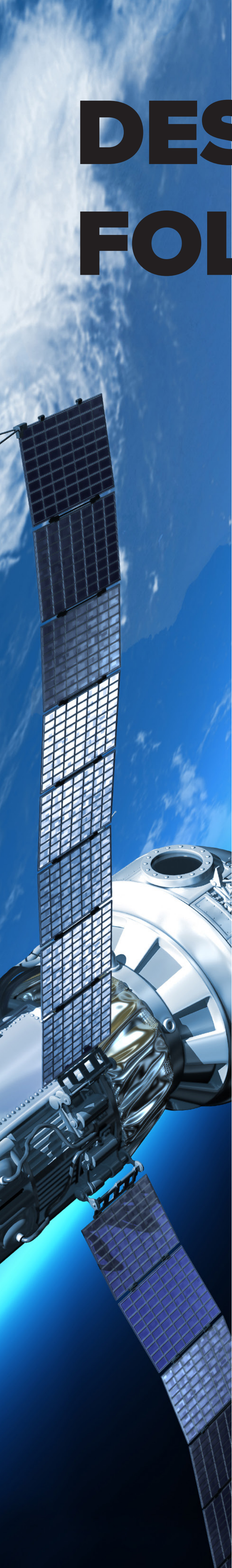

DESIGN A FOLDING SOLAR PANEL

Grades 6–8, 9–12

60–90 minutes

DESIGN CHALLENGE

Design and construct a foldable “solar panel” made of aluminum foil that fits in a small container and expands without tearing.

SUPPLIES AND EQUIPMENT

Per whole group to share:

- ☐ Aluminum foil
- ☐ 100–500 craft sticks
- ☐ 100–500 straws
- ☐ 100–500 pipe cleaners
- ☐ Examples of origami (optional)
- ☐ 100 rubber bands
- ☐ Ruler or tape measure

Per team:

- ☐ 1 aluminum foil box with metal rip bar removed
- ☐ Cardboard or chipboard from recycled boxes
- ☐ 1 roll tape
- ☐ 1 bottle glue
- ☐ 1 pair scissors
- ☐ 1–2 plastic rods or wooden dowels

A student designing a solar array using an accordion fold. Credit: Try Engineering.

GETTING READY

Remove rolls of foil from their boxes. Cut sheets of aluminum foil 3' long for each team’s panel.

If desired, prepare examples of origami to inspire the folding solar panel designs. Designs and instructions for origami folds of varying complexity can easily be found online.

INTRODUCTION

Ask questions to get participants thinking about folding and design.

- What do you have at home that folds up for storage? (Lawn chair, card table, etc.)

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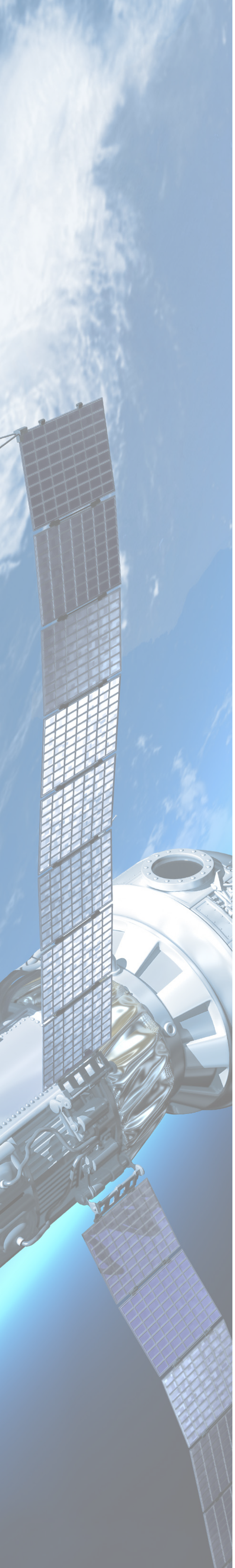


INTRODUCTION (CONTINUED)

- Folding laundry is a chore that some people don't like. Why do we do it? (So our clothes fit in drawers and don't wrinkle.)

The large solar arrays on the International Space Station are 115 feet long by 38 feet wide. The James Webb Space Telescope (scheduled to launch in October 2018) is the size of a tennis court. Both of these are far too large to send into orbit without making them smaller, so they must be folded to fit. Engineers must plan how these devices will fold up to fit in the rocket and how they will unfold once they are in space. Engineers address this and many other challenges when working with objects destined for space.

INSTRUCTIONS

Get participants thinking about how much space objects take up and how they could be folded to be smaller. For example, show origami creations as well as the paper from which they were made.

Introduce the design challenge. Participants will work in teams of 3–4 to design a folding aluminum foil "solar panel" that fits in an aluminum foil packaging box and can open to its full dimensions without tearing. Give them the following constraints:

- The unfolded dimensions of the solar panel must be as close to 1' x 3' as possible.
- The solar panel must be taped to the bottom of the box.
- The solar panel can only be touched by one hand when unfolding.
- Optional: The solar panel must rigidly keep its unfolded shape without being held by a person.

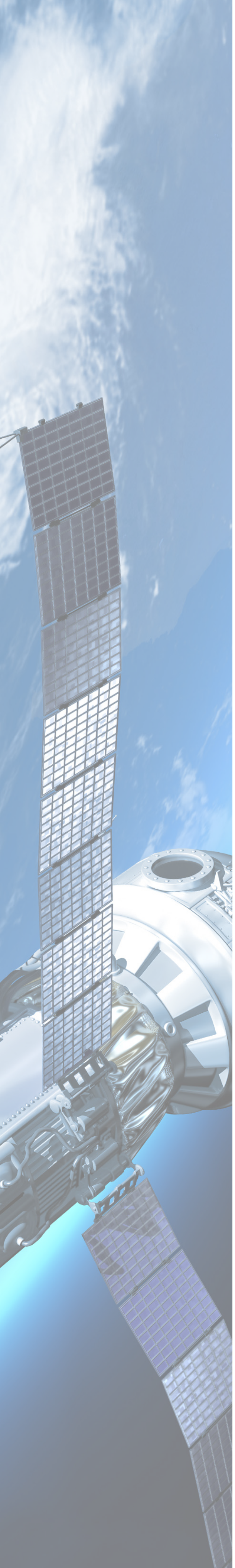
Give the participants 5–10 minutes to brainstorm their designs. Suggest that they keep origami in mind; engineers take inspiration from the work of others to create a design that fits their needs. Encourage them to make drawings or small-scale models to help communicate their ideas. Each team must decide on a final design as a group, as well as the materials they will use.

Give the groups 20–40 minutes to build their designs.

- Check in with each team during the build time. If teams are frustrated, give them a hint but avoid building anything for them.

Give each team a chance to show off their design to the rest of the group by asking them to present on the following points:

- Demonstrate the solar panel's operation.
- Share inspiration and difficulties.
- Explain whether working on a team made the solar panel more successful, and how they think engineers work in teams.



INSTRUCTIONS (CONTINUED)

Evaluate the success of each design.

- ◻ Was the solar panel able to fit into the box?
- ◻ Did the solar panel extend to 1' x 3' without tearing?
- ◻ Was the solar panel able to be unfolded with one hand?

ACTIVITY VARIATIONS

Make the design challenge more difficult by using tissue paper instead of foil.

RELEVANT TERMINOLOGY

Electricity: A form of energy caused by the flow of electrons that occurs naturally and can be transferred through conductive materials like wires.

Solar array: Another name for solar panel; made of solar cells that convert light energy or photons into electrical energy through the photovoltaic effect.

Working on the port overhead solar array wing of the International Space Station. Credit: NASA.

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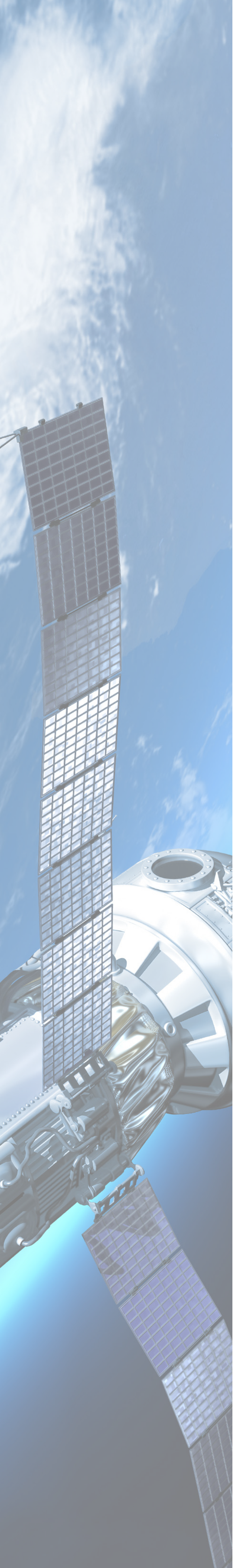


GUIDANCE FOR YOUNGER CHILDREN

QUESTIONS TO ASK AFTER THE ACTIVITY

- What were you looking for when selecting materials for your solar panel?
- What did you learn by testing your solar panel after designing it?
- After testing your solar panel, did you make any changes to your design? (Explain that engineers test and retest designs and are always looking to make things better.)
- What examples or ideas did you consider when designing and folding your solar panel?

ENGINEERING CONNECTIONS

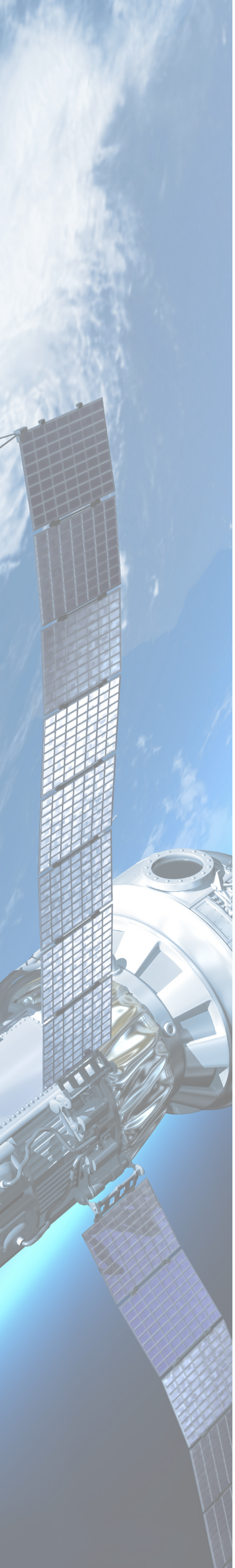
Mechanical engineering is a field of engineering that requires knowledge of engineering, physics, and different materials to create machines or parts for them. And sometimes engineers need to know about art, as well! For example, Brian Trease, a mechanical engineer at NASA, designed solar panels based on the Japanese art of folding paper called origami. Solar panels used in space already were designed to fold up, but Brian believes that by folding solar panels like paper is folded in origami, it's easier to get these panels into space.

One type of origami fold that he uses is called the Miura fold. This allows the panel to be folded and fit into a small space while being carried into space, but then opened into a big checkerboard that can catch the sun and power the satellite. The Miura fold also makes the launch of a solar panel easier because there is only one way to open or close it: pull on one corner. Brian used the Miura fold to design a solar panel prototype that looks like a blooming flower and, when opened, forms a big, flat, circular surface to catch sunlight and generate electricity.

SCIENCE CONNECTIONS

Plants use the energy in sunlight to create their own food in a process called photosynthesis. Solar power is generated through a similar process. Energy in sunlight is converted into electricity using solar panels, which are also called photovoltaic cells. These solar panels are a necessary part of every satellite in orbit. However, they are far too big to launch on a rocket without folding them up in some way.

Folding is an important feature of human-made and natural structures. Nature folds objects to fit them into a small space. For example, a butterfly's wings are folded until it hatches from its chrysalis. Petals fold inside a flower bud. Products like bicycles and chairs can be designed to fold for storage in small spaces. Folding bridges allow cars and boats to share waterways. Folding stents that are inserted into veins and arteries allow doctors to treat weakened blood vessels. Even DNA is folded. The DNA in a single cell of your body is six feet long! However, because it is folded by special proteins, it can fit into a microscopic cell. Folding is one way to make efficient use of space.



GUIDANCE FOR OLDER YOUTH AND ADULTS

QUESTIONS TO ASK AFTER THE ACTIVITY

- Why is it so important for solar panels to be foldable when going into space?
- How did you go about selecting materials for designing your folding solar panel?
- After testing your prototype, what refinements did you make to your design?
- What designs did you use as inspiration when folding your solar panel?

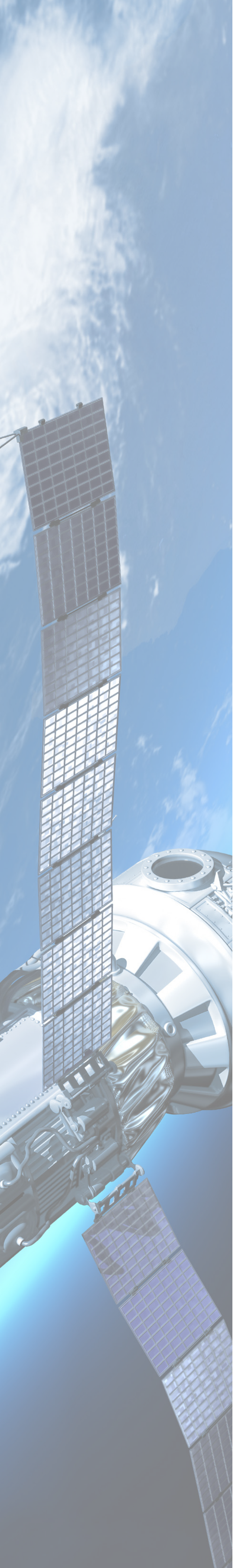
ENGINEERING CONNECTIONS

To deliver payloads (cargo and satellites) during the Space Shuttle program years, a device called the Canadarm was used. This series of robotic arms was built into each shuttle cargo bay and was used to load, unload, capture, and move cargo and satellites when in orbit. In order for the shuttle to both take off and land, the arm needed to fit into the cargo bay along with the payload so that the cargo doors could close. To accomplish this, NASA engineers designed the Canadarm to be 50 feet long with six joints that are similar to a shoulder, elbows, wrists, and fingers.

SCIENCE CONNECTIONS

For engineers to design objects that can be folded up to fit into constrained spaces, they need a strong understanding of the mathematics of shapes. This area of study is called geometry. The most basic shapes in that field that most everyone knows about are ones like squares, rectangles, circles, and triangles. However, those are all known as two-dimensional shapes.

When folding objects to fit into three-dimensional spaces such as a rocket's cargo bay, engineers must be able to understand how their two-dimensional shapes can be attached to one another and then folded or unfolded to form three-dimensional shapes. This can be very complex and often requires the assistance of computers. Basic three-dimensional shapes include spheres (like a ball), cylinders (like a soup can), and cones (like a birthday hat). However, NASA engineers are likely to deal with much more complex shapes that go by names like *oblate spheroid*, *truncated tetrahedron*, and *disphenoid*. No matter the name, geometry is a necessary field of study for engineers wishing to fit big objects into small spaces!



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ACKNOWLEDGMENTS

Activity courtesy of IEEE TryEngineering.org

http://tryengineering.org/sites/default/files/lessons/folding.pdf

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