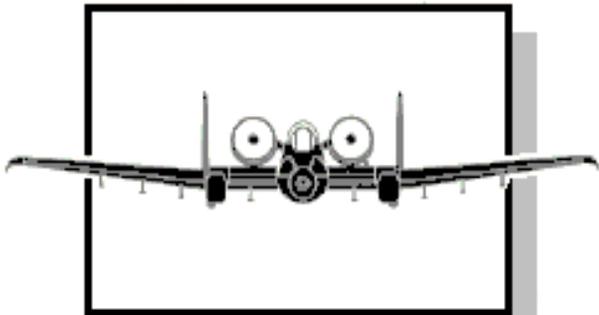
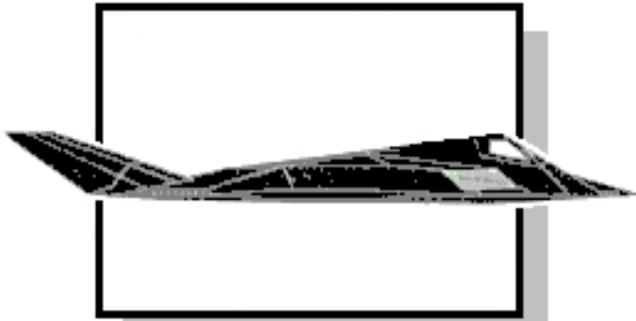


Fostering Aviation Activities

JUNIOR HIGH LEVEL

AN AVIATION CURRICULUM GUIDE



Edited by:
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Federal Aviation Administration
Office of Human Resources and Management
Washington, D.C. 20591

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ACKNOWLEDGMENTS

To the Reader,

The Federal Aviation Administration is pleased to present four educational documents designed for teachers on aerospace education. They are directed to elementary and secondary schools. The documents are:

Future Aspiring Aviators: Primary K-3
Flying Ace Activities: Middle Grades 4-6
Fostering Aviation Activities: Junior High 7-8
Flight and Aviation: Secondary 9-12

We extend accolades to Northeastern Illinois University, Chicago, Illinois for the assistance and support in this project. We wish to recognize and applaud NEIU President, Dr. Gordon H. Lamb for his vision, enthusiasm and encouragement regarding the appointment of professor Margaret R. Lindman, Ed.D. to spearhead this project, at our request.

We are also pleased that the Chicago Teachers Center, a branch of NEIU's College of Education, which services teachers schools and school districts in and around the Chicago metropolitan area is now an FAA Resource Center.

Margaret R. Lindman, Ed.D., is a professor in the department of Curriculum and Instruction at Northeastern Illinois University, Chicago, Illinois. Dr. Lindman has been a teacher educator for more than 35 years. She is well known for her work in aviation and aerospace education. She conducts a Wings and Space Institute for educators at Northeastern yearly and has made presentations at many other aviation-related workshops and conferences. Formerly, Dr. Lindman was a captain in the Civil Air Patrol and also External Aerospace Education Officer for the Illinois Wing, C.A.P. Dr. Lindman was the advisory editor for the Tanglely Oaks Publishing Company for many years and has written numerous articles and documents for educational publication.

Dr. Lindman's charge was to update, streamline, and modify former curriculum documents of the Aviation Education Division, FAA. The documents included Aviation Science Activities for Elementary Grades, Aviation Curriculum Guide for Middle School Level, Secondary School Level, and a Model Aerospace Curriculum, by Aimee Dye, and the August Martin High School by Mervin K. Strickler, Jr. These earlier documents continue to be available and may be accessed by computer.

Dr. Lindman retained the essence of the earlier documents in the revision. Much of the material in the current documents is based on the works of Mervin K. Strickler, Jr., Ed.D., who has been the foremost authority on aerospace education for the past 35 years.

Because these publications are aimed at teachers, Dr. Lindman felt it essential to involve teachers from the beginning development and organization of the materials through the field testing phase. Therefore, she enlisted the aid of Rosamond D. Hilton, formerly of the Chicago Public Schools, Chicago, Illinois, to act as her assistant throughout the project.

Dr. Lindman organized a project writing committee with the assistance of School District #187, North Chicago, Illinois. The former Director of Academic Affairs, Ms. Roycealee J. Wood, took the lead district-wise. She arranged for biweekly half day meetings between teachers, Dr. Lindman and Mrs. Hilton. She sat in on work groups and saw that necessary materials were distributed.

The faculty members on the committee were Delores Clark, Science Consultant, and classroom teachers Dorothy Ashby, Ethel Booker, Ronald Carlson, William Petrosky, Ann Sanders, and Lawrence Sorenson.

The committee decided that there should be a total of four documents: early childhood, middle grades, junior high, and secondary. This would act as a target for teachers. Those that have gifted classes might decide to move up a level, those dealing with less able students might decide to use the lower level. The documents emphasize science and mathematics, although some language arts and social studies and other activities are included. After dividing into grade level teams, the committee under the supervision of Dr. Lindman and Mrs. Hilton evolved their own approach to the development and presentation of the individual documents. Therefore, each document has its own unique aspects while some threads run throughout all of them.

When the documents were completed they were reviewed by a team of educators from Northeastern Illinois University, who made additions, deletions, and recommendations. The University FAA Publications Committee consisted of Harvey Barrett, Ed.D., science educator, Janet Bercik, Ed.D., Clinical Experiences Director and supervisor (elementary and secondary), Joanne Frey, Ed.D., elementary, Elizabeth Landerholm, Ed.D., early childhood specialist, Jill Althage, MLS and Kristine Tardiff, MLS, librarians.

Finally, the documents were field tested under Dr. Lindman's supervision. Our thanks to all those North Chicago District #187 teachers who participated in the 10-week field test.

It is our hope that these documents will be beneficial to teachers throughout the country as we are propelled into the 21st century.

Sincerely,

Phillip S. Woodruff

Director, Office of Human Resource Management

INTRODUCTION

Among the many responsibilities of the Federal Aviation Administration is that of educating the public regarding aviation, related technologies, and sciences about the impact aviation makes on our modern day lives. If the United States is going to continue as a world leader in aviation and space, our young people must be taught to cope with and efficiently use the rapidly changing technological advances.

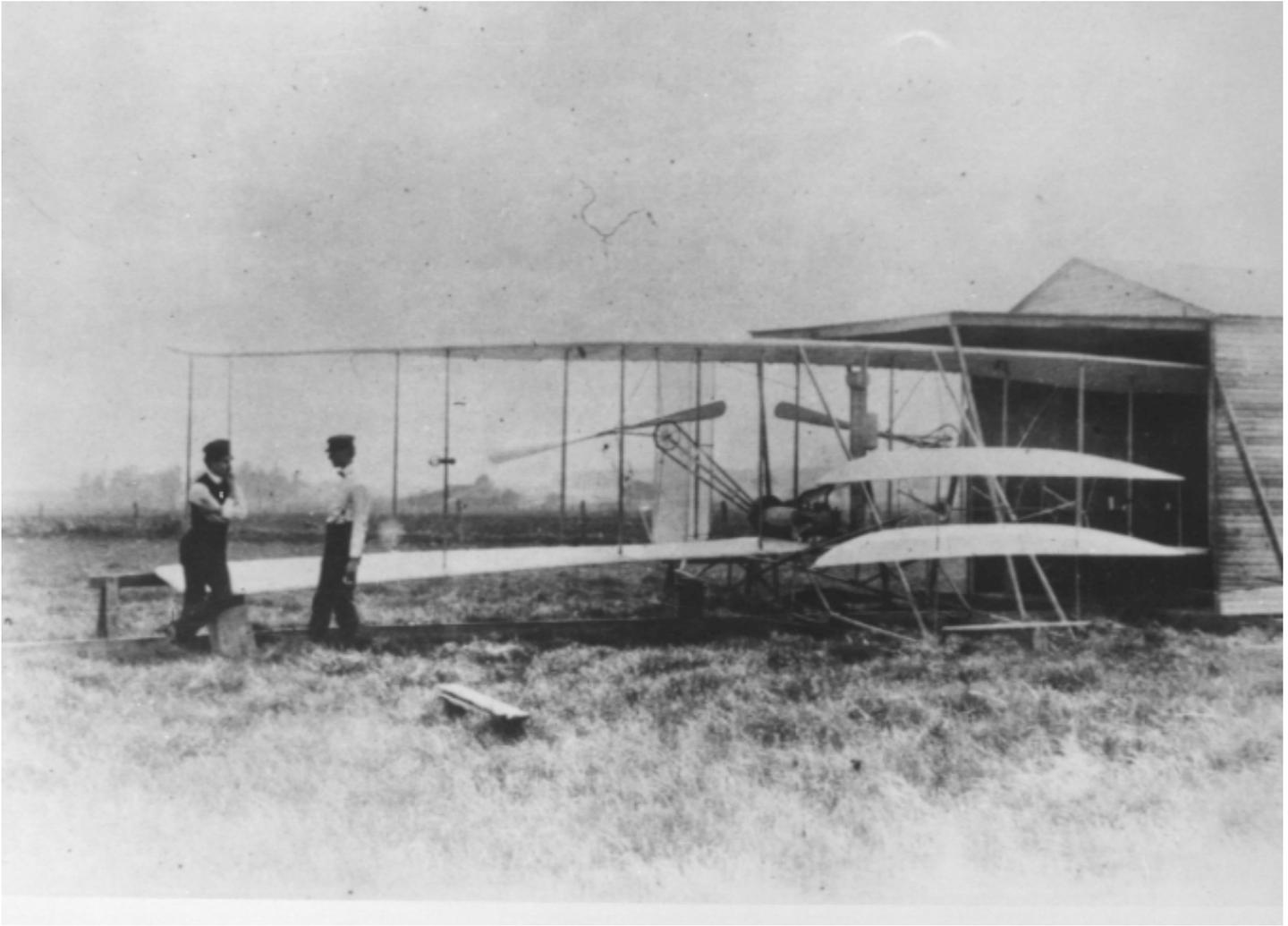
The study of flight has been a source of fascination since the beginning of time. Studies indicate that aviation education has high motivational appeal producing dramatic student gains in science, mathematics and other content areas.

The activities and learning tasks included in this guide are hands-on and serve to demonstrate the motivational aspects of aviation. Activities included indicate how aviation can be integrated into existing curriculum while skills in the various instructional areas are being developed.

This guide is designed for Junior High teachers and others who work with preteens and teenagers, with an emphasis on science and mathematics related activities. No specialized teacher training in aviation education is required to utilize this guide.

The activities range from simple to complex experiences in order to provide for a wide range of student abilities and interests. On the following pages are pictures of four historic experimental planes: the 1903 Wright Flyer, the 1927 Spirit of St. Louis, and 1986 Rutan Voyager, and the 1989 Stealth Bomber.

These pictures may be laminated and used as a base for an aerospace education bulletin board, for student jigsaw puzzles, a beginning study of aircraft identification and/or as an introduction to research activities for papers on the history of flight. Building and designing model airplanes is another avenue to peak the interest of the students during or after they pursue the aerospace learning activities in this booklet.



1903 Wright Flyer

Wingspan - (40 ft x 4 in)

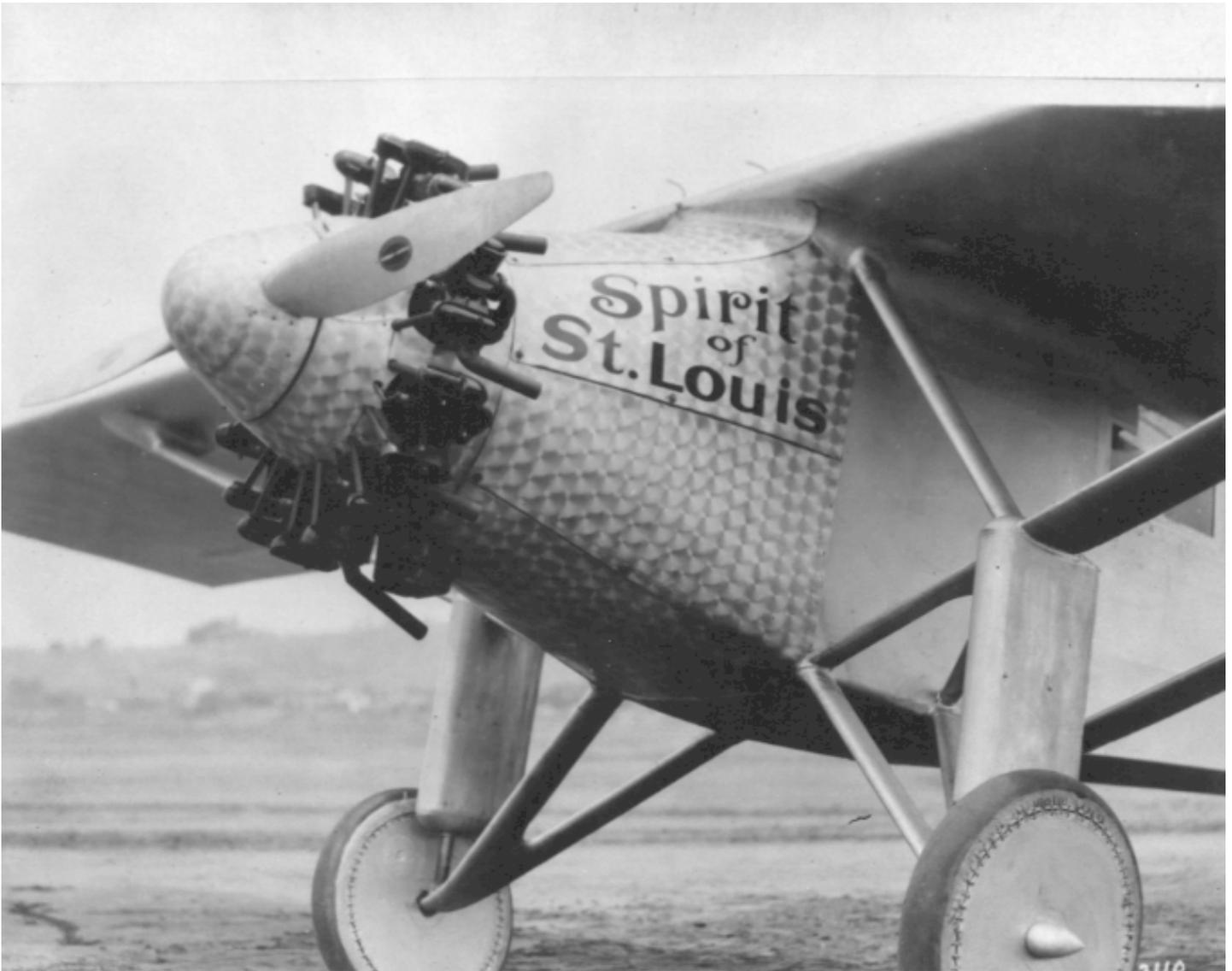
Height - (9 ft x 3 1/4 9 in)

Length - (21 ft)

Wings - (605 lb)

This plane flew four times on December 17, 1903. The longest flight was 59 seconds and covered 852 feet. The pilot for the first and third flights was Orville Wright. Wilbur, his brother, flew the plane for the second and fourth flights.

The Wright flyer is now on display at the National Air and Space Museum (NASM), Smithsonian Institution in Washington, D.C.



Ryan NYP 'Spirit of St. Louis'

Wingspan - 46 ft

Height - 9 ft x 10 in

Length - 27 ft

Gross Weight - 5,135 lbs

In 1927, Charles A. Lindbergh flew solo the "Spirit of St. Louis" nonstop from New York to Paris in 33 hours, 33 minutes. This small airplane is made of wood, steel tubing and fabric and is powered by a 220 - horsepower Wright Whirlwind J-5-C engine. It is on display at the National Air and Space Museum (NASM), Smithsonian Institution, Washington, D.C.

[PICTURE CURRENTLY UNAVAILABLE]

Rutan Voyager

Wingspan - 110.8 ft

Height - 10.3 ft

Length - (37'.6")

Gross take-off Weight - 9,694.5 lbs

Dick Rutan and Jeana Yeager completed a nonstop unrefueled flight around the world in 'Voyager' from Edwards Air Force Base, California on December 23, 1986. The flight took 9 days and 3 minutes and covered 22,860 miles at an average speed of 115.6 miles per hour. The plane traveled at an altitude between 7,000 and 11,000 feet, although it reached 20,000 feet to avoid storms over Africa. The air cooled front engine develops 130 horsepower; the liquid cooled rear engine develops 110 horsepower. "Voyager" departed with approximately 1,168 gallons of fuel-which weighed more than the plane itself! - and returned with only 15 gallons remaining. It is on display at the National Air and Space Museum (NASM), Smithsonian Institution, Washington, D.C.

P. 17 the Rutan Voyager, Ian Gould, Rourke Enterprises, Inc. Viro Beach, Fla, 329 & 9.

SELECTED AEROSPACE TOPICS IN CURRICULUM CONTEXT

Often educators who teach about aviation and space education are challenged by administrators, other teachers and parents who question the validity of such study. The following list indicates just some of the specific ways this topic interrelates with traditional studies.

How they are built is **INDUSTRIAL ARTS**
 Who controls them is **GOVERNMENT**
 What they cost is **ECONOMICS**
 Where they land is **SOCIAL STUDIES**

Where they fly is **GEOGRAPHY**
 Who made them fly is **HISTORY**
 How they fly is **SCIENCE**

AGRICULTURE

Australia's aviation
 Crop dusting
 Cloud seeding
 Economic implications
 Food and nutrition
 International Agricultural
 Aviation Centre
 International Flying Farmers
 Photosynthesis
 Weather
 Weather satellites

Eclipse
 Galaxies
 Interplanetary travel
 Light
 Mariner probes
 Meteors
 Moon
 Observatories
 Orbiting observatories
 Orbits and trajectories
 Planetariums
 Planets
 Solar System
 Stars

Government in aerospace
 Ground service and
 maintenance
 Manufacturing
 Occupations
 Pilots and pilot
 certificates
 Pilot training
 Spacecraft design
 Stewards and
 stewardesses
 Test pilots
 Women in aerospace

ART

Balloons
 Commemorative stamps
 and medals
 Da Vinci, Leonardo
 History of aviation
 Insignia
 Interiors of aircraft
 Kites
 Medals and decorations
 Model aircraft
 Mythology
 Objects of art
 Photography
 Pilot and crew wings
 Science fiction
 Trophies and awards

Sun
 Telescopes
 Ultraviolet
 Universe
 X-rays

CHEMISTRY

Air
 Alloys
 Atoms
 Atmosphere
 Chemical energy
 Closed ecological system
 Elements
 Fuels
 Gases
 Lubricants
 Propellants
 Specific Gravity

BIOLOGY

Animals in space
 Aviation medicine
 Bird flight
 Circadian rhythm
 Closed ecological system
 Extraterrestrial life
 Hydroponics
 Photosynthesis
 Space biology

EARTH SCIENCE

Air masses
 Applications technology
 satellites
 Astrogeology
 Astronautics
 Astronomy
 Atmosphere
 Aurora
 Aviation weather
 Boyle's Law
 Charts

ASTRONOMY

Asteroids
 Astronautics
 Astronomy
 Comets
 Constellations
 Cosmic rays

CAREER GUIDANCE

Air traffic control
 Army aviation
 Astronauts
 Careers
 Charter flying
 Flight instruction
 General aviation

Compasses
Earth
Environmental research
satellites
Explorer satellites
Geodetic satellites
Gravity
Greenhouse effect
Cosmos satellites
Latitude and longitude
Lightning
Lunar charts
Magnetic course
Maps and mapping
Mariner probes
Meteorology
Navigation techniques
Oceanographic research
Orbiting observations
Pilotage
Precipitation
Ranger
Sounding rockets
Surveyor
Van Allen belts
Weather
Weather maps and charts
Weather satellites

ECONOMICS

Aerospace industry
Airports
Bush flying
Cargo aircraft
Commercial airlines
Commercial air transports
Crop dusting
Economic implications
Flight simulators
General aviation
Government contracts
Government in aerospace
Jet aircraft
Jumbo jets
Manufacturing
Supersonic transports

GENERAL SCIENCE

Airplane
Astronomy
Atmosphere
Atoms

Barometric pressure
Bernoulli's principle
Bird flight
Clouds
Electricity
Energy
Engines
Fog
Galaxies
Helicopters
Jet Aircraft
Launch vehicles
Man in flight
Matter
Mercury program
Photography
Planets
Radio communications
Satellites
Saturn rockets
Space stations
Stars
Sun
Walk in space
Weather
Weather satellites

GEOGRAPHY

Bush flying
Cartography
Charts
Compasses
Course plotting
Latitude and longitude
Magnetic course
Maps and mapping
Photography
U.S.S.R. aerospace
activities

GEOGRAPHY

Astrogeology
Geodetic satellites
Mountain, desert, and
jungle flying
Ranger
Surveyor

GOVERNMENT

Aerospace industry
Air Commerce Act

Air traffic control
Apollo
Army aviation
Coast Guard aviation
FAA
Flight service station
Government contracts
Instrument Flight Rules
Marine Corps aviation
Mercury program
Military aviation
Military space program
National Transportation
Safety Board (NTSB)
NASA
National Airspace System
Naval aviation
Pilots and pilot certificates
Registration of aircraft

HEALTH

Aerospace medicine
Animals in space
Astronauts
Circadian rhythm
Drug effects
Environmental control
systems
Food and nutrition
Human engineering
Life-support systems
Man in flight
Manned spaceflight
Man-powered flight
Spacesuits
Temperature control
Weightlessness

HISTORY

Ace
Air Commerce Act
Air raid
Altitude records
Balloons
Barnstormers
Biographies
Bomber aircraft
Bush flying
Commemorative stamps
and medals
Dirigibles
Distance records
Endurance records

First World War aircraft
Flying Circus
Gliders
History of aviation
Man-powered flight
Mythology
Science fiction
Second World War
 Aircraft
Speed records
Women in aerospace
World War I
World War II

HOME ECONOMICS

Fabrics
Flight Attendants
Spacesuits
Interiors of aircraft

MATHEMATICS

Binary numbers
Celestial navigation
Course plotting
Doppler navigation
Information systems
Navigation techniques
Orbits and trajectories
Parabola
Telemetry
Weight and balance

METEOROLOGY

Air
Air masses
Atmosphere
Barometric pressure
Clouds
Convection currents
Earth science
Evaporation and condensation
Fog
Humidity
Precipitation
Turbulence
Weather maps and charts
Weather satellites
Wind

PHYSICS

Aerodynamics
Aircraft propulsion systems
Airfoil
Airplane
Airspeed indicator
Astronautics
Attitude control
Automatic landing
Avionics
Bank
Bearing
Bernoulli's principle
Boyle's Law
Center of gravity
Computers
Doppler effect
Dynamic soaring
Electricity
Electromagnetism
Electronics
Energy
Engines
Flight Management
Gas turbine engines
Gyroscope
Heat energy
Heat shields
High-lift devices
Hydraulic systems
Hypersonic flight
Instrument panel
Lasers
Launching
Lifting-body vehicles
Maneuvers
Matter
Measurement of power
Metals and metallurgy
Newton's Laws
Noise
Nuclear energy
Nuclear propulsion
Plasma
Power management
Radar
Radiation
Radio
Reciprocating engines

Rendezvous and docking
Robots
Rotating combustion engines
Sailplanes
Semiconductors
Shock wave
Solar cells
Space propulsion systems
Supersonic flight
Television
Temperature scales
Wind tunnels
Wings
X-rays

SOCIAL STUDIES

Air defense systems
Air forces of the world
Airmail
Air taxis
Apollo
Army aviation
Atlas missile
Berlin airlift
Biographies
Blockhouse
Bombs
Careers
Cargo aircraft
Communications satellites
Crop dusting
Demonstration teams
DEW line
Economic implications
Educational implications
Eurosace
European aerospace activities
Fighter aircraft
Fixed base operation
Flight (as passenger)
Flight test programs
Flying doctor services
Forest fire control
Gemini
General aviation
Gliders
Gliding
Government in aerospace
Hangars
Helicopters

Heliports
High-speed surface transportation
History of aviation
Homebuilt aircraft
Instrument flight techniques
Insurance
Interplanetary travel
Jet aircraft
Jumbo jets
Kamikaze
Kennedy Space Center
Korean War
Launch facilities
Launch vehicles
Luftwaffe
Lunar bases
Lunar exploration
Manned Orbiting Laboratory
Manned spaceflight
Manufacturing
Mercury program
Military aircraft
Military implications
Military space program
Missiles
Mythology
NASA
Naval aviation
NORAD
Oceanographic research
Polar flights
Police and fire controls
Preflight training
Production techniques
Program management
Radio communications
Rescue and recovery service
Rockets and rocketry
Runways
Safety statistics
Sailplanes
Satellites
Saturn rockets
Search and rescue
Social implications
Space Stations
Sport flying

Strategic Air Command
Supersonic transports
Systems engineering
Technological projections
Unidentified flying objects
U.S.S.R. aerospace activities
Utility aviation
Weaponry
Wind tunnels

SPEECH AND COMMUNICATIONS

Air traffic control
Communications satellites
Ground control approach
Morse code
Phonetic alphabet
Terminology of aerospace

I. EARLY HISTORY AND GROWTH

Suggested Activities

1. Have students research and report on the ideas of flying as expressed by early man.
 - a. Winged men of Egypt.
 - b. Winged bulls of Assyria
 - c. Sinbad, the sailor
 - d. Arabs and their flying carpets.
 - e. Simon, the Magician during the time of Nero.
 - f. Oliver, the Monk, with Daedalian wings.
 - g. The Saracen (11th century) robe with rods which spread like wings.
2. Read the myths "Daedalus" and "Phaeton."
3. Make a time line of pictures of early flying machine designs such as those of da Vinci, early gliders, balloons, and all types of powered aircraft from the Wright Brothers to modern times.
4. Write original stories concerning the Greek mythology of aviation.
5. Read and illustrate flight ideas related to Native American legends.
6. Make reports on the progress of aviation such as:
"The Story of Air Transportation Today"
"The Story of Air Transportation in the Future."
7. Discuss the parachute and its role in aviation.
8. Make small parachutes to exhibit with model airplanes.
9. Visit a museum if possible; if not, have a discussion and reports on the National Air and Space Museum in Washington, D.C.
10. Make comparison charts about past and present flight records.
11. Report on:
 - a. Invention of the kite.
 - b. Gunpowder rockets.
 - c. da Vinci's sketches of aircraft and parachute.
 - d. Montgolfier Brothers' balloon.
 - e. Ferdinand von Zeppelin's dirigible.
 - f. Sir George Cayley.
 - g. Otto Lilenthal.
 - h. Samuel Pierpont Langley.
 - i. How air mail service developed.
 - j. Byrd's first visit to the South Pole, 1929; North Pole, 1926.
 - k. Amelia Earhart
 - l. First trans-Pacific flight.
 - m. Round-the-world flights.
 - n. First experiments with helicopters.
12. Make models of early type gliders.
13. Make or display a time line depicting aerospace events during mankind's history.
14. Write a biographical sketch of:
 - a. Robert Goddard
 - b. Wright Brothers
 - c. Amelia Earhart
 - d. Charles Lindbergh
 - e. General William "Billy" Mitchell
 - f. Edward Rickenbacker
 - g. General Daniel "Chappie" James
 - h. James H. Doolittle
15. Develop a "Current Events in Aviation" notebook or bulletin board.
16. Present reports on the latest rocket developments.

II. PROPERTIES OF AIR

Suggested Activities

1. To prove that air is a real substance:
 - a. Blow up a paper bag and burst it.
 - b. Blow into a Ziploc plastic bag and seal it.
 - c. Push an inverted glass with dry paper in the bottom into a pan of water.
2. To test for air resistance do the following experiments. Time each drop.
 - a. Drop a sheet of paper from a ladder.
 - b. Roll or crumple a second sheet of paper and drop it from the same height.
 - c. Cut a third sheet of paper in half lengthwise; lap the cut edge over to form a wide cone; and drop it.
 - d. Make a paper ice cream cone by rolling a fourth sheet of paper and taping the outer edge. Drop it from the experimental spot.
 - e. Discuss the results and generalizations that can be made.
3. Demonstrate the “braking action” of air. Drag a spring type clothespin through the air (or water), then attach a ketchup bottle cap and repeat. Notice the additional drag.
4. Identify the layers of air and some characteristics of each.
5. Explain the difference between the terms air and atmosphere.
6. Make a circle graph showing the composition of air.
7. Explain similarities of characteristics between air and water such as weight, mass, pressure, density, etc.
8. Draw a picture of an airfoil. Use lines to demonstrate the stream of air moving over and under the airfoil.
9. Discuss the reasons for designing streamlined cars, trains, and airplanes.
10. Construct mobiles of inflated balloons. Observe changes in the balloons after one day, two. Discuss reasons for the changes.
11. Fill bio-degradable balloons with helium (available at a welder’s supply store). Attach a postcard with your name and address requesting that the finder return the card. Discuss why and when you must release them. Release the balloons on a windy day.
12. Blow soap bubbles. Discuss what they are; why they break, etc.
13. Examine and manipulate a bicycle pump or perfume atomizer. Feel the air stream as the plunger is pushed.

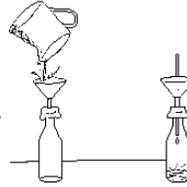
PROPERTIES OF AIR

ILLUSTRATED ACTIVITIES AIR TAKES UP ROOM

1. Equipment:
Soda pop bottle
Small funnel
Soda straw
Modeling clay
Cupful of water

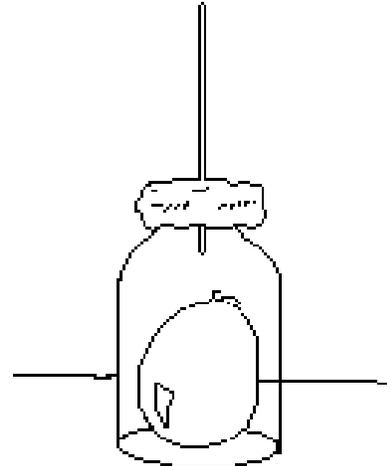
Seal the funnel tightly into the neck of the bottle with modeling clay. Quickly pour the cup of water into the funnel. The water stays in the funnel because the air in the bottle cannot get out.

Pass the straw through the funnel into the bottle. Suck out a mouthful of air. Some of the water goes down into the bottle, taking the place of the sucked out air.



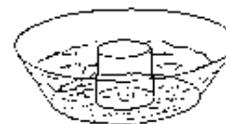
2. Equipment:
Wide-necked bottle or jar with an air-tight lid
Soda straw
Modeling clay
Small balloon
Thread

Blow the balloon up just enough to fit very loosely in the bottle. Tie a thread around the neck of the balloon so the air will not escape. Drop the balloon into the bottle. Punch a hole in the lid and insert the straw; reseal it with modeling clay. Screw the lid on the bottle. Suck some of the air out of the bottle through the straw and place your finger over the top of the straw to prevent air from rushing back into the bottle. The balloon gets larger because the air inside the balloon expands as the air pressure decreases in the bottle.



3. Equipment:
Water glass
Cork
Large glass bowl
Facial tissue

Fill the bowl three-fourths full of water. Drop the cork on the top of the water. Invert the glass over the cork and push to the bottom of the bowl. The cork goes to the bottom of the bowl under the glass. Air in the glass keeps the water out.

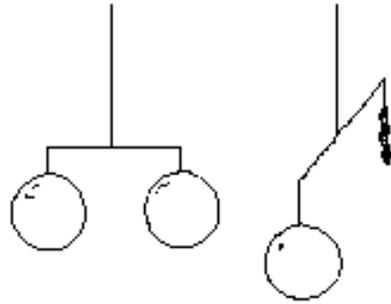


AIR HAS WEIGHT

4. Equipment:

- Wooden dowel stock or tinker toy stick about a foot long
- String, 1 yard
- 2 identical balloons

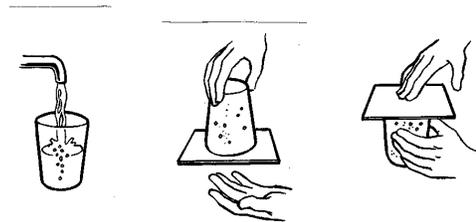
Inflate the balloons to the same size, and tie them at their necks with a piece of string. Tie one balloon to each end of the dowel. Attach another piece of string to the center of the dowel and suspend it from a convenient place. Balance the dowel stock. Prick one balloon with a pin. As the air rushes out, the pricked balloon shoots up and the heavier, air-filled one drops down.



5. Equipment:

- Water glass
- Piece of thin, flat cardboard

Fill glass to the top with water. Place the cardboard over the glass. Carefully turn the glass upside down, holding cardboard tightly to the glass. Take your hand away from the cardboard. The cardboard stays in place against the glass. Tilt the glass or hold it sideways, and the cardboard still remains in place.

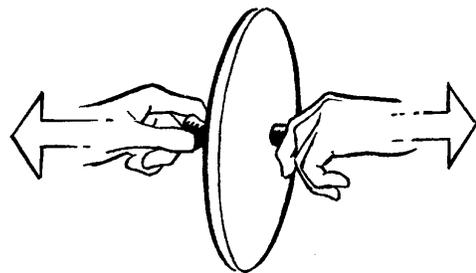


At A and B the upward and downward pressures balance, but at C the upward pressure of air is greater than the downward pressure of water and holds the cardboard in place.

6. Equipment:

- 2 large, flat, rubber sink-stoppers

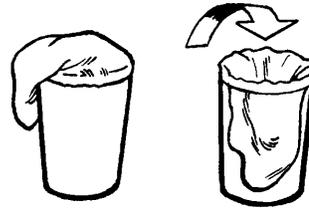
Air pressure tug-of-war: After wetting their surfaces, press the two sink-stoppers together so that no air is between them. Ask a friend to pull on one while you pull the other. You can't pull them apart. But just let the air get in between the pads or plungers, and presto! they separate.



7. Equipment:

- Balloon
- Water glass
- Pan of hot water
- Scissors

Cut the neck off a balloon. Heat an empty glass in a pan of hot water. Slip the opening of the balloon over the mouth of the glass. Let the glass cool. The cool air contracts and sucks the balloon into the glass.



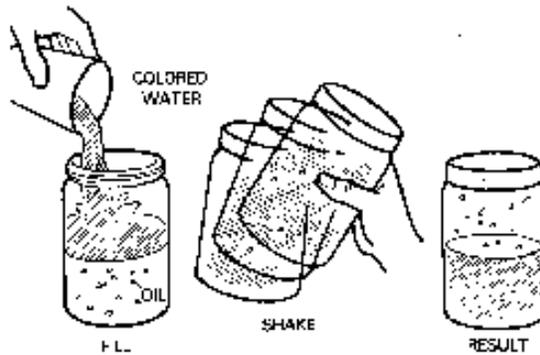
WARM AIR HOLDS MORE
MOISTURE THAN COLD AIR

8. Equipment:

- Teakettle with a spout
- Hot plate or burner
- Large strainer
- 2 trays of ice cubes
- Medium sized pan with handle

Boil water in the teakettle until steam comes from the spout. Notice that the steam disappears into the air almost immediately. Fill the strainer full of ice cubes and hold it near the spout of the teakettle so the steam will pass through it. Clouds form as the steam cools. Help the students understand why.

Fill the pan with ice cubes and hold it where the steam from the teakettle will hit the sides of the pan. When the hot vapor or steam hits the sides of the pan, little drops of water gather on the outside of the pan and drip like rain. Why?



III PRINCIPLES OF FLIGHT

SUGGESTED ACTIVITIES

1. Discuss weight.
2. Drop the balls of different size and weight, at the same time and observe that both strike the floor simultaneously.
3. Discuss gravitational differences on the earth and the moon.
4. Compute and compare the weight of objects on the earth and the moon.
5. List some objects that temporarily defy gravity: birds, kites, blowing leaves, gliders, airplanes, rockets, etc.
6. Draw the shape of an airfoil with lines indicating the airstream over and under it. Label areas of low pressure and high pressure. Ask: How does air lift kites, leaves, etc.?
7. Identify Lift as the force that opposes gravity.
8. Identify Drag as the force that opposes lift.
9. Recall the action of wind against the hand when it was put outside the window of a moving automobile. What caused the drag against the hand?
10. Demonstrate Newton's Laws.
 - a. First Law: Show that a small model car needs to be pushed to start it moving and that it will keep moving until something stops it (air, friction or another object).
 - b. Second Law: Push a small model car with varying amounts of force to show that speed of movement is related to thrust. i.e., Relate the other examples of thrust; tossing a baseball, pedaling a bicycle, "shooting" a marble, etc.
 - c. Third Law: Demonstrate action and reaction by inflating a balloon and suddenly releasing it. Discuss its actions.
11. Make paper airplanes and fly them. Discuss the action of the four forces: gravity, lift, thrust and drag.
12. Draw an airplane. Use arrows to show where lift, gravity, thrust and drag occur.

IV. AVIATION APPLICATIONS OF BASIC PRINCIPLES OF SCIENCE

Suggested Activities

A. Bernoulli's Principles: If in a stream tube, the velocity of a fluid is increased, the pressure at that point is decreased perpendicular to the direction of flow.

1. Hold the edge of a piece of paper between the thumb and forefinger, letting the rest of the paper curve over the top of the hand to form an airfoil. Blow over the top of the curved surface.
2. Suspend two ping-pong balls about one inch apart. Blow between them.
3. Build a wind tunnel.
4. Discuss different types of aircraft wings and their effect on flight.
5. Identify other structural parts of a plane where Bernoulli's principle applies.

B. Inertia: A body at rest remains at rest and a body in motion remains in motion until acted upon by some outside force.

1. Place a stack of blocks on a small cart. Pull the cart in a straight line and then suddenly swerve the cart. What happens? Stack the blocks and stop and start the cart quickly. What happens?
2. Suspend a 100 gm. weight on a spring balance. Quickly raise the balance and note the reading. Quickly lower the balance and note the decrease in weight as it starts to drop.
3. Newton's Law of Acceleration: The force required to give an acceleration is directly proportional to the acceleration. $F = wa/g = \text{force}$ required to give an acceleration of 'a'. $w = \text{weight of the accelerating body}$.
 1. Discuss what a pilot means by the "G" forces on a body in flight.
 2. Discuss how the above laws account for centrifugal and centripetal force.
 3. Roll a marble down an

inclined plane and watch it gain speed. Try to determine its rate of acceleration.

D. Newton's Third Law of Motion: To every action there is an equal and opposite reaction.

1. Fill a balloon with air and release it suddenly. Account for its motion after its release.
2. Explain the relationship between thrust and weight in view of this law.
3. Tie a string to two adjacent corners of a cardboard, and pull it through the air.

E. Friction: Fluid friction varies according to the square of the velocity. Dry sliding friction is independent of speed.

1. Measure the force required to pull a wooden block along a smooth surface. Place rollers under it, and measure again. Remove the rollers and lubricate.
2. Rub the palms of your hands together briskly and note the heat generated. Next, place a small amount of oil between the palms and then rub them together.
3. Clamp one end of a meterstick to table. Apply rotational force to illustrate torque.

Discuss:

- a. Where the effect of these forces are found in the plane.
 - b. Safety factors and the air regulations that pertain to them.
4. Discuss the effect of friction in high velocity flight.
 5. Explain why heat is a factor in high speed flight.
 6. Discuss ways in which friction is helpful in flight.

F. Types of Forces: tension, bending, compression, shear, torsion.

1. Illustrate these forces by running a thread over a pulley and attaching weights. Bend a wire until it breaks. Note the heat at the point of flexing.
2. Place a matchbox, or other light box, under weights.
3. Note the action of scissors on paper.
4. Align two metal bars side by side with a hole through each. Insert a match through the holes and pull the bars.

G. Speed of Sound:

1. Use a metronome and strike a drum every half second. Have others in the group increase their distance from the drum gradually until they reach a point where they cannot hear the sound of one drum stroke until the next is completed. Measure the distance of the group from the drum. Can you compute the speed of sound?
2. Discuss the meanings of sound barrier, Mach number and sonic boom.

H. Archimedes' Principle: A body in a fluid is buoyed up by a force equal to the weight of the displaced fluid.

Weigh a body of known volume in air and then in water. Calculate the difference in weight under these two circumstances. Compare this with the weight of the displaced water.

I. Pascal's Law: If we increase the pressure in a liquid that increase will be transmitted equally and undiminished in all directions to the confined liquid.

1. Obtain a hydraulic jack and study its construction and action. Invite a mechanic to explain the action of an automobile hydraulic system.
2. Fill a large plastic bottle with water. Force a stopper in the opening. Continue to explain the action of an automobile hydraulic system.

2. Fill a large plastic bottle with water. Force a stopper in the opening. Continue to apply pressure on the stopper until the bottle bursts.

J. Boyle's Law: The volume of a gas varies inversely with the pressure and temperature, remaining constant.

$$K = PV$$

P = absolute pressure

V = Volume

K = constant

1. Place a partially inflated balloon in a vacuum jar and evacuate the jar. Note the increase in the size of the balloon. Discuss.
2. Discuss how the principle illustrated above can apply to aviation.
3. Explain why weather balloons burst upon reaching high altitudes.

K. Charles' Law: The volume of a gas varies directly, its absolute temperature pressure remaining constant.

$$K = V/T$$

V = Volume

T = Absolute temperature

1. Fill a balloon with cool air place it near a radiator. Observe.
2. Obtain an air thermometer. Explain its action.
3. Discuss the first balloon ascensions made by open-bottomed canopies filled with hot air.

L. Temperature Considerations

1. Measurement Fahrenheit Celsius

$$5/9 = c/F - 32$$

- a. Demonstrate:
 - (1) The principle of a thermometer.

- (2) Various types of thermometers.
- (3) Two kinds of thermometer scales.

- b. Make an alcohol thermometer.
- c. Make a chart that shows the relationship between Fahrenheit and Celsius thermometers.
- d. Solve problems by converting one scale to another.
- e. Keep temperature charts: Hourly, daily, weekly, indoors, outdoors, etc.

2. Insulation

Temperature radiation

Thermal currents

- a. Discuss how radiant energy will raise the temperature of objects.
- b. Demonstrate the effect of color and surface on the absorption of heat.
- c. Demonstrate the effect of heating and cooling upon air movements.
- d. Demonstrate convection currents by showing how air circulates through open windows.

M. General Principles Which Underlie the Basic Causes of Weather and Climate Conditions.

1. Air movement is caused by weight and pressure difference.

- a. Discuss and observe different kinds of barometers.
- b. Construct a mercury barometer.
- c. Keep a daily record of pressure changes.
- d. Construct a convection current box.
- e. Discuss the meaning of "normal air pressure."
- f. Discuss different units in which air pressure can be expressed.
- g. Discuss factors causing pressure variations.

2. The ability of air to hold water vapor lessens as it cools.

- a. Determine the "dew point" temperature of the atmosphere.

- b. Observe "clouds" at the spout end of a boiling tea kettle.
- c. Build hygrometer and a psychrometer.

3. Clouds.

The nature and significance of clouds is determined by temperature, turbulence, foreign particles and water vapor content.

- a. Learn to identify clouds and determine their significance.
- b. Observe, record, and draw the types of clouds viewed for several successive days or weeks.
- c. Discuss cloud seeding.

ACTIVITY

THE WIND TUNNEL

A wind tunnel is a tunnel-like chamber through which air is forced at controlled velocities to study the airflow about an object suspended within it. Some wind tunnels are large enough to permit the action of wind pressure on huge airplanes or missiles to be observed, and in these the wind velocity may have a force of several thousand miles per hour. Other wind tunnels are small, with scale models of airplanes mounted in them. The wind tunnel described below is a simple one.

1. Equipment:

Piece of furnace pipe about 4 feet long
Piece of plioilm, acetate, or some other transparent material for the tunnel window.
Separations from a cardboard carton*
Scotch tape
Corrugated box.

Small electric fan
Bookbinding tape or similar adhesive tape
2 Small hooks, the kind used for hanging
Metal shears

2. Directions:

Open the cardboard separators and reinforce the corners with scotch tape. Open the corrugated box on both ends and push the flaps inside the box to make the box stronger. Fit the cardboard separators into one end of the box. They should fit snugly.

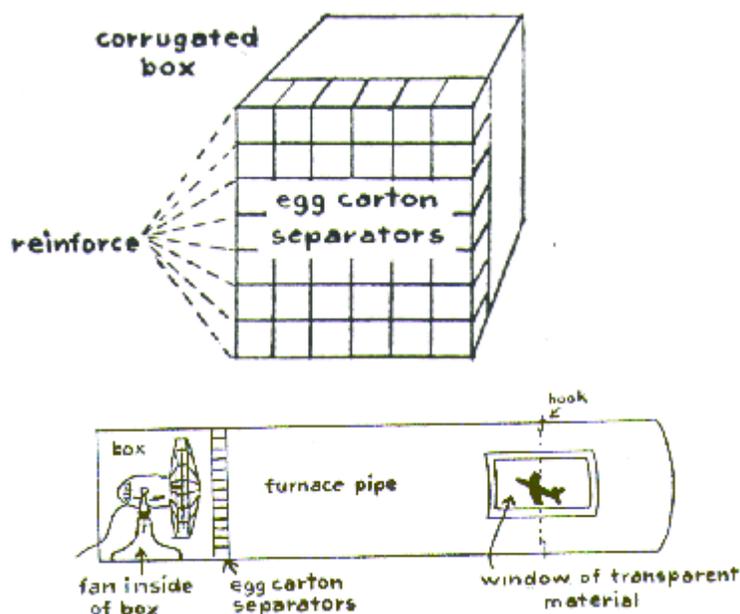
With a pair of metal shears cut a window near one end of the furnace pipe. Cover the window with the transparent material, securing it to the pipe with book-binding tape. Fasten the hooks in the pipe so that when the glider is suspended from the top hook it can be observed from the window. Set the cardboard separators flush against the furnace pipe, at the end opposite the window. Set the electric fan inside the box containing the cardboard separator. These separators straighten the swirling air current from the electric fan.

3. To suspend a Paper Glider in a Wind Tunnel:

2. Equipment:
Airplane rubber
Notebook reinforcement rings
Glue
Pin

Purchase airplane rubber (by the yard) at a hobby shop. Slip one end of the rubber between two notebook reinforcement rings and glue them together.

Fasten this end to the glider as shown in the diagram; then anchor with a pin.



V. PARTS OF AN AIRPLANE

Suggested Activities

A. *The Airframe*

1. Display pictures of airplanes from magazines, books, airlines, etc.
2. Review the basic parts of a plane that make up the plane's airframe, wing, fuselage, tail assembly and landing gear and their functions.

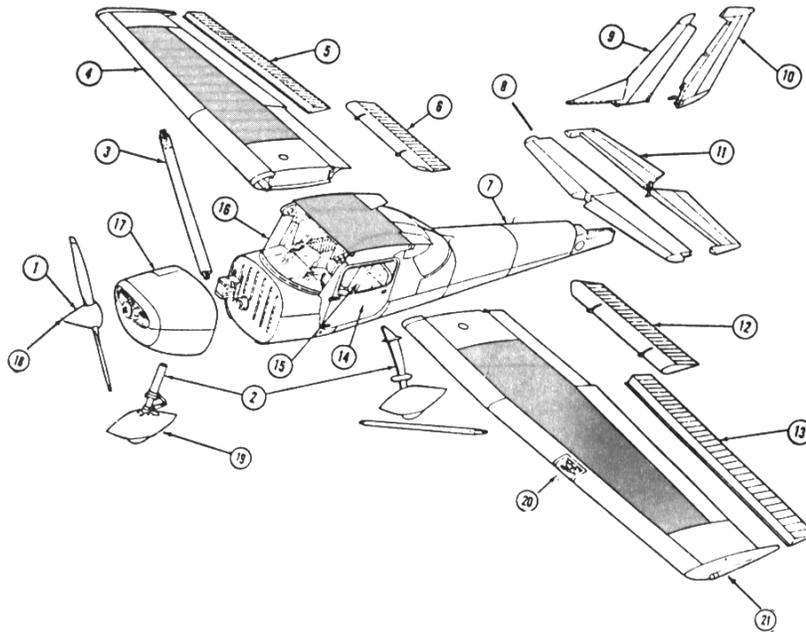
B. *Control Surfaces*

3. Introduce the term *control surfaces as parts* which control the stream of air over parts of the plane.
4. Use a model airplane to identify the control surfaces of the wing: flaps and ailerons. Raise and lower the flaps and illustrate with a chalkboard drawing the effect of each of these on the airstream. Explain how these are used in takeoff and landing.
5. Use a model airplane to identify the ailerons on the wings. Use a chalkboard drawing to demonstrate the effect that moving the ailerons has on the air and, in turn, the plane.
6. Construct model gliders from kits or balsa wood. Experiment with raising the right aileron and lowering the left. Launch the glider and observe its movement through the air. Then raise the left aileron and lower the right before launch. Compare the results of the two trial launches.
7. Use the model airplane or glider to identify parts of the tail assembly: rudder, horizontal stabilizer and elevators.
8. Use the model gliders made by students. Raise the elevators and launch the glider. Bring the elevators level with the stabilizer and launch the glider. Discuss the results.
9. To observe the effects of moving the rudder, bend the rudder to the left and launch the glider. Then turn the rudder to the right and launch. Notice the directions the glider takes.
10. Experiment with the reaction produced by a combination of controls:
 - a. Left ailerons down, right up, rudder right, elevators down.
 - b. Left aileron down, right up, rudder right, elevators up.
 - c. Left aileron up, right down, rudder left, elevators down.
 - d. Left aileron up, right down, rudder left, elevators up.
11. Have students record their observations of the movements of the plane produced by

combinations of controls and explain reasons for the various movements.

12. Identify the *leading edge* and the *trailing edge* of the wing.
13. Use duplicated copies of an airplane drawing. Have students label the parts of the airframe and the surface controls.
14. Make paper gliders and experiment with control surfaces.
15. Use the model airplane or glider to practice basic movements of an airplane.
 - a. Pitch-- the motion of the plane around the lateral axis.
 - b. Yaw--the movement of the plane around the vertical axis.
 - c. Roll--motion of the plane around the longitudinal axis.
16. Discuss *camber* and *chord* of an airfoil and how they may differ.

The Main Parts Of an Airplane



- | | |
|---------------------------------|------------------------------|
| 1. Propeller | 12. Left Wing Flap |
| 2. Landing Gear | 13. Left Wing Aileron |
| 3. Wing Strut | 14. Door |
| 4. Wing | 15. Seat |
| 5. Right Wing Aileron | 16. Windshield |
| 6. Right Wing Flap | 17. Engine Cowl |
| 7. Fuselage | 18. Spinner |
| 8. Horizontal Stabilizer | 19. Wheel Cover |
| 9. Fin and Dorsal | 20. Landing Light |
| 10. Rudder | 21. Wing Tip Light |
| 11. Elevator | |

VI. AERONAUTICAL CHARTS

A. Aeronautical Charts: Maps used by airplane pilots. Each chart represents a small part of the country. It shows the cities, highways, railroads, rivers, and lakes which the pilot can see from the air. It gives the heights of hills and mountains, and shows such things as water towers and high wires. Every landmark which can be seen from the air is shown on the charts.

1. Display sectional charts or, if possible, distribute one per four or five students.
2. Locate the Chart's symbol key. Copy the symbols for:
 - a. cities
 - b. small communities
 - c. single buildings
 - d. highways
 3. railroads
 - f. radio towers
 - g. power lines
 - h. VOR stations
 - I. airports
3. Call attention to and discuss possible meanings of the colors on the chart.
4. On the legend of the chart find the scale which shows colors. Practice finding locations with various altitudes.
5. Discuss the importance to the pilot of the colors on the chart.
6. Choose two towns or cities and "fly" the route between them. Measure the mileage with a ruler. Write it in inches and centimeters.

B. Using the Scale of Miles

All aeronautical charts have been drawn to exact scale. The smallest scale is on an *aeronautical planning chart*; it is 80 miles to an inch. This inch on the chart represents 5,000,000 inches on the ground. The largest scale is on the *sectional* it is a ratio of approximately 1:5,000,000, which means that on this chart; 8 miles to an inch. This is a ratio of approximately 1:500,000.

Example: What is the distance between two airports, if they are six inches apart on an aeronautical chart which has a scale of 32 miles to one inch?

Solution: 1 inch on the chart represents 32 miles on the ground. Multiply 32×6 to find the distance. $32 \times 6 = 192$ miles.

Example: If the scale on a chart is 80 miles to one inch, how many inches will represent a distance of 340 miles?

Solution: 80 miles on the ground is shown by 1 inch on the chart. Divide 340 by 80 to find the number of inches.

$$340 \div 80 = 4 \frac{1}{4} \text{ inches}$$

PROBLEMS: Find the missing number in each of the following problems:

- | Scale | <i>Distance on Chart</i> | <i>Distance on Ground</i> |
|-----------------|--------------------------|---------------------------|
| 1. 1 in.=16 mi. | 4 in. | ? |
| 2. 1 in.=16 mi. | $3 \frac{1}{2}$ in. | ? |
| 3. 1 in.=80 mi. | $4 \frac{3}{4}$ in. | ? |
| 4. 1 in.=32 mi. | ? | 100 mi. |
| 5. 1 in.=8 mi. | ? | 75 mi. |
| 6. ? | $9 \frac{1}{2}$ in. | 304 mi. |
| 7. ? | $7 \frac{1}{8}$ | 114 mi. |
| 8. 1 in.=32 mi. | $5 \frac{11}{16}$ in. | ? |
9. If the scale of a chart is 1:1,000,000, what is the approximate number of miles on the ground which is represented by one inch on the chart/
 10. If the scale of a chart is 32 miles to one inch, what is the approximate ratio of the scale?

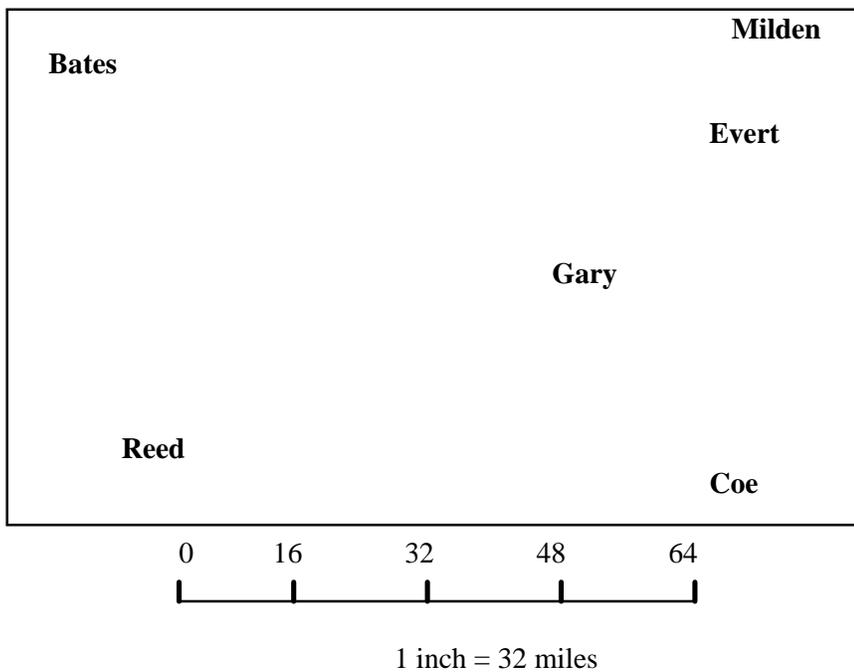
C. Using the Chart to Find Directions. The scale on a chart is easily used to find the distance between any two places on the chart. Use a ruler to measure between the two places. Then change the measurement to miles by the use of the scale.

Example: Cameron is $1 \frac{7}{8}$ inches from Vinson on a chart which has been drawn on a scale of 1 inch to 8 miles. What is the distance between Cameron and Vinson?

Solution: Multiply $1 \frac{7}{8}$ by 8 to find the number of miles. $1 \frac{7}{8} \times 8 = 15 \frac{7}{8} \times 8 = 15$ miles.

Practice Chart

Six cities are shown on a practice chart which has been prepared for use in the problems below. Notice the scale which is shown beneath the chart.



PROBLEMS: Find the distance in inches on the chart and the distance in miles on the ground for the following problems.

<i>Flight</i>	<i>Distance in Inches</i>	<i>Distance in Miles</i>
1. Reed to Evert	2 5/8 in.	84 mi.
2. Bates to Coe	?	?
3. Reed to Gary	?	?
4. Gary to Coe	?	?
5. Bates to Gary	?	?

Use the scale of 1 inch to 80 miles for the following.

- | | | |
|--------------------|---|---|
| 6. Reed to Coe | ? | ? |
| 7. Bates to Milden | ? | ? |
| 8. Bates to Evert | ? | ? |
| 9. Milden to Evert | ? | ? |
| 10. Reed to Milden | ? | ? |
11. Use the practice chart and a scale of 1 inch = 64 miles to find the distance between Bates and Reed.
12. Use a scale of 1 inch = 16 miles to find the distance between Coe and Milden.

ANSWER SHEET

Answers to Scale Problems

Distance On:

Scale	Chart	Ground	
1. 1 IN = 16 MI	4 IN =	64 MI	(16 x 4 = 64)
2. 1 IN = 16 MI	3½ IN =	56 MI	(16 x 3½ = 56)
3. 1 IN = 80 MI	4¾ IN =	380 MI	(80 x 4¾ = 380)
4. 1 IN = 32 MI	3 1/8 IN =	100 MI	(100 ÷ 32 = 3 1/8)
5. 1 IN = 8 MI	9 3/8 IN =	75 MI	(75 ÷ 8 = 9 3/8)
6. 1 IN = 32 MI	9½ IN =	304 MI	(304 ÷ 9½ = 32)
7. 1 IN = 16 MI	7 1/8 IN =	114 MI	(114 ÷ 7 1/8)
8. 1 IN = 32 MI	5 11/16 IN =	182 MI	(32 x 5 11/16 = 182)

9. Known: Sectional Chart Scale of 1:500,000 is about 8 miles to the inch then a scale of 1:1,000,000 is about 16 miles to the inch; or, $1,000,000 \div 12 \div 5280 = 15.78 = 16$ MI.
10. Known: $1:1,000,000 = 16$ miles then 32 miles = 1 IN at a scale of 1:2,000,000; or, $2 \times 12 \times 5280 = 2,027,520$ or about 2,000,000.

Answers to Chart Problems

- Scale 1 IN = 32 MI (Distance in inches x 32 =)
1. 25/8 IN = 84 MI
 2. 2¾ IN = 88 MI
 3. 13/8 IN = 44 MI
 4. 1 IN = 32 MI
 5. 1¾ IN = 56 MI

- Scale 1 IN = 80 MI (Distance in inches x 80 =)
6. 2 1/8 IN = 170 MI
 7. 2½ IN = 200 MI
 8. 2 11/16 IN = 215 MI
 9. 5/16 IN = 25 MI
 10. 29/16 IN = 205 MI

- Scale 1 IN = 64 MI (Distance in inches x 64 =)
11. 1¼ IN = 80 MI

- Scale 1 IN = 16 MI (Distance in inches x 16 =)
12. 17/16 IN = 23 MI

VII. THE COMPASS

A. *The Magnetic Compass:* An aircraft instrument which shows the pilot his direction of flight.

A magnetic compass is designed in such a way that the needle always points to the north, which is considered to be 0° . The other directions are known in relation to north (0°).

1. Display a magnetic compass or picture of compasses. Show both mounted and unmounted types.
2. Examine and discuss the pocket compass hikers carry.
3. Explain the difference between *magnetic* north and *true* north.
- *4. Draw a large circle. Make a vertical line through the center and an intersecting horizontal line through the vertical line. Label the points N, S, W, and E. These represent the cardinal points on a compass.
5. *Intercardinal points* are points between the cardinal points. Locate northwest, northeast, southwest and southeast on the circle.
6. Draw a circle. Draw a vertical line through the circle. Label the points 0° and 180° . Add points 90° and 270° by drawing a horizontal line through the circle, intersecting the vertical

*A good series of lessons on fundamental principles with worksheets and pictures for duplication is included in *Aviation for the Elementary Level*, Beech Aircraft Corporation, Wichita, KS 67201.
line. Complete the circle by marking points at intervals of 30 degrees. Determine that a circle has 360 degrees. Compare this drawing to a compass dial.

7. Use a pencil to “fly” a course or heading of 30° , 150° , 24° , 30° , etc.
8. Display pictures of a magnetic compass used in an airplane.
9. Discuss the markings on the magnetic compass. Explain that the compass card remains stationary while the aircraft rotates around it, allowing the compass heading (direction being flown) to show in the compass “window.”
10. Practice reading the magnetic compass.
11. Construct simple, working compasses.

B. Using the Compass to Find Directions.

PROBLEMS: Find the number of degrees for each of the directions below.

<i>Direction</i>	<i>Number of Degrees</i>
1. North	0°
2. East	?
3. South	?
4. West	?
5. Northeast	?
6. Southeast	?
7. Southwest	?
8. Northwest	?
9. What direction is shown by a compass reading of 360° ?	

10. What angle of flight is taken by a plane which flies exactly halfway between west and northeast?

NOTE: More complicated problems on use of the magnetic compass may be found in *Pilot's Handbook of Aeronautical Knowledge*.

VII. ALTIMETER

A. Altimeter: An instrument in an airplane which shows the height (altitude) of the plane above sea level.

1. Display an altimeter or picture of altimeter.
2. Describe the function and operation of altimeters.
3. Practice reading the altimeter.
4. Construct altimeter dials using paper plates. Attach construction paper hands with brass paper fasteners.
5. Practice reading and setting the paper "altimeters."
6. Make rough sketches of objects such as office buildings, towers, mountains, etc. and their heights above sea level. Solve problems concerning:
 - a. the altitude a plane must fly in order to be 1,000 feet, 5,000 feet, etc. over each object.
 - b. how high over each object a plane will be if it flies at 2,000 feet; 3,200 feet; 4,500 feet, etc.

B. Temperature Changes with Differences in Altitude
The average loss of heat is about 3.5 degrees Fahrenheit for each thousand feet increase in altitude up to about seven to ten miles.

Example: If the temperature on the ground is 80°, what is the temperature of the air at 5,000 feet altitude?
Solution: The temperature change is 3.5° per 1,000 feet. Since the altitude is 5,000 feet, multiply 3.5 by 5. $3.5 \times 5 = 17.5$ degrees. The temperature at 5,000 feet is $80^\circ - 17.5^\circ = 62.5^\circ$.

PROBLEMS

<i>Ground Temperature</i>	<i>Temperature at:</i>	<i>Air Temperature</i>
1. 70°	3,000 feet	?
2. ?	4,000 feet	56°
3. 83.5	7,000 feet	?
4. ?	20,000 feet	0°
5. 88.5°	?	76°
6. 0°	2,000 feet	?
7. 74.5°	11,000 feet	?
8. 65°	12,000 feet	?
9.	If the temperature is 22° at 21,000 ft. altitude, what is the ground temperature?	
10.	What is the temperature at 17,000 ft. altitude when the ground temperature is 92°?	

NOTE: Problems dealing with altimeter corrections to compensate for atmospheric changes in pressure and temperature may be found in the *Pilot's Handbook of Aeronautical Knowledge*, FAA, 1979.

ANSWERS

<i>Ground Temperature</i>	<i>Altitude</i>	<i>Ambient Temperature</i>
1. 70°	3,000 FT	59.5°
2. 70°	4,000 FT	56°
3. 83.5°	7,000 FT	59°
4. 70°	20,000 FT	0°
5. 88.5°	3,570 FT	76°
6. 0°	2,000 FT	-7°
7. 75.5°	11,000 FT	36°
8. 65°	12,000 FT	23°
9. 95.5°	21,000 FT	22°
10. 92°	17,000 FT	35.5°

IX. TACHOMETER

A. Tachometer: A device for counting. It is used to show the number of revolutions per minute (RPM) of the aircraft engine. An airplane needs one tachometer for each of its engines.

1. Display a tachometer or pictures of tachometers.
2. Recall the automobile odometer. Discuss the similarity of its functions with the function of a tachometer.
3. Construct tachometer dials from paper plates and attach hand with a brass paper fastener.
4. Practice reading tachometers at various settings.
5. Relate revolutions per minute (RPM) to speeds on a stereo turntable such as 33 1/3, 45 and 78 RPM.
6. Discuss reasons why automobiles have only one odometer, but airplanes may have two or more tachometers.

B. An airplane's engines often run faster than its propellers. For example, on one airplane, the most efficient engine speed is 3,000 RPM, while the most efficient propeller speed is about 1,500 RPM. A set of reduction gears permits the engine to run at 3,000 RPM while the propeller turns at 1,500 RPM. When this happens, the ratio of engine RPM to propeller RPM is two to one (2:1). Other ratios can range from 4:3 to 3:1.

Example: If an airplane runs at 3780 RPM, and the ratio of engine speed to propeller speed is 3:1, what is the speed of the propeller?

Solution: Since this ratio of engine speed to propeller speed is 3:1, divide 3780 by 3 to find the propeller speed. $3780 \div 3 = 1260$ RPM.

Example: What is the ratio between an engine speed of 3050 RPM and a propeller speed of 1220 RPM?

Solution: Divide 3050 by 1220 to find the ratio. $3050 \div 1220 = 2.5$

The ratio is 2.5 or 2.5:1. This ratio may also be written as 5:2.

PROBLEM: Find the missing number in each of the problems.

	<i>Engine Speed</i>	<i>Propeller Speed</i>	<i>Ratio of Engine Speed to Propeller Speed</i>
1.	3160 RPM	?	2:1
2.	3400 RPM	?	5:2
3.	?	1450 RPM	3:2
4.	?	1250 RPM	3:1
5.	3150 RPM	1575 RPM	?
6.	2800 RPM	1680 RPM	?
7.	1800 RPM	?	4:3
8.	?	1470 RPM	16:7
9.	What is the ratio between an enginespeed of 2910 RPM and a propeller speed of 1940 RPM?		
10.	If an airplane propeller turns at 1120 RPM and the ratio of engine speed to propeller speed is 12:7, what is the engine speed?		

ANSWERS

	Engine Speed	Propeller Speed	Ratio	
1.	3160	1580	2:1	$(3160 \div 2 =)$
2.	3400	1360	5:2	$(3400 \div 5 \times 2 =)$
3.	2175	1450	3:2	$(1450 \times 3 \div 2 =)$
4.	3750	1250	3:1	$(1250 \div 3 =)$
5.	3150	1575	2:1	$(3150 \div 1575 =)$
6.	2800	1680	1:7:1	$(2800 \div 1680 =)$
7.	1800	1350	4:3	$(1800 \div 4 \times 3 =)$
8.	3360	1470	16:7	$(1470 \times 16 \div 7 =)$
9.	2910	1940	1:5:1 (3:2)	$(2910 \div 1940 =)$
10.	1920	1120	12:7	$(1120 \times 12 \div 7 =)$

NOTE: Problem #6 solution could be written 17:10 in the same manner as problem #9, i.e., 1.1:1 - 3:2.

X. TIME IN AVIATION

The clock is one of the most useful flight instruments. It is used in the figuring of such important items as the time required for a flight, the average ground speed, and determining the airplane's position. All these are more crucial in aviation than in ground transportation.

A. Military Time is measured in twenty-four hour units.

The unit begins at 0001 hours after midnight and continues to the following midnight which is 0000 hours. Twelve o'clock noon is 1200 hours. Time after noon begins at 1300 hours and continues to midnight.

	Standard	Military
Examples:	9:00 a.m.	0900 hours
	10:30 a.m.	1030 hours
	12:00 noon	1200 hours
	1:15 p.m.	1315 hours
	6:49 p.m.	1849 hours
	10:30 p.m.	2230 hours
	12:00 p.m.	0000 hours

PROBLEMS:

Change the standard time to military time.

- | | |
|--------------|----------------|
| 1. 1:40 p.m. | 6. 12:30 p.m. |
| 2. 5:16 p.m. | 7. 11:49 p.m. |
| 3. 7:39 p.m. | 8. 2:32 p.m. |
| 4. 6:47 p.m. | 9. 12:20 p.m. |
| 5. 8:35 p.m. | 10. 11:43 p.m. |

Change the military time to standard time.

- | | |
|---------------|----------------|
| 1. 0430 hours | 6. 2041 hours |
| 2. 1619 hours | 7. 1022 hours |
| 3. 0003 hours | 8. 2347 hours |
| 4. 1317 hours | 9. 0103 hours |
| 5. 2148 hours | 10. 1508 hours |

B. Time Required for a Flight

Example: What will be the length of a flight of 329 miles at an average speed of 94 MPH?

PROBLEMS:

Solution: Divide 329 by 94.

$329 \div 94 = 3 \frac{1}{2}$ hours = 3 hours, 30 minutes.

Find the time required for flights in problems such as the following:

	<i>Average</i>	
<i>Distance</i>	<i>Ground Speed</i>	<i>Time</i>
1. 275 miles	110 MPH	?
2. 180 miles	45 MPH	?
3. 585 miles	130 MPH	?
4. 2475 miles	275 MPH	?
5. 1875 miles	600 MPH	?
6. 195 miles	65 MPH	?

7. 230 miles 100 MPH ?
8. 280 miles 120 MPH ?
9. What is the length of a flight of 450 miles at an average speed of 90 MPH?
10. A plane flies 370 miles at an average ground speed of 95 MPH. What time is required for the flight?

C. Average Ground Speed.

The problems in this section are applications of the familiar TIME, RATE and DISTANCE formulas which can be used in problems of automobiles and trucks as well as aircraft. Average ground speed is the RATE in these problems:

$$\text{RATE} \times \text{TIME} = \text{DISTANCE}$$

$$\text{DISTANCE} \div \text{TIME} = \text{RATE}$$

$$\text{or } \frac{\text{DISTANCE}}{\text{TIME}} = \text{RATE}$$

$$\text{DISTANCE} \div \text{RATE} = \text{TIME}$$

$$\text{or } \frac{\text{DISTANCE}}{\text{RATE}} = \text{TIME}$$

Example: What is the average ground speed for a flight of 400 miles in 3 hours, 20 minutes?

Solution: Divide 400 by $3\frac{1}{3}$ hours:

$$400 \div 3\frac{1}{3} = 400 \div \frac{10}{3} = 400 \times \frac{3}{10} = 120 \text{ MPH}$$

PROBLEMS: Find the average speed for each of the flights in problems such as the following:

	Distance	Time	Average Ground Speed
1.	285 miles	3 hours	?
2.	780 miles	6½ hours	?
3.	800 miles	51/3 hours	?
4.	1260 miles	4 hours, 40 min	?
5.	2875 miles	6 hours, 15 min	?
6.	675 miles	4½ hours	?
7.	594 miles	3 hours, 18 min	?
8.	245 miles	2 hours, 27 min	?
9.	What is the ground speed for a flight of 595 miles in three and one-half hours?		
10.	An airplane flies 1104 miles in 4 hours, 36 minutes. What is the average ground speed?		

D. Fuel Consumption.

Having plenty of gasoline is more important in aviation than in driving a car. The pilot must be able to plan his flight to have more fuel than he needs. He figures the amount of gasoline his plane should use, and adds a reserve for emergencies. A fuel reserve of 25% is usually allowed.

1. Figuring the amount of fuel without a reserve:

Example: How much gasoline will be used in a flight of two hours, twenty minutes if the engine uses six gallons per hour?

Solution: Change two hours, twenty minutes to 140 minutes. Multiply $\frac{140}{60}$ by 6 to find the amount of fuel used.

$$\frac{140}{60} \times 6 = 14 \text{ gallons}$$

PROBLEMS: Find the number of gallons of fuel which will be used in flights.

Flying Time	Fuel Consumption Per Hour	Amount of Fuel Used
1. 3 hrs., 30 min.(3.5)	6 gallons	?
2. 5 hrs., 20 min.(5.33)	12 gallons	?
3. 4½ hrs (4.5)	5 gallons	?
4. 4 hrs., 22½ min. (4.375)	20 gallons	?
5. 6 hrs., 10 min.(6.17)	40 gallons	?
6. 2 hrs., 24 min.(2.4)	5 gallons	?
7. 3 hrs., 12 min.(3.2)	15 gallons	?
8. 5 hrs., 5 min. (5.08)	18 gallons	?

9. How much gasoline will be consumed in a flight of three hours, forty minutes if the engine uses nine gallons per hour?

$$(3.67 \times 9 + ?)$$

10. An airplane makes a flight of six hours, forty-two minutes. The engine uses an average of 18 gallons of gasoline per hour. How much gasoline will be consumed during the flight?

2. Figuring the amount of fuel needed with a percentage reserve:

Example: How much gasoline will be needed for a flight of four hours, twenty minutes if the engine uses nine gallons per hour, and a fuel reserve of 25% is desired?

Solution: Change four hours, twenty minutes to 4.33 hours. Multiply 4.33 by 9 to find the amount of fuel to be used.

$$4.33 \times 9 = 38.57 \text{ gallons.}$$

Since a fuel reserve of 25 % is to be carried, 38.57 gallons = 75% of total fuel to be carried.

Divide 38.57 by .75 to find the total amount of fuel.
 $38.57 \div .75 = 51.96$ gallons.

PROBLEMS: Find the number of gallons of gasoline needed to include a 25% fuel reserve for the flights.

Flying Time	Fuel Consumption Per Hour	Amount of Fuel Used	Amount to Include 25% Reserve
1. 3 hrs, 40 min.	9 gallons	?	?
2. 2 hrs., 30 min.	8 gallons	?	?
3. 2 hrs., 24 min.	5 gallons	?	?
4. 4 hrs., 20 min.	12 gallons	?	?
5. 6 hrs., 50 min.	24 gallons	?	?

Find the number of gallons of gasoline needed to include a 20% fuel reserve for the flights.

6. 4 hours	6 gallons	?	?
7. 3 hours, 30 min.	9 gallons	?	?
8. 3 hours, 20 min.	15 gallons	?	?
9. 8 hours, 20 min.	24 gallons	?	?
10. 4 hours, 10 min.	18 gallons	?	?

ANSWERS

A. Military Time

- | | |
|-------------|--------------|
| 1. 0140 HRS | 6. 1230 HRS |
| 2. 1716 HRS | 7. 2349 HRS |
| 3. 1939 HRS | 8. 1432 HRS |
| 4. 1874 HRS | 9. 1220 HRS |
| 5. 2035 HRS | 10. 2343 HRS |
| | |
| 1. 4:30 AM | 6. 8:41 PM |
| 2. 4:19 PM | 7. 10:22 AM |
| 3. 12:03 AM | 8. 11:47 PM |
| 4. 1:17 PM | 9. 1:03 AM |
| 5. 9:48 PM | 10. 3:08 PM |

B. Time Required for a Flight

Distance	Average GS	Time
1. 275 miles	110 MPH	2.5 = 2 HRS 30 MIN
2. 180 miles	45 MPH	4 HRS
3. 585 miles	130 MPH	4.5 = 4 HRS 30 MIN
4. 2475 miles	275 MPH	9 HRS
5. 1874 miles	600 MPH	3.125 = 3 hRS 7 1/12 MIN
6. 195 miles	65 MPH	3 HRS
7. 230 miles	100 MPH	2.3 = 2 HRS 18 MIN
8. 280 miles	120 MPH	2.33 = 2 HRS 20 MIN
9. 450 miles	90 MPH	5 HRS
10. 370 miles	95 MPH	3.9 = 3 HRS 54 MIN

C. Average Ground Speed

Distance	Time	Average GS
1. 285 miles	3 HRS	95 MPH
2. 780 miles	6 1/2 HRS	120 MPH
3. 800 miles	5 1/3 HRS	150 MPH
4. 1260 miles	4 HRS 40 MIN	270 MPH
5. 2875 miles	6 HRS 15 MIN	460 MPH
6. 675 miles	4 1/2 HRS	150 MPH
7. 594 miles	3 HRS 18 MIN	180 MPH
8. 245 miles	2 HRS 27 MIN	100 MPH
9. 595 miles	3 1/2 HRS	170 MPH
10. 1104 miles	4 HRS 36 MIN	240 MPH

D. Fuel Consumption

1. No Reserve

	Flying Time	Fuel Consumption* (GPH)	Fuel Used (Total)
1.	3.5 HRS	6 GPH	21 GAL
2.	5.33 HRS	12 GPH	64 GAL (63.96)
3.	4.5 HRS	5 GPH	+ 23 GAL (22.5)
4.	4.275 HRS	20 GPH	+ 88 GAL (87.5)
5.	6.17 HRS	40 GPH	+ 247 GAL (246.8)
6.	2.4 HRS	5 GPH	12 GAL
7.	3.2 HRS	15 GPH	48 GAL
8.	5.08 HRS	18 GPH	+ 92 GAL (91.44)
9.	3.66 HRS	9 GPH	+ 33 GAL (32.94)
10.	6.7 HRS	18 GPH	+ 121 GAL (120.6)

*GPH--Gallons Per Hour

+Round up to next gallon (a safety consideration)

2. With Reserve

	Flying Time	GPH	Fuel Used		Plus Reserve
1.	3.66 HRS	9 GPH	33 GAL (32.94)	25%	44 GAL (43.92)
2.	2.5 HRS	8 GPH	20 GAL	25%	27 GAL (26.6)
3.	2.4 HRS	5 GPH	12 GAL	25%	16 GAL
4.	4.33 HRS	12 GPH	52 GAL (51.96)	25%	70 GAL (69.28)
5.	6.83 HRS	24 GPH	164 GAL(163.92)	25%	219 GAL (218.56)
6.	4.0 HRS	6 GPH	24 GAL	20%	30 GAL
7.	3.5 HRS	9 GPH	32 GAL (31.5)	20%	40 GAL (39.375)
8.	3.33 HRS	15 GPH	50 GAL (49.95)	20%	63 GAL (62.44)
9.	8.33 HRS	24 GPH	200 GAL(199.2)	20%	249 GAL
10.	4.17 HRS	18 GPH	76 GAL (75.06)	20%	94 GAL (93.83)

VI. Air Speed Indicator

A. Airspeed Indicator: An instrument which shows the speed at which an airplane is moving through the air.

1. Display an airspeed indicator or a picture of one.
2. Discuss similarities of the airspeed indicator and an automobile speedometer.
3. Discuss differences of the airspeed indicator and automobile speedometer in terms of:
 - a. what is being measured
 - b. the units of measurement used.
 - c. relationship to actual speed
4. Practice "reading" airspeed indicator.
5. Explain the purpose of the green arc, white arc, yellow arc, and red line.
6. Determine the "caution range" of the airspeed indicator.
7. Review the relationship between miles and nautical mile ($1 \text{ knot} = \frac{1}{1.6} \text{ statute miles per hour}$).

B. Corrections to Indicated Air Speed for Differences in Altitude

The *indicated air speed* on the airspeed indicator will seldom be the actual speed of the airplane. Airspeed indicators show airspeed at sea level. As the plane rises in altitude, the air becomes thinner and it does not offer as much pressure against the airspeed indicator. Therefore, the indicator reads less than the *true air speed*.

True Air Speed can be obtained by adding two percent of the *indicated air speed* for each thousand feet of altitude.

Example: What is the true air speed of a plane which flies at 5000 feet altitude if the *indicated air speed* is 150 miles per hour?

Solution: The correction is two percent per thousand feet of altitude. Since the altitude is 5000 feet, multiply 2% by 5.

$$2\% \times 5 = 10\%$$

10% of the indicated air speed is 150 miles per hour is $150 \times .10 = 15$.

True air speed is $150 + 15 = 165$ miles per hour.

PROBLEMS: Find the true air speed in problems such as the following:

<i>Altitude</i>	<i>Indicated Air Speed</i>	<i>True Air Speed</i>
-----------------	----------------------------	-----------------------

1. 2000 feet 100 MPH ?
2. 3500 feet 110 MPH ?
3. 3000 feet 180 MPH ?
4. 10000 feet 210 MPH ?
5. 2700 feet 115 MPH ?
6. 4500 feet 140 MPH ?
7. 6000 feet 120 MPH ?
8. 2500 feet 90 MPH ?
9. What is the true air speed of a plane which flies at an altitude of 7000 feet with an indicated air speed of 230 MPH?
10. What is the true air speed of a plane which flies at 16000 feet with an indicated air speed of 312 MPH.

C. Corrections for Wind.

An airplane is carried along with movements of the air in which it flies. Because the air is nearly always in motion, the speed of the plane over the ground may be either more or less than the *indicated air speed*.

Ground speed can be obtained by adding the wind speed to the *indicated air speed* whenever the plane flies *with* the wind. This is called a tail wind.

Example: What is the ground speed if the indicated speed is 110 MPH and the plane is flying with a tail wind of 20 MPH?

Solution: Ground speed is $110 + 20 = 130$ MPH.

Ground Speed can also be obtained by subtracting the wind speed from the *indicated air speed* whenever the plane is flying *against* the wind. This is called a head wind.

Example: What is the ground speed if the *indicated air speed* is 110 MPH and the plane is flying against a wind of 20 MPH?

Solution: Ground speed is $110 - 20 = 90$ MPH.

PROBLEMS: Find the ground speed in such problems as the following:

<i>Indicated Air Speed</i>	<i>Head Wind</i>	<i>Tail Wind</i>	<i>Ground Speed</i>
1. 115 MPH		25 MPH	?
2. 120 MPH	15 MPH		?
3. 160 MPH		27 MPH	?
4. 70 MPH		15 MPH	?
5. 95 MPH	13 MPH		?
6. 160 MPH	27 MPH		?
7. 105 MPH	5 MPH		?
8. 260 MPH	40 MPH		?
9.	What is the ground speed of an airplane which flies at true air speed of 215 MPH in a tail wind of 55 MPH?		

10. What is the ground speed of an airplane which flies at a true air speed of 160 MPH into a head wind of 32 MPH?

NOTE: More complicated problems of aerial navigation in which winds are at various angles to the line of flight can be found in the *Private Pilot Airplane Written Test Guide*.

- D. Corrections for Differences in both Altitude and Wind
Corrections must be made for both altitude and wind to find the *actual ground speed* of an airplane.

Example: An airplane flies at 6000 feet altitude into a head wind of 30 MPH at an indicated air speed of 120 MPH. What is its ground speed?

Solution: The correction for altitude is 2% per thousand feet of altitude. Since the altitude is 600 feet, $6 \times 2\% = 12\%$. Multiply the indicated air speed of 120 MPH by .12.

$$120 \times .12 = 14.40 \text{ MPH}$$

True air speed is $120 + 14.40 = 134.40 \text{ MPH}$.

Subtract the head wind of 30 MPH from the true air speed,

$$134.40 - 30 = 104.40 \text{ MPH}$$

ground speed.

PROBLEMS: Find the ground speed in problems such as:

Altitude	Indicated Air Speed	Head Wind	Tail Wind	Ground Speed
1. 1.3000 ft.	120 MPH		15 MPH	?
2. 4000 ft.	150 MPH	20 MPH		?
3. 8000 ft.	160 MPH		25 MPH	?
4. 3350 ft.	165 MPH		19 MPH	?
5. 4700 ft.	215 MPH	27 MPH		?
6. 6500 ft.	170 MPH	30 MPH		?
7. 5000 ft.	110 MPH	40 MPH		?
8. 7000 ft.	140 MPH		35 MPH	?

9. What is the ground speed of an airplane which flies at 7500 feet at an indicated air speed of 135 MPH into a head wind of 30 MPH?
10. A plane flies with a 40 MPH tail wind at an indicated air speed of 135 MPH into a head wind of 30 MPH?

B. True Airspeed Computations

ANSWERS

	Altitude (ft)	IAS (MPH)	TAS (MPH)	Correction Factor
1.	2,000	100	104	+ 4%
2.	3,500	110	117.7	+ 7%
3.	3,000	180	190.8	+ 6%
4.	10,000	210	252	+ 20%
5.	2,700	115	121.2	+ 5.4%
6.	4,500	140	152.6	+ 9%
7.	6,000	120	134.4	+ 12%
8.	2,500	90	94.5	+ 5%
9.	7,000	230	262.2	+ 14%
10.	16,000	312	411.84	+ 32%

IAS-- Indicated Airspeed

TAS--True Airspeed

CAS--Calibrated Airspeed--Not Used Here--Instrument Error Correction

C. Corrections for Wind (Groundspeed)

	TAS (MPH)	Headwind (MPH)	Tailwind (MPH)	Groundspeed (MPH)
1.	115		25	140
2.	120	15		105
3.	160		27	187
4.	70		15	85
5.	95	13		82
6.	160	27		137
7.	105	5		100
8.	260	40		220
9.	7500 FT - 135 MPH - 30 MPH Headwind (-)			$135 + 15\% = 155.25 - 30 = 125.25$
10.	4000 FT - 120 MPH - 40 MPH Tailwind (+)			$120 + 8\% = 129.6 + 40 = 169.6$

D. Altitude and Wind Airspeed Corrections

	Altitude (FT)	IAS (MPH)	Headwind (MPH)	Tailwind (MPH)	Groundspeed (MPH)
1.	3000	120		15	142.20
2.	4000	150	20		142.00
3.	8000	160		25	210.60
4.	3350	165		19	195.05
5.	4700	215	27		208.21
6.	6500	170	30		162.10
7.	5000	110	40		81.00
8.	7000	140		35	194.60
9.	7500	135	30		125.25
10.	4000	120		40	169.60

XII. MEASUREMENT

Applications:

- A. Linear Measure
 - 1. Length of runways
 - 2. Distances traveled
 - 3. Altitude
 - 4. Dimensions of planes; wing span, length of fuselage, etc.
- B. Square Measure
 - 1. Areas of wings having different shapes
 - 2. Areas of airports, runways and taxi strips
- C. Volume Measure
 - 1. Fuel capacity
 - 2. Oxygen tank capacity
 - 3. Cargo space
- D. Angular Measure
 - 1. Speed of propeller rotation
 - 2. Wind drift angle
 - 3. Heading
 - 4. Angle of climb
 - 5. Glide path
 - 6. Sweepback of wing
 - 7. Propeller pitch
- E. Force and Pressure Measure
 - 1. Lift
 - 2. Drag
 - 3. Gravity
 - 4. Thrust
- F. Time Measurement
 - 1. Time zones
 - 2. Estimated time of arrival (ETA)
 - 3. Time spend en route (ETE)

- G. Rate of Speed
 - 1. Air speed
 - 2. Ground speed
 - 3. Wind speed
- H. Temperature
 - 1. Engine temperature
 - 2. Free air temperature

SAMPLE PROBLEMS:

- 1. The area of a wing is $105\frac{3}{8}$ square feet. Change the fraction of a square foot to square inches.
- 2. An airline flight from New York to Los Angeles takes 7 hours and 55 minutes. If the plane leaves New York at 9:30 a.m. Eastern Time, what time would it arrive in Los Angeles, which is Pacific Time?

ANSWERS

- 1. Area of wing is $105\frac{3}{8}$ FT²
Change fraction of FT² to IN²
 $1 \text{ FT}^2 = 144 \text{ IN}^2$ $144 \times \frac{3}{8} = 54 \text{ IN}^2$
- 2. Departs 9:30 AM + 7 HRS 55 MIN
Arrives 5:25 PM Eastern Time
Arrives 2:25 PM Pacific Time (-3 HRS)

XIII. FRACTIONS, DECIMALS AND PERCENT

Applications

- A. Problems related to a change in:
 - 1. Airspeed
 - 2. Ground speed
 - 3. Amount of fuel
 - 4. Amount of cargo
 - 5. Number of passengers
 - 6. Altitude
- B. Specifications of various aircraft may be compared:
 - 1. Maximum airspeed in level flight
 - 2. Maximum effective ceiling
 - 3. Take-off speed
 - 4. Landing speed
 - 5. Horsepower of engine

 - 6. Weight limitations
 - 7. Dimensions

SAMPLE PROBLEMS:

1. If one mile per hour equals 1.467 feet per second, find the missing numbers:

Miles Per						
Hour:	1	8	200	158½	87.25	
Feet Per						
Second	1.467	?	?	?	?	?

2. A U.S. gallon is .8327 of a British Imperial gallon. If the fuel capacity of a transport plane is 3278 U.S. gallons, how many British Imperial gallons does it hold?

ANSWERS

Fractions, Decimals and Percent

Sample Problems:

1.

MPH	1	8	200	158½	87.25
FPS	1.467	11.736	293.4	232.52	127.99

 FPS = MPH x 1.467 inversely MPH = FPS x .682
2. 3278 US Gallons x .8327 = 2729.6 British Gallons
 U.S. GAL x .8327 = British Gallons inversely British Gallons x 1.2009 = US Gallons

XIV Graphs

Applications:

- A. Altitude records
- B. Comparative transportation safety records
- C. Number of passengers carried each year
- D. Number of planes manufactured
- E. Number of airports of each class
- F. Speed records of aircraft.

2. $V_m = 19.76(d)^{1/3}$ is the formula for the maximum vertical speed of an airplane in miles per hour when the drag loading in pounds per square foot is known. Make a graph of this formula from $d = 0$ to $d = 100$. Use the graph to compute the following:

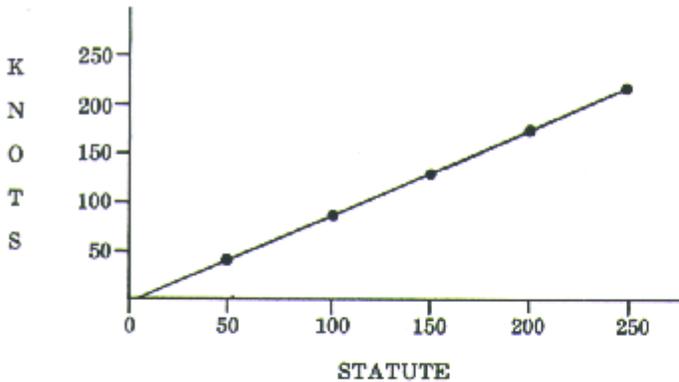
d					
lbs/sq. ft.	16	35	56	78	95
V_m					
M.P.H.	?	?	?	?	?

SAMPLE PROBLEMS:

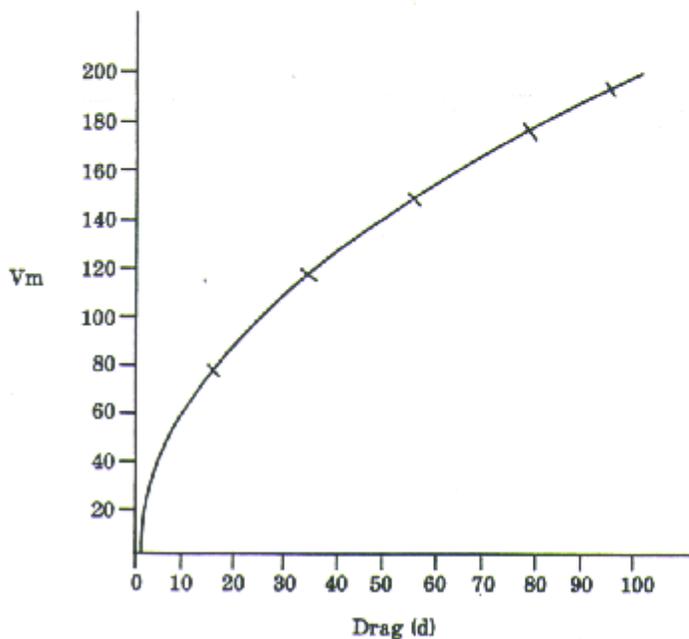
- 1.. $K = .86845$ is the formula for changing statute miles per hour to knots. Make a graph of this formula from $S = 0$ to $S = 250$.

GRAPHS:

1.



$$\begin{aligned}
 \text{Kts} &= .86845 \times \text{Statute MPH} \\
 &\times 50 = 43.42 \text{ Kts} \\
 &\times 100 = 86.85 \text{ Kts} \\
 &\times 150 = 130.27 \text{ Kts} \\
 &\times 200 = 173.69 \text{ Kts} \\
 &\times 250 = 217.11 \text{ Kts}
 \end{aligned}$$



$$\begin{aligned}
 V_m &= 19.76(d)^{1/3} = 19.76 \sqrt[3]{d} \\
 d = 16 \text{ then } V_m &= 4(19.76) = 79 \\
 35 &= 118 \\
 56 &= 148 \\
 78 &= 174 \\
 95 &= 192
 \end{aligned}$$

XV. READING AND INTERPRETING MAPS AND GLOBES

Suggested Activities

1. Discuss the shape of the earth.
2. Demonstrate flatness of the earth at the poles.
3. Demonstrate with an orange:
 - a. the entire globe
 - b. small part of the globe
 - c. half of the globe
4. Explain how a mercator projection is made.
5. Draw a rough outline of the continents on a large grapefruit; slit the top and bottom with a knife; remove the peel in four sections, press flat and display.
6. Using globe, determine lines of latitude and longitude.
7. Use a basketball as a globe; draw prime meridian and lines of longitude; draw equator and lines of latitude.
8. Demonstrate suntime during daytime and night with a globe and flashlight.
9. Discuss degrees of longitude and latitude.
10. Determine to the nearest degree the location of several world cities.
11. Make cones in math. Place over the globe and trace reflected lines on the surface.
12. Discuss conic projection.
13. Define degree in nautical miles and in minutes of an arc. (One degree = 60 nautical miles: one minute of arc = 1 nautical mile.)
14. List the important features of a map based on a Mercator projection.
15. Draw a map of the area around your city.
16. Draw a map of your state: put in cities, highways, railroads, airports, etc.
17. Draw maps of air routes of the state features.
18. Make a vocabulary chart pertaining to maps and map symbols.
19. Draw a map with different altitudes shown in various colors.
20. Learn the relationship between time and distance.
 $360^{\circ} = 24$ hours $10^{\circ} = 40$ min.
 $15^{\circ} = 1$ hour $1^{\circ} = 4$ min.
21. Draw a chart of time zones in the U.S.
22. Discuss the International Date Line.
23. Discuss the need for a uniform time system.
24. Discuss the effects of traveling through many time zones on the human body (jet lag).
25. Discuss daylight saving time.
26. Show examples of the time in various major cities of the world when it is noon in your community.

XVI. CHANGING CONCEPTS OF TIME AND SPACE

Suggested Activities;

1. Trace Man's progress in relationship to transportation.
 2. Compare speeds of early means of transportation with today's airplane travel speeds.
 3. Figure distances from the U.S. to five countries in hours instead of miles.
 4. Make a comparison of the number of passengers carried by airlines today with that of twenty years ago.
 5. Display different kinds of maps used in aviation. Explain how the airplane conquers mountains and oceans, thus bringing countries closer together.
 6. Study the history of mail. Make posters showing a comparison of the time and cost of sending airmail and regular mail.
 7. Organize a pen-pal club with students in overseas schools. Display letters, pictures, etc. from them. Learn some of the foods, customs, religion and economic problems of the country.
 8. Compare construction and maintenance of highways and airways.
 9. Discuss the role of aviation in the aid to people in disaster areas and for medical emergencies.
 10. Construct a bar graph showing the length of time it took the Pilgrims to come to America and the time it takes to fly from Europe to America today.
 11. Invite a travel agent to discuss foreign travel.
 12. Compare the rate of air accidents with those of other modes of travel.
 13. Write to a travel agency requesting free materials on a city in a foreign country.
 14. Review: Early history of communications from Native American picture writing to the airmail stamp.
 15. Discuss the nearness to the whole world that has been made possible by the development of aviation.
 16. Discuss reasons for the rapid improvement in the science of weather since the development of the airplane and of the weather satellite.
 17. Discuss:
 - a. Population trends toward centers of air transportation.
 - b. Cultural understanding due to increased travel in foreign countries.
 - c. Why aviation is the main transportation system in Alaska.
 - d. Influence of aviation in increasing technology in underdeveloped nations.
 - e. The increasing change in our thinking about distances in terms of travel time rather than miles or kilometers.
18. Make a list of well-known artists in the fields of entertainment and sports and discuss how air travel makes it possible for them to appear in different countries from one day to another.

XVII. LISTENING, SPEAKING AND VIEWING

SUGGESTED ACTIVITIES:

1. Interview someone in the field of aviation.
Determine appropriate questions to ask to gain the information needed.
2. Relate personal experiences with air planes.
3. Research skywriting. List some problems involved such as winds or clouds.
4. Invite a CB operator to your class and have the CB demonstrated for you.
5. Build a class crystal radio from a commercial kit or from "scratch." A radio show or reference books will help you.
6. Check the newspapers for radio and television programs about aviation.
7. Participate in a panel discussion on such topics as:
"The History of Aviation"
"Recent Developments in Rockets"
"Effects of Aviation on My Community."
8. Pretend you are the air traffic controller and make a tape of control tower to plane conversations.
9. Identify why oral communication is important at an airport.
10. Practice the correct way to request an airline reservation.

XVIII. READING COMPREHENSION

Suggested Activities

1. Read the poem "Darius Green and His Flying Machine." During discussion recall examples of:
 - a. cause and effect relationships
 - b. motives and feelings from actions and speech of characters
 - c. clues to time and location
 - d. foreshadowing of later events.
2. Research ideas of flying as expressed by early man in mythology and legend:
 - a. The Greek god, Hermes
 - b. Pegasus
 - c. Phaeton
 - d. Daedalus and Icarus
 - e. Sinbad, the sailor and his roc
 - f. Arabs and their flying carpets
 - g. Simon, a Roman magician in the time of Rome, who tried to fly from a tower.
 - h. Wan-Hoo, the Chinese ruler who attached 47 large rockets to his chariot to fly to the moon.
3. Compare ancient myths and legends about flight to modern tales about space creatures, little green men from Mars, etc.
4. Write original stories concerning "Impossible" developments in aviation or space in the future.
5. Read one space-related story (real science fiction, or fantasy). Make notes on elements of fact and those of opinion. Give a written or oral report on the story.
6. Read one biography relating an act of bravery and heroism in aviation such as:
 - a. Amelia Earhart
 - b. Charles Lindbergh
 - c. Eddie Rickenbacker
 - d. Richard Byrd
 - e. James "Jimmy" Doolittle
 - f. Charles "Chuck" Yeager
7. Make a brief outline of the above biography:
 - a. Early Life
 - b. Accomplishments
 - c. Later, Life
8. Use this outline to present an oral or written report.
9. Find out about the Japanese custom of flying kites to celebrate children.
10. Not all birds can fly. Use library reference books to find two birds that cannot fly. Write a brief explanation to tell why these birds cannot fly.
11. Read several aviation articles from a current magazine and condense them into a report.

XIX. MEDIA CENTER SKILLS

Suggested Activities

1. Using the library's card files, prepare a bibliography of books and materials on topics such as:
"The History of Aviation"
"The Theory of Flight"
2. Use the Reader's Guide to Periodical Literature to list references on aviation which might be obtained and which are not currently in your library pertaining to the above topics.
3. Read extensively on any one topic of aviation, using cross-references in the encyclopedia.
4. Prepare a list of aviation words and arrange them in proper alphabetical order. Determine the proper pronunciation from the dictionary. (Use such words as air, aileron, aeronautics, aerology, aviation, avionics, aerodynamics, altitude, altimeter, audio, etc.)
5. Use an atlas to find the latitude and longitude of five cities.
6. Find flight records broken in the last ten years.
7. Locate the fiction and nonfiction materials on aviation.
8. List magazines currently in print which deal with aviation.
9. View films, filmstrips, and slides showing aircraft development.
10. Use the card catalog to copy the author card, title card and subject for a book such as:
 - a. *Fat Man from Space* by Daniel M. Pinkwater.
 - b. *Jack the Bum and the UFO* by Janet Schulman.
 - c. *The Year of the Flying Machine* by Genevive Foster.
11. Prepare a research paper listing all references, footnoting, etc.
12. Locate the following materials in your library. Tell the content and purpose of each:
 - a. card catalog
 - b. dictionaries
 - c. encyclopedias
 - d. atlas
 - e. almanac
 - f. Reader's Guide to Periodical Literature
 - g. newspaper
 - h. current magazines
 - I. Who's Who
 - j. biographical reference books
 - k. literature reference books
 - l. vertical file
 - m. microfilm

- n. listening centers
- o. computer

XXII. SOME AEROSPACE CAREERS

- A. Specialized Training--specific occupational training including high school, trade and technical education, on-the-job training, and formal study at college:

Aerial Photographer	Pilot
Assembler	Skilled Craftsperson
Communication Technician	Technical Illustrator
Computer Technician	Technician
Drafting Technician	Teletypist
Fabrication Inspector	Tool and Die Maker
Machine Operator	

- B. College and University Training--training which leads to a baccalaureate degree after four years of study:

Airport Manager	Mathematician
Architect	Production Technician
Communication Specialist	Quality Control Inspector
Computer Programmer	Research Technician
Data Systems Analyst	Safety Engineer
Development Technician	Sanitarian
Industrial Planner	Science Writer

- C. Advanced Study and Specialized Experience--graduate study and specific work experiences:

Aeronautical Engineer	Geographer
Astronaut	Geologist
Astronautical Engineer	Group Engineer
Astronomer	Industrial Engineer
Biomedical Engineer	Mechanical Engineer
Chemist	Metallurgist
Chief Flight Mechanic	Meteorologist
Dietician	Molecular Biologist
Engineer	Operations Analyst
Environmental Engineer	Physicist
Flight Surgeon	Research Mathematician

XXIII. CAREERS IN AVIATION

Suggested Activities

1. Discuss the magnitude of the industry including such factors as:
 - a. Production
 - b. Operations
 1. Airplane
 2. Airport
 - c. Maintenance
 - d. Research and development
2. Review classifications of aviation: commercial, general and military.
3. Prepare charts showing a comparison of aviation industry growth with other industries.
4. List as many aviation jobs as possible in a ten minute period and compile these into a master list.
5. Group aviation careers into categories such as:
 - a. Services
 - b. Technical
 - c. Manufacturing
 - d. Sales
 - e. Special purpose flying
6. Collect pamphlets and booklets on careers found in the field of aviation. (See Materials and Resources in this section.)
7. Display pictures to class showing participation in various aviation occupations.
8. Arrange an aviation career corner in the classroom or library.
9. Write a letter to the personnel department of an airline company requesting information on career opportunities.
10. Set up appointments at a nearby airport to interview persons in various job categories. Tape record your interview and present it to the class.
11. Discuss the importance of aptitudes and interests in choosing a career.
12. Research and report on an aviation career. Discuss duties, working conditions, qualifications, training requirements, earnings and hours.
13. Organize a Career Day at your school. Arrange to invite speakers, show films, arrange exhibits, etc.
14. Select a city in which an aviation industry is located. Write the Chamber of Commerce for information on employment.
15. Invite a "career" Air Force person to speak to the group.
16. Discuss:
 - a. How does one learn about job openings?
 - b. What steps are taken to apply for a job?
17. Collect job advertisements from newspapers, magazines, etc. and make a classified section.
18. Discuss terminology, abbreviations, etc. in job advertisements.
19. Write a job advertisement for a position that interests you.
20. Fill out job applications to gain experience in applying for any position.
21. Discuss personal traits that interviewers take note of, such as good grooming, posture, punctuality, etc. Emphasize the importance of first impressions.
22. Read materials on interviewing techniques.
23. Conduct class interviews for specific jobs.
24. Make a list of schools offering training in a job you would like.
25. Discuss and list types of engineers employed in aviation. Explain some functions of computer specialists in aviation.
26. List aviation careers that may require a license.
27. Discuss benefits to the science of meteorology due to the growth of aviation.
28. Discuss the implications of aviation growth on other fields.
29. List aviation careers by the training required to enter the occupation.
30. Discuss how a change in government spending affects an industry like aviation.
31. Discuss the immediate employment situation in the career field and project trends which may have bearing on future entry into the field.
32. Identify the different routes (educationally) one might take to get into a particular career, including training, licensing, certification, and other special requirements.

Bibliography of Sources for the Junior High Audience and Educators

Beach, L. (1991). World Class Geography, Instructor, 100(6), 27-28, 37-39.

Describes a Louisiana elementary school's multidisciplinary geography program. The class selects a destination to which they travel by imaginary plane (created in the classroom), and the teacher integrates cross-curricular skills. Students research and discuss the trip (resources, flight plans, passports, and travel logs) and write descriptive postcards and journalistic accounts.

Bonnet, R. & Keen, G. D. (1992). Space and Astronomy. Blue Ridge Summit, PA.:TAB

Advised for grades 5 through 8. Forty-nine science fair projects related to space and astronomy are proposed in this book. The projects include creating analogies to help people better understand astronomical figures and making three-dimensional models of planets.

Berliner, D. (1990). Distance Flights. Minneapolis: Lerner.

Recommended for grades 5 through 8. The historical development of flight is traced from Louis Bleriot, the first person to fly across the English Channel, to Dick Rutan and Jeanna Yeager, who in 1986 flew nonstop around the world.

Branley, F. (1990). The Christmas Sky. New York: HarperCollins.

Suggested for grades 3 to 7. Illustrations by Stephen Fieser. This book describes scientific explanations about the stellar and planetary configurations in the sky at the time of Jesus' birth.

Briggs, C.S., (1991). At the Controls: Women in Aviation. Minneapolis: Lerner.

Recommended for grades 5 through 8. This book includes biographies of aviators such as Jerrie Cobb, Bonnie Tiburzi and others. The author also traces the history of modern aviation through the achievements of these female aviators.

Brown, P. L., (1990). Star and Planet Spotting: A Field Guide to the Night Sky New York: Sterling.

Grades 6-8. This book guides the reader on how to identify stars in the night sky. It tells the best time to view and what to bring when out in the field at night.

Colton, Ted. Safety in the Air: A Curriculum About Flight and Air Traffic Control Designed for Middle School Students. Federal Aviation Administration, Washington, DC, 1983. ERIC, ED 284 135.

This unit of six lessons is designed to familiarize sixth, seventh, and eighth grade students with air traffic safety and the individuals who make air traffic safety possible. Each lesson consists of a statement of the concept fostered, a list of objectives, a short discussion on the focus of the unit, and instructional strategies for lesson topics and activities. The major lesson topics are: behavior and properties of air, the theory of flight and the physical properties of air that contribute to flight; the growing volume of air traffic and the necessity for air traffic control; visual flight rules; instrument flight rules, and airport terminal facilities.

Dye, Aimee. Aviation Curriculum Guide for Middle Grade School Level. Secondary School Level Coalition of Indian Controlled School Boards, Inc., Denver, Colorado, 1984. ERIC, ED 248 134.

This curriculum guide consists of activities and experiences which are organized into four sections by curricular area. These areas are: Language arts (listening, speaking, and viewing; reading comprehension; media

center skills); mathematics (aircraft instruments and aviation applications of mathematics); science (theory of flight and aviation applications of science); and social studies (history and growth of aviation; maps, charts, and globes; methods used in aerial navigation; changing concepts of time and space; and aviation careers). Each section includes a separate table of contents, an overview, a list of objectives, and lists of recommended activities and materials. The guide is designed especially for teachers who have had no special training in aviation education and is not intended to be used as a separate course of study in aviation. Consequently, it can most effectively be used to supplement existing curricular materials.

Eckford, Jim. "Ballooning Comes of Age: Make Your Own Balloon." Aviation/Space 1 (Summer 1983): 72-73.

This article provides instructions for building a working model of a hot-air balloon. It offers suggestions for a successful flight, and it indicates that children can be involved in the projects.

Ethnographic Resources for Art Education Project. Play-things as Art Objects: Ideas and Resources. Kites and Sound Making Objects and Playing Cards and Dolls Birmingham, Polytechnic Department of Art, Birmingham, England, 1983. ERIC, ED 249 158.

Here are five booklets on playthings as art objects. They draw together information about historical, ethnographic, and play traditions of various world cultures. The first two booklets are most relevant. Booklet one gives an overview of ideas and resources about kites, etc. The second booklet discussed the distribution and origin of kites--Japan, Korea, Guatemala, and Southeast Asia. There is a section included which related kites to science and provides songs about kites.

Gehardt, Lillian N, ed. Subject Guide to Children's Books in Print 1989-1990 New York; R.R. Bowker, 1989.

Here is an annual subject index which provides educators with information about which trade books are in print, their price, and publishing information. Books on our topic may be found under these subject headings: Aeronautics; Aeronautics--Accidents; Aeronautics--Biography; Aeronautics--Commercial; Aeronautics--Flights; Aeronautics--History; Aeronautics--Military; Aeronautics--Safety Measures; Aeronautics--Vocational Guidance; Air Pilots; Aircraft; Aircraft Carriers; Airplanes; Airplanes, Military; Airplanes--Models; Airplanes--Piloting; Airships; Astronautics; Astronautics--Biography; Astronauts; Balloons; Bombers; Flight; Flying Saucers; Interplanetary Voyages; Jet Planes; Kites; Manned Space Flight; Outer Space Exploration; Pilots and Pilotage; Rocketry; Rockets (Aeronautics); Space Exploration (Astronautics); Space Flight; Space Sciences; and Space Vehicles; Space Vehicles--Models; Weather; Weather Forecasting; and Women in Aeronautics.

Gerlovich, Jack and David Fagle. "Aerospace Education: A Pilot Program." Science Teacher 50 (May 1983): 68-69.

Here is a description of a K-12 aerospace program. The ninth-grade (pilot program) consists of history, applications (principles of flight, weather, navigation), research, and careers. The program evaluation is reported.

Greger, Margaret. "Kites in the Classroom." School Art 84 (January 1985): 18-20.

There are class-tested designs of easy to make and decorate kites. Inexpensive materials are used. One will find within this article instructions for making a Vietnamese kite.

Hosking, Wayne. Flights of Imagination. An Introduction to Aerodynamics National Science Teachers Association, Washington, DC, 1987. ERIC, ED 282 712.

This document traces some of the history of kites and provides teachers and students with basic information about kite components and flight dynamics. The major portion of the book provides students with 18 projects that deal with: shapes that will fly; kites compared with gliders; lift; air flow; the angle of attack in

flying kites; measurements; the use of dihedral angles for stability; positioning kites using a tail; materials; box kites; making height readings; making wind gauges; constructing a wind vane; the study of wind; the aspect ratio of a kite; the weight to area factor; wind speed and lift; and force. The appendices contain information on materials for kites, when to fly a kite, where to fly a kite, how to fly a kite, and kite safety, along with a glossary, resource list, and a bibliography. There are also included a metric conversion chart and reproducible template for making a wind gauge and a weather vane.

Housel, David C. and Doreen K.M. Housel. Come Fly With Me! Exploring Science 7-9 Through Aviation/Aerospace Concepts. Aerospace Education Council of Michigan, Lansing, Michigan, 1984. ERIC, ED 265 021.

This guide contains 67 activities dealing with various aerospace/aviation education concepts. The activities are presented in units related to physical science, earth science, and life science. There is even a section related to student involvement in the space shuttle programs. Each activity includes information on the subject, grade level, group size, time required, teaching strategy, type of activity, concept(s) fostered, and skills to be taught. In addition each activity contains objectives, materials needed, teacher background information, instructional strategies, suggested extension activities, and a code corresponding to resources found in the appendix. The resources include films, books, and additional materials arranged by topic areas. There are lists of computer software, addresses of media agencies as well as Michigan resource centers and people.

Irons, C. & Irons, R. (1991). Ideas. Arithmetic Teacher, 49(2), 18-25.

Presents activities for the K-2, 3-4, 5-6, and 7-8 levels focusing on the role of numbers and language in a real-world situation. Students are asked to discuss, describe, read, and write about numbers they find in toy shops, the post office, in sports, and at airports. Provides appropriate worksheets.

Kelch, J. (1990). Small Worlds: Exploring the 60 Moons of Our Solar System New York: Julian Messner.

Suggested for grades 6 through 8. The author provides a description of the origin, characteristics, and discovery of the sixty moons in our solar system.

Kline, R. The Ultimate Paper Airplane.

This book contains seven different models of aircraft featured on "Sixty Minutes."

Mander, J., Dippel, G. & Gossage, H. The Great International Paper Airplane Book

Competition winning entries are clearly diagrammed to cut, fold and fly.

Maurer, R. (1990). Airborne: The Search for the Secret of Flight New York: Simon & Schuster.

Suggested for grades 4-8. Illustrations by Brian Lies. The author and illustrator vividly describe the development of flight from balloons and gliders to helicopters and airplanes. The text is accompanied by activities that simulate the principles of flight.

Millsbaugh, B.P. (1992). Aviation and Space Science Blue Ridge Summit, PA: TAB Books.

This book includes projects dealing with air density, wind, balloons, gliders, spacecraft, and many more aviation and space related categories.

Milson, James L. "How High is Up?" Science and Children 25(April 1988): 18-20.

Milson describes how to construct a simple device that students can use to estimate how high their kites are flying as well as the heights of other objects.

Mirus, Edward A. Jr. "Microcomputers, Model Rockets, and Race Cars." American Annals of the Deaf 130 (November 1985): 431-435.

The industrial orientation program at the Wisconsin School for the Deaf presents problem solving situations to all seventh and eighth grade hearing-impaired students. This user-friendly software guides students individually through complex computations involving model race cars and rockets.

National Aeronautics and Space Administration. (1991). Aviation & Space Education: A Teacher's Resource Guide Washington, DC, ERIC ED 341579.

This resource guide contains information on curriculum guides, resources for teachers, computer related programs, audio/visual presentations, model aircraft and demonstration aids, training seminars and career education, and an aerospace bibliography for the primary grades. Each entry includes all or some of the following items: title, an address and phone number, and a brief description. Topics include the history of flight and model rockets.

National Aeronautics and Space Administration. Film Catalog: John F. Kennedy Space Center Washington, DC, 1987. ERIC, ED 300 277.

This is a catalog listing the titles and abstracts for over 150 films that are available from NASA on topics regarding space flight, meteorology, astronomy, NASA programs, satellites, research, safety, technology, and earth sciences. Ordering and usage information are also included. For 37 of these films, a lesson guide is provided. Each guide lists objectives, vocabulary, preparatory activities, follow up activities, evaluation ideas, related information sources, and ideas for presenting the lesson.

National Information Center for Educational Media(NICEM) Index to 35mm Educational Filmstrips 8th ed., Albuquerque, New Mexico: National Information Center for Educational Media, 1985.

Here is a three volume subject index and directory of producers/distributors with brief annotations. Other indexes available from NICEM are: Index to Educational Audio Tapes, Index to Educational Slides, and Film & Video Finder. Look under these headings: Industrial and Technical Education(look under Aviation, General Aeronautics; Aviation, Military: Aviation, Rockets; Aviation, Space; Aviation, Structures); Earth Science (then look under Physics--Aerodynamics); and Social Science (look under Transportation--Air).

O'Connell, Susan M., ed. The Best Science Books & A-V Materials for Children Washington, DC: American Association for the Advancement of Science, 1988.

The annotated bibliography is divided into two sections: books and audiovisual materials consisting of films, filmstrips, and videocassettes. In the Table of Contents of the books section, look under these headings: Mathematics and Physical Sciences (then look under Earth Sciences--Meteorology, Climatology, Atmosphere. Under the heading, Engineering, look under Transportation- Aerodynamics; air-craft types, aviators, astronautics and astronauts). In the Table of contents of the A-V Materials, also look under Earth Sciences and Engineering--Aerospace Engineering.

Oklahoma Curriculum Improvement Commission High Flight: Aerospace Activities K-12 Oklahoma State Department of Education, Oklahoma City, 1982. ERIC, ED 222 345.

Within this document are discussions of Oklahoma aerospace history, the history of flight, and the interdisciplinary aerospace activities. Each activity includes the concept, purpose, list of necessary materials, and

procedures. Topics include planets, the solar system, rockets, airplanes, air travel, space exploration, principles of flight, kites, air motion/pressure, satellites, and others. Activities include: vocabulary exercises, word searches, crossword puzzles, simple science experiments, various art and mathematics activities. Also included are key words, a list of instructional aids, and an evaluation sheet.

Pilger, Mary Anne. Science Experiments Index for Young People Englewood, Colorado: Libraries Unlimited, 1988.

Here is a guide to experiments and activities which are available in elementary and intermediate science books. The experiments run from the very easy to the more difficult. Begin by looking in the index for these subjects: Aerodynamics, Air, Airplanes, Flight, Gliders, Gravity, Kites, Rockets, Space Science, Space Travel, and Spacecraft. Then note the book entry number and page number(s). Turn to the back of the book entitled "Books Indexed." Here you will find the book citation by entry number.

Porcellino, M. (1991). Young Astronomer's Guide to the Night Sky Blue Ridge Summit, PA.: TAB

Recommended for grades 5 and up. This book is a good reference for young astronomers. It gives the reader a guide to locate constellations, identify stars, know when to look for meteor showers, and observe the changing phases of the moon. It also tells the readers how to join amateur astronomy clubs throughout the country.

Probasco, George. "In the Schools: Balloons Away." Science and Children 20(October 1982): 20-21.

Probasco discusses seventh-grade weather activities which include a comparison of barometric pressure and temperature charts and the launching of postcards attached to three helium-filled balloons.

Saterstrom, Mary H., ed. Educators Guide to Free Science Materials 30th ed. Randolph, Wisconsin: Educators Progress Service, 1989.

This is an annual annotated index which is very helpful for finding 16mm films, filmstrips, slides, audiotapes, and printed materials. Aerospace education materials are found only in the sections listing 16mm films and printed materials. Although the guide is not free, educators will find a gold mine of material which is. Subjects which will locate the most information on this subject are: Aerial Combat; Aerial Defense; Aerobatics; Aerodynamics; Aerospace Education; Air Combat; Aircraft Carriers; Aircraft Design; Aircraft History; Aircraft Industry; Aircraft Maintenance, Aircraft Rescue; Aircraft Safety; Aircraft Testing; Air Defense; Air Demonstrations; Air Force; Air Masses; Airplanes, Model; Air Navigation; Airports; Air Shows; Air Traffic; Air Traffic Control; Air Transportation; Apollo; Astronauts and Astronautics; Aviation, Model; Flight Safety; Flight Testing; Flying Boats; Gyroscopes; Jetliner; Missile Development; Missiles and Missile Testing, Missile Sites, Moon Flights; NASA; National Airspace System; Naval Aviation; Navy; Pilots and Piloting; Polar Flights; Radar; Rockets and Rocketry; Satellites; Spacecraft; Space Entry and Re-Entry; Space Exploration and Research; Space Flight; Spacelab; Space Launches, Space Medicine, Space Navigation; Spaceport; Space Programs; Space Science; Space Shuttle; Space Technology, Space Transportation, Space Walk; Test Pilots; Thunderbirds; Weather and Weather Forecasting; and Weightlessness.

Scarnati, J.T. (1992). The Hoey Machine, Science Activities 29(2), 30-35.

Describes how students can make and use Hoey Machines to learn how mechanical energy can be transferred from one object to another within a system. The Hoey Machine is made using a pencil, eight thumbtacks, one pushpin, tape, scissors, graph paper, and a plastic lid.

Schaff, F. (1990). Seeing the Sky: 100 Projects, Activities and Explorations in Astronomy New York: Wiley.

Advised for grades 4 and up. These hands-on activities and science fair projects are related to astronomy. The book offers ideas on how to set up experiments and design projects about the planets, stars, and constellations. It provides good illustrations on how to use telescopes, binoculars, and other tools of astronomy.

Schkenker, R. (1990). "Why Kites Fly. Teacher Background for DSO for DoDDS Japan Day with Kites." ED326395.

This paper discusses the physical principles behind the flying ability of both kites and airplanes. This background material was developed for a program in which a Japanese kite maker conducts kite making and flying classes in the Japan School District Elementary Schools of the Department of Defense Dependents Schools (DoDDS), Pacific Region. The two principles critical to understanding of Newton's Law and Bernoulli's Principle. While other factors such as the friction between the air particles moving over the flying surface and the material comprising the flying surface are important, these two factors explain the major components of lift and therefore the major reasons kites fly.

Schmidt, N. Discover Aerodynamics with Paper Airplanes

Activities and reproducible plans for building paper airplanes make principles of flight real.

Sneider, Cary and others. "Learning to Control Variables With Model Rockets: A New-Piagetian Study of Learning in Field Settings." Science Education 68(July 1984): 465-486.

Here is a report on the testing of the effectiveness of a program designed to teach young people how to conduct and interpret a controlled experiment. The results show that the ability to control variables can be taught using the program of activities related to designing, building, and launching model rockets.

Spitzer, Michael. "Tie Your Lesson to a Kite." Outdoor-Communicator 13(Fall 1982): 15-18.

Spitzer describes kites and kite flying in different countries and throughout history. He notes that the same principles govern kite behavior and the flight of airplanes.

Stafford, Alva R. Earth Science. Grade 8. Houston Independent School District, Houston, Texas, 1981. ERIC, ED 242 556.

This curriculum guide is designed for use with the Charles E. Merrill textbook, "Focus on Earth Science: and laboratory manual, teaching guide, and student review and reinforcement guide. There are supporting materials provided in the appendix which includes activities on rockets, measurements, and tides; tips for maintaining saltwater aquariums, etc.

Strickler, Mervin K., Jr. Federal Aviation Curriculum Guide for Aviation Magnet School Programs Federal Aviation Administration, Washington, D.C., 1994. AHT-100-1-94.

This publication is designed to provide the following: a brief history of the role of aviation in motivating young people to learn; examples of aviation magnet activities, programs, projects and school curriculums; documentation of the benefits of aviation education for students; examples of what one person can do to facilitate aviation magnet education activities, projects, programs, curriculums; curricular and program models for use, adaption or modification; identification of resources for planning a program of aviation education; information about and examples of curricula to prepare for the many career opportunities in aviation and transportation; and guidelines and information for FAA Aviation Education Counselors.

Strickler, Mervin K., Jr. Guidelines for Federal Aviation Administration Regional Aviation Education Coordinators and Aviation Education Facilitators Federal Aviation Administration, Washington, DC, 1983. ERIC ED 247 118.

Information in this document is on the history of aerospace/aviation education, FAA educational materials, aerospace/aviation curricula, FAA responses to requests from schools and colleges, etc. In the appendices there is additional information which includes: the scope of aerospace education; a list of aerospace course opportunities in various subject areas; a guide to FAA aviation education supplementary materials (listing materials by curricular areas for primary, intermediate grade, and junior high school levels; and a list of FAA, CAP, and National Aeronautics and Space Administration regional offices).

Stine, G. H. Handbook of Model Rocketry 6th edition

This revised and updated editions of model rocketeer's "bible" show how to safely build, launch, track, and recover model rockets- and have fun doing it.

Strongin, H. & Others. Science on a Shoestring 2nd edition

Often elementary and junior high teachers search for effective, inexpensive, and easy-to-understand science activities. This document was designed with those teachers and their students in mind. It provides hands-on science activities that focus around three components: (1) themes broad, unifying ideas that pervade science, math and technology; (2) processes-- the techniques used to develop and test scientific concepts; and (3) concepts-- including the vocabulary and the key information children need to develop and communicate scientific ideas. Over 45 activities related to matter, change, and energy are presented.

Turner, Thomas N. "Flight-of Fancy: Teaching the Lure and Love of Flight to Elementary School Students."Social Studies 79(January-February 1988): 37-38.

This article describes how the history of flight can be used to encourage elementary school children to read, discuss, and do research on an aviation topic. It outlines several activities that can be used to encourage student interest.

Vogt, G. (1992). Rockets: A Teaching Guide for an Elementary Science Unit on Rocketry Washington, DC.: National Aeronautics and Space Administration.

Utilizing simple and inexpensive equipment, elementary and middle school science teachers can conduct interesting, exciting, and productive units on rockets. This teaching guide includes a brief history of rockets, Newton's law of motion, many activities, and a list of commercial suppliers of model rocketry.

Wolff, Kathryn, Susan M. O'Connell, and Valerie J. Montenegro. (editors)AAAS Science Book of Lists 1978-1986 Washington, D.C.: American Association for the Advancement of Science, 1986.

In the Table of Contents, look under the heading, Engineering, then find the subheading, Transportation (Aviation: historical and biographical treatment and Aerodynamics, aircraft types).

The journal articles and ERIC documents listed have been located via the Silver Platter Compact Disk Program 1983- May 1995.

VIDEOS

AVIATION

Freedman, R. (1992). The Wright Brothers: How They Invented The Airplane [Videocassette]. American School Pubs. SRA School Group.

This is an informative biography of how the Wright brothers, Orville and Wilbur took to the sky.

Holiday Video Library. The History of Flight Video [Videocassette].

An hour presentation of the first flying machines to the sophisticated space shuttle. Students relive the excitement of these amazing inventions.

National Free Flight Society. (1993). The Joy of Flying Free [Videocassette].

In this video, the hobby of flying scale model aircraft is introduced with participants describing their experiences.

Westmoreland, N. (Producer & Director). (1994). Cleared to Land. [Videocassette]. Westmoreland Productions.

This hour video comes highly recommended from the Video Rating Guide for Libraries. What makes this especially captivating is the creative use of film and music to narrate the experience of flight. Suggested for Pre-Kindergarten to Primary.

JUVENILE LITERATURE

Aaseng, N. (1992). Breaking the Sound Barrier. New York: J. Messner.

Chronicles the events leading up to the breaking of the sound barrier, focusing on the test pilots who risked their lives to achieve supersonic flight.

Bendick, J. (1992). Eureka! It's an airplane!. Brookfield, CT:Milbrook Press.

Describes the development of the airplane and some of the inventions that have made it a more common means of transportation.

Berliner, D. (1990). Distance Flights. Minneapolis: Lerner.

Recommended for grades 5 through 8. The historical development of flight is traced from Louis Blériot, the first person to fly across the English Channel, to Dick Rutan and Jeanna Yeager, who in 1986 flew nonstop around the world.

Blackman, S. (1993). Planes and Flight. New York: F. Watts.

Describes some of the different devices, including hot air balloons, gliders, airplanes, and jets, used to get people into the air. Includes various projects.

Branley, F.M. (1991). The Big Dipper. New York: Harper-Collins.

Freedman, R. (1991). The Wright Brothers: How they invented the Airplane

Follows the lives of the Wright brothers and describes how they developed the first airplane.

Gallant, R.A. (1991). The Constellations: How They Came to Be New York: Four Winds.

Gunning, T. G. (1992). Dream Planes. New York: Dillon Press.

Describes some recent advances and future technological possibilities in the field of air transportation.

Haynes, R. M. (1991). The Wright Brothers. Englewood Cliffs, NJ:Silver Burdett Press.

Traces the lives of the Wright brothers and describes how they showed the world how to fly

Jennings, T.J. (1993). How Flying Machines Work New York: Kingfisher Books.

Examines, in text, labeled diagrams, and illustrations, how various types of airplanes and other flying machines work and the kinds of functions they perform. Includes instructions for related projects and experiments.

Jeunesse, G. & Verdet, J.P. (1992). The Earth and the Sky. New York: Scholastic.

Maynard, C. (1993) I wonder why planes have wings and other questions about transport New York: Kingsfisher Books.

Answers questions about transportation and vehicles, including "Do airships run on air?" and "Why don't ships sink?"

Nahum, A. (1990). Flying Machine New York: Knopf.

A photo essay tracing the history and development of aircraft from hot-air balloons to jetliners. Includes information on the principles of flight and the inner workings of various flying machines.

Pearl, L. (1994). The Story of Flight. Mahwah, N.J.: Troll Associates.

Surveys the history of aviation, from the first attempts to modern supersonic planes.

Randolph, B. (1990). Charles Lindbergh New York: Watts.

Robson, P. (1992). Air, Wind & Flight New York: Gloucester Press.

Schulz, W. A. (1991). Will and Orv. Minneapolis: Carolrhoda Books.

Taylor, J.W.R. (1990). The Lore of Flight New York: Mallard Press.

Taylor, R.L. (1993). The First Flight Across the United States: The Story of Calbraith Perry Rodgers and his airplane, the Vin Fiz New York: F. Watts.

A biography of the pioneering aviator, trained by the Wright brothers, who completed the first flight across the United States in 1911.

Welch, B. (1992). The Wright Brothers: Conquering the Sky New York: Fawcett Columbine.

Wood, T. (1993). Air Travel. New York: Thomson Learning.

Discusses the development and different parts of aircraft, how air traffic is controlled, and the effects of air transport on the world.

Kits

The various kits available through Delta Education: The Middle School Catalog, Nashua NH phone 1-800-442-5444.

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Or Kits and Supplies available through

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Juvenile Literature

----- (1992). *The Visual Dictionary of Flight*.
New York: Dorling Kindersley.

GOVERNMENT RESOURCES

The Eisenhower National Clearinghouse is to:

encourage the adoption and use of k-12 curriculum materials and programs which support national goals to improve teaching and learning in mathematics and science by providing better access to resources for all who are interested in creating an effective learning environment.

The Clearinghouse will accomplish this by:

creating and maintaining a comprehensive, multi-media collection of materials and programs which will be distributed in a timely manner through a national system using both traditional formats and advanced computing and telecommunications technologies.

Federal Aviation Administration. (1994). *Guide to Federal Aviation Administration Publications*. Washington, DC: U.S. Department of Transportation.

A helpful guide to current FAA publications.

How to Get Ahead When Things Keep Changing!

FEDIX/MOLIS

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AN ELEMENTARY AVIATION GLOSSARY

101 WORDS AND DEFINITIONS

AERODYNAMICS--Study of the forces of air acting on objects in motion relative to air.

AILERON--Control surfaces hinged at the back of the wings which by deflecting up or down helps to bank the airplane.

AIR--A mixture of gases making up the atmosphere which surrounds the earth.

AIRFOIL--A streamlined surface designed in such a way that air flowing around it produces useful motion.

AIRPLANE--A mechanically-driven, fixed-wing, heavier-than-air craft.

AIRPORT--A tract of land or water for the landing and takeoff of aircraft. Facilities for shelter, supply, and repair are usually found there.

AIRSPEED--Speed of the aircraft relative to the air through which it is moving.

AIRWAY--An air route marked by aids to air navigation such as beacons, radio ranges and direction-finding equipment, and along which airports are located.

ALTIMETER--An instrument for measuring in feet the height of the airplane above sea level.

ALTITUDE--The vertical distance from a given level (sea level) to an aircraft in flight.

AMPHIBIAN PLANE--An airplane that can land on both land and water.

ANEMOMETER--Instrument to measure speed of wind.

ASCEND--Climb.

ATMOSPHERE--Blanket of air surrounding the earth.

ATTITUDE--Position of the airplane relative to the horizon, ie., a climbing attitude, straight-and-level attitude, etc.

AVIATION--A term applied to all phases of the manufacture and operation of aircraft.

BANK--A flight maneuver in which one wing points toward the ground and the other to the sky.

BAROMETER--An instrument to measure pressure of the atmosphere.

BEACON--A light or other signal indicating direction.

CEILING--Height above ground of cloud bases.

CHART--An aeronautical map showing information of use to the pilot in going from one place to another.

CIRRUS--Type of high thin cloud.

COCKPIT--The portion of the inside of the airplane occupied by the person(s) operating the airplane, and containing the instruments and controls.

COMPASS--An instrument indicating direction.

CONTACT--Switching on the ignition of an aircraft engine. "Contact" is the word of warning that someone is about to turn on the ignition.

CONTROL TOWER--A glassed-in observation tower on the airport from which control tower operators observe and direct airport air and ground traffic.

COURSE--The direction over the earth's surface that an airplane is intended to travel.

CROSSWIND--Wind blowing from the side, not coinciding with the path of flight.

CUMULUS--Type of cloud formed in puffs or domeshaped.

CURRENT--Stream of air; also, up-to-date.

DEAD STICK LANDING--Landing made without the engine operating.

DEGREE--1/360th of a circle, or 1/90th of a right angle.

DIVE--A steep angle of descent.

DRIFT--Deviation from a course caused by crosswise currents of air.

ELEVATION--The height above sea level of a given land prominence, such as airports, mountains, etc.

ELEVATORS--Control surfaces hinged to the horizontal stabilizer which control the pitch of the airplane, or the position of the nose of the airplane relative to the horizon.

ENGINE--The part of the airplane which provides power, or propulsion, to pull the airplane through the air.

FIN--A vertical attachment to the tail of an aircraft which provides directional stability. Same as vertical stabilizer.

FLAPS--Hinged or pivoted airfoils forming part of the trailing edge of the wing and used to increase lift at reduced airspeeds.

FLIGHT PLAN--A formal written plan of flight showing route, time enroute, points of departure and destination, and other pertinent information.

FORCE--A push or pull exerted on an object.

FREIGHT--Cargo.

FRONT (weather)--Boundary of two overlapping air masses. When cold air is advancing on warm air, it is said to be a cold front; warm air advancing on cooler air is a warm front.

FUSELAGE--The streamlined body of an airplane to which are fastened the wings and tail.

GEAR--The understructure of an airplane which supports the airplane on land or water; wheels, skis, pontoons. Retractable gear folds up into the airplane in flight. Gear that does not retract is called "fixed."

GLIDE--A motion of the airplane where the airplane descends at an angle to the earth's surface.

GLIDER--A fixed wing, heavier-than-air craft having no engine.

GRAVITY--Force toward the center of the earth.

HAIL--Lumps or balls of ice falling to the earth out of thunderstorms.

HANGAR--Building on the airport in which airplanes are stored or sheltered.

HAZARD--Obstructions or objects or threats to the safety of the passenger and aircraft.

HIGH PRESSURE AREA--Mass of air characterized by high barometric pressure.

HORIZONTAL--Parallel to the horizon.

HUMIDITY--Amount of invisible moisture in a given mass of air.

INSTRUMENTS--Dials or gauges by which information about the flight, airplane, or engine is relayed to the pilot. When the pilot flies the airplane solely by reference to the gauges, he is said to be flying "on instruments."

KNOT--A measure of speed, one knot being one nautical mile per hour.

LAND--The act of making the airplane descend, lose flying speed, and make contact with the ground or water, thus ending the flight.

LANDING PATTERN--A set rectangular path around the airport which airplanes follow to land.

LIFT--An upward force caused by the rush of air over the wings, supporting the airplane in flight.

LOW PRESSURE AREA--Mass of air having low atmospheric pressure.

METEOROLOGY--The scientific study of the atmosphere.

MOISTURE--Water in some form in the atmosphere.

MONOPLANE--An airplane having one set of wings.

MULTI-ENGINE--Having more than one engine.

PARACHUTE--A fabric device attached to objects or persons to reduce the speed of descent.

PEDALS--Foot controls in the cockpit by which the pilot controls the action of the rudder.

PILOT--Person who controls the airplane.

PRECIPITATION--Any falling visible moisture; rain, snow, sleet, hail.

PRESSURE--Force in terms of force per unit area.

PROPELLER--An airfoil which the engine turns to provide the thrust, pulling the airplane through the air.

RADAR--Beamed radio waves for detecting and locating objects. The objects are "seen" on the radar screen, or scope.

RAMP--Area outside of airport buildings where airplanes are parked to be serviced or to pick up and discharge passengers and cargo.

RUDDER--Control surface hinged to the back of the vertical fin.

RUNWAY--A surface or area on the airport designated for airplanes to take-off and land.

SEAT BELT--Belts attached to the seat which fasten around the pilot and passengers to hold them firmly in their seats in bouncy air and during takeoffs and landings.

SEAPLANE--An airplane that operates from water.

SLIPSTREAM--Current of air driven back by the propeller.

STABILIZER--Horizontal surface which stabilizes the airplane around its lateral axis.

STALL--The reduction of speed to the point where the wing stops producing lift.

STATIONARY--Something that does not move is said to be stationary. A front along which one air mass does not replace another.

STRATUS--Layered clouds.

STEAMLINE--An object shaped to make air flow smoothly around it.

TACHOMETER--Instrument which measures the speed at which the engine crankshaft is turning, hence the propeller speed in r.p.m.'s (revolutions per minute).

TAIL--The part of the airplane to which the rudder and elevators are attached. The tail has vertical and

horizontal stabilizers to keep the airplane from turning about its lateral axis.

TAKE-OFF--The part of the flight during which the airplane gains flying speed and becomes airborne.

TERMINAL--Building on the airport where people board planes, buy tickets, and have their luggage handled. Flight services are frequently located at the air terminal.

THRUST--Forward force.

TRANSMITTER--Microphone, or part of the radio that sends the message.

TRICYCLE LANDING GEAR--Airplane's landing wheels, two under the wings and one under the nose.

TURBULENCE--Irregular motion of air; uneven currents of air.

TURN--Maneuver which the airplane makes in changing its direction of flight.

UPDRAFT--Vertical currents of air.

VELOCITY--Speed.

VERTICAL--Ninety degrees from the horizon.

VISIBILITY--Distance toward the horizon that objects can be seen and recognized. Smoke, haze, fog, and precipitation can hinder visibility.

VORTEX--A circular, whirling movement of air forming a space in the center toward which anything caught in the vortex tends to move.

WEATHER--Condition of the atmosphere at a given time with respect to air motion, moisture, temperature, and air pressure.

WIND--Air in motion, important to aviation because it influences flight.

WIND SOCK--A cone-shaped, open-ended cylinder of cloth to catch the wind and show its direction.

WINGS--Part of the airplane shaped like an airfoil and designed in such a way to provide lift when air flows over them.

ZOOM--The climb for a short time at an angle greater than the normal climbing angle, the airplane being carried upward at the expense of airspeed.

ANSWER SHEET

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