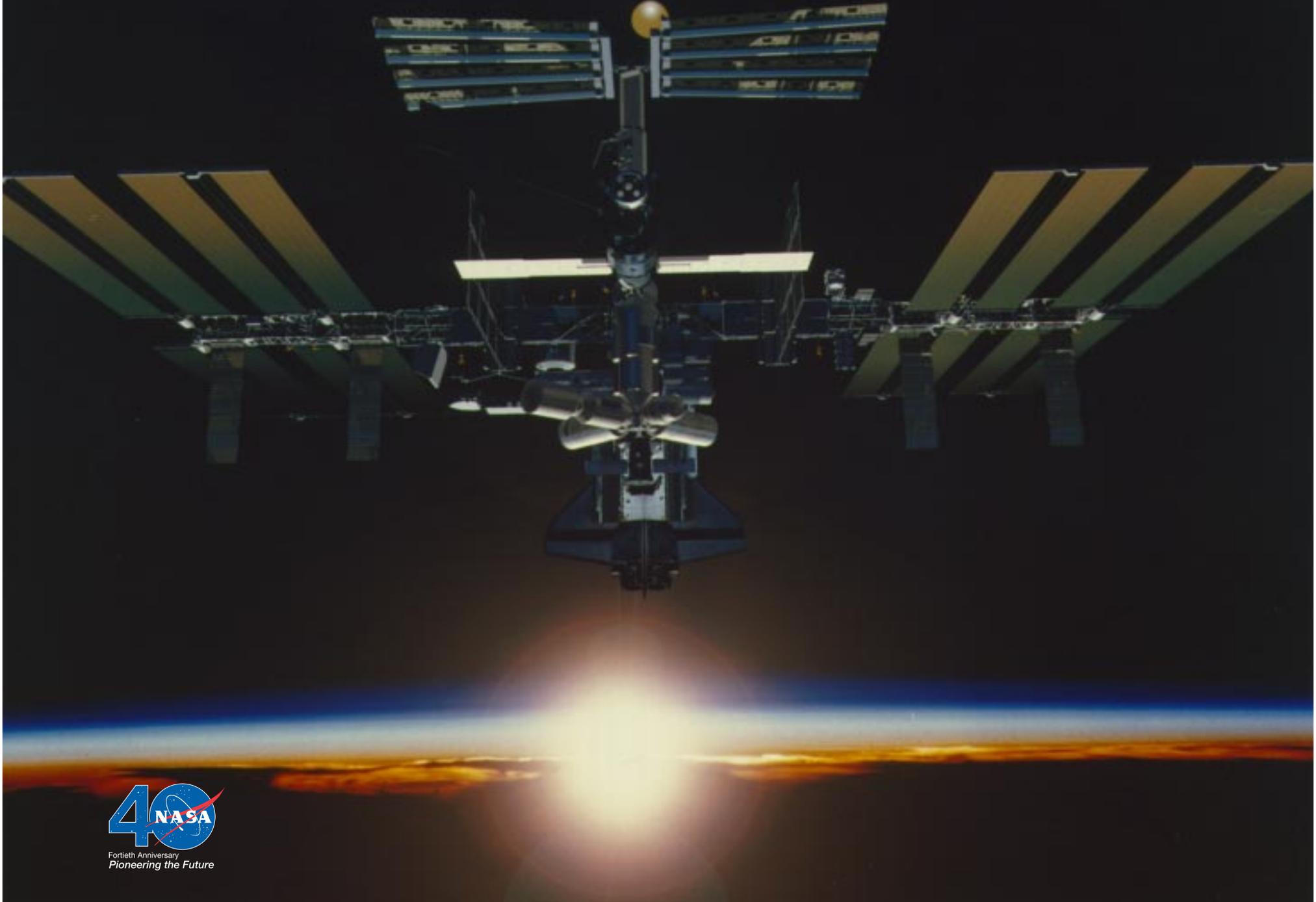# The International Space Station

The International Space Station: A dream… a vision… a reality.

Introduction

The International Space Station (ISS) is an unparalleled international, scientific, and technological cooperative venture that is opening a new era of human space exploration and research that will provide benefits to people on Earth. The ISS, the largest spacecraft in history, will be launched on more than 40 launches using three different launch vehicles. Comprising six different laboratories, the ISS will enable unprecedented advances in biological, medical, materials, and industrial research.

Phase II of the ISS program began after the successful completion of the Shuttle-*Mir* program (Phase I). Phase II of ISS development consists of 10 separate flights. These flights, the focus of this poster, begin the construction phase and are the foundation for the ISS. In the activity, students will design and build their own space station. This will provide them with the foundation so their vision of a space station can become a reality.

Flight Background Information

The A stands for American. The R stands for Russian. The following flights are listed in the order of launch.

Flight 1A/R (Russian Proton Rocket)

The first element launched was the Control Module named *Zarya*, the Russian word for "sunrise." *Zarya* provides propulsion control capability and power through the early assembly stage. It also provides fuel storage and rendezvous and docking capability to the Service Module. The 18,182-kilogram pressurized spacecraft was launched on a Russian Proton rocket. As assembly continues, *Zarya* will provide orbital control, communications, and power for the U.S.-built Node 1, *Unity*. During this period, *Zarya* will control the motion and maintain the altitude of the Space Station's orbit. It will also generate and distribute electrical power and provide ground communications. In the later stages of ISS assembly, *Zarya* will primarily provide storage capacity. It will be used throughout the life of the Space Station.

Flight 2A (Shuttle Flight**)**

On flight 2A, *Unity* and Pressurized Mating Adapters (PMA) 1 and 2 were launched. The PMA-1 connects the U.S. and Russian elements. The PMA-2 provides a Shuttle docking location. *Unity*'s six ports provide connecting points for

Zarya, as well as the Z1 truss, airlock, cupola, Node 2, and the Multi-Purpose Logistics Module, to be delivered later. *Unity* is a connecting passageway to the living and working areas of the ISS—the U.S. Habitation and Laboratory Modules—and airlock. It is the first major U.S.-built component of the ISS. It contains more than 50,000 mechanical items, 216 lines to carry fluids and gases, and 121 internal and external electrical cables using 9.7 kilometers of wire.

Flight 1R (Russian Proton Rocket)

Flight 1R will launch the Russian Service Module, the primary Russian element. The Service Module will provide the Environmental Control and Life Support System elements and will be the primary docking port for the Progress resupply vehicles. It will also provide propulsive attitude control and reboost capabilities, early Space Station living quarters, electrical power distribution, the data processing system, the flight control system, and communications. Although many of these systems will be supplemented or replaced by later U.S. ISS components, the Service Module will always remain the structural and functional center of the Russian segment of the ISS.

Flight 2A.1 (Shuttle Flight)

The flight element for 2A.1 is the Spacehab Logistics Double Module. The purpose of the double spacehab flight is to provide a logistics flight for the early assembly missions. It will carry equipment to further outfit the Service Module and equipment that can be off-loaded from the early U.S. assembly flights. The Double Module has the capacity to hold up to 4,536 kilograms as well as the ability to accommodate powered payloads.

Flight 3A (Shuttle Flight)

Flight 3A will deliver the Integrated Truss Structure (ITS) Z1. The Z1 truss will be used as a mounting location for the P6 Truss Segment and Photovoltaic (solar array) Module. This Photovoltaic Module will provide power for the early science that will be done on the ISS. Also being delivered on this flight will be the third Pressurized Mating Adapter and the Control Moment Gyros (these will provide nonpropulsive attitude control). In addition, the Ku-band communications system will be installed on this flight (and later activated on flight 6A). This system provides video capabilities to support ISS scientific research and television transmissions.

Flight 2R (Russian Soyuz Rocket)
This launch will establish the first ISS three-person crew, or Expedition I. The Commander will be a U.S. Astronaut and the other two crew members will be Russian Cosmonauts. The Soyuz vehicle will provide crew return capability without the Shuttle present. The first crew will spend 5 months on the ISS.

Flight 4A (Shuttle Flight)
The completion of this flight reflects the temporary installation and activation of the P6 truss segment. The P6 Photovoltaic Module is the first of four U.S. solar-based power sources. It will be moved and permanently attached to the P5 truss after flight 13A. Two Photovoltaic Thermal Control System radiators will provide early active thermal control. Also, the S-band communications system will be activated. This will provide radio communications on a specific frequency and the capability of transferring data.

Flight 5A (Shuttle Flight)
Flight 5A will deliver the U.S. Laboratory Module. This lab will provide a shirt-sleeve environment for research, technology development, and repairs by the on-orbit crew. The U.S. Laboratory will distribute several systems, including Life Support, Electrical Power, Command and Data Handling, Thermal Control, Communications, and Flight Crew Systems. There will be a total of 24 racks for experiments in the U.S. Laboratory.
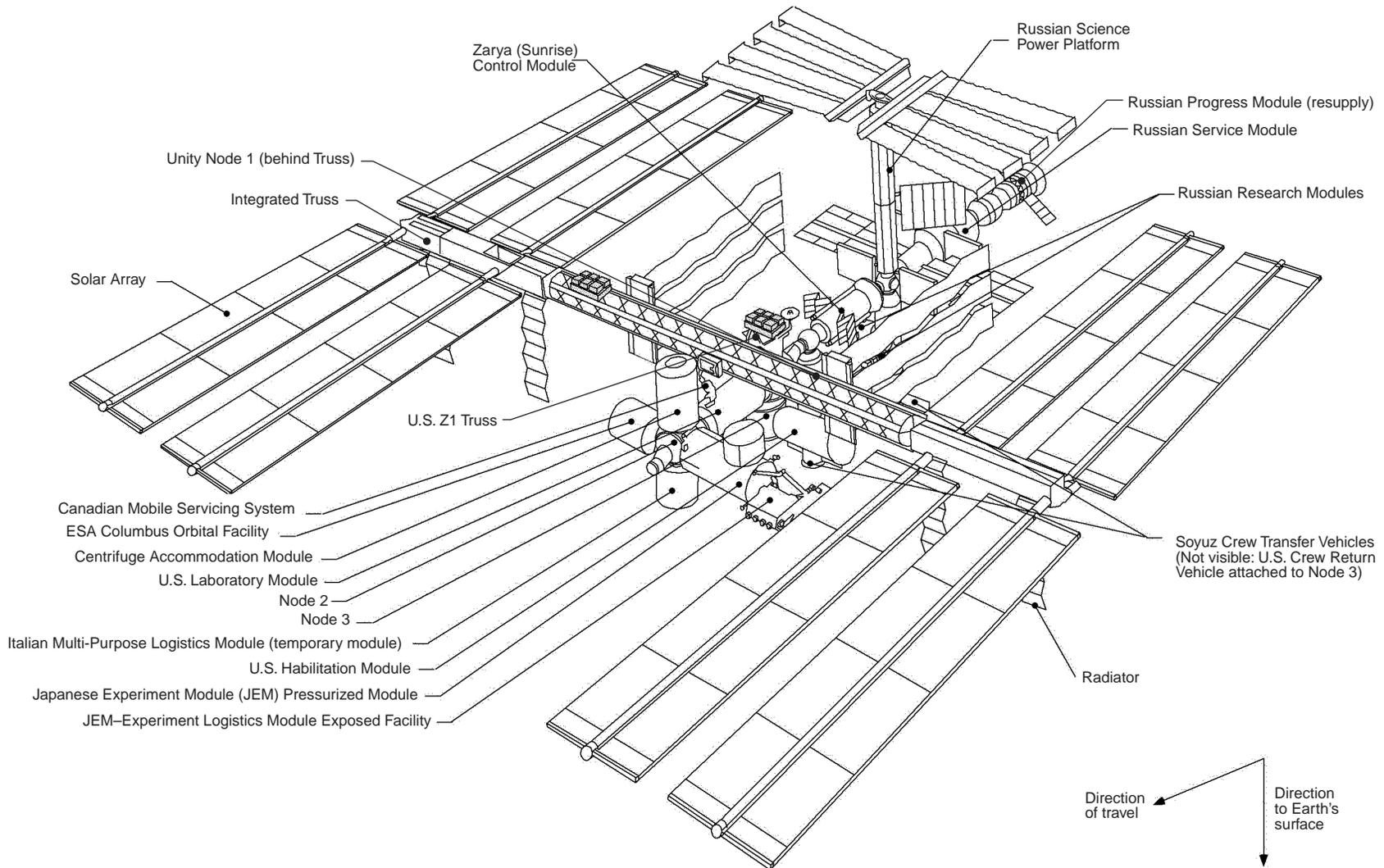
Flight 6A (Shuttle Flight)
This flight will outfit the U.S. Laboratory. Also during this flight a UHF antenna will be provided that will allow space-to-space communications capability for the U.S.-based Extravehicular Activity (EVA), also known as a *spacewalk*. In addition, the Canadian Space Station Remote Manipulating System will be delivered and activated. This is the next generation in robotic arms, and it will be bigger, better, and smarter than the Space Shuttle's robotic arm. It is 17 meters long when fully extended and has seven motorized joints. The arm is capable of handling large payloads and assisting with docking the Space Shuttle. It is self-relocatable so that it can be attached to complementary ports spread throughout the Space Station's exterior surfaces.

Flight 7A (Shuttle Flight)
The Joint Airlock will be delivered on this flight. It will provide ISS-based EVA capability for both U.S. and Russian spacesuits. The airlock will be attached to *Unity*. It has a total pressurized volume of 27 cubic meters. Also delivered on this flight will be the High Pressure Gas Assembly, which augments the Service Module gas resupply system. Each bottle is installed separately and capable of recharge on orbit (limited to oxygen).

Access the Space Station Home Page to learn about Phase III assembly and general Space Station information: **http://spaceflight.nasa.gov**

Zarya (Sunrise)
Control Module

Russian Science
Power Platform

Russian Progress Module (resupply)

Russian Service Module

Unity Node 1 (behind Truss)

Integrated Truss

Russian Research Modules

Solar Array

U.S. Z1 Truss

Canadian Mobile Servicing System

ESA Columbus Orbital Facility

Centrifuge Accommodation Module

U.S. Laboratory Module

Node 2

Node 3

Soyuz Crew Transfer Vehicles
(Not visible: U.S. Crew Return
Vehicle attached to Node 3)

Italian Multi-Purpose Logistics Module (temporary module)

U.S. Habilitation Module

Japanese Experiment Module (JEM) Pressurized Module

JEM–Experiment Logistics Module Exposed Facility

Radiator

Direction
of travel

Direction
to Earth's
surface

NASA

INTERNATIONAL
SPACE STATION

Space Station Construction Activity

Adapted from an activity provided by Space Center Houston.

Topic: Construction of a Space Station

Objective: The students will create a model of the International Space Station given a set of materials and parameters.

Science Standards
Science as Inquiry
Science and Technology: Abilities of Technological Design
History and Nature of Science: Science as a Human Endeavor, Nature of Science

Mathematical Standards

Problem Solving	Number Systems and Number Theory
Communicating	Computation and Estimation
Reasoning	Measurement
Mathematical Connections	

Universals of Technology
Designing and developing technological systems
Determining and controlling the behavior of technological systems
Linkages
Physical systems

Materials Needed

Plastic kitchen wrap	Square centimeter paper
Craft sticks	Individual serving cereal boxes
Aluminum foil	Flexible straws
Small buttons	Balances
Soft drink cans	Rulers
Toothpicks	Scissors
Cardboard tubes (toilet paper size)	Glue
Styrofoam food trays	Masking tape

Correlation of Materials to Space Station Components
Plastic kitchen wrap = Photovoltaic (PV) arrays
Craft sticks = Support structure for Photovoltaic (PV) arrays and thermal radiators
Aluminum foil = Thermal radiators
Cylindrical cans = Modules 1 (habitation) and 2 (laboratory)
Cardboard tubes (cut into thirds) = Docking port
Styrofoam food trays (cut into 4-cm wide strips) = Truss segments
Individual serving size cereal boxes = Module 3 (core)
Buttons = Control jets
Flexible straws = Robotic arm
Toothpicks = Miscellaneous decorations, supports, etc.

Procedure

Explain to the students that NASA engineers need their help. They need new ideas for the International Space Station.

1. Collect the necessary materials or instruct students to bring them from home. Display a model of the "old" International Space Station (this poster will do) as you discuss each individual component and its function: Module 1—habitation, Module 2—laboratory, Module 3—core (Resource Node), PV arrays, thermal radiators, docking port, control jets, and robotic arm.

2. Show the constraints that must be followed for the design:
(a) One hundred square centimeters of PV array will support the electrical needs of 500 cm^3 of module volume.
(b) All modules must be connected to at least one other module.
(c) Seventy-five square centimeters of thermal radiators will support the colling needs of 500 cm^3 of module volume.
(d) The length of the truss can not be longer than 50 cm.
(e) The control jets must be positioned so that they will not fire on any component of the Space Station and can move it in any direction.

Space Station Construction Activity *Continued*

(f)   The docking module should be positioned so that there is a clear, straight path to it for the orbiter to dock.

(g)   The robotic arm should be placed to maximize the number of components that it can reach.

3. Depending on the amount of freedom you think your class can handle or their mathematical background, go through the procedure pages with them or allow them to work through the pages with their groups, assigning different roles for each group member to accomplish.

4. To simplify the determination of the volume of the soft drink cans, use the can's maximum diameter for calculations.

5. Have the groups construct their Space Station.

We want you to build a new model of the International Space Station and present it to the class for approval. Of course, because of some limitations we have on size and weight of the Space Station, we do have a few requirements for you. Please assist us in creating a model that follows the guidelines.

Modules Design (student section)

1. Weigh Module 1 (habitation) and record. Mod.1 = _____grams

2. Take can (circular face down) and trace the cross-sectional area on paper.

3. Estimate the center point of the circle.

4. Find the diameter (distance across the circle).   d = _____cm

5. Find the radius (distance from center point to the edge). r = _____cm

6. Find the area of the cross section. The area is equal to π (3.14) times the radius. The formula is $A = \pi \times r^2$

Area = π x _____x_____ = _____cm^2
               radius   radius   Area

7. Find the height of the can. Height = _____cm

8. Multiply the area from number 6 above with the height of the can in number 7 to obtain the volume of Module 1. The formula is $V = \pi r^2 \times h$.

_____cm^2 x _____cm = _____cm^3
        Area from 6   Height from 7   Volume of
                                                                              can

Using the same formulas, find the volume of the other can (Module 2) — the Laboratory Module.   Volume of Module 2 = _____cm^3

9. Weigh Module 3 (core) and record.   Module 3 = _____grams

10. Measure Module 3.   Length = _____cm   Height = _____cm
                                        Width = _____cm

Now that you have the volume for Modules 1 and 2, obtain the volume for Module 3—the Core Module. The Core Module is where the brains of the Space Station exists. In your model, a box (rectangular prism) has been used to represent the core. The formula for finding the volume of a rectangular prism is

V = _____ x _____x _____= _____cm^3
          Length   Width   Height

11. The next step is to find the sum of the weight for all of the modules and the sum of the volume of Modules 1, 2, and 3.

Weight=Module 1	_____	grams
Weight=Module 2	_____	grams
Weight=Module 3	_____	grams
Total weight of modules	_____	grams
Volume=Module 1	_____	cm^3
Volume=Module 2	_____	cm^3
Volume=Module 3	_____	cm^3
Total volume of modules	_____	cm^3

Space Station Construction Activity *Continued*

PV Array Design (student section)

1. Total volume of Modules 1, 2, and 3 _____ cm³.

2. One hundred cm² of PV array will support the electrical needs of a module with a volume of 500 cm³. How many square centimeters of PV array will be needed to support the entire Space Station?

    Total area of PV modules _____ cm².

3. Construct a PV array as shown in the illustration.

4. Measure the area of the cellophane used in your array.

   _____ x _____ = _____ cm²
        length   width   area

5. How many arrays will be needed to support the entire Space Station? Divide your answer for number 2 by your answer for number 4.

    _____ cm² / _____ cm² = _____
      answer 2   answer 4   # of arrays

6. Construct the number of arrays you will need.

7. Weigh your arrays and record the total mass in grams.

    Total mass of the arrays _____ g.

Set them aside when completed.

Cellophane

Popsicle Sticks

Cellophane with
Popsicle Sticks
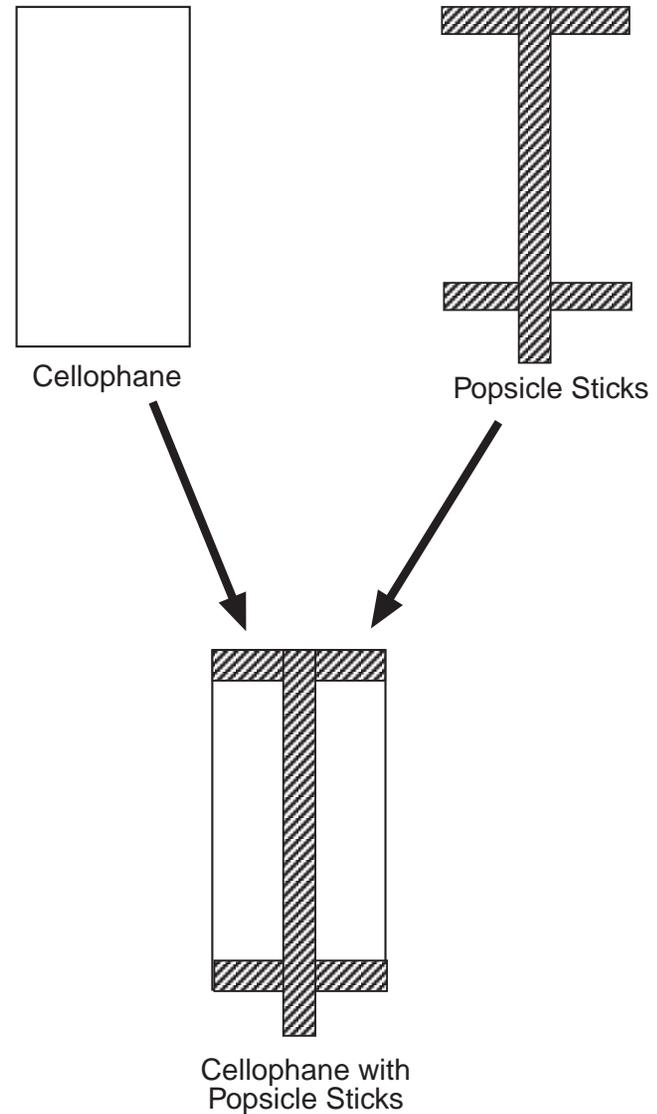
Space Station Construction Activity *Continued*

Thermal Radiator Design (student section)

The thermal radiators are used to help cool the Space Station. There are some restrictions for your design.

1. Total volume of Modules 1, 2, and 3 _____ cm^3.

2. Seventy-five cm^2 of thermal radiators can support the cooling needs of a module with a volume of 500 cm^3. How many square centimeters of thermal radiators will be needed to support the entire Space Station?

   Total area of thermal radiators _____ cm^2.

3. Construct a thermal radiator as shown in the illustration.

4. Measure the area of the aluminum foil used in your thermal radiator.

   _____ x _____ = _____ cm^2
      length   width   area

5. How many thermal radiators will be needed to support the entire Space Station? Divide your answer for number 2 by your answer for number 4.

   _____ cm^2 / _____ cm^2 = _____
     answer 2   answer 4   # of radiators

6. Construct the number of thermal radiators you will need.

7. Weigh your thermal radiators and record the total mass in grams.

8. Total mass of the thermal radiators _____ g.

When completed, set them aside.

Aluminum
Foil

Popsicle Sticks

Aluminum Foil with
Popsicle Sticks
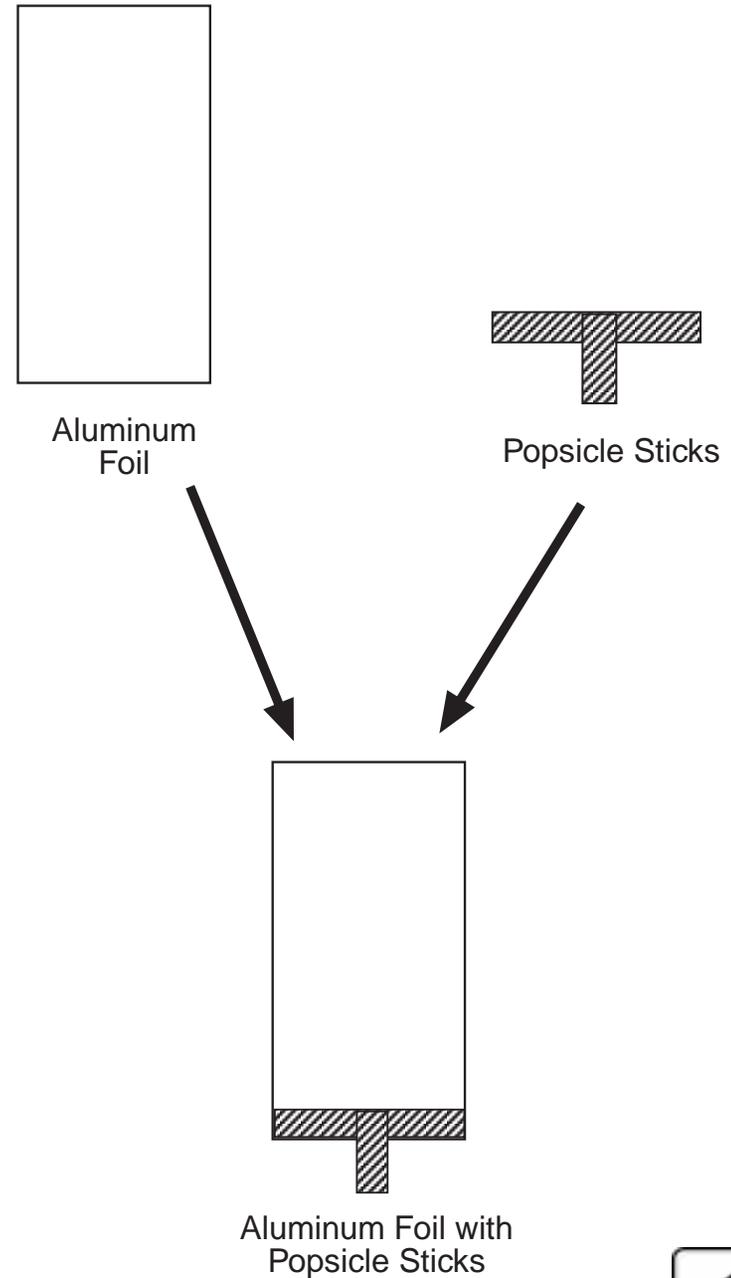
Space Station Construction Activity *Continued*

Final Design (student section)

1. The first task is to decide where all of the components of the Space Station will be in your model. Using centimeter paper, make a sketch of each part and where you would like to put it. Design the truss according to where the PV arrays and thermal radiators will be. Remember the truss requirements.

2. Construct a truss. Take the food trays and, if necessary, cut them to meet your specifications. Connect them together. Popsicle sticks can be used to help support connections. The truss does not need to be in one line, but according to the constraints, it cannot be longer then 50 cm.

3. Glue the modules together and connect them to the truss in the proper position.

4. Connect the PV arrays in their proper position.

5. Place the thermal radiators in their proper position.

6. Put the docking port (toilet paper roll) on one of the modules.

7. Glue the control jets (buttons) on any of the Space Station components except the radiators or PV arrays. Remember to check the requirements.

8. Place the robotic arm (flexible straw) on the Space Station. Do not put it on the PV arrays or radiators. Maximize the distance it can reach on the other parts of the Space Station.

Weight Calculations (student section)

1. Find the total weight of your Space Station.

2. First, take the sum of the weights for the modules, PV arrays, thermal radiators, and truss structure:

Weight	Modules	_____grams
+	PV arrays	_____grams
+	Thermal Radiators	_____grams
+	Truss Segments	_____grams

Weight = _____grams

Getting a total weight for the International Space Station will be done this way. It will be impossible to get a total weight of the Space Station at one time. The International Space Station will never be assembled here on Earth. It will be assembled on orbit.

3. If possible, weigh your entire model. Use this figure to compare the accuracy of weighing individual pieces as compared to the entire Space Station.

Space Station Weight = _____grams

4. How close was the weight in number 2 to the weight in number 3? Subtract number 2 from number 3.

	Space Station Weight (number 3)	_____grams
–	Weight (number 2)	_____grams
	Difference =	_____grams

Discussion
1. Why are there restrictions on the individual components of the Space Station?
2. Why is it important for the truss not to be over 50 cm?
3. Why do the control jets need to be pointed away from the Space Station components?
4. Why did you choose the design you did?

Extensions
1. Have the students write instructions for building a Space Station.
2. Design a campaign for advertising the Space Station. Use video and/or print products.
3. Invite parents, faculty, and the local press to a Space Station expo. The completed Space Stations and the advertising campaigns can be displayed. Group members can discuss their designs.

Assessment
Students will comply with all set parameters and complete the needed math functions in order to meet those guidelines.

For more information about the International Space Station, please visit
http://spaceflight.nasa.gov

NASA Resources for Educators

NASA's Central Operation of Resources for Educators (CORE) was established for the national and international distribution of NASA-produced educational materials in audiovisual format. Educators can obtain a catalog and an order form by one of the following methods:

- NASA CORE
  Lorain County Joint Vocational School
  15181 Route 58 South
  Oberlin, OH 44074
- Phone (440) 774-1051, Ext. 249 or 293
- Fax (440) 774-2144
- E-mail: *nasaco@leeca.esu.k12.oh.us*
- Home Page: *http://spacelink.nasa.gov/CORE*

Educator Resource Center Network

To make additional information available to the education community, the NASA Education Division has created the NASA Educator Resource Center (ERC) Network. ERCs contain a wealth of information for educators: publications, reference books, slide sets, audio cassettes, videotapes, telelecture programs, computer programs, lesson plans, and teacher guides with activities. Educators may preview, copy, or receive NASA materials at these sites. Because each NASA Field Center has its own areas of expertise, no two ERCs are exactly alike. Phone calls are welcome if you are unable to visit the ERC that serves your geographic area. A list of the centers and the regions they serve includes:

AK, AZ, CA, HI, ID, MT, NV, OR, UT, WA, WY
NASA Educator Resource Center
Mail Stop 253-2
NASA Ames Research Center
Moffett Field, CA 94035-1000
Phone: (650) 604-3574

CT, DE, DC, ME, MD, MA, NH, NJ, NY, PA, RI, VT
NASA Educator Resource Laboratory
Mail Code 130.3
NASA Goddard Space Flight Center
Greenbelt, MD 20771-0001
Phone: (301) 286-8570

CO, KS, NE, NM, ND, OK, SD, TX
JSC Educator Resource Center
Space Center Houston
NASA Johnson Space Center
1601 NASA Road One
Houston, TX 77058-3696
Phone: (281) 483-8696

FL, GA, PR, VI
NASA Educator Resource Laboratory
Mail Code ERL
NASA Kennedy Space Center
Kennedy Space Center, FL 32899-0001
Phone: (407) 867-4090

KY, NC, SC, VA, WV
Virginia Air and Space Museum
NASA Educator Resource Center for
NASA Langley Research Center
600 Settler's Landing Road
Hampton, VA 23669-4033
Phone: (757) 727-0900 x 757

IL, IN, MI, MN, OH, WI
NASA Educator Resource Center
Mail Stop 8-1
NASA Lewis Research Center
21000 Brookpark Road
Cleveland, OH 44135-3191
Phone: (216) 433-2017

AL, AR, IA, LA, MO, TN
U.S. Space and Rocket Center
NASA Educator Resource Center for
NASA Marshall Space Flight Center
P.O. Box 070015
Huntsville, AL 35807-7015
Phone: (256) 544-5812

MS
NASA Educator Resource Center
Building 1200
NASA John C. Stennis Space Center
Stennis Space Center, MS 39529-6000
Phone: (228) 688-3338

NASA Educator Resource Center
JPL Educational Outreach
Mail Stop 601-107
NASA Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109-8099
Phone: (818) 354-6916

CA cities near the center
NASA Educator Resource Center for
NASA Dryden Flight Research Center
45108 N. 3rd Street East
Lancaster, CA 93535
Phone: (805) 948-7347

VA and MD's Eastern Shores
NASA Educator Resource Lab
Education Complex - Visitor Center
Building J-1
NASA Wallops Flight Facility
Wallops Island, VA 23337-5099
Phone: (757) 824-2297/2298

Regional Educator Resource Centers (RERCs) offer more educators access to NASA educational materials. NASA has formed partnerships with universities, museums, and other educational institutions to serve as RERCs in many states. A complete list of RERCs is available through CORE, or electronically via NASA Spacelink at *http://spacelink.nasa.gov*

NASA On-line Resources for Educators

NASA's Education Home Page serves as a cyber-gateway to information regarding educational programs and services offered by NASA for educators and students across the United States. This high-level directory of information provides specific details and points of contact for all of NASA's educational efforts and Field Center offices.

Educators and students utilizing this site will have access to a comprehensive overview of NASA's educational programs and services, along with a searchable program inventory that has cataloged NASA's educational programs. NASA's on-line resources specifically designed for the educational community are highlighted, as well as home pages offered by NASA's four areas of research and development (including the Aeronautics and Space Transportation Technology, Earth Science, Human Exploration and Development of Space, and Space Science Enterprises).

Access these resources through the NASA Education Home Page: *http://www.hq.nasa.gov/education*

NASA Television (NTV) features Space Shuttle mission coverage, live special events, interactive educational live shows, electronic field trips, aviation and space news, and historical NASA footage. Programming includes a Video (News) File from noon to 1 p.m., a NASA Gallery File from 1 to 2 p.m., and an Education File from 2 to 3 p.m. This sequence is repeated at 3 p.m., 6 p.m., and 9 p.m., Monday through Friday. The Education File features programming for teachers and students on science, mathematics, and technology, including *NASA… On the Cutting Edge*, a series of educational live shows.

These interactive live shows let viewers electronically explore the NASA Centers and laboratories or anywhere scientists, astronauts, and researchers are using cutting-edge aerospace technology. The series is free to registered educational institutions. The live shows and all other NTV programming may be taped for later use.

NTV is transmitted on the GE-2 Satellite, Transponder 9C at 85 degrees West longitude, vertical polarization, with a frequency of 3880.0 megahertz (MHz) and audio of 6.8 MHz—or through collaborating distance learning networks and local cable providers. For more information on NASA Television, contact:
NASA Headquarters, Code P-2, NASA TV, Washington, DC 20546-0001
Phone: (202) 358-3572
NTV Home Page: *http://www.hq.nasa.gov/ntv.html*

How to Access NASA's Education Materials and Services, EP-1998-03-345-HQ This brochure serves as a guide to accessing a variety of NASA materials and services for educators. Copies are available through the ERC network, or electronically via NASA Spacelink. NASA Spacelink can be accessed at the following address: *http://spacelink.nasa.gov*

Please take a moment to evaluate this product at
http://ehb2.gsfc.nasa.gov/edcats/educational_wallsheet
Your evaluation and suggestions are vital to continually improving NASA educational materials. Thank you.

EW-1998-09-130-HQ