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ABSTRACT

The document was prepared to serve as a guide to adult educators and others interested in specific information relating to the National Aeronautics and Space Administration (NASA), and to provide a source of information of the breadth and scope of space explorations including space benefits to mankind. The course is organized into eight units of study: (1) the beginning of space exploration, (2) rocketry and propulsion systems, (3) unmanned and manned space flight, (4) to the moon and back, (5) Apollo mission results and practical returns from space investment, (6) the space program today--information and available resources, (7) basic scientific concepts relating to the space program, and (8) space programs. The format of each unit is the same: an introduction and rationale, a pre-assessment, and the unit objectives, followed by the unit's content in the form of an outline several pages in length; vocabulary, suggestions for the teacher, a listing of illustrative resources, and a post-assessment conclude each unit. Appended are a glossary, suggested learning activities, and a comprehensive examination. (Author/AJ)

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space awareness

an adult education curriculum resource guide

This public document was promulgated at an annual cost of $3,978.01 or $3.97 per copy to serve as an instructional guide for adult educators and others interested in specific information relating to the National Aeronautics and Space Administration and to provide a source of information of the breadth and scope of space explorations including space benefits to mankind.

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FOREWORD

The purpose of this publication is to provide a resource guide for teachers in adult education. It represents a cooperative effort between the F~~orida Department of Education and the National Aeronautics ~~d Space Administration to provide adult citizens an opportunity for a better understanding of the space program.

The subject matter is designed not only to provide information on past, present and future space programs but to point out benefits and practical returns of the space investment to this country.

It is hoped that this course of study will stimulate interest and understanding while building a well informed citizenry totally aware of the benefits of space exploration.

Floyd T. Christian

Commissioner of Education

PREFACE

This course is designed to provide adults with a greater knowledge of the activities and the results of the National Aeronautics and Space Administration. It is one of the many tools employed to provide the widest practicable and appropriate dissemination of information to the public in general.

In order to have a truly informed citizenry, which understands the United States efforts in aeronautics and the exploration of space for peaceful purposes and the benefit of mankind, information must be made available to the public on a level understandable to the layman. Whether the adult who enrolls in this course is a housewife, a farmer, a businessman, a laborer, a college graduate, a high school dropout or represents any other classification or status, he will receive information of the breadth and scope of space exploration which will develop not only an awareness of space but an excitement and interest which will lead to further quest for information and understandings.

It is important that the general public know something of the origin of space exploration. How and when did efforts to explore space begin? Who were some of the men, and great thinkers, who first conceived that humans could fly, that rockets could be built, that man could explore outer space, that man could reach the moon, that space technology could be used to promote human welfare?

This course will impress upon the adult that the space mission begins many years before the dramatic climax of a tremendous vehicle blasting off into space. This is the most dramatic episode in the space mission; however, it is but one brief episode in the total picture. It is, in fact, the culmination of years of work involving hundreds of thousands of hours of human efforts and millions of dollars worth of equipment.

ACKNOWLEDGEMENTS

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The author of this document, Mr. Marvin Jones, was a former supervisor of adult education programs in Brevard County School District and researched this project at the Kennedy Space Center. This was arranged through an inter-governmental exchange program in which Mr. Jones worked as a NASA employee on loan from Brevard County. In this position the author observed the space program first hand and discussed his work with Kennedy Space Center engineers and scientists responsible for the success of the program.

OVERALL SUGGESTIONS TO THE TEACHER

Nothing in the process of educating adults puts the student more at ease than to give him a test and tell him to answer the questions if he knows the answers, that it is an educational activity rather than a testing activity, that it does not have to be returned to the teacher, that in the course of the unit under study he will receive answers to the questions, that if at any time he has questions concerning the test he is free to consult the teacher, and finally, that at a given time he will be given answers to the test questions for self-evaluation. This we suggest for the pre-assessment activity. It is further suggested that the pre-assessment be given at the beginning of the unit, followed by the introduction of the unit. Along with the introduction of the unit, the words from the Space Awareness vocabulary should be given to the students. You should decide the most effective way to present the words after observing the class. Writing the words on a chalk board, duplicating word lists for handouts, or even pronouncing and spelling aloud for the students to write are some methods for consideration. An advantage in the use of the vocabulary is the use of the activity to promote study at home. Use this as a homework assignment without the pressure of the conventional work to be returned to the teacher. Use the word lists primarily to help the adult build a working Space Awareness vocabulary. Have the student define the words and add them to a notebook which he keeps for himself. Decide whether or not you want to conduct an activity of using the words in sentences after you observe the type of group you are working with. Many of the words can only be found in NASA publications which you will be able to acquire in quantity for use as handouts for your classes. When the student has a publication and the word list in his possession, his search for the words will certainly stimulate out-of-class reading. You have your complete glossary to refer to for really difficult and hard to find definitions to aid the student.

For lecture periods you should draw from your own experiences, from the outline as presented in this guide, or from NASA publications. Again the make-up of your class or group will dictate lecture material, how often lectures should be given, length of lectures, etc.

During the course of the unit, you should note the progress of your class as a whole. How well did they do on the pre-assessment? Are they continuing to seek answers to the questions? How are they progressing on the word list? Are they asking questions freely? Which activity stimulates the most interest (laboratory type activities, lectures, films, field trips)? Answers to these questions will suggest courses of future action on your part.

It is suggested that periods of planning be spent by you and your students, as to how best to achieve the purposes of the unit. You must remain in control of the situation and guide the thinking of the group in the planning. It is well, however, for the adults to feel that they have a share in the procedure.

It has been suggested previously that the type, the make-up, or even the level of academic achievement of the adults you are working with, should dictate content, methods, techniques, etc. There is no area in which this procedure should be adhered to more than in determining the evaluation. To evaluate or not to evaluate? In some situations, you must of necessity evaluate (high school credit or completion). There will be other situations in which a formal evaluation will be questionable (general interest groups or Adult Basic Education classes). You should consider the post-assessment as a means of informal evaluation without the emphasis on pass or fail for some groups. The post-assessment could very well be used as a formal evaluation if circumstances warrant this. Another suggestion is that the comprehensive examination in the appendix be utilized all or in part, as the need arises, if this procedure produces desired results.

In addition to these overall suggestions, specific suggestions will be made for each unit.

UNIT I - THE BEGINNING OF SPACE EXPLORATION

INTRODUCTION

This unit presents some of the early theories and accomplishments in man's attempt to conquer space and shows that present-day successes were based on some of this early scientific work.

The beginning of space exploration must begin with the myths and legends of our earliest civilizations. Mankind's unquenchable desire to extend his horizons has its roots almost back to the beginning of time. This unit stresses the continuity of ideas and the progress as new theories were developed, tested, rejected or adapted and accepted. Our sophisticated rocketry of today has its roots in the past.

History tells us that flight has always challenged man's imagination. Most of man's early attempts with flying devices ended in failure. Some men were finally successful in flying their machines, but only after they began to understand and apply basic aerodynamic principles.

The technology of space exploration is a rapidly growing one. This unit also stresses the point that as modern as space flight may seem, most of the basic knowledge necessary for putting satellites into orbit or for launching an interplanetary space vehicle was given to us by Johannes Kepler and by Sir Isaac Newton (1642-1727) hundreds of years ago.

Even though rockets were born hundreds of years ago, only during the past decade were they actually used to lift man into space after science developed better propulsion and guidance systems.

This unit will familiarize adult students with the contributions of Copernicus, Kepler and Newton. The students will also learn about the work of Leonardo da Vinci, the Montgolfier brothers, Henry Giffard, the Wright brothers, Galileo, and Dr. Robert Goddard during the course of the unit.

RATIONALE

The appreciation of the historical aspects incorporated within the study of space awareness allows the learner the opportunity to perceive the linear development of space travel. The realization that an extreme number of variables has affected the "space thinkers" of the past and the present certainly reveals the creative endurance necessary in the study of space exploration. Awareness of the struggle and the accompanying creations enhances the positive reinforcement involved in learning about space. The general public will be in a better position to understand and appreciate man's efforts to explore space if there is information available through this unit of early attempts to fly and explore the heavens.

PRE-ASSESSMENT

1. Match the following individuals and their contributions to space exploration. In the space before each statement in Column A, print the <u>one</u> letter from Column B which correctly identifies the person or persons responsible for the contribution.

COLUMN A

_____ 1. Made the first practical use of the telescope to discover many new facts about astronomy.

_____ 2. Studied bird flight and drew pictures of wings which he thought could be attached to the arms and legs of a man to enable him to fly.

_____ 3. Founded present-day astronomy with his theory that the earth is a moving planet.

_____ 4. Built and flew the first successful engine-powered airship.

_____ 5. Called the "father" of modern rocketry.

_____ 6. The first to build a successful balloon.

_____ 7. Developed long-range military rockets that carried explosives during the early 1800's.

_____ 8. Built a gasoline-powered airplane and flew it successfully in 1903.

_____ 9. Discovered how the universe is held together through his theory of gravity.

_____ 10. Discovered three laws of planetary motion.

COLUMN B

A. Charles A. Lindbergh
B. Leonardo Da Vinci
C. The Montgolfier Brothers
D. Henry Giffard
E. Orville and Wilbur Wright
F. Nicolaus Copernicus
G. Galileo
H. Johannes Kepler
I. Sir Isaac Newton
J. Sir William Congreve
K. Dr. Robert H. Goddard
L. Amelia Earhart

GENERAL OBJECTIVES

1. To acquaint the student with the origin of space exploration.
2. To bring about an awareness that the advances in space

exploration are the result of developments hundreds of years ago.

3. To promote interest in the further study of space exploration and its results.

SPECIFIC OBJECTIVES

1. Given the names of outstanding contributors to space exploration, the student will select the main contribution of each from a list.
2. From a list of vehicles driven by rocket power, the student will select the one which is acknowledged to be the first practical vehicle developed.
3. Given a list of events in the exploration of space, the student will identify the one event which heralded the beginning of the space age.
4. Given eight characteristics descriptive of the National Aeronautics and Space Administration (NASA), and the National Advisory Committee for Aeronautics (NACA), the student will classify them correctly.

CONTENT

I. Leonardo da Vinci (1452-1519) pioneered studies of flying.
   A. Studied bird flight and drew many pictures of wings which he thought could be attached to the arms and legs of a man so he could fly.
   B. Made drawings of parachutes, propellers, and helicopters.
   C. Never attempted to build any aircraft.

II. Montgolfier brothers of France were the first to build a successful balloon.
   A. Built big balloons filled with hot air in 1783.
   B. Men in baskets floated freely through the air for the first time in history.

III. Henry Giffard built and flew the first successful engine-powered airship.
   A. Cigar-shaped craft.
   B. Steam engine.
   C. Speed of more than six miles an hour.

IV. Orville (1871-1948) and Wilbur (1867-1912) Wright took up gliding as a hobby.
   A. Built gliders and tested them in 1900 and 1901.
   B. Built wind tunnel to test various kinds of wings for aircraft.
   C. Made a light gasoline engine.
   D. Built a gasoline-powered airplane and flew it successfully on December 17, 1903.

V. Wright brothers' first airplanes flew only 31 miles an hour.
   A. Planes had been built that could speed along at more than 100 mph by 1912.
   B. Historical long-distance flight by Charles A. Lindbergh in 1927.
      1. Non-stop flight from New York to Paris.
      2. 3,610 miles across the ocean.
      3. Thirty-three and a half hours flying time.
      4. People realized the airplane had "come of age."
   C. James H. Doolittle won races at speeds close to 300 mph by 1932.
   D. Jet propelled and rocket propelled planes made it possible for men to fly faster than sound in 1940. (More than 760 mph.)

VI. Nicolaus Copernicus (1473-1543) founded present-day astronomy with his theory that the earth is a moving planet. His theory laid the foundations for the telescopic discoveries of Galileo, the planetary laws of Johannes Kepler, and the gravitation principle of Sir Isaac Newton.
   A. Demonstrated that the sun, not the earth, was the center of the solar system, as earlier astronomers had believed.
   B. He showed that the planets of the solar system, including earth, keep revolving around the sun.

VII. Galileo (1564-1642) made the first practical use of the telescope to discover many new facts about astronomy.
   A. First important observation concerned the moon.
   B. Discovered that the moon was not a smooth sphere shining by its own light.
   C. Observed that the moon's surface was marked by valleys and mountains and that it showed only the light it reflected.
   D. Most sensational discovery was the four bright satellites of Jupiter in 1610.
   E. Firmly upheld the theory of Copernicus that the earth moves around the sun.

VIII. Johannes Kepler (1571-1630) astronomer and mathematician discovered three laws of planetary motion.
   A. Every planet follows an oval-shaped path, or orbit, around the sun, called an ellipse. The sun is located at one focus of the elliptical orbit.
   B. An imaginary line from the center of the sun to the center of a planet sweeps out the same area in a given time. Planets move faster when they are closer to the sun.
   C. The time taken by a planet to make one complete trip around the sun is its period.

IX. Sir Isaac Newton (1642-1727) scientist, astronomer, and mathematician discovered how the universe is held together through his theory of gravity.
   A. Concept of a universal force came to him while he was drinking tea in the garden and saw an apple fall.
   B. Concluded one and the same force pulls the apple to earth and keeps the moon in its orbit.
   C. The force of universal gravitation makes every pair of bodies in the universe attract each other.
      1. The force depends on the amount of matter in the bodies being attracted.
      2. The force also depends on the distance between the bodies.
   D. The force by which the earth attracts or pulls a large rock is greater than the pull on a small pebble because the rock contains more matter.
   E. Many types of motion are due to one kind of force.
      1. Gravitational force of the sun keeps the planets in their orbits.
      2. Gravitational force of the earth attracts the moon and an apple.

X. Rocket - a projectile consisting of a cylinder filled with a combustible substance which when ignited produces gases that escape through a vent in the rear and drive their container forward by the principle of reaction.
   A. Scientists believe rockets were invented by the Chinese.
   B. Chinese historians described "arrows of flying fire" that were used in war in the year A.D. 1232.

XI. A rocket propelled by powdered fuel was devised by a German engineer, VonEichsteadt, in 1405.
   A. Used by both Chinese and Germans as military weapons.
   B. Effectiveness limited to a frightening display of fireworks.

XII. Sir Isaac Newton gave the laws of motion which actually told what made the rocket go during 1667-69. (Many years after the invention of the rocket).
   A. A body in a state of rest remains at rest, and a body in motion tends to remain in uniform motion unless acted upon by some outside force.
   B. The rate of change in the momentum of a body is proportional to the force acting on a body and is in the direction of the force.
   C. To every action there is an equal and opposite reaction.

XIII. Sir William Congreve developed long-range military rockets that carried explosives during the early 1800's.
   A. Solid Fuel rockets.

B. Sixty pounds in weight.
C. Travel a mile and a half.
D. Used in the War of 1812 by the British during the seige of Fort McHenry. (Inspired the phrase "the rockets' red glare," used by Francis Scott Key in his "The Star-Spangled Banner.")

XIV. Robert H. Goddard (1882-1945), scientist, was the father of modern rocketry and space flight.
A. Proved by test that a rocket works in a vacuum.
B. Worked out the mathematics of rocket action.
C. Developed rockets equipped with propellant pumps, gyrocontrols, and instrumentation.
D. Wrote a treatise, "A Method of Reaching Extreme Altitudes" (1919), in which he proposed trying to reach the moon.
E. Delivered a ton of explosives as far as 200 miles from launch site.

XV. The first practical vehicle driven by rocket power was developed during World War II.
A. German V-1 was followed by vastly improved V-2 rocket.
B. German V-2, outstanding rocket developed in the war.
1. Liquid fuel.
2. Forty-six feet long.
3. Over fourteen tons in weight at take-off.
4. Achieved a speed in flight of more than 3,000 miles per hour at a peak altitude of sixty miles.

XVI. Larger and more powerful rocket weapons than the V-2 were developed in post-war years in America and Russia.

XVII. United States Army, Navy and Air Force began the use of large rockets as tools of research.
A. Began using V-2 rockets captured from Germany.
B. Later used new rockets developed as weapons or as research vehicles.
C. Sponsored extensive program for studying the upper atmosphere with high altitude rockets.

XVIII. U.S. Navy Viking, example of a rocket built and used solely as a research vehicle.
A. Fourteen Vikings launched from 1949-1957.
B. Record height of 158 miles for a single-stage missile set by a Viking.
C. Instruments in Viking missiles gathered information concerning temperature, density, composition, and winds in the upper atmosphere.
D. Instruments recorded the intensity of cosmic rays and meteoric particles, and the ultra-violet radiation of the sun.

XIX. The SPACE AGE opened on October 4, 1957.

A. Russia launched world's first satellite, Sputnik I, with three-stage rocket.
   1. Metal sphere weighing 184 pounds.
   2. Contained radio transmitter and devices for measuring temperature and pressure inside the satellite.

B. Sputnik II launched on November 3, 1957.
   1. Weighed over half a ton.
   2. Carried instruments for measuring cosmic rays, ultraviolet and x-ray radiation.
   3. Contained small passenger compartment in which a dog, Laika, remained alive for about a week.

C. United States Army blasted first American satellite, EXPLORER I, into orbit with a four-stage rocket on January 31, 1958.
   1. Weighed only 30.8 pounds (14 Kgs).
   2. Contained many minature instruments for measuring radiation and temperature in space.
   3. Made possible the first important discovery in space, the existence of radiation belts around the earth.

XX. Increased interest in scientific research developed in the United States following launching of first satellites.

A. Space exploration began in earnest.

B. Important objectives for space travel emerged.
   1. Research into the nature of space.
   2. Satellites for defense.
   3. Exploration of worlds beyond the earth.
   4. Programs of practical benefit to mankind.

XXI. President Dwight D. Eisenhower signed the National Aeronautics and Space Act into law on July 29, 1958.

A. His action brought into being an organization to:
   1. Plan, direct, and conduct aeronautical and space activities.
   2. Arrange for participation by the scientific community in planning scientific measurements and observations.
   3. Provide for the widest practical and appropriate dissemination of information concerning its activities and the results thereof.
   4. Guide the Nation into the Space Age.

B. Space activities related to defense were to continue in the Department of Defense.

C. Reflecting general concern in Congress over the relationship between space technology and national defense, the Space Act added a Civilian-Military Liaison Committee, appointed by the President, to ensure full interchange of information and data acquired in NASA and Defense Department Programs.

XXII. On October 1, 1958, as a result of the approval of the National Aeronautics and Space Act, the American Government established a civilian agency, the National Aeronautics and Space Administration (NASA), and the military space program.

A. NASA absorbed the National Advisory Committee for Aeronautics (NACA).
   1. NACA was founded in 1915 by an act of Congress.
   2. NACA's responsibility was defined in a joint resolution of Congress: "...it shall be the duty of the Advisory Committee for Aeronautics to supervise and direct the scientific study of the problems of flight, with a view to their practical solution, and to determine the problems which should be experimentally attached, and to discuss their solution and their application to practical questions. In the event of a laboratory or laboratories, either in whole or in part, being placed under the direction of the committee, the committee may direct and conduct research and experiment in aeronautics in such laboratories."

B. NASA's responsibility designated to conduct and coordinate the United States non-military research into problems of flight within and beyond the earth's atmosphere.

SPACE AWARENESS VOCABULARY

Satellite	Gravity	Astronomy
Orbit	Planet	Inertia
Ellipse	Rocket	Orbital rocket
Sphere	Propellant	

SUGGESTIONS FOR THE TEACHER

There are several possible ways of beginning the study of this unit in such a way as to arouse interest in space exploration and to suggest additional study. The following ways may be considered:

1. A story, well told, of one of the many myths and legends about space and the heavenly bodies. Perhaps you remember reading the Greek myth about Daedalus and Icarus who made wings of wax and feathers to fly to the Sun. One of the ancient legends tells about Alexander the Great who attempted to reach the heavens in a chariot drawn by eagles. There is an old Chinese legend that explains how the Chinese arrived on Earth from the Moon. The great hero of India, Ramayana, was a space traveler in legend.

Research some of these myths and legends, select one and tell it to your adult class to stress that man has always longed to travel out into space, to visit other planets, to explore the Moon, and to determine the conditions that exist in the regions beyond the earth's atmosphere.

2. Raise questions about man's ancient desire to fly and his early attempts at flying.

3. Consider a film in the introduction of the unit. The NASA film, Seeds of Discovery, (color) 26:30 minutes, could serve the purpose. This film begins with the early beliefs of Copernicus regarding space and progresses to a modern period. A little out of date, but nonetheless very interesting and informative. This film has been rated excellent by adult educators.

Following the introduction of the unit, you should refer to the overall suggestions to the teacher as you progress through the unit.

In guiding the thinking of your students as you work and plan together, you may want to offer some activities for their consideration.

Consider dividing the class or group of adults into committees to research and discuss such topics as:

1. Man's Desire to Fly in Ancient Times
2. Early Attempts at Flying
3. First Successful Engine-powered Airship
4. First of the Wright Brothers' Airplanes

Follow these suggestions with discussions on what the students discovered about the topics, calling attention to the long span of time these events covered. Encourage your adult class to offer other topics that they are interested in and select the ones that are pertinent to this unit for discussion.

Encourage your students to read biographies of some of the famous pioneers in aviation, such as Orville and Wilbur Wright, Charles A. Lindbergh, Amelia Earhart, and others.

Guide the students in organizing a bulletin board on "Early Astronomers." Encourage a group of volunteers to construct a bulletin board of the contributions of Galileo, Copernicus, Kepler and Newton.

Trace the history of rocket propulsion beginning with the Chinese to the present including Dr. Robert H. Goddard, the "father" of modern rocketry. Use this activity as a lead-in to Unit II.

Refer to the appendix for laboratory type activities for this unit and use them as you deem appropriate for the group you are working with.

ILLUSTRATIVE RESOURCES

NASA Publications:
EP-57 America in Space/The First Decade - Man in Space
Fifty Years of Aeronautical Research
EP-22 This is NASA
EP-58 Propulsion

Textbooks:
Wolfe, Battan, Fleming, Hawkins, and Skornik, Earth and Space Science, D. C. Heath and Company, Boston

MacCracken, Decker, Read and Yarian, Scientists Solve Problems, L. W. Singer Company, Second Edition

Brandwein, Beck, Strahler, Hollingworth and Brennan, The World of Matter-Energy, Harcourt, Brace and World, Inc.

Films:
Seeds of Discovery (color) 26:30 minutes
Steps to Saturn (color) 22 minutes
Canaveral to Kennedy (color) 7:30 minutes
Biography of A Missile (black and white) 28 minutes
Countdown to Rendezvous (color) 13:37 minutes
Father of the Space Age (black and white) 18 minutes

POST ASSESSMENT

I. In the following list, circle the one which is acknowledged to be the first practical vehicle developed.
   A. Scout
   B. Jupiter C
   C. German V-2
   D. Delta
   E. Vanguard

II. In the following list, circle the one event that heralded the beginning of the space age.
   A. Russian cosmonaut, Yuri A. Gagarin, orbited the Earth in a spaceship for the first manned space flight.
   B. Astronaut Neil A. Armstrong became the first man to set foot on the Moon.

C. Explorer I, the first U.S. satellite, went into orbit and discovered Van Allen radiation surrounding the Earth.

D. Sputnik I, the first artificial satellite, was launched by Russia.

E. Russia's Luna 9 made the first soft landing on the Moon.

III. Across from each statement check whether it is a characteristic of NASA or of NACA.

	NASA	NACA
1. Founded in 1915 by an Act of Congress.	____	____
2. Established on October 1, 1958.	____	____
3. A civilian agency.	____	____
4. Has the duty to supervise and direct the scientific study of the problems of flight.	____	____
5. Has the responsibility of conducting and coordinating the United States non-military research into problems of flight within and beyond the Earth's atmosphere.	____	____
6. Absorbed, in its establishment, an agency founded in 1915 by an Act of Congress.	____	____
7. Responsible for development, managerial and flight operational responsibilities as well as research.	____	____
8. Authority diffused in a committee rather than centralized with a single executive.	____	____

PRE-ASSESSMENT ANSWER KEY

I. B. F. D. H. C. A. J. I. G. E.

POST-ASSESSMENT ANSWER KEY

I. C. German V-2

II. D. Sputnik I, the first artificial satellite, was launched by Russia.

III.

	NASA	NACA
1.		X
2.	X	
3.	X	
4.		X
5.	X	
6.	X	
7.	X	
8.		X

UNIT II - ROCKETRY AND PROPULSION SYSTEMS

INTRODUCTION

Rockets are not new to mankind; they have been used in warfare and for fireworks displays for hundreds of years.

Scientists believe rockets were invented by the Chinese. Chinese historians described "arrows of flying fire" that were used in war in the year A.D. 1232. Within a few dozen years, rockets were being used in wars in Europe to set fire to enemy fortifications.

A Russian high school teacher, Konstantin E. Tsiolkovsky (1857-1935), was the first to develop the correct theory of rocket action. He described his theory in a paper which was published in 1903. Robert Goddard (1882-1945) began the first scientific experiments with rockets in the United States. Regarded as the "father of the modern rocket," he predicted the use of rockets to explore high altitudes. His paper, "A Method of Reaching Extreme Altitudes," was published in 1919 by the Smithsonian Institution. In 1926, Dr. Goddard built the first liquid-fuel rocket. Four years later he fired a rocket which rose to a height of 610 meters (2,000 feet) at a speed of 800 kilometers (500 miles) an hour. He assisted the United States Government by rocket research in World War II.

Rocket development was paced by the demands of war. The first German V-2 ballistic missile was fired unsuccessfully twice in 1942 before its first successful launching in

October that year. It was to become operational as a field weapon less than two years later, only a few months after the pulse-jet powered V-1 flying bomb was used to bomb London.

A rocket differs from other types of jet-propelled engines because it carries its own oxygen, thus, eliminating the need for oxygen in the air to burn the fuel. A rocket motor, however, uses large amounts of fuel, so most rocket motors can operate only for short periods of time before they run out of fuel.

After the war, many experiments were conducted in the United States with captured German rockets. On December 14, 1946, a V-2 rose to a height of 182 kilometers (114 miles) above the White Sands Proving Ground, New Mexico.

The first large high-altitude sounding rocket designed and built in the United States was known as the Wac Corporal.

In February, 1949, a two-stage rocket was fired by the United States Army. A small Wac Corporal was set in the nose of a V-2 rocket. The V-2 was fired. When it reached an altitude of 32 kilometers (20 miles), the Wac Corporal was fired from the nose of the V-2. The smaller rocket rose to 400 kilometers (250 miles) and reached a speed of 800 kilometers (5,000 miles) per hour.

On July 24, 1950, a modified German V-2, with an Army Wac Corporal second stage was successfully fired from Cape Canaveral. Called "Bumper," the vehicle was launched from the old Pad 3 site, east of Complex 36, and is recorded as the first Cape launch. (See figure one.) The rocket was 14 meters (47 feet) long, and 2.3 meters (5 feet, 5 inches) in diameter. Weighing 12,805 kilograms (28,229 pounds), its propellants were alcohol and liquid oxygen. It had a thrust of 27,216 kilograms (60,000 pounds) and a range of 354 kilometers (220 miles) maximum.

The Space Age opened on October 4, 1957, when Russia launched the world's first satellite, Sputnik I, with a three-stage rocket.

RATIONALE

The appreciation of the historical aspects incorporated within the study of space awareness allows the learner the opportunity to perceive the linear development of space exploration. The realization that an extreme number of variables has affected the "space thinkers" of the past and present certainly reveals the creative endurance necessary in the study of space exploration. Awareness of the struggle and the accompanying creations enhance the positive reinvorcement involved in learning about space.

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PRE-ASSESSMENT

I. Across from each statement below, check whether it is a characteristic of a Jet or a Rocket.

	Jet	Rocket
1. This engine depends upon the atmosphere for oxygen to release the energy of the fuel.	____	____
2. These engines are designed to fly in the Earth's atmosphere. Oxygen in the air serves as the oxidizer.	____	____
3. Operating in space, these engines do not have the advantage of picking up their propellant as they move on.	____	____
4. This engine carries its own fuel plus oxygen or other chemicals.	____	____
5. An oxidizer must be carried to substitute for the oxygen in the Earth's atmosphere for this engine.	____	____
6. This engine picks up most of its propellant, the air, as it moves along.	____	____
7. This is the only engine capable of propulsion in space.	____	____

II. Place an X in front of the four statements which are characteristics of the new approach to launch operations known as the "Mobile Concept."

____ 1. The space vehicle is assembled and tested in the Vehicle Assembly Building.

____ 2. The Apollo spacecraft consists of a Command Module, a Service Module and a Lunar Module.

____ 3. The space vehicle is erected for checkout, transfer and launch on the Mobile Launcher.

____ 4. The Transporter transfers the space vehicle and Mobile Launcher to the launch site.

____ 5. Skylab is the NASA experimental space station program scheduled to become operational in 1973.

____ 6. The Mobile Service Structure provides external access to the vehicle and spacecraft at the launch site.

____ 7. The Space Shuttle is envisioned as a space transportation system that will materially reduce the cost of space operations.

GENERAL OBJECTIVE

To develop a basic understanding of rocketry and propulsion systems.

SPECIFIC OBJECTIVES

1. Given a list of seven characteristics descriptive of jet and rocket engines, the student will classify them correctly.

2. Given five characteristics of liquid and solid fuels, the student will classify them correctly.

3. Given a list containing names of six NASA launch vehicles, in Column A, the student will select the correct descriptive phase for each from a list in Column B.

4. Given six characteristics descriptive of liquid-fuel rockets and solid-fuel rockets, the student will classify them correctly.

5. From a list, the student will select <u>four</u> characteristics of the new approach to launch operations known as the "mobile concept."

CONTENT

I. Review definitions of a rocket, Unit I.

II. A rocket differs from other types of jet-propelled engines.
   A. Does not need oxygen in the air to burn the fuel because it carries its own oxygen.
   B. Moving through air slows down the flight of a rocket.
   C. Oxygen needed for burning rocket fuel is contained inside the rocket, either in a separate tank or in the fuel itself.
   D. Rocket motor develops more power than any other engine.
   E. Weight is the lowest for each pound of thrust it produces.
   F. Rocket motor uses large amount of fuel - most operate

only for a short period of time before they run out of fuel.

Jet	Rocket
1. Jet engines depend upon the atmosphere for oxygen to release the energy of the fuel.	1. The rocket carries its own fuel plus oxygen or other chemicals.
2. Jet engines are designed to fly in the earth's atmosphere where a supply of oxygen is present - the oxygen serves as the oxidizer.	2. The rocket must carry an oxidizer of some kind to substitute for the oxygen the jets get from the air.
3. The jet engine picks up most of the propellant, the air, as it goes along.	3. Rocket engines, operating in space, do not have the advantage of picking up their propellant as they go.

III. Rockets are the only engines capable of propulsion in space.

A. Only engine that can produce propulsive force while moving at high speeds. (A bullet once fired can only lose velocity. The rocket engine continues to consume fuel in flight and continually adds to its velocity until burnout.)
B. Develops the greatest thrust per pound of engine weight.
C. Economy of fuel consumption is low compared to a jet engine.
D. Carries its own fuel plus oxygen or other chemicals.
E. Moves through the air by burning a fuel which gives off a jet exhaust of gas.
F. Burning gases inside the rocket make a pressure which pushes forward against the front end of the rocket.
G. Oxygen needed for burning the fuel is contained inside the rocket, either in a separate tank or in the fuel itself.

IV. Some solid fuels are made by mixing rubber, resin, or asphalt with a compound containing oxygen. Others are mixtures of guncotton and nitroglycerine.

A. Must contain fuel <u>and</u> oxidizer.
B. Fuel and oxidizer are mixed in proper proportions, and the materials used are such that the combination can be made into any durable shape.
C. The fuel oxidizer mixture when fashioned to a particular size and shape of a rocket is called grain.
D. One type of grain is composed of nitrocellulose and nitroglycerine.

V. Solid fuel rockets are like the skyrockets used in fireworks displays.
   A. Motor has two main parts.
      1. A combustion chamber where the fuel is burned.
      2. A nozzle from which the burned gases are exhausted in a jet.
   B. Fuel and oxidizer mixture usually formed into a layer on the inside of the rocket casing with an opening in the center going the length of the rocket's engine.

VI. Liquid-fuel rockets usually carry two kinds of fuel stored in separate tanks.
   A. One liquid, the oxidizer, carries the oxygen needed for burning. It often is simply oxygen in liquid form. It may also be nitric acid.
   B. The other liquid may be alcohol for a liquid-oxygen rocket, or aniline for a nitric-acid rocket.
   C. Liquids are mixed when forced into combustion chamber.
   D. Some liquid-fuel combinations start burning on contact (hypergols), other must be set on fire.

VII. Liquid-fuel rockets are mostly high-altitude rockets.
   A. Motor has four main parts.
      1. A combustion chamber.
      2. An injector which introduces the fuel into the combustion chamber.
      3. An exhaust nozzle.
      4. A cooling system.
   B. First liquid-fuel rocket successfully tested in 1926, by the American pioneer in rocketry, Dr. Robert H. Goddard.

VIII. A large rocket can carry a smaller rocket on its nose, forming a single unit.
   A. Single unit, or combination of two rockets, is called a two-stage rocket.
   B. The large rocket, which is fired first, often is called a booster.
   C. Smaller rocket fires after the large rocket has used up its fuel.
   D. Two-stage rockets climb higher than single rockets of the same size and weight.
   E. Three or more rockets placed together to fire one after another is called a multi-stage or multiple-step rocket.
   F. Most rockets used to launch satellites and space vehicles are multi-stage rockets.

IX. NASA developed a family of reliable launch vehicles of different sizes, shapes and capabilities.
   A. Scout
      1. Smallest of the basic launch vehicles.

2. A reliable and relatively inexpensive launch vehicle for payloads weighing up to 109 kilograms (240 pounds).
3. Has four stages, is 21 meters (68 feet) high (less the spacecraft), and has a maximum diameter of 1.2 meters (4 feet) at its widest cross section.
4. The only U.S. launch vehicle with solid propellants exclusively.
5. The first-stage has a thrust of 39,952 kilograms (88,000 pounds).
6. Used for unmanned small satellite missions, high-altitude probes, and re-entry experiments.

B. Centaur
1. Centaur, launched by Atlas stage, is the first U.S. rocket system to utilize liquid hydrogen and liquid oxygen.
2. Atlas-Centaur, with Atlas first stage and Centaur second stage, is the most advanced of the Atlas based series of launch vehicles.
3. The two-stage liquid-fueled vehicle develops a total thrust of 195,955 kilograms (432,000 pounds). Atlas thrust: 187,347 kilograms (402,000 pounds). Centaur thrust: 13,608 kilograms (30,000 pounds).
4. Launched Applications Technology Satellites, Orbiting Astronomical Observatory 2, and Mariners 6 & 7.
5. Launched the highly successful Surveyor spacecraft that soft-landed on the lunar surface and relayed photographs back to Earth.
6. Five of seven Surveyors successful in 18 month period (1966 - 1968).
7. Returned over 88,000 pictures of the Moon.

C. Delta
1. Employs components developed by the Air Force and Navy.
2. Workhorse NASA vehicles for a wide range of satellite missions and space probes.
3. Two liquid-fueled stages topped by a solid-fuel stage.
4. Height of 32.3 meters (106 feet) and a weight of 90.7 metric tons (100 tons).
5. Total thrust of the first stage, including 3 strap-on solid rockets, 148,781 kilograms (328,000 pounds).
6. Launched the first orbiting Solar Observatory, some of the Tiros weather satellites, and used in the communications - satellite Echo 1, Telstar, Relay, and Syncom programs.

D. Redstone
1. The favorite of the Von Braun (Dr. Wernher Von Braun) group working for the Army, the Redstone was a direct descendent of the V-2.

2. Army liquid fuel field missile.
3. Range of 322 kilometers (200 miles).
4. Nearly 21 meters long (70 feet) and slightly under 2 meters (6 feet) in diameter, the Redstone had a speed at burnout, the point of propellant exhaustion, of 6,080 kilometers (3,800 miles) per hour.
5. Used in research programs, including Project Mercury.
6. Used to launch Shepard and Grissom, first two Americans to go into space.

E. Atlas
1. Liquid fuel Air Force ICBM.
2. America's first operational ICBM.
3. Range of 12,872 kilometers (8,000 miles) at 965 kilometer (600 mile) ceiling.
4. Height of 25 meters (82 feet).
5. Thrust of 163,296 kilograms (360,000 pounds) at liftoff.
6. Fuel: RP-1 and Lox.
7. Can be launched from underground (silo) sites.
8. Widely used in space projects, including Mercury man-in-space program.

F. Titan II
1. Air Force ICBM.
2. Height of 33 meters (109 feet) and a thrust of 195,220 kilograms (430,000 pounds).
3. Fuel: Hypergolic - RFNA- UDMH.
4. Speed of 27,200 kilometers (17,000 miles) per hour with about a 965 kilometer (600 mile) ceiling.
5. Diameter about 3 meters (10 feet).
6. Used in the Gemini program.

G. Saturn IB
1. Height (with spacecraft): 68 meters (223 feet).
2. Weight: 544,320 kilograms (1,200,000 pounds).
3. Thrust of 725,760 kilograms (1.6 million pounds).
4. Provide capacity needed for manned space flight, lunar exploration, and interplanetary flights with unmanned vehicles.
5. Launched Apollo 7, the first manned Apollo Earth-orbital mission.
6. Scheduled for use in the Skylab program.
7. The Nation's only facilities for launching the Saturn IB are located in Florida at Kennedy Space Center.

H. Saturn V
1. Nation's largest and most powerful launch vehicle.
2. Composed of 3 stages and an instrument unit.
3. Height (with Apollo spacecraft): 111 meters (363 feet).
4. Weight: 2,889 metric tons (6,370,000 pounds).

5. Develops 3,470,040 kilograms (7,650,000 pounds) of thrust at liftoff.
6. Fire cannot burn without oxygen. Since rocket engines operate in space where there is no oxygen, a supply must be carried along (See II A). All Saturn mainstage engines use liquid oxygen for this purpose. To achieve the desired rocket engine reaction, the liquid oxygen, or LOX, is mixed with a flammable fuel, a spark is provided, and the engines roar to life with power comparable to thousands of ordinary gasoline engines.
7. Used on manned lunar missions.
8. The Nation's only facilities for launching the Saturn V are located in Florida at Kennedy Space Center.

X. Saturn V and the "mobile concept" - provision for the assembly and checkout of the Apollo/Saturn V vehicle in the controlled environment of a building, its transfer to a distant launch site and launch with a minimum of time on the pad.
   A. Vehicle Assembly Building - where the space vehicle is assembled and tested.
   B. Launch Control Center - houses display, monitoring and control equipment for checkout and launch operations.
   C. Mobile Launcher - upon which the space vehicle is erected for checkout, transfer and launch and which provides internal access to the vehicle and spacecraft during testing.
   D. The Transporter - transfers the space vehicle and Mobile Launcher to the launch site.
   E. The Crawlerway - a specially prepared roadway over which the Transporter travels to deliver the Apollo/ Saturn V to the launch site.
   F. The Mobile Service Structure - provides external access to the vehicle and spacecraft at the launch site.
   G. The launch site - site from which the space vehicle is launched on Earth orbital and lunar missions.

XI. Specific impulse - the measure of a rocket's performance is the thrust per pound of fuel used per second and can be expressed as seconds.
   A. Present chemical propellants are rated at 250 seconds. (About 200 seconds was the specific impulse given for the V-2 rocket of World War II).
   B. It is believed that the impulse measurements can be increased to about 400 seconds.
   C. As specific impulse is increased, larger payloads are possible with the same quantity of propellant.
   D. Scientists are experimenting to develop a new type

engine with a much greater specific impulse rating than present engines.

E. Larger vehicles not needed to go deeper into space--new type engines can accomplish this.

XII. Rockets of the future may include atomic rockets and electric rockets.

A. Atomic rockets would heat fuel with a nuclear reactor, instead of burning fuel, to produce a jet of hot gases.

B. When perfected, atomic rockets will be two or three times as efficient as solid or liquid fuel rockets.

C. Electric rockets would depend on jet of electrically charged particles instead of a jet of hot gas molecules.

1. Would use a large amount of power and produce only a small force.
2. Could operate for weeks or months at a time.
3. Could not push a vehicle away from earth but would be more efficient engine than other kinds for propelling a vehicle in outer space.

SPACE AWARENESS VOCABULARY

Combustion	Solid-fuel
Force	Single-stage-rocket
Velocity	Multi-stage-rocket
Nitroglycerine	Liquid fuel
Oxidizer	Action
Hypergols	Reaction

SUGGESTIONS FOR THE TEACHER

It is recommended that this unit be introduced by a demonstration. One suggestion would be to prove, through experimentation, Newton's Third Law of Motion. Consider releasing an air-filled balloon, throwing balls while on roller skates, or observing the action of a water hose as a demonstration.

Following the demonstration, you should take advantage of the interest of the students to present some background information. Ex. "The history of rockets date back to 1232 A.D. when the Chinese used them against the Mongols. There are smatterings of reports of rockets being used at different times through the succeeding years. Study of rockets was accelerated in the late 19th century. The science of rocketry has developed rapidly during the last 30 years.

We are in the age of rockets and space. Research rockets have been successfully fired and much valuable information has thereby been acquired."

In your discussion of background information, emphasize the following concepts:

1. Rockets can travel in airless space because they carry their own oxygen source and do not need air for lift.

2. The rocket's propulsion system must exert enough thrust to escape the Earth's gravity.

3. A rocket that carries a warhead is called a missile. A rocket that carries a satellite, a capsule, or a probe is called a launch vehicle.

Following the introduction of the unit, you should refer to the overall suggestions to the teacher as you progress through the unit.

Refer to the appendix for laboratory type activities for this unit and use them as you deem appropriate for the group you are working with.

ILLUSTRATIVE RESOURCES

NASA Publications:

NF-8/12-67	Space Launch Vehicles
0001 Spacefacts	The birth of Rocketry
PAFB July/70	America's Spaceport, John F. Kennedy Space Center, Office of Public Affairs
NF-38/12-67	Electric Power Generation in Space
EP-58	Propulsion

Textbooks:

Wolfe, Battan, Fleming, Hawkins, and Skornik, Earth and Space Science, D. C. Heath and Company, Boston

MacCracken, Decker, Read and Yarian, Scientists Solve Problems, L. W. Singer Company, Second Edition

Brandwein, Beck, Strahler, Hollingworth and Brennan, The World of Matter-Energy, Harcourt, Brace and World, Inc.

Brandwein, Beck, Strahler, Hollingworth and Brennan, The World of Living Things, Harcourt, Brace and World, Inc.

Films:

Saturn Propulsion Systems (color) 14 minutes

The Fourth Ring of Saturn (color) 26 minutes
Powering Apollo (color) 4:45 minutes
The Service Module (color) 4 minutes
Saturn Third Stage (color) 5:30 minutes

POST ASSESSMENT

I. Across from each statement, check whether it is a characteristic of solid fuel or liquid fuel.

	Solid Fuel	Liquid Fuel
1. This fuel is made by mixing rubber, resin, or asphalt with a compound containing oxygen.	____	____
2. This combination could consist of oxygen in liquid form and alcohol.	____	____
3. This combination could consist of nitric acid and aniline.	____	____
4. Some combinations could start burning on contact while others must be ignited.	____	____
5. This type fuel is composed of nitrocellulose and nitroglycerine.	____	____

II. In the space before each word in Column B, print the one letter of the statement in Column A which best describes that word.

COLUMN A

A. This vehicle launched Apollo 7, the first manned Apollo Earth-orbital mission.
B. The first U.S. rocket system to utilize oxygen and liquid hydrogen.
C. Considered the workhorse of NASA vehicles, this rocket launched the first Orbiting Solar Observatory.
D. This is the U.S. largest and most powerful launch vehicle.
E. This vehicle can be launched from underground (silo) sites.
F. This vehicle is an Air Force ICBM with a top speed of 27,200 kilograms (17,000 miles) per hour.
G. The smallest of the basic launch vehicles this one is the only U.S.

COLUMN B

____ 1. Delta
____ 2. Redstone
____ 3. Atlas
____ 4. Titan II
____ 5. Saturn IB
____ 6. Saturn V
____ 7. Scout
____ 8. Centaur

launch vehicle with solid propellants exclusively.

H. Developed by German, this was the first practical vehicle driven by rocket power.

I. This U.S. Navy vehicle is an example of a rocket built and used solely as a research vehicle.

J. This vehicle was used to launch the first two Americans to go into space, Shepard and Grissom.

III. Across from each statement, check whether it is a characteristic of a liquid-fuel rocket or a solid-fuel rocket.

	Liquid-Fuel Rocket	Solid-Fuel Rocket
1. This rocket usually carries two kinds of fuel stored in separate tanks.	____	____
2. There are two main parts to the motor of this rocket: (1) A combustion chamber and (2) A nozzle from which the burned gases are exhausted.	____	____
3. This type rocket was tested successfully in 1926 by Dr. Robert H. Goddard.	____	____
4. The motor of this rocket has four main parts: (1) A combustion chamber, (2) A fuel injector, (3) An exhaust nozzle and (4) A cooling system.	____	____
5. Most rockets of this type are high-altitude rockets.	____	____
6. These rockets are similar to those used in fireworks displays.	____	____

PRE-ASSESSMENT ANSWER KEY

I.
1. Jet
2. Jet
3. Rocket
4. Rocket
5. Rocket
6. Jet
7. Rocket

II. 1, 3, 4, 6

POST ASSESSMENT ANSWER KEY

I.
1. Solid Fuel
2. Liquid Fuel
3. Liquid Fuel
4. Liquid Fuel
5. Solid Fuel

II.
1. C
2. J
3. E
4. F
5. A
6. D
7. G
8. B

III.
1. Liquid-fuel rocket
2. Solid-fuel rocket
3. Liquid-fuel rocket
4. Liquid-fuel rocket
5. Liquid-fuel rocket
6. Solid-fuel rocket

UNIT III - UNMANNED AND MANNED SPACE FLIGHTS

INTRODUCTION

In 1955, the United States announced to the world that it would launch several artificial Earth satellites as part of its contribution to the I.G.Y. program. Soon after, Russian scientists stated that their nation would carry out a similar plan. Scientists and missile engineers had long recommended such a program as an extension of their rocket research into the upper air. At last, the world learned in 1955, the long-discussed exploration of space was to be attempted.

The first successful Earth satellite was Sputnik I, launched by Russia on October 4, 1957. It was a metal sphere, weighing 83 kilograms (184 pounds), and it carried a radio transmitter and devices for measuring temperature and pressure inside the satellite. A much larger object, Sputnik II, was placed in orbit within a month, on November 3, 1957. This second satellite weighed over 0.453 metric tons (half a ton) and carried instruments for measuring cosmic rays, ultra-violet and x-ray radiation, and a small passenger compartment in which a dog, Laika, remained alive for a week.

The first American satellite, Explorer I, was launched on January 31, 1958. Though only 14 kilograms (30.8 pounds), it was packed with many minature instruments for measuring radiation and temperature in space.

Of all the types of artificial satellites, the communications satellites may have the most direct impact on everyday life. These satellites have provided the means for developing an unlimited global communications system. Television depends heavily on transmission via satellite.

Score is considered to be the first satellite of this type, though strictly, it was not a communications satellite. Score and Courier, another of the early communications satellites, were both delayed repeater satellites; they received information from one part of the Earth and stored the message on a tape recorder for later transmission on command. President Eisenhower's Christmas message to the world had been recorded prior to launch on Score and later was transmitted to Earth. This was the first "voice from space." This type of a satellite was abandoned in favor of instantaneous repeater satellites.

Echo I, the first true communications satellite is called a passive satellite because it simply is used to bounce a signal received from one point on the Earth to another point.

Telstar and Relay are active repeater satellites because they receive, amplify, and rebroadcast messages. These satellite projects, launched in medium-altitude orbits, were initiated by private enterprise. Telestar provided the first transmission of live television across the Atlantic Ocean.

Syncom, another active repeater satellite, was the first satellite to revolve in a synchronous orbit. In a synchronous orbit, a satellite revolves at a rate which will keep it above a fixed point at all times, making the satellite appear to be stationary. The successful performance of the Syncom satellites led to the founding of the Communications Satellite Corporation which patterned its first commercially operational communications satellite, Early Bird, after Syncom.

The remarkable success of the early satellites led steadily toward the inevitable transition from unmanned to manned flights.

Nineteen hundred sixty-one was the year in which man first left his planet for ventures into the unknown environment beyond. First honors for space flight went to Russian Air Force Major Yuri Gagarin.

On May 5, 1961, American astronaut Alan B. Shepard entered a Mercury spacecraft at Cape Canaveral, Florida, and propelled by a Redstone rocket, roared upward and southward to a maximum height of 185 kilometers (115 miles). Fifteen minutes later, he dropped into the Atlantic Ocean where he and his Mercury capsule were recovered by waiting ships. The space age was indeed a reality.

RATIONALE

Man has always longed to travel out into space--to visit other planets, to explore the moon, and to determine the conditions that exist in the regions beyond the Earth's atmosphere. A combination of unmanned and manned space exploration is necessary for man to pursue these goals. A different type of situation arises when launching satellites that are manned as compared to the launching of unmanned satellites.

The learner suddenly becomes involved in an entity that demands an understanding of the variables affecting life in space. What are the factors that differentiate unmanned from manned space flights? Ascertaining the psychological and physiological barriers encountered by man in traveling into space can offer a revealing picture of the dynamic human forces affiliated with manned space flights.

PRE-ASSESSMENT

I. In the space before each item in Column B, print the <u>one</u> number of the statement from Column A which best describes that item.

COLUMN A

1. The speed an object must reach to overcome the effect of the Earth's gravity.
2. Attained when a satellite travels over both the north and south poles.
3. A natural or artificial body which orbits around a planet.
4. The path taken by one celestial body as it revolves around another.
5. An equatorial west-to-east satellite traveling at an altitude of 22,300 statute miles at which it makes one revolution in 24 hours.
6. The orbital point of a satellite when it is nearest the Earth.
7. Rockets which attain an altitude of more than one Earth radius (6,436 kilometers) (4,000 miles).
8. The orbital point of a satellite when it is farthest from the Earth.
9. The speed at which an object traveling tangent to the Earth's surface falls around the Earth.
10. The rate of change of velocity.
11. The position of the Earth or another planet when it is farthest from the Sun.
12. A unit of length equal to the distance light travels in one year.

COLUMN B

____A. Satellite
____B. Orbit
____C. Perigee
____D. Apogee
____E. Escape Velocity
____F. Orbital Velocity
____G. Probe
____H. Polar Orbit
____I. Synchronous Orbit
____J. Acceleration

GENERAL OBJECTIVES

1. To bring about an awareness of the functions of unmanned and manned space flight in the exploration of space.

2. To introduce the students to the many problems of enabling man to live and work in space.

SPECIFIC OBJECTIVES

1. The student must be able to correctly match a list of aerospace terms in Column B with the definition of each from a list in Column A.

2. The student must be able to classify correctly six given characteristics descriptive of Projects Mercury, Gemini and Apollo.

CONTENT

I. A satellite is a natural or artificial body which orbits around a planet.
   A. The Moon is the only natural satellite of the Earth.
   B. Many artificial satellites travel around the Earth (man-made Moons).

II. Unmanned space flight is that of satellites sent into space, acting on command from the Earth with no man on board.
   A. Unmanned flights can be sent into radiation belts where there are deadly cosmic rays.
   B. Unmanned flights can be sent into high-temperature regions of the upper atmosphere.
   C. Commands are sent from a radio station to the unmanned satellite.
   D. Many maneuvers can be accomplished by remote control.
      1. Cameras can be set and operated.
      2. Weights can be moved around inside the spacecraft to change its spinning motion.
      3. The spacecraft can be interrogated. Scientists can ask the spacecraft to send back all information collected since the last communication.
   E. Instruments packed aboard the satellite to measure various quantities are called <u>sensors</u>.
      1. Sensors measure temperature inside the satellite at all times. Overheating or freezing affects its operation.
      2. Electrons in space are counted by <u>Geiger tubes</u> which conduct electricity momentarily when an electron penetrates the tube.
      3. The magnetic field in space is measured by coils

of wire which produce an electric current when they pass through the magnetic field.

4. Light from the Sun and stars can be analyzed by spectrographs.

F. Measurements made by sensors and relayed to scientists on Earth is done by the process of telemetry.

1. Telemetry is the radio transmission of messages from artificial satellites to Earth tracking stations. (Discussed also in Unit VII.)
2. Electrical signals from sensors are sent back to Earth as radio signals.
3. Various signals are separated by a special telemetry receiver.
4. When an electronic computer is placed in a satellite to perform some of the calculations, the telemetry consists of a series of pulses which represent numbers or letters.

III. Unmanned scientific spacecraft have probed for facts about matter, radiation and magnetism in space, and have collected data relating to the Moon, Venus, Mars, the Sun and some of the stars, and reported their findings to ground stations on Earth.

A. The first satellite, Sputnik I, was launched by Russia on October 4, 1957.
B. The first American satellite, Explorer I, was launched on January 31, 1958.

IV. ORBIT, in astronomy, is the path taken by one celestial body as it revolves around another.

A. The orbit of the Moon is the path it takes around the Earth.
B. In space travel, orbit is the path of an artificial satellite or spacecraft.
C. PERIGEE is the point in the orbit of the Moon or an artificial satellite when it is closest to the Earth.
D. APOGEE is the point in the orbit of the Moon or an artificial satellite when it is farthest from the Earth.

V. Every orbit is the result of two forces.

A. One force necessary to the achieving of an orbit is the momentum of the satellite or spacecraft to continue in a straight line.
B. The other force is the gravitational pull which tends to pull the satellite or spacecraft back to Earth.

VI. Escape velocity is the speed an object must reach to overcome the effect of Earth's gravity.

A. Velocity of excape is about 40,000 kilometers (25,000 miles) per hour or 11 kilometers (7 miles) per second.
B. Research and mathematics have discovered that when

an object leaves the Earth's vicinity at the tremendous speed of 40,000 kilometers (25,000 miles) per hour, the object will never fall back to Earth.

C. Rapid acceleration is necessary to attain excape velocity.

D. Since rocket engines can only create thrust for a short time, and considering that the very powerful engines use fuel at a tremendous rate, escape velocity must be attained in a matter of a few minutes.

VII. Orbital velocity is the speed at which an object traveling tangent to the Earth's surface actually falls around the Earth. (Tangent is the type of path an object would take if released from a spinning object. Mud or water flying off a spinning bicycle or automobile wheel flies off tangent to the spinning wheel.)

A. If an object is propelled straight up at 40,000 kilometers (25,000 miles) per hour, it will continue indefinitely into space.

B. To achieve an orbit, an object must attain a speed of approximately 29,000 kilometers (18,000 miles) per hour.

1. The orbital velocity, 29,000 kilometers (18,000 miles) per hour, is considered intermediate speed when compared to 40,000 kilometers (25,000 miles) per hour which is the escape velocity.
2. It is impossible for a person to shoot an object from the Earth with the right speed and direction to make it fall in a path around the Earth.

C. A rocket can accomplish this feat (Number 2 above) by propelling a satellite to the desired height and then redirecting the satellite about the Earth. To illustrate: "Imagine that a person is on a platform 483 to 644 kilometers (300 to 400 miles) above the Earth. If he were able to throw a ball at a speed of 29,000 kilometers (18,000 miles) per hour, the ball would circle the Earth. The pull of the Earth and the momentum of the ball, which would tend to send it into space, would balance. The ball would circle the Earth and in a matter of about 90 minutes, the ball would approach the person from the opposite direction. The ball thrown might circle the Earth every 90 to 100 minutes for years to come."

VIII. If a satellite is launched with a speed that is insufficient to keep it in circular orbit, it will fall back and either strike the ground or the lower atmosphere.

A. Once an orbit is achieved, some satellites are said to be in a polar orbit.

1. A polar orbit is the orbit of an Earth satellite that passes over or near the north and south poles.

2. Satellites launched into polar orbit can survey the entire Earth during each orbit and thus have an advantage over satellites in equatorial orbit. (A satellite in equatorial orbit travels a course around the Earth's equator.)
3. The satellite in polar orbit is useful in the areas of global surveillance, weather reconnaissance, and communications relay, where observation of all of the Earth's surface is important.

B. Once an orbit is achieved, some satellites are said to be in synchronous orbits.
1. A synchronous satellite is an equatorial west-to-east satellite orbiting the Earth at an altitude of approximately 35,900 kilometers (22,300 miles) at which altitude it makes one revolution in 24 hours, synchronous with the Earth's rotation.
2. Satellites such as syncom and Early Bi... are in synchronous orbits.
3. If such a satellite is moving east over the equator, it appears to stay over one position on the Earth, since its period is equal to the rotational period of the Earth.

IX. By the time NASA was created in 1958, various government agencies had already made numerous studies of the potential advantages of artificial satellites in weather forecasting and communications.
A. Weather satellites have been orbited for studying storm regions and for assisting in the preparation of forecasts.
B. Today, thousands of pictures of the Earth's spiraling cloud systems are taken every day to help forecast weather and to give meteorologists the big picture so they can better understand the fair and foul weather systems that wheel across the planet's surface.

X. The Army, Navy, and industry began studying weather satellites in the early 1950s.
A. The Radio Corporation of America (RCA) applied to meteorology the experience it had gained studying television-equipped satellites for the Air Force.
1. After it was created in 1958, NASA supported the RCA work.
2. The RCA weather satellite concept eventually became known as TIROS (Television Infrared Observation Satellites).

B. Tiros satellites, the first orbiting "weathermen," were launched from Cape Kennedy Complex 17 by Delta vehicles beginning in April 1960.

XI. The National Oceanic and Atmospheric Administration (NOAA) is responsible for the day-to-day operation of weather satellites, but NASA has been assigned the task of developing and procuring new spacecraft and meteorological sensors as well as providing launch and tracking services. Note: NOAA is the successor to the Environmental Science Services Administration (ESSA).

XII. NASA now has three active weather satellite programs under which new cameras and other sensors are tested in space.
   A. The Improved Tiros Operational Satellite (ITOS) Program, involving the development, procurement, testing, and launch of a new generation of operational meteorological satellites for NOAA on a reimbursable basis.
      1. The Improved Tiros Operational Satellite (ITOS) represents a major step forward in that it can take cloud-cover pictures at night.
      2. Since clouds stand out vividly at night in infrared pictures, ITOS, therefore, offers 24 hour coverage of the Earth.
      3. ITOS 1, which was called Tiros M. before launch, was orbited by a Delta rocket on January 23, 1970.
   B. The Nimbus Program, in which new techniques and sensors are developed using the Nimbus Spacecraft as a test vehicle.
      1. Nimbus, a large sophisticated satellite, was conceived in 1959 at Goddard Space Flight Center.
      2. Two objectives defined the Nimbus program.
         a. Develop and flight test advanced sensors and technology basic to meteorological research, the atmospheric sciences, and the orbital survey of Earth resources.
         b. Two wing-like solar panels, which are automatically pointed toward the Sun, provide power to the spacecraft and the instruments.
   C. The Synchronous Meteorological Satellite (SMS) Program, under which a new geostationary weather satellite is being designed to satisfy the requirements of NOAA's National Operational Meteorological Satellite System (NOMSS).

XIII. The U.S. Army in its perpetual search for more reliable and more secure long-distance communications built the first active communication satellite.
   A. SCORE (an acronym for Signal Communication by Orbiting Relay Equipment) was launched on December 18, 1958.
   B. The Army followed up its success with SCORE by orbiting Courier in 1960.

XIV. Communication satellites can carry many different signals at the same time (this makes them superior to telephone cables).

A. These satellites receive messages from one town on the Earth and pass the signals on to another town, even though the towns are hidden from each other by the curvature of the Earth (this makes them superior to short-wave radio).

B. Communication satellites such as Echo, Telstar, Relay, Syncom, Early Bird, and Intelsat, launched on Delta and Centaur vehicles from Cape Kennedy, have contributed to improved communications between continents.

XV. Unmanned space probes led the way in the exploration of the Moon's surface and environment.

A. In practice, rockets which attain an altitude of less than 1 Earth radius (6,428 kilometers) (4,000 miles) are called <u>sounding rockets</u>. Those which attain an altitude of more than 1 Earth radius are called <u>probes</u> or <u>space probes</u>.

B. Probes were utilized to obtain data for manned lunar landings.

C. Results of probes yielded clues to the origin of the Moon, the solar system and perhaps the universe.

D. Probes obtained data concerning the Van Allen belts.

E. In order of marksmanship and technical sophistication required, the feasible space probe missions are:

1. A near miss or flyby;
2. A hard landing or unbraked impact;
3. A swing around the Moon, coming back toward Earth;
4. An orbit around the Moon; and
5. A soft landing. As mission difficulty increases so does scientific potential of the probe.

XVI. The U.S. undertook its first lunar exploration in the Ranger Program.

A. Ranger probes were launched from August 23, 1965.

1. There were nine Rangers in the series.
2. The first two were designed to test techniques for use on lunar and planetary spacecraft.
   a. They measured the particles and fields present in interplanetary space.
   b. They were aimed in the general direction of the Moon.
3. The next three Rangers "rough landed" seismometer packages on the lunar surface.
4. The final four Rangers took close-up pictures of the lunar surface before crash landing on it.
   a. These Rangers provided data for planning lunar landing of Apollo astronauts.
   b. The Rangers weighed between 306 and 367 kilograms (675 and 810 pounds).

XVII. The Surveyor Program consisted of a series of seven soft-landing lunar probes built to reconnoiter the Moon's surface in preparation for the Apollo manned landing.

A. The Surveyor's were launched from May 30, 1966 to January 7, 1968.
B. The first Surveyors were primarily picture-taking spacecraft.
C. Later Surveyors added experiments in soil mechanics and analyzed surface composition.
D. The weights of the Surveyors varied between 270 and 286 kilograms (596 and 630 pounds) at lunar landing.

XVIII. The planetary probe program of the Jet Propulsion Laboratory in Pasadena was called Mariner.
A. The first, Mariner I, was launched July 22, 1962, but had to be destroyed by the Cape Kennedy Safety Officer when it veered off course.
B. Mariner II was successfully launched toward Venus on August 27, 1962. Mariner II passed within 34,556 kilometers (21,598 miles) of Venus.
C. Mariners III and IV were Mars probes.
D. On October 19, 1967, Mariner V flew past Venus some 10,151 kilometers (6,300 miles) from the planet's center.
E. Mariners six and seven were put on their Martian course by Atlas Centaur launch vehicle which lifted off at 8:29 p.m. EST February 24 and 5:22 p.m. March 27. Number six took 156 days to make the outward trip; number seven, 130 days. The difference in trip time is accounted for by the orbital motion of Earth and Mars. (See figure two.)
F. Mariner Mars 1971 Program was the first U.S. mission to orbit another planet.
   1. A failure of the second stage of the Atlas Centaur in May prevented Mariner 8 from achieving trajectory to Mars.
   2. Mariner 9 was successfully launched on May 30, 1971, and encountered Mars on November 13, 1971.
   3. Objective of Mariner 9 was to explore Mars for at least 90 days in orbit, to map about 70 percent of the planet's surface and to view selected areas during dynamic changes on Mars. (See figure three.)

XIX. The U.S. Pioneer space probes flew toward the Moon; they were instrumented to explore space between the Earth and Moon (called cislunar space).
A. Five Pioneers were launched during 1958-60.
   1. The Pioneer that came closest to the Moon was Pioneer IV (launched March 3, 1959), which passed 59,680 kilometers (37,300 miles) from the Moon on its way into orbit about the Sun.
   2. The first five, called the early Pioneers, contributed greatly to man's understanding of the

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Earth's Van Allen Region and the solar wind.

3. The last of the earlier group, Pioneer V, was launched March 11, 1960.
   a. Radio communication was maintained with Pioneer V until June 26, 1960.
   b. Pioneer V confirmed the existence of previously theorized interplanetary magnetic fields.

B. The first of the new Pioneers was Pioneer VI which was launched December 16, 1965 into an orbit between Earth and Venus.

C. On August 17, 1966, Pioneer VII was launched into an orbit between Earth and Mars.

D. Pioneer VIII was launched December 13, 1967.

E. Pioneer 9 was launched in 1968 with the mission of acquiring additional data on solar plasma and energetic particles and magnetic fields propagated by the Sun towards the Earth.

F. A three-stage Atlas-Centaur launch vehicle put Pioneer 10 on a near perfect Jupiter-bound trajectory at 8:49 p.m. EST on March 2, 1972, in a launch from Cape Kennedy, Florida. (See figure four.)
   1. Pioneer 10 is the first spacecraft to be placed on a trajectory to escape from a solar system into interstellar space.
   2. Experiments on board Pioneer 10 will measure numbers and characteristics of asteroids and will make a variety of measurements of Jupiter's atmosphere, the planet's heat balance (related to its presumed internal energy source), its magnetic fields and radiation belts, and other characteristics.
   3. Pioneer 10 is planned to fly by Jupiter on December 3, 1973. After passing Jupiter, it may well continue transmitting data to Earth on the Sun's atmosphere and interstellar phenomena out to the orbit of Uranus, more than three billion kilometers (two billion miles) away.

G. The Pioneer Project is managed by the National Aeronautics and Space Administration's Ames Research Center, Moffett Field, California.

XX. Once NASA proved the feasibility of the synchronous communication satellite, the technology was used by a commercial enterprise called the Communications Satellite Corporation (COMSAT).
   A. COMSAT was created by an act of Congress on August 30, 1962, and was assigned two major tasks.
      1. One task was to establish an operational system of communication satellites.
      2. The other task was to enlist the support of

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foreign governments in setting up international service.

B. COMSAT's task of enlisting the support of foreign governments in setting up international service was accomplished through organization of the International Telecommunications Consortium (INTELSAT) which now includes more than 70 member countries.
   1. The Consortium owns the communication satellites, called INTELSATs.
   2. Regular transoceanic service commenced in 1967, with synchronous communication satellites stationed over the Atlantic and Pacific oceans.
   3. The Intelsats are all geostationary spacecraft carrying small rocket engines that move them to and keep them at selected spots over the Equator.
   4. There are now four generations of Intelsats, with a trend toward bigger and better satellites with each new generation.
   5. Compared with the 1965 Intelsat I, also called Early Bird, which was not much bigger than a waste basket the 1970 Intelsat IVs, which consists of satellites 0.5368 meters (17.6 feet) high, represent an important advance in terrestrial communications.

C. NASA's role is to provide launch and tracking services for COMSAT on a reimbursable basis and pursue new ideas in the technology of communication satellites.

D. In comparison, NASA's efforts are directed primarily toward development of new spacecraft and sensors, while COMSAT is concerned more with ground operations and the practical applications of the data acquired by the satellites.

XXI. Scientific satellites carry instruments to measure magnetic fields, space radiation, the Sun, etc.

A. The Explorer series of scientific satellites began before NASA was created.
   1. Army Explorer I, the first of the long series (37), was the first U.S. satellite, and was launched on January 31, 1958.
   2. Explorers II, III, and IV were also Army satellites. All other Explorers were launched by NASA.
   3. Explorers II and V failed.
   4. Explorer satellites varied widely in design and purpose.

B. The Orbiting Solar Observatory (OSO) is the smallest of the observatory class of satellites and carry fewer instruments.
   1. With four OSOs in the series, the weights vary between 204 and 294 kilograms (450 and 650 pounds).
   2. Some OSO experiments are located in the spinning

wheel section, while others are in the sail which points continuously at the Sun.

C. The Orbiting Geophysical Observatorys (OGOs) consisted of a family of five which was built by NASA.
   1. OGOs are large and relatively sophisticated.
   2. With weights between 454 and 590 kilograms (1,000 to 1,300 pounds), OGOs were designed to carry twenty or more experiments in the fields of geophysics, space physics, and astronomy.

D. The Orbiting Astronomical Observatorys (OAOs) are large, sophisticated satellites designed to study the stars in the ultraviolet region of the spectrum and to carry out associated experiments in space science.
   1. The OAOs are programmed to search for and follow certain guide stars.
   2. Once the telescope locks onto a guide star, the star tracker sends its coordinates to guidance and control systems.
   3. OAO I, launched April 8, 1966, weighed 1770 kilograms (3,900 pounds).

E. The Biosatellite family of recoverable scientific satellites was designed to study the effects on living things of such phenomena as weightlessness, weightlessness combined with radiation, and removal from the diurnal (day-night) cycle on Earth.
   1. Biosatellite I, launched December 14, 1966, could not be brought down as scheduled because of retrorocket failure. Efforts to locate the craft during its anticipated normal reentry on February 14, 1967, were unsuccessful.
   2. Biosatellite II carried frog eggs, microorganisms, plants, and insects on an orbital flight that lasted about two days.
   3. NASA launched Biosatellite II from Cape Kennedy, Florida, on September 7, 1967. About two days later, ground controllers ordered the satellite to fire retrorockets, slowing it so that it fell out of orbit toward the Earth. As it parachuted down over the Pacific Ocean near Hawaii, the spacecraft was retrieved in the air by a United States Air Force plane.

XXII. NASA's Earth Resources Technology Satellite (ERTS) program began at Goddard Space Flight Center in 1966.

A. Four program objectives were identified.
   1. To define those practical problems where space technology can make beneficial contributions.
   2. To conduct research on sensors and establish their utilities in Earth observation.
   3. To develop and qualify sensors and spacecraft.
   4. To develop handling and processing techniques for

Earth resources survey data.

B. Early ERTS work concentrated on sensors because this was the area with the most unknowns.
   1. Flights with manned air and spacecraft already have shown the probable usefulness of various types of infrared, ultraviolet and microwave instruments on an unmanned spacecraft.

C. Estimates of money that could be saved annually in the United States alone, as a result of Earth resource information, run over a billion dollars.
   1. Practical applications of ERTS instruments are many.
      a. Agriculture and Forestry.
         (1) Construction of better topographic maps and farm planning - applicable instrumentation, cameras.
         (2) Estimations of crop types, densities, and expected yields - applicable instrumentation, cameras.
         (3) Identification of insect infestation and disease patterns and "early warnings" - applicable instrumentation, cameras, and infrared.
         (4) Calculation of the damage from disease and insect infestations - applicable instrumentation, cameras, and infrared.
         (5) Census of livestock - applicable instrumentation, cameras.
         (6) Estimation of soil moisture content and irrigation requirements - applicable instrumentation, infrared, and microwave.
         (7) Census of forest tree types and estimation of logging yield - applicable instrumentation, cameras, and infrared.
         (8) Early warnings of fire, disease, and insect infestation in forests - applicable instrumentation, cameras, and infrared.
      b. Oceanography
         (1) Forecasts of sea state and ice hazards for shipping - applicable instrumentation, cameras, infrared, and microwave.
         (2) Location of high biological activity from surface temperature for fishing fleets - large schools of surface-feeding fish may also be pinpointed - applicable instrumentation, cameras, infrared, and microwave.
         (3) Location of drifting oil slicks - applicable instrumentation, cameras, and infrared.
         (4) Survey of coastal geography, including

detailed shoreline topography, identification of steam erosion patterns, and mapping of shallow areas - applicable instrumentation, cameras.

(5) Collection of such scientific data as the location of areas of bioluminescence, estimation of plankton density and the pinpointing of red tides, fish schools, and algae concentrations - applicable instrumentation, cameras, and infrared.

c. Hydrology and Water Resource Planning.

(1) Inventory of water in regional basins by measurement of lake levels, river flow rates, irrigation patterns, and drainage patterns - applicable instrumentation, cameras, and infrared.

(2) Control and early warning of floods by monitoring rainfall, weather prediction, and drainage basin surveys - applicable instrumentation, cameras, and infrared.

(3) Identification of water pollutants and polluters from maps of thermal discharges and the spectral "signatures" of specific pollutants - applicable instrumentation, cameras, infrared, microwave, and ultraviolet.

(4) Estimation of water resources through snow and frozen water surveys and the location of seepage and other ground water sources - applicable instrumentation, cameras, infrared, and microwave.

d. Geology and Mining.

(1) Deteution of mineral (including oil) from topography, drainage patterns, magnetic fields, and direct identification of minerals - applicable instruments, cameras, infrared, microwave, and ultraviolet.

(2) Prediction of earthquakes from slight temperature differences, soil moisture content, and topographical distribution - applicable instrumentation, cameras, infrared, microwave.

(3) Prediction of volcanic activity from temperature changes - applicable instrumentation, infrared.

(4) Prediction of landslides from soil moisture and slope of terrain - applicable instrumentation, cameras, and infrared.

(5) Location of goethermal power sources from surface temperature measurements - applicable instrumentation, infrared.

e. Transportation, Navigation, and Urban Planning (Cartography).
   (1) Construction of detailed maps of rural and urban areas to help plan traffic arteries, terminals - applicable instrumentation, cameras.
   (2) Estimation of air, road, and sea traffic - applicable instrumentation, cameras.
   (3) Surveys of urban areas, indicating housing and population densities, park areas, housing and development, and types of settlement for purposes of planning renewal and new building programs - applicable instrumentation, cameras.

2. Although photographs taken from aircraft and manned spacecraft are most promising, the whole field is still in an embryonic state.
   a. Some Earth resources data will be gathered by aircraft and ground-based surveys.
   b. Most effective mix or sensor carriers has not been established yet.
   c. Information acquisition, transmission and processing is a major part of the undertaking.
   d. An infrared radiometer reading means little to an agriculturist making a crop survey - data must be converted into terms understandable to the user and then tagged with geographical and time coordinates. (See figure five.)

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MANNED SPACE FLIGHT

I. The unmanned space flights paved the way for manned space flights.
   A. Russian Air Force Major Yuri Gagarin was the first man in space in flight on April 12, 1961, which carried him 322 kilometers (200 miles) above the Earth and lasted 108 minutes.
   B. American Astronaut Alan B. Shepard was the second man in space in a flight on May 5, 1961, which carried him 185 kilometers (115 miles) above the Earth and lasted 15 minutes. (See figure six.)

II. Plans for selection of volunteers for the manned space flight program received much discussion.
   A. The final choice of the method of selection was made by President Eisenhower in 1958.
   B. The men would be chosen from the existing pool of military test pilots.
   C. The men had to be under 40 years of age and under 0.141584 meters 180 milliliters (5 feet 11 inches) tall.
   D. They had to be in excellent physical condition.
   E. The future astronauts had to hold a bachelor's degree or to have acquired the equivalent education and had to have graduated from test pilot school.
   F. Finally, they had to have completed 1,500 hours minimum total flying time, and qualified in jet aircraft.

III. The final selections from the list of volunteers turned up seven names, when only six were desired.
   A. All seven astronauts candidates were equally well qualified, all wanted to volunteer, and so NASA finally decided to name seven astronauts for Project Mercury.
   B. The first seven, whose names were to become familiar throughout the world, were announced in April 1959.
      1. Senior in age and date of rank was Marine Lieutenant Colonel John H. Glenn, Jr.
      2. Lieutenant Commander Walter M. Shirra, Jr., Lieutenant Commander Alan B. Sheppard, Jr., and Lieutenant Malcolm Scott Carpenter came from the U.S. Navy.
      3. Captain Donald K. Slayton, Captain Leroy Gordon Cooper, Jr., and Captain Virgil I. Grissom were from the Air Force.
   C. The second group was named in September 1962, and the third group in October 1963.
   D. The first scientist-astronauts were selected in June 1965, and no piloting experience was required. However, if they weren't pilots, they did receive flight

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training. The list was narrowed from 422 applications to six selected.

E. A fourth group, this time of 19 astronauts, was announced in April 1966, all of them qualified jet pilots. In 1967, the National Academy of Sciences nominated a second group of scientists for training as astronauts, which produced eleven astronauts to be, with doctorates in science.

IV. In order to survive in outer space, man must take with him his Earth environment.
   A. If an astronaut were to step onto the Moon unprotected, death would result quickly.
      1. Gases in the body of the astronaut would expand.
      2. The astronaut's body liquids would boil.
      3. Oxygen would flow out of the astronaut's lungs, blood, and body tissues.
      4. In sunlight the astronaut would be scorched by temperature as high as 250 degrees Fahrenheit. In shadows or at night fall, the temperatures would quickly drop to 100, 200, or even 250 degrees below zero.
   B. Man in space must live within a pressurized enclosure.
      1. The simplest form of pressurized enclosure is the space suit which can sustain the astronaut for a short time.
         a. The space suit is airtight and completely encloses the astronaut.
         b. The suit is "pumped up" to provide the astronaut with his own atmospheric envelope.
      2. The more complex form of pressurized enclosure is the space capsule.
         a. The Mercury capsule had little room for movement, a limitation imposed by the restricted amount of weight its booster could place in orbit.
         b. Difficulty of movement and other reasons made taking off and putting on a space suit inadvisable.
   C. The Gemini capsule presented a similar but smaller problem as that of the Mercury capsule.
      1. The Gemini capsule was more spacious.
      2. Gemini astronauts spent extended periods of time in their "long-johns."
   D. The Apollo spacecraft was greatly improved.
      1. In Apollo, astronauts have adequate living and working space needed in a cabin pressurized for comfort.
      2. The astronauts move about in shirt-sleeve freedom.
      3. Astronauts experience stress upon acceleration and deceleration of the spacecraft and are protected by the spacecraft cabin and the space suits.

4. When the human body is suddenly accelerated or decelerated, the body is affected.
    a. Acceleration exists as the space vehicle starts to rise from the Earth.
    b. Deceleration exists as the vehicle attempts to return to Earth and must be slowed down before landing.
5. In the spacecraft, the position and design of the astronaut's couch helps him withstand the forces of acceleration and deceleration.

V. Food for the astronauts must be preserved and specially prepared for trips in space.
  A. The food must be prepared so that it can be consumed by astronauts who are weightless.
  B. The food must be consumed in an environment where everything is weightless, including the food.
  C. Menu items range from cereals, orange juice, and toast, to meats, eggs, fish and fruit salad.
  D. Solid foods are dehydrated and packed in bite-sized portions, in tubes, or as concentrates enclosed in plastic bags in which water may be added with a water gun.

VI. Astronauts must be careful to prevent food particles or water droplets from escaping.
  A. In a weightlessness condition, such particles would drift in the cabin.
  B. Drifting food particles and water droplets could result in problems with sensitive equipment.

VII. A weightless condition is present in the absence of gravity.
  A. A person stepping on a scale to weigh himself could find that he weighs 68 kilograms (150 pounds).
    1. The weight of 68 kilograms (150 pounds) is the amount of the pull of gravity of the Earth on him.
    2. The pull of gravity gives him weight.
    3. He is being pulled toward the center of the Earth.
    4. Remove the pull of gravity and he becomes weightless.
  B. Without gravity a person still has mass.
    1. Mass is the actual amount of matter of which a person is composed.
    2. Mass exists without gravity but it does not weigh anything.
    3. In distant space, one is too far from Earth to be affected by gravity very much.
  C. Theories of some scientists differ as to the way a person will feel when he is weightless for a long period of time.
    1. In a weightless condition, the sensation will be

very much like seasickness.

2. The person in a weightless condition will have a sense of well-being.
3. The person in a weightless condition will have a sense of falling constantly.

D. Weightlessness has not proven to be a problem for astronauts.

VIII. NASA's manned space flight program was conceived in three steps or projects, Mercury, Gemini and Apollo.

IX. Project Mercury became an official program of NASA on November 26, 1958.

A. Originally, Project Mercury was assigned only two broad missions by NASA--first, to investigate man's ability to survive and perform in the space environment; and second, to develop the basic space technology and hardware for manned space flight programs to come.

B. The one-man Mercury spacecraft was shaped somewhat like a bell (truncated cone). It was 2.9 meters (9.5 feet) high and 1.8 meters (6 feet) across at the base. It weighed approximately 1,928 kilograms (4,250 pounds) at lift-off and 1,089 kilograms (2,400 pounds) at recovery.

C. Two boosters were chosen--the Army's Redstone with 35,380 kilograms (78,000 pounds) of thrust and the Air Force's Atlas with 166,471 kilograms (367,000 pounds) of thrust--for suborbital and orbital flights, respectively.

D. A space milestone was reached in the Mercury program when on February 20, 1962, Astronaut John H. Glenn, Jr., the first American in orbit, completed three circuits in Friendship 7.

E. On May 15-16, 1963, Astronaut L. Gordon Cooper, Jr., completed a 22-orbit mission of 34½ hours in Faith 7, triumphantly concluding the flight phase of Project Mercury which consisted of four manned orbital flights.

F. Among the significant aerospace medical information derived from Mercury were the following:

1. Consumption of food and beverages and sleeping during space flight were proved possible.
2. The radiation dose received by the astronauts was considered medically insignificant.
3. All measured physiological functions remained within anticipated ranges throughout all flights. There was no significant degradation of pilot function attributable to space flight.
4. There was no evidence of abnormal sensory, psychiatric, or psychological responses to space flight.

G. Other notable accomplishments of Project Mercury were the following:

1. Development of a NASA management system that could carry out more advanced manned space flight ventures.
2. Exploration of the fundamentals of spacecraft reentry.
3. Starting a family of launch vehicles from existing rockets that led to new booster designs.
4. Setting up of an Earth-girdling space tracking system that was later modified for the Gemini and Apollo projects.
5. Training of a pool of astronauts that could be augmented to meet the requirements of future space exploration programs.

X. Project Gemini was named after the constellation Gemini (Twins).

A. NASA decided to follow the Mercury's basic "capsule" design for Gemini spacecraft, saving time and engineering efforts. But the two-man craft was wider, taller, and more than twice as heavy as the Mercury.

B. Since Mercury's Redstone and Atlas boosters lacked the power to orbit the heavier two-man craft, a modified version of the military Titan II became the Gemini Launch Vehicle (GLV), with a lift-off thrust of 195,048 kilograms (430,000 pounds).

C. Project Gemini extended orbital missions up to two weeks at a time and developed the techniques for orbital rendezvous and docking, in which two space vehicles are maneuvered close together and finally joined.

D. From the first Gemini unmanned flight on April 8, 1964, to the final manned flight ending November 15, 1966, Gemini flight time totaled 974 hours, 37 minutes, and 42 seconds. Of this, 969 hours, 51 minutes, and 26 seconds were manned.

E. The highest altitude reached by the manned Gemini spacecraft was 1,373 kilometers (853 miles) during the Gemini XI mission. This set a world's record.

F. Orbital rendezvous was accomplished 10 times and docking was accomplished 9 times during Gemini missions. Docking, first accomplished on March 16, 1966, in the Gemini 8 experiment, is another Gemini first in space.

G. Gemini astronauts spent a total of 12 hours and 12 minutes without the protection of their spacecraft in "space-walk" and other activities.

H. Gemini astronauts took photographs of Earth and its cloud cover, providing a new wealth of information for geographers, meteorologists, and oceanographers. There photographs indicated that sensing from orbit may be a good way to locate and observe Earth's resources: water, minerals, oil and others. A new atlas is based on photographs of Earth taken by the astronauts during Gemini flights.

I. Gemini experiments validated life-support techniques, equipment, and concepts for future space missions. The experiments suggested that man could safely conduct operations in space for as long as 30 days.

XI. Apollo, the largest and most complex of the manned space flight programs had as its goal the landing of astronauts on the Moon and their safe return to Earth. A detailed discussion of Project Apollo follows in Unit IV.

SPACE AWARENESS VOCABULARY

Project Mercury	Sputnik	Spectrograph
Project Gemini	Parabola	Spectrum
Project Apollo	Radius	Solar system
Orbital velocity	Hyperbola	Apogee
Escape velocity	Radiation	Rendezvous
Meteoroid	Van Allen Belt	Perigee
Weightlessness	Deceleration	Probe
Acceleration	ITOS	NOAA
COMSAT	INTELSAT	ERTS

SUGGESTIONS FOR THE TEACHER

It is most important that adults begin the study of a new unit with interest and enthusiasm. A hurriedly given directive from the teacher that a particular NASA publication should be read for the next class meeting will rarely arouse the feeling that what is coming is sure to be fascinating and important.

A dramatic situation can be found which will be of general appeal to the class and which will suggest the theme of the unit to be studied. A comparison of two films might serve the purpose. Show a film which highlights unmanned flight and a film illustrating manned flight. A film on unmanned flight which is rated excellent for adult students is the <u>The First Soft Step</u>. This black and white 29 minute film provides a detailed look at the overall mission and accomplishments of the Surveyor program to soft-land a picture-taking craft on the surface of the Moon. Questions are skillfully asked and answered in language that the lay adult can understand. <u>Our Man In Space</u> is a 16:30 minute color film which could provide the manned flight picture. This NASA film provides excellent coverage and photography of Shepard's flight, offers a good suspense-type buildup, and is rated excellent for adult education.

Both of these films can be introduced, shown, and discussed very easily in the same class period. In your introduction of the films, drive home the fact that the students will be studying unmanned and manned flight, purposes and goals of each, and why unmanned flight had to precede manned flight.

For alternative interest stimulating activities, consider having your class design and equip an imaginary spacecraft with all of the systems necessary for a manned mission in space. You may also want to display models or pictures of Mercury, Gemini and Apollo capsules and discuss the reasons for the differences in them. Have your class organize a bulletin board of news and pictures concerning launchings and spacecraft.

Following the unit introduction, you should refer to the overall suggestions to the teacher at the beginning of the guide as you progress through the unit.

Refer to the appendix for laboratory-type activities for this unit and use them as facilities and circumstances permit in your particular situation. The group of adults you are working with will also influence the type of activities you select.

ILLUSTRATIVE RESOURCES

NASA Publications:

EP-40	Communications Satellites
EP-27	Meteorological Satellites
EP-57	American in Space/The First Decade-Man in Space
NF-27	Living in Space
EP-54	NASA Spacecraft
NF-3	Biosatellite II
NF-26	A Report from Mariner IV
NF-21	Pioneer
S-5	Weightlessness
S-7	Orbits and Revolutions
NF-B	Mariner II Reports
EP-53	Putting Satellites to Work
EP-52	Exploring the Moon and Planets
EP-84	Satellites at Work
NF-9	Manned Space Flight: Projects Mercury and Gemini
NASA PAFB	America's Spaceport

Textbooks:

Wolfe, Battan, Fleming, Hawkins, and Skornik, Earth and Space Science, D. C. Heath and Company, Boston

MacCracken, Decker, Read and Yarian, Scientists Solve Problems, L. W. Singer Company, Second Edition

Brandwein, Beck, Strahler, Hollingworth and Brennan, The World of Matter-Energy, Harcourt, Brace and World, Inc.

Brandwein, Beck, Strahler, Hollingsworth and Brennan, The World of Living Things, Harcourt, Brace and World, Inc.

Films:

The Four Days of Gemini IV (color) 28 minutes
The Flight of Sigma 7 (color) 27 minutes
Gemini XII Mission (color) 25 minutes
The Legacy of Gemini (color) 27:40 minutes
Ariel II (color) 26:30 minutes
The First Soft Step (black and white) 29 minutes
The Mastery of Space (color) 58 minutes
Astronaut Training (color) 7:30 minutes
The Space Suits (color) 5 minutes
Our Man in Space (color) 16:30 minutes
Flight of Freedom Seven (color) 10 minutes
Friendship 7 (color) 58 minutes

POST ASSESSMENT

I. To the right of each of the following statements, check whether it applies to Project Mercury, Project Gemini, or Project Apollo.

	Mercury	Gemini	Apollo
1. Experimentation during this project validated life support techniques, equipment, and concepts for future space missions.	____	____	____
2. This was the largest of NASA's manned space flight programs.	____	____	____
3. This project extended orbital missions up to two weeks at a time and developed the techniques for orbital rendezvous and docking.	____	____	____
4. The mission of this project was to investigate man's ability to survive and perform in the space environment and to develop the basic space technology and hardware for manned space flight programs to come.	____	____	____
5. Astronaut L. Gordon Cooper concluded the flight phase of this project when he completed a 22-orbit mission of 34½ hours.	____	____	____
6. During this project, astronauts performed the first "space walk" activity of the U.S. space program.	____	____	____

PRE-ASSESSMENT ANSWER KEY

I.
__3__ A.
__4__ B.
__6__ C.
__8__ D.
__1__ E.
__9__ F.
__7__ G.
__2__ H.
__5__ I.
__10__ J.

POST-ASSESSMENT ANSWER KEY

I.
1. Gemini
2. Apollo
3. Gemini
4. Mercury
5. Mercury
6. Gemini

UNIT IV - TO THE MOON AND BACK (PROJECT APOLLO)

INTRODUCTION

Man has progressed steadily from early rockets through satellites to manned flight.

The exploration of space follows the pattern by which flight within the atmosphere was mastered. Each new development provides a platform from which to take the next step, and each step adds an increment of scientific knowledge and technological skill.

Building on the manned space technology accumulated through the Mercury and Gemini programs and utilizing the knowledge of the Moon gained through the Ranger, Lunar Orbiter, and Surveyor programs, NASA's Apollo Program was targeted to achieve the national goal, set by the late President Kennedy, of a manned lunar landing by the end of the 1960's. The goal was achieved on July 20, 1969, when Apollo II astronauts successfully executed history's first lunar landing. Carrying out the epochal voyage were Commander Neil A. Armstrong, Command Module Pilot Michael Collins and Lunar Module Pilot Edwin E. Aldrin.

Compared to the earlier stages of the flight, the return mission was routine. Early on July 24th, the crew began to make ready for re-entry and splashdown. Rough weather in the planned landing area forced a shift to an alternate aiming point 346 kilometers (215 miles) down range. The spacecraft re-entered the atmosphere at 122,000 meters (400,000 feet) at 12:35 p.m., E.D.T., and 13 minutes later splashed into the Pacific Ocean. The astronauts were picked up by the prime recovery ship Hornet.

Thus, in 195 hours, 18 minutes and 35 seconds, Apollo II and Astronauts Armstrong, Aldrin and Collins moved the world into a new era.

RATIONALE

What does it take to travel to the Moon and back? Many superficial reasons for going to the Moon exist but frequently the more relevant are not readily revealed to the typical observer. Perception of the pre-flight training of the astronauts, development of the launch vehicle, functions attached to the exploration of the Moon, and the return trip to Earth necessitates a deep understanding of the many variables affecting this phenomenal accomplishment. The learner needs to be cognizant of the diverse number of simultaneous and sequential events incorporated within the total scheme. Knowledge of these events will motivate the student in developing a deeper consideration of this unique round trip.

PRE-ASSESSMENT

1. In the list which follows, circle the letter of each of the five Apollo mission objectives.

   A. To land astronauts on the Moon.
   B. To place a manned spacecraft in orbital flight around the Earth.
   C. To explore the lunar surface.
   D. To demonstrate that man could perform effectively during extended periods in space.
   E. To conduct scientific experiments on the Moon to furnish scientific data on Earth.
   F. To obtain lunar samples.
   G. To develop rendezvous and docking techniques.
   H. To return astronauts safely to the Earth.
   I. To test the performance of astronauts, both within and outside the protective environment of a spacecraft.

GENERAL OBJECTIVE

1. To help adults become familiar with space travel through a study of vehicular assembly, launching, landing at destination and return flight.

SPECIFIC OBJECTIVES

1. The student will select from a list containing distractors, five Apollo mission objectives.

2. Given seven characteristics descriptive of the three sections of the Apollo spacecraft, the student will classify them correctly.

3. Given a map of the United States showing the location of principle NASA facilities, the student will select the three locations where culminating efforts in the Apollo program were centered.

CONTENT

I. Exploration of the Moon is part of the National Aeronautics and Space Administration's manned space flight Apollo Program.

II. Project Apollo was the largest and most complex of NASA's manned space flight programs.

III. The goals identified for Project Apollo were to land American explorers on the Moon and bring them safely back to Earth and establish the technology to meet other

National interests in space. The mission objectives of Apollo were also clearly identified.

A. To land astronauts on the Moon.
B. To explore the lunar surface.
C. To conduct scientific experiments on the Moon to furnish scientific data on Earth.
D. To obtain lunar samples.
E. To return astronauts safely to the Earth.

IV. The mission accomplishments of Apollo are numerous.

A. Astronauts have landed on the Moon.
B. Astronauts have explored the lunar surface.
C. Scientific experiments have been conducted and data produced on Earth.
D. Lunar samples have been gathered and returned to Earth for study.
E. All astronauts have returned safely to Earth.

V. Preparations for the launch of astronauts to the Moon were extremely complex and involved almost all of the nation's 50 states in a manned space flight team made up of people from government, industry, and the educational community.

A. Culminating efforts in the Apollo Program were centered in three large NASA installations.
    1. The Manned Spacecraft Center at Houston, Texas, selected and trained the astronauts, developed the spacecraft, and conducted the flight missions.
    2. The Marshall Space Flight Center at Huntsville, Alabama, was responsible for development of the giant, 86 meters (281 feet) Saturn V launch vehicle.
    3. The John F. Kennedy Space Center in Florida assembles and pre-flight tests the rockets and spacecraft in the world's largest building, moves the upright vehicle to the launch pad, and conducts the launches.
B. A study of photographs from Lunar Orbiters were used in plotting the destination of the astronauts (area of Moon landing).

VI. The Apollo spacecraft was made up of three sections or modules.

A. The command module was designed to accommodate three astronauts in a "shirtsleeve" environment; i.e., the astronauts were able to work, eat, and sleep in the module without pressure suits.

VII. The Saturn V launch vehicle launched Apollo on its lunar exploration missions. (See figure seven.)

A. The entire assembly stood 111 meters (363 feet) tall

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(more than the length of a football field) and weighed 2,889 metric tons (6,370,000 pounds) fueled.

1. The fuel of the first two Saturn stages and part of the third stage was employed to place Apollo into Earth orbit.
2. At the proper position and time for achieving a lunar trajectory, the third stage was refired, which accelerated the assembly to about 40,000 kilometers (25,000 miles) per hour.
3. After burnout of the third stage, the crew disconnected the joined command and service modules (parent craft) and connected the command module nose to nose with the LM.

B. Once the astronauts reached the Moon's vicinity, Apollo was rotated to a tail forward position and a rocket in the service module was operated to swerve Apollo into a circular orbit about 161 kilometers (100 miles) above the moon.

1. At this point, two astronauts entered the LM, detached it, and by firing the LM's engine, they entered an orbit with a low point only a few miles above the Moon.
2. The two astronauts selected a landing spot, descended from orbit, and landed the LM on the Moon while the third crewman continued to orbit the Moon in the command module.

VIII. The two astronauts explored the Moon's surface near their landing site, took pictures, collected samples, and conducted scientific experiments.

IX. On the mission of Apollo 15, the ability of the astronauts to explore was significantly enhanced by the use for the first time of a Lunar Roving Vehicle (LRV). (See figure eight.)

A. The LRV was developed to eliminate the limited range of the astronauts during their exploration on the Moon's surface.

B. The LRV was a four wheeled vehicle which weighed about 181 kilograms (400 pounds) and was powered by two silver zinc batteries. The batteries drove electric motors each of the four wire-meshed wheels.

1. The command module, like the crew compartment of an airliner, had windows, and contained controls and instruments (including a computer) of various kinds which enabled the astronauts to pilot their craft.
2. Since the command module was the only one of the three modules to return to Earth, it was built to survive the tremendous deceleration forces and intense beating caused by reentry into the atmosphere at 40,000 kilometers (25,000 miles) per

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hour. This is the speed on return to Earth from a lunar mission.

3. In the atmosphere, the Apollo crew was able to guide the spacecraft to a selected landing area.
4. The command module was cone shaped, 3.5 meters (11 feet, 5 inches) high, and had a base diameter of 3.9 meters (12 feet, 10 inches).

C. The service module was equipped with rocket engines and fuel supplies which enabled the astronauts to propel their craft into and out of lunar orbit and to change their course and speed in space.
   1. The service module was jettisoned just before the Apollo entered Earth's atmosphere.
   2. The service module was 7.5 meters (24 feet, 7 inches) high, and had a base diameter of 3.0 meters (12 feet, 10 inches).

D. The lunar module (LM) was the "space ferry" which transported two Apollo astronauts down to the Moon, carried them from the Moon's surface into lunar orbit, and rendezvoused with the Apollo command and service modules in lunar orbit.
   1. Among the LM's equipment were rockets for slowing down before landing on the Moon and for maneuvering in orbit, and four spiderlike legs that were extended to support the spacecraft on the Moon's surface.
   2. The legs and landing rockets were left on the Moon.
   3. After the two-man crew of the LM returned to the command module, the LM was either jettisoned and fired into a lunar orbit that would prevent its interfering with future missions, or it was cast off and driven from orbit into the lunar surface, thus, making a last contribution to science. (NOTE: See Apollo 12, Unit V).
   4. The lunar module was 7 meters (22 feet, 11 inches) high and had a base diameter of 3.0 meters (13 feet).

E. Designed for as long as 78 hours of operation, the LRV had a top speed of 13 kilometers (8 miles) per hour and a cruising speed of 10 kilometers (6 miles) per hour. Its range was approximately 480 kilometers (65 miles) and payload capacity was 500 kilograms (1,100 pounds).

F. The LRV was carried to the Moon in the cargo compartment of the descent stage of the lunar module in a folded position.

X. The return trip to Earth began with the two astronauts entering their LM and blasting off, using the LM's lower section as a launch pad.

A. The astronauts entered orbit and steered the LM to connect with the command module (rendezvous and dock).
B. After the two astronauts entered the command module, they turned the spacecraft around, and jettisoned the LM.
C. At this point they fired a rocket in the service module to boost the parent craft out of lunar orbit toward Earth.

XI. One of the most critical phases of the return to Earth for Apollo was atmosphere entry.
A. The astronauts checked their course by sighting the Earth, the Moon, and the Stars, and they received information from tracking stations on Earth.
B. At a speed of 40,000 kilometers (25,000 miles) per hour, which is the Earth-approach velocity of a spacecraft returning from a lunar mission, the astronauts had to follow an extremely precise course called an entry corridor to avoid burning up or bouncing back in space.
C. The crew corrected the flight path by operating rockets in the service module to adjust Apollo's course properly and head for the atmosphere at the proper altitude and angle.
D. When they reached the entry corridor, the astronauts jettisoned the service module, turned the command module around, and began their reentry.
E. As they descended, friction with the air slowed the module and made the heat shield glow
F. The astronauts controlled the descending module and directed it toward the landing area.
G. After the searing heat and heavy deceleration forces of atmosphere entry were passed, the spacecraft released large parachutes which stabilized and slowed the spacecraft for landing. The three astronauts floated down into the Pacific Ocean. (See figure nine.)
H. Recovery forces which were deployed in the expected landing area picked up the spacecraft and the crew.

SPACE AWARENESS VOCABULARY

Payload	Space Medicine	Meteor
Command Module	Astronaut	Meteoroid
Service Module	Posture sense	Meteorite
Lunar Module	Quarantine	Re-entry
Jettison	Debrief	Space Myopia
Friction	Lunar	Parking Orbit

SUGGESTIONS FOR THE TEACHER

It would be well to introduce this unit with an explanation of the fact that the student will not encounter a detailed account

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of Project Apollo in this unit but rather an account of a typical Apollo mission. A detailed account of each Apollo mission follows in Unit V.

A NASA film, Apollo Lunar Mission Profile, should be considered as an aid in the introduction of this unit. This is a 31 minute, color film, which presents a step-by-step analysis of what is involved in an Apollo flight. Rated excellent for adult education, the film offers a good explanation of the precise timing that was essential for the success of Apollo.

In lieu of, or in conjunction with the film, you may distribute the NASA educational publication NF-40/11-67 entitled Journey to the Moon. This is an excellent fold-out of pictures and explanations of the entire lunar journey in simplified terms, from launch to recovery.

In the course of the unit, you may consider a discussion of the various ways of preserving food. Have the students collect items that could be found in the home demonstrating various ways of preserving food. Which of the various processes will be most advantageous to space flight? Include an examination of the processes of refrigeration, drying, freeze-drying, freezing and canning.

Have students make reports on the methods of waste disposal in the space program (Reference - NASA Facts, NF-27, Living in Space).

Introduce the students to various kinds of water purification systems. Some students might be able to make models of some of these systems. How might one of these be used in space?

Have the students make a study of how valuable exercise is to the human system. What happens to living things without exercise? What are isometric exercises? Have the students do some isometric exercises. Why are these exercises good for astronauts to do?

In addition to these suggestions, refer to the overall suggestions to the teacher.

Refer to the appendix for other activities and use them as you deem appropriate for the group of adults you are working with.

ILLUSTRATIVE RESOURCES

NASA Publications:
NF-23 Manned Space Flight: Apollo
NF-27 Living in Space
NF-40 Journey to the Moon
NF-41 Food for Space Flight

NF-33 Saturn V
S-4 The Countdown
S-5 Weightlessness

Textbooks:

Wolfe, Battan, Fleming, Hawkins, and Skornik, Earth and Space Science, D. C. Heath and Company, Boston.

MacCracken, Decker, Read and Yarian, Scientists Solve Problems, L. W. Singer Company, Second Edition.

Brandwein, Beck, Strahler, Hollingworth and Brennan, The World of Matter-Energy, Harcourt, Brace and World, Inc.

Films:

Apollo IV: The First Giant Step (color) 11 minutes
Lunar Receiving Lab (color) 7:45 minutes
Apollo Lunar Mission Update (color) 17 minutes
Apollo Lunar Mission Profile (color) 31 minutes
Apollo Mission Highlights (color) 5 minutes
The Lunar Module (color) 5 minutes

POST-ASSESSMENT

I. To the right of each statement, check whether it is a characteristic of the Command Module, Service Module, or Lunar Module.

	Command Module	Service Module	Lunar Module
1. Contained supplies, fuel and rocket engine.	___	___	___
2. This was similar to a crew compartment of a commercial jet airliner.	___	___	___
3. This was the only section of the three-section space-craft which returned to Earth.	___	___	___
4. This carried two of the three Apollo astronauts to the Moon's surface and landed.	___	___	___
5. This was jettisoned after the two astronauts rejoined the third one in the parent craft.	___	___	___

	Command Module	Service Module	Lunar Module
6. This had to be constructed to withstand tremendous deceleration forces and intense heat.	___	___	___
7. The module which contained rocket engine which enabled the astronauts to maneuver into and out of lunar orbit and alter their course and speed in space.	___	___	___

PRE-ASSESSMENT ANSWER KEY

1. A. To land astronauts on the Moon.
   C. To explore the lunar surface.
   E. To conduct scientific experiments on the Moon to furnish scientific data on Earth.
   F. To obtain lunar samples.
   G. To return astronauts safely to the Earth.

POST-ASSESSMENT ANSWER KEY

I. 1. Service Module
   2. Command Module
   3. Command Module
   4. Lunar Module
   5. Lunar Module
   6. Command Module
   7. Service Module

UNIT V - APOLLO MISSION RESULTS AND PRACTICAL RETURNS FROM SPACE INVESTMENT

INTRODUCTION

Man's body is adapted to the conditions found on Earth. If the conditions changed, even a little, life would become difficult or impossible.

In space, man's body must be supplied with almost the same environment as on Earth.

Conditions on other planets probably prevent life, as we know it. However, most scientists agree that the appropriate conditions need not necessarily resemble those on Earth nor must all life be comparable to Earth forms.

Much is being learned about our planet and other heavenly bodies from satellites, probes, and man's journeys into space. But man is continuing his explorations to gain more knowledge.

In the late 1950's a major goal of the United States space program was identified as manned flight to the Moon and safe return to Earth. Projects Mercury, Gemini and Apollo were to provide the steps to accomplish this goal.

Project Mercury put manned spacecraft into a controlled Earth orbit to investigate man's performance capabilities and his capacity to withstand the environment of space. Furthermore, it tested and successfully recovered the vehicle.

Project Gemini fulfilled its original objectives of extending orbital missions up to two weeks at a time and developing the techniques for orbital rendezvous and docking.

The same technique of orbital rendezvous, but around the Moon instead of the Earth, enabled the astronauts in the three-man Apollo spacecraft to achieve lunar landings.

On July 20, 1969, Apollo II Commander Neil A. Armstrong set foot on the Moon, climaxing the series of manned space flights that began with Project Mercury on May 5, 1961.

This unit builds upon the discussion of Project Apollo in the preceding unit and goes into details of each of the Apollo missions.

Since the successful completion of the Apollo 17 mission ended the Moon exploration flights, it appeared fitting to include in this unit some of the many practical returns from the space investment.

RATIONALE

What benefits accumulate from the manned space flight program? This information gives the learner a new insight into the value of space exploration. Suddenly, the impact of this knowledge impresses upon the student the many assets affiliated with traveling to the Moon and back. Some of these affect us directly and many indirectly. To fully appreciate the benefits, a more complete diagnosis will reveal a series of eye-opening experiences to the student.

PRE-ASSESSMENT

1. In the space before each Apollo mission in Column B, print the one number from Column A which best describes that mission.

COLUMN A

1. The first flight of the lunar module (unmanned).
2. The astronauts remained on the surface of the Moon for 33½ hours in this third manned lunar landing.
3. The first flight of the lunar module (manned), in Earth orbit.
4. Three astronauts lost their lives when a fire developed in this spacecraft during ground tests.
5. This was the last daytime launch in the Apollo program.
6. Scheduled to be the third manned lunar landing, this mission was aborted enroute to the Moon.
7. This mission marked the first flight of the Apollo/Saturn V space vehicle (unmanned), and utilized for the first time Kennedy Space Center's Complex 39 launch facilities.
8. This mission, the first launch from Complex 39B, was the first manned flight of the lunar module to low lunar orbit.
9. This was the second unmanned Apollo/ Saturn V flight.
10. This was a mission of a direct flight of a full-size spaceship from the Earth to the Moon and back.
11. This was the first manned Apollo/ Saturn V flight and also the first manned lunar orbit mission.
12. The launching of two separate sections of a spaceship from Earth into orbit, joining them together, and sending them as a single spacecraft to land on and take off from the Moon.
13. This was the only night time launch of the Apollo series.
14. This was the first manned Apollo spacecraft Earth-orbital flight.
15. During this second manned lunar landing, astronauts on this mission

COLUMN B

____ A. Apollo 1
____ B. Apollo 4
____ C. Apollo 5
____ D. Apollo 6
____ E. Apollo 7
____ F. Apollo 8
____ G. Apollo 9
____ H. Apollo 10
____ I. Apollo 11
____ J. Apollo 12
____ K. Apollo 13
____ L. Apollo 14
____ M. Apollo 15
____ N. Apollo 16
____ O. Apollo 17

COLUMN A (con'd.)

recovered pieces from unmanned Surveyor III spacecraft.

16. Astronauts on this mission demonstrated rendezvous and docking with Agena, multiple Agena restart in orbit, controlled landing and emergency recovery.
17. This was the first manned lunar landing. Neil A. Armstrong became the first man to set foot on the Moon at 10:56 p.m., E.D.T., July 20, 1969.
18. A space milestone was reached on this mission when Astronaut John H. Glenn, Jr., the first American in orbit, completed three circuits in Friendship 7.
19. On this mission, astronauts used the Lunar Roving Vehicle (LVR) for the first time.
20. Astronauts on this mission demonstrated spacecraft systems and crew compatibility for four days.

GENERAL OBJECTIVES

1. Given a list of Apollo missions 1 through 17 (there are no missions or flights officially designated as Apollo 2 or Apollo 3) in Column B, the student will select the correct description of the mission from a list in Column A.

2. From a list of possible problems, the student will select the one problem that faced the Apollo 13 crew during their mission.

3. Given a list containing the names of five astronauts in Column B, the student will select the one positive identification statement for each from a list in Column A.

CONTENT

I. Apollo, the largest and most complex of the manned space flight programs, had as its goal the landing of astronauts on the Moon and their safe return to Earth.
   A. The Apollo program was directed by the Office of Manned Space Flight, NASA, Washington, D. C.
   B. The project was a joint responsibility of the Manned Spacecraft Center, Houston, Texas, the Marshall Space Flight Center, Huntsville, Alabama, and the John F. Kennedy Space Center, Florida.

C. The development of the launch vehicles was the responsibility of the Marshall Space Flight Center.
D. The Manned Spacecraft Center was responsible for the development of spacecraft systems and astronaut selection and training.
E. Kennedy Space Center received, inspected, assembled and pre-flight tested launch vehicles and spacecraft, and conducted the launch of vehicles which were employed in the Apollo program.

II. During a manned ground test of an Apollo spacecraft while the vehicle was atop the Saturn 1B booster, a flash fire in the command module resulted in the deaths of Astronauts Gus Grissom, Ed White, and Roger Chaffee on January 27, 1967.
A. NASA immediately established a review board to determine the cause of the fire and the changes which would be necessary to prevent such fires in the future.
B. The review board presented its findings to the NASA administrator. While the exact cause of the fire was not determined conclusively, the board recommended a number of changes, including the elimination of most of the combustible materials in the spacecraft, the protection of wires in the spacecraft, and the installation of a quick-opening hatch. These and other changes were incorporated in later spacecraft,
C. On April 24, 1967, Dr. George E. Mueller, Associate Administrator for Manned Space Flight, NASA, officially designated the test as Apollo 1 and also announced that the forthcoming Saturn V flight would be called Apollo 4. There were no missions or flights officially designated as Apollo 2 and 3.

III. The November 9, 1967, launch of Apollo 4 was the first flight of the Apollo/Saturn V space vehicle (unmanned).
A. The facilities of Kennedy Space Center's Complex 39 were used for the first time for this launch. (Note: Complex 39 is described in detail in Unit VI.)
B. The spacecraft reached an altitude of 17,974 kilometers (11,234 miles), entered the atmosphere at a speed of 40,000 kilometers (24,917 miles) per hour and splashed down in the Pacific six miles from the recovery ship after a flight of eight hours, 37 minutes. This flight qualified the heat shield for lunar flight.

IV. A Saturn 1B launched Apollo 5 on January 22, 1968.
A. This was the first Earth-orbital test (unmanned) of the LM.
B. A wrong number in the guidance logic caused immediate shutdown of the descent engine, and led to a series of abnormal events. The LM performed very well, however, and accomplished most of its objectives, including its

ability to abort a landing on the Moon and to return to the command module during its orbiting lunar flight.

V. Apollo 6, the second test of the Saturn V launch vehicle, was launched on April 4, 1968.
   A. Although problems developed with the launch vehicle, the spacecraft's accomplishments were impressive.
   B. Accomplishments included the longest single burn in space of the service propulsion engine, and another successful test of the heat shield.

VI. Apollo 7 saw a return to the Saturn 1B as it was launched from LC 34 on October 11, 1968.
   A. This was the first manned Apollo spacecraft Earth-orbital mission.
   B. Lasting 260 hours, this was considered a very successful flight.
   C. The crew was composed of Astronauts Walter M. Schirra, Jr., Donn F. Eisele, and Walter Cunningham.

VII. On December 21, 1968, a Saturn V launched Apollo 8 from LC 39.
   A. This was the first manned Apollo/Saturn V flight.
   B. Apollo 8 was also the first manned lunar orbit mission.
   C. The crew of Apollo 8, Frank Borman, James Lovell, and William Anders, flew for 147 hours and accomplished 10 moon orbits.

VIII. Apollo 9 was launched on March 3, 1969, after a 3-day delay because all three astronauts had mild colds.
   A. This was the first manned lunar module Earth-orbital flight.
   B. Launched by a Saturn V vehicle, Apollo 9 successfully accomplished separation and rendezvous.
   C. The 10-day mission was flown by Astronauts James A. McDivitt, David R. Scott, and Russell L. Schweickart.

IX. Apollo 10, launched on May 18, 1969, completed all orbital maneuvers required for landing on the Moon except for actual landing.
   A. This was the first manned flight of the lunar module to low lunar orbit. Stafford and Cernan spent about 8½ hours in the LM and came within 15,240 meters (50,000 feet) of landing site No. 2.
   B. Astronauts Thomas P. Stafford, John W. Young and Eugene A. Cernan made up the crew for the 8-day mission of Apollo 10.

X. At 10:56 p.m., E.D.T., Sunday, July 20, 1969, Astronaut Neil A. Armstrong, Spacecraft Commander of Apollo 11, set foot on the Moon.
   A. As he took his epochal step to the surface of the

Moon, Armstrong commented, "That's one small step for man, one giant leap for mankind."

B. Apollo 11 was launched by a Saturn V vehicle on July 16, 1969, with a crew consisting of Armstrong, Michael Collins, and Edwin "Buzz" Aldrin. (See figure ten.)

C. On the Moon, Armstrong's attention was first directed at the nature of the surface material. He inspected the LM for possible damage incurred in landing, established the experimental base Tranquility, and collected lunar surface materials.

D. Once the LM inspection and the sample collection were completed, Aldrin got out of the LM for the first time and with Armstrong "unveiled" a plaque with the following inscription:

"Here Men From Planet Earth
First Set Foot Upon the Moon
July 1969 A.D.
We Came In Peace for All Mankind"

E. The astronauts set up lunar experiments.
   1. The seisometer experiment was designed to record and report events affecting the physical structure of the Moon.
   2. The laser reflector experiment provided very precise information on the Moon's distance from Earth and its orbital path.

F. With the completion of the lunar experiments and the return trip to Earth, the Apollo 11 crew was picked up from the Pacific recovery area on July 24, 1969.

XI. Apollo 12 was launched on November 14, 1969, by a Saturn V vehicle. (See figure 11.)

A. This was the second manned lunar landing.

B. Astronauts Charles Conrad, Jr., Alan L. Bean, and Richard F. Gordon, Jr. made up the Apollo 12 crew.

C. Astronauts Conrad and Bean established experimental base Ocean of Storms, deployed the Apollo Lunar Surface experiments Package (ALSEP), and recovered pieces from unmanned Surveyor III spacecraft as they performed two EVA's (extra-vehicular activities) of 3½ hours each.

D. In previous missions, the LM ascent stage had been jettisoned and fired into an orbit that would prevent its interfering with future missions. This time the Intrepid was to make a last contribution to science by being destroyed. With the crew reunited in the command and service module the LM was cast off and driven from orbit into the lunar surface. (NOTE: See Lunar Module, Unit IV.) The results of the LM's impact on the Moon's surface astounded the geophysicists. The shock waves registered on the lunar

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seismometer for 55 minutes, building up to a peak at the 8-minute mark and then slowly declining.

E. The Apollo 12 crew was picked up in the Pacific recovery area on November 24, 1969.

XII. Apollo 13, with astronauts James Lovell, Fred Haise and Jack Swigert aboard, was launched by a Saturn V on April 11, 1970.

A. Astronaut Jack Swigert, a member of the Apollo 13 backup crew, replaced Thomas K. Mattingly on the prime crew after Mattingly was exposed to measles.

B. When a liquid oxygen tank (LOX) exploded in the service module the explosion wiped out the CSM's main supply of life-sustaining oxygen and power.

C. The LM became the lifeboat after the CSM became a partial wreck, drifting in space.

D. Mission Control aborted the mission enroute to the Moon and ordered the crew into the LM for return to Earth. A safe landing was effected in the Pacific on April 17, 1970. (See figure 12.)

E. Even though classes as a failure, Apollo 13 produced much significant new information which prompted the title "Successful Failure."

XIII. Apollo 14 embodied modifications recommended as a result of the abortive Apollo 13 mission.

A. A Saturn V vehicle launched Apollo 14 on January 31, 1971, with Astronauts Alan B. Shepard, Jr., Stuart A. Roosa and Edgar D. Mitchell aboard.

B. Astronauts Shepard and Mitchell established experimental base Fra Mauro, conducted two EVA's, and stayed on the Moon 33½ hours in this third manned lunar landing.

C. This was a very successful mission with the exception of docking difficulties (five attempts at docking were made before latches finally sprang into place on the sixth attempt).

D. The crew was picked up from the Pacific recovery area on February 9, 1971.

XIV. Astronauts David R. Scott, Alfred M. Worden and James B. Irwin were crew members when Apollo 15 was launched on July 26, 1971.

A. The primary purpose of this mission was to gather more information, not only about the Moon but also about the Earth, the Sun, and the solar system.

B. The astronauts landed in the Hadley-Apennine region and while on the surface of the Moon, conducted three EVA's which totaled 18 hours, 37 minutes.

C. This mission marked the first use of the Lunar Rover.

D. On August 7, 1971, the Apollo 15 astronauts returned to Earth bearing about 77 kilograms (170 pounds) of Moon rocks and thousands of photographs.

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XV. Apollo 16 was a flight of 265 hours and 51 minutes, which began at Kennedy Space Center, Florida at 12:54 p.m., E.S.T., Sunday, April 16, 1972, and ended with splashdown at 2:45 p.m., E.S.T., Thursday, April 27, in the Pacific Ocean, 346 kilometers (215 miles) southeast of Christmas Island.

A. Apollo 16's purpose was to increase man's knowledge about the Moon, planets and solar system.

B. The astronauts established experimental base Descartes, conducted three EVA's totaling a record 21 hours, and brought back to Earth 94.5 kilograms (213+ pounds) of Moon rocks.

C. The crew for this highly successful mission consisted of Astronauts John W. Young, Thomas K. Mattingly II, and Charles M. Duke, Jr.

XVI. The launch of Apollo 17 at 12:33 a.m., E.S.T., Thursday, December 7, 1972, was the third of a trio of final flights in the Apollo series. The three, Apollo 15, 16, and 17, differed from the earlier Apollo flights. They used a more advanced configuration of Apollo spacecraft which utilized more fully the space vehicle's transportation system for exploration capabilities. They also employed the lunar roving vehicle to extend the area of exploration. (See figure 13.)

A. Astronauts for the Apollo 17 mission were Commander Eugene A. Cernan, Command Module Pilot Ronald Evans and Lunar Module Pilot Harrison Schmitt.

B. The astronauts conducted three EVA's and collected about 54 kilograms (120 pounds) more of rocks than they had planned. This necessitated a reduction in their liftoff weight and the Moon explorers left a large bag of unneeded equipment on the surface.

C. As they prepared for their 5:56 p.m., E.S.T., liftoff from the Moon on Thursday, December 14, Cernan and Schmitt unveiled a plaque that read, "May the spirit of peace in which we came be reflected in the lives of all mankind." The plaque, which was signed by the three Apollo 17 astronauts and President Richard M. Nixon, also contained these words: "Here man completed his first exploration of the Moon, December, 1972 A.D."

D. The Apollo 17 astronauts splashed down in the Pacific Ocean on Tuesday, December 19.

XVII. When the Apollo 17 astronauts established experimental base Taurus-Littrow, the station complemented four other such installations set up on the Moon. The Apollo 12 astronauts set one upon the Ocean of Storms in November, 1969, Apollo 14 in the Fra Mauro region in February, 1971, Apollo 15 at the Hadley Apennine site in August, 1971, and

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Apollo 16 at Descartes in April, 1972. This network represents the fulfillment of a long-cherished aspiration by the world' scientific community.

A. By receiving information from similar stations at different locations on the Moon, scientists can make measurements and directional determinations more precisely than with information from only one site.

B. Each station is known as an Apollo Lunar Surface Experiment Package (ALSEP) and is set up by the astronauts.

C. The instruments are connected by cables to a radio transmitting station and a nuclear generator. The generator provides electricity for the operation of each instrument and the transmitter. Information from these stations is transmitted to Earth each day.

XVIII. The following account is included to provide the interested student with a more detailed account of ALSEP.

A. Seismic experiments (active and passive).
   1. Passive Seismic Experiment (PSE) - used to measure extremely small vibrations of the Moon's surface by use of a seismometer.
   2. Similar to instruments used on Earth to study vibrations caused by earthquakes and by man-made explosions.
   3. Motion is detected electrically by the capacitor and the electrical signal sent by radio to the Earth.
   4. By analyzing the time Moonquakes and vibrations from manmade impacts take to travel through the highlands, scientists will be able to determine the density of the lunar crust under the highlands.

B. Active Seismic Experiment (ASE) - complementary to the Passive Seismic Experiment (PSE) in two ways, scale and source of energy.
   1. The PSE was designed to study the whole Moon - the ASE to study the local landing site.
   2. Rather than wait passively for natural events to occur on the Moon to produce sound waves, the ASE provides its own sources.
   3. Sound waves are produced by explosions on the lunar surface - small ones made while astronauts are on the surface and large ones after they leave the site and return to Earth.

C. Solar Wind Spectrometer Experiment - measures solar wind, plasma emanating from the sun.

D. Solar Wind Composition Experiment (SWC) - utilizes a sheet of aluminum foil like the familiar household item used to wrap food.
   1. The foil, exposed on the lunar surface to the solar wind, traps within it individual particles

of the solar wind.
2. Foil is returned to Earth and examined in the laboratory - particles include at is of many chemical elements, such as hydrogen, helium, neon and argon.

E. Lunar Surface Magnetometer Experiment (LSM) - because the magnetic field at the surface of the Moon can change in amplitude, frequency, and direction, the LSM is used to measure the magnetic field in three directions.
1. Sensors are located at the ends of three booms - direction of each sensor is 90 degrees to that of each of the other two sensors.
2. LSM used to measure the variation with time of the magnetic field at the surface of the Moon - variations caused by electromagnetic waves that emanate from the Sun and travel through space.

F. Laser Ranging Recro-Reflector Experiment - permits long-term measurements of the Earth-Moon distance by acting as a passive target for laser beams directed from observatories on Earth.
1. Help scientists detect continental drift on the Earth and the wobbling of the earth as it spins on its axis.
2. Obtains important data on Earthquakes.

G. Heat Flow Experiment (HFE) - heat sensors placed in holes that the astronauts drill into the Moon to obtain information about the Moon's internal temperature.
1. Lunar surface drill used by Apollo 15 crew was redesigned for Apollo 16 (Problem of drilling the hole was caused by failure of the drill to expel the cuttings from the hole).
2. Heat measurements among fundamental data needed to determine history and evolutionary status of a planetary body.
3. HFE measures rate at which interior is losing energy to outer space.
4. Heat flowing to the surface of the Moon from the interior produced mostly by slow decay of natural radio-active elements thorium, uranium, and potassium.

XIX. In addition to the wealth of scientific information that is being transmitted from the Moon to Earth through ALSEP instruments, there is also a broad range of practical results from the space investment for the benefit of all mankind. Certain benefits accrued from the total space program and were not indigenous to the Apollo program.

A. Communications.
1. Intelsat Communication Satellite.
2. International Telecasting and Broadcasting.

3. Miniature TV Transmitters.
4. Miniature TV Camera.
5. Phototransistor Mosaic.

B. Weather forecasting.
1. Meteorological Satellite.
2. Anal 's of Hurricane Mechanisms.
3. Ear   iake Prediction System.
4. Tornado and Fire Storm Analysis.
5. Development of sensors - devices which can sense from orbit such atmospheric conditions as temperature, pressure, moisture, and air movement.
6. Estimated savings possible from an accurate 2-week forecast - savings in farming, fishing, construction, and other fields would be billions of dollars each year.

C. Business.
1. Reliability Technique.
2. Waste Disposal.
3. Waste Food Conversion.
4. Waste Management.
5. Waste Purification.

D. Medicine.
1. Medical Training and Diagnosis.
2. Breathing Sensor.
3. Cardiac Catheter.
4. Cardiovascular Pressure Transducer.
5. Computer Enhancement of X-ray Photographs.
6. Cardiotachometer.
7. Ear Instrument.
8. Heart Monitor.
9. Electrocardiograms by Telephone.
10. Laser Surgery.
11. Heart-assist Pump.

E. Education.
1. Oculometer.
2. Portable Planetarium.
3. Teaching Devices.
4. Education and Research.
5. NASA program assistance to institutions of higher learning, State and local school authorities and professional associations in the conduct of courses, institutes and workshops for pre- and in-service teachers.
6. NASA compiles relevant information its programs produce into curriculum supplements which are made available to teachers.
7. The Spacemobile.

F. Home and Marketplace.
1. Adhesives.
2. Aluminum Foil.
3. Cryogenic Insulation.

4. Fireproofing.
5. Flat Conductor Cable.
6. High-strength Plastic Pipe.
7. High-temperature Plastics.
8. Inorganic Paints.
9. Metals, Alloys and Substitutes.
10. New Class of Plastics.

G. Transportation.
1. Automated Quality Control.
2. Highway Safety.
3. Navigation.
4. Shipping Safety.
5. Solar Cells (Silicon and Cadmium Sulfide).

SPACE AWARENESS VOCABULARY

Seismometer	Laser
Meteorological satellite	Inorganic compound
Communication satellite	Cryogenic
Solar cell	Oculometer

SUGGESTIONS FOR THE TEACHER

A check amoung the members of the class as to what phase of man's journey to the Moon and back they consider most critical, will be a good point for a lively discussion for this unit.

The introduction should be related to the predominant interest of the students in the content of this unit. Interests may not be the same for all classes or groups of adults. In general, for adults, the excitement of the Moon voyage is likely to be less appealing than the presentation of the scientific knowledge and practical benefits derived from the space program. The teacher is the best judge of this for his class. A film, Your Share in Space, may be effective in the introduction of this unit. This is a 27-minute color film which discusses why space exploration is important and how man benefits and increases his knowledge through gains made in the space program.

An alternative to this introduction could be the showing of the film, Apollo/Saturn V, a 14-minute color film or Spaceport U.S.A., a 22-minute color film. Either of these films would serve as a lead-in to a discussion of Apollo.

A display of spacecraft models (pictures if models are not available) may arouse considerable interest.

Have the students think of ways they may realize benefits from space.

The introduction of the unit should be followed by a planning session with the students.

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In addition to these suggestions, refer to the overall suggestions to the teacher.

Refer to the appendix for other activities and use them as you deem appropriate for the group of adults you are working with.

ILLUSTRATIVE RESOURCES

NASA Publications:
NF-23 Manned Space Flight: Apollo
NF-33 Saturn V
Mission Report, Apollo 11
Mission Report, Apollo 12
Apollo 13, A successful Failure
Apollo 14, Science at Fra Mauro
Apollo 15 at Hadley Base
Apollo 16 at Descartes
On the Moon with Apollo 17
Fact Sheet - Benefits for Mankind from Space Research
Medical Benefits from Space Research
Report of the Committee on Science and Astronautics, U.S. House of Representatives, For the Benefit of all Mankind

Textbooks:

Wolfe, Battan, Fleming, Hawkins, and Skornik, Earth and Space Science, D. D. Heath and Company, Boston.

MacCracken, Decker, Read and Yarian, Scientists Solve Problems, L. W. Singer Company, Second Edition.

Brandwein, Beck, Strahler, Hollingworth and Brennan, The World of Matter-Energy, Harcourt, Brace and World, Inc.

Films:

Returns From Space (color) 28 minutes
Echo in Space (color) 14 minutes
Your Share in Space (color) 27 minutes
Apollo/Saturn V (color) 14 minutes
Spaceport U.S.A. (color) 22 minutes
Testing Apollo (color) 5 minutes
The Command Module (color) 6 minutes

POST-ASSESSMENT

I. Place a check in the blank in front of the one problem that faced Apollo 13 crew which resulted in the abortion of the mission.

____ 1. The space suits started to show an increase in temperature from the automatically reduced flow of coolant.

____ 2. The automatic control system developed short circuits and malfunctioned during retro-fire and reentry.

____ 3. A liquid oxygen tank exploded in the service module resulting in the loss of the CSM's main supply of life-sustaining oxygen and power.

____ 4. Astronauts noticed that paint which had been provided to protect the lunar module against the Sun's extreme heat was blistering and flaking off.

II. In the space before each astronaut's name in Column B, print the number of the one positive identification statement for each from the list in Column A.

COLUMN A

1. This was the only astronaut member of a backup crew who replaced one of the prime crew members for an Apollo mission.
2. This was the first American to orbit the Earth (Friendship 7).
3. This astronaut was the first American rocketed into space (Freedom 7).
4. This was the first astronaut to wait in lunar orbit for the return of two astronauts from the Moon.
5. A 20-minute "space walk" by this astronaut was a first for Americans.
6. The longest flight of the Mercury missions, 34 hours, 19 minutes, and 49 seconds, was flown by this astronaut.
7. This astronaut was the first man ever to set foot on the Moon.

COLUMN B

___A. John H. Glenn, Jr.
___B. Edward H. White, II
___C. Alan B. Shepard
___D. Neil A. Armstrong
___E. Jack Swigert

PRE-ASSESSMENT ANSWER KEY

I.

4 A.	14 E.	17 I.	___ M.
7 B.	11 F.	15 J.	___ N.
1 C.	3 G.	6 K.	___ O.
9 D.	8 H.	2 L.	

POST-ASSESSMENT ANSWER KEY

I. x 3. A liquid oxygen tank exploded in the service module resulting in the loss of the CSM's main supply of life-sustaining oxygen and power.

II. 2 A. 5 B. 3 C. 7 D. 1 E.

UNIT VI - THE SPACE PROGRAM TODAY - INFORMATION AND AVAILABLE RESOURCES

INTRODUCTION

NASA today is a future-oriented organization of about thirty thousand employees acting in concert with industry, universities, and other Government agencies on a variety of projects in aerospace science and technology, including aeronautical research.

Today, the space program benefits man in many ways. Goal after goal has been successfully realized since NASA began with enactment of Public Law 85-568, the National Aeronautics and Space Administration Act of 1958. New knowledge, improved weather forecasting, better global communications, and new products, processes, and techniques applicable to industry, medicine, and education are among the countless benefits accruing to man from the space program.

Now that Projects Mercury, Gemini, and Apollo have been concluded, the knowledge man has gained from these missions will be utilized in future space exploration programs. Apollo 17, the last of the Apollo manned missions which was completed in December, 1972, climaxed a series of manned space flights that began with the Mercury suborbital flight of May 5, 1961.

While the Apollo manned missions were expanding man's knowledge of the Moon, NASA was proceeding with the Skylab program to establish the nation's first manned Earth-orbiting space station.

Today, the focus of the space program is on the Skylab project. Skylab is seen as the forerunner of larger and more advanced space stations and manned interplanetary spacecraft. The space station following Skylab may be a 6 to 12 man modular structure that could remain in orbit for as long as ten years. Its parts, or modules, would be flown into orbit individually and assembled there.

Another notable characteristic of the space program today is the conducting by NASA of a broad program of international cooperation in space and aeronautics. Scientists of more than seventy countries and jurisdictions have participated with NASA in joint satellite and sounding rocket projects, ground-based support such as tracking and data acquisition from spacecraft, and programs of technical training and visitor exchange.

On the home front, hundreds of companies, large and small, use NASA data dissemination centers at six universities.

The centers are designed to help industry apply technical advances made during research on space projects.

Companies are alerted to technological developments by NASA's TECH BRIEFS that describe promising innovations. Sometimes a single innovation can become an important part of an industrial process or an industry in itself.

In 1969, NASA organized Technology Application Teams. Upon request, the teams assist in identifying and applying technology derived from aerospace research and development to solve problems of national concern, such as air and water pollution, highway safety, law enforcement, urban construction, mass transportation, and mine safety.

NASA has, from its inception, realized the tremendous importance of public relations. Periodic briefings are conducted for the press by NASA. These briefings are sometimes voluntary while at other times they are requested by the press.

Daily newspapers are put on mailing lists to receive public information regarding the space program. Major news media networks have established permanent buildings or trailers at Kennedy Space Center, Florida to cover launches.

NASA educational programs reach hundreds of thousands of students each year. Carefully trained former public school teachers and supervisors conduct lecture-demonstrations at school assemblies and classroom discussions.

More than twenty-five thousand teachers participate yearly in courses, workshops, institutes, and conferences conducted by universities and colleges, professional associations, and local and county school districts in conjunction with NASA.

To bridge the gap between information available in standard texts and the rapidly expanding knowledge to which NASA is contributing, NASA has produced a variety of publications and films. Among these are curriculum supplements that relate space to such subjects as biology, chemistry, industrial arts, physics, and mathematics; and booklets, fact sheets, films, and tape recordings to provide general information about specific aspects of the space program.

RATIONALE

NASA began with enactment of Public Law 85-568, the National Aeronautics and Space Act of 1958, approved July 29, 1958, authorizing establishment of the National Aeronautics and Space Administration. What is the status of NASA today? The learner will consider the number of operations involved in coordinating the many complex activities associated with such large facilities. The different localities, diverse number of occupations, and endless modifications reveal to the student that NASA is constantly encountering new challenges. What are these challenges and how they are incorporated within the total NASA picture can undoubtedly invigorate the interested adult into a deeper quest for knowledge about the space program.

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PRE-ASSESSMENT

1. In the following list, circle the letter of each of the seven NASA services to educational programs.

   A. Consultants
   B. Private Tours
   C. Analysis of Lunar Samples
   D. Speakers
   E. Technology Application Teams
   F. Spacemobile
   G. NASA's Tech Briefs
   H. Publications
   I. Data Dissemination Centers
   J. Audio Visual Materials
   K. Exhibits
   L. Field Trips

2. Put an X in front of the two examples which show the emphasis placed on public relations by NASA Headquarters.

   ___ 1. Established training program for news commentators.
   ___ 2. Conducts periodic briefings for the press, both voluntarily and by request.
   ___ 3. Conducts polls to assess public opinion of the space program.
   ___ 4. Placed daily newspapers on mailing list to receive public information regarding the space program.

3. Put an X in front of the three examples which show the emphasis placed on public relations by the Public Affairs Office at Kennedy Space Center.

   ___ 1. Conducts pre-launch press briefings.
   ___ 2. Made special provisions for Russian newsmen to cover manned flights.
   ___ 3. Issues permanent admittance badges to newsmen.
   ___ 4. Cooperated with major news media networks in establishing permanent facilities to cover launches.
   ___ 5. Eliminated all restrictions on visits by newsmen.

GENERAL OBJECTIVES

1. To develop an awareness of the nature and scope of the present day space program.

2. To develop an awareness of sources of available information and resources on the space program.

SPECIFIC OBJECTIVES

1. The student will select from a list containing distractors, the seven major components of Complex 39, the nation's first operational spaceport.

2. Given a list of the network of NASA facilities, in Column A, the student will select the correct location of each from a list in Column B.

3. Given a list of industrial companies, in Column A, the student will select the correct service provided at Kennedy Space Center of each from a list in Column B.

4. The student will select from a list containing distractors, seven NASA services to educational programs which include those sponsored by state departments of education, colleges and universities, and civic groups.

5. Given a list, the student will select the two examples which show the emphasis placed on public relations by NASA Headquarters.

6. Given a list, the student will select the three examples which show the emphasis placed on public relations by the Public Affairs Office at Kennedy Space Center.

CONTENT

I. NASA began with enactment of Public Law 85-568, the National Aeronautics and Space Act of 1958, approved July 29, 1958, and authorizing establishment of the National Aeronautics and Space Administration.
   A. Agency took tangible form on October 1, 1958, with assignment to it of the 43-year-old National Advisory Committee for Aeronautics (NACA).
   B. Charged with carrying out the stated policy of the United States that "activities in space should be devoted to peaceful purposes for the benefit of all mankind."
   C. Today, a future-oriented organization of about thirty thousand employees acting in concert with industry, universities, and other Government agencies on a variety of projects in aerospace science and technology, including aeronautical research.

II. A network of NASA facilities makes up the total space program today.
   A. NASA Headquarters, Washington, D. C.
      1. Formulates policy.
      2. Coordinates activities of space flight centers,

research centers, and other installations which comprise the National Aeronautics and Space Administration.

B. Ames Research Center, Moffett Field, California
   1. Concerned with laboratory and flight research in space missions and in aeronautics.
   2. Space interest fields include atmosphere entry research, fundamental physics, materials, guidance and control, chemistry and life sciences.
   3. Space flight projects - management of scientific probes and satellites, and payloads for flight experiments.
   4. Management of Project Pioneer.

C. Flight Research Center, Edwards, California
   1. Concerned with manned flight within and outside the atmosphere.
   2. In biotechnology, man-machine integration problems are studied.

D. Goddard Space Flight Center, Greenbelt, Maryland
   1. Named for the rocket pioneer, Dr. Robert H. Goddard.
   2. Responsible for development and management of a broad variety of unmanned Earth-orbiting satellite and sounding rockets projects.
   3. Major projects include Orbiting Observatories, Explorers, Nimbus, and Earth Resources Technology satellites.
   4. Nerve center for worldwide tracking and communications network for both manned and unmanned satellites.

E. Jet Propulsion Laboratory, Pasadena, California.
   1. Research, development and flight center operated for NASA by California Institute of Technology.
   2. Primary role - the investigation of planets using automated scientific spacecraft.
   3. Supports research and advanced development related to flight projects and the design and operation of the Deep Space Network, which tracks, communicates with, and commands spacecraft on lunar, interplanetary, and planetary missions.

F. Langley Research Center, Hampton, Virginia
   1. Oldest of NASA Centers.
   2. Provides technology for manned and unmanned exploration of space and for improvement and extension of performance, utility and safety of aircraft.
   3. Conceives, develops and operates simulators for aircraft and for lunar landing projects, and conducts V/STOL flight research.
   4. Charged with overall project management for Viking.

G. Lewis Research Center, Cleveland, Ohio
   1. Primary missions - aircraft and rocket propulsion

and space power generation.
2. Technical management of such rocket stages as the Agena and Centaur.
3. Operates an extension, Plum Brook Station at Sandusky, Ohio, with facilities for propulsion research and development, including a nuclear reactor.

H. George C. Marshall Space Flight Center, Marshall Space Flight Center, Alabama
1. Scientists and engineers here design and develop launch vehicles essential to Apollo and other major missions.
2. Concerned with launch vehicles of the Saturn class, payloads, related research and studies of advanced space transportation systems.
3. Manages Skylab project.

I. Nuclear Rocket Development Station, Jackass Flats, Nevada
1. Managed by Space Nuclear Systems Office, a joint operation of NASA and the Atomic Energy Commission.
2. Scene of many tests of reactors and experimental rocket engines.

J. Wallops Station, Wallops Island, Virginia
1. One of oldest and busiest ranges in the world - 300 or more experiments are sent aloft each year on vehicles which vary in size from small meteorological rockets to the four-stage Scout with orbital capability.
2. Devotes effort to aeronautical research and development and in exporting the United States space technology to the international community.

K. John F. Kennedy Space Center, Florida
1. Nation's first spaceport.
2. Makes pre-flight tests, prepares and launches manned and unmanned space vehicles for NASA.
3. Launches manned Apollo missions, unmanned lunar, planetary, and interplanetary missions, and scientific meteorological and communications satellites.

III. Even though the principal facilities of NASA are located in a limited number of states, NASA principal prime contractors and subcontractors provide direct employment to countless thousands of workers for the production of both space related hardware and services in all 50 states, the District of Columbia and in 41 of the free world's foreign countries who support the global space network.

A. A compilation of the location of all NASA principal contractors and subcontractors over a time span since July 1, 1960, follows:

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State	No. of Cities Affected	No. of Business Firms
Alabama	31	469
Alaska	3	31
Arizona	13	67
Arkansas	4	6
California	235	4,524
Colorado	13	80
Connecticut	75	309
Deleware	6	18
District of Columbia	1	360
Florida	58	774
Georgia	17	101
Hawaii	6	12
Idaho	7	10
Illinois	88	371
Indiana	44	108
Iowa	11	17
Kansas	16	50
Kentucky	7	25
Louisiana	13	440
Maine	9	10
Maryland	70	571
Massachusetts	108	716
Michigan	70	249
Minnesota	17	111
Mississippi	18	112
Missouri	20	118
Montana	3	5
Nebraska	4	12
Nevada	7	30
New Hampshire	19	39
New Jersey	155	501
New Mexico	8	75
New York	182	1,083
North Carolina	28	68
North Dakota	2	2
Ohio	90	672
Oklahoma	11	81
Oregon	8	27
Pennsylvania	184	598
Rhode Island	10	29
South Carolina	12	18
South Dakota	4	4
Tennessee	19	73
Texas	61	622
Utah	9	23
Vermont	10	16
Virginia	39	577

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State	No. of Cities Affected	No. of Business Firms
Washington	15	43
West Virginia	11	15
Wisconsin	29	83
Wyoming	2	6
Total U.S. Cities and Business Firms representing 50 states plus District of Columbia	1,882	14,369
Foreign Countries and Business Firms	41	165

B. A grand total of 1,923 cities and foreign countries and 14,534 businesses affected by NASA contracts and subcontracts.

NOTE: Statistics compiled by the Astronautics and Aeronautics Committee for the Honorable Louis Frey, Jr., Congressman 5th District, State of Florida, 1969.

IV. In 1972, the federal budget called for social action spending in the amount of $100 billion while NASA budget fell to a low of 3.2 billion.

1972 FEDERAL BUDGET ESTIMATE

SOCIAL ACTION PROGRAMS	Percent of Total Budget	Expenditures in Billions of Dollars
Income Security	26.5%	$ 60.7
Health	7.0	16.0
Veterans Benefits & Services	4.6	10.6
Education & Manpower	3.8	8.8
Community Development & Housing	2.0	4.5
TOTAL	43.9%	$100.6

SPACE RESEARCH & TECHNOLOGY	Percent of Total Budget	Expenditures in Billions of Dollars
TOTAL	1.4%	$3.2

V. The NASA budget for fiscal year 1973 continued the transition from the era of the Apollo manned lunar landings to the post Apollo space program.
   A. Outlays of 3.2 billion recommended for 1973.
   B. Recommendation for 1973 approximately the same as in 1972.
   C. Recent Program Improvements.
      1. Redirected nuclear rocket and outer planets exploration programs to provide a better balance in future space investments.
      2. Increased emphasis on programs that provide direct benefits, such as weather, communications, navigation and earth resources satellites, and on programs to increase scientific knowledge.
   D. 1973 Budget Activities
      1. Develop the space shuttle to reduce future cost of space operations.
      2. Prepare for unmanned exploration of Mars and Jupiter.
      3. Operate the first earth resources technology satellite.
      4. Develop a new generation weather satellite to provide major improvements in weather problems.
      5. Begin to utilize NASA's capabilities for earth-bound transportation problems.
   E. Results noted at the end of 1972.
      1. Achieved first successful manned landing on the moon and successfully completed five additional lunar landings.
      2. Sent unmanned spacecraft to photograph Mars.
      3. Demonstrated ability of experimental communications satellite to provide medical information directly to remote areas.
      4. Used multispectral pictures from aircraft to detect environmental problems.
   F. The budget for Fiscal Year 1973:

SPACE RESEARCH AND TECHNOLOGY
(IN MILLIONS OF DOLLARS)

Program	1971 Actual	1972 Est.	1973 Est.	Recommended budget authority for 1973
Manned space flight:				
Earth orbital program....	804	973	1,128	1,376
Lunar program..........	1,081	664	443	197

Program	1971 Actual	1972 Est.	1973 Est.	Recommended budget authority for 1973
Space science and applications	661	766	853	1,013
Space technology	272	220	188	172
Aeronautical technology	210	226	251	295
Supporting space activities	365	344	339	326
Deductions for offsetting receipts:				
Proprietary receipts from the public	-11	-13	-11	-11
Total	3,381	3,180	3,191	3,378

VI. About 25 of the 150 member staff in the NASA Headquarters, Washington, D. C. Public Relations office works directly with the press.
   A. Periodic briefings are conducted for the press by NASA.
      1. Volunteered by NASA.
      2. Requested by the press.
   B. Daily newspapers put on mailing list to receive public information regarding space program.

VII. Spot announcements, 30 seconds to 2 minutes, made on television for public information of NASA programs, progress, achievements.

VIII. NASA services to educational programs include those sponsored by state departments of education, colleges and universities, and civic groups.
   A. Consultants - assist in developing course content, coordinating programs, and providing infromation about available resources.
   B. Speakers - requested from NASA Headquarters and the several NASA Centers to discuss specific space-related topics for programs.
   C. Spacemobile - NASA traveling space science lecture-demonstration unit available on request for a standard 50-minute presentation and for special lectures on space-related subjects.
   D. Publications - A "Directors Kit," a packet of NASA educational publications, is provided to the directors of adult education programs. Materials concerned with

specific NASA projects are also available from the NASA Centers.

E. Audio-visual - selected films are available on request.

F. Exhibits - exhibits of spacecraft and space exploration activities are available on request.

G. Field trips may be arranged to NASA Centers and pertinent industrial complexes.

IX. Office of Technology Utilization was created by NASA Headquarters to aggressively encourage the use of new aerospace technology in non-aerospace endeavors.

A. Technology Utilization Program - information includes improved techniques, procedures, programs, products, devices, materials, processes, compositions, systems, machines, apparatuses, articles, fixtures, tools, methods and scientific data.

B. Anything developed by NASA or under NASA contract represents potential feedback on the taxpayers' investment in the space program.

C. NASA data dissemination centers at six universities utilized by hundreds of companies, large and small.

D. NASA's TECH BRIEFS - describe promising innovations that alert companies to technological developments.

E. Space Application Teams.

1. Biomedical Application Team organized in 1967.
2. Technology Application Team organized by NASA in 1969.
3. Teams assist in identifying and applying technology derived from aerospace research and development to solve problems of national concern, such as air and water pollution, highway safety, law enforcement, urban construction, mass transportation, and mine safety.

X. Adapting space technology to earthly uses is in keeping with the stated policy of the United States that "activities in space should be devoted to peaceful purposes for the benefit of all mankind." Some examples follow:

A. Ultraviolet photo tubes - invented for spacecraft, used as flame detectors in fire alarm systems.

B. Techniques and systems for computerized enhancement of telecasts from spacecraft millions of miles away - applied to human x-rays.

C. Research in effects of space radiation on body cells - indicated intercellular linkages that may help to explain certain types of cancer.

D. Systems used to monitor the health of astronauts on distant flights - adapted so that nurses at a single hospital center can watch the conditions of critically ill patients in numerous rooms.

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E. Stress devices for measuring rocket thrust - show internal stresses in dams and warn of any critical structural weakening.
F. Research to reduce fire hazards in Apollo spacecraft - yielded materials highly resistant to fire that offer great promise in commercial and residential fire prevention.
G. An electronic switch that can be activated by eye movements of an astronaut when high gravity forces might limit his arm and leg movements - adapted for non-space uses, including self-guidance by partially paralyzed patients in wheel chairs.

XI. Midway between Jacksonville and Miami, on Florida's east coast, the National Aeronautics and Space Administration operates the huge Spaceport from which astronauts travel to the Moon.

XII. Selection of Cape Kennedy site.
A. Originally selected following World War II as a testing area for long range guided missiles.
B. Approved as the site to accommodate tracking stations to measure the flight of research and development vehicles on July 8, 1947.

XIII. Authorization by Congress to acquire and construct the Atlantic Missile Range.
A. Range assigned to the Air Force for management.
B. Atlantic Missile Range became Eastern Test Range.

XIV. Launch Complex 39, the nation's first operational spaceport, was developed and operated by the Kennedy Space Center.
A. Designed to accommodate the massive Apollo/Saturn V space vehicles.
B. Reflects the new "mobile concept" approach.
1. The assembly and checkout of the Apollo/Saturn V vehicle in the controlled environment of a building.
2. The transfer of the Apollo/Saturn V vehicle from the building to a distant launch site.
3. Launch with a minimum of time on the launch pad.

XV. The major components of Complex 39.
A. Vehicle Assembly Building
B. The Launch Control Center
C. The Mobile Launcher
D. The Transporter (See figure 14.)
E. The Crawlerway
F. The Mobile Service Structure
G. The Launch Site

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XVI. The Industrial Area of the Kennedy Space Center is located 5 miles south of Complex 39.

A. Dr. Kurt H. Debus, Director of the Kennedy Space Center, and staff are located here. (See fugure 15.)

B. Administrators, scientists, engineers and technicians plan and accomplish operations associated with pre-launch testing and preparing space vehicles for a mission.

C. Kennedy Space Center's basic organization was changed in June 1966 when NASA approved a restructuring which allowed greater utilization of the Center's management resources.

D. The Directorate of Launch Operations executes all launch assignments.
   1. Controls and integrates the work of stage contractors at the launch site to the degree necessary to achieve NASA's objectives without relieving the contractors of their mission responsibilities.
   2. Assures, before launch, that engines, guidance, propellant flow systems, spacecraft, and experiments, will function as designed in space.
   3. Consists of three principal departments:
      a. Launch Vehicle Operations
      b. Spacecraft Operations
      c. Unmanned Launch Operations

E. Contained also in the KSC organizational structure are three other first line directorates whose chief function is to support launch operations requirements.
   1. Technical Support - Directorate manages and directs the maintenance and operation of all specialized test and launching facilities and related equipment, except launch vehicle stages and spacecraft and associated ground support equipment controlled by the Launch Operations Director.
      a. Information Systems - a major department within the Technical Support Directorate. Responsible for the supervision of telemetry, data acquisition, handling and distribution, commercial and scientific automatic data processing and calibration, and maintenance of a reference standards laboratory.
      b. Support Operations - a major department within the Technical Support Directorate. Responsible for the equipment, propellant logistics services, technical support shops and laboratories, and technical communications.
   2. Design Engineering - Directorate provides continuing engineering support for launch facilities and ground systems and devices solutions to mechanical, civil and electrical - electronic requirements for existing or new launch facilities.

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3. Installation Support - Directorate collects in one management element all base housekeeping functions such as supply, security, fire fighting, industrial health services, reproduction and photography.

F. Administration - Directorate includes procurement, contract negotiations, personnel administration, and a Centerwide resources management system.

G. Latest directorate (1970) established at KSC is that of Center Planning and Future Programs.

1. Directorate works closely with the Office of Manned Spacecraft Center and the Marshall Space Flight Center in formulating the manned space projects.
2. Chief interest centers on the logistics shuttle, the space transportation system which is expected to become the mainstay of the NASA Program in the future.

XVII. People (the human element) are the most important aspect of the space program.

A. A vertible cross section of professions and trades are represented among employees at the John F. Kennedy Space Center.

1. Welders
2. Radio Technicians
3. Doctors of Medicine
4. Engineers
5. Scientists
6. Mechanics
7. Tinsmiths
8. Writers
9. Photographers
10. Truck Drivers
11. Policemen
12. Etc.

B. John F. Kennedy Space Center employment levels over an eight year period.

	FY64	FY65	FY66	FY67
Civil Service	1,977	2,469	2,654	2,785
Apollo Contractors	911	1,748	5,850	8,032
Unmanned Contractors	188	1,448	1,331	1,549
Support Contractors	3,204	4,116	7,739	9,116
TOTALS	6,280	9,781	17,574	21,482

(Con'd.)	FY68	FY69	FY70	FY71
Civil Service	2,911	3,000	2,967	2,600
Apollo Contractors	6,990	9,160	4,768	3,926
Unmanned Contractors	1,553	940	962	952
Support Contractors	9,829	9,000	7,011	5,681
TOTALS	21,283	22,100	15,378	12,859

C. The John F. Kennedy Space Center employment levels may be compared to more than 300,000 men and women who have been involved in the National space program over the years.

XVIII. Some of the giant companies of American industry as well as smaller and more specialized organizations are engaged at Kennedy Space Center.

A. Boeing Aircraft Company
   1. The largest employer at Kennedy Space Center.
      a. Provides plant engineering, maintenance, logistics support, security and publications.
      b. TWA operates a Visitors Information Center and Greyhound Bus Lines, a subcontractor, conducts public tours of the Space Center.

B. Bendix Corporation provides launch support services for Complex 39.

C. Federal Electric Corporation provides instrumentation, data acquisition and processing and communications support for the Space Center.

D. McGregor & Werner, Inc. provides reproduction services.

E. General Electric - services and equipment for checkout and integration of manned spacecraft.

F. Pan American World Airways - engineering support and modification services for launch, test, laboratory and supporting facilities.

G. Boeing Company - Saturn V first stage builder, site activation, luanch support.

H. Chrysler Corporation - Manufacturers of Saturn 1B first stage launch support.

I. McDonnell Douglas Corporation - fabricates the Saturn 1B second stage, the Saturn V third stage and the Delta launch vehicle.

J. North American Rockwell - builds Saturn V second stage and Apollo spacecraft.

K. International Business Machines Corporation - provides the Saturn 1B and Saturn V instrument units.

L. Grumman Aircraft Engineering Company, Inc. - contractor for the Apollo lunar module.
M. General Dynamics/Convair - contractor for the Atlas-Centaur vehicle.
N. New World Services - library.
O. Pan American World Airways - medical services.
P. Technicolor Corporation provides photographic services.

XIX. The nature of the activities conducted at the nation's only spaceport commands the existance of an extremely thorough Public Affairs Office.

A. Pre-launch press briefings are held at Kennedy Space Center.
   1. Keep Community leaders appraised of launch progress.
   2. Local leaders include Brevard County's bank presidents, Chamber of Commerce presidents, school superintendent, etc.
   3. Still photographs are produced and made available to public.
B. Permanent admittance badges issued to newsmen.
   1. Newsmen come and go at will with exceptions.
   2. Monday through Friday visits.
   3. Normal working hours only for visits.
C. Major news media networks established permanent buildings or trailers at Kennedy Space Center to cover launches.
   1. Admittance badges are issued to a large number of foreign newsmen for each launch.
   2. Russia has never sent a newsman to cover a launch through Apollo 17.

XX. Early in the development of the John F. Kennedy Space Center, NASA entered into an agreement with the Department of Interior's Bureau of Sport Fisheries and Wildlife to establish a wildlife refuge within the confines of the Center. (See figure 16.)

A. Paragraph 10 of the agreement states:

   > "The Bureau shall use said property as a National Wildlife Refuge to promote the conservation of wildlife, fish and game, for recreational and educational purposes, and for other purposes embodying the principles and objectives of planned multiple land use"

B. The refuge boundaries are superimposed on those of the Spaceport except for the areas required to support Apollo and programs such as Skylab in 1973 and the Space Shuttle in the future.

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C. Wildlife thrives on the Refuge. There are raccoons, armadillos, bobcats, feral hogs, deer, alligators, many varieties of snakes, and a large number and variety of birds. The complete Refuge list of bird varieties contains more than 250 species. (See figure 17.)

SPACE AWARENESS VOCABULARY

Mobile Concept	Crawlerway
Planetary	VAB
Interplanetary	Launch Control Center
Missile	Mobile Launcher
Tracking Station	Transporter
Mobile Service Structure	

SUGGESTIONS FOR THE TEACHER

Refer to the overall suggestions at the beginning of this guide.

This unit will help to emphasize the idea that the activities of the National Aeronautics and Space Administration are conducted nationwide.

It would be well to introduce the unit with a forceful illustration of progress in the space program. Any of the following techniques could be effective.

1. A field trip to a NASA installation. Since this guide is used primarily in the state of Florida, a trip to the John F. Kennedy Space Center should be considered. For other areas, there are other NASA facilities available. A brief history of the facility should stress its beginning, its growth, and its present status. For Floridians, a book entitled Kennedy Space Center Story, which is updated periodically, is a must for this activity.
2. A film, Spaceport U.S.A. (color) 22 minutes. Very good for the adult who is unfamiliar with the space program in general and KSC in particular. Interesting; good photography and valuable general information for the layman. For a film of more general interest, consider Within This Decade (color, with some black and white segments) 28:30 minutes. This film is a compilation of segments of other films showing achievements and future plans for the space program.
3. Presentation of publication, This is NASA, EP-22, (for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 - Price 45 cents). Pages 18 and 20 of the publication lists all principal NASA facilities and their responsibilities.

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These two pages could be xeroxed as handouts if quantities of this publication are not available.

Following the unit introduction, you should refer to the overall suggestions to the teacher as you progress through the unit.

In addition to the resources suggested here, refer to the entire list for this unit. All contain information appropriate for discussion of Unit VI.

ILLUSTRATIVE RESOURCES

Fact Sheet 03, Launch Complex 39 Facilities
EP-22, This is NASA
0-6, John F. Kennedy Space Center
Harris, Gordon L., Kennedy Space Center Story, 1971
Student Lecture Tour Program Bulletin, Kennedy Space Center, Florida
NASA Tour Bulletin, Kennedy Space Center, Florida
NASA Technology Utilization Program, U.S. Government Printing Office, Washington, D.C. 1971, 0444 926
Earth Orbital Science, U.S. Government Printing Office, Washington D.C. 1971, 0422 166
Medical Benefits from Space Research, Office of Technology Utilization, NASA Washington, D.C. 1970
Exploring Earth Resources from Space, U.S. Government Printing Office, Washington, D.C. 1971, 3300 0385
The Family of Man - Prospects for Progress, Urban and Public Affairs, General Electric Co., Valley Forge Space Technology Center 19101
This is NASA, U.S. Government Printing Office, Washington, D.C.
For the Benefit of All Mankind, General Electric
Weather in Motion, U.S. Government Printing Office

Textbooks:

Wolfe, Battan, Fleming, Hawkins, and Skornik, Earth and Space Science, D.D. Heath and Company, Boston

MacCracken, Decker, Read and Yarian, Scientists Solve Problems, L. W. Singer Company, Second Edition

Brandwein, Beck, Strahler, Hollingworth and Brennan, The World of Matter - Energy, Harcourt, Brace and World, Inc.

Films:

Spacequest '68 (color) 28 minutes
Apollo/Saturn V (color) 14 minutes
Spaceport U.S.A. (color) 22 minutes
Within this Decade (color, some black and white parts) 28.30 minutes

Spacequest '67 (color) 28 minutes
The First Short Step (color) 7 minutes
Minus Three Miles (color) 6:50 minutes
Testing Apollo (color) 5 minutes
The Command Module (color) 6 minutes

POST-ASSESSMENT

I. In the following list, circle the letter of each of the seven major components of Complex 39, the nation's first operational spaceport.

A. Vehicle Assembly Building
B. The Visitors Information Center
C. The Crawler Way
D. Technology Utilization Program
E. The Launch Site
F. The Mobile Launcher
G. The National Advisory Committee for Aeronautics
H. The Transporter
I. Manned Spacecraft Operations Building
J. The Launch Control Center
K. The Eastern Test Range
L. The Mobile Service Structure

II. In the space before each NASA facility in Column A, print the letter from Column B which correctly identifies the location.

____ 1. NASA Headquarters
____ 2. Ames Research Center
____ 3. Flight Research Center
____ 4. Goddard Space Flight Center
____ 5. Jet Propulsion Laboratory
____ 6. Langley Research Center
____ 7. Lewis Research Center
____ 8. Manned Spacecraft Center
____ 9. George C. Marshall Space Flight Center
____10. Nuclear Rocket Development Station
____11. Wallops Station
____12. John F. Kennedy Space Center

A. Greenbelt, Maryland
B. Marshall Space Flight Center, Alabama
C. Edwards, California
D. Sandusky, Ohio
E. Moffett Field, California
F. Cocoa, Florida
G. Jackass Flats, Nevada
H. Washington, D.C.
I. Pasadena, California
J. Wallops Island, Virginia
K. Hampton, Virginia
L. Las Vegas, Nevada
M. Cleveland, Ohio
N. Kennedy Space Center, Florida
O. Houston, Texas

III. In the space before each industrial company in Column B, print the number of the service provided at Kennedy Space Center from the list in Column A.

COLUMN A

1. Provides reproduction services
2. Provides photographic services
3. Provides the Saturn 1B and Saturn V instrument units
4. Provides launch support services for Complex 39
5. Manufacturers Saturn 1B first stage launch support
6. Contractor for the Apollo Lunar Module
7. Provides library services
8. Contractor for the Atlas-Centaur vehicle
9. Provides plant engineering, maintenance, logistics support, security and publications
10. Builds Saturn V second stage and Apollo spacecraft
11. Provides instrumentation, data acquisition and processing and communications support
12. Provides services and equipment for checkout and integration of manned spacecraft
13. Fabricates the Saturn 1B second stage, the Saturn V third stage and the Delta launch vehicle
14. Provides engineering support and modification services for launch, test, laboratory and supporting facilities
15. Provides satellite monitoring services of Earth resources

COLUMN B

___A. Boeing Aircraft Company
___B. Bendix Corporation
___C. Federal Electric Corporation
___D. McGregor and Werner, Inc.
___E. General Electric
___F. Pan American World Airways
___G. Chrysler Corporation
___H. McDonnell Douglas Corporation
___I. North American Rockwell
___J. International Business Machines Corp.
___K. Grumman Aircraft Engineering Co., Inc.
___L. General Dynamics/Convair
___M. New World Services
___N. Technicolor Corporation

PRE-ASSESSMENT ANSWER KEY

1. A. D. F. H. J. K. L.

2. 2. 4.

3. 1. 3. 4.

POST-ASSESSMENT ANSWER KEY

I. A. C. E. F. H. J. L.

II.

H 1.	I 5.	B 9.
E 2.	K 6.	G 10.
C 3.	M 7.	J 11.
A 4.	O 8.	N 12.

III.

9 A.	14 F.	6 K.
4 B.	5 G.	8 L.
11 C.	13 H.	7 M.
1 D.	10 I.	2 N.
12 E.	3 J.	

UNIT VII - BASIC SCIENTIFIC CONCEPTS RELATING TO THE SPACE PROGRAM

INTRODUCTION

Throughout the centuries man has looked upon the heavens as a source of wonderment, inspiration, and knowledge. The relationships among objects in space and man on Earth have found to affect more phenomena than was ever imagined. Inquiry into everything, from the migration of birds, the origin of the cosmos, and the sources of energy "powering" the universe to the existence of extraterrestrial life and the structure of the Earth, is dependent largely upon our ability to interpret information received from space.

In some cases man can stay on the Earth and merely "look" into space with the aid of specially designed tools. In other cases he designs special tools to go into space for the purpose of collecting information that will help him answer his questions about conditions there. At other times, man's tools are so inadequate that man himself must venture into space to seek first hand information.

With various instruments, man has been able to detect, amplify, magnify, collect, compare, classify, measure, and decipher the information he has obtained.

Telemetry permits man to know on Earth what is happening in a vehicle far in space. It involves the radio transmission of a measurement of some kind, such as acceleration, course, voltage, pressure, or temperature. To accomplish this transmission, new types of transducers, or energy transformers, have been developed so that, for example, a temperature is not measured by a thermometer which has to be looked at, but by a thermoelectric device which produces voltage changes which, in turn, are transmitted for recording or display at a remote location.

This unit concerns itself with some of the basic scientific concepts relating to the space program which can be readily enforced through the use of teacher lectures along with audio-visual aids, thus, eliminating the necessity of scientific experiments in a laboratory.

RATIONALE

History tells us that flight has always challenged man's imagination. Most of man's early attempts with flying devices ended in failure. Some men were finally successful in flying with their machines.

Rockets were born hundreds of years ago, but only recently were actually used to lift man into space after science developed better propulsion and guidance systems.

The rapid advance of the sciences, in a short span of years, has changed the course of human events for all time.

This unit of the curriculum guide is designed to give the student an awareness of some of the basic scientific concepts relating to the space program. The basic concepts will orient the student to scientifically analyze the total spectrum of space.

PRE-ASSESSMENT

Complete each of these sentences by drawing a circle around the correct word or phrase that belongs in the blank space.

1. _______________ discovered two zones of radiation in existence around the Earth.

   a. Dr. Robert H. Goddard b. Sir Isaac Newton
   c. Sir William Congreve d. Dr. James VanAllen

2. Dark spots on the Sun are known as _______________.

   a. flares b. sunspots c. magnetic fields
   d. solar wind

3. The Earth has the shape of an _______________ which means it is like a sphere, but flattened at the poles.

   a. Oblate spheroid b. oval c. apogee d. ellipse

4. The constant turning motion of the Earth is called _________.

   a. revolution b. rotation c. orbital motion
   d. gravitation

5. The Earth's moving around the sun is its _______________.

   a. revolution b. rotation c. orbital motion
   d. gravitation

6. _______________ carried frog eggs, microorganisms, plants, and insects into space in an experiment designed to study the effects on living things of such phenomena as weightlessness, weightlessness combined with radiation, and removal from the day-night cycle on Earth.

   a. Explorer I b. Biosatellite c. ATS-F
   d. Mariner IV

7. The _______________ is the most electronically complex unmanned spacecraft ever developed by the U. S.

   a. Orbiting Solar Observatory (OSO) b. ATS-G
   c. Orbiting Astronomical Observatory (OAO) d. Mariner

8. Finding and following spacecraft as they crisscross the sky overhead is called _______________.

   a. telemetry b. attitude control c. relay
   d. tracking

9. Flights of _______________ are short in terms of time and distance.

   a. sounding rockets   b. satellites   c. space probes
   d. jet aircraft

10. _______________ will broadcast educational TV programs to villages and rural areas in a joint experiment with India.

   a. Intelsat   b. ATS-F/G   c. Nimbus   d. Mariner II

11. The radio transmission of messages from artificial satellites to Earth tracking stations is called _______________.

12. The _______________, first launched in 1962, measured energetic particles emitted from the sun and provided information on sunspots.

   a. Orbiting Astronomical Observatory (OAO)   b. Nimbus 1
   c. Intelsat I   d. Orbiting Solar Observatory (OSO)

13. The goal of Mariner V was to provide scientists with information about the planet _______________.

   a. Jupiter   b. Venus   c. Saturn   d. Mars

14. Mariner IV was launched with the goal of providing scientists with information about the planet _______________.

   a. Mars   b. Venus   c. Jupiter   d. Saturn

15. _______________satellites orbit over the Equator at altitudes of about 35,900 kilometers (22,300 miles) and to the observer on the Earth below, appear to remain in the same spot in the sky.

   a. Synchronous   b Geostationary   c. Communication
   d. Meteorological

GENERAL OBJECTIVE

To help adults become familiar with basic Earth, physical, and biological science information as it relates to the space program.

SPECIFIC OBJECTIVES

1. The student is to be able to complete a 15-item multiple-choice examination on the subject matter contained in Unit VII. The lower limit of acceptable performance will be nine items answered correctly within an examination period of 45 minutes.

2. Given seven characteristics descriptive of the Orbiting Astronomical Observatory (OAO), and the Orbiting Solar Observatory (OSO), the student will classify them correctly.

3. Given a list of satellites in Column B the student will select the one correct launch objective of each from a list of objectives in Column A.

CONTENT

I. Dr. James VanAllen discovered two zones of radiation in existence around the Earth.
   A. The doughnut shaped zones are called the VanAllen radiation belts or zones.
   B. The central part of the first zone is approximately 3,200 kilometers (2,000 miles) from Earth while the central part of the second zone is 16,000 kilometers (10,000 miles).
   C. Explorer and Pioneer satellites provided scientists with information about radiation in the zones.

II. Physicists using instruments in Antarctica to learn more about Earth's magnetic field found that it is probably affected by other magnetic fields out in space.
   A. The dark spots on the Sun are known as sunspots and are considered to be the Sun's "storms".
   B. The sunspots, large enough to be seen by the eye when examined through darkened glass, originate beneath the surface and cause great columns of gas to rise to the surface. The gases expand rapidly, flow outward from the center of the spot, and cause a violent, whirling motion in the surface gases around the spot.
   C. Brilliant eruptions known as flares occur near sunspots, and strong magnetic fields develop in the area of the spots.
   D. Disturbances on the Sun are tremendous in size, dwarfing the Earth by comparison. The largest sunspots cover an area on the Sun more than 30 times the surface of the Earth.

III. The Orbiting Astronomical Observatory (OAO) was designed to collect important information about the Sun and the stars.
   A. The OAO, NASA's largest scientific satellite, is the most electronically complex unmanned spacecraft ever developed by the United States. (See figure 18.)
   B. The OAO measured the magnetic field of the Earth.

IV. The Orbiting Solar Observatory (OSO) was first launched in 1962.

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A. An important innovation on OSO-1 was the "sail" portion of the spacecraft that always pointed at the Sun.
B. Accurate instrument pointing is crucial to space astronomy. The OSO-1 was the first satellite to lock onto a star, the Sun, with instruments that saw outside the visible portion of the spectrum.
C. The OSO contributed in ever-increasing ability to find specific stars and point instruments at them, steadily, for long periods of time.
D. The OSO measured energetic particles emitted from the Sun and provided information on sunspots.

V. The Earth has the shape of an oblate spheroid, which means it is like a sphere, but flattened at the poles.
   A. The constant turning motion of the Earth is called <u>rotation</u>.
   B. Earth's moving around the Sun is its <u>revolution</u>. (NOTE: Review Kepler's law of planetary motion, Unit I.)

VI. A great deal of information about Venus and Mars has been acquired through close range observations made possible by NASA's Mariner spacecraft.
   A. Mariner II came within 34,632 kilometers (21,645 miles) of Venus and provided man with the most significant advances in knowledge about the planet Venus.
   B. Mariner V, launched to Venus on June 14, 1967, to refine results from Mariner II and acquire new information, swept within about 40,000 kilometers (2,500 miles) of the planet in October 1967.
   C. Mariner V provided data that enabled scientists to draw several conclusions.
      1. An apparent Venusian surface temperature that may be as hot as 800 degrees F was revealed.
      2. The atmosphere has critical refactivity (atmosphere is so deep and dense it could capture light and radio waves so that they circle the planet rather than go to the surface or shoot out into space).
      3. The major constituent of the Venus atmosphere appears to be carbon dioxide.
      4. Complete answers on the surface of Venus, the atmosphere, and the possibility of life, were not provided.
      5. Mariner flights carrying more elaborate instruments were required before additional conclusions could be drawn.
   D. Mariner IV swept by Mars on July 14, 1965 (Mariners I and III failed). NOTE: Review "Mariner", Unit III, No. XVIII.
      1. A Martian surface pockmarked by craters was revealed.
      2. The atmosphere of Mars was shown as only about one per cent as dense as Earth's (much less than needed for most types of Earthly life).

3. There was no detection of a Martian magnetic field, nor a radiation region such as exists around the Earth.
4. The data increased knowledge about the properties of the solar plasma, is made up of atomic particles of hydrogen, helium, and other elements.

VII. NASA's Biosatellite II (See Unit III, No. XXI-E experiment was designed to study the effects on living things of such phenomena as weightlessness, weightlessness combined with radiation, and removal from the diurnal (day-night) cycle on Earth.

A. Biosatellite I, launched December 14, 1966, could not be brought down as scheduled because of retrorocket failure. Efforts to locate the craft during its anticipated normal reentry on February 14, 1967, were unsuccessful.

B. NASA launched Biosatellite II from Cape Kennedy on September 7, 1967.
   1. Two days after launch, ground controllers ordered the satellite to fire retrorockets, slowing it so that it fell out of orbit toward Earth. As it parachuted down over the Pacific near Hawaii, the spacecraft was retrieved in the air by a United States Air Force plane.
   2. Biosatellite II carried frog eggs, microorganisms, plants, and insects.

C. Living cargo was subjected during flight to weightlessness alone and to weightlessness combined with radiation which was artificially applied from a source on the spacecraft.
   1. It appeared that Earth's gravity controlled plant growth to a greater degree than previously realized.
   2. Bacteria seemed to multiply more readily in space than on Earth (for every 10,000 that NASA sent up, a billion returned - experimenters theorized without the restraints of gravity, the bacteria found it easier to take in nutrient and give off waste, thus allowing a greater part of their metabolism to be devoted to reproduction).
   3. As on Earth, young and rapidly dividing cells in a weightless environment appeared to be more severely affected by radiation than mature slowly growing cells.
   4. Plant life reacted for more to weightlessness than animal life.
   5. Scientists cautioned that Biosatellite II experiments were with relatively simple organisms and the findings could not be transferred directly to man.
   6. Biosatellite II experiments and other experiments which followed, added new dimensions to man's knowledge about life.

VIII. Some conclusions have been reached in the arguments for or against the existence of life on other planets.

A. The MOON has great temperature fluctuation from night to day.
   1. There is no water on the surface of the Moon.
   2. Below the lunar surface the temperature may be warm enough, but there is no water in which the molecules can come together.

B. The phenomenon of parts of MARS' changing color with the seasons could be caused by vegetation or by an inorganic material.
   1. There is little water and very little atmosphere on Mars.
   2. The temperature on Mars appears to be suitable for life.

C. On Venus, evidence indicates that water vapor is not present.
   1. Because of the greenhouse effect, the temperature on Venus may be as high as 400 degrees C.
   2. The pressure may be extremely high on Venus, up to 8 Earth atmospheres.

D. Radio information indicates that electrical discharges are taking place on JUPITER.
   1. One region of Jupiter has the proper temperature for life.
   2. If life does exist on Jupiter, the organisms are probably very small, since organism size is probably universely proportional to the strength of gravity.

E. All other planets in the solar system may reasonably be eliminated on the basis of temperature alone.
   1. Our galaxy should be considered as representative of all galaxies.
   2. According to the scientific theory of the origin of life on Earth, life will occur given favorable planetary conditions and a very long period of time.
   3. The first billion years of the Earth's history were probably required for life to form.
   4. This (No. 3 above) eliminates all planets around stars larger than the Sun, since the star would not have lived long enough to produce life.
   5. Stars which are smaller than the Sun can support life on planets that are at about the same distance as the Earth.
   6. Astronomical data have indicated that many stars have planets around them.
   7. If one Sun-like star in 1 million has a planet that is at the same distance from the star as the Earth is from the Sun, then in our galaxy alone there would be 100,000 planets with conditions similar to those on Earth.

8. There are billions of galaxies.
9. The chances of life occurring elsewhere appear very great.

IX. Telemetry is the radio transmission of messages from artificial satellites to Earth tracking stations.
 A. Instruments (sensors) placed on board spacecraft to measure various quantities such as temperature inside the satellite, electrons in space, and the magnetic field in space, relay the measurements to the scientist on Earth by the process of telemetry.
 B. A telemetry system is used to transmit information from a satellite to a ground station.

X. Finding and following spacecraft as they crisscross the sky overhead is called tracking.
 A. The majority of satellites and space probes carry radio transmitters that continuously signal their locations to tracking antennas on the ground. These are called beacons.
 B. Other spacecraft, such as Gemini, included transponders in their payload.
 C. A transponder is a beacon that sends out a signal when it is triggered by a radio or radar signal from Earth.

XI. Different kinds of spacecraft require different methods of tracking.
 A. Flights of sounding rockets are short in terms of time and distance. These rockets can be easily tracked by radars and telescopes located right at the launch site.
 B. Satellite tracking is more difficult than that of soundind rockets.
  1. As rockets rise from the launch pad, gain altitude, and arch over toward the southeast out over the Atlantic (assuming a Cape Kennedy launch), they are followed by launch site radars and optical instruments.
  2. Jettisoning lower stages and ascending rapidly, the rocket is passed from tracking station to tracking station along a chain of islands and ships stretching to Ascension Island in the South Atlantic.
  3. As the spacecraft approaches Africa it should be in orbit.
  4. If African tracking stations know where to look they can pick up (acquire) the satellite, track it, and pass it on to the next station.
  5. Satellite tracking requires stations around the world, hence, a network of stations rather than a few instruments at the launch site.
 C. The tracking of lunar probes, deep space probes, and interplanetary probes are still more difficult.

1. More than a worldwide network is needed to watch them.
2. A special radio tracking scheme is needed.

D. Each type of spacecraft has its own set of requirements for tracking.
   1. Sounding rockets require launch site radars and optical tracking equipment.
   2. Required for the tracking of satellites is a worldwide network of radio, radar, and optical tracking stations.
   3. For space probes, worldwide networks of long distance radio tracking stations are required.

XII. NASA operates three global networks and sponsors the operation of a fourth to keep tabs on its many spacecraft.
   A. The Space Tracking and Data Acquisition Network (STADAN) tracks unmanned scientific and applications satellites.
   B. The Smithsonian Astrophysical Observatory Optical Network (SAO) is used for precision tracking of satellites.
   C. The Manned Space Flight Network (MSFN) tracks manned satellites and lunar spacecraft.
   D. The Deep Space Network (DSN) tracks lunar, planetary and deep space probes.

XIII. The Applications Technology Satellite (ATS) is a project of NASA's Goddard Space Flight Center.
   A. The first five spacecraft in the ATS series were launched from December 7, 1966, through August 12, 1969.
   B. The intent was to place all five in synchronous or geostationary orbits.
      1. Synchronous satellites' periods of rotation about the Earth are the same as the Earth's period of rotation about its spin axis.
      2. Geostationary satellites orbit over the Equator at altitudes of about 35,000 kilometers (22,300 miles). To the observer on the Earth below, these satellites appear to remain in the same spot in the sky.
   C. Several communication experiments and tests of cameras and other sensors were successfully concluded during the flights of the first five ATS spacecraft.
   D. ATS-6 and ATS-7 (ATS-F and G) represent a new generation of spacecraft. The basic spacecraft design, which is dominated by a 30-foot umbrella-like antenna, will be unique among the hundreds of manmade craft now in orbit around the Earth.
      1. The two spacecraft, scheduled for launch in 1973 (F) and 1975 (G) will be placed in geo-synchronous (stationary) orbit 35,900 kilometers (22,300 miles) above the equator.
      2. The ATS-F and G spacecraft will be supported by NASA's Space Tracking and Data Acquisition Network

(STADAN) and four special ATS ground stations which will take part in several of the communication experiments.

3. The first satellite (ATS-F) will first be placed in a geostationary orbit over the equator where it can see and be seen from almost one third of the Earth's area. The spacecraft can, however, be moved from one spot to another by its rocket motor as the experiments require.
4. Not all ATS experiments deal with communications. All ATS satellites carry some scientific instrumentation because no scientific satellites presently operate in geostationary orbits. The ATSs, therefore, provide a unique opportunity to position scientific sensors at specific spots over the Earth's equator at fixed altitudes.
5. Practical experiments on ATS-F/G are many and varied. Some are listed here:
   a. The Laser Experiment
      The light emitted by lasers can carry much more information than radio waves. Because the world's demand for more communication may outstrip the capacity of radio systems, NASA is laying the groundwork for laser communication links between satellites and Earth stations and from satellite to satellite.
      (Laser experiment is on the ATS-G only.)
   b. The Millimeter Wave Experiment
      In addition to exploring optical wavelengths with the laser, ATS-F/G will help expand the useful radio spectrum into the millimeter region of the spectrum (10 mm is equivalent to 30,000 MHz). The mojor objective is the precise definition of communication channels at these high frequencies.
   c. The Radio Frequency Interference Experiment
      At the frequencies used for the microwave relay of conversations and business data (6,000 MHz), there is significant interference from the radio noise created by lightning and other atmospheric phenomena. ATS-F/G will carry a special receiver to record this noise which will help in understanding and overcoming it.
   d. The Radio Dispersion Experiment
      When radio signals pass through the Earth's atmosphere and ionosphere, frequencies are changed slightly and so are the time relationships between signals. Called frequency and time dispersion, respectively, these phenomena cause trouble in the transmission of digital data - as from one computer to another. This experiment is aimed at understanding dispersion

better and finding ways to circumvent it.

e. Radio Beacon Experiment
By directing radio signals at several frequencies toward the Earth, this ATS experiment will enable scientists to measure the effects of ionized particles on propagation paths beyond the atmosphere.

f. The Very High Resolution Radiometer Experiment (VHRRE)
The VHRRE consists of a telescope with detectors sensitive to both visible and infrared radiation. Because clouds emit less infrared radiation than the ground, the infrared detector can help make pictures of them even at night. Cloud-cover pictures, taken day and night, are important for better weather forecasting.

g. The Ion Engine Experiment
Small thrusts can be generated without the expenditure of much propellant by electrically accelerating cesium ions to high velocities. If the experimental ion engine on ATS is successful, future synchronous satellites may use ion engines to help them maintain their stations over specific spots on the Equator.

h. Indian Educational Television Test
ATS-F and G will broadcast educational TV programs to villages and rural areas in a joint experiment with India.

i. Integrated Scientific Experiments
Most scientific satellites orbit well below the 35,900 kilometer (22,300 mile) geostationary orbits. Consequently, there is comparatively little data on the charged particle environment at ATS altitudes. Because communication and future meteorological satellites will operate in this region, it is imperative to understand this environment better. That is the purpose of this experiment.

XIV. Close-up pictures of Mars was the primary goal of Mariner IV.
   A. A television camera was mounted on the scanning platform.
   B. An electron beam converted each picture on the vidicon tube into a TV-type signal which could be immediately transmitted to a ground station or stored on magnetic video tape.
   C. The ground station was equipped to reconstruct the picture from the TV signals.
   D. Once transmission was made, the video tape was erased and used again.

SPACE AWARENESS VOCABULARY

Phenomenon	Galaxy	Retrorocket
Magnetic field	Earth rotation	Environment
Sun spot	Earth revolution	Molecule
Solar flare	Atmosphere	Telemetry
Solar wind		

SUGGESTIONS FOR THE TEACHER

It would be well to introduce this unit with a film. One for consideration is the NASA film, Orbiting Solar Observatory, a 26-minute color film. It discusses and explains how the Sun works and the effects it has on the Earth and space travel. This film is rated excellent for adult education.

Try to obtain quantities of NASA publications Earth Orbital Science, and Satellites at Work for handouts to your class. These are colorful, interesting reference materials with many illustrations and the 28 pages in each are very easily read.

Considering the nature and make-up of your class, you might like to have the students learn the names and order of planets by using a nonsense quotation to help: "Many Vicious Elephant Move Jungles Searching Unfriendly Native Parties." It goes without saying that this activity could only be used with a special type group.

Have the students begin keeping a Moon chart showing the changes of the Moon.

Discuss on a simple level, the work of Aristotle---how people accepted and believed his ideas regarding an Earth-centered Universe.

Refer to the overall suggestions for the teacher at the beginning of the guide and select additional activities from the appendix if you deem them appropriate for your class.

ILLUSTRATIVE RESOURCES

NASA Publications:
EP-83 Earth Orbital Science - Space in the Seventies
EP-84 Satellites at Work - Space in the Seventies
EP-39 Report from Mars - Mariner IV
Live Science in a Space Age Setting, a report submitted to NASA on materials developed at Wayne State University
Aerospace Curriculum Resource Guide, Massachusetts Department of Education in Cooperation with NASA
Space Resources for Teachers - Biology, A curriculum Project prepared by the University of California

Space Resources for Teachers - Space Science, Developed at Columbia University in cooperation with the Goddard Institute for Space Studies

Textbooks:

Wolfe, Battan, Fleming, Hawkins, and Skornik, Earth and Space Science, D. C. Heath and Company, Boston

MacCracken, Decker, Read and Yarian, Scientists Solve Problems, L. W. Singer Company, Second Edition

Brandwein, Beck, Strahler, Hollingworth and Brennan, The World of Matter-Energy, Harcourt, Brace and World, Inc.

Films:

Project Echo (color) 27 minutes
Orbiting Solar Observatory (color) 26 minutes
Communications (color) 8:30 minutes
Guidance and Navigation (color) 6:30 minutes
Examining the Moon (color) 7 minutes
Celestial Mechanics and the Lunar Probe (color) 10 minutes

POST-ASSESSMENT

I. In the space before the name of each satellite in Column B, print the number of the one launch objective associated with the satellite from Column A.

1. To conduct experiments on laser communication links between satellites and Earth stations and from satellite to satellite.

2. To provide for the global collection and distribution of meteorological data from all sources.

3. To broadcast educational TV programs to villages and rural areas in a joint experiment with India.

4. To acquire information about the planet Mars.

5. To develop and flight test advanced sensors and technology basic to meteorological research,

____A. Mariner IV
____B. Mariner V
____C. Biosatellite II
____D. ATS-F/G
____E. ATS-G

the atmospheric sciences, and the orbital survey of Earth resources.

6. To conduct experiments designed to study the effects on living things of such phenomena as weightlessness, weightlessness combined with radiation, and removal from the diurnal (day-night) cycle on Earth.

7. To acquire information about the planet Venus.

8. To improve the positional accuracy of geodetic control stations and spacecraft tracking stations.

II. To the right of each of the statements below, check whether it is a characteristic of the Orbiting Astronomical Observatory (OAO) or the Orbiting Solar Observatory (OSO).

	OAO	OSO
1. This is the largest of NASA's scientific satellites.	___	___
2. An important innovation on this satellite was the "sail" portion of the spacecraft that always pointed at the Sun.	___	___
3. Accurate instrument pointing has been crucial to space astronomy, and this satellite was the first to lock onto a star--the Sun--with instruments that saw outside the visible portion of the spectrum.	___	___
4. This is the most electronically complex unmanned spacecraft ever developed by the United States.	___	___
5. This satellite measured the magnetic field of the Earth.		
6. This satellite contributed to the ever-increasing ability of scientists to find specific stars and point instruments at them--steadily, for long periods of time.	___	___
7. This spacecraft measured energetic particles emitted from the Sun and provided information on sunspots.	___	___

III. It is recommended that the pre-assessment activity be administered again.

PRE-ASSESSMENT ANSWER KEY

1. Dr. James Van Allen
2. sunspots
3. oblate spheroid
4. rotation
5. revolution
6. Biosatellite II
7. OAO
8. tracking
9. sounding rockets
10. ATS-F/G
11. telemetry
12. OSO
13. Venus
14. Mars
15. Geostationary

POST-ASSESSMENT ANSWER KEY

I. 4 A.
7 B.
6 C.
3 D.
1 E.

II. 1. OAO
2. OSO
3. OSO
4. OAO
5. OAO
6. OSO
7. OSO

III. See Pre-Assessment Answer Key

UNIT VIII - SPACE PROGRAMS

INTRODUCTION

Manned space flight programs have been primarily concerned until now with learning how to operate effectively and safely in space environment while accomplishing missions of increasing complexity and value. The astronauts have been test pilots undertaking experimental flights. Overall, our objective has been to build a manned space flight capability. Now, an increasingly complex set of missions using increasingly complex spacecraft has been completed successfully in the Mercury, Gemini and Apollo Programs. Their success attests to the maturing of that capability. With this capability in hand, we can pay considerably more attention to the scientific objectives that can be achieved by employing men at the scene of the activity. We have established follow-on programs to the lunar landing in which scientifically trained astronauts will employ Apollo space vehicles in programs oriented toward scientific experimentation. (See figure 19.)

Such a program is the Skylab Program. Three astronauts occupy this Earth orbiting laboratory for continuous periods as long as two months. They use the equipment installed to conduct scientific experiments, make solar observations and to determine the effects of long space missions on the health of the crewmen.

Another program, the Space Shuttle, has as its goals, to bring into operation a fully reusable vehicle capable of

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carrying up to 29,500 kilograms (65,000 pounds) of payload (passengers, cargo or a combination of the two) on both legs of the round trip between Earth and Earth orbit. This low cost transportation system can be developed without increasing NASA funding over the current 1972-73 budget.

Other future space programs are outlined in Unit VIII.

RATIONALE

What are the different space programs presently incorporated within the NASA perspective at the present time? Awareness of the orientation developed and how it is affecting man will assuredly stimulate the mind. The cooperative agreement between the U. S. and Russia in space exploration and the ecological research developed are only two of the many interesting projects challenging NASA today. An investigation into the future characterizes the creativity necessary for the continuation of these unique programs.

CONTENT

I. Project Apollo's lunar missions ended when Apollo 17, with astronauts Eugene A. Cernan, Harrison H. Schmitt and Ronald E. Evans aboard the spacecraft America, splashed down in the South Pacific at 2:24 p.m., Tuesday, December 19, 1972.

II. Skylab is America's first experimental space station, the next advance in manned space flight following Project Apollo's lunar missions. (See figure 20.)
   A. Three-man crews conduct over 50 experiments during space missions as long as 59 days in the Skylab workshop, America's first manned space station.
   B. Skylab evaluates systems and techniques designed to gather information on Earth's resources and environmental problems such as pollution of air and water, flooding, erosion, weather, crop deterioration, and mineral deposits.

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1. Solar telescopes are substantially increasing man's knowledge of the Sun and the multitude of solar influences on Earth's environment.
2. Medical experiments on Skylab are planned to increase knowledge of man himself and his relationship to his Earthly environment and adaptability to space flight.
3. Skylab also experiments with industrial processes which may be enhanced by the unique weightless and vacuum environment of orbital space flight.

III. The Skylab mission began when at 1:30 p.m. EST on May 14, 1973, a two-stage Saturn V vehicle lifted off from Pad A of Launch Complex 39, at the Kennedy Space Center in Florida. Atop the giant rocket rode an unmanned Orbital Workshop the size of a three bedroom house.
   A. The Skylab payload consisted of the Workshop, Apollo Telescope Mount, Airlock Module, and Multiple Docking Adapter. (See figure 21.)
   B. About one minute after lift off aerodynamic forces ripped off the combination sun-screen and micrometeroid shield.
      1. Instrumentation reported that the cabin was beginning to overheat badly. Temperatures reached 125 degrees Fahrenheit or higher.
      2. The Sun's rays were beating down directly on the unprotected craft.
      3. The same accident had torn off one of two solar power wings (intended to transform the Sun's rays into electrical energy) and the other stuck before it could deploy.
      4. Skylab suffered a serious loss of electrical power and an overheated condition due to the loss of the shielding's thermal protection. Ground controllers jockeyed the orbiting space station from one attitude to another to control temperatures and still obtain enough sunlight for power generation.

IV. Skylab 2 (SL-2), the Apollo Command-Service Module that was to take Astronauts Charles Conrad, Jr., Joesph P. Kerwin, and Paul J. Weitz into orbit to rendezvous with the unmanned Workshop, had been scheduled for launch on May 15, 1973, one day after SL-1.
   A. The launch had to be postponed.
   B. Efforts began to devise a sunshield that the astronauts could deploy in space. Several different approaches were worked out, and the astronauts practiced for many hours on the maneuvers they would have to perform to hook up the shield outside the space station once they had completed rendezvous.
   C. The skillful changing of the spacecraft's attitude by

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ground controllers began to pay off. Temperatures dropped gradually from the extreme 125 degrees Fahrenheit and higher that instruments had been registering.

D. While it seemed that certain foods, medicines, and other perishables aboard the spacecraft may have been ruined by the excessive heat, the astronauts would have enough extra cargo space to carry needed replacement supplies into orbit with them.

V. With the cheerful motto, "We fix anything," Conrad, Kerwin and Weitz were launched on May 25, 1973, by a Saturn 1B vehicle to rendezvous with the Orbiting Workshop, 10 days behind schedule.

A. The crew ran into trouble when they caught up with the Workshop and started to dock but, after considerable difficulty, docking was completed.

B. After docking and entering the Skylab, the crew extended a folded canopy through the scientific airlock on the Sun side of the Workshop. Once outside the spacecraft, the nylon and aluminized mylar material was deployed mechanically, like a parasol, to form a 22 by 24 foot rectangular thermal shield over the Workshop's exposed area. This approach, one of three concepts the astronauts had trained with at the Johnson Space Center and in the zero-gravity simulator at the Marshall Space Flight Center, offered the least difficult means of quickly bringing the heating problem under control.

VI. On June 7, Conrad and Kerwin performed an Extravehicular Activity (EVA) and followed procedures radioed up by a group of specialists to remove a strap that held the solar wing undeployed.

A. Kerwin and Conrad cut the strap, broke a restraining bolt, and erected the solar wing.

B. Within hours the solar wing was supplying electricity and Skylab was in full working order to carry out its planned 270 scientific and technical investigations.

VII. The second EVA was performed on June 19 when Pete Conrad and Paul Weitz recovered exposed film from the solar telescope and reloaded it with fresh film for the SL-3 mission. On the film they recovered was recorded a scientific "first"---magnificent pictures of the first solar flare ever photographed by human beings from outside the Earth's atmosphere.

A. In the end, nearly all of SL-2's scientific and medical objective's were achieved, and the still orbiting Workshop was considered in good shape for occupation by future crews.

B. The SL-2 crew shut down operations on the Workshop, transferred to their CSM, and started on the return trip to Earth.

VIII. On June 22, after 28 days in space, the astronauts returned to Earth in the Command Service Module (CSM), splashing down in the Pacific south west of San Diego.
   A. The spacecraft was recovered by helicopter and brought aboard the carrier intact to ensure the quick and safe recovery of experimental data and materials.
   B. It had been proven that men could live and work in space for almost a month and still come back with no lasting ill effects.

IX. SL-3 was launched on July 28, 1973, at 7:08 a.m. EDT after the launch schedule was moved up from August 8, 1973.
   A. The new launch date scheduled the mission at a time when the relationship of the Sun to the orbital plane was most favorable, and therefore provided the most power for conducting experiments.
   B. The crew---Commander Alan L. Bean, Science Pilot Owen K. Garriott, and Pilot Jack R. Lousma---was boosted into orbit in a CSM atop a Saturn 1B launch vehicle.
   C. After docking, the SL-3 crew entered Skylab, reactivated its systems, and proceeded to inhabit and operate the orbital assembly.
   D. After a successful 59 days in space, the crew returned to Earth, splashing down on September 25, 1973.

X. At this writing, SL-4 is scheduled for launch in November, 1973.

XI. The goal of the Skylab Program is the accomplishment of four basic objectives.
   A. The first of these objectives is to conduct scientific investigations in Earth orbit.
      1. The investigations are designed to take advantage of space operations to learn more about the universe, the space environment, and the phenomena that exist in the solar system.
      2. Investigations will be made of the manner in which the phenomena that exist in the solar system influence the Earth environment.
   B. Another objective is that of applications in Earth orbit.
      1. These experiments include development and evaluation of efficient techniques using man for sensor operation, discrimination, data selection and evaluation, control, maintenance and repair, assembly and setup, and mobility.
      2. Other experiments include studies in meteorology, Earth resources, and communications. The proper relationship between manned and unmanned applications operations will also be examined.

C. Long-duration space flights of men and systems is another objective of the Skylab Program.
   1. The unique capabilities of man as a participant in space flight activities will be exploited in the Skylab Program.
   2. Measurements will be made of life-support systems and sub-systems of space vehicles.
   3. Man's psychological responses and aptitudes in space will be evaluated and postmission readaptation to the terrestrial environment will be analyzed as a function of progressively longer mission.
   4. Included in the medical areas to be studied are nutritional and musculoskeletal functions, cardiovascular function, hematology and immunology, neurophysiology, pulmonary function, and metabolism.

D. The last of the four basic objectives is that of the effective and economical development of future space programs.
   1. Skylab missions will give man the capability to operate in space for increasingly longer periods of time.
   2. The technology developed in the Skylab Program will provide the basis for the design and development of future long-duration space stations. (See figure 22.)

XII. Space exploration, by its very nature, demands international cooperation.

A. International cooperation will become more prevalent in the future.

B. Space exploration holds great promise of bringing nations of this Earth closer together in the peaceful conquest of space.

C. Cooperation between the United States and Russia on specific space programs has covered such things as mutual exchange of lunar surface samples.
   1. They have established procedures for expansion of combined future space research.
   2. An exchange of data on weather monitoring information has been effected.
   3. They have defined technical requirements for joint design of compatible docking and rendezvous systems for spacecraft. (See figure 23.)

XIII. A Joint US/USSR Working Group concerned with guidance and control systems met in Moscow, May 11-17, 1972, to continue discussion of lights, docking targets, communications systems and other requirements of the manned spacecraft control systems.

XIV. The United States and the Soviet Union signed an agreement

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on May 24, 1972, during a visit to the Soviet Union by President Richard M. Nixon, committing them to a rendezvous and docking in space in 1975 and another agreement providing for an expanded exchange of scientists and technical information.

A. Officials at the Manned Spacecraft Center in Houston set a tentative date for the launch of the astronauts from Cape Kennedy on June 14, 1975.
B. Training exercises are planned in the United States for cosmonauts and in the Soviet Union for the astronauts.
C. The agreement authorizing the joint space flight outlined certain specifics.
    1. To cooperate in the fields of space meteorology
    2. To study the natural environment
    3. To explore near Earth space, the Moon and other planets
    4. To study areas of space biology and medicine

XV. A second Joint Working Group concerned with compatibility of docking systems and tunnels met in Houston, Texas from March 27 to April 3, 1972, and considered docking system components terminology, interface elements and assemblies and a docking system scale model.

XVI. NASA and the Academy of Sciences of the USSR approved the recommendations of the two Joint Working Groups on compatible rendezvous and docking systems for manned spacecraft discussed in XIII and XV of this unit.

A. Since these meetings there have been other meetings of these and other working groups.
B. The results of these other meetings are pending approval by NASA and the USSR Academy of Sciences.

XVII. The 1975 U. S.-Russian joint spaceflight is less sophisticated than the two countries originally planned but it still opens a new era of international cooperation in space.

XVIII. On January 5, 1972, President Richard M. Nixon stated that "The United States should proceed at once with development of an entirely new transportation system designed to help transform the space frontier of the 1970's into familiar territory, easily accessible for human endeavor in the 1980's and 1990's... The continued preeminence of America and American industry in the aerospace field will be an important part of the shuttle's payload."

XIX. The goal of the Space Shuttle is to bring into operation a fully reusable vehicle capable of carrying up to 29,500 kilograms (65,000 pounds) of payload (passengers, cargo or a combination of the two) on both legs of the round trip between Earth and Earth orbit.

A. The shuttle system consists of a manned orbiter, which will be the world's first space airplane, and booster hardware for ground launching.

B. The orbiter, a delta-winged manned vehicle roughly the size of a DC-9 airplane, will be designed to carry more than 90 percent of the nation's currently planned and future forecasted satellites into Earth orbit.

C. The cargo compartment, which can accommodate experiments and passengers, will be about 4½ meters (15 feet) in diameter and up to 18 meters (60 feet) long.

D. The shuttle will be launched vertically with a pilot and a co-pilot at the helm and two flight engineer crew members. (See figure 24.)

   1. Two solid propellant booster rockets will supply most of the take off power.
   2. Maximum G forces on launch and reentry will be no more than a mild 3 G.
   3. About 40 kilometers (25 miles) high, the boosters will separate and descend by parachute to the ocean surface. There they will be recovered and returned to the launch site for re-use.
   4. The orbiter (the main section of the shuttle) will continue flying on the power of its liquid-propellant engines, supplied by a large external tank. After these two sections reach orbit, the tank will separate and a small rocket will cause it to reenter and land itself in a remote ocean area.
   5. The orbiter will reach its mission position, 100 to 200 nautical miles above the Earth, in less than 12 minutes.
   6. Once the orbiter's missions are completed (the orbiter will be able to carry out space missions lasting at least seven days), the vehicle will be piloted into Earth's upper atmosphere, maneuvering as a spacecraft until it reaches an approximate 122,000 meter (400,000 foot) altitude. Here, its aerodynamic surfaces and controls will take over for an aircraft type landing on a conventional runway near the launch site. (See figure 25.)
   7. Special materials covering the orbiter's entire surface will protect the interior from the searing heat of re-entry.
   8. After landing the orbiter will then be serviced and readied for another flight. As ground crews gain experience in readying it for subsequent flights, the turnaround time will be reduced to two weeks. Each orbiter will be designed to fly more than 100 missions.

E. The shuttle system is designed ultimately to permit scientists, doctors, and laboratory technicians, both men and women, to work in space without need of special flight training.

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F. The initial launch and landing site for the shuttle will be at the Kennedy Space Center, Florida. This site will be used for research and development launches, expected to begin in 1978, and for all operational flights launched into east-west orbits.
G. Toward the end of the decade it is planned that a second operational site will be added at Vandenberg Air Force Base, California, for north-south orbits. The basic shuttle facilities required at Vandenberg are planned to be provided by the Department of Defense.
H. It is estimated that development of the shuttle system will cost about $5.15 billion (about one-fourth the cost of the Apollo program), and it will take six years to produce the initial test vehicle.
I. Each flight will cost about $10.5 million, far less than any other space vehicle with an equivalent payload capacity.
J. Each payload pound the shuttle carries will cost about $160.00, as compared to a current $900.00 and up per pound, with conventional launch vehicles.
K. On July 26, 1972, NASA announced the selection of the Space Division of North American Rockwell for "negotiation" of a contract to begin development of the space shuttle system. (See figure 26.)

XX. In NASA's Man on Mars Project, manned flights similar to the Apollo lunar missions may be attempted in the 1980's. (See figure 27.)
A. NASA's basic strategy is similar to that employed in lunar exploration; namely, the following sequence of ever-more-sophisticated spacecraft: fly-by, orbiter, unmanned lander, and manned lander.
1. "Fly-by" spacecraft such as NASA's Mariners pass close to Mars and scan it with instruments.
2. The "Orbiter" spacecraft surveys the planet from orbit. Nasa's Lunar Orbiters typify this class.
3. The "Unmanned Lander" spacecraft softlands on the surface and radios data back to Earth. Example: America's lunar Surveyor spacecraft. (Also unmanned missions for sample returning when atmospheric and surface samples are acquired and brought back to Earth.)
4. The "Manned Lander" is that spacecraft such as used in the Apollo flights to the Moon.
B. Viking is a follow-on to the 1964-65, 1969 and the 1971 Mariner flights to Mars.
1. The first two Mars missions, in 1965 and 1969, flybys of the planet, sent back pictures and information on the Martian atmosphere.
2. Mariner 8 fell victim to a failure of the Centaur stage of the Atlas-Centaur launch vehicle and did

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not achieve a trajectory towards Mars.

3. Mariner 9 was successfully launched on May 30, 1971, and arrived at Mars on November 13, 1971.
    a. Mariner 9 gave scientists a long look at the Martian surface and helped them select propitious targets for thc Viking landers.
    b. A mapping mission of the Martian surface was undertaken and a study was made of the features of Mars that vary with time.

C. The Viking Project was to have been launched in 1973 but was rescheduled to 1975.

D. Langley Research Center, Hampton, Virginia, is charged with overall project management for Viking and responsibility for the lander portion of the spacecraft. Jet Propulsion Laboratory, Pasadena, California, will manage the orbiter portion of the project and is responsible for tracking and data acquisition.

E. Viking will consist of two instrumented spacecraft which will be placed in orbit around Mars with each spacecraft detaching a landing capsule for descent to the surface and soft landing. Mission objectives include the detection of life on the planet if it exists.

SPACE AWARENESS VOCABULARY

Skylab	Trajectory	Unmanned Lander
Shuttle	Orbiter	Manned Lander
Fly-by	Project Viking	Space Station

SUGGESTIONS FOR THE TEACHER

Historians in the centuries ahead will record the 1970s as the critical decade that bridged the evolution between spatial exploration and the successful harnessing of space for the practical benefits of man on Earth. The principal means of transportation that will make such a monumental transition possible, in such a relatively short span of time, is the Space Shuttle which is discussed in this unit.

Considering the fact this unit does not have a pre-assessment nor post-assessment activity, you should take the opportunity to review in depth what man has accomplished in the space program to date. Use this review to stimulate the students to eagerly seek information on what is to come.

There are several possible ways of beginning the study of this unit in such a way as to arouse new interest and to suggest additional study.

Discussion of an imaginary trip to some other planet is always interesting. This might well be used to raise many questions. Which planet is always interesting. This might well be used to raise many questions. Which planet would be most interesting to visit? How far away is it? How could we go there and how could we get back? What has already been accomplished in the U. S. Space Program toward the exploration of other planets?

Lead your students in a discussion covering the transition from Apollo 17 to Skylab. What were the accomplishments of Project Apollo? How are the accomplishments of the Apollo program to be used in the Skylab Project?

Have your students suggest ways in which they personally could benefit from the Space Shuttle.

Try to acquire NASA publications NF-43, Skylab, and NF-44, Space Shuttle, in sufficient quantities to make them available to your class. These are fold outs that are very well illustrated and explains these two programs in language the layman can understand.

If you elect to introduce the unit with a film, consider, To Worlds Beyond. This is a 27 minute color film which begins with Jules Verne's predictions and shows through photography and simulation how one travels through space. This is a very informative film and it is rated excellent for adult education.

In addition to these suggestions, refer to the overall suggestions for the teacher at the beginning of the guide.

ILLUSTRATIVE RESOURCES

NASA Publications:
NF-43 Skylab
NF-44 Space Shuttle
EP-22 This is NASA
EP-57 America in Space/The First Decade - Man in Space
EP-81 Man in Space - Space in the Seventies
EP-75 Space Station - Key to the Future
American in Space/The First Decade - Exploring the Moon and Planets

Textbooks:

Wolfe, Battan, Fleming, Hawkins, and Skornik, Earth and Space Science, D. C. Heath and Company, Boston.

MacCracken, Decker, Read and Yarian, Scientists Solve Problems, L. W. Singer Company, Second Edition.

Brandwein, Beck, Strahler, Hollingworth and Brennan, The World of Matter-Energy, Harcourt, Brace and World, Inc.

Films:
Rehearsal for the Moon (color) 7:10 minutes
A Mission for Mariner (color) 12:30 minutes
To Worlds Beyond (color) 27:15 minutes
Behind the Headlines in Space (color) 29 minutes
The Guaymas Story (color) 27:15 minutes

POST-ASSESSMENT

I. To the right of each statement, check whether it is a characteristic of the Command Module, Service Module, or Lunar Module.

	Command Module	Service Module	Lunar Module
1. Contained supplies, fuel and rocket engines.	___	___	___
2. This was similar to a crew compartment of a commercial jet airliner.	___	___	___
3. This was the only section of the three-section spacecraft which returned to Earth.	___	___	___
4. This carried two of the three Apollo astronauts to the Moon's surface and landed.	___	___	___
5. This was jettisoned after the two astronauts rejoined the third one in the parent craft.	___	___	___
6. This had to be constructed to withstand tremendous deceleration forces and intense heat.	___	___	___
7. The module which contained rocket engine which enabled the astronauts to maneuver into and out of lunar orbit and alter their course and speed in space.	___	___	___

PRE-ASSESSMENT ANSWER KEY

I. A. To land astronauts on the Moon.
   C. To explore the lunar surface.
   E. To conduct scientific experiments on the Moon to furnish scientific data on Earth.
   F. To obtain lunar samples.
   G. To return astronauts safely to the Earth.

POST-ASSESSMENT ANSWER KEY

I. 1. Service Module
   2. Command Module
   3. Command Module
   4. Lunar Module
   5. Lunar Module
   6. Command Module
   7. Service Module

II. The Manned Spacecraft Center at Houston, Texas
The Marshall Space Flight Center at Huntsville, Alabama
The John F. Kennedy Space Center in Florida

APPENDIX - A

SPACE AWARENESS
GLOSSARY

A

acceleration. 1. The rate of change of velocity. 2. The act or process of accelerating, or the state of being accelerated.

acceleration of gravity (symbol g). The uniform increase in speed of a freely falling body - 32 feet per second.

action. A thrust or applied force exerted in one direction that is equal to a force (reaction) in the opposite direction.

alga (plural, algae). Any plants of a group of unicellular and multicellular primitive organisms that include the Chlorella, Scenedesmus, and other genera.

The green algae and blue-green algae, for example, provide a possible means of photosynthesis in a closed ecological system, also a source of food.

aphelion. The position of the earth or another planet when it is farthest from the sun.

apogee. That point at which a natural or man-made satellite in its orbit is farthest from the earth.

artificial. 1. That which is contrived by art rather than nature. 2. That which is produced or effected by man to imitate nature.

astronaut. 1. A person who rides in a space vehicle. 2. Specifically, one of the test pilots selected to participate in Project Mercury, Project Gemini, Project Apollo, or any other United States program for manned space flight.

astronomy. The science that treats of the location, magnitudes, motions, and constitution of celestial bodies and structures.

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

atomic particles. Tiny particles such as electrons, protons, and neutrons, making up atoms.

aurora. An effect seen in the night sky from the earth, resulting from electrified particles streaming from flares from the surface of the sun.

aurora australis. The southern lights or aurora occurring in the Southern Hemisphere.

aurora borealis. The northern lights, or the aurora in the Northern Hemisphere.

axis. A line about which a rotating body, such as the earth, turns.

B

bacterium (plural, bacteria). Any of a class of microscopic plants having round, rodlike, spiral, or filamentous single-celled or non-cellular bodies often aggregated into colonies or motile by means of flagella, living in soil, water, organic matter, or the bodies of plants and animals, and being autotrophic, saprophytic, or parasitic in nutrition and important to man because of their chemical effects and as pathogens.

biosatellite. An artificial satellite which is specifically designed to contain and support man, animals, or other living material in a reasonably normal manner for an adequate period of time and which, particularly for man and animals, possesses the proper means for safe return to the earth.

biosensor. A sensor used to provide information about a life process.

biosphere. That transition zone between earth and atmosphere within which most forms of terrestial life are commonly found; the outer portion of the geosphere and inner or lower portion of the atmosphere.

biotelemetry. The romote measuring and evaluation of life functions, as e.g., in spacecraft and artificial satellites.

bipropellant. A rocket propellant consisting of two unmixed or uncombined chemicals (fuel and oxidizer) fed to the combustion chamber separately.

bipropellant rocket. A rocket using two separate propellants which are kept separate until mixing in the combustion chamber.

blast off. A missile launch. (Slang)

blockhouse. (Also written "block house"). A reinforced concrete structure, often built underground or partly underground, and sometimes dome-shaped to provide protection against blast, heat, or explosion during rocket launchings or related activities; specifically, such a structure at a launch site that houses electronic control instruments used in launching a rocket.

booster rocket. 1. A rocket engine, either solid or liquid fuel, that assists the normal propulsive system or sustainer engine of a rocket or aeronautica vehicle in some phase of its flight. 2. A rocket used to set a launch vehicle in motion before another engine takes over.

C

capsule. 1. A box-like 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.

The term, "spacecraft," is preferred to capsule for any man-carrying vehicle.

carbon dioxide. A heavy gas in the air; does not support oxidation; an important compound necessary for the manufacture of sugars during photosynthesis.

circle. 1. A closed plane curve every point of which is equidistant from a fixed point within the curve. 2. The orbit or period of revolution of a heavenly body.

combustion. 1. An act or instance of burning. 2. A chemical process (as an oxidation) accompanied by the evolution of light and heat.

command module. 1. One of the three sections of the Apollo spacecraft. 2. The only one of the three sections of the Apollo spacecraft which returns to earth. 3. The crew compartment of the Apollo spacecraft.

communications satellite. A satellite designed to reflect or relay electromagnetic signals used for communications.

computer. An electronic machine that can analyze data and perform complex calculations with great speed; used frequently for other machines under automation.

crawlerway. A specially prepared roadway over which transporters carry space vehicles and mobile launchers to launch pads.

cryogenic materials. Those metals and alloys which are usable in structures operating at very low temperatures, and usually possess improved strength properties at these temperatures.

cryogenic propellant. A rocket fuel, oxidizer, or propulsion fluid which is liquid only at very low temperatures.

cryogenics. 1. The study of the methods of producing very low temperatures. 2. The study of the behavior of materials and processes at cryogenic temperatures.

cryogenic temperature. Temperatures within a few degrees of absolute zero.

D

data-acquisition station. A ground station at which various functions to control satellite operations and to obtain data from the satellite are performed.

data- link. Any communications channel or circuit used to transmit data from a sensor to a computer, a readout device, or a storage device.

data-processing. Application of procedures, mechanical, electrical, computational, or other, whereby data are changed from one form to another.

datum. Any numerical or geometrical quantity or set such quantities which can serve as a reference or a base for measurement of other quantitites.

For a group of statistical references, the plural form is data; as geographic data for a list of latitudes and longitudes. Where the concept is geometrical the plural form is datums; as in two geodetic datums have been used.

debrief. To interrogate (as a pilot) in order to obtain useful information.

deceleration. The act or process of moving, or causing to move, with decreasing speed.

decontamination. The act of removing chemical, biological, or radiological contamination from, or neutralizing it on, a person, item, or area.

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.

deep - space - probes. Spacecraft designed for exploring space to the vicinity of the moon and beyond. Deep space probes with specific missions may be referred to as "lunar probe," "Mars probe," "solar probe," etc.

E

earth revolution. 1. The moving of the earth around the sun. 2. The motion of the earth in its orbit; one complete cycle of the movement of the earth in its orbit.

earth rotation. The constant turning motion of the earth.

earth satellite. A body that orbits about the earth; specifically, an artificial satellite placed in orbit by man.

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

ecological system. A habitable environment, either created artificially, such as in a manned space vehicle, or occurring naturally, such as the environment on the surface of the earth, in which man, animals, or other organisms can live in mutual relationship with each other.
Ideally, the environment furnishes the sustenance for life, and the resulting waste products revert or cycle back into the environment to be used again for the continuous support of life.

electromagnet. A coil of wire, with an iron core, in which a magnetic field is produced by an electric current.

electromagnetic waves. Transverse waves that travel through space at the speed of light.

energy. The capacity for doing work.

environment. An external condition of the sum of such conditions, in which a piece of equipment or a system operates, as in "temperature environment," "vibration environment," or "space environment."
Environments are usually specified by a range of values, and may be either natural or artificial.

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 second; from Mars, 3.2 miles per second; and from the Sun, 390 miles per second.

evaporate. To change from a liquid to a gas, as from water to water vapor.

explode. 1. To burn suddenly so that there is violent expansion of hot gases with great disruptive force and a loud noise. 2. To burst violently, as a result of pressure from within.

extraterrestrial life. Life forms evolved and existing outside the terrestrial biosphere.

F

flyby. An interplanetary mission in which the vehicle passes close to the target planet but does not impact it or go into orbit around it.

force. 1. A push or a pull on an object. 2. The cause of the acceleration of material bodies measured by the rate of change of momentum produced on a free body.

frequency. The rate at which wave lengths pass a given point in a second; as the vibrations of sound or electromagnetic waves.

friction. The resisting action of two surfaces as they slide or roll over each other.

fuel. Any substance that can burn and thus release heat energy to do work.

With a liquid-propellant rocket engine, fuel is ordinarily distinguished from an oxidizer where these are separate.

fuel cell. A device which converts chemical energy directly into electrical energy but differs from a storage battery in that the reacting chemicals are supplied continuously as needed to meet output requirements.

G

g force (or G). An acceleration equal to the acceleration of gravity, approximately 32.2 feet per second at sea level;

used as a unit of stress measurement for bodies undergoing acceleration.

galaxy. A vast assemblage of stars, nebulae, etc., composing an island universe separated from other such assemblages by great distances.

The sun and its family of planets is part of a galaxy commonly called the Milky Way. The nearest galaxy to the Milky Way is the spiral galaxy Andromeda at a distance of approximately 800,00C light years.

[illegible]. A prefix meaning "earth," as in "geology," "geophysics."

Some writers use the established terms such as "ge[illegible]logy" to refer to the same concept on other bodies [illegible] the solar system, as "the geology of Mars," rather than "areology" or "marsology," "geology of the Moon," rather than "selenology."

geodetic. Pertaining to geodesy, the science which deals with the size and shape of the earth.

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.

gyroscope. A device that spins and, by its motion, keeps a vehicle from changing its course.

H

hazard. A source of danger.

humidity. 1. The amount of water vapor in the air. 2. Specifically, relative humidity.

hydrogen. The lightest of the elements.

hydrosphere. That part of the earth that consists of the oceans, seas, lakes, and rivers; a similar part of any other spatial body if such a body exists.

hyperbola. An open curve with two branches, all points of which have a constant difference in distance from two fixed points called focuses.

hypogolic propellants. Rocket propellants that ignite spontaneously when mixed with each other.

I

inertia. 1. Tendency of an object at rest or when in motion to continue in motion at the same speed in a straight line. 2. Resistance to acceleration.

infrared radiations. 1. Electromagnetic radiation lying in the wavelength interval from about 75 microns to an indefinite upper boundary sometimes arbitrarily set at 1000 microns (0.01 centimeter). Also called long-wave radiation. 2. Radiations lower in frequency than red light, but longer in wavelength.

inorganic compound. In general a substance which does not contain carbon or a compound containing carbon.

internal combustion. The burning of fuel inside a cylinder or combustion chamber to provide power for doing work.

interplanetary. Existing, carried on, or operating between planets.

International Geophysical Year (I.G.Y.). An 18-month period from July 1957 through December 1958 in which scientists from many nations cooperated in special studies on the Earth and space; extended indefinitely as the I.G.C. or the International Geophysical Cooperation.

J

jet. 1. A strong well-defined stream of fluid either issuing from an orifice or moving in contracted duct, such as the jet of combustion gases issuing from a reaction engine, or the jet in the test section of a wind tunnel. 2. A jet engine, as, an airplane with jets slung in pods.

jet engine. 1. Broadly, any engine that ejects a jet stream of gas or fluid, obtaining all or most of its thrust by reaction to the ejection. 2. Specifically, an aircraft engine that derives all or most of its thrust by reaction to its ejection of combustion products (or heated air) in a jet and that obtains oxygen from the atmosphere for the combustion of its fuel (or outside air for heating, as in the case of the nuclear jet engine), distinguished in this sense from a rocket engine. A jet engine of this kind may have a compressor, commonly turbine-driven, to take in and compress air (turbojet), or it may be compressorless, taking in and compressing air by other means (pulsejet, ramjet).

jettison. 1. To make jettison of. 2. To cast off as an encumbrance, discard. 3. To drop from an airplane in flight.

K

Kepler laws. The three empirical laws governing the motions of planets in their orbits, discovered by Johannes Kepler (1571-1630). These are: (a) the orbits of the planets are ellipses, with the Sun at a common focus; (b) as a planet moves in its orbit, the line joining the planet and Sun sweeps over equal areas in equal intervals of time (also called law of equal areas); (c) the squares of the periods of revolution of any two planets are proportional to the cubes of their mean distances from the Sun.

kilometer (abbr. km.). A unit of distance in the metric system.

1 kilometer = 3280.8 feet = 1093.6 yards = 1000 meters = 0.62137 statute miles = 0.53996 nautical miles.

L

laser. (From light amplication by stimulated emission of radiation.) A device for producing light by emission of energy stored in a molecular or atomic system when stimulated by an input signal.

launch. 1. The action taken in launching a rocket from the surface. 2. The resultant of this action, i.e., the transition from static repose to dynamic flight by the rocket. 3. The time at which this takes place. 4. The action of sending forth a rocket, probe, or other object from a moving vehicle, such as an aircraft or spacecraft.

Launch Control Center. Located at the Kennedy Space Center, Florida, and is adjacent to the VAB and connected to the high bay area by an enclosed bridge. All phases of launch operations at Complex 39 are controlled from the four-story Launch Control Center.

lift-off. The action of a rocket vehicle as it separates from its launch pad in a vertical ascent.

A lift-off action performed by a rocket; a launch is action performed upon a rocket or upon a satellite or spaceship carried by a rocket.

light-year. A unit of length equal to the distance light travels in one year.

liquid fuel. A rocket fuel which is liquid under the conditions in which it is utilized in the rocket. See liquid propellant.

liquid propellant (abbr. LP). Specifically a rocket propellant in liquid form.
Examples of liquid propellants include fuels such as alcohol, gasoline, aniline, liquid ammonia, and liquid hydrogen; oxidants such as liquid oxygen, hydrogen peroxide (also applicable as a monopropellant), and nitric acid; additives such as water; and monopropellants such as nitromethane.

liquid propellant rocket engine. A rocket engine using a propellant or propellants in liquid form. Also called liquid-propellant 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.

lunar. Of or pertaining to the Moon.

lunar crater. A depression, usually circular, on the surface of the Moon, usually with a raised rim called a ringwall.
Craters range in size up to 250 kilometers in diameters. The largest craters are sometimes called walled plains. The smaller, 15 to 30 kilometers across, are often called craterlets and the very smallest, a few hundred meters across, heads.
Craters are named after people, mainly astronomers.

lunar gravity. The force imparted by the Moon to a mass which is at rest relative to the Moon. It is approximately 1/6 of the Earth's gravity.

Lunar Module. One of the three sections of the Apollo spacecraft. Carries two men from lunar orbit to the Moon's surface for exploration and then back into lunar orbit for rendezvous with the Command and Service Modules.

lunar orbit. Orbit of a spacecraft around the Moon.

lunar probe. A probe for exploring and reporting on conditions on or about the Moon.

Lunik. Russian term for a space probe launched to the moon's vicinity or to impact on the Moon.

M

magnet. A body which produces a magnetic field around itself.

magnetic. 1. Of or pertaining to a magnet. 2. Of or pertaining to a material which is capable of being magnetized. 3. Related to or measured from magnetic north.

magnetic field. A region of space wherein any magnetic dipole would experience a magnetic force or torque; often represented as the geometric array of the imaginary magnetic lines of force that exist in relation to magnetic poles.

manned. Of a vehicle occupied by one or more persons who normally have control over the movements of the vehicle, as in a manned aircraft or spacecraft, or who perform some useful function while in the vehicle.

manned lander. As the Apollo flights to the Moon.

meteor. 1. 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. 2. A bit of matter from space that glows as it falls through the Earth's atmosphere.

meteorite. Any meteoroid which has reached the surface of the Earth without being completely vaporized.

meteoroid. A solid object moving in interplanetary space, or a size considerably smaller than an asteroid and considerably larger than an atom or molecule.

meteorological satellite. Photographs the Earth's cloud cover and measures infrared (heat) radiation. Tiros I, the first meteorological satellite, was launched on April 1, 1967, giving the weatherman his first long-term observing eye in space.

missile. Any object thrown, dropped, fired, launched, or otherwise projected with the purpose of striking a target. Short for ballistic missile, guided missile.
Missile should not be used loosely as a synonym for rocket or spacecraft.

mobile concept. Provides for assembly and checkout of Apollo/Saturn V vehicles in the controlled environment of a building and their subsequent transfer to launch pad several miles away. This permits more frequent launches.

mobile launcher. Serves as an assembly platform within the Vehicle Assembly Building (VAB, a component of Complex 39 at Kennedy Space Center) and as a launch platform and umbilical tower at the launch site. A 446-foot high structure, the mobile launcher weighs 12 million pounds.

mobile service structure. One of the major components of Complex 39 at Kennedy Space Center. Provides external access to the spacecraft at the launch site.

module. A self-contained unit of a launch vehicle or spacecraft which serves as a building block for the overall structure. The module is usually designated by its primary function as command module, lunar landing module, etc.

molecule. An aggregate of two or more atoms of a substance that exists as a unit.

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

N

NACA (abbr). National Advisory Committee for Aeronautics. The predecessor of NASA.

NASA (abbr). National Aeronautics and Space Administration. Historically, establishment of NASA, on October 1, 1958, followed the launch of Sputnik I, the first man-made Earth satellite, which a year before had sparked a world wide chain reaction of events.

Newton laws of motion. A set of three fundamental postulates forming the basis of the mechanics of rigid bodies, formulated by Newton in 1687.

The first law is concerned with the principle of inertia and states that if a body in motion is not acted upon by an external force, its momentum remains constant (law of conservation of momentum). The second law asserts that the rate of change of momentum of a body is proportional to the force acting upon the body and is in the direction of the applied force. The third law is the principle of action and reaction, stating that for every force acting upon a body there exists a corresponding force of the same magnitude exerted by the body in the opposite direction.

nitrogen. A colorless, tasteless, odorless, gaseous element that constitutes 78 percent of the atmosphere by volume and is a constituent of all living tissues.

nitroglycerine. A heavy oily explosive poisonous liquid obtained by nitrating glycerol and used chiefly in making dynamites and in medicine as a vasodilator.

O

oculometer. A scientific instrument which is an ultrasensitive scanning device that monitors minute eye movements. It was developed under contract through the NASA Electronics Research Center in Boston for the specific purpose of human factors research.

This device could be experimentally used in a learning exercise where the oculometer observes hesitation on the part of the student reading a foreign language on a movie screen.

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.

"Orbit" is commonly used to designate a closed path and "trajectory" to denote a path which is not closed. Thus, the trajectory of a sounding rocket, the orbit of a satellite.

2. To go around the Earth or other body in an orbit. as in number 1 above.

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 iis orbit, as in "its orbital velocity at the apogee is less than at the perigee."

orbiter. As a spacecraft surveys a planet from orbit. NASA's lunar orbiters typify this class.

OSO (abbr). Orbiting Solar Observatory. OSO I was launched by the United States on March 7, 1962. It is designed in particular to gather information on the emission by the sun of x and y rays, ultraviolet light, neutrons, protons, and electrons which cannot be obtained from the Earth's surface.

oxidizer. Specifically, a substance (not necessarily containing oxygen) that supports the combustion of a fuel or propellant.

oxygen. An element that is found free as a colorless, tasteless, odorless gas in the atmosphere of which it forms about 21 percent or combined in water, in most rocks and minerals, and in numerous organic compounds, that is capable of combining with all elements except the inert gases, is active in physiological processes, and is involved esp. in combustion processes.

P

parabola. An open curve all points of which are equidistant from a fixed point, called the focus, and a straight line.

The limiting case occurs when the point is on the line, in which case the parabola becomes a straight line.

parking orbit. An orbit of a spacecraft around a celestial body, used for assembly of components or to wait for conditions favorable for departure from the orbit.

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, rocket, or the like carries over and above what is necessary for the operation of the vehicle for its flight.

perigee. That orbital point nearest the Earth when the Earth is the center of attraction.

That orbital point farthest from the Earth is called "apogee." "Perigee" and "apogee" are used by some 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.

phenomenon. 1. An object or aspect known through the senses rather than by thought or intuition. 2. An object of experience in space and time as distinguished from a thing-in-itself. 3. A fact or event of scientific interest susceptible of scientific description and explanation.

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 very small. The larger planets are accompanied by satellites, such as the Moon. 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 commonly used for celestial observations are called navigational planets. The word planet is of Greek origin, meaning, literally, wanderer, applied because the planets appear to move relative to the stars.

planetary. 1. Of or relating to a planet. Wandering. 2. Having a motion like that of a planet. 3. Terrestrial, worldwide.

plasma. An electrically conductive gas comprised of neutral particles, and free electrons but which, taken as a whole, is electrically neutral.

A plasma is further characterized by relatively large intermolecular distances, large amounts of energy stored in the internal energy levels of the particles, and the presence of a plasma sheath at all boundaries of the plasma.

plasma engine. A reaction engine using magnetically accelerated plasma as propellant.

A plasma engine is a type of electrical engine.

polar orbit. The orbit of an Earth satellite that passes over or near the Earth's poles.

posture sense. A sixth sense that tells what position the parts of the body are in; weightlessness in space causes loss of this sense.

pressure. 1. The application of force to something by something else in direct contact with it. 2. The action of a force against an opposing force. 3. The force or thrust exerted over a surface divided by its area.

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.

Almost any instrumented spacecraft can be considered a probe. However, Earth satellites are not usually referred to as "probes." Also, almost any instrumented rocket can be considered a probe. In practice rockets which attain an altitude of less than one Earth radius (4,000 miles) are called "sounding rockets," those which attain an altitude of more than an Earth radius are called "probes" or "space probes." Spacecraft which enter into orbit around the Sun are called "deep-space probes." Spacecraft designed to pass near or land on another celestial body are often designated "lunar probe," "Martian probe," "Venus probe," etc.

Project Apollo. The last of the three projects directed toward achieving the national goal of the landing of American astronauts on the Moon. The largest and most complex of the manned space flight programs, Project Apollo achieved the goal of landing astronauts on the Moon and returning them safely to Earth in July, 1969, when Apollo II astronauts successfully executed history's first lunar landing.

Project Gemini. One of the three projects directed toward achieving the national goal of the landing of American astronauts on the Moon. Followed Project Mercury which was the first project. Involved two-man spacecraft, provided the first American demonstration of orbital rendezvous and docking, consisted of ten Earth-orbital missions, completed in November, 1966.

Project Mercury. One of the three projects directed toward achieving the national goal of the landing of American astronauts on the Moon. The first U.S. manned space flight program, organized October 4, 1958 and completed on May 16, 1963, consisted of six successful manned missions, involved one-man spacecraft, laid the foundation for Project Gemini.

Project Viking. Project directed toward placing landers on Mars in 1975. Designed to use data from Mariner 9 to provide information and technological experience from which the Viking 1975 Project will benefit. The success of Mariner 9 will be reflected in the Viking orbiter spacecraft. Which will transport the Viking instrumented capsules to Mars for their landing on the planet's surface in 1976.

propellant. 1. The mixture of fuel and oxidizer (and sometimes an additive) either in a liquid or solid state, which when ignited in a combustion chamber changes into gases with a large increase in pressure. The propellant provides the energy for thrust. 2. 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; specifically, a fuel, oxidant, or a combination or mixture of fuel and oxidant used in propelling a rocket.

Propellants are commonly in either liquid or solid form.

purify. 1. To clear from material defilement or imperfection. 2. To free from anything alien, extraneous, improper, corrupting, or otherwise damaging.

Q

quarantine. 1. A restraint upon the activities or communication of persons or the transport of goods designed to prevent the spread of disease or pests. 2. A place in which persons under quarantine are kept. 3. A state of enforced isolation.

R

radiation. 1. The process by which electromagnetic energy is propagated through free space by virtue of joint undulatory variations in the electric and magnetic fields in space. This concept is to be distinguished from conduction and convection.

A group of physical principles known as the radiation laws comprise, to a large extent, the current state of practical knowledge of the complex radiative processes. 2. The process by which energy is propagated through any medium by virtue of the wave motion of that medium, as in the propagation of sound waves through the atmosphere, or ocean waves along the water surface. 3. The emission and propagation of energy through space or a material medium in the form of waves. It is energy traveling as a wave motion. The term when unqualified usually refers to the electromagnetic radiation---gamma rays, x-rays, ultra-violet rays, visible light, infrared rays, and radio waves.

radius. 1. A line segment extending from the center of a circle or sphere to the curve or surface. 2. The distance from a center line or point to an axis of rotation.

ramjet engine. A type of jet engine with no mechanical compressor consisting of a specially shaped tube or duct open at both ends, the air necessary for combustion being shoved into the duct and compressed by the forward motion of the engine, where the air passes through a diffuser and is mixed with fuel and burned, the exhaust gases issuing in a jet from the rear opening. The ramjet engine cannot operate under static conditions.

reaction. 1. A force exerted in a direction opposite to that of an opposing force. 2. The process of chemical change.

reaction engine. An engine that develops thrust by its reaction to a substance ejected from it; specifically, such an engine that ejects a jet or stream of gases created by the burning of fuel within the engine. Also called reaction motor.

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.

reentry. 1. The event occurring when a spacecraft or other object comes back into the sensible atmosphere after being rocketed to higher altitudes; the action involved in this event. 2. The return of a missile or space vehicle into the Earth's atmosphere. High temperatures due to air friction at high speeds are a chief problem of reentry. Ablation materials and techniques are used to combat this problem.

rendezvous. 1. The meeting of two space vehicles at a given point and time in space, and the place at which this takes place. 2. The event of two or more objects meeting with zero relative velocity at a preconceived time and place. 3. The point in space at which such an event takes place, or is to take place.

A rendezvous would be involved for example, in servicing or resupplying a space station.

retrorocket. (From retroacting.) 1. A rocket fitted on or in a spacecraft satellite, or the like to produce thrust opposed to forward motion. 2. A rocket producing thrust in a direction opposite to that of an object's motion. In space flight, it is used to slow down the speed of the space vehicle or to separate one section from another. The retrorocket, for example, can be utilized for slowing a space vehicle on reentry or for landing on another celestial body.

rocket. 1. A device propelled by hot gases ejected rearward. It also is an engine or motor that produces forward thrust by ejecting a stream of hot gases to the rear, and which carries its own oxidizer, being independent of the atmosphere in its operation. Used in all space exploration. 2. A projectile, pyrotechnic device, or flying vehicle propelled by a rocket engine. 3. A rocket engine; any one of the combustion chambers or tubes of a multichambered rocket engine.

rocket engine. A reaction engine that contains within itself, or carries along with itself, all the substances necessary for its operation or for the consumption or combustion of its fuel, not requiring intake of any outside substance and hence capable of operation in outer space. Also called rocket motor.

Chemical rocket engines contain or carry along their own fuel and oxidizer, usually in either liquid or solid form, and range from simple motors consisting only of a combustion chamber and exhaust nozzel to engines of some complexity incorporating, in addition, fuel and oxygen lines, pumps, cooling systems, etc., and sometimes having two or more combustion chambers. Experimental rocket motors have used neutral gas, ionized gas, and plasmas as propellants.

S

satellite. 1. An attendant body that evolves about another body, the primary; especially in the solar system, a secondary body, or moon, that revolves about a planet. 2. An attendant body which revolves about another body, especially in the solar system. An artificial satellite is a manmade body placed in orbit around the Earth or any other celestial body. 3. An object not yet placed in orbit, but designed or expected to be launched into orbit. 4. A manmade object that revolves about a spatial body, such as Explorer I orbiting about the Earth.

seismometer. An instrument used by astronauts in experiments on the Moon to detect Moonquakes.

seismograph. An instrument for recording Earth tremors (earthquakes). Varieties of seismological techniques and equipment are also used in recording nuclear explosions.

Service Module. One of the three sections of the Apollo spacecraft. Contains supplies, fuel and a rocket engine so that astronauts can maneuver their craft into and out of lunar orbit and alter their course and speed in space.

shield. A body of material used to prevent or reduce the passage of particles or radiation.

A shield may be designated according to what it is intended to absorb, as a gamma-ray shield or neutron shield, or according to the kind of protection it is intended to give, as a background, biological, or thermal shield. The shield of a nuclear reactor is a body of material designed to prevent the escape of neutrons and radiation into a protected area, which frequently is the entire space external to the reactor. It may be required for the safety of personnel or to reduce radiation sufficiently to allow use of counting instruments.

shielding. The arrangement of shields used for any particular circumstances; the use of shields.

Shuttle. A future project in U.S. manned space exploration. A vehicle piloted by astronauts that can take up to 12 non-astronauts into space. Scheduled to make its maiden flight in 1977 or shortly thereafter. The shuttle lands horizontally like an airplane and can be used for numerous flights. Scientists and other specialists without astronaut training will be able to carry on research in Earth orbit from the shuttle or fly in it to orbiting space stations. Shuttle passengers can wear conventional clothes and need no special training amid the "shirtsleeve environment" of the cabin that will resemble the passenger compartment of modern airlines.

simulation. A technique of testing space systems or missiles (and human pilots) by creating in the laboratory the conditions of actual flight, or providing machines whose effect is that of a condition of flight.

simulator. A device which provides a specific condition also present in flight or space flight; a device which solves a problem or answers a question by using components which obey the same equations as the system being studied.

single-stage rocket. A rocket vehicle provided with a single rocket propulsion system.

Skylab. The first American experimental space station. Scheduled to be launched into Earth orbit in April 1973.

solar. 1. Of or pertaining to the Sun or caused by the Sun, as solar radiation solar atmospheric tide. 2. Relative to the Sun as a datum or reference, as solar time.

solar battery. An energy reservoir. When a battery is utilized as a continuous source of energy and is not rechargeable, it is called a "primary" battery. When it is used as an energy reservoir and is rechargeable, it is termed a "secondary" battery. Secondary batteries are integral parts of most solar-cell power plants because they can store up the extra power generated by the solar cells while they are in sunlight and then release it when the spacecraft swings into the Earth's shadow.

solar cell. A solar cell converts sunlight into electrical energy, which is often used to charge satellite batteries.

solar flare. A disturbance on the face of the Sun which gives to intense ultraviolet and corpuscular emission from the associated region of the Sun. It affects the structure of the ionosphere and interferes with communications. Giant solar flares are also dangerous to space travelers.

solar-system. The Sun and other celestial bodies within its gravitational influence, including planets, asteroids, satellites, comets, and meteors.

solar wind. Streams of plasma flowing approximately radially outward from the Sun.

solid fuel. A solid propellant.

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.

solid-propellant rocket engine. A rocket engine fueled with a solid propellant. Such motors consist essentially of a combustion chamber containing the propellant, a a nozzle for the exhaust jet, although they often contain other components, as grids, liners, etc.

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 celestial bodies, including the Earth, move. 3. That part of the universe between celestial bodies, possibly infinite.

spacecraft. A vehicle designed to perform certain useful functions in space. It may range in size, cost, and complexity from a simple sounding rocket checking radiation to an extremely complicated machine carrying human life.

space medicine. 1. A branch of aerospace medicine concerned specifically with the health of persons who make, or expect to make, flights into space beyond the sensible atmosphere. 2. The branch of medicine concerned with the study, prevention, cure, or alleviation of physical or mental ailments arising from conditions encountered in or brought on by space flight.

space myopia. A condition experienced by space travelers in which the eye is unable to focus on distant objects.

space station. A large orbiting satellite conceived as a habitable base in space with scientific, exploratory, or military applications. Its facilities would provide for the sustenance of man and the storage of supplies. It could be used as a platform for the launch of other space vehicles.

spectrograph. 1. An instrument used to produce a record of a spectrum. 2. A spectroscope with a photographic recording device.

spectroscope. 1. An apparatus to effect dispersion of radiation and visual display of the spectrum obtained. 2. An instrument for producing and viewing spectra. Spectroscopes are used in one instance for identifying gases in a certain atmosphere or enclosure.

spectrum. 1. In physics, any series of energies arranged according to wavelength (or frequency). 2. The series of images produced when a beam of radiant energy is subject to dispersion. 3. Short for electromagnetic spectrum or for any part of it used for a specific purpose as the radio spectrum (10 kilocycles to 300,000 megacycles.)

sphere. 1. The apparent surface of the heavens of which help forms the dome of the visible sky. 2. One of the concentric and eccentric revolving spherical transparent shells in which according to ancient astronomy, stars, Sun, planets, and Moon are set. 3. A globular body.

Sputnik. A Soviet satellite series; the first one was launched on October 4, 1957. It weighed 184.3 pounds; later vehicles weighed more than 10,000 pounds. Sputnik I was the world's first orbiting man-made satellite.

sunspot. A large "dark" spot appearing in the region of the Sun's photosphere, in the 5 to 40 degrees north and south latitude of the Sun. They vary in number, but hit peaks approximately every 11 years. It is believed that the high periods of static and radio interference is directly related to the Sun cycle. The spots themselves appear to be magnetic in character and whirl, much like Earth cyclones. There is no complete explanation for their origin.

T

technology. 1. A technical method of achieving a practical purpose. 2. The totality of the means employed to provide objects necessary for human sustenance and comfort. 3. Applied science.

telemetry. 1. The science of measuring a quantity or quantities, transmitting the results to a distant station, and there interpreting, indicating, and/or recording the quantities measured. 2. The process of transferring information from one point to another remote point by electromagnetic waves.

tracking station. A station set up to track an object moving through the atmosphere or space, usually by means of radar or radio.

trajectory. In general, the path traced by any body moving as a result of an externally applied force, considered in three dimensions.

Trajectory is sometimes used to mean flight path or orbit, but orbit usually means a closed path and trajectory, a path which is not closed.

transporter. One of the major components of Launch Complex 39 at Kennedy Space Center. The transporter transfers space vehicles and Mobile Launchers to launch pads.

U

unmanned lander. Spacecraft softlands on the surface and radios data back to Earth, e.g., America's lunar Surveyor spacecraft.

V

VAB (abbr). Vehicle Assembly Building. One of the major components of Launch Complex 39 at Kennedy Space Center. Facilities for the assembling and testing of space vehicles.

vacuum. A space devoid of matter, or a space on Earth in which the atmospheric pressure has been reduced as much as possible by pumping systems.

Van Allen Belt, Van Allen radiation belt. (For James A. Van Allen, 1915....) The Zone of high-intensity particulate radiation surrounding the Earth beginning at altitudes of approximately 1000 kilometers.

The radiation of the Van Allen belt is composed of protons and electrons temporarily trapped in the Earth's magnetic field. The intensity of radiation varies with the distance from the Earth.

velocity. The rate of motion of a body traveling in a given direction. It is a vector quantity including both magnitude (speed) and direction in relation to a given frame of reference. It is employed in its higher magnitudes as a means of overcoming the force of gravity.

VTOL (abbr). Type of aircraft having a vertical take-off and landing capability.

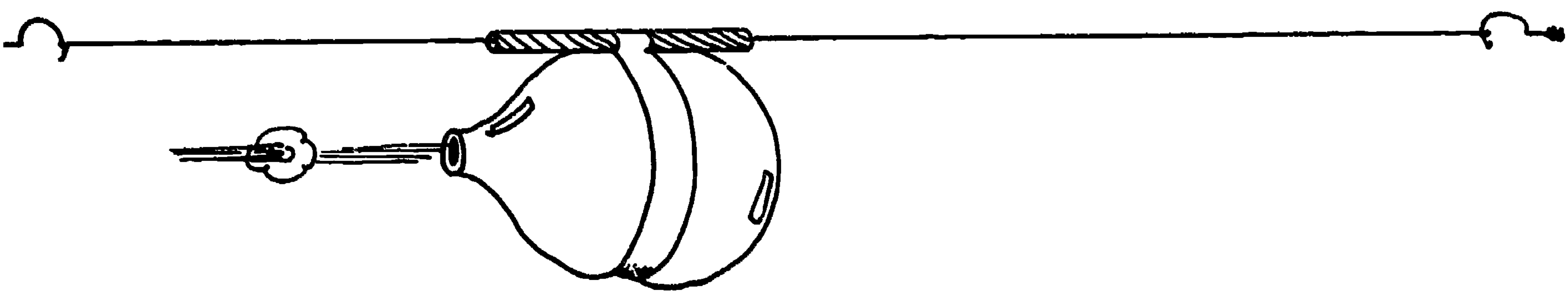
W

weightlessness. 1. 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.

2. A condition in which gravitational and other external forces acting on a body produce no stress, either internal or external, in the body. 3. The absence of gravity or the balancing of gravitational force with an equal and opposite force, such as with centrifugal force.

APPENDIX - B



SUBJECT ROCKET VEHICLE

TOPIC Construction of an Action-Reaction Engine

CONCEPT The rocket's basic operation is based on Newton's Third Law of Motion: "For every action there is an equal and opposite reaction."

MATERIALS

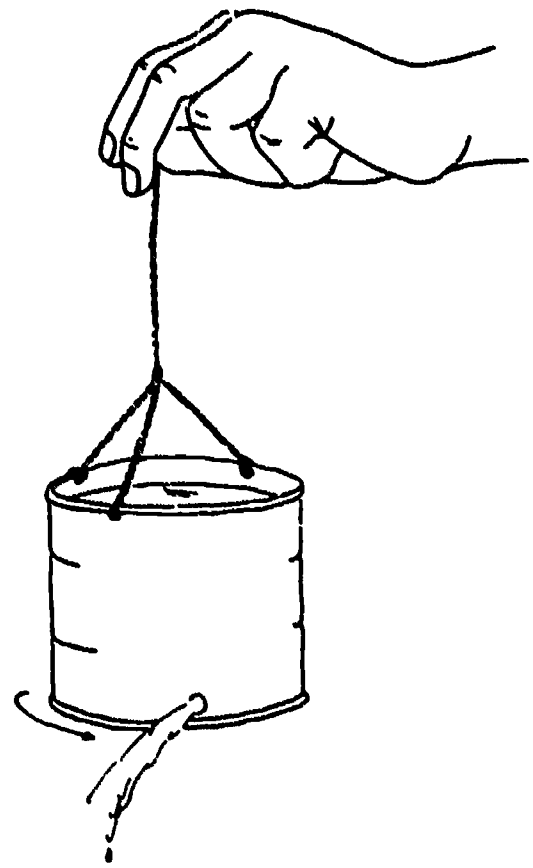
- Nylon fish line
- Plastic Straw
- Long Balloon
- Tape

PROCEDURE

1. Tie the fish line between two points in the room.
2. Holding the nozzle of the balloon so the air cannot escape, inflate the balloon and tape it to the straw.
3. String the fish line through the straw, still holding the nozzle of the balloon.
4. Now release your hold on the nozzle and note what happens.

RELATED QUESTIONS

A. What made the balloon go?
B. How do you suppose this same balloon might perform in a complete vacuum?
C. What would happen to the range of the balloon if the string had a steeper incline. Why, then, do we launch rockets vertically, and then arc them over into horizontal flight? (Consider air friction and speed.)



SUBJECT	ROCKET VEHICLES
TOPIC	Construction of an Action-Reaction Engine
CONCEPT	The rocket's basic operation is based on Newton's Third Law of Motion: "For every action there is an equal and opposite reaction."
MATERIALS	Water Cord Coffee Can Hammer & Small Nails

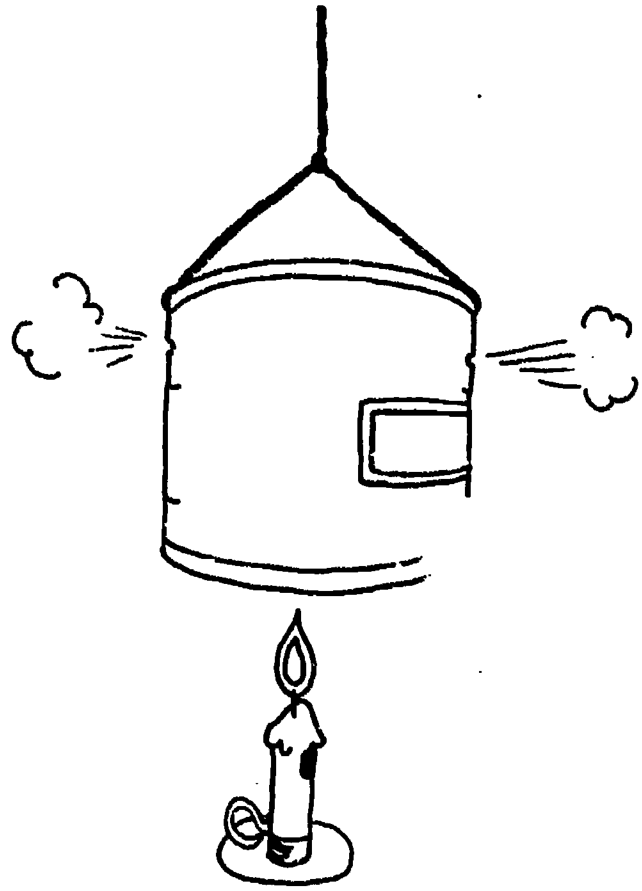
PROCEDURE

1. Punch a small hole in side of coffee can at bottom. Bend nail to side so water will pour out hole at angle. Then remove nail.

2. Fill can with water and observe can as water leaks out.

RELATED QUESTIONS

A. How does Newton's Third Law apply here?
B. From what you have seen, how can we turn a satellite with a supply of liquid or gas?
C. How can you modify this experience so that you may use steam?



ACTION AND REACTION

A. 1. Sit on a bar stool or piano stool with your feet off the floor.

2. Throw a pillow in one direction--you will rotate on the stool in the opposite direction. The heavier the object thrown, the better the backward force you will experience.

B. A simple Herds engine

1. Punch holes on opposite sides of the can near the top.

2. Add about ½ inch of water to the can and cap tightly.

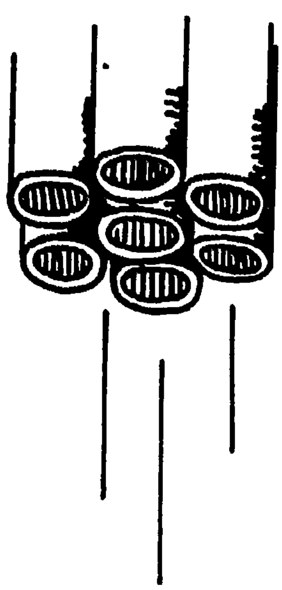
3. Suspend the can by a string. Heat the can with a burner or alcohol lamp.

CLUSTERING AND STAGING

CONCEPT: Rocket engines can be combined in clusters or groups. By doing this, greater total thrust can be achieved than by building one huge rocket engine.

TEACHER INFORMATION:

Clustering



Rockets can also be stacked (staged) on top of one another. By doing this, dead weight can be eliminated from the rocket as it ascends by releasing the stage that has burned all of its fuel, and allowing it to fall back into the atmosphere. Thus the remaining stages do not have to drag the dead weight of the burned out stage along with them. This enables the remaining stages to increase in velocity and climb in altitude.

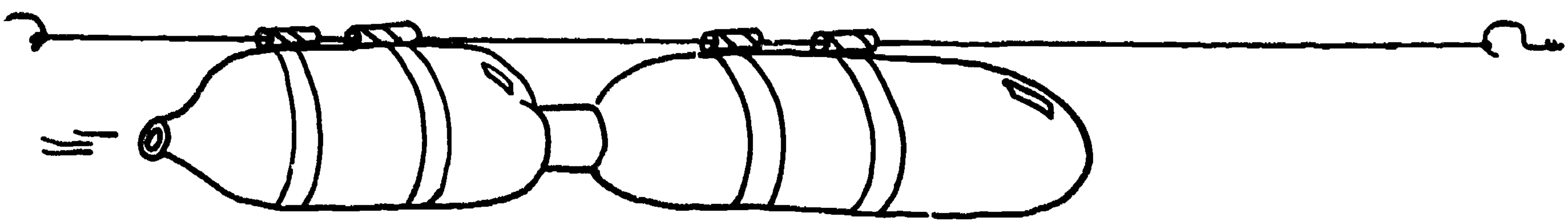
Using these advancements in our technology, man is able to send various sizes and weights out into space either to be placed in orbit around our earth or sent out into deep space.

We can expect some dramatically new forms and types of rockets in the future. New fuels such as nuclear power, ion power, and power from plasma engines are some examples.

ACTIVITY I Staging

Given: One truck, one jeep, and one motorcycle, each with a range of 200 miles. Gas tanks are full and sealed. How could you get across a desert to the nearest oasis 600 miles away?

ACTIVITY II Stack three bricks one on top of the other. Lift all three from the floor. Drop the lower one. Is as much energy required to continue lifting the remaining two bricks? Continue to raise the bricks, dropping the second brick. What is observed?



SUBJECT	ROCKET VEHICLES
TOPIC	Staging
CONCEPT	Staging vehicles enables us to increase payload capabilities.
MATERIALS	Two or three long balloons (6" or more) Hooks for attaching line Plastic straws Tape Nylon Fishing Line Estes dummy rocket engine 3 bricks

PROCEDURE

1. Attach line between two points (the longer the better.)
2. Insert dummy rocket engine into nozzle of an inflated balloon.
3. Push an uninflated balloon about an inch into the dummy rocket engine and inflate the balloon.
4. You may also include a third balloon for a third stage.
5. Attach balloons to straws (short pieces) with tape close together. Slide over line.
6. Release the first balloon which will push the others ahead of it.
7. Discuss advantages of staging with reference to gravity, atmospheric density, etc.

RELATED QUESTIONS

A. Why do the stages become successively smaller rather than the other way around?

B. What advantage is there to dropping the stages as their fuel is consumed?

ACTIVITY I-GIVEN: One truck, one jeep, and one motorcycle, each with a range of 200 miles. The gas tanks are full and sealed.

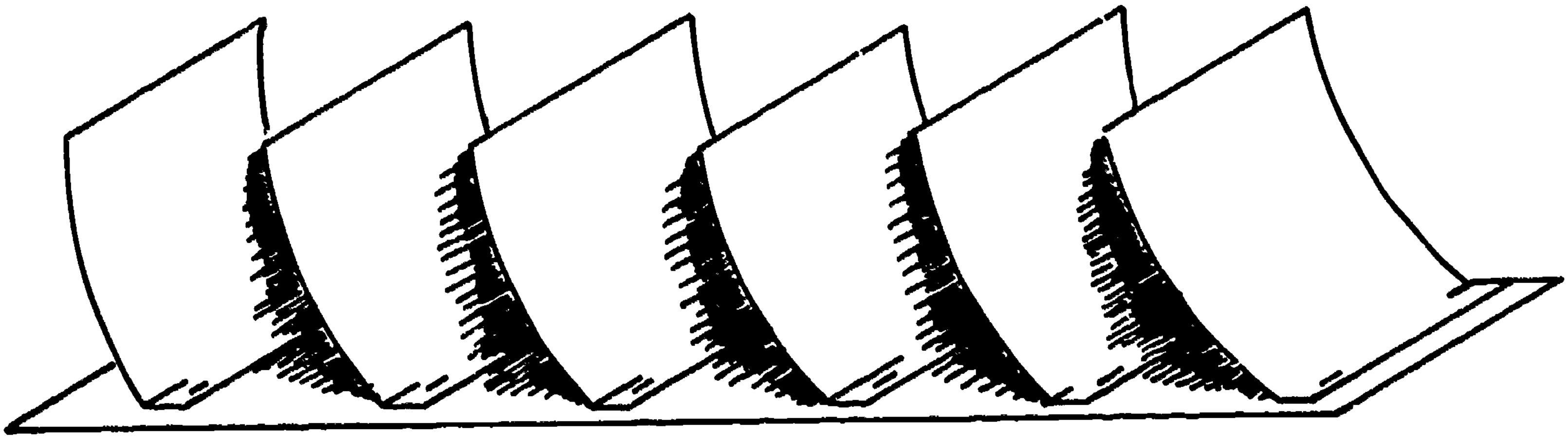
PROBLEM: How could you get across a desert to the nearest oasis 600 miles away?

AVTIVITY II

1. Stack three bricks on top of each other.
2. Lift all three from the floor.
3. Drop the lower one. Does it require as much energy to continue lifting the remaining two bricks?
4. Continue to raise the bricks dropping the second and third bricks. What do you observe?

CONCLUSIONS

Relate what you have seen to rockets and fuel tanks (full and empty).



SUBJECT LUNAR GEOLOGY

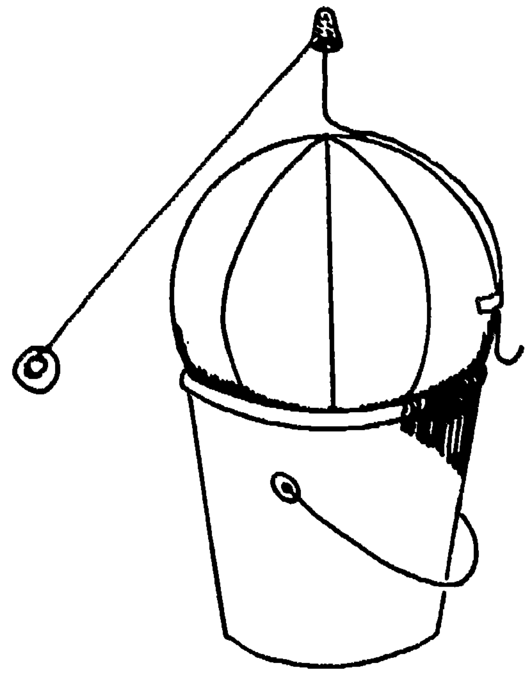
TOPIC "Moon Roving Vehicles"

CONCEPT The nature of the moon's surface requires use of novel and unique "wheels."

MATERIALS
Oak Tag or Bristol Board
Scissors
Stapler
Scotch Tape
Pencil

PROCEDURE
1. Cut 2 strips of oak tag 2" by 18".
2. Cut 6 strips of oak tag 2" by 3" from one of the 2" by 18" strips.
3. Staple 3" strips to 18" strip at 2 intervals.
4. Draw ends of long strip together to form the rim of the wheel.
5. Attach loose ends to the pencil.
6. This wheel is a model of the "metalastic" wheel concept developed by the Grumman Aircraft Corporation. This configuration is under exhaustive research at the present time.

RELATED QUESTIONS
A. By rolling the wheel over objects of different heights and shapes, determine what advantages or disadvantages it has for lunar logistics.
B. Speculate as to what other shapes could be used other than conventional wheels.
C. Make a list of characteristics necessary for any type of device which would transport astronauts on the lunar surface.
D. Can you invent a different type of moveable device to explore surface of the moon?



SUBJECT	SPACE MOTION, GUIDANCE AND DISTANCE
TOPIC	Satellite Orbits
CONCEPT	Type of orbit is determined by the angle of insertion.
MATERIALS	Basketball; Coat hanger; Tape; Two or three feet of string; Weight; Pail; Thimble

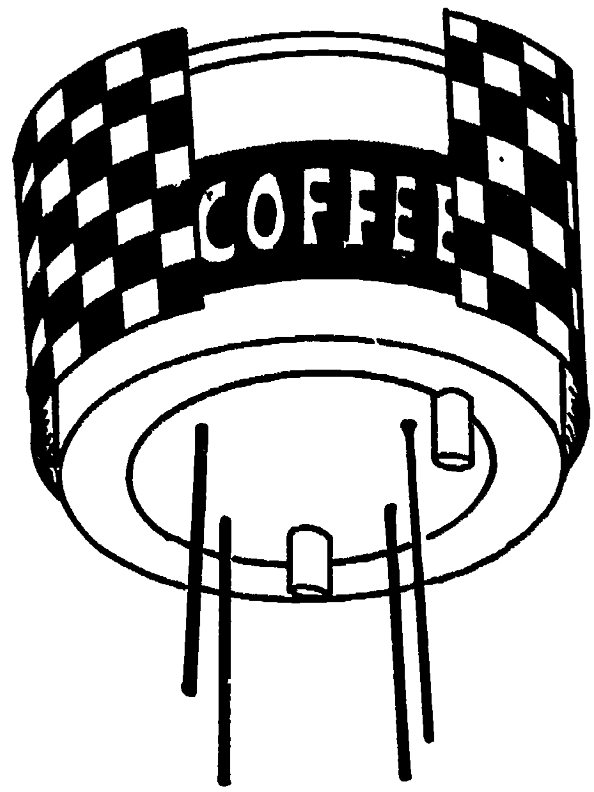
PROCEDURE

1. Place ball in pail; bend coat hanger and tape to ball; attach string to cap and place it on top; attach weight to string.
2. This device represents earth and satellite.
3. Push weight away from ball and observe how and where it turns.
4. Lightly push weight away at different angles.
5. Experiment with speed, angles, pushing it after it is in motion, etc.
6. Determine what a sub-orbit, elliptical and circular orbit are. Discuss perigee and apogee.

RELATED QUESTIONS

A. What other factors might affect an orbit, other than angle, speed, etc.

B. Can you develop ways of graphically showing how an orbit is drawn?



SUBJECT — UNMANNED SPACECRAFT

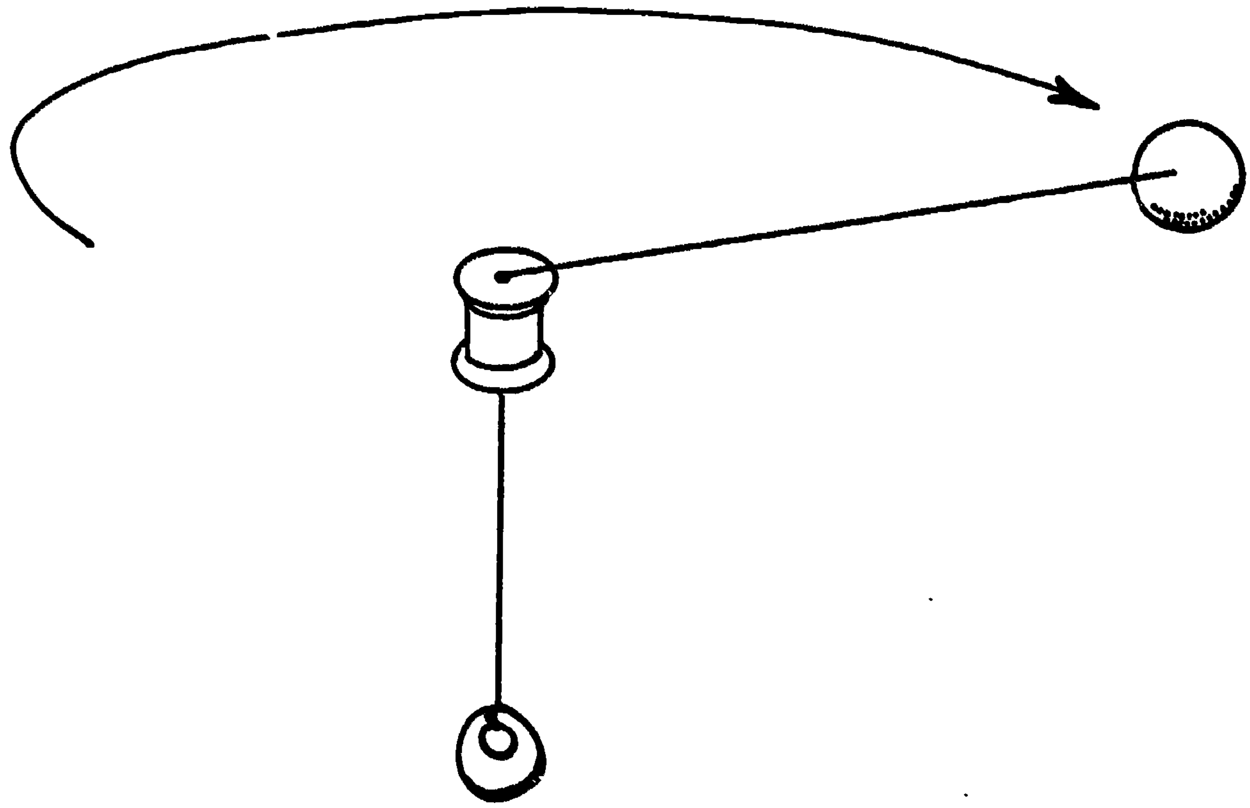
TOPIC — Weather in the Space Age

CONCEPT — Weather satellites are helping meteorologists to predict weather more accurately.

MATERIALS — Coffee can; Coat hanger; Tempera paint - blue & white; Art paper; 2 Wooden dowels - 1" diameter preferred

PROCEDURE

1. Puncture coffee can on bottom with four holes.
2. Cut coat hangers to desired length (the distance between any two holes) and bend to form a squared U.
3. Insert bent hangers through holes.
4. Cut wooden dowels and glue on the bottom of coffee can 120° apart.
5. Cut art paper to a size necessary to cover sides of can. Paint paper in blue and white checkerboard pattern to resenble solar cells.
6. Discuss Tiros' contributions and future possibilities.



SUBJECT SPACE MOTION, GUIDANCE AND DISTANCE

TOPIC Orbit Velocity

CONCEPT Many forces act upon a space craft as it is orbiting our earth.

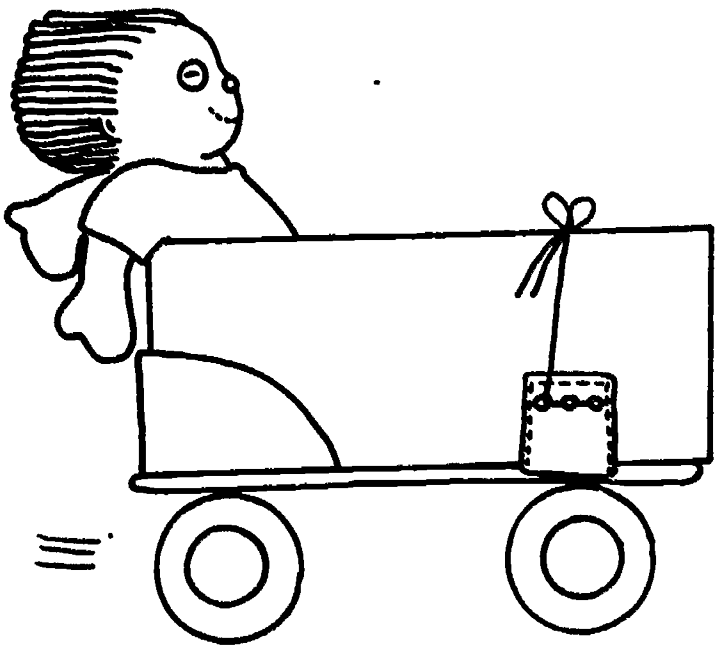
MATERIALS
One 3' piece of heavy cord
Sponge baseball
Coat Hanger
Very heavy weight (1 lb.)
Metal sleeve or wooden spool
Wire cutters

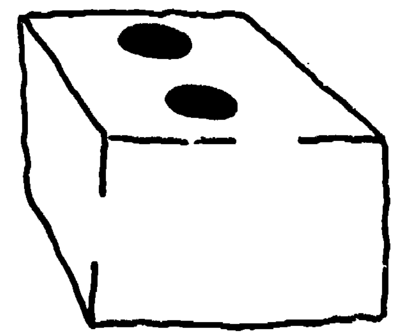
PROCEDURE

1. Attach hanger to ball. Run a weighted cord through the sleeve and attach to the eye hook.
2. Swing ball around until velocity of the ball counterbalances the weight.
3. Observe what happens at varying velocities.
4. Determine what forces work on a satellite and what keeps it in orbit.

RELATED QUESTIONS

A. If you cut the string, what would happen to the ball? What would this represent?
B. What do the varying velocities show?
C. How would you show an elliptical orbit using this device?
D. What forces are acting upon the orbiting object?





SUBJECT MAN IN SPACE

TOPIC Deceleration of Spacecraft

CONCEPT A sudden and drastic change in velocity imposes great stress (g-force) on a moving object.

MATERIALS

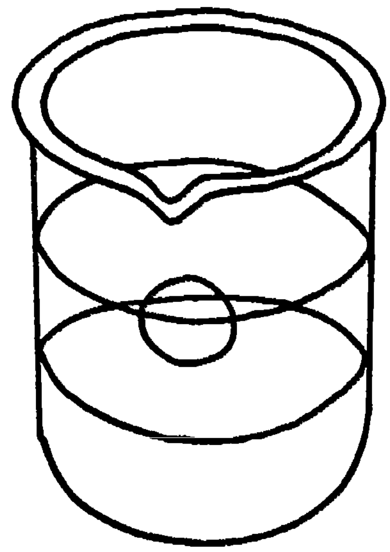
One Roller Skate	Shoe Box
Brick	Rag Doll
String	

PROCEDURE

A. Seat a doll at the back end of a shoe box which has been tied to a roller skate.
B. Give the skate a push so that it will roll across the table and hit a brick.
C. Repeat the experiment with the doll sitting with its back against the front end of the box.
D. Note the difference in what happens to the doll in the second collision compared with the first.

RELATED QUESTIONS

1. What is the term we use to describe the increased weight acting upon the doll in both instances?
2. Using the observed results, organize a general statement as to the proper body position for a person undergoing rapid acceleration or deceleration.
3. Relate your findings to manned spacecraft and the position of the astronaut's body in relation to forces acting upon it during lift-off and re-entry.
4. Make a chart of other reasons why these positions are best.



SUBJECT MAN IN SPACE

TOPIC "Weightlessness - Handling of Liquids"

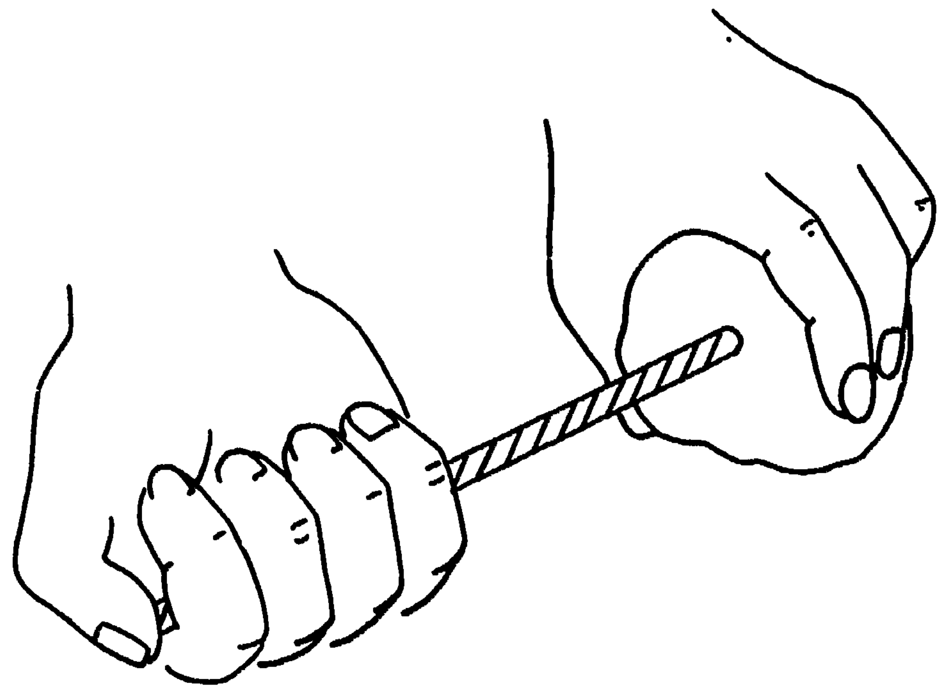
CONCEPT Liquids behave differently in a weightless condition.

MATERIALS
- Olive Oil
- Rubbing Alcohol
- Pencil
- Beaker (250 cc)
- Water

PROCEDURE
A. Fill the beaker about ¼ full of water.
B. Add a few drops of olive oil (making sure that the oil is together and not scattered).
C. Add alcohol very slowly to be suspended in the water and alcohol solution.
D. Take a pencil and break up the oil globule into many smaller ones.
E. Notice the shape they immediately assume.

RELATED QUESTIONS
1. Considering the nature of the action of the olive oil as demonstrating how liquids behave in a weightless condition, make a general statement that could be applied to the behavior of all liquids in space.
2. How might weightlessness interfere with the following:

   a. Food and water storage?
   b. Capsule housecleaning?
   c. Digestive process?
   d. Fuel storage and pumping?
   e. Others?



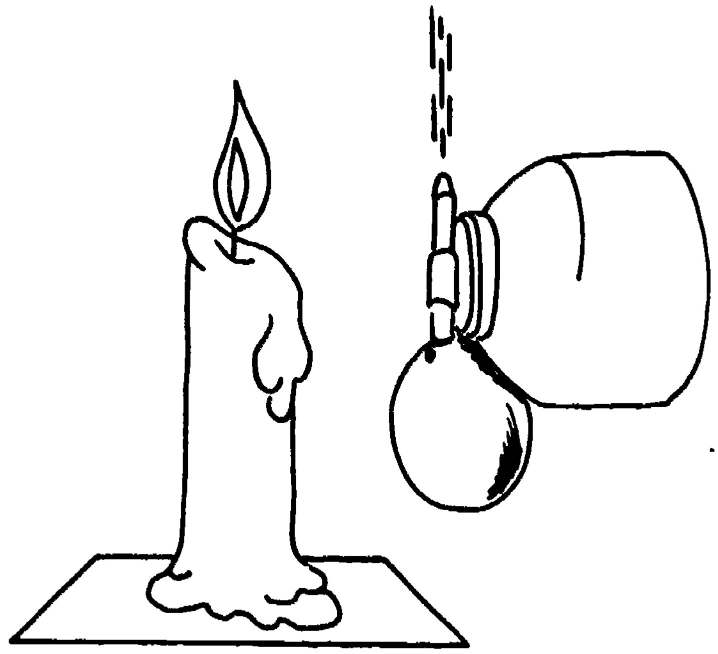
SUBJECT	MAN IN SPACE
TOPIC	Space Hazards--Micrometeoroids
CONCEPT	Because small particles travel through space at tremendous speeds, they are easily able to penetrate a spacecraft.
MATERIALS	Paper Staw and Plastic Straws of different sizes, and raw potato

PROCEDURE

1. Hold the potato in your hand (between the thumb and index finger). Do not hold it in the palm of your hand.
2. With the straw in the other hand, try to drive the straw through the potato.
3. If after a few trys you have no success, try covering the end of the straw with your thumb in order to trap an air column.
4. Just before you attempt to pierce the potato with the straw, bring the potato quickly toward the straw.
5. Repeat, using different sizes of straws.

RELATED QUESTIONS

A. Relate this activity to particles traveling in space. How do size and speed affect the ability of the straw to penetrate potato?
B. Devise methods by which spacecraft might be protected from meteoroids traveling in space.



SUBJECT	ROCKET VEHICLES
TOPIC	Rocket Fuel Combustion
CONCEPT	By increasing the surface area, you increase ignition and burning rate.
MATERIALS	Beaker with alcohol Candle mounted on card Evaporating dish Spray bottle Alcohol

PROCEDURE

1. Plunge burning splint into beaker of alcohol.
2. Light an evaporating dish of alcohol and observe burning rate.
3. Light the candle and let the wax drop on the card.
4. Mount the candle in the wax before it cools.
5. Holding the spray bottle parallel to the flame, spray the alcohol across the flame (keep the spray back from the flame two or three feet).
6. Note the reaction.

RELATED QUESTIONS

A. By spraying the alcohol, why did you get such instant conbustion?
B. How might this concept affect the design of a rocket motor?
C. If your clothing was on fire and the only liquid nearby was an open vat of gasoline, would you jump into the vat? Why or why not?

APPENDIX - C

APPENDIX - C

SPACE AWARENESS
Pre-test and Post-test Questions
Answer Key

UNIT I

Pre-test Questions
Multiple Choice

1. The Montgolfier brothers of France were the first to (a) build an airplane, (b) launch a rocket, (c) build a successful balloon, (d) discover liquid fuel for rockets. C

2. The first successful engine-powered airship was built and flown by (a) the Wright Brothers, (b) Henry Giffard, (c) Wernher Von Braun, (d) Hermann Oberth. B

3. The Wright brothers' first airplanes flew only (a) 31 miles per hour, (b) 75 miles per hour, (c) 25 miles per hour, (d) 80 miles per hour. A

4. Jet propelled and rocket propelled planes made it possible for man to fly faster than sound in (a) 1936, (b) 1914, (c) 1940, (d) 1945. C

5. Nicolaus Copernicus (a) discovered three laws of planetary motion, (b) founded present-day astronomy, (c) developed liquid fuel rockets, (d) built gliders. B

6. The first practical use of the telescope to discover many new facts about astronomy was made by (a) Nicolaus Copernicus, (b) Johannes Kepler, (c) Sir Isaac Newton, (d) Galileo. D

Post-test Questions
Completion

1. Even though ________________ studied birds in flight and drew many pictures of wings, parachutes, propellers and helicopters, he never attempted to build any aircraft.

   Ans. Leonardo da Vinci

2. Astronomer and mathematician, _______________, discovered three laws of planetary motion.

   Ans. Johannes Kepler

3. ________________, scientist, astronomer, and mathematician

discovered how the universe is held together through his theory of gravity.

Ans. Sir Isaac Newton

4. The mathematics of rocket action was worked out by ________________, who was known as the father of modern rocketry.

Ans. Robert H. Goddard

5. The ________________, the first practical vehicle driven by rocket power, was developed during World War II in ____________.

Ans. German V-2/Germany

6. The first satellite to be sent into a successful orbit was ___________ on October 4, ___.

Ans. Sputnik I/1957

7. The first American satellite, _______________, was launched successfully on January 31, ____.

Ans. Explorer I/1958

8. The National Aeronautics and Space Administration was established October 1, ____.

Ans. 1948

9. In its formation, NASA absorbed the agency, ____, which had been in existance for 43 years.

Ans. NACA

10. Copernicus evolved the theory that the ________ was at the center of the universe and that the ____________ and stars revolved about it.

Ans. Sun/Earth

11. We see the Moon by the light from the ________ that is _____________ to the Earth.

Ans. Sun/reflected

UNIT II

Pre-test Questions
Multiple Choice

1. Unless acted upon by an outside force, an object in motion tends to (a) revolve, (b) remain in motion, (c) speed up, (d) rotate — B

2. A rocket can travel in outer space because it (a) uses oxygen of the atmosphere, (b) is weightless in space, (c) carries its own oxygen supply, (d) does not require oxygen — C

3. A rocket consisting of a number of rockets joined together is known as a (a) jet, (b) satellite, (c) Projectile, (d) multi-stage rocket — D

4. According to Sir Isaac Newton, to every action there is an equal and opposite (a) air speed, (b) thrust, (c) reaction, (d) combustion — C

5. The first vehicle designed for space exploration was the (a) Air Force ICBM, (b) Atlas, (c) Redstone, (d) Saturn IB — D

Post-test Questions
True-false

1. Scientists believe rockets were invented by the Chinese. — True

2. A rocket propelled by powdered fuel was devised by a German engineer, Von Eichsteadt, in 1405. — True

3. Chinese historians never recorded information that would substantiate the fact that rockets were invented by the Chinese. — False

4. Many years after the invention of the rocket, 1667-69, Sir Isaac Newton gave the laws of motion which actually told what made the rocket go. — True

5. Rocket and jet engines are the only engines capable of propulsion in space. — False

Completion

6. Propellants used in rockets are either ________ or ________.

   Ans. liquid/solid

7. The burning of fuel provides the ________ necessary to propel a rocket.

   Ans. thrust

8. Before a rocket can leave the atmosphere, it must overcome the _____________ pull of the Earth.

   Ans. gravitational

9. A single unit, or combination of two rockets, is called a ___________ rocket.

   Ans. two-stage

10. The large rocket, which is fired first, often is called a _________.

    Ans. Booster

11. Rockets of the future may include atomic rockets and ____________ rockets.

    Ans. Electric

12. How are the expanding gases within the rocket formed?

    Ans. The chemical reaction between a fuel and an oxidizer forms the expanding gases within a rocket.

13. What makes up a rocket propellant?

    Ans. Together the fuel and oxidizer are called the rocket propellant.

14. What is an example of a solid propellant?

    Ans. Gunpowder

15. What are two disadvantages in using a solid propellant in rockets?

    Ans.
    1. The use of a solid propellant requires rocket parts made of metals that can resist extremely high temperatures.
    2. Solid fuels deteriorate with age.

16. What is a monopropellant?

Ans. A monopropellant is a liquid propellant consisting of a single liquid containing both fuel and oxidizer.

17. What is a bipropellant?

Ans. A bipropellant is a liquid propellant consisting of two liquids, the fuel and the oxidizer in separate containers.

18. Give an example of a monopropellant.

Ans. hydrogen peroxide

19. Give an example of a bipropellant.

Ans. liquid hydrogen and liquid oxygen

20. What is the advantage of a multi-stage rocket?

Ans. The various stages ignite and detach themselves, thereby getting rid of unnecessary weight as the flight goes on.

UNIT III

Pre-test Questions
Completion

1. The path in which an artificial satellite circles the Earth is known as its ________.

   Ans. orbit

2. In outer space, the speed of a satellite is reduced by ________________.

   Ans. air friction

3. A _____________ is a natural or artificial body which orbits around a planet.

   Ans. satellite

4. The ______ is the only natural ____________ of the Earth.

   Ans. Moon/satellite

5. The great distance between a satellite in orbit and the Earth is called _____________.

   Ans. apogee

Post-test Questions
Multiple Choice

1. An object which man shoots into space to circle the Earth is called (a) a star, (b) an artificial satellite, (c) an asteroid, (d) a meteorite <u>B</u>

2. A man-made Moon will continue in flight if a balance is established between the forward motion of the object and (a) the Earth's gravity, (b) air resistance, (c) thrust, (d) air speed <u>A</u>

3. The speed which must be achieved by a space vehicle to orbit the Earth is (a) 23,000 miles per hour, (b) 13,000 miles per hour, (c) 17,500 miles per hour, (d) 3,000 miles per hour <u>C</u>

4. The Tiros satellites were designed to (a) launch a man into space, (b) study the planet Venus, (c) observe weather conditions, (d) land on the Moon <u>C</u>

5. An astronaut experiences weightlessness (a) on take off, (b) while in orbit, (c) on re-entry, (d) when landing <u>B</u>

6. The smallest distance between the satellite in orbit and the Earth is called (a) perigee, (b) polar orbit, (c) synchronous orbit, (d) escape velocity. <u>A</u>

7. The Van Allen belt is (a) an area for space travel, (b) a safety device for astronauts, (c) a zone of radiation, (d) a time zone around the Earth. <u>C</u>

8. The first man in space was (a) an American, (b) a Russian, (c) an Englishman, (d) a German <u>B</u>

9. The first American astronaut in space was (a) John Glenn, (b) Alan L. Bean, (c) Alan B. Shepard, (d) Neil A. Armstrong. <u>C</u>

10. When the period of a satellite in orbit is the same as that of the Earth, it is said to be in an elliptical orbit, (b) a synchronous orbit, (c) a polar orbit, (d) a parking orbit <u>B</u>

11. What two major conclusions were drawn from Project Mercury?

    Ans. 1. These flights showed that man could exist in a weightless condition in space for some time.
    2. These flights showed that astronauts could exert some control over their vehicle while in orbit.

12. What did the first manned flight of Project Gemini show?

    Ans. It showed that astronauts could change the orbital path of their spacecraft.

13. What major accomplishment did Astronaut Edward H. White perform during the second flight of Project Gemini?

    Ans. He left the space capsule, staying outside for 22 minutes.

14. Name three functions of satellites.

    Ans. 1. Observe and report on weahter
    2. Help navigators at sea
    3. Communications

15. What is a space probe?

    Ans. A space probe is any vehicle launched into space to explore the Moon or any of the planets.

16. Indicate the prime target for each of the following space probes:

A. Ranger ___Moon___
B. Surveyor ___Moon___
C. Mariner II ___Venus___
D. Mariner IV ___Mars___

17. Match the following terms and statements.

1. _E_ plasma fuel
2. _F_ open orbit
3. _H_ polar orbit
4. _B_ perigee
5. _G_ apogee
6. _C_ closed orbit
7. _D_ equatorial
8. _A_ orbit

A. Occurs when a spaceship circles the Earth.
B. Is the closest orbital point to Earth.
C. Occurs when orbital velocity is reduced.
D. Occurs when a space ship circles the equator.
E. Gives off energy when an electric spark is sent through it.
F. Occurs when a space ship reaches escape velocity and does not circle the Earth.
G. Is the farthest orbital point from the Earth.
H. Occurs when a spaceship travels over the north and south poles

UNIT IV

Pre-test Questions

1. Number the following events of Project Apollo in their proper time sequence.

    A. __8__ The service module is discarded.
    B. __1__ The Saturn V serves as a Launch vehicle.
    C. __5__ Two of the astronauts investigate the Moon.
    D. __4__ Retro-rockets are used for Moon landing.
    E. __2__ The spaceship is attached to the last stage.
    F. __3__ The command and service units turn 180°.
    G. __6__ The LEM is discarded.
    H. __7__ The service module blasts the command unit out of the Moon's orbit.

Post-test Questions
True-false

1. A payload can only be carried by one rocket. False
2. Attaching one rocket on top of another is called staging. True
3. An orbital rendezvous occurs when one spaceship finds another in space. True
4. A very small error in the initial guidance of a spaceship could put it off course as much as 20,000 miles. True
5. Astronauts are placed so that they are lying down during takeoff so that their weight is distributed evenly. This helps reduce the possibility of trauma and of pooling of blood in the lower extremities. True
6. The useful cargo carried on a space mission exclusive of propellants, the frame and tanks, or heat-shield, is called the payload. True
7. The primary purpose for the landing of astronauts on the Moon was to establish a space station. False
8. The three-man Apollo spacecraft in which the astronauts journey to the Moon consists of two sections, the command module and the lunar module. False
9. Of the three astronauts who travel to the Moon, only two actually set foot on the Moon. True

10. Special alloys that are heat resistant and a fiber glass shield that absorbs heat as it melts protects a space capsule against burning up upon re-entry to the Earth's atmosphere. True

Completion

11. The __________ module of the Apollo spacecraft is designed to allow three men to eat, sleep and work in it without wearing pressure suits.

Ans. Command

12. The section of the Apollo spacecraft which contains supplies, fuel and a rocket engine is the __________ module.

Ans. service

13. The __________ module carries the astronauts and the fuel necessary to slow down the fall to the Moon and make a soft landing as well as fuel for returning to the _______ module.

Ans. lunar/command

14. Apollo 15 astronauts used for the first time a __________ __________ vehicle which significantly enhanced their ability to explore the surface of the Moon.

Ans. lunar roving

UNIT V

Pre-test Questions
True-false

1. Apollo, the second largest and most complex of the manned space flight programs, had as its goal the landing of astronauts on the Moon and their safe return to Earth. — False

2. The Apollo program is directed by the Office of Manned Space Flight, NASA, Washington, D. C. — True

3. The widespread efforts in Project Apollo are centered in three large NASA installations, the Manned Spacecraft Center at Houston, Texas, the Marshall Space Flight Center at Huntsville, Alabama, and the Kennedy Space Center in Florida. — True

4. The Manned Spacecraft Center at Houston, Texas, assembles and tests the rockets and spacecraft, moves the upright space vehicle to the launch pad, and conducts the launches. — False

5. The Marshall Space Flight Center in Huntsville, Alabama, is responsible for development of the giant 280-foot-tall Saturn V launch vehicle. — True

Post-test Questions
True-false

1. The Kennedy Space Center in Florida selects and trains the astronauts, develops the spacecraft, and conducts the flight missions. — False

2. Apollo 8 was the first manned flight of the lunar module, and completed successfully attempts to separate and rendezvous. — False

3. Apollo 9, with astronauts Frank Borman, James Lovell, and William Anders, carried men on the first orbit of the Moon. — False

4. Apollo 10 completed all orbital maneuvers required for landing on the Moon except for actual landing. — True

5. The first man to set foot on the Moon, Astronaut Neil A. Armstrong, accomplished this feat at 10:56 p.m., E.D.T., Sunday, July 20, 1969. — True

Match the following terms and statements.

1. C Seismometer
2. L Tranquility
3. J Apollo 11
4. A Rendezvous
5. O Communications Satellites
6. K Ocean of Storms
7. S Waste Food Conversion
8. F Apollo 12
9. M Fra Mauro
10. H Meteorological Satellites
11. E Apollo 13
12. N Hadley Rille
13. T Breathing Sensor
14. G Apollo 14
15. B Descartes
16. Q Oculometer
17. D Apollo 15
18. R Cryogenic Insulation
19. P Solar Cell
20. I Apollo 16

A. The meeting of two space vehicles at a given point and time in space, and the place at which this takes place.
B. Experimental base established on the Moon by Astronauts John W. Young and Thomas K. Mattingly.
C. Used in experiments on the Moon to detect Moonquakes.
D. Astronauts used the Lunar Roving Vehicle for the first time.
E. Flight by James Lovell, Fred Haise, and Jack Swigert called "Successful Failure."
F. Astronauts Charles Conrad, Jr., Alan L. Bean, and Richard F. Gordon, Jr. made this flight.
G. Encountered docking difficulties in space.
H. Tiros series
I. Astronauts set a record in conducting three extravehicluar activities totaling 21 hours.
J. Astronauts left plaque on the Moon--"Here Men from Planet Earth First set Foot Upon the Moon July 1969 A.D."
K. Experimental base on the Moon established by Charles Conrad, Jr., and Alan L. Bean.
L. Experimental base established on the Moon by Astronauts Neil A. Armstrong and Edwin "Buzz" Aldrin.
M. Experimental base on the Moon by Astronauts Alan B. Shepard and Stuart A. Roosa.

N. Experimental base on the Moon established by David R. Scott and Alfred M. Worden.

O. The Intelsat Family

P. Converts sunlight into electrical energy, which is often used to charge satellite batteries.

Q. Space benefit to mankind pertinent to area of education.

R. Space benefit to mankind pertinent to areas of the home and market place.

S. Space benefit to mankind pertinent to the area of business.

T. Space benefit to mankind pertinent to the area of medicine.

U. Based on technical developments made during NASA's Syncom Program in the early 1960's.

UNIT VI

Pre-test Questions
Completion

1. The Director of the Kennedy Space Center, ________________, and his immediate staff is located in the Headquarters Building of the Industrial Area.

   Ans. Dr. Kurt H. Debus

2. The Public Affairs Office of the Kennedy Space Center is headed by ____________________________.

   Ans. Mr. Gordon Harris

3. The nation's first operational spaceport, ________________, was designed to accomodate the massive Apollo/Saturn V space vehicles.

   Ans. Launch Complex 39

4. More than ____________ men and women have been involved in the National space program.

   Ans. 300,000

5. Approximately ____________ people are employed at the John F. Kennedy Space Center.

   Ans. 16,000

Post-test
True-false

1. About 25 of the 150 member staff in the NASA Headquarters, Washington, D. C., Public Relations Office works directly with the press. True

2. Russia has sent a newsman to cover only one of the launches in the Apollo series. False

3. NASA issues a large number of admittance badges to foreign newsmen for each launch. True

4. The Educational Programs Office at the Kennedy Space Center, headed by William Nixon, conducts a student lecture tour program as a part of its activities. True

5. NASA's total budget estimate for fiscal year 1973 is 294.4 million dollars. True

Match the following terms and statements.

1. __E__ NASA Headquarters, Washington, D. C.
2. __H__ National Aeronautics and Space Administration
3. __F__ Ames Research Center
4. __J__ Flight Research Center
5. __L__ Goddard Space Flight Center
6. __P__ Jet Propulsion Laboratory
7. __O__ Langley Research Center
8. __S__ Lewis Research Center
9. __G__ Manned Spacecraft Center
10. __R__ George C. Marshall Space Flight Center
11. __B__ Nuclear Rocket Development Station
12. __A__ Wallops Station
13. __M__ John F. Kennedy Space Center
14. __D__ Office of Technology Utilization
15. __I__ Spacemobile
16. __K__ National Advisory Committee for Aeronautics
17. __Q__ Tracking Station
18. __N__ Launch Complex 39
19. __C__ Boeing Aircraft Company

A. Located in Virginia this is one of the oldest and busiest ranges in the world.
B. Located at Jackass Flats, Nevada, this is the scene of many tests of reactors and experimental rocket engines.
C. Largest employer at Kennedy Space Center.
D. Created by NASA Headquarters to aggressively encourage the use of new aerospace technology in non-aerospace endeavors.
E. Coordinates activities of space flight centers, research centers, and space installations.
F. Located at Moffett Field, California, was responsible for management of Project Pioneer.
G. Located at Houston, Texas, responsible for the selection and training of astronauts.
H. Began with enactment of Public Law 85-568, approved July 29, 1958.
I. Traveling space science lecture-demonstration unit.
J. Located at Edwards, California, concerned with manned flight within and outside the atmosphere.
K. Absorbed by the creation of NASA on October 1, 1958.
L. Located at Greenbelt, Maryland, named for outstanding rocket pioneer.

M. Major NASA Launch organization for manned and unmanned space missions.
N. The nation's first operational spaceport.
O. Oldest of NASA centers is located at Hampton, Virginia.
P. Located at Pasadena, California, with the primary role of investigating planets using automated scientific spacecraft.
Q. Set up to locate and follow an object moving through space, usually by means of radio or radar.
R. Located in Alabama, manages Skylab project.
S. Located in Cleveland, Ohio, with primary missions of research and development in aircraft and rocket propulsion and space power generation.
T. The Global Satellite System of the International Telecommunications Satellite Consortium.

UNIT VII

Pre-test Questions
Completion

1. ______________________ discovered two zones of radiation in existance around the Earth.

   Ans. Dr. James Van Allen

2. The central part of the first zone of radiation is approximately _______ miles from Earth.

   Ans. 2,000

3. The central part of the second zone of radiation is approximately _______ miles from Earth.

   Ans. 10,000

4. ____________ and ___________ satellites provided scientists with information about radiation in the zones.

   Ans. Explorer/Pioneer

5. Physicists using instruments in _____________ to learn more about Earth's magnetic field found that it is probably affected by other magnetic fields out in space.

   Ans. Antarctica

6. Dark spots on the Sun are known as ________________.

   Ans. Sunspots

7. ________________ are large enough to be seen by the eye when examined through darkened glass.

   Ans. Sunspots

8. The Earth has the shape of an ____________________ which means that it is like a sphere, but flattened at the poles.

   Ans. oblate spheroid

9. The constant turning motion of the Earth is called ____________________.

   Ans. rotation

10. The Earth's moving around the Sun is its ________________.

Ans. revolution

Post-test Questions

Match the following terms and statements.

1. __D__ Astronautics
2. __A__ OAO
3. __E__ Space Station
4. __B__ Telemetry
5. __F__ OSO
6. __I__ Biosatellite II
7. __J__ ATS
8. __C__ STADAN
9. __H__ Synchronous Satellite
10. __G__ Mariner IV

A. Measured the magnetic field of the Earth.
B. The radio transmission of messages from artificial satellites to Earth tracking stations.
C. Network for tracking unmanned scientific and applications satellites.
D. The science of space flight.
E. Projected station constructed in space and designed to operate as a satellite of the Earth.
F. Measured energetic particles emitted from the Sun and provided information on Sunspots.
G. Primary goal was to provide close-up pictures of Mars.
H. Period of rotation about the Earth is the same as the Earth's period of rotation.
I. Designed to study the effects on living things of such phenomena as weightlessness.
J. Project of NASA's Goddard Space Flight Center.
K. Projected type of air craft capable of interplanetary travel.

UNIT VIII

Pre-test Questions
Completion

1. The __________ project scheduled for April 1973, is designed to expand knowledge of manned Earth orbital operations and to accomplish carefully selected scientific, technological and medical investigations.

   Ans. Skylab

2. The __________ __________ will be able to operate in a mode similar in many ways to large commercial air transports.

   Ans. Space Shuttle

3. The United States and the Soviet Union signed an agreement on __________, 19____, committing them to a rendezvous and docking in space in 19____.

   Ans. May 24, 1972/1975

4. After Mariner IX gives scientists a look at the Martian surface and helps them select propitious targets for landing, the __________ landers will follow in 1975.

   Ans. Viking

5. Officials anticipate the use of a __________ fuel and water recoverable booster for the Space Shuttle.

   Ans. :olid

Post-test Questions
True-false

1. The Skylab mission, scheduled for April 1973, will consist of 4 flights, 1 unmanned and 3 manned. True

2. The vehicle used in the Space Shuttle program will be designed for a lifetime of at least 500 flights. False

3. The operating crew on the Space Shuttle would consist of a pilot and a co-pilot. True

4. Unlike Project Apollo, the Man on Mars Project will not have to utilize unmanned spacecraft as a beginning but go directly to manned flights. False

5. Mariner IX was successfully launched on May 30, 1971 and arrived at Mars on November 13, 1971. True

Match the following terms and statements.

1. B ERTS
2. E Space benefit to man in agriculture
3. G Space benefit to man in Oceanography
4. D Space benefit to man in Hydrology
5. J Space benefit to man in Geology
6. F Space benefit to man in Cartography
7. H Apollo 17
8. A Skylab
9. C Space Shuttle
10. I Man on Mars Project

A. Experimental space station program of NASA which is scheduled for April 1973.
B. NASA's Earth Resources Technology Satellite Program began at Goddard Space Flight Center in 1966.
C. Goals are to bring into operation a fully reusable vehicle capable of carrying up to 50,000 pounds of payload on both legs of the round trip between Earth and Earth orbit.
D. Through cameras and infrared, control and early warning of floods by monitoring rain fall, weather prediction, and drainage basin surveys.
E. Through infrared and microwave, estimation of soil moisture content and inigation requirements.
F. Through cameras, construction of detailed maps of rural and urban areas to help plan traffic arteries and terminals.
G. Through cameras, infrared, and microwave, location of high biological activity from surface temperature for fishing fleets--large schools of surface-feeding fish may also be pinpointed.

H. Last manned space flight, scheduled for December 1972.
I. Manned flights similar to Apollo lunar missions may be attempted in the 1980's.
J. Through cameras, infrared, and microwave, prediction of earthquakes from slight temperature differences, soil moisture content, and topographical distribution.
K. Spacecraft surveys the planet from orbit.

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of education
tallahassee, florida
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commissioner