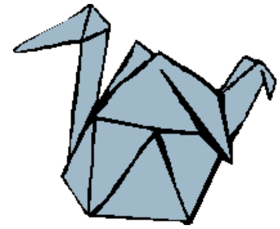
Folding Matters



Provided by TryEngineering - www.tryengineering.org

Lesson Focus
Lesson focuses on how the process of folding has impacts on engineering and is evident in nature. Students consider many applications of folding such as parachutes, wings in a cocoon, heart stents, and solar panels in space. They work in teams to create a model out of everyday items of a solar panel that can be folded (for transport) and expanded (in space). Students design their solar panel on paper, build it for transport, and open or test it. All teams evaluate their results, reflect on their design, and present to the class.

Lesson Synopsis
The "Folding Matters" lesson explores how engineers have to incorporate folding and unfolding into many mechanical devices including shunts, telescopes, and deployable solar panels for spacecraft. Students work in teams to develop a "foldable" solar panel out of everyday items that can fit into a foil or plastic wrap box, yet be able to expand to 1 foot or about 30 cm, by 3 feet or about 90 cm with at least 80% of the surface comprised of solar panel (aluminum foil). Teams develop their designs on paper, determine what materials they need, build their design, present it to the class, compare their team's design with those of other student teams, reflect on the experience, and share observations with the class.

Age Levels
8-18.

Objectives
- Learn about folding technology.
- Learn about engineering design.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

Anticipated Learner Outcomes
As a result of this activity, students should develop an understanding of:
- engineering design
- folding technology
- teamwork

Lesson Activities
Students explore how the folding of materials is sometimes critical to the functionality or shipment of a product. Students work in teams to develop a solar panel that can be folded into a small box and then deployed to its original size. The unfolded "panel" will be constructed out of everyday items including aluminum foil and must be at least 1 foot or about 30 cm, by 3 feet or about 90 cm in size when unfolded. Students work in teams to select materials, design the solar panel and engineer the folding process. They build and pack their solar panel into a small box and unfold it to determine damage or functionality. They compare their designs to those of other student teams, reflect on the experience, and share observations with the class.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Resource Sheet (attached)
- Student Worksheet (attached)

Alignment to Curriculum Frameworks

See curriculum alignment sheet at end of lesson.

Internet Connections

- TryEngineering (www.tryengineering.org)
- James Webb Space Telescope (http://jwst.gsfc.nasa.gov)
- Protein Folding (http://folding.stanford.edu/English/Science)
- National Science Education Standards (www.nsta.org/publications/nses.aspx)
- ITEA Standards for Technological Literacy (www.iteaconnect.org/TAA)

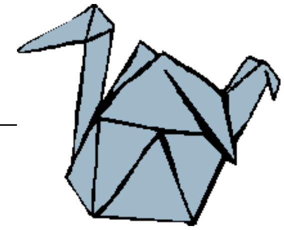
Recommended Reading

- Trash Origami: 25 Paper Folding Projects Reusing Everyday Materials (ISBN: 978-0804841351)
- Karakuri: How to Make Mechanical Paper Models That Move (ISBN: 0312566697)
- Geometric Folding Algorithms: Linkages, Origami, Polyhedra (ISBN: 978-0521857574)

Optional Writing Activity

- Write an essay or a paragraph identifying three items you now recognize have required a folding plan either for shipping or storing.

Folding Matters



For Teachers:
Teacher Resources

◆ **Lesson Goal**

The "Folding Matters" lesson focuses on how the process of folding has impacts on engineering and is evident in nature. Students consider many applications of folding such as parachutes, wings in a cocoon, heart stents, and solar panels in space. They work in teams to create a model out of everyday items of a solar panel that can be folded (for transport) and expanded (in space). Students design their solar panel on paper, build it for transport, and open or test it. All teams evaluate their results, reflect on their design, and present to the class.

◆ **Lesson Objectives**

- Learn about folding technology.
- Learn about engineering design.
- Learn how engineering can help solve society's challenges.
- Learn about teamwork and problem solving.

◆ **Materials**

- Student Resource Sheets
- Student Worksheets
- Class Materials: aluminum foil box with metal rip bar removed for safety (note, the aluminum foil will be used as part of the student team materials) – each student team "solar panel" must fit into the empty aluminum foil box.
- Student Team Materials: aluminum foil, tape, cardboard, rubber bands, ruler, popsicle sticks, plastic rods, straws, pipe cleaners, paper clips, glue, scissors, balsa wood, cotton balls, paper, fabric, and other classroom materials.

◆ **Procedure**

1. Show students the student reference sheets. These may be read in class or provided as reading material for the prior night's homework.
2. To introduce the lesson, consider asking the students how they think a large parachute fits into a tiny backpack....have them consider whether they can fit more into a suitcase if everything is folded neatly, or if items are jumbled in a ball.
3. If internet access is available, have students read about the James Webb Space Telescope (http://jwst.gsfc.nasa.gov) and watch the animation showing how the engineers involved have planned how the telescope will have to unfold in space at http://jwst.gsfc.nasa.gov/resources/JWSTSpacecraftDeployAnimation-longversion.mov.
4. Teams of 3-4 students will consider their challenge, review available materials and develop a detailed drawing showing their solar panel including a list of materials.
5. Students next build their solar panel, and fit it into a standard box that foil is sold in (about 12.25 inches or 31 cm long by 2 inches or 5 cm square).
6. Teams then demonstrate the removal of their solar panel to the class, and observe the designs developed by other student teams.
7. Teams reflect on the challenge, and present their experiences to the class.

◆ **Time Needed**

One to three 45 minute sessions.

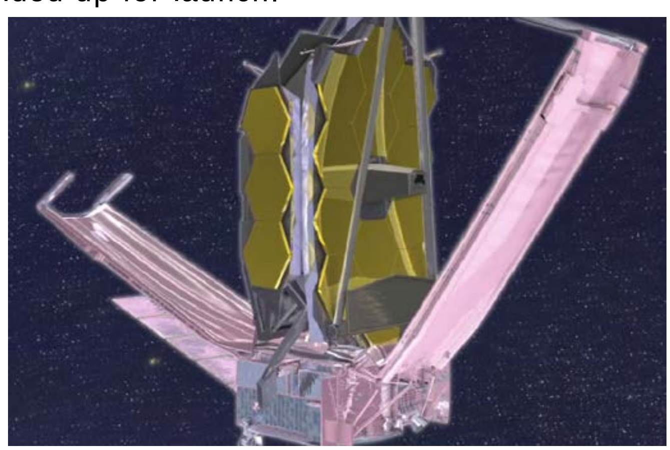
Student Resource: Why Folding Matters

Folding and unfolding of materials is an important element in engineering design. Consider a telescope, where circles of metal have to fit neatly within the next in order to expand and be stored compactly. Parachutes are another example…they have to be folded in such a way to deploy properly but also to be stored in a compact back pack. The same is true of wings of a butterfly folded and growing in a cocoon. It is also true of solar panels that are used in space. Spacecraft have limited storage areas, so whatever is carried to space must be folded in a compact way and then deployed with an engineering system so the solar panels unfold and are functional. Heart stents work the same way…a small device is sent via a tube to the heart and then when released at the end of the tube it must unfold or open, and then function as engineered.

Unfolding the James Webb Space Telescope

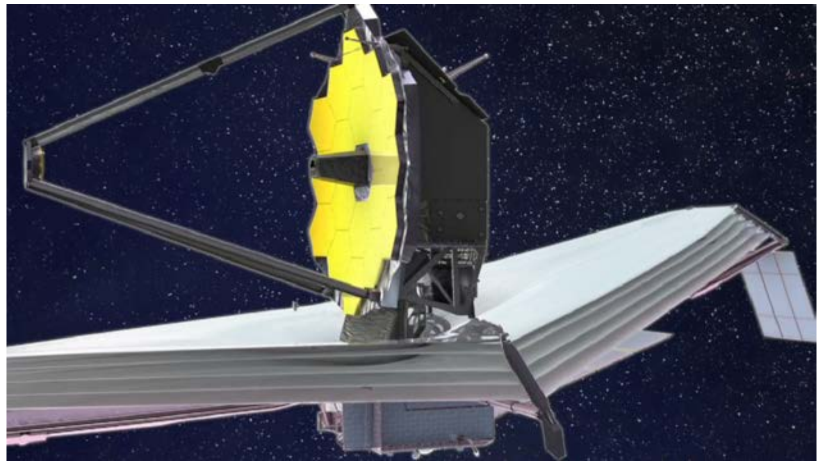
The James Webb Space Telescope is a large, infrared space telescope. It will find the first galaxies that formed in the early Universe, connecting the Big Bang to our own Milky Way Galaxy. It will peer through dusty clouds to see stars forming planetary systems, connecting the Milky Way to our own Solar System.

It is a joint project of NASA, the European Space Agency, and the Canadian Space Agency. The project is working toward a 2018 launch date. Although engineers, scientists and manufacturers are still in the process of building all of the instruments that will fly aboard NASA's James Webb Space Telescope, they had to figure out long ago, how it was going to "unfold" in space. That's because the Webb Telescope is so big that it has to be folded up for launch.



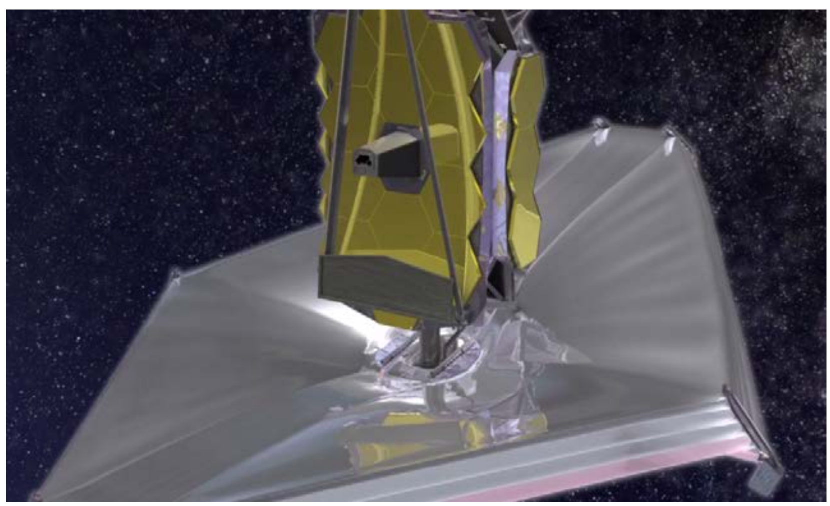
An animation of how the telescope will open up in space once it achieves orbit, was created by the Image center at Northrop Grumman Aerospace Systems, Redondo Beach, California. The Webb Telescope is roughly 65 feet (21 meters) from end to end and about 3 stories high. "Animation helps designers and their colleagues to fully visualize and explain the complex motions required to deploy this observatory," said Mike Herriage, Webb Telescope Deputy Program Manager at Northrop Grumman. "And while it’s a visual tool, producing accurate animation is a technical challenge as well."

Student Resource: Unfolding the James Webb Space Telescope (continued)



The Webb Telescope is extremely large and cannot fit in a rocket unless it is folded. It has a sunshield the size of a tennis court and an 18-segment mirror that looks like a honeycomb. Because of its large size, the telescope needs to be folded up to fit in the rocket. The sunshield will be compactly folded, much like a parachute, around the front and back of the telescope. The mirror segments are mounted on the "spine" or backplane of the telescope and the segments on the left and right sides of the honeycomb shape are folded in the rocket.

Once the Webb telescope is on its way to its final orbit, approximately 1 million miles from the Earth, engineers at Northrop Grumman will issue commands to the Webb Telescope to unfold it. "Think of the sunshield as five candy wrappers the size of a tennis court," said Mark Clampin, Webb Telescope Observatory Project Scientist at NASA's Goddard Space Flight Center, Greenbelt, Maryland.

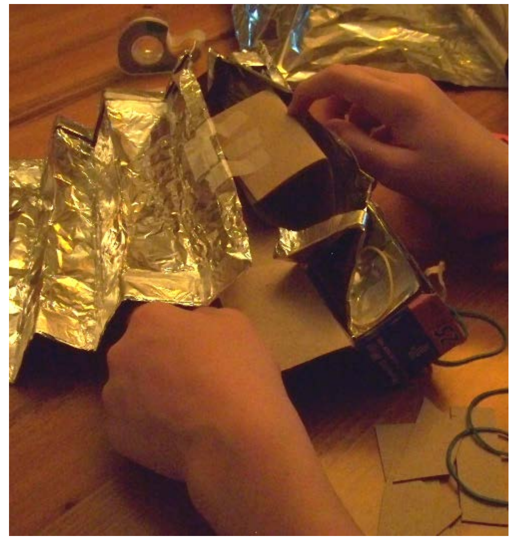


The first part of the telescope to unfold will be the solar panel, followed by the communications antenna. Next, the five layers of sunshield will drop into place from the front and back, spread out into a kite shape. The "secondary mirror support structure," an arm-like feature holding the secondary mirror assembly will then drop down from its folded center perch, and finally, the side mirror segments will be moved forward to form the complete "honeycomb."

More details are at http://jwst.gsfc.nasa.gov and you can watch an animation of the unfolding at http://jwst.gsfc.nasa.gov/resources/JWSTSpacecraftDeployAnimation-longversion.mov.

Student Worksheet:
Solar Panel Folding Challenge

◆ **Engineering Teamwork and Planning**



You are part of a team of engineers given the challenge of developing a solar panel that can be folded into a box for shipping to the international space station. Your solar panel must be at 1 foot or about 30 cm, by 3 feet or about 90 cm in size when unfolded.

◆ **Research Phase**

Read the materials provided to you by your teacher. If you have access to the internet, watch the video showing the planned folding of the James Webb Space Telescope at http://jwst.gsfc.nasa.gov/resources/JWSTSpacecraftDeployAnimation-longversion.mov.

◆ **Planning and Design Phase**

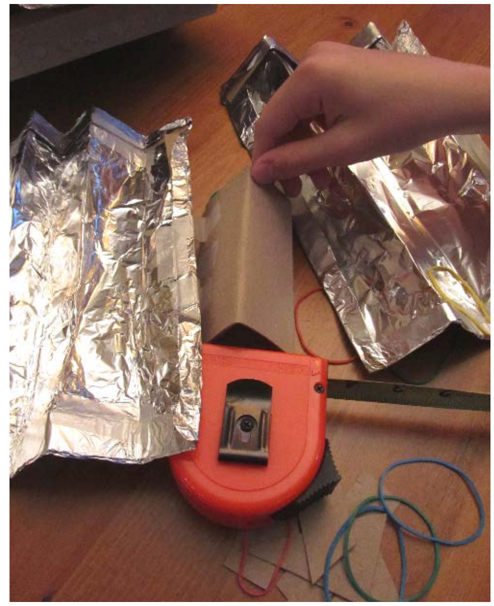
You were given a range of items to build with.
Consider what materials you will need and in the box below draw your solar panel and include a parts list.

Materials you will need:

Student Worksheet:
Solar Panel Folding Challenge

◆ **Presentation Phase**

Present your plan and drawing to the class, and consider the plans of other teams. Be sure to watch what other teams are planning and consider the aspects of different designs that might be an improvement on your team's plan. You may wish to fine tune your own design at this phase.



◆ **Build it! Test it!**

Next build your solar panel and fold it. You may share unused building materials with other teams, and trade materials too.

◆ **Presentation**

Present your solar panel to the class and deploy it from the box. You should be able to open your panel to the full size you originally built, with no tears in the foil.

◆ **Reflection**

Complete the reflection questions below:

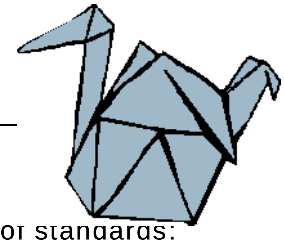
1. How similar was your original design to the actual solar panel your team built?

2. If you found you needed to make changes during the construction phase, describe why your team decided to make revisions.

3. Which solar panel folding design of your class worked best? Why?

4. Do you think that this activity was more rewarding to do as a team, or would you have preferred to work alone on it? Why?

5. If you could have used one additional material (tape, glue, wood sticks, foil -- as examples) which would you choose and why?



For Teachers:
Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆National Science Education Standards Grades K-4 (ages 4-9)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- ✦ Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of

- ✦ Properties of objects and materials
- ✦ Position and motion of objects

CONTENT STANDARD D: Earth and Space Science

As a result of their activities, all students should develop an understanding of

- ✦ Objects in the sky

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ✦ Abilities of technological design
- ✦ Understanding about science and technology
- ✦ Abilities to distinguish between natural objects and objects made by humans

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- ✦ Science and technology in local challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- ✦ Science as a human endeavor

◆National Science Education Standards Grades 5-8 (ages 10-14)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- ✦ Abilities necessary to do scientific inquiry

CONTENT STANDARD D: Earth and Space Science

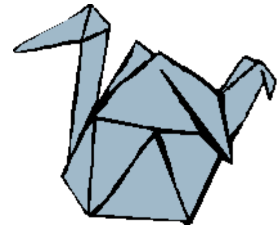
As a result of their activities, all students should develop an understanding of

- ✦ Earth in the solar system

CONTENT STANDARD E: Science and Technology

As a result of activities in grades 5-8, all students should develop

- ✦ Abilities of technological design
- ✦ Understandings about science and technology



For Teachers: Alignment to Curriculum Frameworks (cont.)

◆National Science Education Standards Grades 5-8 (ages 10-14)

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Risks and benefits
- Science and technology in society

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- History of science

◆National Science Education Standards Grades 9-12 (ages 14-18)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of

- Motions and forces

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Historical perspectives

◆Next Generation Science Standards Grades 2-5 (Ages 8-11)

Engineering Design

Students who demonstrate understanding can:

- 3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2.Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

For Teachers:
Alignment to Curriculum Frameworks (cont.)

◆Next Generation Science Standards Grades 6-8 (Ages 11-14)

Engineering Design

Students who demonstrate understanding can:

- MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

◆Next Generation Science Standards Grades 9-12 (Ages 14-18)

HS-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

- HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

◆Standards for Technological Literacy - All Ages

The Nature of Technology

- Standard 1: Students will develop an understanding of the characteristics and scope of technology.
- Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

- Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- Standard 5: Students will develop an understanding of the effects of technology on the environment.
- Standard 6: Students will develop an understanding of the role of society in the development and use of technology.
- Standard 7: Students will develop an understanding of the influence of technology on history.

Design

- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- Standard 11: Students will develop abilities to apply the design process.
- Standard 12: Students will develop abilities to use and maintain technological products and systems.