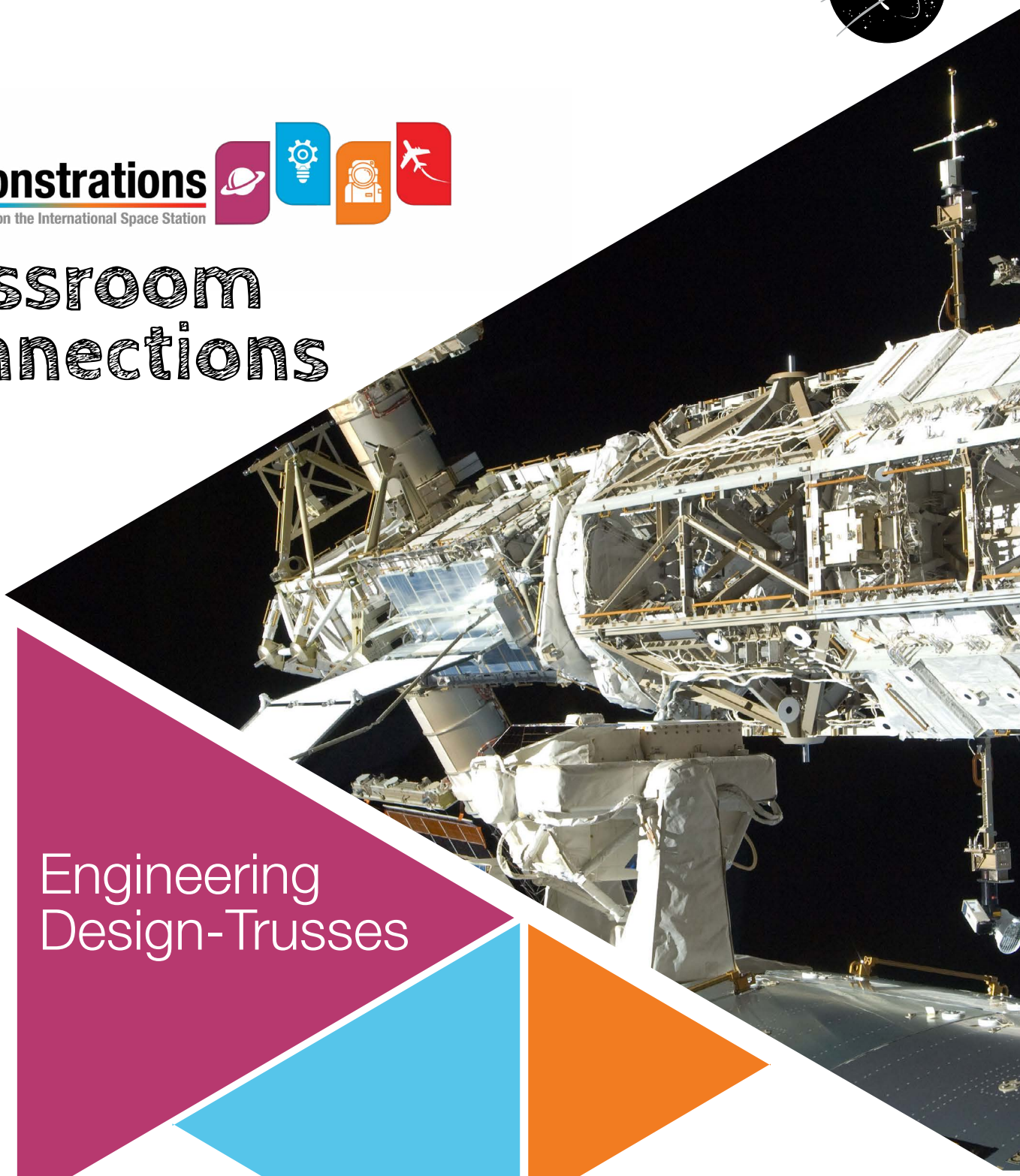
National Aeronautics and Space Administration

STEMonstrations
Education in Action on the International Space Station

# Classroom Connections



## Engineering Design-Trusses

For more STEMonstrations and Classroom Connections, visit www.nasa.gov/stemonstation.

www.nasa.gov

# Engineering Design-Trusses

## Background

Grade Level: **6th-8th**

Suggested Time: **50 minutes**

Next Generation Science Standards (NGSS):

**MS-ETS1-4.**

**Engineering Design.**

*Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.* Grade: Middle School (6-8)

### Background

The International Space Station's integrated truss structure acts as a backbone. The truss supports the solar arrays and radiators. The solar arrays provide electrical power for the space station, and the radiators help remove heat that accumulates. The integrated truss structure contains 10 segments which supports 16 solar array panels. The total length of the integrated structure is equal to the length of a football field, including the end zones.

The truss structures are made of triangle shapes for strength. They are covered in panels to shield the utility cables from impacts with space debris, radiation from the Sun and the harmful environment of space. In addition, the integrated truss segment has a rail cart called the mobile transporter. The cart can act as a base for moving the robotic arm.

The truss is designed and engineered to support the station's large mass. Even though the space station operates in the microgravity of space, it is still designed to withstand compression, tension, torsion and shear forces acting upon it.

In this lesson, student teams will explore how different shapes hold up to forces. Using their knowledge, they will build models of a truss structure and test their designs by adding weights.

**Forces that Act on Trusses:**

Compression – A squishing force
Tension – A stretching force
Torsion – A twisting force
Shear – Two opposing forces at the same point

### Objective

Following this activity, students will be able to:

- Understand the importance of engineering design.
- Identify forces acting on a truss.
- Identify how the structural design of a truss will withstand multiple forces acting on it.

### Materials

- Hot glue guns (1 per group)
- Hot glue (1 stick per group)
- Popsicle sticks (7 sticks per group)
- Box of drinking straws
- Straight pins
- Chairs
- Chalkboard erasers or textbooks
- Meter stick

## Procedure

- Inquiry Activity Discussion

Do not give background information to the students to allow for discovery-based learning. Ask students to complete the following activity, questions and discussion. Use the discussion to segue into the STEMonstrations-Engineering Design-Trusses video.

- Activity

1. Divide students in groups of four
2. Distribute one hot glue gun, seven popsicle sticks, and one hot glue stick per group. Have students plug in hot glue gun.
3. Students will create one square and one triangle by gluing the ends of each stick together. See Figure 1 for example.

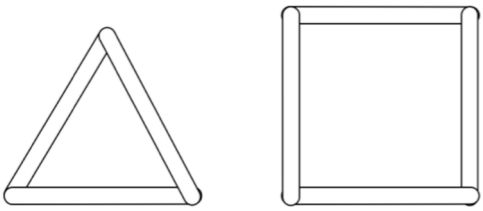


***Figure 1***

4. After glue dries, students will explore by standing shapes up on desk, holding in place, and applying a force to the top and sides. It is ok if shapes break during exploration.
5. Discuss which shape appears to be the strongest.
6. If the shapes are not broken, glue the triangle on the square and repeat top and side forces. See Figure 2 for example. If shapes are broken, recreate new shapes if time and materials allow.

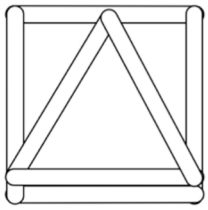


***Figure 2***

7. Discuss the strength of the triangle and square combination.

- Further Discussion:

1. Have you ever seen a truss on Earth? If so, can you explain the purpose of a truss?
2. What forces must trusses withstand?
3. Have you ever heard or seen compression, tension, torsion, or shear forces on Earth? If so, can you explain any of the forces?
4. What are some characteristics of truss structures? Can we recognize any shapes?
5. Do trusses exist in space?

Now check out a video from the space station to learn the importance of trusses 220 miles above Earth.

- Watch and Discuss Video:

Watch the video STEMonstrations: Engineering Design-Trusses

Reinforce how and why the integrated truss structure is able to support the station's large mass. Use the background information provided to check facts.

- Activity:

1. Show the picture of the space station. Point out the integrated truss structure. Explain that it is the backbone of the space station and is used to support the large mass of the space station. The truss supports the solar arrays and radiators which power and cool the space station.
2. Divide students into teams of four. Give each team 50 straws and 10 straight pins.
3. Explain that students will work in teams to build model trusses out of straws.
4. Challenge teams to build the strongest trusses possible between two chairs at a set distance.
5. Teams will add weights, such as chalkboard erasers, until their truss breaks or collapses..

- Final Discussion

Share models and discuss why some designs worked better than others. Discuss the four forces acting on the trusses. Students should figure out that triangles in combination with beams are the strongest geometric shapes to use. Have them examine the picture of the space station, specifically the integrated truss structure. Ask them to identify triangles and beams in the truss. End by discussing ways their models could be redesigned to support more weight.

**Resources:**

https://www.nasa.gov/pdf/179225main_ISS_Poster_Back.pdf

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