International Space Station Basics

The International Space Station (ISS) is the largest orbiting laboratory ever built. It is an international, technological, and political achievement. The five international partners include the space agencies of the United States, Canada, Russia, Europe, and Japan.

The first parts of the ISS were sent and assembled in orbit in 1998. Since the year 2000, the ISS has had crews living continuously on board. Building the ISS is like living in a house while constructing it at the same time. Building and sustaining the ISS requires 80 launches on several kinds of rockets over a 12-year period. The assembly of the ISS will continue through 2010, when the Space Shuttle is retired from service.

When fully complete, the ISS will weigh about 420,000 kilograms (925,000 pounds). This is equivalent to more than 330 automobiles. It will measure 74 meters (243 feet) long by 110 meters (361 feet) wide. This is equivalent to a football field, including the end zones. The pressurized volume will be 935 cubic meters (33,023 cubic feet), larger than a five-bedroom house. The solar array surface area will be 2,500 square meters (27,000 square feet), which is an acre of solar panels and enough to power 10 average-sized homes with 110 kilowatts of power.

The ISS orbits between 370 and 460 kilometers (230–286 miles) above Earth's surface. The average distance is similar to the distance between Washington, DC, and New York, NY. The ISS orbits at a 51.6-degree inclination around Earth. This angle covers 90 percent of the populated area of Earth.

When fully assembled, the ISS will be the third brightest object in the sky, after the Sun and Moon. Every 3 days, the ISS passes over the same place on Earth. To find out when the ISS will be visible from any given city, visit *http://www.spaceflight.nasa.gov/realdata/sightings/index.html.*

It takes about 90 minutes for the ISS to circle Earth one time. The ISS orbits Earth 16 times per day, so astronauts can see 16 sunrises and 16 sunsets each day! During the daylight periods, temperatures reach 200 ºC, while temperatures during the night periods drop to -200 ºC. The view of Earth from the ISS reveals part of the planet, not the whole planet. In fact, astronauts can see much of the North American continent when they pass over the United States. To see pictures of Earth from the ISS, visit *http://eol.jsc.nasa.gov/sseop/clickmap/.*

Components of the ISS

The components of the ISS include shapes like canisters, spheres, triangles, beams, and wide, flat panels. The modules are shaped like canisters and spheres. These are areas where the astronauts live and work. On Earth, carbonated drinks come packaged in small canisters to hold the pressurized liquids efficiently. Similarly, the U.S. Laboratory Destiny holds a pressurized atmosphere. Russian modules like Zvezda (which means "star") and Zarya (which means "sunrise") consist of a combination of spheres and canisters.

Triangles and beams are used for strength on Earth in structures like bridges. The truss that forms the backbone of the Station is made up of many triangular structures and beams.

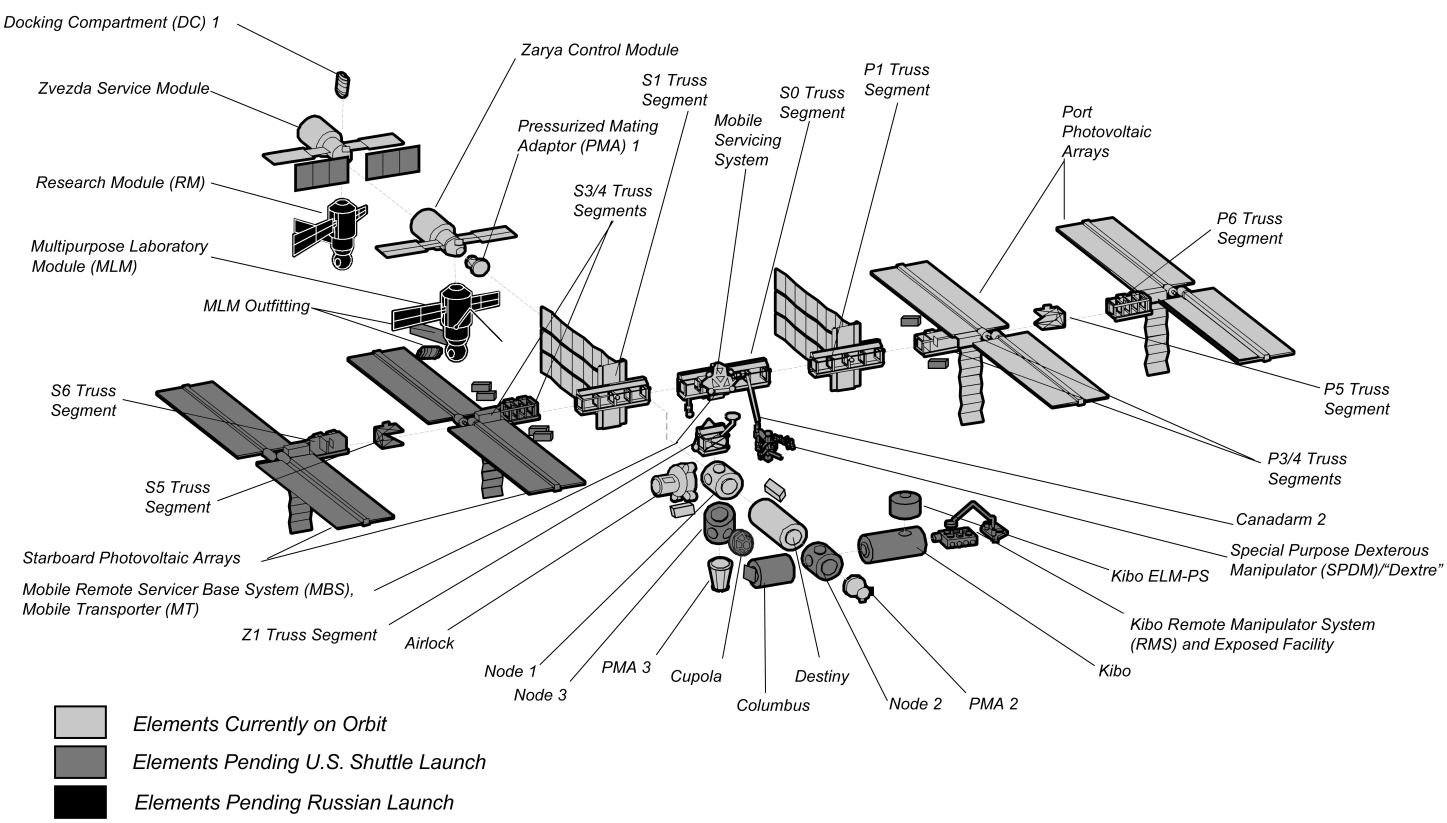
Panels are wide, flat surfaces used to cover large areas. On the ISS, the solar panels are used to collect sunlight and convert this energy into electricity. Likewise, radiators are waffle-shaped panels used to get rid of extra heat that builds up in the Station.

The ISS also has a robotic arm known as the Remote Manipulator System. It is used to help construct the Station by grappling and moving modules or by moving astronauts into position to work on the Station. The robotic arm was built by Canada and is called Canadarm 2. The first Canadarm is on the Space Shuttle and is used to retrieve cargo from the Shuttle bay.

Components of the ISS (continued)

Module	Length	Launched
Zarya	12.8 m (42 ft)	1998
Unity	5.5 m (18 ft)	1998
Zvezda	13.1 m (43 ft)	2000
Z1 Truss	4.6 m (15 ft)	2000
P6 Truss	18.3 m (60 ft)	2000
Solar Array	73.2 m (240 ft)	2000
Destiny	8.5 m (28 ft)	2001
Canadarm 2	16.9 m (56 ft)	2001
Quest Airlock	5.5 m (18 ft)	2001
Pirs Airlock	4.9 m (16 ft)	2001
S0 Truss/Mobile Transporter	13.4 m (44 ft)	2001
Mobile Base	5.8 m (19 ft)	2002
S1 Truss	13.7 m (45 ft)	2002
P1 Truss	13.7 m (45 ft)	2002
P3/P4 Truss	13.7 m (45 ft)	2006
P5 Truss	3.3 m (15 ft)	2006
S3/S4 Truss	13.7 m (45 ft)	To be launched
S5 Truss	3.3 m (15 ft)	To be launched

Module	Length	Launched
Node 2	6.1 m (21 ft)	To be launched
Columbus	6.9 m (22.6 ft)	To be launched
Experiment Logistics Module (ELM)		
Pressurized Section (PS)	3.9 m (12 ft)	To be launched
Dextre	3.5 m (11.4 ft)	To be launched
Kibo	11.2 m (36.7 ft)	To be launched
S6 Truss	13.7 m (45 ft)	To be launched
ELM Exposed Section	4.9 m (16.1 ft)	To be launched
Kibo Exposed Facility	5.6 m (18.4 ft)	To be launched
Russian Multi-Purpose Laboratory Module	12.8 m (42 ft)	To be launched
Node 3	6.1 m (21 ft)	To be launched
Cupola	3 m (9.8 ft)	To be launched
Russian Research Module	12.8 m (42 ft)	To be launched
Soyuz	7 m (22.9 ft)	Ongoing
Progress	7.4 m (24 ft)	Ongoing



Four Easy Ways To Obtain NASA Educational Materials

The NASA Office of Education works collaboratively with NASA's Mission Directorates to promote education as an integral component of every major NASA research and development mission. These efforts result in innovative and informative educational materials that engage student interest in science, technology, engineering, and mathematics. NASA makes these resources available in four convenient ways:

- Access educational resources online from NASA's Web site.
  http://www.nasa.gov/education/materials
- Visit a NASA Educator Resource Center (ERC).
  http://www.nasa.gov/education/ercn
- Order select materials through OfficeMax.
  http://www.nasa.gov/education/officemax
- Purchase materials from the Central Operation of Resources for Educators (CORE).
  http://www.nasa.gov/education/core

NASA's ERC Network

The NASA ERCs are located throughout the United States, the U.S. Virgin Islands, and Puerto Rico. ERCs offer information about NASA and its educational resources and services. Personnel provide inservice and preservice training using NASA curriculum support materials. ERC team members also collaborate with educational organizations to foster systemic initiatives at local, state, and regional levels.
http://www.nasa.gov/education/ercn

OfficeMax

NASA and OfficeMax have partnered to provide educators with a print-on-demand service to acquire NASA curriculum support materials. Using the Internet, educators can search an online database of NASA materials, preview them, order online, and pick them up at the nearest OfficeMax—all for a nominal fee. If educators reside more than 50 miles from an OfficeMax, the materials can be shipped to them for an additional postage charge.
http://www.nasa.gov/education/officemax

The NASA Web Site

The NASA portal at *http://www.nasa.gov* serves as the gateway for information on missions, research, programs, and services offered by NASA. The educational sections provide educators with access to curriculum support materials and resources produced through collaborations with NASA's Mission Directorates. Materials may be downloaded and printed from the following locations:

Educator Guides, Classroom Activities, Posters, Lithographs, Brochures, and Bookmarks
http://www.nasa.gov/education/materials

Themed Collections of Online Resources
http://www.nasa.gov/audience/foreducators/topnav/schedule/extrathemes/index.html

Classroom Subject Matter Topics
http://www.nasa.gov/audience/foreducators/topnav/subjects/about/index.html

NASA Education Express Mailing List
Sign up for announcements about NASA products and activities.
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CORE

CORE serves as the worldwide distribution center for NASA-produced multimedia materials. For a minimal charge, CORE will provide curriculum support materials to educators who are not able to visit one of the NASA ERCs or who are looking for large quantities of materials. Through CORE's online catalog, educators can use the mail-order service to purchase NASA education materials, such as classroom modules by subject area, DVDs, and CD-ROMs. Closed-captioned and audio-descriptive versions of many materials are available. More information on CORE, including the online catalog, is available at the following location: *http://www.nasa.gov/education/core.*

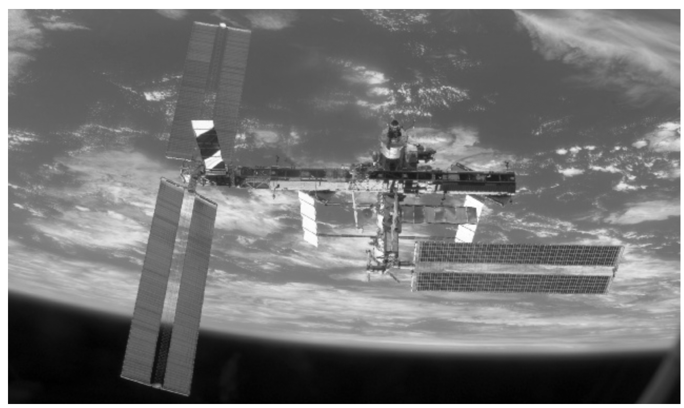
Integrated Truss Background

The Integrated Truss Structure acts as a backbone for the International Space Station. A truss is a segment or part of the whole Integrated Truss Structure. The trusses are used to support the solar arrays and radiators. The solar arrays provide energy for the Station, and the radiators get rid of extra heat that builds up in the Station. When complete, the Integrated Truss Structure will contain 10 segments and support 16 solar array panels. The total length of the integrated structure will be equal to the length of a football field, including the end zones. Truss segments are labeled based on their location. *P* stands for "port," which is a nautical term for "left." *S* stands for "starboard," which is a nautical term for "right." *Z* stands for "zenith," meaning "up" or "away from Earth." External utilities like power, data, and video are routed to the Station through the truss segment.

The first truss segment to be added to the Station, called Z1, was attached to the top of the Unity node module. Then truss segment P6 was mounted on top of Z1, and its solar arrays and radiator panels were deployed to support the early ISS. Subsequently, S0 was mounted on top of the Destiny laboratory, and the horizontal truss members P1 and S1 were then attached to S0. P1 and S1 filled up the entire Shuttle cargo bay. Each one is 13.7 meters (45 feet) in length, which is the length of a school bus.

The next truss segment to be installed was the P3/P4 Truss, which supplied a second set of solar arrays and radiator panels. P5, which was the size of a sport utility vehicle, was then attached to the end of P3/P4. As the remaining members of the truss are added, P6 will be relocated from its current location on Z1 and attached to P5 at the outer end of the Station's port side.

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 Structure has a rail cart that can move back and forth along the trusses. Called the mobile transporter, the cart can act as a base for moving the Station's robotic arm when assembling parts of the Station.



This picture of the International Space Station shows the Integrated Truss Structure.

Straw Truss Activity

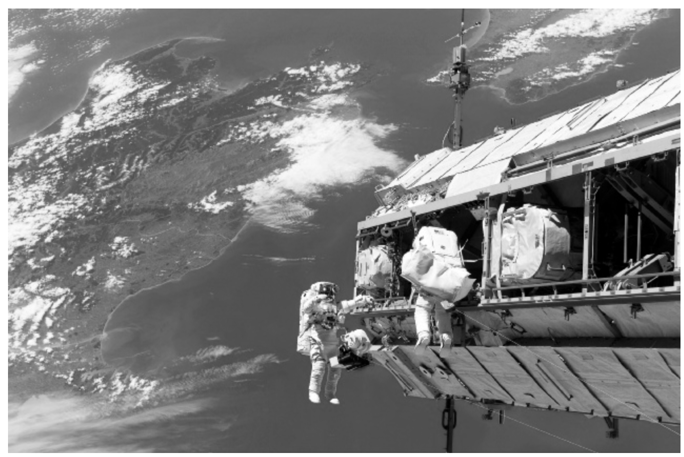
Background
One of Educator Astronaut Barbara Morgan's and Tracy Caldwell's jobs on STS-118 is to work together using the robotic arm to move the S5 Truss (which means the fifth starboard truss segment) from the cargo bay of the Space Shuttle to the International Space Station (ISS). Truss segments are structures that make up the backbone of the ISS. They are made of triangle shapes for strength. The S5 Truss is the size of a sport utility vehicle. It will be the connecting point for more solar arrays and radiators. External utilities like power, data, and video will be routed to the Station through the truss segment.

Standard 9
Students will develop an understanding of engineering design and of the roles of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Assessment
Teams will build models of truss structures for a space station using straws. They will test the structures for strength by weighing them down with chalkboard erasers or books.

Materials
- Box of drinking straws
- Straight pins
- Chairs
- Chalkboard erasers or textbooks
- Meter stick

Procedures
1. Show the picture of the ISS. Point out the truss. Explain that it is the backbone of the ISS and is used to support the solar arrays, which power the 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 longest and strongest trusses possible between two chairs.
5. Teams will test the strength of the trusses by weighing them down with chalkboard erasers or textbooks.
6. Discuss what types of structures were the strongest. Students should figure out that triangles are the strongest. Have them examine the poster of the ISS truss. Are there triangles in the truss?



Astronauts work on part of the truss of the International Space Station during STS-115. Notice the triangle-shaped structure inside the truss.

Remote Manipulator (Robotic) Arm Background

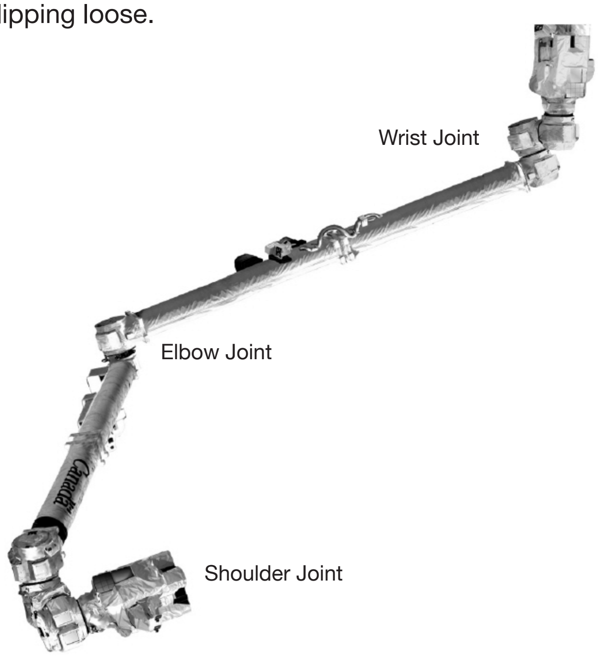
The robotic arm of the ISS has a long name: Space Station Remote Manipulator System (SSRMS). Developed by Canada, the SSRMS is a bigger, better, smarter version of the Space Shuttle's robotic arm. It is 17 meters long when fully extended and has seven motorized joints. These joints act like a shoulder, elbow, wrist, and fingers.

This arm is capable of handling large cargos to construct the ISS. The SSRMS can act like an inchworm; it can attach to one anchor pin at one end and flip the other end over to attach at another anchor pin.

End Effector

The part of the robotic arm that grabs objects is called an "End Effector." This wire-snare device is designed to fit over special grapple fixtures (knobbed pins) on the Shuttle, ISS, and ISS modules.

The End Effector is like a mechanical hand with a cylinder 33.2 centimeters in diameter by 25.8 centimeters deep. It contains three cables (like a snare) that close around a grapple pin onto the module. Then the cables become rigid with enough force to prevent the captured object from slipping loose.



The ISS robotic arm.

Using the Robotic Arm

The movement of the robotic arm is controlled by the ISS's arm control unit. The hand controllers used by the astronauts tell the computer what the astronauts would like the arm to do. Built-in software examines the astronauts' commands and calculates which joints to move, in what direction to move them, how fast to move them, and to what angle to move. As the computer issues the commands to each of the joints, it also looks at what is happening to each joint every 50 milliseconds. The astronaut watches three closed-circuit televisions to monitor the movement of the robotic arm.

Technical Details of the Space Station Arm

Length: 16.9 m (56 ft)
End Effector Diameter: 77.3 cm (30.4 in)
Boom Diameter: 35.6 cm (14.0 in)
Wrist Joint: Three degrees of movement (pitch/yaw/roll)
Elbow Joint: One degree of movement (pitch)
Shoulder Joint: Three degrees of movement (pitch/yaw/roll)
Translational Hand Controller: Left, right, up, down, forward, and backward movement of the arm
Rotational Hand Controller: Controls the pitch, roll, and yaw of the arm

Anchored to the International Space Station's Canadarm 2 foot restraint, European Space Agency (ESA) astronaut Christer Fuglesang, STS-116 mission specialist, participates in the mission's second spacewalk.

ISS End Effector Activity

National Standards

Science content
Abilities of technological design

Technology Education Content

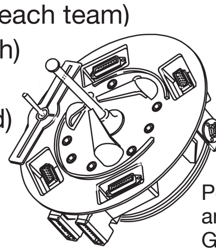
Standard 8
Students will develop an understanding of the attributes of design.

Standard 11
Students will develop abilities to apply the design process.

Assessment
Review tables or charts created by students. Pay attention to the ideas students have for improving grapple fixtures.

Materials

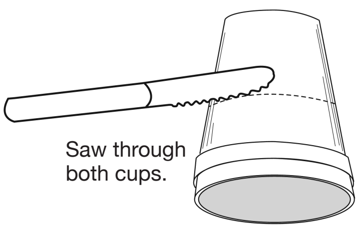
- Styrofoam coffee cups (2 for each team)
- 12-cm pieces of string (3 each)
- Cellophane tape
- Plastic picnic knives (serrated)
- Straw (1 each)



Power and Data Grapple Fixture.

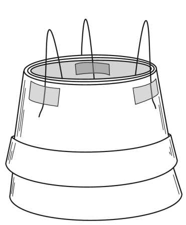
Make the End Effector
Procedure

1. Have students work in pairs or small groups.



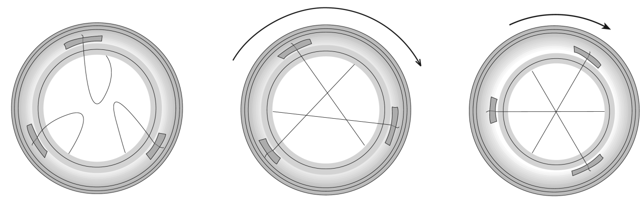
2. Nest the two cups together and cut through both cups where indicated in the diagram by the dashed line. Smooth the cut edges by scraping them with the picnic knife edge.
3. Cut three 12-centimeter lengths of string.
4. Tape the end of the first string to the side of the inner cup just below the cut edge. Tape the other end of the string to the outside of the cup, but do not press this piece of tape tightly yet.

Tape the string loop from the outside of one cup to the inside of the other.



5. Repeat step 4 twice more, but place the strings about a third of the way (120 degrees) around the cup from the first string.

6. While holding the rim of the inner cup, rotate the outer cup until the three strings cross each other. The strings will have some slack. Pull the end of the strings on the outside until they are straight and intersect exactly in the middle of the opening. Press the tape on the outside to hold the strings.



Open position. Rotate outer cup. Continue rotating to close snares.

Use the End Effector
Procedure

1. Use the end effector to pick up the straw. Have someone hold the straw upright. Open the end effector so that the strings are not crossing each other. Slip the end effector over the straw so that the straw extends down the center and not through any of the loops. Rotate the outer cup until the strings grasp the straw. Pick up the straw.
2. The straw may be too slippery to be held securely. How might the straw be modified so that it can be held? Design a standard grapple fixture that can be mounted to the straw model truss (from the Straw Truss Activity) so that it can be picked up.
3. Compare your grapple fixture to two other grapple fixtures designed by your classmates. Draw them in the squares below.

4. Which one works the best? Use complete sentences to explain why.
5. Create a chart or table that evaluates the strongest and weakest points of each grapple fixture you compared.
6. How can you improve your design? Use complete sentences.

Remote Manipulator (Robotic) Arm Activity

Background

To assemble part of the ISS, Educator Astronaut Barbara Morgan and Tracy Caldwell jointly will operate the robotic arms on the Space Shuttle and the ISS to move the S5 Truss from the cargo bay to the ISS. To move the truss, they must rely on a camera view of the module. Neither can look out the window and see what they are working on directly.

Standard 9

Students will develop an understanding of engineering design and of the roles of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Assessment

Teams will demonstrate how to use a robotic arm with a grapple fixture of their own design to move a model truss (made from straws) and dock it on a piece of paper.

Materials

- Blindfold (1 per team)
- Truss model from Straw Truss Activity
- End effector from ISS End Effector Activity

Procedures

1. Explain how the Remote Manipulator System (robotic arm) works. (See Robotic Arm Background page.)
2. Have students build the end effector of the robotic arm. (See ISS End Effector Activity.)
3. After building the end effector, have teams design a grapple fixture for the straw truss model. (See Straw Truss Activity.)
4. Challenge teams of four students each to design a robotic arm that will pick up the model straw truss and place it on a piece of paper.

Team Roles

One student is the robotic arm, but he or she cannot touch the straw truss by hand. The second student is the video camera person who reports what he or she sees. The third student is the remote manipulator operator who is blindfolded and gives the commands. The fourth team member is the taskmaster who writes the directions and walks the team through the transfer process one step at a time.

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