Additional Extensions

- Construct models of historical rockets. Refer to the reference list for picture books on rockets to use as information on the appearance of various rockets. Use scrap materials for the models such as:
  - Mailing tubes • Cardboard • Tubes from paper rolls • Spools
  - Coffee creamer packages (that look like rocket engine nozzles)
  - Egg-shaped hosiery packages (for nose cones) • Tape
  - Styrofoam cones • Spheres • Cylinders • Glue

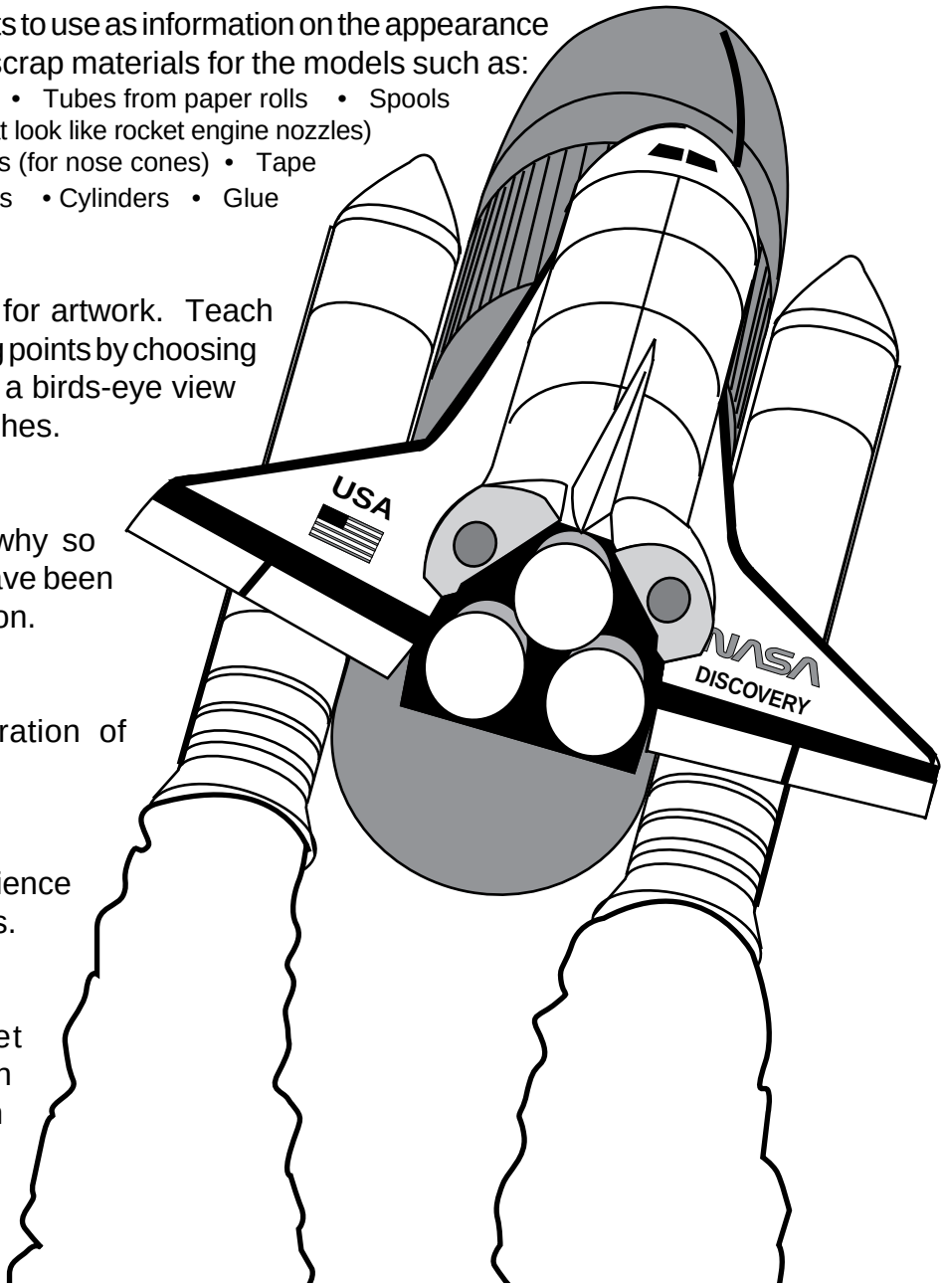
- Use rockets as a theme for artwork. Teach perspective and vanishing points by choosing unusual angles, such as a birds-eye view for picturing rocket launches.

- Research the reasons why so many different rockets have been used for space exploration.

- Design the next generation of spaceships.

- Compare rockets in science fiction with actual rockets.

- Follow up the rocket activities in this guide with construction and launch of commercial model rockets. Rocket kits and engines can be purchased from craft and hobby stores and directly from the manufacturer. Obtain additional information about model rocketry by contacting the National Association of Rocketry, P.O. Box 177, Altoona, WI 54720.



- Contact NASA Spacelink for information about the history of rockets and NASA's family of rockets under the heading, "Space Exploration Before the Space Shuttle." See the resource section at the end of this guide for details.

Glossary

Action - A force (push or pull) acting on an object. See Reaction.

Active Controls - Devices on a rocket that move to control the rocket's direction in flight.

Attitude Control Rockets - Small rockets that are used as active controls to change the attitude (direction) a rocket or spacecraft is facing in outer space.

Canards - Small movable fins located towards the nose cone of a rocket.

Case - The body of a solid propellant rocket that holds the propellant.

Center of Mass (CM) - The point in an object about which the object's mass is centered.

Center of Pressure (CP) - The point in an object about which the object's surface area is centered.

Chamber - A cavity inside a rocket where propellants burn.

Combustion Chamber - See Chamber.

Drag - Friction forces in the atmosphere that "drag" on a rocket to slow its flight.

Escape Velocity - The velocity an object must reach to escape the pull of Earth's gravity.

Extravehicular Activity (EVA) - Spacewalking.

Fins - Arrow-like wings at the lower end of a rocket that stabilize the rocket in flight.

Fuel - The chemical that combines with an oxidizer to burn and produce thrust.

Gimbaled Nozzles - Tiltable rocket nozzles used for active controls.

Igniter - A device that ignites a rocket's engine(s).

Injectors - Showerhead-like devices that spray fuel and oxidizer into the combustion chamber of a liquid propellant rocket.

Insulation - A coating that protects the case and nozzle of a rocket from intense heat.

Liquid Propellant - Rocket propellants in liquid form.

Mass - The amount of matter contained within an object.

Mass Fraction (MF) - The mass of propellants in a rocket divided by the rocket's total mass.

Microgravity - An environment that imparts to an object a net acceleration that is small compared with that produced by Earth at its surface.

Motion - Movement of an object in relation to its surroundings.

Movable Fins - Rocket fins that can move to stabilize a rocket's flight.

Nose Cone - The cone-shaped front end of a rocket.

Nozzle - A bell-shaped opening at the lower end of a rocket through which a stream of hot gases is directed.

Oxidizer - A chemical containing oxygen compounds that permits rocket fuel to burn both in the atmosphere and in the vacuum of space.

Passive Controls - Stationary devices, such as fixed rocket fins, that stabilize a rocket in flight.

Payload - The cargo (scientific instruments, satellites, spacecraft, etc.) carried by a rocket.

Propellant - A mixture of fuel and oxidizer that burns to produce rocket thrust.

Pumps - Machinery that moves liquid fuel and oxidizer to the combustion chamber of a rocket.

Reaction - A movement in the opposite direction from the imposition of an action. See Action.

Rest - The absence of movement of an object in relation to its surroundings.

Regenerative Cooling - Using the low temperature of a liquid fuel to cool a rocket nozzle.

Solid Propellant - Rocket fuel and oxidizer in solid form.

Stages - Two or more rockets stacked on top of each other in order to reach higher altitudes or have a greater payload capacity.

Throat - The narrow opening of a rocket nozzle.

Unbalanced Force - A force that is not countered by another force in the opposite direction.

Vernier Rockets - Small rockets that use their thrust to help direct a larger rocket in flight.

NASA Educational Materials

NASA publishes a variety of educational resources suitable for classroom use. The following resources, specifically relating to the topic of rocketry, are available from the NASA Teacher Resource Center Network. Refer to the next pages for details on how to obtain these materials.

Liftoff to Learning Educational Video Series That Relate to Rockets

Space Basics
Length: 20:55
Recommended Level: Middle School
Application: History, Physical Science
Space Basics explains space flight concepts such as how we get into orbit and why we float when orbiting Earth. Includes a video resource guide.

Newton in Space
Length: 12:37
Recommended Level: Middle School
Application: Physical Science
Newton in Space demonstrates the difference between weight and mass and illustrates Isaac Newton's three laws of motion in the microgravity environment of Earth Orbit. Includes a video resource guide.

Other Videos

Videotapes are available about Mercury, Gemini, Apollo, and Space Shuttle projects and missions. Contact the Teacher Resource Center that serves your region for a list of available titles, or contact CORE (See page 109.).

Publications

McAleer, N. (1988), Space Shuttle - The Renewed Promise, National Aeronautics and Space Administration, PAM-521, Washington, DC.
NASA (1991), Countdown! NASA Launch Vehicles and Facilities, Information Summaries, National Aeronautics and Space Administration, PMS-018-B, Kennedy Space Center, FL.
NASA (1991), A Decade On Board America's Space Shuttle, National Aeronautics and Space Administration, NP-150, Washington, DC.
NASA (1987), The Early Years: Mercury to Apollo-Soyuz, Information Summaries, National Aeronautics and Space Administration, PMS-001-A, Kennedy Space Center, FL.
NASA (1991), Space Flight, The First 30 Years, National Aeronautics and Space Administration, NP-142, Washington, DC.
NASA (1992), Space Shuttle Mission Summary, The First Decade: 1981-1990, Information Summaries, National Aeronautics and Space Administration, PMS-038, Kennedy Space Center, FL.
Roland, A. (1985), A Spacefaring People: Perspectives on Early Spaceflight, NASA Scientific and Technical Information Branch, NASA SP-4405, Washington, DC.

Lithographs

HqL-367 Space Shuttle *Columbia* Returns from Space.
HqL-368 Space Shuttle *Columbia* Lifts Off Into Space.

Suggested Reading

These books can be used by children and adults to learn more about rockets. Older books on the list provide valuable historical information rockets and information about rockets in science fiction. Newer books provide up-to-date information about rockets currently in use or being planned.

Asimov, I. (1988), Rockets, Probes, and Satellites, Gareth Stevens, Milwaukee.
Barrett, N. (1990), The Picture World of Rockets and Satellites, Franklin Watts Inc., New York.
Bolognese, D. (1982), Drawing Spaceships and Other Spacecraft, Franklin Watts, Inc., New York.
Branley, F. (1987), Rockets and Satellites, Thomas Y. Crowell, New York.
Butterfield, M. (1994), Look Inside Cross-Sections Space, Dorling Kindersley, London.
Donnelly, J. (1989), Moonwalk, The First Trip to the Moon, Random House, New York.
English, J. (1995), Transportation, Automobiles to Zeppelins, A Scholastic Kid's Encyclopedia, Scholastic Inc., New York.
Fischel, E. & Ganeri, A. (1988), How To Draw Spacecraft, EDC Publishing, Tulsa, Oklahoma.
Furniss, T. (1988), Space Rocket, Gloucester, New York.
Gatland, K. (1976), Rockets and Space Travel, Silver Burdett, Morristown, New Jersey.
Gatland, K. & Jeffris, D. (1977), Star Travel: Transport and Technology Into The 21st Century, Usborn Publishers, London.
Gurney, G. & Gurney, C. (1975), The Launch of Sputnik, October 4, 1957: The Space Age Begins, Franklin Watts, Inc., New York.
Malone, R. (1977), Rocketship: An Incredible Voyage Through Science Fiction and Science Fact, Harper & Row, New York.
Maurer, R. (1995), Rocket! How a Toy Launched the Space Age, Crown Publishers, Inc., New York.
Mullane, R. M. (1995), Liftoff, An Astronaut's Dream, Silver Burdett Press, Parsippany, NJ.

Neal, V., Lewis, C., & Winter, F. (1995), Smithsonian Guides, Spaceflight, Macmillan, New York. (Adult level reference)
Parsons, A. (1992), What's Inside? Spacecraft, Dorling Kindersley,m Inc., New York.
Ordway, F. & Leibermann, R. (1992), Blueprint For Space, Science Fiction To Science Fact, Smithsonian Instutition Press, Washington DC.
Quackenbush, R. (1978), The Boy Who Dreamed of Rockets: How Robert Goddard Became The Father of the Space Age, Parents Magazine Press, New York.
Ride, S. & Okie, S. (1986), To Space & Back, Lee & Shepard Books, New York.
Shayler, D. (1994), Inside/Outside Space, Random House, New York.
Shorto, R. (1992), How To Fly The Space Shuttle, John Muir Publications, Santa Fe, NM.
Vogt, G. (1987), An Album of Modern Spaceships, Franklin Watts, Inc., New York.
Vogt, G. (1989), Space Ships, Franklin Watts, Inc., New York.
Winter, F. (1990), Rockets into Space, Harvard University Press, Cambridge, Massachusetts. (Adult level reference)

Commercial Software

Physics of Model Rocketry
Flight: Aerodynamics of Model Rockets
In Search of Space - Introduction to Model Rocketry
The above programs are available for Apple II, Mac, and IBM from Estes Industries, 1295 H. Street, Penrose, Colorado 81240

Electronic Resources for Educators

The following listing of Internet addresses will provide users with links to educational materials throughout the World Wide Web (WWW) related to rocketry.

NASA Resources
NASA SpaceLink
http://spacelink.msfc.nasa.gov

NASA Home Page
http://www.nasa.gov/

NASA Goddard Space Flight Center Space Science Education Home Page
hhtp://www.gsfc.nasa.gov/education/education_home.html

NASA Kennedy Space Center Addresses
http://www.ksc.nasa.gov/
http://www.ksc.nasa.gov/mdss/MDSS.html
http://www.ksc.nasa.gov/elv/elvpage.htm
http://www.ksc.nasa.gov/elv/DELTA/delta.htm

NASA Jet Propulsion Laboratory
http://newproducts.jpl.nasa.gov/calendar/

NASA Space Shuttle
http://shuttle.nasa.gov/

Shuttle Mission Home Page Address:
http://shuttle.nasa.gov/

Launch Vehicles Newsgroups
news:sci.space.shuttle
news:sci.space.tech

Other Rocketry Resources
Andoya Rocket Range
http://www.arr.nsc.no/

Boeing
http://www.boeing.com/sealaunch.html
http://www.boeing.com/x-33-rlv.html

ESA and Space Transport Systems
http://www.esrin.esa.it/htdocs/esa/progs/mstp.html

History of Rockets
http://www.c3.lanl.gov/~cjhamil/SolarSystem/rocket.htm

History of Space Exploration
http://www.c3.lanl.gov/~cjhamil/SolarSystem/history.html

Lockheed Martin Missiles and Space
http://www.lmsc.lockheed.com/

McDonnell Douglas Aerospace
http://pat.mdc.com/

NASDA New Space Transportation Systems
http://www.nasda.go.jp/technical/rocket_e.html

Orbital and Planetary Launch Services
http://www.cis.ohio-state.edu/hypertext/faq/usenet/space/launchers/faq.html

Russian "FSU" Space Missions and Vehicles
http://solar.rtd.utk.edu/~jgreen/rusguide.html

Space Shuttle
http://www.yahoo.com/Science/Space/Space_Shuttle

NASA Educational Resources

NASA Spacelink is an electronic information system designed to provide current educational information to teachers, faculty, and students. Spacelink offers a wide range of computer text files, software, and graphics related to the aeronautics and space program. For callers who reach Spacelink via the World Wide Web, the system offers links to additional educational resources.

Documents on the system are chosen for their educational value and relevance to aeronautics and space education. Information and educational materials are available on topics including:

- lesson plans
- software
- current NASA news
- NASA educational publications
- teaching activities
- historical information
- NASA images
- future projects
- special features available to educators
- NASA educational programs & services
- answers to questions on NASA aeronautics and space-related topics
- schedule for NASA Television

The system may be accessed by computer through direct-dial modem or the Internet.

Modem line:	(205) 895-0028
Terminal emulation:	VT-100 required
Data format:	8-N-1
Telnet:	spacelink.msfc.nasa.gov

Spacelink fully supports the following Internet services:

World Wide Web:	http://spacelink.msfc.nasa.gov
Gopher:	spacelink.msfc.nasa.gov
Anonymous FTP:	spacelink.msfc.nasa.gov
Internet TCP/IP address:	192.149.89.61

For more information, contact: Spacelink Administrator, Education Programs Office, Mail Code CL01, NASA Marshall Space Flight Center, Huntsville, AL 35812-0001. Voice phone: (205) 961-1225
E-mail: comments@spacelink.msfc.nasa.gov

NASA Education Satellite Videoconference Series is offered as an inservice education program for educators through the school year. The content of each program varies, but includes aeronautics or space science topics of interest to elementary and secondary teachers. NASA program managers, scientists, astronauts, and education specialists are featured presenters. The videoconference series is free to registered educational institutions. To participate, the institution must have a C-band satellite receiving system, teacher release time, and an optional long distance telephone line for interaction. Arrangements may also be made to receive the satellite signal through the local cable television system. The programs may be videotaped and copied for later use. For more information, contact: Videoconference Producer, NASA Teaching From Space Program, 308 A CITD, Oklahoma State University, Stillwater, OK 74078-0422
E-Mail: nasaedutv@smtpgate.osu.hq.nasa.gov

NASA Television features programming that has three blocks—Education File, History File, and News Video File—repeated at intervals 24 hours a day. Programs feature:

- Space Shuttle mission coverage
- Interactive education videoconferences
- Aviation and space news
- Live special events
- Electronic field trips
- Historical NASA footage

The *Education File* features programming for teachers and students on science, mathematics, and technology. You and your class can investigate exciting NASA research endeavors in aeronautics, microgravity, planetary sciences, human exploration of space, Earth systems, robotics, and more. Educators are welcome to videotape NASA TV. For more information, contact: NASA TV, NASA Headquarters, Code P-2, Washington, DC 20546 Phone: (202) 358-3572

NASA Teacher Resource Center Network

To make additional information available to the education community, the NASA Education Division has created the NASA Teacher Resource Center (TRC) network. TRCs 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. Because each NASA field center has its own areas of expertise, no two TRCs are exactly alike. Phone calls are welcome if you are unable to visit the TRC that serves your geographic area. A list of the centers and the geographic regions they serve starts at the bottom of this page.

Regional Teacher Resource Centers (RTRCs) offer more educators access to NASA educational materials. NASA has formed partnerships with universities, museums, and other educational institutions to serve as RTRCs in many states. Teachers may preview, copy, or receive NASA materials at these sites. A complete list of RTRCs is available through CORE.

NASA 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 of these materials and an order form by written request, on school letterhead to:

NASA CORE
Lorain County Joint Vocational School
15181 Route 58 South
Oberlin, OH 44074
Phone: (216) 774-1051, Ext. 293 or 294

IF YOU LIVE IN:		Center Education Program Officer	Teacher Resource Center
Alaska Arizona California Hawaii Idaho Montana	Nevada Oregon Utah Washington Wyoming	Mr. Garth A. Hull Chief, Education Programs Branch Mail Stop 204-12 **NASA Ames Research Center** Moffett Field, CA 94035-1000 PHONE: (415) 604-5543	NASA Teacher Resource Center Mail Stop T12-A **NASA Ames Research Center** Moffett Field, CA 94035-1000 PHONE: (415) 604-3574
Connecticut Delaware District of Columbia Maine Maryland Massachusetts	New Hampshire New Jersey New York Pennsylvania Rhode Island Vermont	Educational Programs Code 130 **NASA Goddard Space Flight Center** Greenbelt, MD 20771-0001 PHONE: (301) 286-7206	NASA Teacher Resource Laboratory Mail Code 130.3 **NASA Goddard Space Flight Center** Greenbelt, MD 20771-0001 PHONE: (301) 286-8570
Colorado Kansas Nebraska New Mexico	North Dakota Oklahoma South Dakota Texas	Dr. Robert W. Fitzmaurice Center Education Program Officer Education & Information Services Branch - AP2 2101 NASA Road 1 **NASA Johnson Space Center** Houston, TX 77058-3696 PHONE: (713) 483-1257	NASA Teacher Resource Room Mail Code AP2 2101 NASA Road 1 **NASA Johnson Space Center** Houston, TX 77058-3696 PHONE: (713) 483-8696
Florida Georgia Puerto Rico Virgin Islands		Dr. Steve Dutczak Chief, Education Services Branch Mail Code PA-ESB **NASA Kennedy Space Center** Kennedy Space Center, FL 32899-0001 PHONE: (407) 867-4444	NASA Educators Resource Laboratory Mail Code ERL **NASA Kennedy Space Center** Kennedy Space Center, FL 32899-0001 PHONE: (407) 867-4090

IF YOU LIVE IN:	Center Education Program Officer	Teacher Resource Center
Kentucky North Carolina South Carolina Virginia West Virginia	Ms. Marchelle Canright Center Education Program Officer Mail Stop 400 **NASA Langley Research Center** Hampton, VA 23681-0001 PHONE: (804) 864-3313	NASA Teacher Resource Center for **NASA Langley Research Center** Virginia Air and Space Center 600 Settler's Landing Road Hampton, VA 23699-4033 PHONE: (804)727-0900 x 757
Illinois Indiana Michigan Minnesota Ohio Wisconsin	Ms. Jo Ann Charleston Acting Chief, Office of Educational Programs Mail Stop 7-4 **NASA Lewis Research Center** 21000 Brookpark Road Cleveland, OH 44135-3191 PHONE: (216) 433-2957	NASA Teacher Resource Center Mail Stop 8-1 **NASA Lewis Research Center** 21000 Brookpark Road Cleveland, OH 44135-3191 PHONE: (216) 433-2017
Alabama Arkansas Iowa Louisiana Missouri Tennessee	Mr. Jim Pruitt Acting Director, Education Programs Office Mail Stop CL 01 **NASA Marshall Space Flight Center** Huntsville, AL 35812-0001 PHONE: (205) 544-8800	NASA Teacher Resource Center for **NASA Marshall Space Flight Center** U.S. Space and Rocket Center P.O. Box 070015 Huntsville, AL 35807-7015 PHONE: (205) 544-5812
Mississippi	Dr. David Powe Manager, Educational Programs Mail Stop MA00 **NASA John C. Stennis Space Center** Stennis Space Center, MS 39529-6000 PHONE: (601) 688-1107	NASA Teacher Resource Center Building 1200 **NASA John C. Stennis Space Center** Stennis Space Center, MS 39529-6000 PHONE: (601) 688-3338
The Jet Propulsion Laboratory (JPL) serves inquiries related to space andplanetary exploration and other JPL activities.	Dr. Fredrick Shair Manager, Educational Affairs Office Mail Code 183-900 **NASA Jet Propulsion Laboratory** 4800 Oak Grove Drive Pasadena, CA 91109-8099 PHONE: (818) 354-8251	NASA Teacher 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
California (mainly cities near Dryden Flight Research Facility)		NASA Teacher Resource Center Public Affairs Office (Trl. 42) **NASA Dryden Flight Research Facility** Edwards, CA 93523-0273 PHONE: (805) 258-3456
Virginia and Maryland's Eastern Shores		NASA Teacher Resource Lab NASA Goddard Space Flight Center **Wallops Flight Facility** Education Complex - Visitor Center Building J-17 Wallops Island, VA 23337-5099 Phone: (804) 824-2297/2298