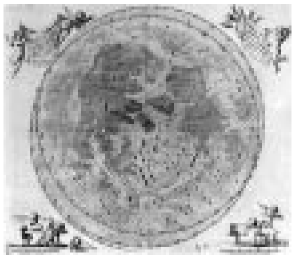
Unit 1



Pre-Apollo Activities

Distance to the Moon
Diameter of the Moon
Reaping Rocks

Before Apollo 11 astronauts Neil A. Armstrong and Edwin E. "Buzz" Aldrin Jr. stepped on the Moon on July 20, 1969, people had studied the Moon by eye, telescope, and images from spacecraft. The theme of Unit 1 is a basic introduction to the Moon -- how it looks from Earth, how far away it is, and how big it is. The activities allow students to make comparisons between the Moon and Earth as well as to make predictions about the Moon rocks.

Encourage students to sketch and describe nightly observations of the Moon and keep a written record of date and time. Nightly charting of the Moon helps students recognize Moon phases as well as the bright and dark terrains.

Scale models and proportional relationships are featured in the first two activities. The "Distance to the Moon" and "Diameter of the Moon" activities introduce students to techniques of measuring distances in space indirectly.

This unit also includes an activity to collect and study rocks called "Reaping Rocks." This activity should follow a more comprehensive lesson on basic rock and mineral identification. The activity also extends learning to the Moon and asks students to predict how their rock collections will compare with lunar samples.

A Resource Section for Unit 1 is on Page 24.

Unit 1

Resource Section

This list presents possible independent and commercial sources of items to complement the activities in Unit 1. The sources are offered without recommendation or endorsement by NASA. Inquiries should be made directly to the appropriate source to determine availability, cost, and ordering information before sending money. Contact your NASA Educator Resource Center (see Page 146) for more lists of resources available directly from the National Aeronautics and Space Administration.

Maps

The Earth's Moon by National Geographic Society. Wall map showing nearside and farside. Also includes graphics with captions explaining eclipses, lunar phases, tides, and other phenomena. U.S. and Soviet landing/impact sites are shown. The reverse side has an index of lunar named features and selected photographs from the Apollo missions.
National Geographic Society
Educational Services, Department 91
Washington, D.C. 20036
1-800-368-2728 or FAX 1-301-921-1575

Giant Moon Map by Rand McNally. Wall map showing the nearside. Contact Rand McNally directly, or order it through:
Astronomical Society of the Pacific
390 Ashton Ave.
San Francisco, CA 94112
1-415-337-2624

Maps of Earth, Moon, Mars, etc.
U.S. Geological Survey Map Sales
Box 25286
Denver Federal Center
Denver, CO 80225
303-236-7477
(Ask for Customer Service)

Globes

Edmund Scientific Co.
101 E. Gloucester Pike
Barrington, NJ 08007-1380
1-609-573-6270 or FAX 1-609-573-6295

Lunar Phase Calendars

Celestial Products
P.O. Box 801
Middleburg, VA 22117
1-800-235-3783 or FAX 1-703-338-4042

Earth Rock Sample Sets

Ward's Natural Science Establishment, Inc.
P.O. Box 92912
Rochester, NY 14692-9012
1-800-962-2660

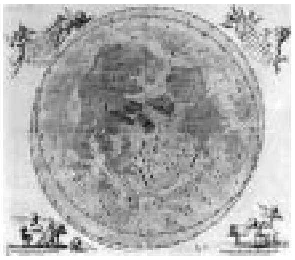
Slides

Glorious Eclipses slide set
Astronomical Society of the Pacific
390 Ashton Ave.
San Francisco, CA 94112
1-415-337-2624

Other Teacher's Guides

Exploring Meteorite Mysteries: Teacher's Guide with Activities, NASA EG-1997-08-104-HQ.
M. Lindstrom et. al., 1997
Companion volume available from NASA Educator Resource Centers or CORE (refer to Page 146 of this book.)

Return to the Moon: Moon Activities Teacher's Guide, 1990
Challenger Center for Space Science Education
1101 King Street, Suite 190
Alexandria, VA 22314
1-703-683-9740



Distance to the Moon

Purpose

To calculate the distance between scale models of Earth and the Moon.

Background

As long as people have looked at the Moon, they have wondered how far away it is from Earth. The average distance to the Moon is 382,500 km. The distance varies because the Moon travels around Earth in an elliptical orbit. At perigee, the point at which the Moon is closest to Earth, the distance is approximately 360,000 km. At apogee, the point at which the Moon is farthest from Earth, the distance is approximately 405,000 km.

Distance from Earth to the Moon for a given date can be obtained by asking a local planetarium staff. Students interested in astronomy may enjoy looking at *The Astronomical Almanac* printed yearly by the U.S. Government printing office. When the Apollo 11 crew landed on the Moon on July 20, 1969, they were 393,309 km away from home.

In this activity students will use simple sports balls as **scale** models of Earth and the Moon. Given the astronomical distance between Earth and the Moon, students will determine the scale of the model system and the distance that must separate the two models.

The “Moon ABCs Fact Sheet” lists the Earth's diameter as 12,756 km and the Moon's diameter as 3,476 km. Therefore, the Moon's diameter is 27.25% of Earth's diameter. An official basketball has a diameter of 24 cm. This can serve as a model for Earth. A tennis ball has a diameter of 6.9 cm which is close to 27.25% of the basketball. (The tennis ball is actually 28.8% the size of the basketball.) These values are very close to the size relationship between Earth and the Moon. The tennis ball, therefore, can be used as a model of the Moon.

The scale of the model system is determined by setting the diameter of the basketball equal to the diameter of Earth. This is written as a simple relationship shown below:

$$24 \text{ cm} = 12{,}756 \text{ km}$$

Expressed more simply, 1 cm in the model system equals 531.5 km in space:

$$1 \text{ cm} = 531.5 \text{ km}$$

Distance to the Moon

Using this scale, the basketball-tennis ball separation in centimeters (**x**) is derived:

$$\mathbf{x} = \frac{382{,}500 \text{ km}}{531.5 \text{ km}} = 719.7 \text{ cm}$$

The value **x** may be rounded to 720 cm and converted to meters so that the students need to place the basketball and tennis ball 7.2 m apart.

Preparation

Review and prepare materials listed on the student sheet.
If it is not possible to obtain an official-size basketball and tennis ball, then you can use other spherical objects or circles drawn on paper. Clay balls may be used as models. For example, for two clay balls, 10 cm diameter and 2.7 cm diameter, the scale is 1 cm = 1,275.6 km. At this scale, students need to separate the clay balls by 3 m.

In Class

Divide the students into cooperative groups. Students must keep track of units of measure.

Wrap Up

Did the students have an accurate idea of the size relationship between Earth and the Moon before doing this activity?

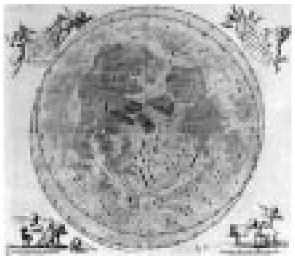
Did the effect of separating the scale models help them visualize the distance to the Moon?

Extensions

1. How long did it take Apollo astronauts to travel to the Moon?

2. Have students measure the circumferences of various spheres so that each group uses a different pair of models.

3. Instead of using the average distance to the Moon, use the distance from July 20, 1969, to recall the Apollo 11 landing or use the distance for today.



Distance to the Moon

Purpose

To calculate the distance between scale models of Earth and the Moon.

Key Word

scale

Materials

"Moon ABCs Fact Sheet"

sports balls

calculator

meter tape

Procedure

1. If Earth were the size of an official basketball, then the Moon would be the size of: another basketball? soccer ball? baseball? tennis ball? golf ball? marble?

____

____

2. The diameter of Earth in kilometers is:

____

3. The diameter of the Moon in kilometers is:

____

4. What percentage of Earth's diameter is the Moon's diameter?

____

5. Use the list below to change or confirm your answer to Question 1.

	diameter in cm
official basketball	24
size 5 soccer ball	22
official baseball	7.3
tennis ball	6.9
golf ball	4.3
marble	0.6

If Earth is a basketball, then the Moon is a:

____

6. Use an official basketball as a model of Earth. Use a second ball, the one you determined from Question 5, as a model of the Moon.

7. Determine the scale of your model system by setting the diameter of the basketball equal to the diameter of Earth.

_________cm = ______________________km therefore,

1 cm = [ ] km

8. If the distance to the Moon from Earth is 382,500 km, then how far apart must you separate the two scale models to accurately depict the Earth/Moon system?

Using the scale value in the box from Step 7, the model separation in centimeters (**x**) is derived:

$$\mathbf{x} = \frac{\text{actual distance to the Moon in kilometers}}{\text{scale value in kilometers}}$$

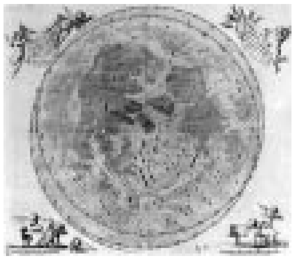
$$x = \frac{\boxed{}}{\boxed{}}$$

x = _________________centimeters

The two scale models must be separated by __________ meters.

9. Set up your scale model of the Earth/Moon system. Does it fit in your classroom?

Diameter of the Moon



Purpose

To calculate the diameter of the Moon using proportions.

Background

The diameter of the Moon is proportional to the diameter of a cardboard disk, given that you know the distance to the Moon and the distance to the cardboard disk.
The relationship is:

$$\frac{\mathbf{d}}{\mathbf{l}} = \frac{\mathbf{D}}{\mathbf{L}}$$

so that:

$$\mathbf{D} = \mathbf{L}(\mathbf{d}/\mathbf{l})$$

where **D** = diameter of Moon
d = diameter of cardboard disk
L = distance to Moon
l = distance to cardboard disk

In this activity, students will measure **d** and **l.** They will be given **L.**
They will calculate **D.**

The diameter of the Moon (**D**) is 3,476 km.

Preparation

Review and prepare materials listed on the student sheet.
Choose a day and location for this activity which is best for viewing a full Moon.

A cardboard disk of 2 cm diameter works well. Better accuracy may be achieved by using a larger disk, thus a greater distance **l**. However, if obtaining or cutting cardboard is difficult, then this activity can also be done with dimes. A dime held out at arm's length will cover the Moon.

The distance from Earth to the Moon for a given date can be obtained by asking a local planetarium staff, Or for this activity, students may use an average value of 382,500 km.

Diameter of the Moon

In Class

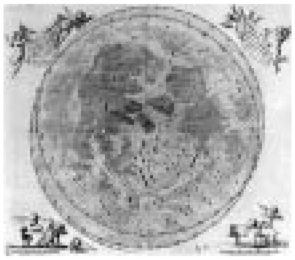
If students work in pairs, then one student can use the string to measure distance from their partner's eye to the disk.

The same units do not have to be used on both sides of the equation, but **d** and **l** have to be the same units. The **D** will be the same unit as **L**.

Wrap-Up

To compute the density of the Moon use the diameter to compute volume and use the mass value of 7.35×10^{22} kg.

Density of the Moon is 3.34 grams/cubic cm.



Diameter of the Moon

Purpose

To calculate the diameter of the Moon using proportions.

Key Words

proportional

Materials

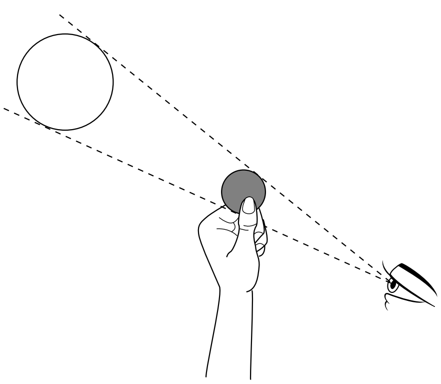
2-cm wide cardboard disk

wooden stake (optional)

meter stick

calculator

string



Procedure

1. On a day when you can see the Moon: place a **cardboard disk** on top of a **stake** or on a window sill so that it exactly covers the Moon from your point of view behind the cardboard disk.

2. Have a friend **measure the distance** from your eye to the cardboard disk.
   Call this distance **l** and write the value here:

   l = ____

3. The distance from Earth to the Moon varies between 360,000 km and 405,000 km. Find the distance for today's date or use an average value for your calculations of 382,500 km.
   Write the value that you are going to use here:

   L = ____

4. What is the diameter of the cardboard disk?

   d = ____

5. The diameter of the Moon is proportional to the diameter of your cardboard disk by this equation:

$$\frac{d}{l} = \frac{D}{L} \qquad \text{so that, } D = L(d/l)$$

where: **D** = diameter of Moon
d = diameter of cardboard disk
L = distance to Moon
l = distance to cardboard disk

Results

1. By your calculations, the diameter of the Moon is:

   D = ______________________________

2. Compare your result with the accepted diameter of the Moon. How close did you get?

   ____

   ____

3. How many times smaller is the diameter of the Moon than the diameter of Earth?

   ____

   ____

4. When you calculated the diameter of the Moon, did you have to use the same units on both sides of the equation?

   ____

   ____

5. How and where could you find the value for the distance to the Moon for today's date?

   ____

   ____

   ____

6. What else would you need to know to compute the density of the Moon? Try it.

   ____

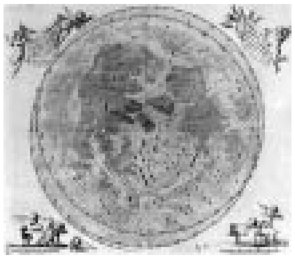
   ____

   ____

   ____

   ____

   ____



Reaping Rocks

Purpose

To make predictions about the origin of lunar rocks by first collecting, describing, and classifying neighbor-hood rocks.

Background [also see "Teacher's Guide" Pages 6, 7, photo on15,16]

Geologists are scientists who study the formation, structure, history, and processes (internal and on the surface) that change Earth and other planetary bodies.

Rocks and the **minerals** in them give geologists key information about the events in a planet's history. By collecting, describing and classifying rocks, we can learn how the rocks were formed and what processes have changed them.

Geologists classify rocks into three types:

Igneous - rock formed when magma cools and hardens either below the surface (for example, granite) or on the surface during volcanic events (for example, basalt).

Sedimentary - rock formed by the collection, compaction, and cementation of mineral grains, rock fragments, and sand that are moved by wind, water, or ice to the site of deposition.

Metamorphic - rock formed when heat and/or pressure deep within the planet changes the mineral composition and grain size of existing rocks. For example, metamorphism changes limestone into marble.

We find all three rock types on Earth's surface and the rocks are constantly changing (recycling), very slowly because of heat, pressure, and exposure to weather and erosion.

The Moon's surface is dominated by igneous rocks. The **lunar highlands** are formed of **anorthosite**, an igneous rock predominantly of calcium-rich **plagioclase feldspar**. The lunar **maria** are made of layers of **basaltic lava**, not unlike the basaltic flows of the Columbia River Plateau or of Iceland. The orange glass found on the Moon's surface is another product of volcanic activity. Moon rocks are not exposed to weather nor are they eroded by wind, water, or ice. The Apollo astronaut's footprints are as fresh as the day they were made.

Preparation

Review and prepare materials listed on the student sheet. Spend time familiarizing the students with rock and mineral identification.

Reaping Rocks

Students may need more than one copy of “My Own Rock Chart” because it has spaces for only three samples. You may want to collect empty egg cartons, small boxes, or trays that the students could decorate themselves to display their rocks. Use of magnifying lenses or a stereo microscope would greatly enhance observations.

“Moon ABCs Fact Sheet” may come in handy during the wrap-up when students try to make predictions about the Moon rocks.

In Class

Talk about the qualities of rocks that we can describe: shape, size, color, texture, and the place where it was found. Then discuss the three rock classifications emphasizing that geologists classify rocks and interpret the origins of rocks based on their observations.

Encourage students to collect a variety of rocks with different colors and textures from your own locality, if possible. Remind them to choose naturally occurring materials – not cement or brick fragments! If it is not possible to collect rocks from the neighborhood, then try to obtain a commerically available set of common rocks. More than one student may choose the same rock. Students could also cut out pictures of rocks from magazines or study pictures of rocks in text books.

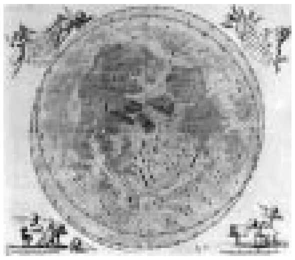
After each rock has been labeled with owner’s name and location where it was found, have the students look carefully at the rock. To help them train their eyes, ask questions like: What colors do you see? Do you see grains? Are the grains large or small? Does the rock look glassy? Or does the rock show a banding pattern? Does the rock look frothy with a lot of holes? Do you see pebbles cemented together? Does the rock contain fossils?

Ask students to describe their rocks with as many adjectives or descriptive phrases as possible. Have the students classify the rocks as igneous, sedimentary, or metamorphic, and then try to interpret the rock origins. “My Own Rock Chart” is designed to help organize their observations and interpretations.

Wrap-up

Conclude the activity by challenging the students to predict what the lunar rocks look like and the possible origins based on what they have just learned about Earth rocks and based on the material in the “Moon ABCs Fact Sheet.”

Display these rock collections and keep them until the students have a chance to compare with the lunar samples in “The Lunar Disk” activity on Page 39.



Reaping Rocks

Purpose

To make predictions about the origin of lunar rocks by first collecting, describing, and classifying neighborhood rocks.

Key Words

geologist

mineral

rock

igneous

sedimentary

metamorphic

Materials

rocks

empty egg carton, box, or other collection tray

labels

magnifying lens or stereo microscope

“My Own Rock Chart”

“Moon ABCs Fact Sheet”

Procedure

1. Display your **rocks** on a tray or **egg carton**, and **label** each one with the location of where you found it.

2. Look carefully at each rock with and without a **magnifying lens or stereo microscope**. What details can you see under magnification?

3. Describe what you see by filling out “**My Own Rock Chart**.” Use as many adjectives or descriptive phrases as you can.

4. Classify your rocks as igneous, sedimentary or metamorphic. Try to interpret how your rocks were formed; that is, the origins. Add this information to your chart.

5. Now, based on your chart and the “**Moon ABCs Fact Sheet**,” predict what the Moon rocks will look like.

____

____

____

____

____

6. How do you think the different Moon rocks might have formed?

____

____

____

My Own Rock Chart

Observations	Rock Sketch			
	Shape			
	Size			
	Colors			
	Texture			
	Collection Site			
Interpretations	Classification			
	Origin			

World Wide Web Resources for Educators for the Moon

Lunar Exploration

Lunar & Planetary Institute (Exploring the Moon)
http://cass.jsc.nasa.gov/moon.html

Johnson Space Center (future human exploration)
http://www-sn.jsc.nasa.gov/explore/explore.htm

International Lunar Exploration Working Group
http://ilewg.jsc.nasa.gov/

National Space Science Data Center (Moon homepage)
http://nssdc.gsfc.nasa.gov/planetary/planets/moonpage.html

Exploring the Moon on-line version of this publication at NASA Spacelink
http://spacelink.nasa.gov/Instructional.Materials/Curriculum.Materials/Sciences/Astronomy/Our.Solar.System/Earth's.Moon/Exploring.The.Moon. Teacher.Guide.4-12/.index.html

Apollo Mission

Apollo Experiment Operations
http://www-sn.jsc.nasa.gov/explore/Data/Apollo/Apollo.htm

Apollo Lunar Surface Journal
http://www.hq.nasa.gov/office/pao/History/alsj/

Clementine Mission

Lunar data from the Clementine Mission
http://nssdc.gsfc.nasa.gov/planetary/clementine.html

Clementine Explores the Moon, annotated slide set
http://cass.jsc.nasa.gov/publications/slidesets/clementine.html

Clementine Mission - Images of the Moon
http://cass.jsc.nasa.gov/research/clemen/clemen.html

Lunar Prospector Mission

Homepage from NASA Ames Research Center
http://lunar.arc.nasa.gov/

Lunar Prospector homepage from Lockheed-Martin
http://juggler.lmsc.lockheed.com/lunar/

National Space Science Data Center
http://nssdc.gsfc.nasa.gov/planetary/lunarprosp.html

Planetary Exploration

Planetary Science Research Discoveries web magazine
http://www.soest.hawaii.edu/PSRdiscoveries/

Hands-on classroom activities for planetary science
http://www.soest.hawaii.edu/spacegrant/class_acts/

NASA Spacelink
http://spacelink.nasa.gov/

Views Of The Solar System (Calvin Hamilton/LANL)
http://bang.lanl.gov/solarsys/

The Nine Planets - Moon pages (Bill Arnett/SEDS)
http://seds.lpl.arizona.edu/nineplanets/nineplanets/nineplanets/luna.html

Welcome to the Planets (PDS/JPL)
http://pds.jpl.nasa.gov/planets/

Guide to the Solar System (McDonald Observatory)
http://stardate.utexas.edu/resources/ssguide/SSG_Contents.html

NSSDC Planetary Image Catalog
http://nssdc.gsfc.nasa.gov/imgcat/

NASA Planetary Photojournal
http://photojournal.jpl.nasa.gov/

NASA Image eXchange (NIX)
http://nix.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 catalogue 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: (205) 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 CS-530
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 provide current educational information and instructional resource materials to teachers, faculty, and students. A wide range of information is available, including science, mathematics, engineering, and technology education lesson plans, historical information related to the aeronautics and space program, current status reports on NASA projects, news releases, information on NASA educational programs, useful software and graphics files. Educators and students can also use NASA resources as learning tools to explore the Internet, accessing information about educational grants, interacting with other schools which are already on-line, and participating in on-line interactive projects, communicating with NASA scientists, engineers, and other team members to experience the excitement of real NASA projects.

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

NASA Television (NTV) is the Agency's distribution system for live and taped programs. It offers the public a front-row seat for launches and missions, as well as informational and educational programming, historical documentaries, and updates on the latest developments in aeronautics and space science. NTV is transmitted on the GE-2 satellite, Transponder 9C at 85 degrees West longitude, vertical polarization, with a frequency of 3880 megahertz, and audio of 6.8 megahertz.

Apart from live mission coverage, regular NASA Television programming includes a Video File from noon to 1:00 pm, a NASA Gallery File from 1:00 to 2:00 pm, and an Education File from 2:00 to 3:00 pm (all times Eastern). This sequence is repeated at 3:00 pm, 6:00 pm, and 9:00 pm, Monday through Friday. The NTV Education File features programming for teachers and students on science, mathematics, and technology. NASA Television programming may be videotaped for later use.

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-1996-11-345-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*