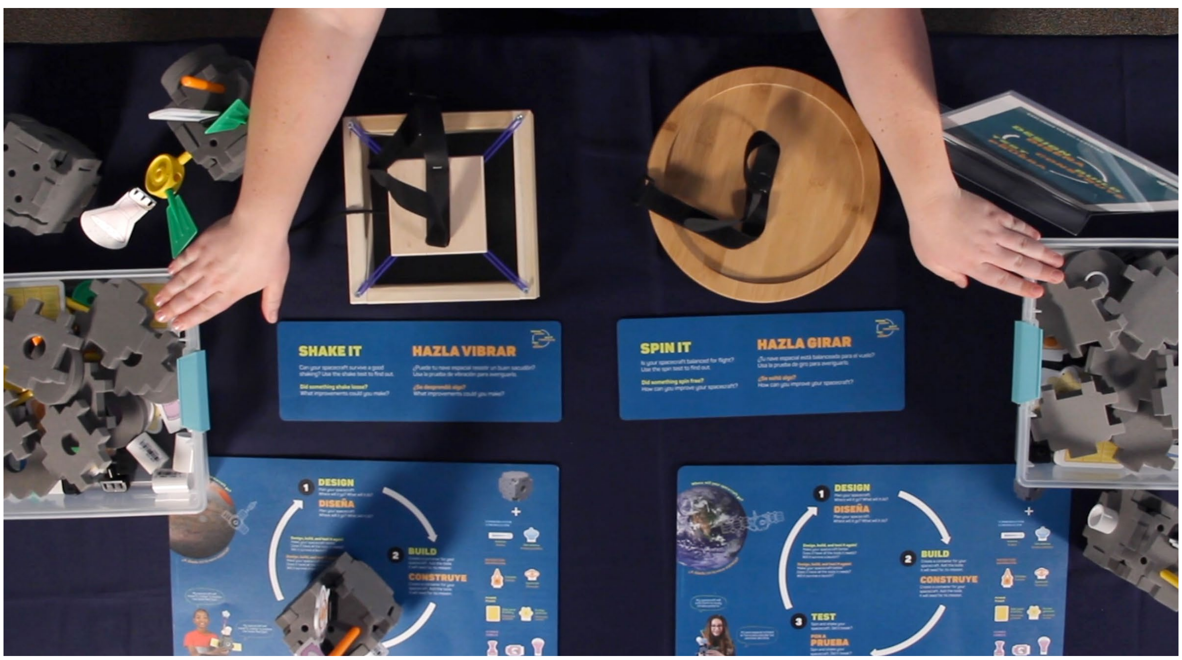
Remind visitors to be careful when testing spacecraft on the shake and spin test contraptions. Overly aggressive shaking and spinning may result in materials flying and/or injured hands. If the elastic bands for the shake test contraption are wearing out, replace them immediately to avoid them snapping during testing. Ask participants to **gently** shake and spin the test contraptions. You can model this behavior yourself.

Advance preparation

Before doing this activity, evenly divide spacecraft couplings, tool connectors, and tool pieces between the two plastic bins. Then place spacecraft body foam pieces on top of these pieces. Arrange the placemats near the edges of the tables so participants can have room to build their spacecraft. Place the spin test and shake test contraptions toward the middle of the table, along with the test placemat. Remember to attach the Command strips to the bottom of the shake test and spin test contraptions. Place four strips on each contraption and set them at the center of a clean, level table. We found that having visitors build their spacecraft on both sides of the table simultaneously before testing them in the middle was the best way to engage multiple visitors with the activity.

Have a little fun! Consider building your own spacecraft to leave out as an example for visitors. This will be a great visual aid as the different components are introduced to visitors as well as an effective attractor to invite visitors to sit down and build their own spacecraft.

We understand that each institution may have different table sizes. Below is a sample table layout that may work for your event. You can also choose to put the test locations toward either end of the table or use more tables to accommodate higher numbers of visitors.



Notes to the presenter

Young visitors may have a difficult time building the container and inserting the tools. Guide them through the process if they are struggling, but allow enough space for them to explore. Remind visitors that NASA spacecraft include tools from each category (power, communication, navigation, and science) to accomplish their missions, and that visitors might want to follow this model too. As noted above, it might be helpful to leave out an example spacecraft so young visitors have inspiration.

Guests, especially young visitors, may need close supervision when they get to the test stations. As noted in the **Safety** section, materials may fly into the air during the tests. Have guests pay close attention during their tests. How did their spacecraft hold up to each test? Which design worked and which didn't? Encourage guests to try to build a better spacecraft, especially if their spacecraft did not stay together. What kinds of designs should be reevaluated? How can we reengineer the spacecraft so that the tools will stay on? Perspective and collaboration are important in designing a spacecraft that can complete a mission, so encourage peer or guardian support.

PHOTO OPPORTUNITY: We've included a dry-erase board so visitors can take their own picture with the spacecraft they designed while holding up the board to identify themselves as an engineer or to name their spacecraft and/or what its mission will be.

Examples:

Engineer: Johnny Appleseed

Spacecraft: BP-2300

Mission: My spacecraft will study how the Sun changes

Some visitors may have questions or want to know more about the tools and categories. **Communication** tools, like a **satellite dish** or an **antenna**, are used to communicate back to Earth. **Power** tools provide energy to the spacecraft, either collected from the Sun using a **solar panel** and **battery** or from heat generated by radioactive decay in a **nuclear generator**. **Navigation** tools, like a **compass** or a **gyroscope**, help guide the direction and orientation of spacecraft in flight. **Science** tools on the spacecraft help scientists make observations, take measurements, or collect samples. A **spectrograph** can separate wavelengths of light and record the data. A **particle collector** can take samples of tiny bits of material found in the path of the spacecraft. A **camera** uses light to collect images of objects.

Conversational prompts

It may help to engage some visitors through storytelling. You can hook the visitors by providing a prompt along the lines of, "NASA needs your help. Your mission is to build a spacecraft that can study clouds and the atmosphere. How should we design your spacecraft to do this mission? What tools will you need?"

If young visitors are struggling to build their spacecraft, you may feel inclined to help them or do it for them. Before this happens, try to engage their guardian by encouraging them to help out their young one(s). That way both the guardian and the young visitor can work together in building their spacecraft.

Ask visitors questions along the way to support their construction of the spacecraft. Challenge their ideas. Would a particle collector or a camera be more effective in data collection for your mission? How should your tools be mounted so they can withstand the shake and spin tests? If your spacecraft failed a test, what changes can be made to make it stronger?

Difficult concepts

The tests in this activity are simplified examples of the extensive and complex tests NASA mission teams use to make sure every mission is a success. Scientists and engineers test to make sure the spacecraft will stay structurally sound during its launch, its exit from Earth's atmosphere, and its time in space. They also test their tools in conditions similar to those in space in labs on Earth that mimic conditions like minimal atmospheric pressure, weightlessness, and extreme temperatures. The tests that take place in these labs ensure the spacecraft will function exactly as planned.

Despite all of this testing, failures can still happen. Some spacecraft have failed to launch off the ground, while others have lost communication while in space or on planets. Some examples that you could share include how NASA's Mars Climate Orbiter was lost during an orbital insertion maneuver due to a mismatch in US customary vs. metric measurements, or the flaw in the Hubble Space Telescope's giant mirror that required corrective optics to be installed during a shuttle mission. Failure is a fundamental part of the learning process and it leads to building better technology.

Staff training resources

Refer to the *Tips for Leading Hands-on Activities* sheet in your activity materials.

- Content Training Video: *https://vimeo.com/366776327*
- Activity Training Video: *https://vimeo.com/366775838*
- Edu-cathalon Facilitation Strategies Video: *https://vimeo.com/304241578*

The NISE Network has a curated list of programs, media, and professional development resources that directly relate to the toolkit. These resources can be viewed and downloaded from: *www.nisenet.org/earthspacekitextensions*

Credits and rights

This activity was adapted from the *Sun, Earth, Universe* exhibition, developed by the Science Museum of Minnesota. Graphics and illustrations courtesy Emily Maletz Graphic Design. More information can be found at: *https://www.nisenet.org/sunearthuniverse.*

Photograph of engineers working on NASA's Juno spacecraft courtesy NASA/JPL-Caltech/ Lockheed Martin.

Photograph of the James Webb Space Telescope courtesy Chris Gunn, NASA.

NISE NATIONAL INFORMAL STEM EDUCATION NETWORK

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