Solar Sail

For the Teacher

Challenge

To design and deploy a solar sail.

Materials

Provide students a selection of materials to choose from:

Materials used for structure:
Pipe cleaners, bamboo skewers, straws, coffee stirrers (plastic or wooden), and/or pieces of scrap cardboard.

Materials used for sail:
Tissue paper, wrapping paper, tin foil, mylar, magazines pages, plastic grocery bags, and/or emergency blankets.

Items required for activity:

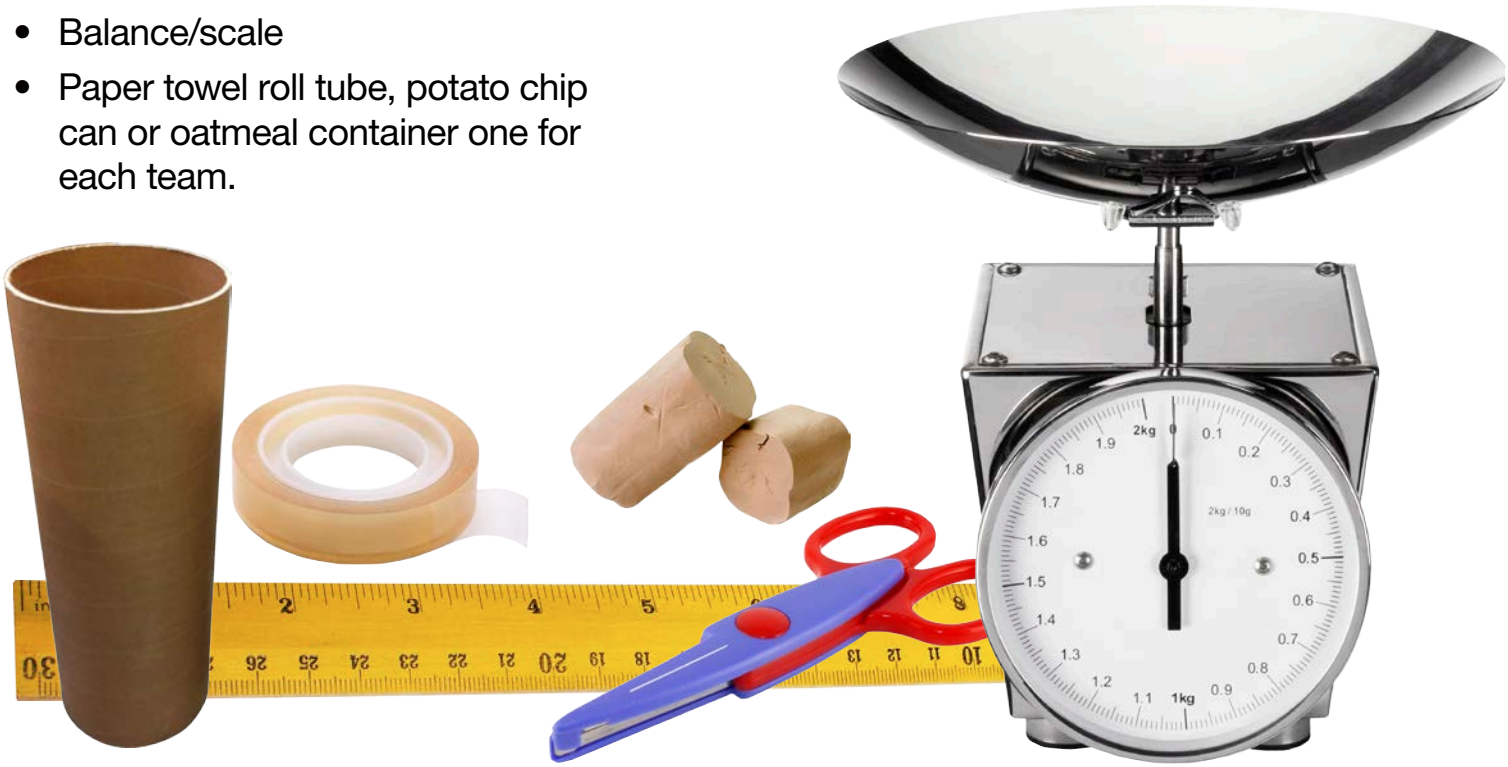
- Clay or play dough
- Scissors
- Clear tape
- Rulers
- Balance/scale
- Paper towel roll tube, potato chip can or oatmeal container one for each team.

Pre-Activity Set-up

In this challenge, students will design a solar sail and deploy it. The sail will need to fold into the "launch tube," then unfold when removed. Designs should be stable enough to stand on their own. If you have resources for simple machines or robotics elements, feel free to incorporate those.

As with all the design challenges, you can give the students a time limit for the design and build phase.

After the students have completed their designs, they will exchange their sail with another group to see if they are easily deployed and stable.



Solar Sail

For the Teacher

Motivate

- Discuss the Solar Sail (see *Background*).
- Videos and more information about NASA's Solar Sail Demonstration are available at *http://www.nasa.gov/mission_pages/tdm/solarsail/solarsail_overview.html*
- Introduce the challenge.

Ask

- Help students answer any questions they have about the challenge.

Imagine

- Be sure all students are communicating and collaborating and that all suggestions and ideas are documented.

Plan

- All drawings should be approved before building begins.

Create

- The mass of the solar sail is critical. It must be as lightweight as possible.

Experiment

- Students will follow the directions and answer questions on the *Experiment and Record* and the *Quality Assurance Student* pages.

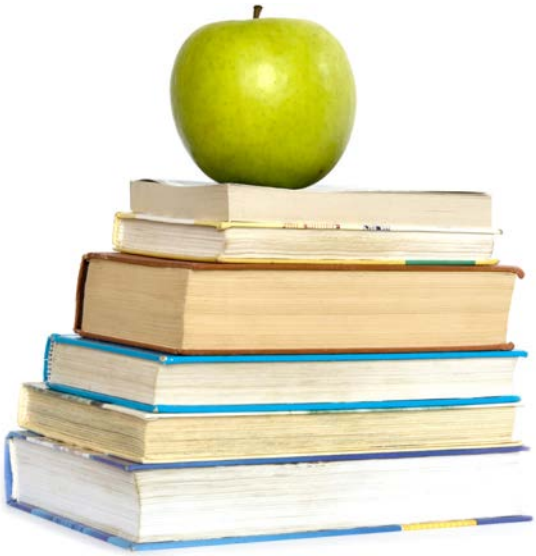
Improve

- After completing the first round of testing, students will make modifications to the designs to make it lighter in weight or deploy more efficiently.

Challenge Closure

Engage the students in a discussion by reviewing all of the data and posing the following questions:

- Which design characteristics provided the most reliable results?
- How do you think your design would work in space? Would you need robotic assistance?
- What did you learn about your team's design while testing another group's design?
- What information could engineers working on this project learn from your group's results?



Background

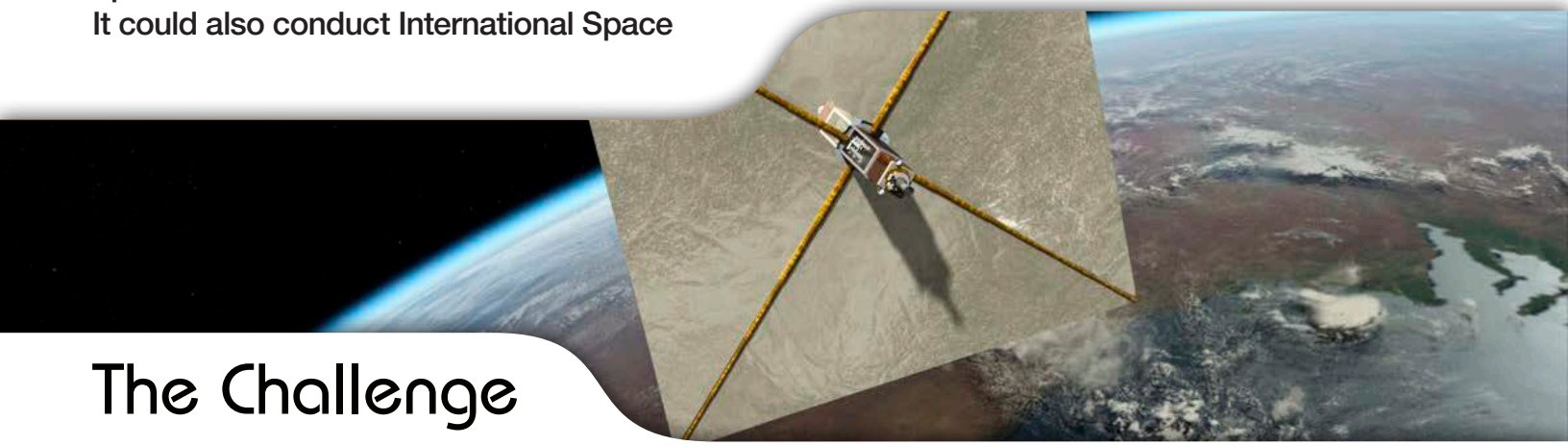
Solar Sail

The Solar Sail Technology Demonstration mission will not only unfurl in space to catch the sunlight, but will also demonstrate that it can navigate through space. The solar sail will use radiation pressure instead of solar wind to move through space. Even though the radiation pressure is very small, in the extremely low friction of space, it will still create enough movement to navigate to different locations.

Being able to navigate the solar sail through space will have a variety of uses to us on Earth. It could be used to create an advanced space-weather warning system to more quickly and accurately alert satellite operators and utilities on Earth of solar flares. It could also conduct International Space Station-keeping operations or hover at high altitudes above Earth for communications and observations.

NASA already knows a solar sail in space will work, as demonstrated in November 2010 with Nanosail D: *http://www.nasa.gov/mission_pages/smallsats/nanosaild.html*

This new solar sail will be the largest ever flown, weighing just 70 pounds and almost 1,200 square meters or about 1/4 the area of a football field. The Solar Sail Demonstration plans to launch on a Falcon 9 as early as 2014. To watch a video and learn more see: *http://www.nasa.gov/mission_pages/tdm/solarsail/#.Unu3h5Q17io*



The Challenge

Design and deploy a solar sail with a surface area not to exceed 2,500 cm^2. The solar sail must deploy from the launch tube, unfurl, and support itself upright on a flat surface. The solar sail must have the lowest mass possible. The design constraints are:

- Use only materials provided to you to create a solar sail.
- The total surface area must not exceed 2,500 cm^2.
- Include a small instrumentation panel for the sail.
- Your solar sail must deploy and unfurl from the launch tube (paper towel roll), with minimal assistance, and once unfurled, it must remain open and stand upright, unassisted on a flat surface.

Reminder For All Challenges

- Be sure to document all testing results.
- Make any necessary design changes to improve your results and retest.
- Complete all conclusion questions.

Our Team's Plan

Solar Sail

ASK

Today you will design a solar sail that will deploy and unfurl in space.
What questions do you have about today's challenge?

IMAGINE

What will the general shape of your solar sail be?

PLAN

Draw and label the parts of your solar sail.

Be sure to include measurements!

Write your plan to deploy the solar sail, unfurl it, and stabilize it on a flat surface.

Experiment & Record

Team Name_____

Test your solar sail to be sure it will unfurl and remain stable.

Mass of solar sail:

Surface area of solar sail:

Show calculations here:

Complete the *Quality Assurance* page. Your team will test another team's design. Please take care of other team's designs as you would expect them to do to yours. Each team's design will be tested and redesigned before exchanging with another team.

Experiment & Record

Challenge Closure

1. Which design characteristics provided the most reliable results?

2. Discuss possible explanations for why the designs with the best results worked better.

3. How do you think your design would work in space? Would you need robotic assistance?

4. What did you learn about your team's design while testing another group's design?

5. What information could engineers working on this project learn from your team's results?

Quality Assurance

Solar Sail

Each team is to review another team's design and model, then answer the following questions:

Team Name	Yes	No	Notes
What was the mass of the design?			
Did the surface area of the solar sail exceed 2,500 cm^2?			
Did the design deploy from the launch tube?			
Did the design sit stable on a flat surface?			

List the specific strengths of the design.

List the specific weaknesses of the design.

Inspected by: _____

Signature: _____

More Fun With Engineering

Solar Sail

Activity One:

On a playground or large outdoor area, measure out the actual dimensions of this new solar sail. Measure out 38 meters on each side. And then discuss how it will fit into a container the size of a dishwasher and weigh only 70 pounds.

Activity Two:

Research about Lagrange points at the following NASA websites. Then read Neil deGrasse Tyson's blog about Lagrange points. After reading all three articles, answer the following questions.

http://www.nasa.gov/missions/solarsystem/f-lagrange.html

http://map.gsfc.nasa.gov/mission/observatory_l2.html

http://www.haydenplanetarium.org/tyson/read/2002/04/01/the-five-points-of-lagrange

List some ways Lagrange points would be useful to NASA.

Do you think it is feasible to put a space station there? Why or why not?