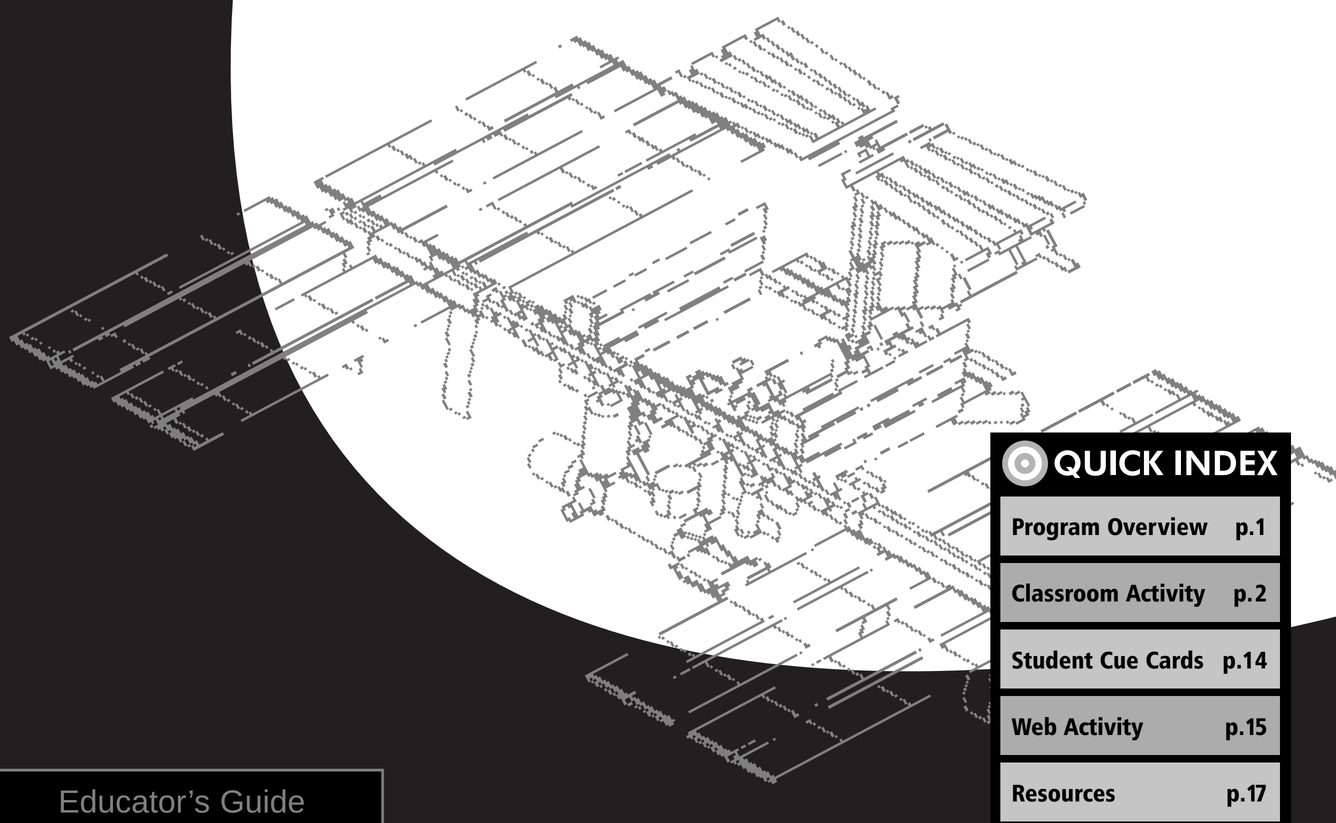
NASA CONNECT

Program 5 in the 2000-2001 Series

Functions and Statistics:

International Space Station: Up to Us



QUICK INDEX

Educator's Guide	
Teachers & Students	Grades 5-8

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PROGRAM OVERVIEW

SUMMARY AND OBJECTIVES

In *Functions and Statistics: International Space Station: Up to Us,* students will learn about the *International Space Station* (ISS), why it is being built, and how it provides first-hand experiences with the space program. NASA engineers will discuss several components of the ISS, their functions, and the different types of research being conducted in the station's unique, microgravity environment. Students will also discover how microgravity affects human beings in space and will observe NASA engineers using functions and statistics in their research on bone loss. By conducting classroom and on-line activities, students will make connections between NASA research and the mathematics, science, and technology they learn in their classroom.

INTERACTIVE ACTIVITIES

Norbert, NASA CONNECT's animated co-host, poses questions throughout the video. These questions direct the instruction and encourage students to think about the concepts being presented. An icon appears in the video to suggest to teachers an appropriate place to pause the video and discuss the answers to the questions. Students record their answers on the Student Cue Cards (p.14).

International Space Station, the hands-on classroom activity, is teacher-created and is aligned with the National Council of Teachers of Mathematics (NCTM) standards, the National Science Education (NSE) standards, and the National Educational Technology (NET) standards. Given a set of materials and constraints, students will work in groups to design an alternative model of the ISS. Through data analysis and interpretation, students will determine the best space station design, based on budget restrictions and component placement.

The on-line activity, "Docking Challenge," is aligned with the NCTM standards, the NSTA standards, and the International Technology Education Association (ITEA) standards. Students begin with a combination of internet-based simulations and hands-on activities to explore the scientific and mathematical concepts behind orbital mechanics. In the "Virtual Docking Challenge" student teams use a video camera, a rolling office chair, and a "docking grid," to communicate with a mission control collaborative team to simulate an effective docking procedure. The "Docking Challenge," is located in Norbert's lab at **http://connect.larc.nasa.gov/iss/lab.html**

RESOURCES

Teacher and student resources (p. 17) support, enhance, and extend the NASA CONNECT program. Books, periodicals, pamphlets, and web sites provide teachers and students with background information and extensions. In addition to the resources listed in this lesson guide, the NASA CONNECT web site **(http://connect.larc.nasa.gov)** offers on-line resources for teachers, students, and parents. By connecting to Norbert's Lab, the NASA CONNECT "Lab Manager" offers assistance to teachers who would like to get the most from the site.

THE CLASSROOM ACTIVITY

BACKGROUND (Adapted from ISS Press Kit)

The *International Space Station* (ISS), is the largest and most complex international scientific project in history. When it is complete, the station will represent a move of unprecedented scale from the home planet. Led by the United States, the *International Space Station* draws upon the scientific and technological resources of 16 nations: Canada, Japan, Russia, 11 nations of the European Space Agency, and Brazil.

More than four times as large as *Mir,* the Russian Space Station, the completed *International Space Station* will have a mass of about 1,040,000 pounds and will measure 356 feet across and 290 feet long, with almost an acre of solar panels to provide electrical power to six state-of-the-art laboratories.

The ISS will be in orbit at an altitude of 250 statute miles with an inclination of 51.6 degrees. This orbit allows the station to be reached by launch vehicles from the international partners to provide a robust capability for the delivery of crews and supplies. The orbit also provides excellent Earth observations, with coverage of 85 percent of the globe and overflight of 95 percent of the population.

U.S. ROLE AND CONTRIBUTIONS

The United States is responsible for developing and ultimately operating major elements and systems aboard the ISS. The U.S. elements include three connecting modules or nodes, a laboratory module, truss segments, four solar arrays, a habitation module, three mating adapters, a cupola, an unpressurized logistics carrier, and a centrifuge module. The various systems being developed by the U.S. include thermal control; life support; guidance, navigation, and control; data handling; power systems; communications and tracking; ground operations facilities; and launch-site processing facilities.

INTERNATIONAL CONTRIBUTORS

The international partners, Canada, Japan, the European Space Agency, and Russia, will contribute the following key elements to the ISS. Canada is providing a 55-foot-long robotic arm to be used for assembly and maintenance tasks on the Space Station. The European Space Agency is building a pressurized laboratory to be launched on the Space Shuttle and logistics transport vehicles to be launched on the *Ariane 5* launch vehicle. Japan is building a laboratory with an attached exposed exterior platform for experiments, as well as logistics transport vehicles. Russia is providing two research modules, an early living quarters called the Service Module, with its own life support and habitation systems, a science power platform of solar arrays that can supply about 20 kilowatts of electrical power, logistics transport vehicles, and the *Soyuz* spacecraft for crew return and transfer. In addition, Brazil and Italy are contributing some equipment to the station through agreements with the United States.

RESEARCH ON THE INTERNATIONAL SPACE STATION

The ISS will establish an unprecedented state-of-the-art laboratory complex in orbit that will be more than four times the size and have almost six times the electrical power of Russia's *Mir*. Research in the station's six laboratories will lead to discoveries in medicine, materials, and fundamental science that will benefit people all over the world. Through its research and technology, the station also will serve as an indispensable step in preparation for future human space exploration.

Protein crystal studies are an example of the type of U.S. research that will be performed aboard ISS. More pure protein crystals may be grown in space than on Earth. Analysis of these crystals helps scientists better understand the nature of proteins, enzymes, and viruses, perhaps leading to the development of new drugs and a better understanding of the fundamental building blocks of life. Similar experiments have been conducted on the Space Shuttle, although they are limited by the short duration of shuttle flights. This type of research could lead to the study of possible treatments for cancer, diabetes, emphysema, and immune system disorders.

Another experiment will consist of growing tissue cultures in microgravity to test new treatments for cancer without harming patients. Life in low gravity will also be researched to determine the long-term effects of reduced gravity on human beings. A centrifuge, located in the Centrifuge Accommodation Module, will use centrifugal force to generate simulated gravity ranging from almost zero to twice that of Earth. Flames, fluids, and metal in space will be the subject of basic research on the ISS to create better alloys and improved materials for applications such as computer chips.

ISS will also observe the Earth to help study large-scale, long-term changes in the environment. Effects of volcanoes, ancient meteorite impacts, hurricanes, and human interactions can be studied. Air pollution and water pollution can be captured in images that will provide a global perspective unavailable from the ground.

Orbital assembly of ISS began a new era of hands-on work in space, involving more space walks than ever before and a new generation of space robotics. About 850 clock hours of space walks, both U.S. and Russian, will be required over five years to maintain and assemble the station. The Space Shuttle and two types of Russian launch vehicles will launch 45 assembly missions. Of these, 36 will be Space Shuttle flights. In addition, resupply missions and changeouts of *Soyuz* crew return spacecraft will be launched regularly. Assembly should be completed by 2006.

NATIONAL STANDARDS

MATHEMATICS (NCTM) STANDARDS

- Understand the meaning of operations and how they relate to each other.
- Use symbolic forms to represent and analyze mathematical situations and structures.
- Analyze characteristics and properties of two-and three-dimensional geometric objects.
- Understand attributes, units, and systems of measurement.
- Apply a variety of techniques, tools, and formulas for determining measurements.
- Build new mathematical knowledge through work with problems.
- Monitor and reflect on mathematical thinking in solving problems.
- Make and investigate mathematical conjectures.
- Organize and consolidate mathematical thinking to communicate with others.
- Use the language of mathematics as a precise means of mathematical expression.
- Understand how mathematical ideas build on one another to produce a coherent whole.
- Recognize, use, and learn about mathematics in contexts outside of mathematics.

SCIENCE (NSE) STANDARDS

- Science as Inquiry
  Abilities necessary to do scientific inquiry
  Understanding scientific inquiry
- Science and Technology
  Abilities of technological design
  Understanding science and technology
- History and Nature of Science
  Science as a human endeavor
  Nature of science

TECHNOLOGY (NET) STANDARDS

- Practice responsible use of technology systems, information, and software.
- Develop positive attitudes toward technology uses that support lifelong learning collaboration, personal pursuits, and productivity.
- Use technology tools to enhance learning, increase productivity, and promote creativity.
- Use technology resources for solving problems and making informed decisions.
- Employ technology in the development of strategies for solving problems in the real world.

INSTRUCTIONAL OBJECTIVES

The students will

- create a model of the space station from a set of materials and parameters.
- work within the constraints of a budget by using consumer math.
- use a balance to determine mass in grams.
- use measurement tools and techniques to determine length, width, and height.
- calculate area and volume.
- analyze and interpret data to determine the best design, based on budget and component placement, for the Space Station.

VOCABULARY

attitude control thrusters - small propulsion device that controls the orientation of the Space Station

core module - section of the Space Station where the brains exist

diameter - distance across a circle through the center point

docking port - section of the Space Station where the Space Shuttle will connect to dock

habitation module - section of the Space Station where astronauts will live

***International Space Station* (ISS)** - facility in space with living quarters, work space, and its own environmental control and power generation equipment

laboratory module - section of the Space Station used to run experiments

photovoltaic (PV) array - device that collects solar energy and converts it into electricity

radius - distance from the center point of a circle to the edge of the circle

robotic arm - mechanical arm used to assemble and repair the Space Station

space shuttle - reusable spacecraft that transports astronauts, satellites, and other material between Earth and space

thermal radiators - panel or section of the Space Station that distributes heat from the electronic equipment

truss -structural support on the Space Station that is used either to mount equipment or to connect sections together

PREPARING FOR THE ACTIVITY

MATERIALS (PER GROUP)

Suggestion: Three students per group

10 **craft sticks**
1 flexible **straw**
10 small **buttons**
3 **soft drink cans**
1 **toilet paper tube**
2 **foam food trays**
3 **transparency sheets**
1 **Space Shuttle Glider Kit**
copy of **Appendix A** (p. 12)

3 sheets of **paper**
2 individual serving **cereal boxes**
balances
ruler
scissors
nontoxic **glue**
tape (recommend duct tape)
30-cm x 30-cm sheet of **aluminum foil**

TIME

Discussion of the activity (reviewing constraints and parameters)	30 min
Assembly of the Space Station and math calculations	45 min

CORRELATION OF SPACE STATION COMPONENTS TO MATERIALS

photovoltaic (PV) arrays = transparency film
support structure for photovoltaic (PV) arrays and thermal radiators = craft sticks
thermal radiators = aluminum foil
modules 1, (habitation) and 2 (laboratory) = soft drink cans
docking port = toilet paper tube
truss segments = foam food trays (cut into 4 cm wide strips)
module 3 (core) = individual serving size cereal boxes
attitude control thrusters = buttons
robotic arm = flexible straws

FOCUS QUESTIONS

1. What is the *International Space Station*?
2. What is significant about having an international Space Station?
3. What will the Space Station astronauts spend most of their time doing?
4. Approximately how much do you think the *International Space Station* will cost?
5. How will NASA engineers construct the I*nternational Space Station*?

THE ACTIVITY

STEP 1: INTRODUCING THE ACTIVITY

1. Collect the necessary materials or instruct students to bring them from home.
2. Display the labeled picture of the *International Space Station* as it may appear upon completion (Appendix B, p. 13). Discuss each individual component and its function: module 1 – habitation, module 2 – laboratory, module 3 – core, PV arrays, thermal radiators, docking port, attitude control thrusters, and robotic arm.
3. Explain to the students that NASA engineers need their help. They need new ideas for the *International Space Station*. Announce: "The National Aeronautics and Space Administration wants you to design and build a new model of the *International Space Station*. You will present your model to the class. Because of some size and weight limitations of the Space Station, there are a few requirements for you to follow in the design process. Please assist NASA in creating a model that follows the guidelines."
4. Review with students the lesson guide section entitled *Correlation of Space Station Components to Materials* (p. 5).
5. Distribute copies of the constraints, Appendix A, p. 12. Discuss the design constraints that must be followed.
6. Organize teams. Each team has three members: a Project Manager, a reader, and a recorder. Group members should rotate during each phase of the project so that everyone plays an active part in the project. The group should collaborate on the final design.
7. Depending on the ability level of the students, explain the steps of the activity or copy the steps and have the students proceed independently.

STEP 2: CONSTRUCTION OF THE MODULES

1. Use a balance to find the mass of module 1 (habitation) and record in Table 1 (p. 10).
2. Place the circular soda can bottom face down and trace the cross-sectional area onto a sheet of paper.
3. Estimate the center point of the circle.
4. Measure the diameter in cm and record in Table 1.
5. Calculate the radius and record in Table 1. The formula is $\mathbf{r = d/2}$.
6. Calculate the area of the cross section and record in Table 1. The formula is $\mathbf{A = \pi r^2}$ ($\pi = 3.14$).
7. Measure the height of the can in cm and record in Table 1.
8. Calculate the volume of module 1 and record in Table 1. The formula is $\mathbf{V = \pi r^2 h}$.

NOTE *To simplify finding the volume of the soft drink cans, use the can's maximum diameter for calculations.*

Students should round all values to the nearest tenth.

9. Calculate the cost of module 1 and record in Table 1. The formula is **V x cost per cm^3 = cost of module 1.**
10. Repeat steps 1 – 9 for module 2 (laboratory). Record all values in Table 1.
11. Use a balance to find the mass of module 3 (core) and record in Table 1.
12. Measure the length (l), width (w), and height (h) for module 3 in cm and record each in Table 1.
13. Calculate the volume for module 3 and record in Table 1. The formula is **V = lwh**.
14. Calculate the cost of module 3 and record in Table 1. The formula is **V x cost per cm^3 = cost of module 3**.
15. Find the sum of the mass of modules 1, 2, and 3 and record the total mass of modules in Table 1.
16. Find the sum of the volume of modules 1, 2, and 3 and record the total volume of modules in Table 1.

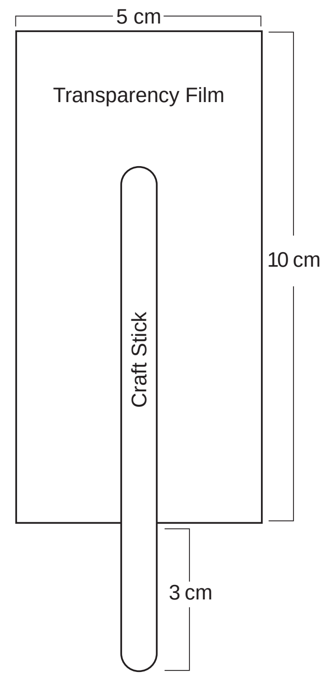


Figure 1: PV Array

STEP 3: CONSTRUCTION OF THE PV ARRAY

Refer to Appendix A: Contraints for Space Station, p.12.

1. Calculate how many square centimeters (total area) of PV array will be needed to support the entire Space Station and record in Table 2 (p.10). The formula is the **total area of PV arrays needed = (total volume of modules/500 cm^3) x 100 cm^2**.
2. Construct one PV array by gluing a craft stick to a 5-cm x 10-cm piece of transparency film. Leave 3 cm of craft stick at the bottom (see figure 1).
3. Calculate the area of the transparency film used in your array and record in Table 2. The formula is **A = lw**.
4. Divide the total area of PV arrays needed by the area of transparency film used in your PV array to determine the total number of PV arrays needed to support the entire Space Station. Record in Table 2.
5. Calculate the total cost of PV arrays and record in Table 2. The formula is **total cost of PV arrays = number of PV arrays x cost per PV array**.
6. Construct the additional number of PV arrays you will need.
7. Use a balance to determine the mass of the PV arrays and record the total mass of PV arrays constructed in Table 2. Set PV arrays aside.

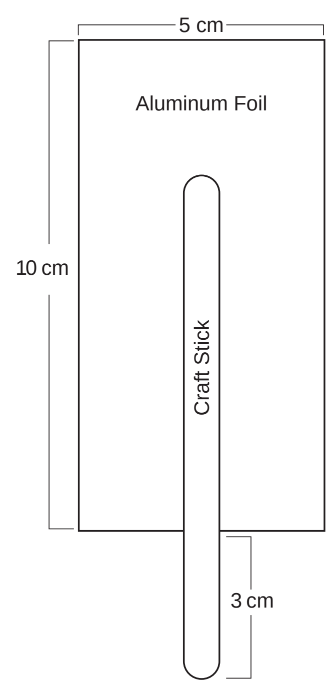


Figure 2: Thermal Radiator

STEP 4: CONSTRUCTION OF THE THERMAL RADIATORS

The thermal radiators are used to help cool the Space Station. There are some restrictions for the design; see Appendix A (p.12).

1. Calculate how many square centimeters (total area) of thermal radiators will be needed to support the entire Space Station and record in Table 3 (p.10). The formula is **total area needed for thermal radiators = (total volume of modules/500 cm^3) x 75 cm^2**.
2. Construct one thermal radiator by gluing a craft stick to a 5-cm x 10-cm piece of aluminum foil. Leave 3 cm of craft stick at the bottom (see figure 2).
3. Calculate the area of aluminum foil used in your thermal radiator and record in table 3. The formula is **A = lw**.

4. Divide the total area needed for thermal radiators by the area of aluminum foil used in your thermal radiator to determine the total number of thermal radiators needed to support the entire Space Station. Record in Table 3 (p.10).
5. Calculate the total cost of thermal radiators and record in Table 3. The formula is **total cost of thermal radiators = number of thermal radiators x cost per thermal radiator**.
6. Construct the number of thermal radiators you will need.
7. Use a balance to determine the mass of the thermal radiators and record the total mass of thermal radiators constructed in Table 3. Set thermal radiators aside.

STEP 4

STEP 5: DESIGNING THE SPACE STATION

1. Decide how the Space Station components will be arranged in your model. Refer to Appendix A: Contraints for the Space Station (p.12).

NOTE

PV arrays and thermal radiators must be attached to the trusses. Be sure to allow enough trusses to attach all PV arrays and thermal radiators. Attitude control thrusters (buttons) and the robotic arm cannot be placed on the thermal radiators or PV arrays.

2. Make a sketch of each part and where you would like to put it.

STEP 4

STEP 6: CONSTRUCTION OF THE TRUSSES

1. Cut foam food trays in 4-cm wide strips. Cut enough strips to measure a total length of 50 cm.
2. Determine the total length needed for the truss, based on your design, and record in Table 4 (p.11).
3. Calculate the total cost of the truss and record in Table 4. The formula is **total cost of truss = total length of truss x cost per cm of length**.
4. Use a balance to determine the total mass of the truss and record in Table 4. Set truss aside.

STEP 4

STEP 7: ASSEMBLY OF THE SPACE STATION

1. Tape or glue the modules together and connect them to the truss.
2. Connect the PV arrays and thermal radiators to the truss.
3. Record the cost of the docking port in Table 5 (p.11).
4. Use a balance to determine the mass of the docking port and record in Table 5.
5. Tape or glue the docking port (toilet paper roll) to the module of your choice.
6. Tape or glue the attitude control thrusters (buttons) to the Space Station.
7. Calculate the total cost of the attitude control thrusters and record in Table 5. The formula is **total cost of attitude control thrusters = number of attitude control thrusters x cost per attitude control thruster**.
8. Place the robotic arm (flexible straw) on the Space Station. Maximize the distance it can reach to the other parts of the Space Station.
9. Record the cost of the robotic arm in Table 5.
10. (Optional) Construct the Space Shuttle Glider using the kit provided. Attach the Space Shuttle to the docking port with tape or glue.

STEP 8: MASS AND COST CALCULATIONS

1. Record in table 6 (p.11) the total mass of modules, PV arrays, thermal radiators, trusses, and the docking port from Tables 1-5.
2. Find the total mass of your Space Station (sum of individual components) and record this value in Table 6.

Because the ISS will be assembled in orbit, the mass of the components must be determined before the necessary components are launched into space..

3. Use a balance to find the total mass of your constructed model and record this value in Table 6.
4. Find the difference, in total mass, of individual components and the total mass the of entire model and record in Table 6. Compare the accuracy of massing individual pieces as compared to massing your entire space station. How close was the total mass (sum of individual components) to the total mass of your constructed model?
5. If the difference in mass is greater than five grams, a one million dollar per gram Keeton Space Tax will be applied. Calculate the Keeton Space Tax as it applies to the design and record in Table 6. If the difference in the mass is less than or equal to five grams, the Keeton Space Tax will not apply to the Space Station.
6. Record in Table 7 (p.11) the costs of module 1, module 2, module 3, PV arrays, thermal radiators, truss, docking port, attitude control thrusters, robotic arm, and the Keeton Space Tax. Calculate the total cost of your space station by taking the sum of all the costs and recording in Table 7. Did you meet your budget constraint of $1 billion?

STEP 9: DISCUSSION

1. Why was there a difference in mass between the sum of the individual components and the mass of the entire space station?
2. Why are there restrictions on the individual components of the Space Station?
3. Why is it important for the truss not to be over 50 cm?
4. Why do the attitude control thrusters need to be pointed away from the Space Station components?
5. How is cost an important factor in creating and designing a space station?
6. Why did you choose the design you did? (Students may want to present their space stations to the class.)

EXTENSIONS

1. Invite parents, faculty, and the local press to a “Space Station Expo.” The completed space stations can be displayed. Group members can discuss their designs.
2. Determine the scale of the students’ space station by using the *International Space Station* as a baseline.
3. Design and construct a full-scale laboratory module to perform student experiments.

STUDENT WORKSHEETS

TABLES 1-3

TABLE 1: MODULE DESIGN

mass of module 1 (habitation)	__________	grams	(step 2.1)
diameter	__________	cm	(step 2.4)
radius	__________	cm	(step 2.5)
area of cross section	__________	cm^2	(step 2.6)
height	__________	cm	(step 2.7)
volume of module 1	__________	cm^3	(step 2.8)
cost of module 1	__________	**dollars**	(step 2.9)
mass of module 2 (laboratory)	__________	grams	(step 2.1)
diameter	__________	cm	(step 2.4)
radius:	__________	cm	(step 2.5)
area of cross section	__________	cm^2	(step 2.6)
height	__________	cm	(step 2.7)
volume of module 2	__________	cm^3	(step 2.8)
cost of module 2	__________	**dollars**	(step 2.9)
mass of module 3 (core)	__________	grams	(step 2.11)
length	__________	cm	(step 2.12)
width	__________	cm	(step 2.12)
height	__________	cm	(step 2.12)
volume of module 3	__________	cm^3	(step 2.13)
cost of module 3	__________	**dollars**	(step 2.14)
total mass of modules 1, 2, and 3	__________	**grams**	(step 2.15)
total volume of modules 1, 2, and 3	__________	**cm^3**	(step 2.16)

TABLE 2: PV ARRAY DESIGN

total area of PV arrays needed	__________	cm^2	(step 3.1)
area of transparency film used in your array	__________	cm^2	(step 3.3)
total number of PV arrays needed for Space Station	__________		(step 3.4)
total cost of PV arrays	__________	**dollars**	(step 3.5)
total mass of PV arrays constructed	__________	**grams**	(step 3.7)

TABLE 3: THERMAL RADIATOR DESIGN

total area needed for thermal radiators	__________	cm^2	(step 4.1)
area of aluminum foil used in your thermal radiator	__________	cm^2	(step 4.3)
total number of thermal radiators needed for space station	__________		(step 3.4)
total cost of thermal radiators	__________	**dollars**	(step 3.5)
total mass of thermal radiators constructed	__________	**grams**	(step 3.7)

TABLES 4-6

TABLE 4: TRUSS SEGMENT DESIGN

total length of truss(es)	__________	cm	(step 6.2)
total cost of truss(es)	__________	**dollars**	(step 6.3)
total mass of the truss(es)	__________	**grams**	(step 6.4)

TABLE 5: FINAL DESIGN

cost of docking port	__________	**dollars**	(step 7.3)
mass of docking port	__________	**grams**	(step 7.4)
total cost of attitude control thrusters	__________	**dollars**	(step 7.7)
cost of robotic arm	__________	**dollars**	(step 7.9)

TABLE 6: MASS CALCULATIONS

total mass of modules 1, 2, and 3	__________	grams	(from table 1)
total mass of PV arrays constructed	__________	grams	(from table 2)
total mass of thermal radiators constructed	__________	grams	(from table 3)
total mass of truss(es)	__________	grams	(from table 4)
mass of docking port	__________	grams	(from table 5)
total mass of your space station (individual components)	__________	**grams**	(step 8.2)
total mass of your space station (constructed model)	__________	**grams**	(step 8.3)
difference in total mass of individual components and total mass of entire model	__________	**grams**	(step 8.4)
Keeton Space Tax (____ grams x $1 million)	__________	dollars	(step 8.5)

TABLE 7: COST CALCULATIONS

total cost of module 1	__________	dollars	(from table 1)
total cost of module 2	__________	dollars	(from table 1)
total cost of module 3	__________	dollars	(from table 1)
total cost of PV arrays	__________	dollars	(from table 2)
total cost of thermal radiators	__________	dollars	(from table 3)
total cost of truss	__________	dollars	(from table 4)
cost of docking port	__________	dollars	(from table 5)
total cost of attitude control thrusters	__________	dollars	(from table 5)
cost of robotic arm	__________	dollars	(from table 5)
Keeton Space Tax	__________	dollars	(from table 6)
total cost of your space station	__________	**dollars**	(step 8.6)

APPENDIX A: CONTRAINTS FOR SPACE STATION

COST OF COMPONENTS

The Space Station Program has a budget of **$1 billion**. Listed below is the cost of each component and section of the Space Station. If a component or section of the Space Station is accidentally broken, a new component or section must be purchased.

module 1 (habitation) . . . . $470, 000 per cm^3

module 2 (laboratory) . . . . $470, 000 per cm^3

module 3 (core) . . . . $470, 000 per cm^3

PV array (includes craft stick and transparency) . . . . $10 million per array

thermal radiator (includes craft stick and aluminum foil) . . . . $10 million per radiator

truss (50 cm) . . . . $1 million per cm of length

docking port. . . . . $100 million

attitude control thrusters . . . . $1 million per thruster

robotic arm . . . . $5 million

MODULES

There must be one habitat module, one laboratory module, and one core module. All modules must be connected to at least one other module.

PV ARRAYS

One hundred square centimeters (100 cm^2) of PV array will support the electrical needs of 500 cm^3 of module volume. (Example: Suppose it takes a 60 watt lightbulb to light up a room that is 300 square feet. If you have a room that is 1200 square feet, you would need four lightbulbs to light up the room.)

THERMAL RADIATORS

Seventy-five square centimeters of thermal radiators will support the cooling needs of 500 cm^3 of module volume.

TRUSS

The total length of all trusses cannot exceed a total of 50 cm. The 50 cm can be broken into multiple sections.

DOCKING PORT

The docking port should be positioned in such a way that there is a clear, straight path to it for the Orbiter to dock.

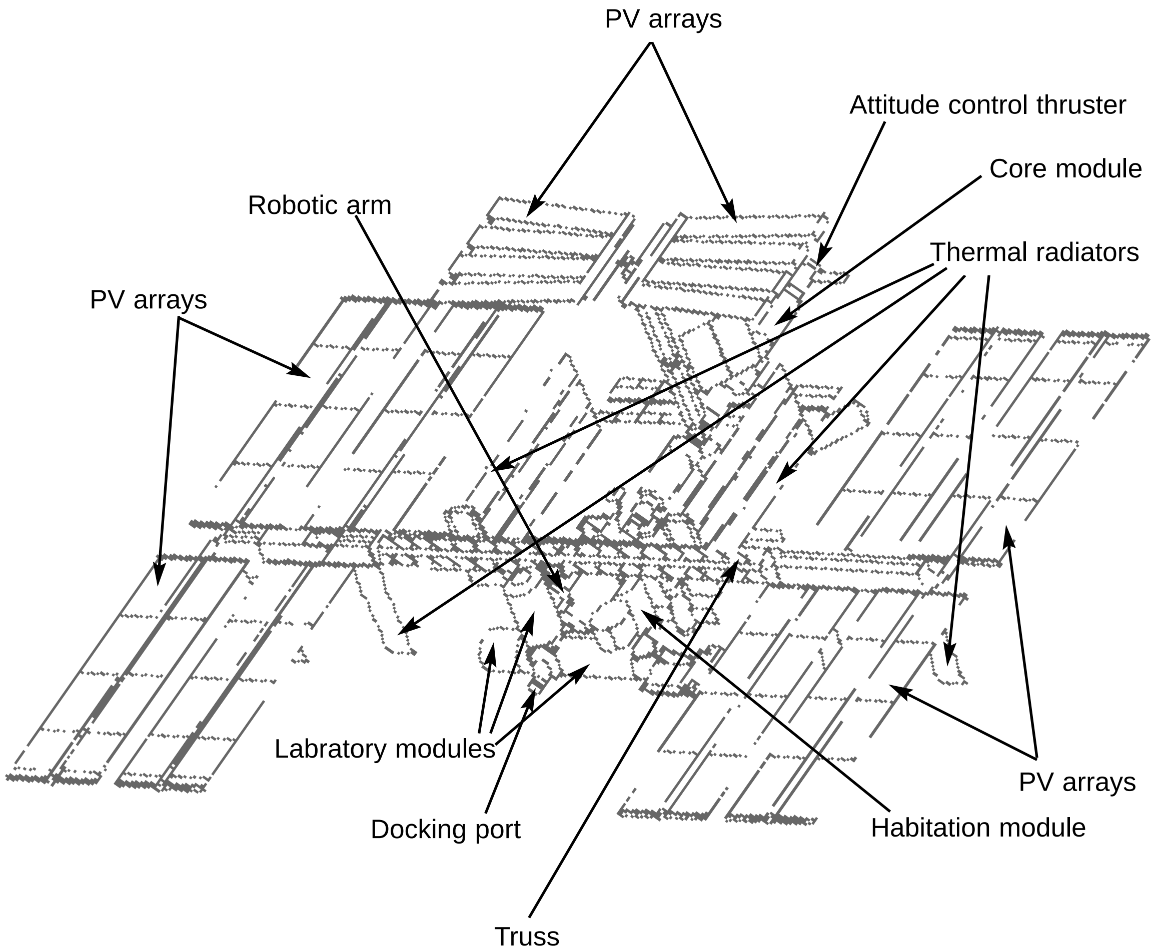
ATTITUDE CONTROL THRUSTERS

A minimum of six attitude control thrusters must be used. The attitude control thrusters must be positioned in order so they will not fire on any component of the Space Station and so they can move in any direction.

ROBOTIC ARM

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

APPENDIX B: SPACE STATION DIAGRAM



STUDENT CUE CARDS

Connie VanPraet-Cremins, ISS Program Outreach Coordinator, NASA Johnson Space Center

1. How will the Space Shuttle attach to the ISS?

2. Describe two ways that the International Space Station will stay in Earth's orbit.

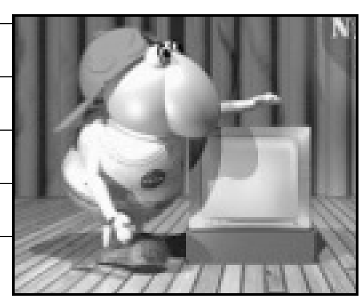
3. Describe the function of the solar arrays, thermal radiators, robotic arm, and truss.

Dr. John-David Bartoe, ISS Program Research Manager, NASA Johnson Space Center

1. What's unique about the research environment on the ISS?

2. How does "zero gravity" affect the fluids in your body?

3. Describe the relationship between time in space and bone loss.



THE WEB ACTIVITY

THE ACTIVITY

The “Docking Challenge” is one of the curriculum resources developed by the NASA Classroom of the Future's *International Space Station* Challenge™ project. In the Docking Challenge, students begin with a combination of internet-based simulations and hands-on activities to explore the scientific and mathematical concepts behind orbital mechanics. In the Virtual Docking Challenge, student teams use a video camera, a rolling office chair, and a "docking grid," to communicate with a mission control collaborative team to simulate an effective docking procedure. This interactive challenge is designed to mirror the types of training simulations that astronauts and cosmonauts conduct to prepare for their Space Station orbital rendezvous and docking maneuvers.

The ISS Challenge web site offers a variety of curriculum supplements to enrich science, math, and technology education. Additional challenges and activities on the ISS Challenge web site address engineering design and scientific research topics. To access the Docking Challenge and other ISS Challenge activities, visit Norbert's lab at **http://connect.larc.nasa.gov/iss/lab.html.**

NATIONAL STANDARDS

TECHNOLOGY (ITEA) STANDARDS

Students should learn the following:

- Communication systems allow information to be transferred from human to human, human to machine, and machine to human.
- The design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message.
- The use of symbols, measurements, and drawings, promotes clear communication by providing a common language to express ideas.
- Design involves a set of steps that can be performed in different sequences and repeated as needed.
- Brainstorming is a group problem-solving design process in which each person in the group presents ideas in an open forum.
- Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

Students should develop abilities to

- Design instruments to gather data.
- Use data collected to analyze and interpret trends to identify the positive or negative effects of a technology.
- Interpret and evaluate the accuracy of the information obtained and determine if it is useful.

SCIENCE (NSE) STANDARDS

- Science as Inquiry
  Abilities necessary to do scientific inquiry
  Understandings about scientific inquiry
- Physical Science
  Motions and forces
- Earth and Space Science
  Earth in the solar system
- Science and Technology
  Abilities of technological design
  Understanding about science and technology
- History and Nature of Science
  Science as a human endeavor

MATHEMATICS (NCTM) STANDARDS

- Understand patterns, relations, and functions.
- Use mathematical models to represent and understand quantitative relationships.
- Analyze change in various contexts.
- Understand measurable attributes of objects and the units, systems, and processes of measurement.
- Apply appropriate techniques, tools, and formulas to determine measurements.
- Build new mathematical knowledge through problem solving.
- Solve problems that arise in mathematics and in other contexts.
- Communicate mathematical thinking coherently and clearly to peers, teachers, and others.
- Analyze and evaluate the mathematical thinking and strategies of others.
- Create and use representation to organize, record, and communicate mathematical ideas.
- Use representations to model and interpret physical, social, and mathematical phenomena.

INSTRUCTIONAL OBJECTIVES

In the "Docking Challenge," students will
- observe and make measurements of an object experiencing steady motion.
- make a prediction about accelerated motion.
- be able to give a word definition of acceleration.
- develop an understanding of the relationship between radius and orbital period.
- use the Orbital Tutorial to collect radius and orbital period data.
- construct a graph of orbital period vs. radius using the data from the Orbital Tutorial.
- compare the results obtained from the Orbital Tutorial to other systems and models.
- use their knowledge of orbits to design, test, and evaluate a procedure for the successful rendezvous of the Space Shuttle and ISS.
- plan and perform measurements and develop a means of calibrating movement for docking.
- develop and evaluate a system for communicating and interpreting navigational instructions.
- evaluate individual and team performance throughout the activity.
- apply scientific concepts regarding orbital science (mass, force, speed).

RESOURCES

BOOKS, PAMPLETS, AND PERIODICALS

Angliss, Sarah: *Cities in the Sky: A Beginner's Guide to Living in Space*. Watts, London, 2000.

Bizony, Piers: *Island in the Sky: The International Space Station.* Aurum Press, London, 1996.

Branley, Franklyn M.: *The International Space Station.* HarperCollins Children's Books, 2000

Cole, Michael D.: *International Space Station: A Space Mission.* Enslow, NJ, 1999.

Messerschmid, Ernst: *Space Station: Systems and Utilization.* Springer, NY, 1999.

Simpson, Theodore R.: *Space Station: An Idea Whose Time Has Come*. Institute of Electrical and Electronics Engineers, NY, 1985.

WEB SITES

Basic Information/Assembly
http://spaceflight.nasa.gov
http://www.pbs.org/wgbh/nova/station
http://quest.arc.nasa.gov/space/events/ksc/
http://www.boeing.com/defense-space/space/spacestation/index.html
http://scipoc.msfc.nasa.gov/
http://school.discovery.com/schooladventures/spacestation/together.html

Location and Viewing of the Space Station
http://www.hq.nasa.gov/osf/station/viewing/issvis.html
http://liftoff.msfc.nasa.gov/temp/stationLoc.html
http://space.com
http://spaceflight.nasa.gov/realdata/sightings/index.html

Space Partners Links
http://scipoc.msfc.nasa.gov/links.html#partners

Interviews with Astronauts and people behind the ISS
http://www.discovery.com/stories/science/iss/iss.html
http://spaceflight.nasa.gov/snapshots.html

Interactive Activities
http://nexus.nasa.gov

Education Materials
http://spacelink.nasa.gov/CORE
http://voyager.cet.edu/iss/activities/farminspace.asp
http://spacelink.nasa.gov/products/Meet.Me.at.the.Station-Overview/

Amateur Radio on the International Space Station
http://ariss.gsfc.nasa.gov

EarthKAM
http://www.earthkam.ucsd.edu/public/iss/

Virtual Space Station
http://nike.larc.nasa.gov/viss.html