NASA EP-21

TEACHING TO MEET THE CHALLENGES OF THE SPACE AGE

BY FLORENCE V. OTHS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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My sincere appreciation is offered to the following teachers and supervisors:

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For cooperation in trying out this material in their classrooms,

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Geraldine Smith, Public School 138, Bronx	Raymond Drescher
Jean Tracy, Public School 146, Bronx	Emanuel Margolies
Edith Wilner, Public School 99, Bronx	Isador Zobel

For reviewing the material and giving me valuable criticism,

Milton Breenberg, Junior High School 123, Bronx	Jack Evansohn
Edward Hom, Junior High School 136, Bronx	Robert Greenberg
Paul Jackson, Junior High School 98, Bronx	Saul Sigelschiffer
Robert Lewis, Junior High School 125, Bronx	Ralph Freyer
Herman La Fontaine, Junior High School 120, Bronx	Abraham Silverman
Bernard Stein, Junior High School 60, Bronx	Sophie Conroy
Lawrence Larkin, Junior High School 101, Bronx	Allan Kurtz
Murray Tubelle, Office of Asst. Supt., 17-18, Bronx	Benjamin E. Strumpf

For the illustrations,

Vivian Siegel, Public School 66, Bronx, Art Specialist
Murray Tubelle, Office of Asst. Supt., Districts 17-18, Science Coordinator

For technical and editorial assistance,

Leonard Simon, Mathematics Coordinator, Bureau of Curriculum Research, N.Y.C.
Allan Simon, Project Director, Loral Electronics Division, Bronx, N.Y.
Marion Kiernan, Guidance Coordinator, Office of Asst. Supt., Districts 17-18, Bronx
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TEACHING TO MEET THE CHALLENGES OF THE SPACE AGE

—A Handbook in Aerospace Education for

Elementary School Teachers

by

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New York City Board of Education

An Aerospace Instructional Materials Project of the Office of Educational Programs and Services of the National Aeronautics and Space Administration and the State University College at Plattsburgh, New York.

Washington, D. C.
Government Printing Office
November 1963

ACKNOWLEDGEMENTS

Teaching to Meet the Challenges of the Space Age, a handbook in aerospace education for elementary school teachers, was conceived and begun at the Aerospace Education Workshop, at State University College Plattsburgh, New York, in July 1962. I attended this workshop as one of twelve teachers selected from several sections of the Nation to participate in a curriculum materials production project, which was supported by the National Aeronautics and Space Administration. In the months that followed, I prepared and refined the manuscript and also gave the materials a try-out with 50 selected teachers and a committee of principals of Districts 17-18, Bronx, the New York City Public Schools.

In expressing my appreciation, I first wish to thank Dr. Benjamin E. Strumpf, Assistant Superintendent of Schools, Districts 17-18, Bronx, New York City, under whose supervision, guidance, encouragement, and assistance, this project was developed. I am sincerely grateful for all the help that so many of my colleagues and associates have given me. Second, I wish to thank the members of the National Aeronautics and Space Administration Staff, particularly, Mr. Everett E. Collin, Chief, Educational Services Branch; Mr. George Gardner, Director, Educational Publications Program, Dr. Mattison L. Story, Educational Specialist. I also thank Mr. John W. Casey, Technical Consultant, Educational Services, and Mrs. Eileen Allen, Editorial Assistant, and Mr. Robert H. Carlton, Executive Secretary, National Science Teachers Association. And finally, I thank Dr. Frederick B. Tuttle, then Associate Dean of the State University College at Plattsburgh and Chairman of the Plattsburgh Workshop Planning Committee, who organized the Workshop and has continued to encourage and assist me in this enterprise.

Florence V. Oths

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INTRODUCTION

How very swift today, the pace of Progress! Tomorrow is today! And yesterday is "way back when." How very true for the children of the Aerospace Age: children who find this world less strange than do we, children filled with curiosity and enthusiasm, imagination and realism—hungering to know what the day after tomorrow may hold.

We, the teachers, have the grave responsibility to help children

- broaden and deepen their knowledge and understanding of the developments taking place around them;
- develop new concepts of distance, size, time, direction, and motion;
- redefine their earth-oriented language so that it has new meaning for use in the Space Age;
- explore, experiment, and speculate about the universe from the vantage point of their space station, the earth.

In order to meet this responsibility, we teachers must develop classroom programs which are in step with the accelerated changes of the Space Age.

TO YOU, THE TEACHER

"EDUCATION IS NOT A DESTINATION: IT IS A JOURNEY"

We designed this teachers' handbook for all elementary school teachers, and especially for those of you who teach grades four, five, and six. Its emphasis on aerospace content illustrates an important principle of modern education, namely, to relate work in the classroom to the world outside. The following pages contain brief, or capsule, samples of interrelated curriculum activity, which we hope will assist you in introducing the space age to your classes.

We have organized the materials of this handbook into six major sections entitled—The Mystery of the Universe, Doorways to the Sky, Spaceward Ho, The Spearheads to Space, The Challenge of Space Exploration, and The Rewards of Space. These, in turn, we subdivided into teaching units.

To provide ready reference for you in planning and teaching the units, we have arranged the background material and topics of each on two face-to-face pages. On the left hand page are content, word study, concepts, vocabulary and readings; facing it, on the right hand page, are numerous suggestions for using the space related content of the preceding and opposite page in your teaching of the several subjects. Printed and audio-visual references and source materials are keyed by numbers in parentheses—(1), (2), etc.—and these titles are listed in Section VII, page 38. At the end of the volume we have included six Manila envelopes, one for each section, for you to file appropriate pictures and clippings.

Listed below are suggestions for using this handbook:

1. Think of this handbook as a curriculum guide for enriching many of the subjects you teach with space-science content.

2. Check the science aspects of this brochure against the science course of study, textbook, or other curriculum material that you may use to provide scope and sequence for your science teaching. Note the number of suggestions the following pages provide for your teaching.

3. Select, adapt, simplify, or embellish the suggestions given in these plans to meet the specific needs of the children in your class.

4. Make every effort to obtain reference materials and other materials of instruction, prior to teaching.

   a. Write for materials to the National Aeronautics and Space Administration, Publications Branch AFEE-1, NASA Headquarters, Washington, D. C. 20546. Also consult Section IX, "Listing of Free and Inexpensive Materials."

   b. Write to NASA to find out when the Spacemobile will be available to visit your school. (See Section XII.)

5. Invent challenging ways for children to use aerospace vocabulary in meaningful situations.

6. Encourage children to find out things for themselves as suggested by the item "For Further Exploration."

7. Keep abreast of current information and add new aerospace terms to the lower left hand corner of the left hand page, under "Updating the Vocabulary."

8. Please remember that these samples of curriculum guidelines are to serve as springboards for capitalizing on children's natural curiosity and imagination. Each can be made the nucleus of countless teaching situations which may involve many aspects of the curriculum.

TO THOSE WHO ARE TEACHING IN THIS EVER-CHANGING WORLD

If we believe that the prime value of education in our fast-evolving world is its power to enable students to invent and to create new learnings, to prepare them to test, absorb, and use in the future things which nobody knows today, then the goal of the twentieth century teachers must be, more than ever, to implant a love of knowledge and the desire to expand it, and to create in the student a climate of receptivity for knowledge that does not yet exist.

Laurence B. Johnson

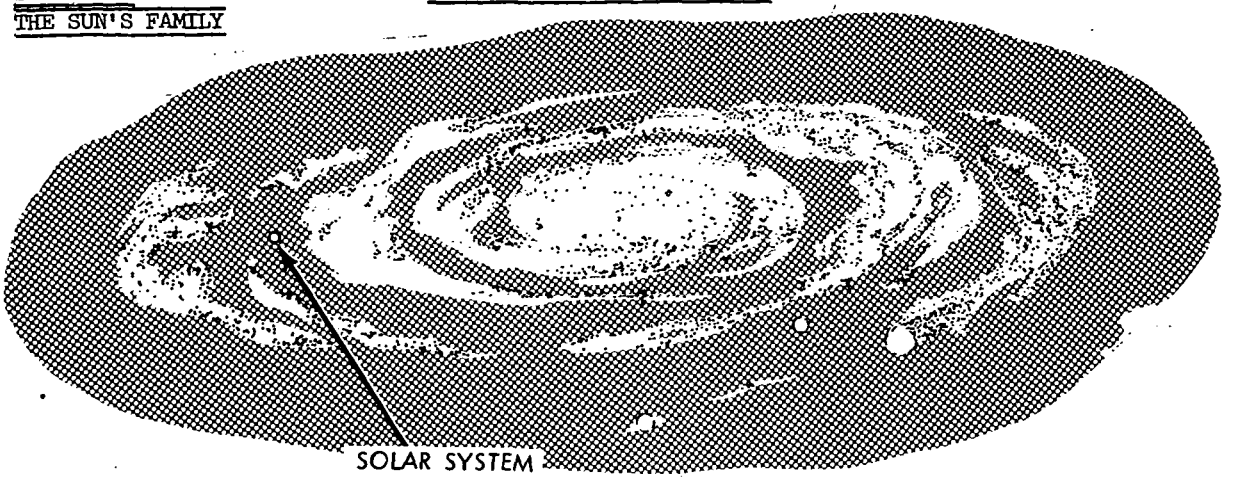
EACH DAY I LEARN MORE THAN I TEACH

Agatha Brown

SECTION I

THE SUN'S FAMILY

THE MYSTERY OF THE UNIVERSE



"TWINKLE, TWINKLE, LITTLE STAR, HOW I WONDER WHAT YOU ARE,
UP ABOVE THE WORLD SO HIGH, LIKE A DIAMOND IN THE SKY."

Did you know that the sun is a star, one of the billions of stars in the universe? It looks larger than the others because it is so close to the earth, only 93 million miles away. Can you imagine how far away the other stars must be that you see in the sky at night?

The sun has been radiating light into space for billions of years. It shines in all directions at the same time and gives heat from its own internal energy to all its family in the solar system. Because of the sun's light and heat, life is made possible on our planet, the earth. Planets are different from stars in that they are not self-luminous. The earth's light comes from the sun.

Imagine the sun as the center of a solar racetrack around which are streaking—

- nine planets each spinning like a top (rotating) and moving around the sun at different speeds (revolving);
- satellites, or little moons, revolving about some planets;
- thousands of asteroids (small planets) racing around the sun;
- and meteors, true visitors from outer space, shooting across the sky.

What a family our sun has. But there are many other suns with families of planets far off in outer space. Little is known about their families. Some day, however, space exploration may tell us what we want to know about them.

Some Related Aerospace Concepts

(1) The sun is a star.
(2) The sun is the center of a system of bodies in space, such as asteroids, comets, and planets, which revolve around it.
(3) In general, all planets move in the same direction in their nearly circular orbits around the sun.
(4) The earth's rotation gives one the impression that the sun and stars move across the sky.
(5) Add others.

FOR A MEANINGFUL VOCABULARY

asteroids	revolving
billions	rotating
energy	satellites
internal	solar
luminous	system
meteors	universe
radiating	

UPDATING THE VOCABULARY

REFERENCES FOR TEACHERS AND CHILDREN

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U. S. National Aeronautics and Space Administration, Orbiting Solar Observatory. Washington, D. C.: National Aeronautics and Space Administration, Office of Educational Programs and Services. (NASA FACTS, B-62) (T)

A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understandings of aerospace facts)

THE SUN'S FAMILY

To provide the class with experiential motivation, introduce the question, "Why do we call the solar system the sun's family?" Show filmstrips such as You and the Universe (1) and The Planets.(2)

LANGUAGE ARTS ORAL	Observing Listening Speaking	- To develop skill in gathering information, have children answer previously prepared questions about the films the class has seen. To encourage skill in story-telling, have children relate and discuss such myths as "Daedalus" and "Phaeton." (3)
LANGUAGE ARTS WRITTEN	Functional writing	- To practice outlining, have class prepare an outline of one of the films observed or stories read.
	Creative writing	- To develop skill in organizing ideas around a topic, have class write a "cooperative" play in which the planets are personified with Mars representing a fierce warrior, Venus, a beautiful lady, Jupiter, a powerful giant.
	Word study	- To foster understanding of combining forms and prefixes, call class attention to combining form uni in the word universe and the prefix pre in predict. Have children add to their word lists such words as unicorn, unified, unicycle, preview, predict, and preschool.
	Punctuation	- To illustrate use of the comma between words of a series, have children write and punctuate sentences with lists of the planets, lists of the seasons, points of the compass, and forces of nature.
	Reading	- To develop skill in obtaining information from published sources, seek answers to questions class may raise about planets. Use encyclopedias, dictionaries, and tables of contents or indexes of such books as Nourse's Nine Planets (4) and Freeman's Fun with Astronomy.(5)
	Literature	- To encourage appreciation for the classics, dramatize selected passages from Bullfinch's The Age of Fable. (6)
SOCIAL STUDIES	Concept development	- To consider new concepts of the relations between the sun and man's life on earth, introduce the question, "How does the sun influence industry around the world?" Talk about clothing, occupations, plant life, and leisure time activities.
	Map or globe skills	- To develop skill in reading map legends, have class make map of solar system with appropriate legend.
SCIENCE	Activity	- Draw a blackboard solar system, your classroom "planetarium."
	Observation	- What differences are there in size and distance among planets?
	Concept	- Our solar system extends over vast distances.
	Follow-up	- Find out more facts about other solar systems.
MATHEMATICS	Concept or skill development	- To develop the concepts of double, triple, etc., have class find out sizes of the planets, and tell approximately how much larger one is than the other; i.e., earth is approximately twice the size of Mars; Mars is one-half the size of earth.
HEALTH EDUCATION		To develop understanding of the sun's contribution to health, discuss Vitamin D and its sources.
ART		To develop understanding of principles governing use of color, use bright and dark colors when constructing backdrops for the play suggested above.
MUSIC		To enrich the listening repertoire of children, set up a "listening corner" in which you have collected a folio of records about space.

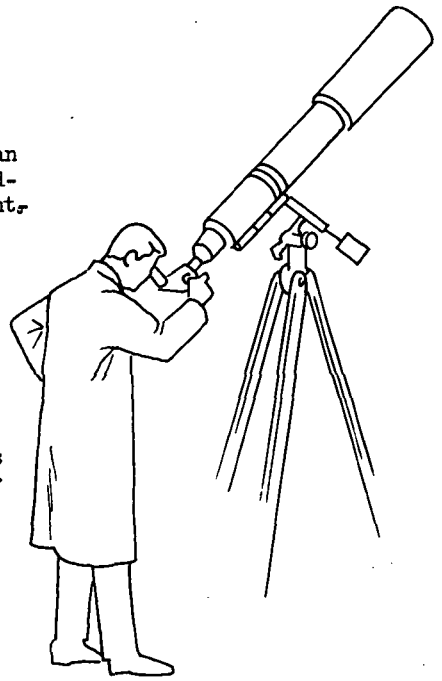
ACTIVITIES FOR REINFORCING LEARNINGS	FOR FURTHER EXPLORATION
Construct a vocabulary chart with solar system terms.	Why do planets remain in their orbits?
Conduct an experiment showing necessity of sunlight for plant growth.	Why does the sun seem to move, rising in the east and setting in the west?
Use a thermometer to show changes of temperature in direct sunlight and in shade.	Why can't we see the stars during the day?
(ADD OTHERS)	(ADD OTHERS)

SECTION I

THE MYSTERY OF THE UNIVERSE

REACHING OUT TO THE STARS

As we look into the sky, we see thousands of stars with the naked eye. By using instruments, we can see many more, which seem to stretch across the sky in a milky band. This Milky Way, called our galaxy, is but one of the many galaxies which make up our universe. We want to find out: How far away are the stars? What is their size, and their color? How do stars move, and why? What pictures, that is, constellations, like Orion and the Big Dipper, do they form in the sky?



When we think of the millions and billions of miles of distance in the solar system, we wonder how one can measure and express the distances between the stars. The astronomers have found that the speed of light, about 186 thousand miles (more than seven times around the earth) per second, is one of the best yardsticks we can use for expressing distances in space. Thus a "light-year" is the distance a pulse of light would travel in one year: 186,000 mi./sec. x 60 sec./min. x 60 min./hr. x 24 hr./day x 365 days/yr.= about 6 million million miles (6×10^{12}).

When we look at the stars, we see light that was emitted years ago. The light from our nearest star, called Proxima Centauri, left it $4\frac{1}{2}$ years ago. That star is thus about $4\frac{1}{2}$ light years away, or $4\frac{1}{2}$ x 6 million million miles.

Some of the instruments to help scientists learn about stars and planets and space itself are the telescope, which enables our eyes to see and our cameras to photograph heavenly bodies; the spectroscope, which helps scientists to learn about the chemical composition of stars and planets; the radio telescope, which measures the intensity of radio waves originating in space; and man-made satellites, which radio information about conditions in space.

We can truly say that when we look at the sky, we are looking not only far into distance, but also far back into time.

Some Related Aerospace Concepts

(1) Stars may be grouped into patterns or figures or constellations.
(2) Stars are used by navigators to tell direction.
(3) Stars are very distant suns that produce their own light.
(4) Add others.

FOR A MEANINGFUL VOCABULARY

astronomers
chemical composition
constellation
galaxy
light-year
Milky Way
satellites
spectroscope
system
telescope

UPDATING THE VOCABULARY

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A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understandings of aerospace facts)

REACHING OUT TO THE STARS

To provide the class with experiential motivation, introduce the question, "What do we want to know about the stars?" Use an appropriate filmstrip dealing with the stars.(7) Take field trip to planetarium, if feasible, and set up bulletin board display in classroom.

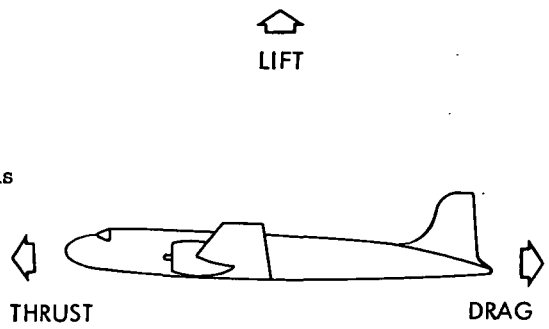
LANGUAGE ARTS ORAL	Observing Listening Speaking	- To encourage appreciation and cultivate observational skills, have children describe the appearance of the sky in different seasons, noting changes in pattern and color. To improve skills in group discussion, have class compare individual observations of the sky. To develop skill in choral speaking, have class read such poems as "Star Tonight" by Sara Teasdale. (8)
LANGUAGE ARTS WRITTEN	Functional writing	- To develop skill in record-keeping, make lists of constellations and keep records of star-gazing experiences.
	Creative writing	- To practice paragraph development, write descriptive paragraphs on such subjects as "I Lived in a Star City," "The Night Has a Thousand Eyes," "A Trip along the Milky Way."
	Word Study	- To improve dictionary skills, find correct pronunciations for star names. Add lists of the names of constellations to daily spelling lists.
	Punctuation	- To increase skill in punctuation, practice the use of commas in the heading, salutation, and complimentary closing of letters to an imaginary pen pal on Mars.
	Reading	- To develop skill in finding specific details, read selected paragraphs from such books as Stars by Zim and Baker. (9)
	Literature	- To enhance appreciation of historic legends, read stories about star myths and accounts of the people who created them. (6)
SOCIAL STUDIES	Concept development	- To develop a better understanding of how the stars helped the ancients, review uses of the stars by the early Phoenicians and by such explorers as Christopher Columbus. Relate to satellite navigation of today.
	Map or globe skills	- To practice skills in interpreting maps of the sky, have class make a sky map of your local area showing the zenith, Polaris, and the easily observed constellations.
SCIENCE	Activity	- Stand in a spot. Note the time. Choose a bright star above a landmark. Mark this spot. Return an hour or so later. Stand in exact same spot.
	Observation	- Is your star in a different place in the sky?
	Concept	- Stars are not always in the same place. They appear to move from east to west.
	Follow-up	- Return to original spot at same time the next night. Note star in original place. This shows that a complete revolution of the earth (sidereal day) has occurred.
MATHEMATICS	Concept or skill development	- To increase skill in reading and writing large numbers, investigate and make a record of the size and distances from the earth to the major stars. To reinforce knowledge of fractional parts, locate stars on sky charts which are one-half or one-fourth or one-third the distance between two known stars.
HEALTH EDUCATION		To stress good health habits, discuss the importance of proper clothing and good posture to avoid chills, colds, and muscle stiffness while watching the sky.
ART		To cultivate skill in blending colors, note the range from blue-white to red in prisms and rainbows and compare to simple spectroscopic studies of the stars.
MUSIC		To develop skill in rote singing, learn songs about star and sky from your music text.

ACTIVITIES FOR REINFORCING LEARNINGS	FOR FURTHER EXPLORATION
Plan a field trip to a planetarium or an observatory.	What are some of the superstitions about objects we see in the sky?
Compile a booklet containing sky charts of various constellations.	What astronomical information can be obtained from almanacs?
Collect pictures of stars, meteors, comets, telescopes, and observatories.	
Make a scrapbook of astronomical news from periodicals.	
(ADD OTHERS)	(ADD OTHERS)

WHAT MAKES AIRPLANES FLY

To know how an airplane flies, we must first understand something about air. Air is a material. It has weight. It is fluid. It resists being crowded and will tend to escape to the nearest place where there is less crowding.

An airplane is lifted into the air when an upward force stronger than the force of its own weight, or its response to gravity, is applied to it. This force is called "lift."



An aircraft obtains lift because of the design of its wings. When the wings are moved through the air rapidly, the air divides and flows both over and under them. Because of the shape of the wing, the air travels across the upper side of the wing farther and consequently travels faster. The faster moving air exerts less pressure on the upper surface of the wing, than the slower moving air exerts on the under surface of the wing. This difference in pressure furnishes lift, which keeps planes aloft.

To move the wings through the air, the airplane's engines provide the motive power or "thrust."

Opposed to this thrust is another force called "drag." It is created by the frictional quality of the air, which tends to resist the airplane's passing through it.

The shape of the airfoil and the force of the engines give the airplane lift and thrust which overcome weight and drag.

Some Related Aerospace Concepts

(1) Four forces are at work: weight, lift, thrust, and drag.
(2) Air in motion (wind) can make other things move.
(3) As a plane moves forward, air moves past the wings.
(4) Add others.

FOR A MEANINGFUL VOCABULARY

airfoil
angle
drag
efficiency
fluid
force
gravity
lift
opposed
partial
propeller
substance
surface
thrust
tilted
vacuum
weight

UPDATING THE VOCABULARY

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A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understandings of aerospace facts)

WHAT MAKES AIRPLANES FLY

To provide the class with experiential motivation, make a bulletin board display of various types of planes; show a filmstrip such as Man Learns to Fly (10); exhibit children's model airplanes; take a trip to an airport.

LANGUAGE ARTS ORAL	Observing Listening Speaking	- To train children to observe carefully, prepare a guide to be used when visiting an airport with such information as kinds and sizes of planes, take-off and landing, and plane parts. To teach them to think sequentially, have them report, "What did we do first?" "What did we do next?"
LANGUAGE ARTS WRITTEN	Functional writing	- To practice the skill of using the correct friendly letter form, have each student write to a sick classmate describing the trip to an airport.
	Creative writing	- To strengthen the skill of developing a topic sentence, write a few on the blackboard such as, "When I took up an airplane for my first solo flight, I . . ."
	Word study	- To discover how words may be formed from "root" words, begin a functional vocabulary list using the root, air. Include meanings.
	Correct usage	- To clarify the concept of agreement in number of subject and predicate, have children proofread their compositions with this rule in mind.
	Reading	- To gain ability in the skill of skimming for culling information, use reference sources such as encyclopedias and almanacs to get main ideas which may be set down in an outline form.
	Literature	- To encourage children to appreciate nonfiction books, provide many such books on an easy reading level, e.g., The How and Why Wonder Book of Flight. (11)
SOCIAL STUDIES	Concept	- To enlarge on the idea of time and distance relationships, use such topics as, "Our World Daily Becomes Smaller." Compare the time taken and the distance covered between the early explorations of the 15th and 16th centuries by Columbus, Magellan, and Balboa with those of today by Lindbergh, Glenn, and Cooper.
	Map or globe skills	- To illustrate the differences between surface and air distances, introduce polar and air route maps. Explain how our concepts of distance have changed.
SCIENCE	Activity	- Use a strip of paper two inches wide and six inches long. Hold it at one end with thumb and forefinger, so that it falls in a curve. Blow over the top of the paper.
	Observation	- In which direction did the paper move?
	Concept	- The pressure is decreased on top of the paper. The greater air pressure below the paper lifts it up.
	Follow-up	- Consult your science text for other experiments which demonstrate Bernoulli's principle.
MATHEMATICS	Concept or skill development	- To reinforce multiplication and division skills, show children how to convert inches to feet, yards to inches, yards to miles, miles to feet.
HEALTH EDUCATION		To emphasize the importance of taking care of our ears, explain how altitude and speed affect our hearing. Have children relate their personal experiences. Experiment with vibrations of sound.
ART		To illustrate the idea of "streamlining," make a time line airplane border showing the construction of planes from their inception to spacecraft.

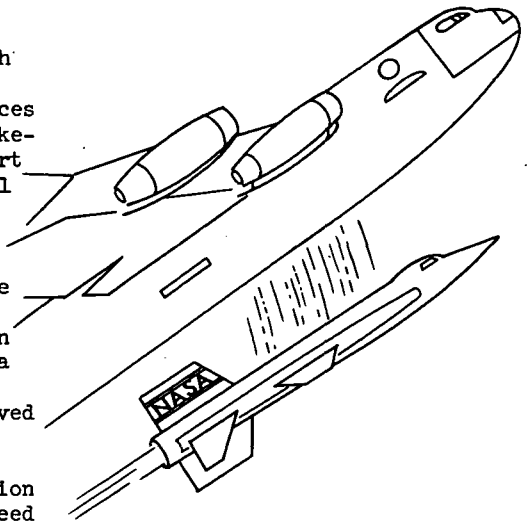
ACTIVITIES FOR REINFORCING LEARNINGS	FOR FURTHER EXPLANATION
Make a picture dictionary of related words.	What are practical uses of planes?
Make a study of flight personnel.	How does a helicopter work?
Construct paper models of planes, hangars, and an airport.	What is the place of the balloon in the air story?
	What training does a pilot need?
	What safety rules must be observed?
(ADD OTHERS)	(ADD OTHERS)

AVIATION IN THE SPACE AGE

The early flights of the Wright brothers seemed truly miraculous. Today, however, aviation has become an indispensable servant of all mankind. High-speed aircraft, traversing miles in fractions of minutes, have made the world seem smaller and have revolutionized our lives.

Solutions to some of the problems of aviation, such as the need for more airport space, safety devices, and improved landing techniques, have resulted in new advances in aircraft design and development. The STOL (short take-off and landing) aircraft is designed to use a very short runway for its take-off and landing. The VTOL (vertical take-off and landing) aircraft rises vertically, then shifts to horizontal flight.

To solve some of the problems of very high altitude and high speed flight, scientists and engineers have developed the X-15 rocket ship. This airplane has flown to an altitude of over 67 miles; it has also flown at a speed of over four thousand miles per hour. When the problems of high altitude and high speed flight are solved by experimental planes such as the X-15, passenger airplanes will be built to fly at such heights and speeds. Someday, we may find ourselves arriving at our destination a couple of hours before we left home because of the speed with which we travel through the time zones.



Some Related Aerospace Concepts

(1) The design of the plane and the speed at which it travels determines the lift.
(2) If a plane is flying at the speed of sound, it is said to be flying at Mach I.
(3) The speed of sound is different at different altitudes.
(4) At sea-level, the speed of sound is about 760 miles per hour.
(5) Add others.

FOR A MEANINGFUL VOCABULARY

altitude
destination
devices
experimental
indispensable
Mach I
STOL
techniques
traverse
vertical
VTOL
X-15

UPDATING THE VOCABULARY

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A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understandings of aerospace facts)

AVIATION IN THE SPACE AGE

To provide class with an experiential motivation, introduce the question, "In what ways will the newly designed aircraft affect our lives?" Show the film, X-15 Documentary. (12)

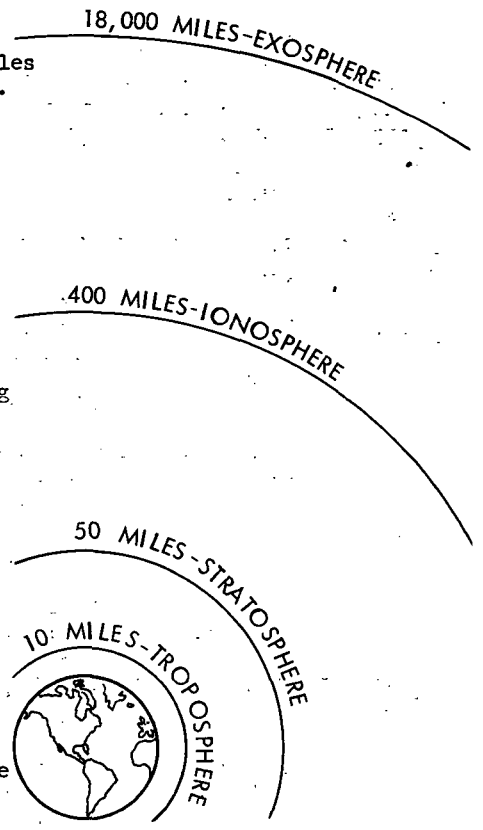
LANGUAGE ARTS ORAL	Observing Listening Speaking	- To increase skill in observing differences and similarities, examine pictures and listen to explanations of X-15 aircraft. (13) To develop skill in describing details, tell about the VTOL, explaining design of wings, take-off, speed attainable.
LANGUAGE ARTS WRITTEN	Functional writing	To improve skill in outlining, prepare outlines for papers on global flight and its implications for the future. Use such topics as speed, international understanding, geographical boundaries, etc.
	Creative writing	- To organize ideas around a topic, write themes suggested by the sentence fragment, "I was flying faster than sound when . . ."
	Word study	- To increase facility in using diacritical marks, have each child make a list of new words encountered in the lesson, using the dictionary for determining placement of diacritical marks.
	Usage and punctuation	- To give practice in writing compound sentences, have children develop the outline suggested above, into a two- or three-paragraph paper, with each paragraph having two compound sentences.
	Reading	- To develop skill in reading for specific details, have students read, "I fly the X-15," by Joseph A. Walker, (14) and articles about the X-15 in newspapers and periodicals that may provide additional information.
	Literature	- To encourage children to read independently, have them report on legends and myths about flight. (6)
SOCIAL STUDIES	Concept development	- To stimulate the children's interest in the influence of environment on man, have them plan an airline trip to Africa, and then read about places they may visit such as Kenya, Congo, and South Africa.
	Map or globe skills	- To develop skills in map reading, draw air travel routes on a globe and then on a map, noting that the shortest air-line route as laid out on a globe may appear to be the longest when plotted on a map.
SCIENCE	Activity	- Seat a doll at the back end of a shoe box which has been tied to a roller skate. Push the skate so that it rolls along the floor over obstructions which suddenly slow it down. Repeat with doll sitting with its back against the front of the box.
	Observation	- What happened to the doll when the roller skate was suddenly slowed?
	Concept	- In the space capsule, the position and design of the astronaut's couch helps him withstand the forces of deceleration (slowing down) as he reenters the atmosphere.
	Follow-up	- Consult your science text for more experiments illustrating this concept.
HEALTH EDUCATION		To encourage understanding of good mental and emotional health, discuss the relationships between one's leisure time, his vacation time, and his general health. Consider the greater accessibility of health and vacation resorts provided by higher and faster-flying aircraft.
ART		To stimulate imagination, make mobiles of fanciful or standard aircraft wing designs.
MUSIC		To appreciate the contributions of other countries to the world of music, learn folk songs of various countries, note their distinctive features, and discuss how aviation has truly made us, in a musical sense, one world.

ACTIVITY FOR REINFORCING LEARNINGS	FOR FURTHER EXPLORATION
Do independent experiments showing principles of gravity.	What happens when very high—and fast-flying airplanes enter the denser atmosphere?
Make aeronautical charts; draw to exact scale.	Why are the pilots of these aircraft not called astronauts?
Construct a time line of aircraft history.	What is meant by Mach number?
Invent names for future aircraft.	
(ADD OTHERS)	(ADD OTHERS)

SECTION III

SPACEWARD HO!

WHAT SPACE IS



Although space seems to be empty, it is really filled with widely dispersed materials, ranging from tiny, sub-atomic particles to such massive bodies as stars and planets. Space surrounds us. The earth, with its life-supporting atmosphere, is one body in space.

Let us ascend through the layers of the earth's atmosphere and learn what happens!

The lower layer of the earth's atmosphere is called the troposphere. It reaches as high as 10 miles above the earth. It is where many weather phenomena occur.

Above the troposphere is the stratosphere which extends to a height of about 50 miles from earth. The winds are very strong there, and the temperature reaches as low as minus 200 degrees Fahrenheit.

The ionosphere is the third layer of atmosphere and reaches a height of 400 miles or so above the earth. Here the air is very thin. It contains electric particles called ions.

The fourth layer, the exosphere, extends outward to about 18 thousand miles. Long before this height is reached, the molecules which compose the air we breathe are so far apart that we could not inhale enough of them to live.

Beyond the exosphere is outer space. Here, we must wear special clothing to protect ourselves; not only from the powerful rays from the sun and outer space, but also from extreme temperatures. We must also bring with us, as we travel through the exosphere and outer space, the air we need to breathe.

Some Related Aerospace Concepts

(1) We live at the bottom of an ocean of air.
(2) Air thins out as we go upward.
(3) It takes up space.
(4) Air has weight and exerts pressure.
(5) The earth's atmosphere does not have a specific and definable boundary.
(6) Space is dark.
(7) The earth, along with its atmosphere, is a body in space.
(8) Add others.

FOR A MEANINGFUL VOCABULARY

ascend	ionosphere
atmosphere	massive
cosmic rays	molecules
exosphere	phenomena
Fahrenheit	stratosphere
infinity	sub-atomic
inhale	temperatures
ions	troposphere

UPDATING THE VOCABULARY

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A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understandings of aerospace facts)

WHAT SPACE IS

To provide the class with experiential motivation, introduce the question, "What does man know about space?" Use an appropriate science book, such as What is Space? (15)

LANGUAGE ARTS ORAL	Observing Listening Speaking	- To cultivate skill in observation, have class answer questions about selected frames in appropriate filmstrips or other available visual aids. (16) Discuss new concepts gained from these aids. Prepare an experiential chart noting these facts.
LANGUAGE ARTS WRITTEN	Functional writing	- To develop skill in organizing, plan a brief handbook of facts about space.
	Creative writing	- To develop skill in writing a topic sentence with three or four related ideas, utilize such beginnings as the following: "As I leave the launch pad in my space capsule, I can see . . ."
	Word study	- To cultivate familiarity with word formation, using roots, prefixes, and combining forms, have class practice with the root sphere, adding ion, tropo, strato, exo, hemi, and others.
	Punctuation	- To increase skill in the use of quotation marks, have class write brief conversational themes using astronauts as characters.
	Reading	- To build understanding of patterns for predicting outcomes, have class read Weather in Your Life, by Irving Adler. (17) Let them form hypotheses about kinds of weather that may occur in various layers of the atmosphere, such as the troposphere and stratosphere, and verify these hypotheses through library research.
SOCIAL STUDIES	Concept development	- To encourage understanding of the space environment, list the new wonders experienced by our spacemen, lights from heavenly objects, communication between earth and space, and problems of reentry into the atmosphere.
	Map or globe skills	- To develop facility in reading bar graphs, have class make a bar graph showing relative heights of zones of the atmosphere. Make another graph showing planet distances from the sun.
SCIENCE	Activity	- Pour water into a rectangular metal can to a depth of about $\frac{1}{2}$ inch. Put a cork stopper loosely into the top opening of the can. Heat the can until water boils, and let steam escape for about 2 minutes. Remove heat source, push stopper tightly into can opening. Wait for can to cool; pour cold water over it to speed cooling.
	Observation	- What happens to the can?
	Concept	- Air exerts pressure.
	Follow-up	- Consult your science textbook for other experiments with air pressure.
MATHEMATICS	Concept or skill development	- To develop skill in reading numbers of large value, have class determine distances involved in leaving earth for destinations in space such as the moon, Venus, Mars, Jupiter, and Saturn. To reinforce skills in division, have class compute length of time it would take to arrive at various space destinations at the speed of 25,000 miles per hour.
HEALTH EDUCATION		To stress man's basic needs for oxygen, food, and water, discuss the effect of space travel upon man as he leaves the earth's environment.
ART		To teach other meanings of the word space, have class design a bulletin board illustrating attractive arrangement, or spacing, of the materials.
MUSIC		To enrich your classroom music program, have children compose simple, original songs about the atmosphere and space.

ACTIVITIES FOR REINFORCING LEARNINGS

Write reports on current happenings in space

Find accounts and pictures telling of conditions encountered in mountain climbing and balloon ascent.

Learn to read a Fahrenheit thermometer. Why are temperatures of minus 200 degrees, minus 500 degrees, or minus 1000 degrees, not shown on your household thermometer?

Build individual vocabulary lists of aerospace terms.

(ADD OTHERS)

FOR FURTHER EXPLORATION

Why is outer space dark?

Why do radio communications become disrupted occasionally?

What are the properties of different layers of the atmosphere?

(ADD OTHERS)

SECTION III SPACEWARD HO!

HARNESSING ROCKET POWER

". . . three, two, one, zero!" And another rocket blasts off toward space.

All rockets ever assembled—even the earliest sky-rocket fireworks—have one thing in common. They all work because of Newton's Third Law of Motion, "For every action there is an equal and opposite reaction."

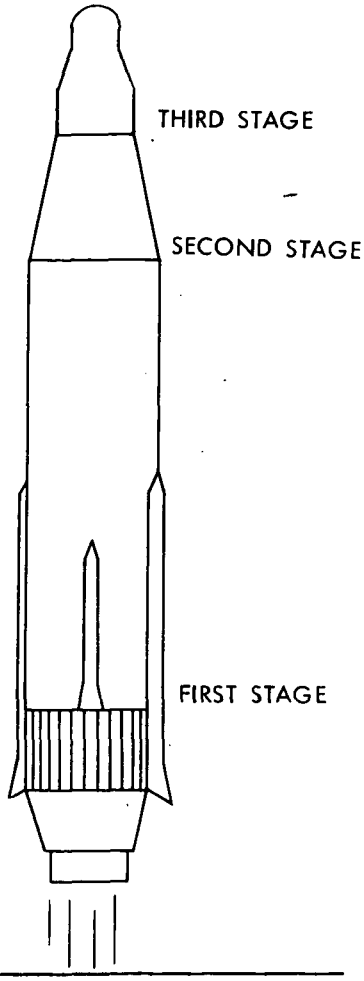
Launch vehicles use either liquid or solid fuels as rocket propellants. Most of the rockets used today have liquid fuel; often the fuel is kerosene and liquid oxygen (LOX).

The speed of the launch vehicle depends upon its design and the amount and kind of propellant it can carry to burn. Our planet, Earth, exercises a gravitational pull so strong that several hundred pounds of propellants are needed to launch only one pound of load.

We learned to overcome the force of gravity by piling one rocket on top of another. In a three-stage rocket, the first stage lifts the rocket only so high, then breaks away when its fuel is burned. The second stage boosts the vehicle higher. The third stage fires to give the vehicle the necessary speed to carry out its mission. As each stage breaks away, the vehicle becomes lighter and moves faster.

After separation from the final stage of the rocket, the nosecone, which contains the payload, such as instruments, warhead, or man, may go into orbit as a satellite or return directly to earth. The nosecones in which astronauts ride must be built to withstand the extremely high temperatures caused by reentry into the atmosphere.

America has learned a great deal about building rockets in the past five years. Vanguard I, one of our first satellite projects, placed a payload of only three pounds in orbit. The mighty Saturn V, now being built, will be able to place nearly 250,000 pounds into earth orbit.



Some Related Aerospace Concepts

(1) Rockets can travel in airless space, because they carry their own oxygen source and do not need air for lift.
(2) The pull of the earth's gravity upon an object weakens as the object moves away from earth.
(3) Jet and rocket vehicles are moved by the force of high pressure gases generated in their engines.
(4) Inertia is the tendency of an object in motion to stay in motion.
(5) Add others.

FOR A MEANINGFUL VOCABULARY

action-reaction
assembled
boosts
chamber
fuel
gravitational
inertia
liquid
LOX
motion
nosecone
opposite
oxygen
payload
propellant
reentry
rocket
stage
warhead

UPDATING THE VOCABULARY

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A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understandings of aerospace facts)

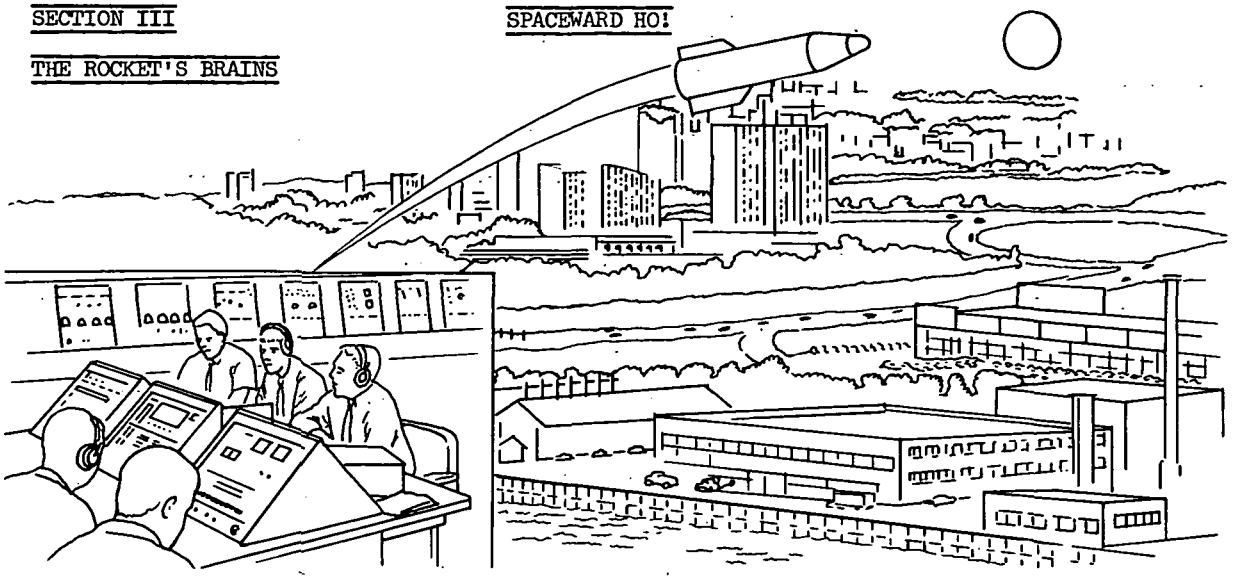
HARNESSING ROCKET POWER

To provide the class with an experiential motivation, use a toy balloon to show the principle of jet propulsion. Start a class bulletin board for rockets and launch vehicles. Read the fable, "The Eagle and the Wren." (18)

LANGUAGE ARTS ORAL	Observing Listening Speaking	- To develop skills in gathering and listing information, keep a log over a period of time, noting illustrations of action and reaction; e.g., boy getting out of rowboat. To increase children's ability to present facts objectively, have class discuss different types of rockets, launch vehicles, and fireworks.
LANGUAGE ARTS WRITTEN	Functional writing	- To develop skill in the sequential arrangement of ideas, prepare a cooperative classbook containing stories of the development of rockets from early times until today.
	Creative writing	- To introduce children to the creative possibilities of poetic expression, read the "Star Spangled Banner," explaining its story. Have them write a simple poem about rockets.
	Word study	- Have the class prepare a glossary of common words used in rocketry, including those on the opposite page.
	Capitalization	- To develop mastery of the rules of capitalization, have children proofread their original poem for the capitalization of each proper name and the first word of each line.
	Reading	- To increase skill in reading for specific details, have children read Jets and Rockets and How They Work, by William P. Gottlieb. (19) Compile list of questions they would want other children to answer were they to read the book.
	Literature	- To stimulate the children's imagination, have them dramatize passages from You Will Go to the Moon, by Mae and Ira Freeman. (20)
SOCIAL STUDIES	Concept development	- To gain new concepts of how the development of an idea proceeds by sudden spurts of progress and long periods of inactivity, have students develop time lines for rocket development through the ages.
	Map or globe skills	- To develop skills in locating places on maps and globes, ask children to indicate by colored pins America's world-wide networks of satellite tracking stations.
SCIENCE	Activity	- Wind up three toys such as a truck, a car, and a motorcycle. Place them at the same starting line. Measure how far each one travelled. Wind them up once again. Place the motorcycle atop the car and the car atop the truck. Allow the truck to go as far as it will, then release the car; when the car stops, release the motorcycle.
	Observation	- What was the total distance travelled by all three toys? How does this distance compare with that travelled by each one?
	Concept	- Rockets are usually built in stages as an efficient means for overcoming the pull of gravity. As the fuel in each stage is consumed, the empty section is detached and falls away.
	Follow-up	- Study and read about rocketry. Bring rocket models to class.
MATHEMATICS	Concept or skill development	- To reinforce concept of subtraction, have children compare the distances that various rockets have travelled in space exploration. Use the charts in STL Space Log. (21) Develop problems with the concepts of rate, time, and distance.
HEALTH EDUCATION		To encourage understanding of good health habits involving food, sleep, and adequate rest, emphasize the importance of the daily check-ups of the astronauts and their health routines.
ART		To stimulate an understanding of the "feeling of a poem, use various art media to illustrate the class-original poems about rocketry and rockets requested above.
MUSIC		To bring new meaning to known words, explain the phrase, "rocket's red glare," as used in the "Star Spangled Banner."

ACTIVITIES FOR REINFORCING LEARNINGS	FOR FURTHER EXPLORATION
Prepare a class reference book that includes the following information about rockets:	Why does the earth have light when space is dark?
List of books used;	Can man's life span enable him to travel great distances to far planets?
Answers to common questions;	What is microminiaturization?
Class stories, pictures and articles, original poems;	What does a rocket carry?
Vocabulary list;	
Bibliography of additional references.	
(ADD OTHERS)	(ADD OTHERS)

THE ROCKET'S BRAINS



Homing pigeons are noted for finding their way to a destination miles away. Man has devised instruments which guide airplanes and spacecraft on their missions. Airplanes use radar for safe passage through clouds and fog.

The guidance systems of many of our long-range rockets have electronic instruments that work on the principle of comparing present position with point of destination. Unless the guidance systems work perfectly, our astronauts of the Gemini and Apollo projects may never return safely to earth.

Space vehicles launched by rockets can be equipped with instruments to detect, measure, and record or radio to earth a wide array of information such as pressure, temperature, speed, and radiation.

Some Related Aerospace Concepts

(1) Radar waves can be beamed in any direction; they bounce back when they strike the target.
(2) Radar can "see" weather in advance; it helps direct planes to fly through clouds.
(3) Add others.

FOR A MEANINGFUL VOCABULARY

Apollo project
destination
electrical energy
Gemini project
guidance
gyroscope
orbit
radar
radiation
target
telemetry
transducer
transmitted

UPDATING THE VOCABULARY

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A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understanding of aerospace facts)

THE ROCKET'S BRAINS

To provide the class with experiential motivation, introduce the question, "How can rockets be guided to their targets?" Show a filmstrip such as What are Satellites? (22)

LANGUAGE ARTS ORAL	Observing Speaking Listening	- To practice observational skills and to further the students' knowledge of space vehicles, show pictures of the family of U. S. launch vehicles. Note the size, weight, and names of each. To develop skill in oral communication, discuss the purpose, thrust power, and speed of the various vehicles. (23) How are they guided to their destinations?
LANGUAGE ARTS WRITTEN	Functional writing	- To develop skill in making an outline, have students outline their research reports on such topics as radar, sonar, telemetry, and gyroscopes, as they are used in rocket guidance.
	Creative writing	- To increase proficiency in paragraph building, assign topic sentences such as, "Do you know the rocket has four senses?"
	Word study	- To reinforce dictionary skills, use word elements from the Latin and Greek, such as, son, rad, tele, and meter, to build other words.
	Punctuation	- To practice terminal punctuation, have children proofread paragraphs giving attention to period, question mark, and exclamation point.
	Reading	- To develop the skill of selecting the main idea of a paragraph, use such books as Rockets, Satellites and Space Travel. (24)
	Literature	- To foster an understanding of the difference between a myth and a legend, have children read from books of myths and books of legends. Discuss distinguishing features.
SOCIAL STUDIES	Concept development	- To show relationships between space exploration and the development of industries, find evidence of increased cooperation among nations. Use National Aeronautics and Space Administration materials. (25)
	Map or globe skills	- To develop skills in reading latitude and longitude, work out orbits of modern space flights.
SCIENCE	Activity	- To illustrate how a gyroscope works, spin a toy gyroscope.
	Observation	- Note that its axis maintains the position in which it was initially placed and resists your efforts to change it.
	Concept	- Every rotating body has stability in space.
	Follow-up	- Have children search for other applications of the principle of the gyroscope.
MATHEMATICS	Concept or skill development	- To emphasize the importance of reliability and accuracy, have children solve multiplication and division problems that involve rate of speed, distance, and time of travel.
HEALTH EDUCATION		To develop proper habits in the care of eyes and ears, have children discuss the parallels between their sense organs and rocket and satellite guidance systems.
ART		To increase understanding of three-dimensional design, prepare mobiles using rockets and space vehicles.
MUSIC		To provide practice in recognizing rhythmic beat, select songs from your music text in 2/4, 4/4, and 6/8 rhythms for which children can write original lyrics with aerospace meanings.

ACTIVITIES FOR REINFORCING LEARNINGS

Build a vocabulary of terms used in rocketry.
Collect pictures of rockets and related subjects.
Make an album of U. S. launch vehicles.
Make a map showing tracking stations.
(ADD OTHERS)

FOR FURTHER EXPLORATION

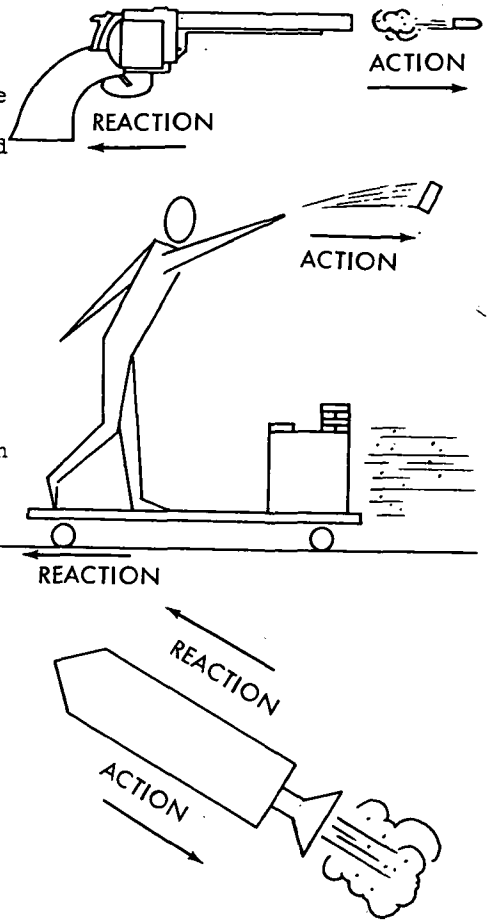
How do tracking stations function?
What kind of guidance systems are used for long range? for short range?
Make a study of the preparation for a rocket launching.
(ADD OTHERS)

MAN-MADE SATELLITES IN ORBIT

We know the moon is a satellite in orbit around the earth, and that it remains in its orbital position because of two physical phenomena: the earth's gravity, which is the force that tends to pull bodies toward its center, and inertia, which is a property of mass that tends to carry an object in a continuing straight line at constant or uniform speed. The moon orbits because of the balanced reaction between the force of the earth's gravity and its own momentum (inertia of motion). There are many simple experiments described in your classroom science books which demonstrate these forces. Do some of them.

An artificial satellite is simply a man-made moon. In revolving about the earth, it obeys the same laws the natural moon and the planets obey in their revolutions. The velocity of a man-made satellite in orbit must be such that for its altitude, its speed and direction of travel combine to withstand the pull of gravity from the earth.

Launching a satellite into orbit so that it will reach orbital velocity usually produces an elliptical orbit. This orbit may be nearly circular or may be such that its perigee (orbital distance nearest the earth) may be only a hundred or so miles, while the apogee (orbital distance farthest from the earth) may be several thousand miles, or it may be anywhere between these extremes.



Some Related Aerospace Concepts

(1) Gravity is the force that pulls all objects to the earth.
(2) The speed necessary for a rocket to overcome the pull of the earth's gravity; i.e., escape velocity, is about 25 thousand miles per hour.
(3) The speed necessary for a satellite to go into orbit close to earth, i.e., orbital velocity, is about 18 thousand miles per hour. Farther from earth the orbital speed of a satellite is less.
(4) Add others.

FOR A MEANINGFUL VOCABULARY

apogee	orbital velocity
artificial	perigee
elliptical	phenomena
escape velocity	revolve
gravity	rotate
inertia	satellite
launching	speed
momentum	velocity

UPDATING THE VOCABULARY

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A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understandings of the aerospace facts)

MAN-MADE SATELLITES IN ORBIT

To provide the class with an experiential motivation, ask the question, "Why does the moon continue in the same orbital position relative to the earth?" Show a filmstrip, such as Rockets to Space. (26)

LANGUAGE ARTS ORAL	Observing Listening Speaking	- To increase children's ability to draw inferences and conclusions from observation and verbal sharing of ideas, have committees make oral reports on how rockets' payloads orbit in space.
LANGUAGE ARTS WRITTEN	Functional writing	- To develop the pupils' ability "to pool" or to coordinate ideas drawn from several sources, have children write a cooperative exposition for a class aerospace booklet about gravity, force, or inertia.
	Creative writing	- To help children gain the facility to use the right word for the right purpose, have them write short tributes to the several astronauts dealing with their accomplishments, training, personality, or character.
	Word study	- To reinforce pupils' skill in syllabication, post a word list with each word syllabified. Use such words as satellite, orbit, and velocity.
	Correct usage	- To encourage proficiency in the proper use of the tenses of irregular verbs, review the forms with pupils, and then have them proofread the compositions suggested above.
	Reading	- To provide practice in gathering information and forming conclusions, make a list of satellites, launch dates, countries involved, and outcomes. Use such books as Erik Bergaust's Satellites and Space Probes. (27)
	Literature	- To help children become aware of styles in writing, have them read such books as Jules Verne's Around the World in Eighty Days, (28) and Lester Del Rey's Rockets Through Space. (29)
SOCIAL STUDIES	Concept or skill development	- To gain deeper insights into the benefits accruing to mankind from space exploration, discuss its impact on transportation, communication, and scientific research.
	Map or globe skills	- To explain the concepts of rotation and revolution, trace the journey of a particular satellite on the globe. Mark with colored thread.
SCIENCE	Activity	Stretch a thread from desk to ceiling in a slanting fashion. Inflate a tube-like balloon. Fasten a soda straw to its side. Run thread through straw. Hold balloon mouth-down at desk level. Release fingers.
	Observation	- In which direction does the air shoot? In which direction does the balloon shoot?
	Concept	- Every action has an equal and opposite reaction.
	Follow-up	- Consult your science text for additional experiments demonstrating action and reaction.
MATHEMATICS	Concept or skill development	- To reinforce children's understanding of the use of ordinals, have them prepare a satellite dateline. To provide practice in understanding comparisons, make up problems which relate space to daily living, e.g., when a rocket nosecone reenters the earth, the nosecone reaches a temperature that is hot enough to cook a turkey in three seconds.
HEALTH EDUCATION		To dramatize the training program of health and fitness routines, have children read and discuss those of the astronauts and test pilots.
ART		To develop the skill of block printing, have pupils prepare aerospace posters for school lobby display.
MUSIC		To make space words more meaningful, have children express their ideas through rhythmic interpretation, e.g., launching, revolving, rotating, count-down.

ACTIVITIES FOR REINFORCING LEARNINGS	FOR FURTHER EXPLORATION
Make individual reports on a satellite.	Read and report on science fiction dealing with space exploration.
Draw pictures of satellites' various shapes.	Present a report on rocket fuels.
Write to industry and NASA for free materials.	Do research for a class written report on the history of U. S. efforts in space.
Set up a Space Bulletin Board for which children help provide the materials.	
(ADD OTHERS)	(ADD OTHERS)

IMPROVING COMMUNICATIONS

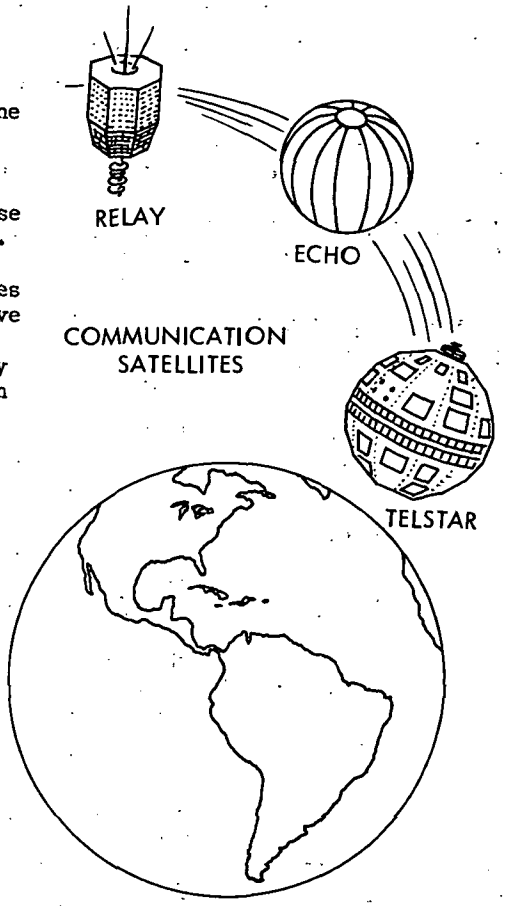
A spacecraft which is of great benefit to man is the communications satellite. One of the first of these is the Echo project. Echo is called a passive satellite because it simply reflects or bounces a message from one point on earth to another. Such satellites as Relay, Syncom, and Telstar, are called active or "repeater" satellites because they receive and rebroadcast messages transmitted to them.

In the past messages have been sent along ground lines such as telephone wires and transoceanic cables. They have also been transmitted without wires by radio waves using the instruments of radio and television. Communication by ground lines is limited in the number of messages that can be carried. Radio transmission is limited because of the tendency of high-frequency waves to travel in a straight line rather than follow the curvature of the earth.

The communications satellites will supplement the cable and microwave devices, opening up more channels and permitting more rapid message transmissions.

The communication satellites are also an answer to long-awaited international television, which might never have come to pass if we had had to rely on cable systems of insufficient information-carrying capacity.

Among the space communications projects are Courier, Echo, Relay, Score, Syncom, and Telstar.



Some Related Aerospace Concepts

(1) Sounds can be reflected from a surface.
(2) Sounds spread out in all directions.
(3) Many objects and materials produce sound when they vibrate.
(4) An echo is a reflected sound.
(5) Add others.

FOR A MEANINGFUL VOCABULARY

apogee	perigee
cable	rebroadcast
capacity	Relay
channels	score
communication	signals
Courier	Syncom
Echo	Telstar
impact	transmission
microwave	transoceanic

UPDATING THE VOCABULARY

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A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understandings of aerospace facts)

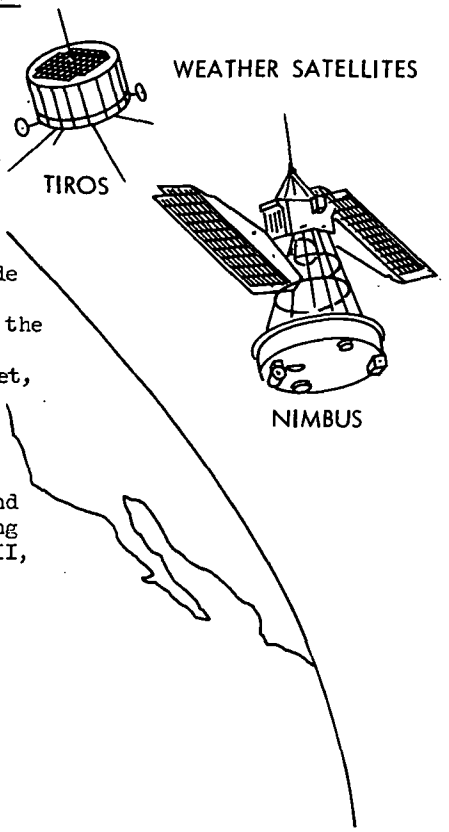
IMPROVING COMMUNICATIONS

To provide the class with an experiential motivation, show film, Approaching the Speed of Sound. (30)

LANGUAGE ARTS	Observing	- To develop understanding of the "line of sight" principle in radio wave transmission, find out how waves travel away from earth and show how the Echo satellite reflects or bounces waves back to earth.
ORAL	Speaking	- To encourage group conversation, have class discuss the difference between active repeater satellites such as Telstar and passive satellites such as Echo.
LANGUAGE ARTS	Functional writing	- To develop facility in following directions, compose a cooperative experiential chart from the material discussed above.
WRITTEN	Creative writing	- To increase skill in developing topic sentences into paragraphs, have class write paragraphs with such topic sentences as, "If I were in the satellite Telstar, I would be . . ."
	Word study	- To increase understanding of word formation, teach the combining form tele. Add root words gram, graph, phone, meter, scope, type, vision, cast. Have class compile word lists of terms relating to communication.
	Correct usage	- To practice correctness of expression, review agreement of subject and verb by using is, are, was, and were in speaking about satellites.
	Literature	- To cultivate skill in discriminating between fact and fiction, read Stations in Space. (31) To develop the skill of drawing inferences study "The Makers of Speed" by Carl Sandburg. (32)
SOCIAL STUDIES	Concept development	- To visualize the progress of communication through the ages, make a bar graph or time line of communication, from the smoke signals of the past to the Syncom of today.
	Map or globe skills	- To develop understanding of the potential of satellites for world-wide communication, show how three Syncom satellites can provide communication for the entire world.
SCIENCE	Activity	- Using a hacksaw, cut lengthwise through a flashlight dry cell. Make a sketch of the cross section of the cell. Point out the essential parts and discuss the use of each.
	Observation	- How does a dry cell "store" electricity?
	Concept	- An electrical current can be produced by chemical action.
	Follow-up	- How do we furnish power for the communications equipment in our satellites? How are solar cells used? What other kinds of energy sources are used?
MATHEMATICS	Concept or skill development	- To reinforce measurement skills, have class review tables of weight, distance, and time. Make a chart showing the communications satellites' apogee and perigee (farthest and nearest distance from Earth), period (time of orbit), and weight.
HEALTH EDUCATION		To emphasize the benefits of better communication, consider the contributions of communications satellites to world-wide education.
ART		To encourage creative expression in drawing, have children illustrate the paragraphs assigned above.
MUSIC		To the tunes of "Row, Row, Row Your Boat" and other rounds, write original lyrics about space.

ACTIVITIES FOR REINFORCING LEARNINGS	FOR FURTHER EXPLORATION
Use home viewing of space TV programs as a basis for class discussion.	How may we soon be receiving television programs from the other side of the world?
Write original poems or songs about space.	How can we prevent "jamming" of satellite telecasts?
Prepare a play about space for presentation in assembly.	How can space serve as a communications highway?
Make an aerospace dictionary.	
(ADD OTHERS)	(ADD OTHERS)

PREDICTING WEATHER



Too often the weatherman has been blamed for his poor weather predictions, but regular weather observations cover only about one-fifth of the earth's surface, and the forecaster may be unaware of changing conditions on the other parts of the earth's surface which might completely alter his prediction.

An earth satellite equipped with television can provide a precise picture of cloud and storm patterns around the entire globe. Tiros, a NASA weather satellite, can circle the earth every ninety minutes and transmit images of cloud formations. These the forecasters can analyze and interpret, thus giving us more accurate weather predictions.

Think of the advantages precise weather information gives to those people who engage in air transportation or agriculture, to those who participate in outdoor events, and to those who live in the paths of destructive storms. Among the present and projected weather satellites are Tiros I, II, III, IV, V, VI, VII and VIII, Nimbus, and a synchronous meteorological satellite.

Some Related Aerospace Concepts

(1) Weather satellites carry improved instruments which take pictures of weather conditions, clouds, storms, etc.
(2) Clouds tell us something about coming weather.
(3) Add others.

FOR A MEANINGFUL VOCABULARY

analyze	prediction
forecaster	satellite
interpret	synchronous
meteorological	television
Nimbus	Tiros
observation	transmit

UPDATING THE VOCABULARY

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A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understandings of aerospace facts)

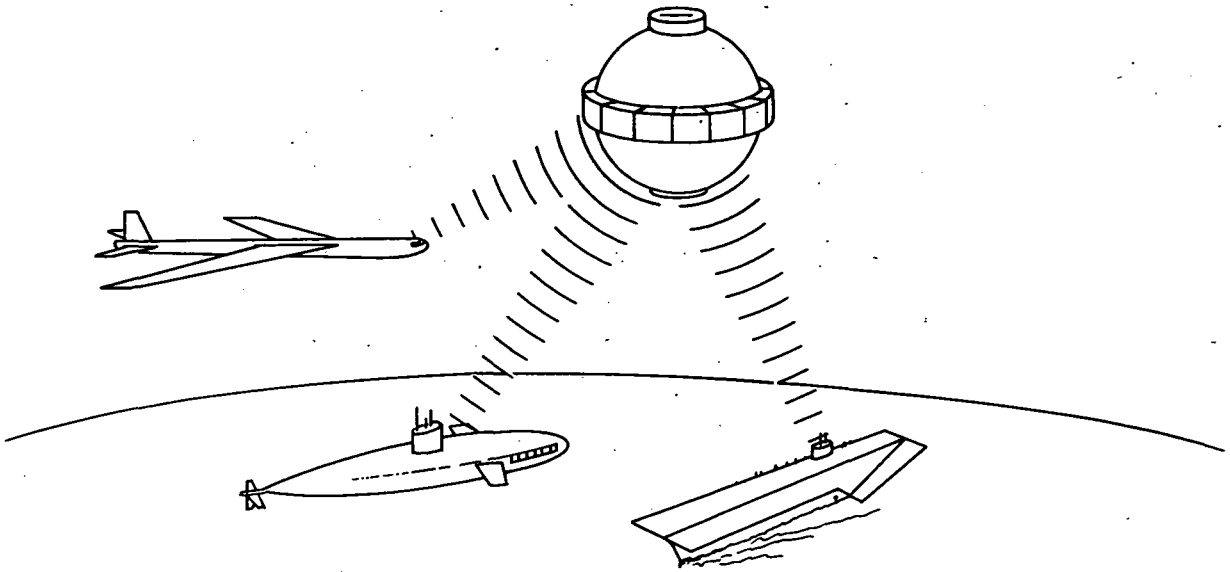
PREDICTING WEATHER

To provide the class with experiential motivation, have children listen to the radio for daily weather reports and keep a record of the number of times the prediction has been accurate.

LANGUAGE ARTS ORAL	Observing Listening Speaking	- To encourage keenness of observation, have class report on cloud formations on a clear day and on a cloudy day. Note weather vanes in the neighborhood. Observe how they move. To cultivate listening skills, have class listen to weather broadcasts and note how they are presented. To enhance conversational ability, have class discuss records they have kept in support of their observations.
LANGUAGE ARTS WRITTEN	Functional writing	- To develop skill in compiling data, keep a record of daily weather predictions, including temperature, barometer reading, wind direction, and visibility.
	Creative expression	- To cultivate skills in interpreting data, have class write about how people in different occupations would react to different weather reports. "If I were a _____ and the forecaster predicted _____, I would _____."
	Word study	- To reinforce skills in syllabication and the use of the accent mark, have the class prepare a weather vocabulary, syllabifying such words as forecaster, predict, hurricane, precise, instrument.
	Punctuation	- To increase skill in the use of the interrogation point, have each member of the class write a series of ten questions about the weather.
	Library skills	- To encourage the use of reference materials, use periodical indexes and local newspapers to obtain information about the weather. Note newspaper pages that give weather information and cut out and collect weather maps for a limited period.
	Literature	- To stimulate breadth of reading interest, read The Wizard of Oz. (33) Have class read widely for information about hurricanes, cyclones, gales, tornadoes, and other weather phenomena.
SOCIAL STUDIES	Concept development	- To develop the concept of the role of weather in man's life, explore man's need for improved weather forecasting. What success has Tiros had in predicting weather?
	Map or globe skills	- To develop skill in reading weather maps, have class learn symbols for rain, snow, clouds, thunderstorms. Construct individual weather maps.
SCIENCE	Activity	- Fill a bottle with hot water. Pour out most of the water, leaving a depth of only about one inch in the bottom of the bottle. Support an ice cube at the mouth of the bottle.
	Observation	- What happens to the warm air as it rises to the top of the bottle?
	Concept	- When warm air rises and cools quickly, fog occurs.
	Follow-up	- Read about the dangers of fog to transportation. Make a study of cloud types.
MATHEMATICS	Concept development	- To develop measurement concepts relating to weather, learn and compare Fahrenheit and centigrade scales and tell why each is used. To practice skill in using graphic methods, prepare graphs showing high and low temperatures in your city for a 30-day period. Prepare problems for children to solve by employing graphs.
HEALTH EDUCATION		To enhance understanding of the relation of weather to health, consider proper clothing, shelter, and food for various kinds of weather.
ART		To explore various media of creative expression, prepare a display of original sky and space pictures.
MUSIC		To build a large rote song repertoire, select songs about clouds, weather, sky, rain, and storms, the words of which will lend themselves to further vocabulary study.

ACTIVITIES FOR REINFORCING LEARNINGS	FOR FURTHER EXPLORATION
Form committees and make reports on the weather satellites.	How can a satellite travel at enormous speeds?
Take a trip to the local weather station.	How do we get weather information from satellites?
Make graphs of weather fluctuations.	Why is reception on radio and TV poor during storms?
Make a dictionary of weather terms.	What are isotherms, isograms, and isobars?
(ADD OTHERS)	(ADD OTHERS)

NAVIGATING BY SATELLITE



The stars, providing navigational fixes for the sailor throughout the ages, are joined now for positional purposes in navigation by navigation satellites. Presently, the U. S. Navy is developing with NASA the Transit navigation satellite system for this function.

A navigation satellite is like a small planet revolving around the earth and having precisely fixed characteristics of motion and position. It can be used as an aid to navigation because its position at any time can be known if its orbit has been precisely determined.

With four of these navigation satellites in orbit at any one time, it appears possible to guarantee navigational fixes on nearly any part of the globe, at least once every $1\frac{1}{2}$ hours. It will be necessary, however, to launch other such satellites, about one each year, to replace those that may be dying, or to fill gaps that may develop in the satellite system.

An improved navigation system would benefit those engaged in air and water transportation by providing them with the necessary information as to their location and the direction of their travel.

Some Related Aerospace Concepts

(1) All navigators must learn to use maps.
(2) A map is a diagram of all or part of the earth's surface on which we can measure distance and direction.
(3) The position of any spot on the earth's surface can be determined by lines called meridians of longitude, and other lines called parallels of latitude.
(4) Add others.

FOR A MEANINGFUL VOCABULARY

cooperative
diagram
latitude
longitude
meridian
navigation
parallel
relation
reliable
satellite
transit

UPDATING THE VOCABULARY

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A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understanding of aerospace facts)

NAVIGATING BY SATELLITE

To provide the class with experiential motivation, raise the question, "How do maps aid in carrying on the world's work?" Show a filmstrip such as Maps and Men. (34)

LANGUAGE ARTS ORAL	Observing Listening Speaking	- To develop skill in comparing and seeing relationships, study various maps used for special purposes. To practice recalling ideas in guided conversation, discuss the special maps used by those who pilot aircraft and boats.
LANGUAGE ARTS WRITTEN	Functional writing	- To practice correct form for business letters, have class write to airlines and aerospace industries requesting free maps.
	Creative writing	- To develop the ability to express ideas clearly, forcefully, and concisely, have class write biographies of famous navigators of the land, sea, or air; describe the specific navigation problems they encountered.
	Word study	- To create a functional spelling list, select map and globe terms such as navigation, longitude, meridian, parallel, zenith, and sphere.
	Punctuation	- To develop sentence-building ability, proofread previously written biographies for run-on sentences. Check for correct punctuation marks at ends of various types of sentences.
	Reading	- To practice skills in locating information from a variety of sources, discover the contributions of the pioneers in space science—Konstantin E. Tsiolkovsky, Robert H. Goddard, Hermann Oberth, Werhner von Braun, Kurt Stehling, and others.
	Literature	- To develop awareness of different literary styles, read fiction, legend, biography, and autobiography relating to space.
SOCIAL STUDIES	Concept development	- To gain an idea of how man has tried to solve navigation problems, have the children write papers on the history of man's efforts to find his way across oceans and deserts.
	Map or globe skills	- To compare the purposes of various kinds of maps, plan an exhibit showing a variety of projections and types of maps. Select a committee to study the purposes of each and have them report to class.
SCIENCE	Activity	- Place a light bulb inside a transparent globe of the earth. Encircle the globe tangent to the equator with a thin sheet of paper.
	Observation	- What kinds of lines are reflected on the paper? Trace these lines and unroll the paper.
	Concept	- A Mercator map is a flat projection. Lines of longitude and latitude are illustrated as parallel straight lines. Areas on such maps become increasingly distorted toward the poles.
	Follow-up	- Read latitude and longitude of various places on the map.
MATHEMATICS	Concept or skill development	- To develop an understanding of simple geometric concepts relating to navigation, identify different kinds of angles and the use of degrees in angular measurement. Practice addition and subtraction of degrees of angles.
HEALTH EDUCATION		To increase understanding of health factors, list some of the health hazards encountered by different kinds of navigators. Discuss food, clothing, shelter, and other health requirements.
ART		To practice the use of the cartoon technique, make a picture story explaining the work of different types of navigators.
MUSIC		To increase the class repertoire of rote songs, learn songs about traveling on land, sea, and air.

ACTIVITIES FOR REINFORCING LEARNINGS	FOR FURTHER EXPLORATION
Make a picture dictionary illustrating the various kinds of projections and maps.	What are the possibilities of navigation satellites for enriching our lives?
Conduct a forum discussion on the subject.	What are some of the instruments used in navigation?
Set up a display of special maps which are used in navigation, aviation, and other forms of transportation.	
(ADD OTHERS)	(ADD OTHERS)

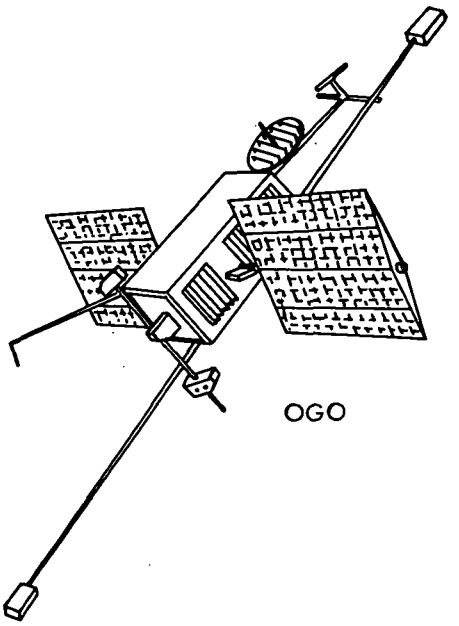
GATHERING SCIENTIFIC DATA

Unmanned satellites and sounding rockets are the scientific instruments which collect thousands of items of information about outer space.

Explorer I, which opened the Space Age for the United States in 1958, helped in the discovery of the lower Van Allen Radiation Zone. Our knowledge of this zone has been important in our conduct of space exploration. Successive Explorers furnished information about micrometeoroids, temperatures in space, radiation and magnetic storms, gamma rays, and other cosmic phenomena.

Vanguard I, in orbit since 1958, has revealed that the earth may be slightly pear-shaped. Other Vanguard satellites have added to our knowledge of the earth's magnetic field.

Discoverer I, launched in 1959, circled the earth in a polar orbit instead of at the equator. Other Discoverers gathered data about propulsion, communications, and performances of the satellite in orbit. They also experimented with techniques for space cabin recovery.



Three satellite observatories, powered by solar cells and nickel-cadmium batteries, will provide a wealth of information about the universe. Try to find out more about the (OAO) Orbiting Astronomical Observatory; (OSO) Orbiting Solar Observatory; and (OGO) Orbiting Geophysical Observatory.

In addition to the data-gathering satellites, our scientists are using sounding rockets, which instead of going into orbit, fall back to earth. These sounding rockets carry instruments to learn about the upper atmosphere, the earth's cloud cover, and the ionosphere.

Some Related Aerospace Concepts

(1) Instrument-bearing rockets investigate the upper atmosphere.
(2) Jet streams of air encircle the world at speeds of over 200 miles per hour.
(3) Upper air research will aid air transportation.
(4) Add others.

FOR A MEANINGFUL VOCABULARY

astronomical	magnetic
cadmium	micrometeoroids
batteries	nickel
Discoverer	observatory
Explorer	orbiting
gamma rays	Van Allen radiation
geophysical	solar cells

UPDATING THE VOCABULARY

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A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understandings of aerospace facts)

GATHERING SCIENTIFIC DATA

To provide the class with experiential motivation, have them view the film Orbiting Solar Observatory. (35)

LANGUAGE ARTS ORAL	Observing Listening Speaking	- To practice organizational skills, clip and categorize pictures from magazines and industrial material on research rockets. To train children in sequential reporting, have them describe and discuss how instruments are used in scientific satellites.
LANGUAGE ARTS	Expository writing	- To develop skill in expository writing, explain in three or four paragraphs what the following standardized satellites are accomplishing or expected to accomplish: the Orbiting Geophysical Observatory (OGO), the Orbiting Solar Observatory (OSO), and the Orbiting Astronomical Observatory (OAO).
WRITTEN	Creative writing	- To enhance skill in concise descriptive writing, use the name of one of the scientific satellites, Vanguard, Explorer, Discoverer, or Alouette, and write an imaginative story on the choice of this name.
	Spelling	- To develop facility in generalizing, work out a spelling rule by changing the letter "y" to "i" in forming the plurals of such words as battery, observatory, and discovery. To practice dictionary skills, discuss the meanings of such technical words as cadmium, gamma rays, micrometeoroids, and solar cells.
	Correct usage	- To practice comparison of adjectives, use examples such as large, larger, largest and little, less, least, in their relation to satellites.
	Reading	- To increase rapid reading ability use such materials as A Book of Satellites for You, by Franklyn Branley (36) and have children answer the question, "How are satellites adding to man's knowledge of the universe?"
	Literature	- To develop the ability to distinguish fact from fantasy, read science fiction books and compare them with factual materials from authentic science sources, such as NASA publications.
SOCIAL STUDIES	Concept development	- To give children an idea of the potential significance of the discoveries of the scientific satellites, have them discuss what man may learn about the universe from the Orbiting Astronomical Observatory.
	Map or globe skills	- To gain greater understanding of latitude and longitude, use map or globe to locate observatories and tracking stations around the world. Show their relationship to each other.
SCIENCE	Activity	- Sprinkle iron filings on a sheet of cardboard or a pane of glass. Lay the card or glass on a horseshoe magnet; tap the card or glass lightly and note evidence of the direction of the lines of magnetic force around the poles of the magnet.
	Observation	- What effects do you observe in the alignment of the filings?
	Concept	- The filings line up along the magnetic lines of force, extending from one pole of the magnet to the other.
	Follow-up	- Using your science text, draw a diagram of the earth's magnetic field. Draw the Van Allen Radiation Belt.
MATHEMATICS	Concept or skill development	- To review and reinforce skills in fundamental processes of division and multiplication, use problems in distance and time involving the speed of light and the speed of sound.
HEALTH EDUCATION		To encourage an understanding of the hygiene of the ear, emphasize rules for proper care of the ears and relate to experiences with sound.
ART		To develop skill in planning an artistic layout, make a bulletin board of pictures of the scientific satellites.
MUSIC		To illustrate that music consists of regulated vibrations, have children observe hammers and strings in a piano. Cut sipping straws into different lengths and blow. Make paper whistles. Play tonettes.

ACTIVITIES FOR REINFORCING LEARNINGS

Make an album of satellites in orbit.
Construct paper models of the several types of satellites.
What are we learning about cosmic rays and solar flares?
(ADD OTHERS)

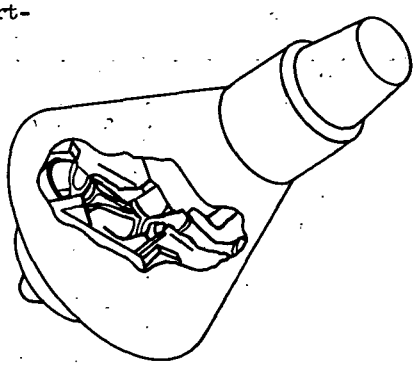
FOR FURTHER EXPLORATION

What knowledge has been obtained from the Orbiting Solar Observatory?
What effect has radiation on the growing of food?
What special TV shows reveal new space information?
(ADD OTHERS)

MAN IN SPACE

Man, with his thirst for knowledge and his love of adventure, has braved the dangers of the oceans, the mountains, the deserts, and the earth's ocean of air. Now he is ready to challenge the perils of space beyond the earth.

Spacemen pioneers, called astronauts, unlike the pioneers of old, are completely dependent upon the abilities and expertness of scientists and engineers. These scientists and engineers design ways to protect space men and to plan for their needs while they are in space.



A spaceman has to carry with him in his cabin (capsule) his own air (oxygen), water, and food, and his own air-conditioning and waste-disposal apparatus. His space suit must be equipped with its own air-conditioning system which operates automatically when needed to perform certain functions. His body is wired with telemetering equipment which informs the physician at the ground station about his physical condition. He also has a two-way radio to keep him in constant touch with a world-wide net-work of ground stations.

A spaceman must withstand the acceleration of the rocket thrust which produces G-forces that increase as acceleration increases. In some rockets, acceleration could produce such high G-forces that a 175-pound man would be subjected to a force of more than 1000 pounds. When the acceleration ends, no force presses on him, and he becomes weightless.

Some Related Aerospace Concepts

(1) Gravity is a force that tends to pull all objects together. It may be best thought of as the force that pulls objects toward the center of the earth.
(2) Our weight shows how much gravity pulls us.
(3) The farther away something is from the earth's center, the smaller the pull of the earth's gravity upon it.
(4) Each star or planet body has its own field of gravity.
(5) Add others.

FOR A MEANINGFUL VOCABULARY

acceleration
astronaut
automatically
capsule
G-force
gravity
oxygen
pioneers
spacemen
systems
telemetering
weightlessness

UPDATING THE VOCABULARY

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A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understandings of aerospace facts)

MAN IN SPACE

To provide the class with experiential motivation, raise the question, "How can our new pioneers meet the challenge of space?" Show a film such as Friendship Seven. (37) Make a display based on the astronauts.

LANGUAGE ARTS ORAL	Observing Listening Speaking	- To improve children's ability in noting details, prepare a list of questions after viewing the above film. Questions should be so worded that a lively discussion will ensue. Children should be encouraged to form their own question.
LANGUAGE ARTS WRITTEN	Functional writing	- To develop skill in outlining, have children make a simple topical outline for a theme on orbiting the earth.
	Creative writing	- To provide practice in writing imaginative compositions, have children describe how they would feel if they were to ride in a spacecraft.
	Word study	- To increase understanding of principles of word formation, use prefixes and roots to form new words. To the root scope, add such combining forms as tele, gyro, spectro, horo, and micro.
	Correct usage	- To review uses of possessive adjectives, proofread for plural and singular possessives, "rocket's power," "rockets' power."
	Reading	- To cultivate the ability to distinguish between relevant and irrelevant materials, read such books as I want to be a Space Pilot (38) and Mickey Mouse and His Spaceship. (39)
	Literature	- To gain competence in differentiating between fact and fiction, read such books as Red Planet by Robert Heinlein. (40)
SOCIAL STUDIES	Concept formation	- To understand man's constant quest to conquer space, read the stories of Daedalus and Icarus, Otto Lilienthal (glider), Montgolfier (balloon), Wright Brothers (airplane).
	Map or globe skills	- To develop an understanding of time zones, plot them on outline maps. Locate the planets on a map of interplanetary space. Map of the Moon and Planets, Rand-McNally Co. (41)
SCIENCE	Activity	- Stand facing a wall two or three feet away and push away from the wall with both hands.
	Observation	- Does your body move? Do your feet move?
	Concept	- The extent of your body movement is limited by the pull of gravity.
	Follow-up	- What would happen if you were on the outside of a space capsule several thousand miles from earth and were to push against the side of the spacecraft?
MATHEMATICS	Concept or skill development	- To develop skill in measuring and in making graphs, construct a bar graph showing the relative speeds and number of orbits of the various man-in-space explorations. To become familiar with the unit "parsec" in the measurement of distance in space, create simple multiplication exercises to show distances between planets and stars. ("Parsec is the abbreviation for parallax second. Each one is equivalent to 19.15 trillion miles. One parsec is equal to 3.26 light years.)
HEALTH EDUCATION		To comprehend what man needs to survive, discuss his various requirements, food, clothing, oxygen, water, and temperature. How are they met on earth and in space?
ART		To encourage creative expression in construction activities, make space helmets or a rocket ship for a play. Draw imaginary views as seen from a spaceship.
MUSIC		To develop musical creativity, write original songs, and/or music, about spacemen, the pioneers of today.

ACTIVITIES FOR REINFORCING LEARNINGS

Write reports on astronauts.
Make a time line, recording the names, and dates and the number of orbits of manned space flights.
Have children make a word list composed of terms associated with astronauts, capsules, and rockets.

(ADD OTHERS)

FOR FURTHER EXPLORATION

What are the plans for the next astronauts?
What is the role of women as space pioneers?
What are some of the life-support problems that scientists and engineers are solving for the astronauts who go into outer space?

(ADD OTHERS)

POSSIBLE DANGERS IN SPACE TRAVEL

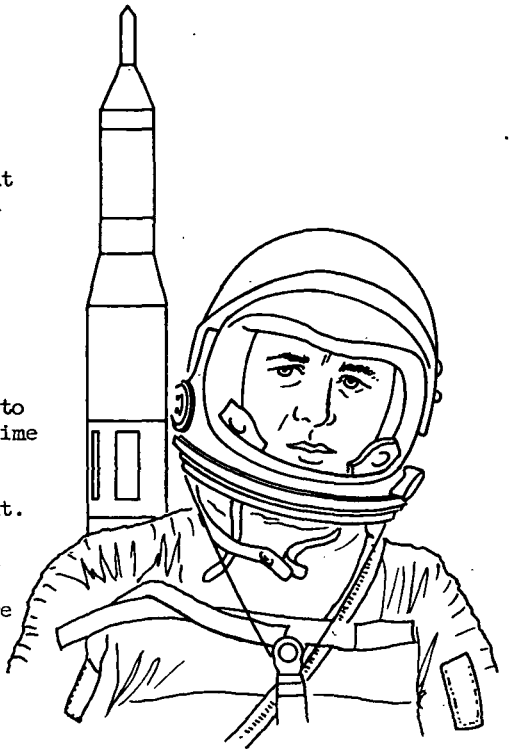
Scientists and engineers are investigating the possible dangers of space travel. They have launched satellites to determine the chances of spacecraft being destroyed by meteors.

They are launching other satellites to learn about the different kinds of rays and particles from the sun and outer space that might kill an astronaut or make him sick.

Complete reliability in the work of those who make and launch spacecraft is vital to the safety of the astronauts.

Other scientists are studying about what happens to one or two astronauts when they are alone for a long time in a small spacecraft. These scientists are searching for ways to relieve the loneliness, anxiety, fear, or boredom which might disturb astronauts on a long flight.

Many satellites launched by the United States and other cooperating nations have increased our knowledge of the nature of the space environment. Among them are the Explorers, the Pioneers, the Orbiting Solar Observatory, Mariner II, Ariel, and Alouette.



Some Related Aerospace Concepts

(1) Man cannot exist in space without controlling his immediate environment.
(2) Space vehicles need to be protected against meteors, radiation, and cosmic dust.
(3) The effects of weightlessness on man are being studied.
(4) Add others.

FOR A MEANINGFUL VOCABULARY

anxiety
engineer
Mariner
observatory
particles
pioneer
rays
reliable
scientist
solar
spacecraft

UPDATING THE VOCABULARY

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A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understandings of aerospace facts)

DANGERS OF SPACE TRAVEL

To provide the class with experiential motivation, view a film showing actual coverage of an astronaut's flight around the world, such as The Mastery of Space. (42)

LANGUAGE ARTS ORAL	Observing Listening Speaking	- To gain a deeper insight into man's dependence on the reliability of others, discuss the precautions taken by the many people involved in launching a spacecraft, as observed in the film.
LANGUAGE ARTS WRITTEN	Functional writing	- To provide practice in the skill of summarizing and organizing ideas, draw up an imaginary log of one of the Project Mercury space voyages.
	Creative writing	- To spur children's imagination, have them describe how they would have felt if they had been with an astronaut on his flight.
	Word study	- To improve children's spelling ability, apply the rule for forming the plural of words ending in y, such as rays, days, anxieties, abilities.
	Punctuation	- To encourage proficiency in using the comma to separate words or phrases in a series, have children create a series of words describing their imagined sensations in space flight.
	Reading	- To help children improve their comprehension, have them read such books as Man Alive in Outer Space. (43) List dangers the space traveller may encounter.
	Literature	- To broaden children's interest in the literature of flight, have them read "Daedalus". (6) How does this legend anticipate one of the perils of space travel?
SOCIAL STUDIES	Concept development	- To instill an appreciation for the courage of explorers and pioneers of the past and present, discuss the reasons why a man risks his life to explore new places.
	Map or globe skills	- To become more proficient in geographic skills, use maps and a globe to follow the paths taken by the various Mercury capsules. Pinpoint the tracking stations.
SCIENCE	Activity	- Shine a desk lamp (representing sunlight) on one side of an object such as a circular piece of cardboard.
	Observation	- How does each side of the object feel?
	Concept	- The side of an object nearest the sun absorbs heat more rapidly than the other side.
	Follow-up	- Try other experiments dealing with the sun's light and its effects.
MATHEMATICS	Concept or skill development	- To practice subtraction skills, have pupils try such exercises as subtracting the perigees from the apogees of the several Mercury flights, noting the difference in flight duration of the longest and shortest orbital flights of Mercury. (44)
HEALTH EDUCATION		To gain a better understanding of the importance of mental health, discuss the necessity for astronauts to have a healthy body, and sound mental attitudes.
ART		To illustrate the fundamentals of artistic bulletin board display, use "elfin - goblin" picturizations to depict the dangers of space travel. Mount newspaper and magazine clippings alongside each to accentuate the truth of the artistic ideas.
MUSIC		To stimulate creative expression, play various music rhythms and have children interpret with bodily movements the take-off, orbit, and reentry phases of an astronaut's flight.

ACTIVITIES FOR REINFORCING LEARNINGS

Write short stories or essays about the extreme care that engineers and workmen must take in constructing launch vehicles and spacecraft.

Add to the class space-scrapbook articles and pictures about dangers of space travel.

Prepare an exhibit for the school lobby of achievement in manned space flight.

Write a letter to a favorite astronaut.

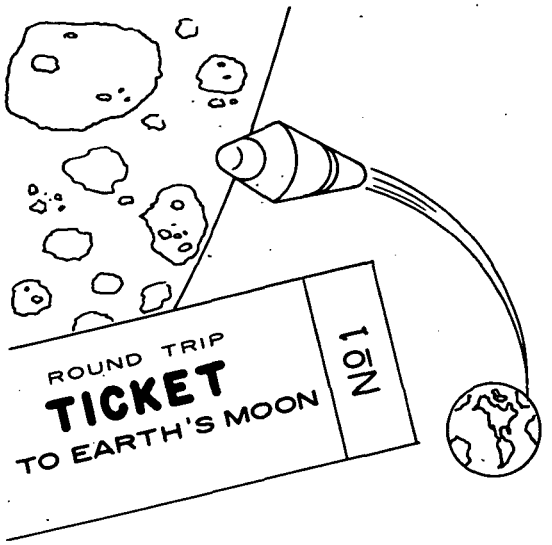
FOR FURTHER EXPLORATION

Why might weightlessness be a problem for man in space?

Why might radiation be a problem for men in space?

What dangers does an astronaut face if his spacecraft fails to attain its assigned orbit?

TOMORROW THE MOON



Where do we go from here?

The moon is our nearest neighbor in space. It is a natural target for our space exploration. Scientists say that the moon may have a slight atmosphere, but no wind or rain, or any significant mountain building activity. Its surface is almost changeless. Because the moon is less massive than the earth its gravitational field is less intense than that of the earth.

The moon offers man an opportunity to study some of the matter of the solar system and may help answer some of the key questions of science, "How was the solar system created?" "How did it develop?" The moon is indeed a made-to-order space station. Before America tries to place a man on the moon, it must first learn more about the moon than has ever been known before.

The first of the programs to learn about the moon is the Ranger program. Some Ranger satellites will circle the moon and take pictures. Others will land instruments on the moon's surface and will send back to earth messages about moonquakes and meteorite impact. Another instrument that will be landed on the moon will have a small TV camera which will send back to earth pictures of moon objects that are as small as one-tenth of an inch across.

Surveyor is a spacecraft that will not only take pictures of the moon, but will also land on the moon. It will send back information about the chemical composition of the moon's soil and check the moon's surface crust to see whether it will support the weight of a man.

Finally, about 1969 or 1970, Project Apollo will take three men to the moon, two of whom will land on its surface.

DISTANCE FROM EARTH TO MOON – ABOUT 239,000 MI

SATELLITES ESCAPE VELOCITY 25,000 MPH

AFTER 48 HRS VELOCITY REDUCED TO – 2,000 MPH

TOTAL TIME TO REACH THE MOON 64 HRS

Some Related Aerospace Concepts

(1) The moon revolves around the earth.
(2) The moon is the space object nearest to earth.
(3) The moon seems to travel across the sky each night from east to west.
(4) The moon seems to change its shape during the month; these changes are called "phases."
(5) The moon is not self-luminous. It reflects the light of the sun.
(6) Add others.

FOR A MEANINGFUL VOCABULARY

Apollo, chemical composition, impact, investigate, meteorite, moonquake, originate, probes, Ranger, Surveyor, target

UPDATE THE VOCABULARY

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A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understandings of aerospace facts)

TOMORROW THE MOON

To provide the class with experiential motivation, raise the question, "Why does man want to reach the moon?" Show a filmstrip, such as Moon - our Nearest Neighbor in Space. (45)

LANGUAGE ARTS ORAL	Observing Listening Speaking	- To increase students' ability to note details and express thoughts clearly, show pictures of the new astronauts. Compare them with the first seven chosen. What is expected from the new ones?
LANGUAGE ARTS WRITTEN	Functional writing	- To evolve a pattern for helping children to write in sequential order, start a time table of events; i.e., past, present, and tentative future, leading to our nation's first moon landing.
	Creative writing	- To develop the skill of writing topic sentences, use such examples as, "When I travelled in the first moon ship."
	Word study	- To clarify the concept of compound words, make individual word lists using the noun moon, e.g., moonshine, moonbeam, moonstruck, moon-faced, moonlight, moonstone, etc.
	Correct usage	- To help children become aware of using correct verb tenses, write sentences comparing the early explorers of the Old World with those of the Space Age.
	Reading	- To encourage children to become better informed, have them bring in articles and pictures about lunar probes and space exploration. Make displays of information obtained from all media of communication.
	Literature	To enhance the reading program, start a classroom library corner featuring science-fiction books, poems, stories, and plays relating to our satellite, the moon.
SOCIAL STUDIES	Concept development	- To train children to think critically, raise the question, "What impact will the first landing on the moon have on history?" Explore the possibilities of the moon's being used as a space station to study the universe.
	Map or globe skills	- To explain why the moon changes in appearance, make a chart showing the earth and the orbit of the moon as it revolves around the earth.
SCIENCE	Activity	- Make a class calendar for a particular month. Have children record their observations of the shape of the moon, every third day.
	Observation	- What changes in the moon's shape have been noted during the month?
	Concept	- The moon revolves around the earth. We can see only portions of the half lighted by the sun and none at all at "new moon."
	Follow-up	- Find out how the moon helps cause the tides. What happens when an eclipse of the moon or of the sun occurs?
MATHEMATICS	Concept or skill development	- To provide practice using the formulae of time, rate, and distance, use examples such as, a jet aircraft travels 500 miles per hour and an orbiting satellite, 175,000 miles per hour; find the time it will take for each to travel 1,000 miles, 1,500 miles, 2,000 miles.
HEALTH EDUCATION		To classify the concept of the basic needs of man, talk about oxygen, food, water, and shelter. Relate these needs to what man may find on the moon.
ART		To illustrate geometric forms, create mobiles using crescents, quadrants, circles, spheres, and hemispheres.
MUSIC		To better appreciate man's life-long interest in the moon, make a list of "moon songs" we sing, found in music texts and other sources.

ACTIVITIES FOR REINFORCING LEARNINGS

Make reports on current moon probes.
Up-date individual vocabulary lists.
Report on books read about the moon.
Make a class scrapbook showing the progress of Project Apollo.
(ADD OTHERS)

FOR FURTHER EXPLORATION

Why is one-half of the moon dark?
How will man be able to survive on the moon?
What causes the moon to stay in orbit around the earth?

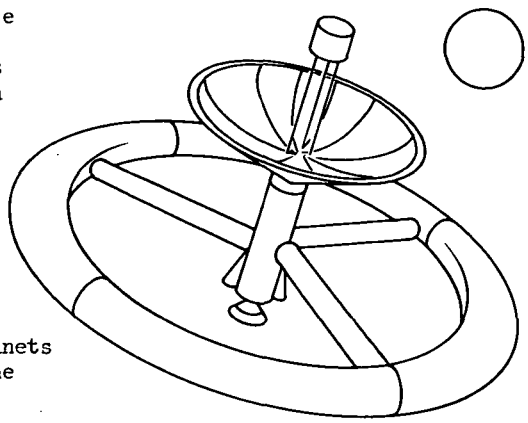
(ADD OTHERS)

TO THE PLANETS AND BEYOND

Our solar system will not be easy to explore. We must first learn more about the planets, the space between the orbits of the planets, and the cosmic matter that comes from beyond our solar system.

Space explorers are most interested in Venus and Mars because they are the planets whose orbits are closest to the earth's orbit.

In 1962, an unmanned planetary spacecraft, Mariner II was launched, with Venus as its target. More than three months later it passed by the planet Venus at a distance of 21,648 miles. Messages sent back from Mariner II indicate that the temperature of Venus may be as hot as 800° Fahrenheit. This temperature, which is hot enough to melt lead, means that life as we know it on earth cannot exist on Venus. Mariner II also furnished much scientific information on the atmosphere surrounding Venus, which apparently contains little oxygen.



Another target will be the planet Mars. Future Mariners will obtain information concerning its atmosphere and temperature, and the presence of life.

Exploration of Mercury, Jupiter, and the other planets will take place when results have been obtained from the Mariner satellites; when new forms of propulsion have been developed; and when problems of placing spacecraft into trajectories to these planets have been solved.

As for exploration beyond the planets: who knows what "impossibles" of today's science may become the "routines" of tomorrow's?

Some Related Aerospace Concepts

(1) There are many problems which must be studied and solved before man can travel for extended periods of time in space.
(2) The radiant energy from the sun may be dangerous to man in interplanetary space.
(3) Problems in building space travel devices require the development of many new materials.
(4) Planets can be seen because they reflect light received from the sun.
(5) Add others.

FOR A MEANINGFUL VOCABULARY

beyond
cosmic
dense
Fahrenheit
orbit
planetary
Mariner II
Mars
Mercury
oxygen
propulsion
resolved
routine
trajectory
Venus

UPDATING THE VOCABULARY

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A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understandings of aerospace facts)

TO THE PLANETS AND BEYOND

To provide the class with experiential motivation, take a field trip to a planetarium or a museum with an aerospace exhibit. Raise the question, "What kind of vacation spots do you think the moon and other planets would make?"

LANGUAGE ARTS ORAL	Observing Listening Speaking	- To develop the skill of reporting, have the class prepare questions which they wish to have answered when they are at the planetarium.
LANGUAGE ARTS	Functional writing	- To help children learn how to organize material, obtain folders from travel agencies as patterns. Have them prepare material to be used in a travel folder about a planet they would like to visit.
WRITTEN	Creative writing	- To help children create "catchy" titles to attract the readers' interest, have them prepare titles for their travel folders.
	Word study	- To practice use of the dictionary, look up the origins of the planets' names. Make individual word lists of descriptive adjectives with related nouns such as the "red planet."
	Punctuation	- To teach the use of quotation marks in recording conversation, have the children write an imaginary conversation they might have with a travel agent who specializes in interplanetary travel.
	Reading	- To enlarge on specific details, have the children read such books as Guide to Outer Space. (46) Have each child select a planet and describe the difficulties he would encounter were he to try to live there.
SOCIAL STUDIES	Concept development	- To appreciate the contribution of the past explorers and pioneers in American history, question the children about the problems our modern pioneers might encounter were they to settle on Mars or one of the other planets.
	Map or globe skills	- To illustrate the relationship between planets, have the children make a large wall map of the solar system. (See Mathematics, below)
SCIENCE	Activity	- Obtain two identical cans. Paint one black, leave one shiny. Invert. Place a thermometer in each through a hole in the center of the bottom. Place in sunlight for about ten minutes.
	Observation	- What is thermometer reading in each can?
	Concept	- Black surfaces absorb radiation and change it into heat. Shiny surfaces reflect radiation.
	Follow-up	- Talk about the clothes we wear during the various seasons and those worn by the astronauts.
MATHEMATICS	Concept or skill development	- To develop the skill of charting to scale, have children represent the planets on the map (see Social Studies, Map skills above), according to their relative sizes and their relative distances from the sun.
HEALTH EDUCATION		To illustrate the basic nutritional rules, prepare charts depicting the seven basic foods. Ask the children to prepare diets for astronauts in training.
ART		To put into effect the concept of three-dimensional representation, construct mobiles of the solar system, models of the constellations, etc.

ACTIVITIES FOR REINFORCING LEARNINGS	FOR FURTHER EXPLORATION
Form a "Space Club." Members should contribute original drawings, creative writings, models, news stories, new sources of information.	How do space ships "know" where they are going?
Design a "Pictionary" border for the classroom wall.	What would life be like aboard a space ship?
(ADD OTHERS)	(ADD OTHERS)

SECTION VI — THE REWARDS OF SPACE

FOR YOU . . . YOUR COUNTRY . . . THE WORLD

"NEW KNOWLEDGE NEEDED" would be an appropriate slogan for a bulletin board in every classroom: it is a key to understanding why man is exploring space.

To enable man to attain this knowledge, we of the schools must cultivate in children the inquiring, creative, and aspiring mind. Already, we begin to see what space research will be doing for us:

1. The placing of men and instruments in an extra terrestrial (out-of-this-world) environment requires that man develop many new products utterly different from anything he had conceived before the beginning of the Space Age. The need to make these products has created new jobs calling for skills and knowledge seldom before used.

2. The equipping of workers with the necessary skills and knowledge calls for an educational system that provides youth with opportunities for schooling beyond the twelfth grade, particularly in the sciences and mathematics.

3. The universe-wide implication of man's search for knowledge of what lies "out-of-this-world" has led to cooperation and understanding between and among nations.

4. The application of space science and technology to the building of weather satellites promises more accurate forecasting of communications satellites, more efficient and economic world-wide communications; and of navigation satellites, safer ocean and air travel.

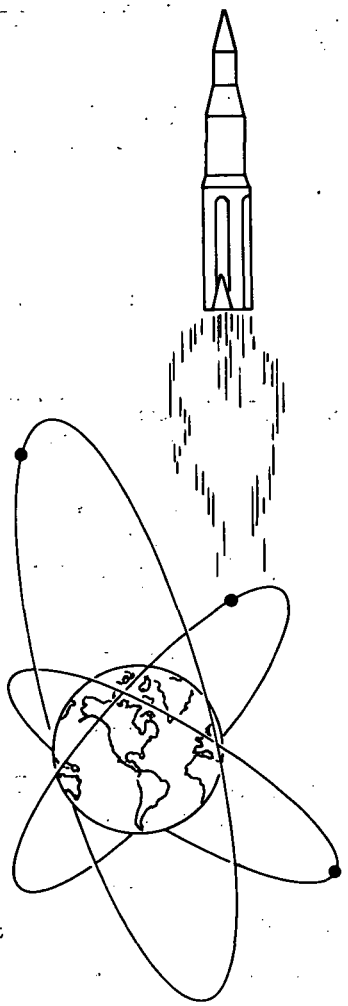
5. The scientific studies and engineering achievements in the space-related sciences have resulted in unlooked-for "fall-out" benefits, which may prove to be as revolutionary as the researches being conducted in outer space. Among such innovations are these important ones:

   a. Microminiaturization, i.e., the employment of small electrical and mechanical parts, such as the transistor in very small radios and hearing aids;

   b. Pyroceram, a material used for the nosecone of a space capsule to withstand the extremes of the cold of outer space and the heat of reentry into the earth's atmosphere, is now being used in kitchenware;

   c. Hydrazine, a drug developed from a liquid fuel propellant shows promise in the treatment of tuberculosis and mental illness;

   d. The successful use of solar energy (energy from the sun) in the solar cells and batteries of satellites may lead to new applications in heating and lighting homes.



FOR A MEANINGFUL VOCABULARY

extra terrestrial
microminiaturization
propellants
pyroceram
research
solar batteries
transistor radios

UPDATING THE VOCABULARY

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A CAPSULE SAMPLE OF INTERRELATED CURRICULUM PLANNING

(Activities to help children develop better skills and understandings of aerospace facts)

THE REWARDS OF SPACE

To provide the class with experiential motivation, raise the question, "How can Space research contribute to world peace and cooperation?" Develop a functional bulletin board display headed, "The New Age of Discovery." Use such captions as, "Direct Discovery," "Direct Utilization," and "By-Products."

LANGUAGE ARTS ORAL	Observing Listening Speaking	To develop the skill of forming inferences from what they see and hear, have children collect clippings about recent social and economic developments resulting from the space exploration effort.
LANGUAGE ARTS WRITTEN	Functional writing	- To improve children's skill in organizing and keeping records, keep a class file of poems, songs, newspaper clippings, short stories, pictures, and TV and radio programs about the social and economic outcome of aerospace exploration.
	Creative writing	- To help children become aware of plot and story design, use one of the captions from the bulletin board and write a narrative in autobiographical form.
	Word study	- To practice the skill of finding derivations, have the children consult the unabridged dictionary to become familiar with origins of aerospace terms. Have them make a class chart.
	Punctuation	- To reinforce the skill of using commas to separate words in a series, to conclude an introductory clause, and to introduce direct quotations, have children proofread the narratives they wrote as suggested above.
	Reading	- To help children discriminate between relevant and irrelevant ideas, have them collect articles about the practical benefits of space exploration, and evaluate the author's point of view.
SOCIAL STUDIES	Concept development	- To gain understanding of the implications of the NASA mission, the peaceful exploration of space, consider the benefits of space exploration to weather forecasting, improved communications, safe navigation, and medical knowledge.
SCIENCE	Activity	- Bring to class a transistor radio. Compare it in size with an older radio which employs vacuum tubes.
	Observation	- How do the sizes of the components of the two radios differ? How long ago did stores begin to sell transistor radios?
	Concept	- Space exploration stimulated the rapid development of microminiaturization.
	Follow-up	- Find other examples of microminiaturization.
MATHEMATICS	Concept or skill development	- To provide review of arithmetic skills and concepts, such as multiplication and division of rate, time, and distance, choose appropriate exercises from preceding sections and their suggested readings.
HEALTH EDUCATION		To gain better insights into the contributions of space research to man's physical well-being on earth, explain the use of sensors, central TV in hospitals, hydrazine in the treatment of tuberculosis, edible algae, and others.
ART		To stimulate creative expression, set up a bulletin display of original drawings and paintings depicting children's reactions to aerospace discoveries.

ACTIVITIES FOR REINFORCING LEARNINGS

Make a list of what you think to be the principle discoveries of Aerospace research.

Prepare a brief talk about the significance of one or more of these discoveries.

(ADD OTHERS)

FOR FURTHER EXPLORATION

What did Mariner II tell us about Venus?

What do we expect to learn about Mars from the Mariner probes?

(ADD OTHERS)

SECTION VII

KEY TO PRINTED AND AUDIO-VISUAL MATERIALS IN INTERRELATED CURRICULUM PLANNING UNITS

1. You and the Universe. Filmstrip. 14 frames, color, $1.66. Encyclopedia Britannica Films, 1150 Wilmette Ave., Wilmette, Ill.

2. The Planets. Filmstrip. 31 frames, color, $5.00. Filmstrip House, 432 Park Ave. South, New York, N. Y.

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The Earth's Atmosphere. Filmstrip. 37 frames, color, $5.75. Jam Handy Corporation, 2621 East Grand Blvd., Detroit, Mich.
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39. Walt Disney Studio. Mickey Mouse and His Space Ship. Adapted by Jane Werner. Golden Press, Inc., 850 Third Ave., New York, N.Y., 1952.

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43. Lent, Henry B. Man Alive in Outer Space. Macmillan Co., 60 Fifth Ave., New York, N. Y., 1961.

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SECTION VIII

GLOSSARY OF SPACE TERMS

Definitions are quoted from Short Glossary of Space Terms NASA SP-1, a publication of the National Aeronautics and Space Administration.

acceleration. The rate of change of velocity. (Decrease in velocity is sometimes called "negative acceleration.").

acquisition and tracking radar. A radar set that locks onto a strong signal and tracks the object reflecting the signal.

aerospace. (From aeronautics and space.) Of or pertaining to both the earth's atmosphere and space, as in "aerospace industries."

apogee. In an orbit about the earth, the point at which the satellite is farthest from the center of the earth; the highest altitude reached by a sounding rocket.

apogee rocket. A rocket attached to a satellite or spacecraft designed to fire when the craft is at apogee, the point farthest from the earth in orbit. The effect of the apogee rocket is to establish a new orbit farther from the earth or to allow the craft to escape from earth orbit.

artificial gravity. A simulated gravity established within a space vehicle, as by rotating a cabin about an axis of a spacecraft, the centrifugal force generated being similar to the force of gravity.

astronaut. One who flies or navigates through space.

atmosphere. The envelope of air surrounding the earth; also the body of gases surrounding or comprising any planet or other celestial body.

attitude. The position or orientation of an aircraft, spacecraft, etc., either in motion or at rest, as determined by the relationship between its axes and some reference line or plane such as the horizon.

aurora. The sporadic visible emission from the upper atmosphere over middle and high latitudes. Also called "northern lights" in the northern hemisphere.

axis. (pl. axes) 1. A straight line about which a body rotates, or around which a plane figure may rotate to produce a solid; a line of symmetry. 2. One of a set of reference lines for certain systems of coordinates.

beam. A ray or collection of focused rays of radiated energy. Radio waves used as a navigation aid.

booster rocket. 1. A rocket engine, using either solid or liquid fuel, that assists the normal propulsion system or sustainer engine of a rocket or aeronautical vehicle in some phase of its flight. 2. A rocket used to set a missile vehicle in motion before another engine takes over. (In sense 2 the term "launch vehicle" is more commonly used.)

capsule. 1. A boxlike component or unit, often sealed. 2. A small, sealed, pressurized cabin with an internal environment which will support life in a man or animal during extremely high altitude flight, space flight, or emergency escape.

comet. A luminous member of the solar system composed of a head or coma at the center of which a presumably solid nucleus is sometimes situated, and often with a spectacular gaseous tail extending a great distance from the head. (The orbits of comets are highly elliptical.)

communications satellite. A satellite designed to reflect or relay radio or other communications waves.

complex. Entire area of launch site facilities. This includes blockhouse, launch pad, gantry, etc. Also referred to as a "launch complex."

control. Specifically, to direct the movements of an aircraft, rocket, or spacecraft with particular reference to changes in altitude and speed.

cosmic rays. The extremely high-energy subatomic particles which bombard the atmosphere from outer space. Cosmic-ray primaries seem to be mostly protons, hydrogen nuclei, but also comprise heavier nuclei. On colliding with atmospheric particles they produce many different kinds of lower-energy secondary cosmic radiation.

countdown. The time period in which a sequence of events is carried out to launch a rocket; the sequence of events.

deceleration. The act or process of moving, or of causing to move, with decreasing speed; the state of so moving.

deep space net. A combination of three radar and communications stations in the United States, Australia, and South Africa so located as to keep a spacecraft in deep space under observation at all times.

ecliptic. The apparent annual path of the sun among the stars; the intersection of the plane of the earth's orbit with the celestial sphere. (This is a great circle of the celestial sphere inclined at an angle of about $23^{\circ}27'$ to the celestial equator.)

ejection capsule. 1. In an aircraft or manned spacecraft, a detachable compartment serving as a cockpit or cabin, which may be ejected as a unit and parachuted to the ground. 2. In an artificial satellite, probe, or unmanned spacecraft, a boxlike unit usually containing recording instruments or records of observed data, which may be ejected and returned to earth by a parachute or other deceleration device.

ellipse. A plane curve constituting the locus of all points the sum of whose distances from two fixed points called "foci" is constant; an elongated circle. See conic section. (The orbits of planets, satellites, planetoids, and comets are ellipses; center of attraction is at one focus.)

escape velocity. The radial speed which a particle or larger body must attain in order to escape from the gravitational field of a planet or star. (The escape velocity from Earth is approximately 7 miles per sec.; from Mars, 3.2 miles per sec.; and from the Sun, 390 miles per sec. In order for a celestial body to retain an atmosphere for astronomically long periods of time, the mean velocity of the atmospheric molecules must be considerably below the escape velocity.)

exosphere. The outermost, or topmost portion of the atmosphere. (In the exosphere the air density is so low that the mean free path of individual particles depends upon their direction with respect to the local vertical, being greatest for upward moving particles. It is only from the exosphere that atmospheric gases can, to any appreciable extent, escape into outer space.)

fixed satellite. An earth satellite that orbits from west to east at such a speed as to remain constantly over a given place on the earth's equator.

g or G. An acceleration equal to the acceleration of the earth's gravity, approximately 32.2 feet per second per second at sea level; used as a unit of stress measurement for bodies undergoing acceleration.

gamma ray. An electromagnetic radiation of wave form emitted by a radioactive nucleus and similar to X rays but of higher energy and shorter wavelength.

gantry. A frame structure that spans over something, as an elevated platform that runs astride a work area, supported by wheels on each side; specifically, short for "gantry crane" or "gantry scaffold."

gimbal. 1. A device with two mutually perpendicular and intersecting axes of rotation, thus giving free angular movement in two directions, on which an engine or other object may be mounted. 2. In a gyro, a support which provides the spin axis with a degree-of-freedom.

gox. Gaseous oxygen.

gravitation. The acceleration produced by the mutual attraction of two masses, directed along the line joining their centers of mass, and of magnitude inversely proportional to the square of the distance between the two centers of mass.

gravity. The force imparted by the earth to a mass on, or close to the earth. Since the earth is rotating, the force observed as gravity is the resultant of the force of gravitation and the centrifugal force arising from this rotation.

guidance. The process of directing the movements of an aeronautical vehicle or space vehicle, with particular reference to the selection of a flight path or trajectory.

gyro. A device which utilizes the angular momentum of a spinning rotor to sense angular motion of its base about one or two axes at right angles to the spin axis. Also called "gyroscope."

heat exchanger. A device for transferring heat from one fluid to another without intermixing the fluids.

igniter. Any device used to begin combustion, such as a spark plug in the combustion chamber of a jet engine, or a squib used to ignite fuel in a rocket.

inertial guidance. Guidance by means of acceleration measured and integrated within the craft.

injection. The process of putting an artificial satellite into orbit. Also the time of such action.

ion. An atom or molecularly bound group of atoms having an electric charge. Sometimes also a free electron or other charged subatomic particle.

ionosphere. The part of the earth's outer atmosphere where ions and electrons are present in quantities sufficient to affect the propagation of radio waves.

launch pad. The load-bearing base or platform from which a rocket vehicle is launched. Usually called "pad."

launch vehicle. Any device which propels and guides a spacecraft into orbit about the earth or into a trajectory to another celestial body. Often called "booster."

lift-off. The action of a rocket vehicle as it separates from its launch pad in a vertical ascent. (A lift-off is applicable only to vertical ascent; a take-off is applicable to ascent at any angle. A lift-off is action performed by a rocket; a launch is action performed upon a rocket or upon a satellite or spaceship carried by a rocket.)

lox. 1. Liquid oxygen. Used attributively as in "lox tank," "lox unit." Also called "loxygen." 2. To load the fuel tanks of a rocket vehicle with liquid oxygen. Hence, "loxing."

Mach number. (After Ernst Mach (1838-1916), Austrian scientist.) A number expressing the ratio of the speed of a body or of a point on a body with respect to the surrounding air or other fluid, or the speed of a flow, to the speed of sound in the medium; the speed represented by this number. (If the Mach number is less than one, the flow is called "subsonic" and local disturbances can propagate ahead of the flow. If the Mach number is greater than one, the flow is called "supersonic" and disturbance cannot propagate ahead of the flow, with the result that shock waves form.)

magnitude. Relative brightness of a celestial body. The smaller the magnitude number, the brighter the body.

main stage. 1. In a multistage rocket, the stage that develops the greatest amount of thrust, with or without booster engines. 2. In a single-stage rocket vehicle powered by one or more engines, the period when full thrust (at or above 90 percent) is attained. 3. A sustainer engine, considered as a stage after booster engines have fallen away, as in "the main stage of the Atlas."

mass. The measure of the amount of matter in a body, thus its inertia. (The weight of a body is a measure of the force with which its mass is attracted by the earth.)

meteor. In particular, the light phenomenon which results from the entry into the earth's atmosphere of a solid particle from space; more generally, any physical object or phenomenon associated with such an event.

meteorite. A meteoroid which has reached the surface of the earth without being completely vaporized.

micro. 1. A prefix meaning divided by one million. 2. A prefix meaning very small as a "micrometeorite."

miniaturize. To construct a functioning miniature of a part or instrument. Said of telemetering instruments or parts used in an earth satellite or rocket vehicle, where room is at a premium. Hence, "miniaturized," "miniaturization."

missile. Any object thrown, dropped, fired, launched, or otherwise projected with the purpose of striking a target. Short for "ballistic missile," "guided missile." (Missile is loosely used as a synonym for "rocket," or "spacecraft" by some careless writers.)

multistage rocket. A vehicle having two or more rocket units, each unit firing after the one beneath it has exhausted its propellant. Normally, each unit, or stage, is jettisoned after completing its firing. Also called a "multiple-stage" or, infrequently, a "step rocket."

nosecone. The cone-shaped leading end of a rocket vehicle, consisting (a) of a chamber or chambers in which a satellite, instruments, animals, plants, or auxiliary equipment may be carried, and (b) of an outer surface built to withstand high temperatures generated by aerodynamic heating. (In a satellite vehicle, the nosecone may become the satellite itself after separating from the final stage of the rocket or it may be used to shield the satellite until orbital speed is accomplished, then separating from the satellite.)

orbit. 1. The path of a body or particle under the influence of a gravitational or other force. For instance, the orbit of a celestial body is its path relative to another body around which it revolves. 2. To go around the earth or other body in an orbit.

orbital velocity. 1. The average velocity at which an earth satellite or other orbiting body travels around its primary. 2. The velocity of such a body at any given point in its orbit, as in "its orbital velocity at the apogee is less than at the perigee."

payload. 1. Originally, the revenue-producing portion of an aircraft's load, e.g., passengers, cargo, mail, etc. 2. By extension, that which an aircraft or rocket carries over and above what is necessary for the operation of the vehicle during its flight.

perigee. The orbital point nearest the earth when the center of the earth is the center of attraction. (That orbital point farthest from the earth is called "apogee." Perigee and apogee are used by many writers in referring to orbits of satellites, especially artificial satellites, around any planet or satellite, thus avoiding coinage of new terms for each planet and moon.)

planet. A celestial body of the solar system, revolving around the sun in a nearly circular orbit, or a similar body revolving around a star. (The larger of such bodies are sometimes called "principal planets" to distinguish them from asteroids, planetoids, or minor planets, which are comparatively small.

An inferior planet has an orbit smaller than that of the earth; a superior planet has an orbit larger than that of the earth. The four planets nearest the sun are called "inner planets;" the others "outer planets." The four largest planets are called "major planets." The word planet is of Greek origin, meaning, literally, wanderer, applied because the planets appear to move relative to the stars.)

primary body. The spatial body about which a satellite or other body orbits, or from which it is escaping, or towards which it is falling. (The primary body of the moon is the earth; the primary body of the earth is the sun.)

probe. Any device inserted in an environment for the purpose of obtaining information about the environment, specifically, an instrumented vehicle moving through the upper atmosphere or space, or landing upon another celestial body in order to obtain information about the specific environment.

radio telescope. A device for receiving, amplifying, and measuring the intensity of radio waves originating outside the earth's atmosphere.

reaction engine. An engine that develops thrust by its reaction to ejection of a substance from it; specifically, such an engine that ejects a jet or stream of gases created by the burning of fuel within the engine. (A reaction engine operates in accordance with Newton's third law of motion, i.e., to every action (force) there is an equal and opposite reaction. Both rocket engines and jet engines are reaction engines.)

recovery. The procedure or action that obtains when the whole of a satellite, or a section, instrumentation package, or other part of a rocket vehicle is recovered after a launch; the result of this procedure.

reentry. The event occurring when a spacecraft or other object comes back into the sensible atmosphere after being rocketed to altitudes above the sensible atmosphere; the action involved in this event.

rendezvous. The event of two or more objects meeting at a preconceived time and place. (A rendezvous would be involved, for example, in servicing or resupplying a space station.)

retrorocket. (From "retroacting.") A rocket fitted on or in a spacecraft, satellite, or the like to produce thrust opposed to forward motion.

revolution. Motion of a celestial body in its orbit; circular motion about an axis usually external to the body. (In some contexts the terms "revolution" and "rotation" are used interchangeably; but with reference to the motions of a celestial body, "revolution" refers to the motion in an orbit or about an axis external to the body, while "rotation" refers to motion about an axis within the body. Thus, the earth revolves about the sun annually and rotates about its axis daily.)

rocket. 1. A projectile, pyrotechnic device, or flying vehicle propelled by a rocket engine. 2. A rocket engine.

rocket propellant. Any agent used for consumption or combustion in a rocket and from which the rocket derives its thrust, such as a fuel, oxidizer, additive, catalyst, or any compound or mixture of these. "Rocket propellant" is often shortened to "propellant."

roll. The rotational or oscillatory movement of an aircraft or similar body which takes place about a longitudinal axis through the body——called "roll" for any amount of such rotation.

rotation. Turning of a body about an axis within the body, as the daily rotation of the earth. See revolution.

satellite. 1. An attendant body that revolves about another body, the primary; especially in the solar system, a secondary body, or moon, that revolves about a planet. 2. A man made object that revolves about a spatial body, such as Explorer I about the earth.

sidereal. Of or pertaining to the stars.

solar cell. A photovoltaic device that converts sunlight directly into electrical energy.

solid propellant. Specifically, a rocket propellant in solid form, usually containing both fuel and oxidizer combined or mixed and formed into a monolithic (not powdered or granulated) grain. See rocket propellant and grain.

sonic speed. The speed of sound; by extension, the speed of a body traveling at Mach I. (Sound travels at different speeds through different mediums and at different speeds through any given medium under different conditions of temperature, etc. In the standard atmosphere at sea level, sonic speed is approximately 760 miles per hour.)

sounding rocket. A rocket designed to explore the atmosphere within 4,000 miles of the earth's surface.

space. 1. Specifically, the part of the universe lying outside the limits of the earth's atmosphere. 2. More generally, the volume in which all spatial bodies, including the earth, move.

spacecraft. Devices, manned and unmanned, which are designed to be placed into an orbit about the earth or into a trajectory to another celestial body.

stage. A propulsion unit of a rocket, especially one unit of a multistage rocket, including its own fuel and tanks.

stationary orbit. An orbit in which an equatorial satellite revolves about the primary at the same angular rate as the primary rotates on its axis. From the primary, the satellite thus appears to be stationary over a point on the primary.

synchronous satellite. An equatorial west-to-east satellite orbiting the earth at an altitude of 22,300 statute miles at which altitude it makes one revolution in 24 hours, synchronous with the earth's rotation.

telemetry. The science of measuring a quantity or quantities, transmitting the measured value to a distant station, and there interpreting, indicating, or recording the quantities measured.

thrust. 1. The pushing force developed by an aircraft engine or a rocket engine. 2. Specifically, in rocketry, the product of a propellant mass flow rate and exhaust velocity relative to the vehicle.

tracking. The process of following the movement of a satellite or rocket by radar, radio, and photographic observation.

trajectory. In general, the path traced by any body, as a rocket, moving as a result of externally applied forces. (Trajectory is loosely used to mean "flight path" or "orbit.")

ultraviolet radiation. Electromagnetic radiation shorter in wavelength than visible radiation but longer than X rays; roughly, radiation in the wavelength interval between 10 and 4000 angstroms. (Ultraviolet radiation from the sun is responsible for many complex photochemical reactions characteristic of the upper atmosphere, e.g., the formation of the ozone layer through ultraviolet dissociation of oxygen molecules followed by recombination to form ozone.)

Van Allen belt, Van Allen radiation belt. (For James A. Van Allen, 1915- .) The zone of high-intensity radiation surrounding the earth beginning at altitudes of approximately 500 miles.

vehicle. In terms of space flight, a structure, machine, or device, such as a rocket, designed to carry a burden through air or space; more restrictively, a rocket craft. (This word has acquired its specific meaning owing to the need for a term to embrace all flying craft, including aircraft and rockets.)

velocity. 1. Speed. 2. A vector quantity equal to speed in a given direction.

(In sense 1, "velocity" is often used synonymously with "speed," as in "the velocity of the airplane," but in such contexts "speed" is properly the preferred term; except in the compound "airspeed," velocity is preferred to "speed" in reference to the motion of air or other fluid.)

weight. The force with which an earth-bound body is attracted toward the earth.

weightlessness. A condition in which no acceleration, whether of gravity or other force, can be detected by an observer within the system in question. (Any object falling freely in a vacuum is weightless; thus an unaccelerated satellite orbiting the earth is "weightless" although gravity affects its orbit. Weightlessness can be produced within the atmosphere in aircraft flying a parabolic flight path.

X ray. Electromagnetic radiation of very short wavelength, lying within the wavelength interval of 0.1 to 100 angstroms (between gamma rays and ultraviolet radiation). Also called "X-radiation," "Roentgen ray." (X rays penetrate various thicknesses of all solids and they act upon photographic plates in the same manner as light. Secondary X rays are produced whenever X rays are absorbed by a substance; in the case of absorption by a gas, this results in ionization.)

yaw. 1. The lateral rotational or oscillatory movement of an aircraft, rocket, or the like about a transverse axis. 2. The amount of this movement, i.e., the angle of yaw.

zero g. Weightlessness.

SECTION IX A LISTING OF FREE AND INEXPENSIVE MATERIALS*

BACKGROUND INFORMATION DIRECTORY OF SOURCES ON LAST PAGE

Can You Talk the Language of Space? Free. Glossary of Space Age Terms. USAF.

The Challenge of Space Exploration. Free. An illustrated 44-page booklet on space, including the following topics: The Space Exploration Vehicles, Celestial Mechanics, Space Environment, Operations in Space, and Man in Space. NASA.

Glossary of Air Traffic Control Terms. Free. Defines words and terms used in communication between pilots and ground personnel in control towers and traffic control centers. FAA

Space: Challenge and Promise. Free. Booklet outlining the history of space research, the space programs in the decade to come, and the role of the aerospace industry. Illustrated. AIA.

The Space Frontier (with Astronautics Glossary). $.50. Background material for an understanding of outer space. Illustrated. NAEC.

STL Space Log. 63-page booklet giving condensed log of space programs and spacecraft details. STL.

United States Aircraft, Missiles, and Spacecraft. Published annually. $1.50. Publication describing the nation's achievement in the aerospace field during the previous year. A complete pictorial record with specifications. NAEC.

PERIODICAL PUBLICATIONS

Aeronautics Bulletin. Free. A four-page leaflet published quarterly. Contains current information regarding aeronautics and the conquest of space. Parks.

Aerospace. Free. Monthly. An official publication of the Aerospace Industries Association. AIA

Aviation News Digest. Free. Weekly summary of aviation news developments. ESSO.

Classroom Clipper. Free. Bi-monthly. For teachers of elementary and junior high schools, each issue includes a complete study unit on a country served by the Flying Clippers. Pan Am.

Go Ahead, New York. Free. Monthly. Aviation news, mainly of New York State. NYS.

Shell Aviation News. Free. Monthly. Av. Dev. Div.

TEACHING GUIDES AND ENRICHMENT MATERIAL

Air World Education Study Series. Free. Units on education and air transportation for teachers of elementary grades. Student materials may also be obtained. TWA.

The Arithmetic of Flying. $.50. A resource unit in air-age concepts, for use in seventh and eighth grade classes or for enriching the arithmetic experiences of gifted pupils in the intermediate grades. NAEC.

Earth and Space Guide for Elementary Teachers. $1.00. Suggested procedures for developing concepts of the earth, the universe, and space travel. Bibliography of books, audio-visual material, and other useful aids. NAEC.

New York City Air-Age Institute Source Books. $.50. A 71-page booklet describing New York City's air-age education program and listing sources of free and inexpensive materials, audio-visual aids, and books for classroom use. Bd. of Ed.

Teaching Guide for the Earth and Space Science Course. $1.00. Offers concrete procedures for teaching the elements of geology, astronomy, meteorology, and oceanography. Bibliography. NAEC.

BIBLIOGRAPHIES (separately published)

Aeronautics and Space Bibliography for Elementary Grades. Free. NASA.

Aeronautics and Space Bibliography for Secondary Grades. Free.

Both of the above are annotated lists of recent books, references, and teaching aids related to space exploration, astronomy, and aviation, for use in the elementary or secondary grades respectively. A list for adults is also available. NASA.

Bibliography of Recent Books about Jets, Rockets, and Space Exploration. (1953-1958). Free. Annotated graded bibliography. Pamphlet No. OE-33002. USOE.

A Selected Bibliography of Books About Jets, Rockets, and Space Exploration. (Published after 1958.) Free. Annotated graded bibliography. Pamphlet No. OF-33002-1. USOE.

A List of Space Travel Articles appearing in the issues of the National Geographic from January 1961. Free. Nat. Geog. Soc.

Pictures, Pamphlets, and Packets for Air/Space Education. Single copy free. Provides a comprehensive list of free or inexpensive Air/Space pamphlets, booklets, charts, pictures, films, etc. For all grade levels. Fifth edition, June 1963. NAEC.

Publications of the Federal Aviation Agency. Free. An annotated listing of titles that range from general information to technical reports. The categories of these publications include: airports, aviation, statistics, training, flight information, and miscellaneous subjects. FAA

*The New York City teachers, who prepared and tried out the teaching suggestions of the preceding pages of this Handbook, used this listing, which was prepared as a curriculum document for the city schools, by Frank Woehr, Principal, Aviation High School, New York City, New York.

A LISTING OF FREE AND INEXPENSIVE MATERIALS

DIRECTORY OF SOURCES

AIA	Aerospace Industries Association of America, Inc., 1725 De Sales Street, N. W., Washington, D. C. 20036
ATA	Air Transport Association of America 1000 Connecticut Avenue, N. W., Washington, D. C. 20006
Am. Av. Pub.	American Aviation Publications 1001 Vermont Avenue, N. W., Washington, D. C. 20005
Av. Dev. Div.	Aviation Development Division Port of New York Authority 111 Eighth Avenue, New York, N. Y. 10011
Bd. of Ed.	Board of Education, City of New York* Publications Sales Office 110 Livingston Street, Brooklyn, New York, N. Y. 11201
ESSO	ESSO 60 East 49th Street, New York, N. Y. 10017
FAA	Federal Aviation Agency Aeronautical Reference Branch (Attn: HQ-620) 800 Independence Avenue, S. W., Washington, D. C. 20553
NAEC	National Aerospace Education Council 1025 Connecticut Avenue, N. W., Washington, D. C. 20006
NASA	National Aeronautics and Space Administration Educational Publications Branch - Code AFEE Washington, D. C. 20546
Nat. Geog. Soc.	National Geographic Society 17th & M Streets, N. W., Washington, D. C. 20036
NYS	New York State, Department of Commerce Bureau of Aviation 112 State Street, Albany, New York. 12207
Pan Am.	Pan American World Airways System c/o Educational Director Pan American Building, New York, N. Y. 10017
Parks	Parks College of Aeronautical Technology St. Louis University, East Street, St. Louis, Missouri.63103
STL	Space Technology Laboratories, Inc. One Space Park, Redondo Beach, California. 90277
TWA	Trans World Airlines Air World Education 380 Madison Avenue, New York, N. Y. 10017
USAF	Headquarters, United States Air Force Recruiting Service Wright-Patterson Air Force Base, Ohio
USOE	U. S. Office of Education c/o Specialist for Aerospace Education Department of Health, Education & Welfare 400 Maryland Avenue, S. W., Washington, D. C. 20202

*Make checks payable to Auditor, Board of Education.

SECTION X NASA EDUCATIONAL PUBLICATIONS

NASA educational publications include booklets and folders on space exploration, the NASA mission, NASA programs and projects; curriculum enrichment materials; conference reports; and NASA FACTS.

The NASA FACTS sheets are designed for bulletin board display, or for insertion in looseleaf notebooks when cut, folded, and punched in accordance with directions supplied. These fact sheets describe NASA programs, with photographs and diagrams of the spacecraft and launch vehicles.

For a current list of educational publications available, mail request to:

Educational Publications, AFEE-1
National Aeronautics and Space Administration
Washington, D.C. 20546

SECTION XI NASA FILMS

NASA's motion picture program embraces space exploration films of general interest, technical films, and a space biology series. For a film list, and information regarding bookings of a free loan basis, write to:

NASA Headquarters
Distribution & Central Film Depository Services
Code AFEE-3
Washington, D.C. 20546

SECTION XII NASA SPACEMOBILES

A Spacemobile is a specially designed vehicle carrying equipment and materials utilized in space science lecture-demonstrations. More than 30 units are operating throughout the United States and in foreign countries.

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Additional information may be obtained by writing to "Spacemobile," Mail Code AFEP, NASA Headquarters, Washington, D.C. 20546.

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