NATIONAL MUSEUM OF THE UNITED STATES AIR FORCE

SATELLITE MATH—Solar Arrays

Students practice math skills and learn about Air Force satellites while building their own satellite from recycled materials. Adapted from a lesson plan provided by NASA

LESSON PLAN

Introduction
Satellites—in this case human-made objects that orbit our planet—are amazing feats of technological achievement. Lessons involving satellites can incorporate all aspects of the curriculum: science, technology, engineering, math, history, geography, language arts, and much more. This lesson plan will focus mostly on math, science, technology and engineering.

Lesson Objective
In this lesson, students will learn about the different types of satellites and their uses and then will work in teams to build their own model satellite, given a set of materials and parameters, using math skills to determine how many and what size solar arrays are required based on the volume of their design.

Problem
Given the necessary ratio of solar array area to bus volume, how many square centimeters of array are needed to supply the students' satellite with its power requirements?

Learning Objectives

The students will
- Learn about the history, types and purposes of—and the technology behind—satellites.
- Learn the name and function of various components of a satellite.
- Work cooperatively in teams to select appropriate building materials for their satellite.
- Compute proper size and number of solar arrays needed to power their satellite based on volume of the bus selected.
- Design their team satellite, using drawing paper
- Build a team satellite within a given set of parameters

Grade Level: 6—8

National Math Standards:
Number and Operations, Algebra, Geometry, Measurement, Problem Solving, Communications and Connections.

National Science Education Standards:
Unifying Concepts and Processes, Science as Inquiry, Physical Science, Earth and Space Science, Science and Technology, Science in Personal and Social Perspective, History and Nature of Science.

Technology Content Standards (from STL):
Technology and Society, Design, Abilities for a Technological World, and The Designed World.

Materials Required:
- Empty cardboard tubes of various sizes
- Empty, clean pop cans of various sizes
- Variety of small cardboard boxes
- Aluminum foil
- Yellow plastic wrap
- Craft sticks
- Wood glue and/or hot glue guns
- Various types of tape
- Rulers, scissors
- Calculators
- Pencils
- PowerPoint presentation
- Drawing paper or graph paper

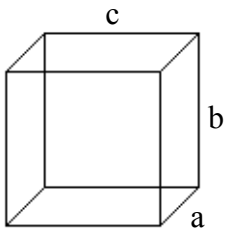
Preparation for activity:

- The teacher will collect or instruct students to bring from home the recycled materials needed to build the satellites.

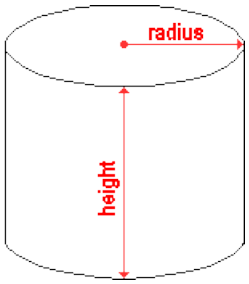
Procedures:

- The students will work in teams of 4 to 5 students
- Begin by showing the Satellite PowerPoint presentation. Emphasize the names, types and functions of the parts of the satellite
- Explain to the students that each team will be building their own satellite with the given supplies:
    - Cardboard tubes of varying diameters and lengths
    - Small cardboard boxes of varying sizes
    - Aluminum soft drink cans of varying sizes
    - Craft sticks for support pieces for solar arrays
    - Aluminum foil
    - String
    - Yellow cellophane wrap for solar arrays
    - Hot glue guns
    - White all-purpose glue
- Problem:
    - How much solar array surface area is required to power your satellite?
    - Given: 100 cm^2 of array will support the electrical needs of the payload components in 500 cm^3 of bus volume.
- Students will decide what type of satellite they are building (communications, Earth remote sensing, scientific research, GPS) and what parts are thus necessary. Then they will choose either a cardboard tube, box or can (as the bus) and other materials necessary to build their satellite (solar arrays, antenna, etc) based on the type of satellite chosen. They may use the PowerPoint slides for ideas.
- To determine the surface area size of their solar arrays, students must first determine the volume of their bus. If necessary, review with the students the formulas for determining the volume of a cube and a cylinder (answer will be in centimeters cubed).

Volume of a cube = $\boldsymbol{a} \times \boldsymbol{b} \times \boldsymbol{c}$



Volume of a cylinder = $\boldsymbol{\pi}\ \mathbf{r}^2 \times \mathbf{h}$



Procedures (continued):

- Next, students need to compare the total volume of their bus to the given statistic that 100 cm^2 of array will support the electrical needs of the payload components in 500 cm^3 of bus volume.

$$\frac{100\ cm^2}{500\ cm^3} = \frac{\text{the area of solar arrays needed by the students in } cm^2}{\text{the total volume of the students' bus in } cm^3}$$

- After calculating the area of solar arrays needed by the students' bus, the students must then divide by the number of solar arrays required by their design to determine the area needed per solar array.

$$\frac{\text{The area of solar arrays calculated}}{\text{The number of solar arrays}} = \text{area of each solar array}$$

- Finally, students must determine what width and length to make the solar arrays in order to reach the desired surface area.

Area of each solar array = length X width

- Students can then construct their satellite, including all the necessary parts based on the type of satellite chosen. See attached suggestions for building the solar array.

Alternate suggestion:

- Students can think of the future and determine new uses for satellites and design their own satellite to meet that purpose. Design constraints would still involve determining the size of the solar arrays based on the bus and the amount of components. However, they could use additional materials to construct their futuristic satellite.

Extension:

- Team presentations—each team of students should prepare a presentation on the type of satellite chosen and the satellite's purpose. All parts should be described and explained. The presentations could involve drawings, dioramas, PowerPoint slides, etc.

- If possible—visit the National Museum of the USAF to see actual satellites on exhibit!

Resources:

- National Museum of the United States Air Force
    - http://www.nationalmuseum.af.mil/exhibits/missile/index.asp
    - http://www.nationalmuseum.af.mil/news/story.asp?id=123220186
    - http://www.nationalmuseum.af.mil/factsheets/factsheet.asp?id=1632
    - http://www.nationalmuseum.af.mil/factsheets/factsheet.asp?id=13575

- http://www.thetech.org/exhibits/online/satellite/

- http://www.howstuffworks.com/satellite.htm

- http://www.noaa.gov/satellites.html

- http://www.nro.gov/kidspages.html

- http://satellites.spacesim.org/english/index.html