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ABSTRACT

This curriculum guide consists of activities and experiences which are organized into four sections by curricular area. These areas (and the major topic areas considered) are: (1) language arts (listening, speaking, and viewing; reading comprehension; media center skills); (2) mathematics (aircraft instruments and aviation applications of mathematics); (3) science (theory of flight and aviation applications of science); and (4) 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, designed especially for teachers who have had no special training in aviation education, is not intended to be used as a separate course of study in aviation. Rather, it can most effectively be used to supplement existing curricular materials. In addition, since there is much correlation between language arts, mathematics, science, and social studies, teachers are encouraged to select from the activities and materials in any area that contribute to the achievement of their teaching goals. (JN)

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Aviation Curriculum Guide

For

—Middle School Level
—Secondary School Level

by

Aimee Dye

Pursuant to Contract Number DOT-FA79WA-4399

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Office of Public Affairs
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This book resulted from a contract between the Federal Aviation Administration, the Coalition of Indian-Controlled Schoolboards and Little Wound School in Kyle, South Dakota. As a consultant to the project, Aimee Dye prepared the *Aviation Curriculum Guide* to enable the teachers at Little Wound School to integrate aviation concepts into their curriculum.

Ms. Dye, a teacher in the Arlington County, Virginia, school system, is well-known for her work in aviation and aerospace education. She has worked extensively with teacher workshops and seminars, and has lectured before regional and national meetings of aviation educators.

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INTRODUCTION

In recent years, debate about the quality of U.S. education has focused attention on the need for more and better science and math instruction to enable young people to cope with rapidly changing technology. The world of aviation is one in which technical skills and proficiency are of paramount importance. Moreover, aviation, more than many other disciplines, has an ability to inspire youth and create an excitement in a classroom setting that can spill over into other academic areas.

As part of an effort to plan for the future of air transportation, the Federal Aviation Administration is engaging in a program of Aviation Education designed to stimulate the young people of America through the use of real world, modern-day applications of aviation technology and science.

Because of its high motivational value, aviation education can contribute measurably to the development of skills in the instructional program. The activities and experiences included here are intended to show how aviation materials and data may be used to motivate learning and how, by using some of the suggested activities and materials, aviation can be taught while developing skill in the instructional areas.

This guide is designed especially for teachers who have had no special training in aviation education, for we believe that teachers need not be specialists in aviation to use aviation data and materials as a practical application of the things they teach in science, mathematics, social studies, English, etc. Teachers, however, do need practical ideas and suggestions on what aviation content to emphasize and how to obtain appropriate instructional materials.

While the original intent in writing this guide was to develop sections on both the middle school and senior high school levels, it was found that the wide range of interests at each level caused much over-lapping of content and activities. In view of this the two pieces of work have been consolidated. Each topic starts with very basic principles and shows varying levels of activities to illustrate these principles. The flexibility of this arrangement makes it possible for the teacher to accommodate the individual differences that range among the students in the class.

The content of the guide is organized into four curricular areas: language arts, math, science and social studies. Career exploration and other topics which are appropriate under more than one curricular area have been grouped arbitrarily. The four basic areas should not be considered as separate, unrelated aviation experiences. There is much correlation between the areas and the teacher is encouraged to select from the activities and materials in any area that contribute to the achievement of the teaching objectives.

The material in the guide is not to be used as a course of study in aviation nor in the several instructional areas which it involves. It can most effectively be used to supplement curricular materials of all instructional areas with aviation and guide the teacher during such ventures.

Credit for the development of this publication should be given to Mary Jo Knouff, Education Specialist in the Office of Public Affairs, Federal Aviation Administration.
Further information about the FAA Education Program can be obtained by writing to the Office of Public Affairs, Aviation Education Program, Federal Aviation Administration, 800 Independence Avenue, SW, Washington, D.C. 20591.

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LANGUAGE ARTS

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OVERVIEW

In this topic the content of aviation is used as a base for the development of functional language arts skills. The suggested activities on the following pages are designed to develop new and precise focusing skills in obtaining and communicating information and, at the same time, to teach specific aviation skills.

Emphasis on the language skills should not detract from the considerable interest and attention students give to aviation materials and data. The lively concern which children are known to have for all phases of aviation can be a source of strong motivation for the achievement of language arts objectives.

Note: The materials and activities in this section are geared to the ability levels of students in the upper elementary grades. Related, supplemental activities can be found in the social studies section of this guide.

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LANGUAGE ARTS

Specific Learnings

– To understand the importance of communications skills in air traffic control: listening, speaking and viewing.

– To develop new and precise focusing skills through listening and viewing.

– To develop skills of record-keeping and observation necessary to communicate findings in a variety of ways.

– To develop curiosity and interest in reading by exploring aviation fact and fiction in literature.

– To develop discriminating and analytical thinking skills in viewing, listening and reading.

– To develop sufficient skill to use the resources of a library or media center for information and individual reading.

I. Listening, Speaking and Viewing

Suggested Activities

1. Listen to instructor or student give a talk or play a record about aviation.
2. Listen to directions for making a paper airplane or helicopter.
3. Identify the purpose of a radio or television program about aviation (to entertain, to inform, to educate, etc.).
4. Answer who, what, when, where questions after a visual presentation (picture, filmstrip or film).
5. Interview someone knowledgeable in the field of aviation. Determine appropriate questions to ask to gain the information needed.
6. Recall, in sequence, events of a story or poem read aloud or told.
7. Relate personal experiences with airplanes.
8. Read about smoke signals used by the Indians. Use a set of diagrams which show some of the messages to report to the class.
9. Research skywriting. List some problems involved such as wind or clouds.
10. Invite a CB operator to your class and have the CB demonstrated for you.
11. Learn the special words and phrases that the airman uses. Enunciate them clearly.
12. Build a class crystal radio from a commercial kit or from "scratch." A radio shop or reference books will help you.
13. Check the newspaper for radio and television programs about aviation.
14. Use the yellow pages of the telephone directory to find aviation advertisements.
15. Determine the main idea after a visual presentation (film or filmstrip).
16. Differentiate between fantasy and reality when listening to and viewing productions.
17. Participate in a panel discussion on such topics as:
    "The History of Aviation"
    "Recent Developments in Rockets"
    "Effects of Aviation on My Community"
18. Make a tape on your recording machine imitating "control tower to plane" conversations.
19. Identify purposes for oral communication by workers at the airport.
20. Compare filmed versions of aviation stories with written work: news program versus newspaper; movie versus book.
21. Identify and discuss various types of visual or oral presentations (drama, comedy, documentary, mystery, etc.).
22. Identify forms of stereotyping in any production (male pilot, female flight attendants, black janitor, weather "man", etc.).
23. Discuss importance of precise listening, speaking and viewing skills at the airport control tower.
24. Give directions on how to get to the airport.
25. Call the weather bureau and listen to the forecast. Re-state in your own words.
26. Practice in the classroom the correct way to request an airline reservation.
27. Explain the action of the airfoil in keeping a plane aloft both with and without illustrations.

Materials and Resources

1. Talks from resource people. Radio or television programs.
2. Pencil and paper for note-taking to be used in reports.
3. Telephone directory yellow pages.
4. Current newspapers.
5. Photographs of different kinds of airplanes collected from airlines.
6. **Readings:**
   a. Donnan and Donnan, *From Raindance to Research*, McKay, 1976.
   b. Blau, Melinda E., *What Ever Happened to Amelia?*, Counterpoint, 1978.
   c. *Great Adventures That Changed Our World*, Reader's Digest Association, 1978.
   d. Ross, Frank, Jr., *Space Shuttle: Its Story and How to Make a Flying Model*, Lothrop, Lee and Shepard, 1979.
   e. Davidson, Jesse, *Famous Firsts in Aviation*, Putnam, 1975.
7. **Filmstrips:**
   a. *How Helicopters Fly.*
   b. *Controlling an Airplane.*
   c. *Jet Flight 923.*
   All from Scott Educational Division, Lower Westfield Road, Holyoke, MA, 01040.
8. **Recordings:**
   a. "Spoken English" to accompany the *Roberts English Series.* Two records per grade level at all grade levels contain demonstration lessons on oral reporting, formal and informal telephone conversations, giving directions, inter-

views, introductions, etc. May be ordered separately or in series from Harcourt, Brace and World, 1372 Peachtree Street, N.E., Atlanta, GA, 30309.

b. Records to accompany the *Patterns of Language* textbook series from the American Book Company. These include literary selections for listening and demonstration lessons on choral reading, radio drama, news reporting, etc. Available for elementary through junior high school levels.

II. 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 chair 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, 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:
   i. Early life
   ii. Accomplishments
   iii. Later life
8. Use your 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.

Materials and Resources

1. Readings:
   a. "Darius Green and His Flying Machine" by John T. Trowbridge, *Best Loved Story Poems.* Garden City Publishers, NY.
   b. Murry, Henry A., *Myth and Myth Making,* G. Broziller Company, NY.
   c. Bullfinch, Thomas, *Mythology,* Harper and Row, 1970.
   d. *Falcon Force,* Civil Air Patrol.
   e. Vent, Henry, *Birds Without Wings.*
   f. Gilleo, Alma, *Air Travel From the Beginning,* Children's Press, 1978.
   g. Hatfield, David D., *Pioneers of Aviation,* Aviation Book Company, 1976.
   h. Ault, Phil, *By the Seat of Their Pants: The Story of Early Aviation,* Dodd, Mead, 1978.
   i. Gibbs-Smith, Howard, *Aviation, A Historical Survey From its Origins to the End of World War II,* Wm. Clausen and Sons, Ltd., 1970.
   j. Mondey, David, *The International Encyclopedia of Aviation,* 1977.
2. Films:
   a. *Icarus, and Daedulus,* 6 min., animated, color. Sterling Productions, NY, 1964.
   b. *Time Flies,* Association Films, Inc., Executive Offices, 866 Third Avenue, NY 10022. Free Loan.
   c. *Kites to Capsules,* 5 min., b/w. FAA Film Service, c/o Modern Talking Picture Service, Inc., 5000 Park St., N., St. Petersburg, FL 33709.
   d. *Oh, How We Flew,* 27 min., b/w. Western Airlines, P.O. Box 92005, World Way Postal Center, Los Angeles, CA 90009.
3. Filmstrips:
   a. *Balloons and Airships*
   b. *Milestones of Flight*
   Both available from National Air and Space Museum, Smithsonian Institution, Washington, D.C., 20560.

III. 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. Look up 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. Readers' 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

Materials and Resources

NOTE: Although most libraries share the same basic arrangement and materials for research, each library will have its own unique characteristics. Before beginning this section, check with your librarian to determine the availability of materials and time for library research.

Teaching Aids:

Flight, a series of 21 two-part sound filmstrips in color. Each of the 21 titles in the series comes as a kit which includes two full-color filmstrips with accompanying audio-cassette tapes, a User's Guide, reproducible student activity sheets including enrichment and evaluation items, a wall chart for illustrating the topic and a set of 8 library cards. May be ordered separately or in series from National Air and Space Museum, Smithsonian Institution, Washington, D.C., 20560.

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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, i.e., 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 dome-shaped.

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

DEAD STICK LANDING—Landing made without the engine operating.

DEGREE—$\frac{1}{360}$ of a circle, or $\frac{1}{90}$ 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 the pitch of the

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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 take-offs 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 (rounds 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 to a certain degree.

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.

ERIC

MATHEMATICS

OVERVIEW

The materials in this topic have been devised to add to the study of mathematics some of the fundamental concepts of aviation, and to give illustrations of some of the uses to which aviation materials and data can be put in the teaching of mathematics. Knowledge of both aeronautics and mathematics are to be developed functionally through applications to the solutions of problems.

Three kinds of information are afforded the teacher of mathematics in this section:

First, there is an introduction to simple and most common aircraft instruments with suggestions for classroom or pupil activities. A group of sample problems is presented involving the use of the instruments.

Next, there is a section which outlines mathematics topics with illustrations of aviation applications. Following this there is a brief listing of problems to show the use of some of the principles and skills involved in the topic. Answers to the problems may be found on page 61.

Finally, there are listed three kinds of teaching and learning resources: mathematics textbooks, aviation materials, and films. Aviation problems frequently appear in mathematics textbooks. While the titles listed may not be in use in the school, single copies are usually available for use as supplemental references. Items listed in the aviation materials are available for purchase at low cost and will provide the teacher with many new resources for the class.

MATHEMATICS

Specific Learnings

- To acquire an elementary knowledge of the purposes and uses of the simplest and most common aircraft instruments.
- To develop skills in the use of mathematical operations through application to the solution of problems.
- To understand the use of the compass in locating position.
- To construct and interpret statistical graphs.
- To use aeronautical charts.
- To apply time, distance and rate formulas to find ground speed and fuel consumption.
- To determine the ratio between engine speed and propeller speed.
- To use and understand military time.
- To gain skill in measurement through the use of aviation data and instruments.
- To become aware of the basic mathematics requirements in the field of aviation.

ERIC

I. 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
   - e. 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 is a ratio of approximately 1:5,000,000, which means that one inch on the chart represents 5,000,000 inches on the ground. The largest scale is on the *sectional chart;* it is 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 × 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.

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

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

	Scale	*Distance on Chart*	*Distance on Ground*
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.	?	$7\frac{1}{8}$ in.	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 $1\frac{7}{8} \times 8$ to find the number of miles. $1\frac{7}{8} \times 8 = \frac{15}{8} \times 8 = 15$ 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.

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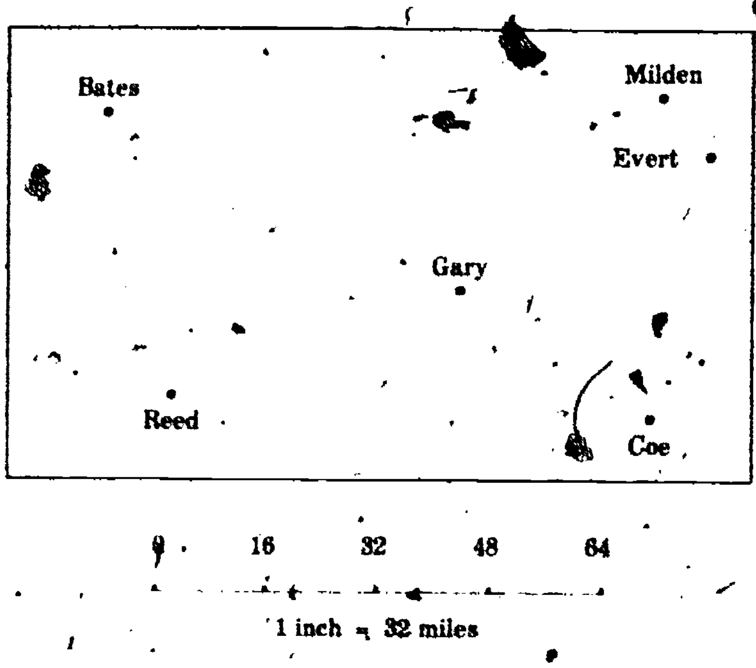
*See availability, page 41.



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

Flight	*Distance in Inches*	*Distance in Miles*
1. Reed to Evert	2⅝ 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.

II. 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 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.

*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.

7. Use a pencil to "fly" a course or heading of 90°, 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.

	Direction	*Number of Degrees*
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*, FAA, 1979.

III. 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 $80° - 17.5° = 62.5°$.

PROBLEMS

Ground Temperature	*Temperature at:*	*Air Temperature*
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.

IV. The 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 function 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 33⅓, 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 ÷ 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 ÷ 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.

Engine Speed	Propeller Speed	Ratio of Engine Speed to Propeller Speed
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 engine speed 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?

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V. Time in Aviation

The clock is one of the most useful of flight instruments. It is used in 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.

Examples:	*Standard Time*	*Military Time*
	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 a.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?

Solution: Divide 329 by 94.

329 ÷ 94 = 3½ hours = 3 hours, 30 minutes

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

Distance	*Average Ground Speed*	*Time*
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. 330 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:

RATE × TIME = DISTANCE

DISTANCE ÷ TIME = RATE

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

DISTANCE ÷ RATE = 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 3⅓ hours:

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

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

Distance	*Time*	*Average Ground Speed*
1. 285 miles	3 hours	?
2. 780 miles	6½ hours	?
3. 800 miles	5⅓ hours	?
4. 1260 miles	4 hours, 40 minutes	?
5. 2875 miles	6 hours, 15 minutes	?
6. 675 miles	4½ hours	?
7. 594 miles	3 hours, 18 minutes	?
8. 245 miles	2 hours, 27 minutes	?

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 $^{140}/_{60}$ 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 hours, 30 minutes (3.5)	6 gallons	?
2. 5 hours, 20 minutes (5.33)	12 gallons	?
3. 4½ hours (4.5)	5 gallons	?
4. 4 hours, 22½ minutes (4.375)	20 gallons	?
5. 6 hours, 10 minutes (6.17)	40 gallons	?
6. 2 hours, 24 minutes (2.4)	5 gallons	?
7. 3 hours, 12 minutes (3.2)	15 gallons	?
8. 5 hours, 5 minutes (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.

   $4.33 \times 9 = 38.57$ 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 hours, 40 minutes	9 gallons	?	?
2. 2 hours, 30 minutes	8 gallons	?	?
3. 2 hours, 24 minutes	5 gallons	?	?
4. 4 hours, 20 minutes	12 gallons	?	?
5. 6 hours, 50 minutes	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 minutes	9 gallons	?	?
8. 3 hours, 20 minutes	15 gallons	?	?
9. 8 hours, 20 minutes	24 gallons	?	?
10. 4 hours, 10 minutes	18 gallons	?	?

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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 knot = 1⅙ 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 $150 \times .10 = 15$ miles per hour.

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

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

	Altitude	*Indicated Air Speed*	*True Air Speed*
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 air 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:

	Indicated Air Speed	*Head Wind*	*Tail Wind*	*Ground Speed*
1.	115 MPH		25 MPH	?
2.	129 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*, FAA, 1979.

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 6000 feet, $6 \times 2\% = 12\%$. Multiply the indicated air speed of 120 MPH by .12.

$120 \times .12 = 14.40$ MPH

True air speed is $120 + 14.40 = 134.40$ MPH

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

$134.40 - 30 = 104.40$ MPH ground speed.

PROBLEMS: Find the ground speed in problems such as:

	Altitude	*Indicated Air Speed*	*Head Wind*	*Tail Wind*	*Ground Speed*
1.	3000 feet	120 MPH		15 MPH	?
2.	4000 feet	150 MPH	20 MPH		?
3.	8000 feet	160 MPH		25 MPH	?
4.	3350 feet	165 MPH		19 MPH	?
5.	4700 feet	215 MPH	27 MPH		?
6.	6500 feet	170 MPH	30 MPH		?
7.	5000 feet	110 MPH	40 MPH		?
8.	7000 feet	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 120 MPH at 4000 feet. What is the ground speed of the airplane?

VII. 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 spent 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?

VIII. 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	$158\frac{1}{3}$	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?

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IX. 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.

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 $S = 250$.
2. $V_m = 19.76(d)^{\frac{1}{2}}$ 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.	?	?	?	?	?

X. Angles and Triangles

Applications:

A. Angle of attack of wing
B. Angle of propeller pitch
C. Angle of sweepback of wings
D. Wind drift angle
E. Angle of climb
F. Angle of dive
G. Direction of flight

SAMPLE PROBLEMS:

1. If two airplanes leave the same airport, one flying a course of 195° and the other a course of 065°, what is the size of the angle between their courses?
2. If a pilot flying a course of 027° makes a 050° turn to the *left*, what is his new course?
3. A pilot wants his true course to be 060°; variation is plus 10°, and deviation is minus 3°.

True Heading	*Variation*	*Magnetic Heading*	*Deviation*	*Compass Heading*
060°	Plus 10°	70°	– 3°	67°
325°	Minus 10°	?	+ 5°	?
165°	Minus 14°	?	– 4°	?
355°	Plus 15°	?	– 3°	?

MATERIALS AND RESOURCES

1. Mathematics Textbooks:
   Johnson, Lindsey and Slesmick: *Algebra.* Menlo Park, California: Addision-Wesley Publishing Company, 1975.
   Nichols, Eugene D. and others. *Modern Intermediate Algebra.* New York: Holt, Rinehart and Winston, Inc., 1969.
   Peters and Schaaf. *Fundamentals of Geometry.* New York: American Book Company, 1981.
   Ulrich, James F. and others. *Geometry,* 2nd ed., New York: Harcourt Brace Jovanovich, Inc., 1972.
   Welchons, A.M. and others. *Plane Geometry.* Massachusetts: Ginn and Company, 1981.

2. Aviation Materials:
   Boyd, K.T. *Air Transport Pilot: A Comprehensive Text and Workshop for the AIP Written Exam.* Iowa State University Press, 1978.
   Buchanek and Bergin. *Piloting/Navigation With the Pocket Calculator.* New York: Tab Books, Inc., 1977.
   Christy and Erickson. *Engines for Homebuilt Aircraft.* New York: Tab Books, Inc., 1978.
   Elliott and Gurney. *Pilot's Handbook of Navigation.* Los Angeles: Aero Publishers, 1977.
   Ellis, Chris. *How to Make Model Aircraft.* New York: Arco Publishing Company, 1975.
   Federal Aviation Administration. *Pilot's Handbook of Aeronautical Knowledge AC 61-23B.* Washington: Department of Transportation, 1979.
   Kershner, William K. *The Instrument Flight Manual: The Instrument Rating.* Iowa State University Press, 1978.
   Morrison, James W. *Instrument Pilot Examination.* New York: Arco Publishing Company, 1979.
   National Ocean Survey, Distribution Division C-44), 6501 LaFayette Avenue, Riverdale, Maryland 20840. *Aeronautical Charts, Catalog of.*
   Smith, Robert T. *Your FAA Flight Exam—Private and Commercial.* Rev. Ed. New York: Tab Books, Inc., 1978.

3. Films:
   Geometry, Curves and Circles. Color Film Associates, New York.
   Geometry: Points, Angles, Lines . . . and Tigers. Bailey Films.
   The Airplane Changes Our World Map. Encyclopedia Britannica Films.

SCIENCE

34

ERIC

OVERVIEW

The scientific principles included in this section were selected after an examination of secondary school science textbooks and aviation study manuals. The activities suggested can be carried on with a minimum of equipment in any type of room.

While resource materials are listed, it is recognized that few schools will be so well equipped. Nor is it necessary that all the materials be available. Many of the films listed are available on a free loan basis and single copies of supplemental books and pamphlets can be purchased at low cost. Local libraries are also a good source of materials and resources.

In the development of the topic, an attempt has been made to start with very basic principles and show varying levels of activities to illustrate these principles. It is suggested that the teacher select from the activities and materials in this section for class use whenever they are appropriate, although the entire contents can be used to good advantage, and the format can be followed closely if this is desired.

SCIENCE

Specific Learnings

— To understand the properties of air: weight, distribution and pressure.

— To understand forces controlling and keeping a plane aloft:
Lift
Drag
Gravity
Thrust

— To understand forces giving motion:
Internal combustion
Jets
Rockets

— To understand the purpose and use of the parts of a plane.

— To develop an understanding of the basic principles of science and their applications to the flight of a plane.

— To understand general principles which underlie causes of weather and climate conditions.

— To recognize that all basic principles of electricity are involved in the operation of aircraft.

ERIC

I. 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 experiment:
   a. Drop a sheet of paper from a ladder and time its drop in minutes or seconds.
   b. Roll or crumple a second sheet of paper and drop it from the same height. Time its drop.
   c. Cut a third sheet of paper in half lengthwise. Lap the cut edge over to form a wide cone. Drop it from the same height and measure its drop.
   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 and time it.
   e. Discuss the results and generalizations that can be made.
3. Demonstrate the "braking action" of air. Drag a clothespin through the air (or water), then attach a bucket (ketchup bottle cap) and repeat. Notice the additional drag.
4. Discuss the speed of objects as they move through air and water.
5. Show air pressure. Place a medicine dropper in a glass of water. Squeeze and note that air leaves. Release and note that water replaces lost air. Hold dropper in the air and note that air pressure keeps water in the tube.
6. Identify the layers of air and some characteristics of each.
7. Explain the difference in the terms air and atmosphere.
8. Make a circle graph showing the composition of air.
9. Introduce the three forms of matter: solid, liquid and gas.
10. Explain similarities of characteristics of air and water such as weight, mass, pressure, density, etc.
11. Hold a strip of paper about 2 inches by 8 inches between the thumb and forefinger; let the paper curve over the top of the hand to form an airfoil. Blow over the top of the curved surface and observe the paper. Elicit generalizations about high and low pressure based on the demonstration above. (Bernoulli's principle).
12. Draw a picture of an airfoil. Use lines to demonstrate the stream of air over and under the airfoil.
13. Discuss the reasons for streamlining in the design of cars, trains, and airplanes.
14. Construct mobiles of inflated balloons. Observe changes in the balloons after a day or two. Discuss reasons for the changes.
15. Determine how air pressure is measured.
16. Locate pictures of barometers and explain how they work.
17. Construct a simple barometer.
18. Fill 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. Release the balloons on a windy day.
19. Relate observations of air in action such as leaves blowing, kites flying, smoke rising, curtains blowing, doors slamming, wind cooling, wet clothes drying, etc.
20. Blow soap bubbles. Discuss what they are, why they break, etc.
21. Examine and manipulate a bicycle pump or perfume atomizer. Feel the stream of air as the plunger is pushed in.

Materials and Resources

1. *Films:*
   a. *How Air Helps Us*, 11 minutes, color. Coronet Films, 1963.
   b. *Learning About Air*, 11 minutes, color. Paramount Films, 1972.
   c. *Nothing But Air*, 11 minutes, black and white, Encyclopedia Britannica Films, 1949.
2. *Readings:*
   a. Use any good elementary or junior high school General Science book depending on the level of the student.
   b. Aviation Science Activities for Elementary Grades, FAA.
   c. *Falcon Force*, Civil Air Patrol.
   d. Martin, Elizabeth F., *Aerospace Activities for Learning and Fun*, University of South Alabama, 1978.
3. *Materials for experiments:*
   a. Notebook paper
   b. Clothespin

c. Ketchup lid
d. Medicine dropper
e. Balloons
f. Paper bags
g. Drinking glass

4. Pictures of weather instruments

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II. Principles of Flight

Suggested Activities

1. Discuss weight.
2. Drop two different size and weight balls at the same time and observe that both strike the floor at the same time.
3. Discuss difference of the gravitational effect on the earth and on the moon.
4. Compute the weight of objects on the earth and the weight of the same objects on the moon.
5. List some objects that temporarily defy gravity: birds, kites, blowing leaves, gliders, airplanes, rockets, etc.
6. Draw shape of an airfoil and lines showing 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. 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?
9. Identify *Drag* as the force that opposes lift.
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. Relate 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 and lift, thrust and drag.
12. Use an encyclopedia to make a report on "Why an Airplane Flies."
13. Study pictures of airplanes to locate airfoils.
14. Draw an airplane. Use arrows to show where lift, gravity, thrust and drag occur.
15. Drop a ping-pong ball into a small funnel. Blow through the small end of the funnel. Explain the results.

Materials and Resources

1. *Films:*
    a. *Gravity—How It Affects Us,* 14 minutes, color. Encyclopedia Britannica Films, 1960.
    b. *Gravity—Weight and Weightlessness,* 11 minutes, color. Film Associates, 1963.
    c. *The Force of Gravity,* 10 minutes, black and white, Young American Films, 1949.
    d. *Making Things Move,* 11 minutes, color. Encyclopedia Britannica Films, 1963.
    e. *How An Airplane Flies,* 56 minutes, color. Shell Film Library, 1433 Sadlier Circle West Drive, Indianapolis, IN 46239. Free loan.
2. *Kits:*
    a. *Aviation Education,* Cessna Aircraft Company, Air Age Education Department, P.O. Box 1521, Wichita, Kansas 67201.
    b. *Aviation for the Elementary Level,* Beech Aircraft Corporation, Wichita, Kansas 67201.
3. *Filmstrip:*
    Lift and Thrust, Scott Educational Division.
4. *Readings:*
    a. Use any good encyclopedia.
    b. *Aviation Science Activities for Elementary Grades,* FAA.
    c. *Falcon Force,* Civil Air Patrol.
    d. *Demonstration Aids for Aviation Education,* FAA.
5. *Materials for experiments:*
    a. Two different size and weight balls such as gold ball and rubber ball.
    b. Model car.
    c. Balloon.
    d. Paper airplane pattern and paper.
    e. Pictures of airplanes.
    f. Small funnel and ping-pong ball.
6. *Teaching Aids:*
    History of Flight Tour, National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560.

III. 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, fusilage, 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 effects 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 aileron 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 movement.
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.

Materials and Resources

1. *Readings:*
   a. Philpott, Bryan, *Making Model Aircraft*, Scribner, 1978.
   b. Dilly, Martin, *This is Model Flying*. Transatlantic Arts, 1976.
   c. Keen, Martin L., *How It Works*, Grossett and Dunlap, 1976.
2. *Films:*
   a. *How an Airplane Flies*, 56 minutes, color. Shell Film Library, 1433 Sadlier Circle West Drive, Indianapolis, IN 46239. Free loan.
3. *Filmstrip:*
   a. *Controlling An Airplane*, Scott Educational Division, Lower Westfield Road, Holyoke, MA 01040.
4. *Demonstration Aids:*
   a. *Aerospace Education Teaching Aids*, Ruth Gold West, 143 S. Gable Road, Paoli, PA 19301. ($2.50)
   b. *Aviation Science Activities for Elementary Grades*, FAA.
   c. *Delta Dart Teachers' Guide*, FAA.
5. *Models:*
   Inexpensive balsa wood gliders may be ordered from:
   a. Gulliow's, Wakefield, MA 01880.
   b. North Pacific Products, Inc., Bend, OR 97701.

IV. Power for Flight

Suggested Activities

A. *Internal Combustion Engine:*
Engines that burn the fuel mixture within the engine. Also known as the reciprocating engine.
1. Define the term internal combustion.
2. Make a list of other devices that use internal combustion engines: cars, lawn mowers, boats, airplanes, etc.
3. Demonstrate the action of a reciprocating engine by comparing it to movements involved in riding a bicycle.
4. Make a study of the strokes in a piston engine.
5. Construct a simple engine motor model.
6. Discuss the function of a carburetor.
7. Make a model to show the action of a carburetor.
8. Make a diagram of an internal combustion engine.
9. Make diagrams showing the four-stroke engine.
10. Report on the types of propellers.

B. *Jet Engines:* Engines that provide thrust based on the principle of equal, opposite reaction to action.
1. Jets provide thrust with *reaction* engines.
2. Review Newton's Third Law of Motion.
3. Inflate a balloon and suddenly release it. Discuss action of reaction in view of its motion.
4. Make a drawing of a ramjet engine.
5. Discuss the functions of the sections of a ramjet engine:
   a. air intake
   b. combustion chamber
   c. exhaust outlet
6. Compare the functions of a ramjet to the five-cycle event of a reciprocating engine.
7. Make a drawing of a turbojet.
8. Compare the turbojet to the ramjet engine.
9. Discuss the purpose of the turbine and the compressor.
10. Make a drawing of a turboprop engine.
11. Compare the turboprop engine to the turbojet.
12. Explain the action of the propeller in a turbojet.
13. State some differences in a turbine engine and a reciprocating engine.
14. Explain how the amount of thrust is measured in jets.
15. Name four types of jet engines and the advantages of each.

Materials and Resources

A. *Internal Combustion Engine*
1. *Readings:*
   a. *Aerospace: The Challenge,* Civil Air Patrol.
   b. *The A.B.C. of the Internal Combustion Engine,* General Motors Corporation, General Motors Building, 3044 West Grand Avenue, Detroit, Michigan.
2. *Teaching Aids:*
   a. *Aerospace Education Teaching Aids,* Ruth Gold West, 142 S. Gable Road, Paoli, PA 19301.

B. *Jet Engines*
1. *Readings:*
   a. *Jet Engines.* The General Electric Corporation, Dept. 2-119, Schenectady, NY.
   b. *Aerospace: The Challenge,* Civil Air Patrol.
   c. Boyne and Lopez, *The Jet Age: Forty Years of Jet Aviation,* Smithsonian Press, 1979.
   d. Wilson and Scagell, *Jet Journal,* Viking, 1978.
2. *Film:*
   a. *How The Jet Engine Works,* American Gas Association, Educational Services, 1515 Wilson Boulevard, Arlington, VA 22209.
3. *Filmstrips:*
   a. *Rocket Power,* Scott Education Division, Lower Westfield Road, Holyoke, MA 01040.

C. *Rocket Engines:* A reaction engine which operates on the same principle as the jet engine. The rocket carries its own fuel and oxygen (oxidizer).

1. Discuss the early history of rockets.
2. Define *inertia.*
3. State Newton's First Law of Motion.
4. Demonstrate Newton's First Law by showing 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 some other object).
5. Discuss uses of rocket engines; experimental aircraft, satellites, space exploration.
6. Review Newton's Third Law.
7. Compare reaction engine with reciprocating engine.
8. Discuss the function of:
   a. combustion chamber
   b. exhaust nozzle
   c. liquid fuel intake
9. Discuss fuel mixture for the liquid fuel rocket.
10. Discuss advantage and disadvantage of solid fuel rockets.
11. Discuss the propellant in solid fuel rockets; its composition and shape.
12. Determine the purpose for building rockets in stages.
13. Discuss ways that jets and rockets are alike.
14. Discuss ways that jets and rockets are different.
15. Construct model rockets from kits.
16. Obtain a launch pad for rockets and hold a rocket launch.

C. *Rocket Engines*

1. *Readings:*
   a. Malone, Robert. *Rocketship: An Incredible Voyage Through Science Fiction and Science Fact.* Harper and Row, 1977.
   b. Baker, David. *Rockets,* Crown, 1978.
   c. Ames, Lee J. *Draw 50 Airplanes, Aircraft & Spacecraft.* Doubleday, 1977.
2. *Film:*
   a. *Packaging Rocket Power,* 27 minutes, color.
   Sperry Univac, Attention: Free Film Library, MS B-218M, P.O. Box 500, Blue Bell, PA 19424.
3. *Filmstrips:*
   a. *Rocket Power,* Scott Education, Lower Westfield Road, Holyoke, MA 01040.
   b. *Balloons and Airplanes.*
   c. *Milestones of Flight.*
   d. *Flight Technology*
   Available from National Air and Space Museum, Smithsonian Institution, Washington, DC 20560.

V. Aviation Applications of Basic Principles of Science

Suggested Activities

A. *Bernoulli's Principle:* If in a stream tube, the velocity of a fluid is increased, the pressure at that point, perpendicular to the direction of flow, is decreased.
   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 wings on aircraft and the effect on flight.
   5. Identify other structural parts of a plane where this principle applies.

B. *Gravitation:* Any two objects are attracted in direct proportion to size and inversely proportional to the square of the distance between their centers.

$$g = \frac{m_1 m_2}{d^2} \qquad T = 2 \quad L/g$$

   g = acceleration due to gravity
   m_1 and m_2 = mass of the two bodies
   T = period of the pendulum in sec.
   L = length of the pendulum in ft.
   1. Drop a steel ball and at the same time throw a second steel ball in a horizontal plane. Observe that both strike the ground at the same time.
   2. Locate the center of gravity in an airfoil and in other objects of various sizes.
   3. Discuss the change in gravitational effect in relation to high-altitude flight; in relation to interplanetary flight.
   4. Read and study gravity through the pendulum.

C. *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. Stack the blocks and stop and start the cart quickly.
   2. Suspend a 100 gm. weight on a spring balance. Quickly raise the balance and note the reading. Lower the balance quickly and note the decrease in weight as it starts to drop.
   3. Discuss the effects of gravity and inertia

Materials and Resources

A. *Bernoulli's Principle*
   1. *Readings:*
      a. McKinley and Bent, *Basic Science for Aerospace Vehicles.* McGraw-Hill, 1972.
      b. Talay, Theodore A., *Introduction to the Aerodynamics of Flight.* NASA, 1976.
      c. Dwiggins, Don, *Why Airplanes Fly.* Golden Gate, 1976.
      d. Adams, Frank David, *Aeronautical Dictionary.* NASA, 1969.
      e. Elmer, James D., *Theory of Aircraft Flight.* Air Force Junior ROTC, 1974.
      f. Use any good high school or junior high school physics or general science textbook depending on the level of the student.
   2. *Filmstrip:*
      a. *Lift and Thrust,* Scott Educational Division, Lower - Westfield Road, Holyoke Road, MA 01040.
   3. *Films:*
      a. *How An Airplane Flies,* 56 minutes, color, Shell Film Library, 1433 Sadlier Circle West Drive, Indianapolis, IN 46239.

B. *Gravitation*
   1. *Readings:*
      a. McKinley and Bent, *Basic Science for Aeronautical Vehicles.* McGraw-Hill, 1972.
      b. *McGraw-Hill Encyclopedia of Science and Technology,* 1960.
   2. *Films:*
      a. *Gravity:* 10 minutes, black and white, Coronet Films.
      b. *The Force of Gravity,* 10 minutes, black and white, Young America Films.

C-D. *Inertia and Law of Acceleration*
   1. *Films:*
   (The following films may be used to enrich and explain any part of the mechanics of flight and explain many clearly defined principles.)
      a. *How An Airplane Flies,* 56 minutes, color, 1976.
      b. *High Speed Flight,* 20 minutes, black and white, 1976.
      Both available on a free loan basis from Shell Film Library, 1433 Sadlier Circle West Drive, Indianapolis, IN 46239.

on the members of a plane as it suddenly changes direction.

D. *Newton's Law of Acceleration:* The force required to give an acceleration is directly proportional to the acceleration.

$F = \frac{w\,a}{g}$ f = force required to give an acceleration of 'a'.

w = 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 observe it gain speed. Try to determine its rate of acceleration.
4. Place a small amount of water in a bucket. Swing it rapidly in a vertical circle. Discuss why the water stays in the bucket.
5. Discuss the action of freely falling bodies, and the action of air resistance on these bodies.

E. *Moment of Force:* The moment is equal to the length of the arm times the force causing rotation.

1. Discuss the effect of moment of force in relation to gravity and lift. Discuss the effect that the shifting of its load would have on a plane.
2. Discuss the meaning of stability. What factors affect it?

F. *Resultant Forces:* The resultant of two or more forces is the single force that would be equal in effect to such forces.

1. Set up a vector table. Use any physics laboratory manual.
2. Discuss the relationship between thrust and drag; between weight and lift.

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

1. Have a student who has fired a shotgun give an account of his first attempt at shooting it.
2. Fill a balloon with air and release it suddenly. Account for its motion after its release.
3. Explain the relationship between thrust and weight in view of this law.
4. Tie a string to two adjacent corners of a cardboard, and pull it through the air.

H. *Friction:* Fluid friction varies as a 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 hands together briskly and note the heat generated.

c. *Making Things Move*, 11 minutes, color, Encyclopedia Britannica Films, 1963.

E. *Moment of Force*

1. *Films:*
   a. *Force and Motion*, 10 min., b/w, Coronet Films.
   b. *Energy and Its Transformation*, 11 min., b/w, Coronet Films.
   c. *An Introduction to Vectors: Coplaner Concurrent Forces*, United World, Inc., 1445 Park Avenue, New York, NY.
2. *Filmstrip:*
   a. *Moment of Force*, Scott Educational Division, Lower Westfield Road, Holyoke, MA 01040.

G. *Newton's Third Law of Motion*

1. *Filmstrips:*
   a. *Jet Power*, Scott Educational Division, Lower Westfield Road, Holyoke, MA 01040.
   b. *How the Jet Engine Works*, American Gas Association, 1515 Wilson Blvd., Arlington, VA 22209.

H. *Friction*

1. *Film:*
   a. *Swish! Science and Curveballs and Gliders*, 20 minutes, color. 1621 West 9th Street, Lawrence, KS 66044.
   (Investigates the concepts of fluid flow, Bernoulli's principle, air pressure, lift, airfoil design, streamlines and even spit balls.)

3. Place a small amount of oil between the palms and then rub them together.
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.

I. *Types of Forces*; tension, bending, compression, shear, torsion.
1. Illustrate these forces by running a thread over a pully 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 shears on paper.
4. Place two metal bars side by side with a hole through each, aligned. Insert a match through the hole and pull the bars.
5. Clamp one end of a meter stick to table. Apply rotational force to illustrate torque.
6. Discuss:
   a. Where the effect of these forces are found in the plane.
   b. Safety factors and the air regulations that pertain to them.

J. *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. Repeat the procedure to discover the effect of the wing. Compute the speed of sound.
2. Discuss the meanings of sound barrier, Mach number and sonic boom.
3. Discuss the physical effect of sound.

K. *Archimedes' Principle:* A body in a fluid is buoyed up by a force equal to the weight of the displaced fluid.
1. 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.
2. Determine the weight of air by first weighing a metal sphere of known volume containing an evacuation valve. Evacuate the sphere with a pump having a closed tube manometer so that the percentage of evacuation can be determined. With the accumulated data calculate the weight of air.
3. Discuss the manner in which Archimedes' Principle applies to lighter-than air craft.

I. *Types of Forces*
1. *Readings:*
   a. McKinley and Bent, *Basic Science for Aerospace Vehicles*, Fourth edition, McGraw-Hill Book Company, 1972.
   b. *The McGraw-Hill Encyclopedia of Science and Technology*, New York, 1971.
   c. Bauer, Frances, *Supercritical Wind Sections*, Springer-Verlag, 1975.

J. *Speed of Sound*
1. *Film:*
   a. *Beyond the Speed of Sound*, 19 min., b/w, Shell Film Library, 1433 Sadlier Circle West Drive, Indianapolis, IN, 46239.

K. *Archimedes' Principle*
1. *Films:*
   a. *The Blimps: Clearly Identified Flying Objects*, Public Relations Film Library, 114 East Market Street, Akron, OH 44316.
   b. *Research in the Atmosphere*, 25 min., color, 1969. NASA, Lyndon B. Johnson Space Center, Education Office, Houston, TX 77058.

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

1. Obtain a hydraulic jack and study its construction and action.
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.
3. Invite a mechanic to explain the action of an automobile hydraulic system.

M. *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. Examine an aneroid barometer and explain the action of it in view of this principle.
4. Explain why weather balloons burst upon reaching very high altitudes.

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

$K = \frac{V}{T}$ V = volume
T = absolute temperature

1. Fill a balloon with cool air and 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.

O. *Temperature Considerations*

1. *Measurement*
   Faherenheit
   Celsius $\frac{5}{9} = \frac{C}{F-32}$
   a. Demonstrate:
      i. The principle of a thermometer.
      ii. Various types of thermometers.
      iii. The two kinds of thermometer scales.
   b. Make an alcohol thermometer.
   c. Make a chart which shows the relationship between Fahernheit and Celsius thermometers.
   d. Solve problems in converting one scale to another.
   e. Keep temperature charts: hourly, daily, weekly, indoors, outdoors, etc.
   f. Discuss the meaning of isotherms.
2. *Insulation*
   Temperature radiation

L. *Pascal's Law*

1. *Films:*
   a. *Harnessing Liquids*, 12 minutes, black and white. Shell Oil Film Library, 1433 Sadlier Circle West Drive, Indianapolis, IN 46239.
   b. *Mechanics in Liquids*, Swank Motion Picture, Incorporated.
   c. *Pressure in Fluids at Rest*, 11 minutes, black and white, Coronet Films, 1965.

M. *Boyle's Law*

1. *Film:*
   a. *Introducing Air*, 11 minutes, color, Bailey Films, Inc. 1962.
2. *Booklets:*
   a. *Demonstration Aids for Aviation Education*, Civil Air Patrol.
   b. Martin, Elizabeth, *Aerospace Activities for Learning and Fun*, University of South Alabama.

N. *Charles' Law*

1. *Readings:*
   a. *Navigation and the Weather*, Civil Air Patrol.
   b. *Satellites at Work*, NASA.
   c. Lewis, Alexander, *Gas Power and Dynamics*, R.E. Krieger, 1978.
   d. Leavy, Thomas A., *Basic Meteorology*, Lab Manual, Grades 9-12, Allegheny Press, 1969.

O. *Temperature Considerations*

1. *Films:*
   a. *Heat—Its Nature and Transfer*, 11 minutes, black and white. Encyclopedia Britannica Films, 1958.
   b. *The Ultimate Energy*, 28 minutes, color, National Audio-Visual Center, 1976.
   c. *Waves and Energy*, 10 minutes, color, E.B.E.C., 1961.
   d. *Hot, Warm, Cold*, 5 minutes, color, MacMillan, 1972.
   e. *Story of a Storm*, 10 minutes, black and white, Coronet Films, 1950.
2. *Films:*
   a. *Nature of Energy*, 10 minutes, black and white, Coronet Films, 1948.
   b. *The Mouse-Activated Candle Lighter*, 5 minutes, color, Prism Productions, 1967.

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.
e. Discuss:
   i. Effect of the atmosphere upon the sun's rays passing through it.
   ii. Differences in absorption of land and water surfaces.
   iii. Cause of land and sea breezes.
   iv. Differences in the angle at which the sun's rays strike the earth during the seasons and how these affect weather.
   v. How thermal currents are used in gliding.
   vi. Effect of the angle of radiation on heating.
   vii. Coriolis effect on winds.

3. *Temperature Lapse*
   a. Demonstrate the temperature difference in the top and bottom of a room.
   b. Draw a chart showing variation of temperature with altitude.
   c. Discuss causes and effect of different lapse rates, of temperature inversion.
   d. Estimate the lapse rates from the type of clouds.
   e. Discuss the difference between wet and dry lapse rates.
   f. Estimate the altitude at the base of a cloud.

$$\text{altitude} = \frac{\text{surface temp.-dew point}}{\text{lapse rate} - 1}$$

   g. Estimate the cloud base temperature.

$$\text{Temp.} = \text{Temp. at earth's surface} - \frac{\text{altitude of cloud}}{\text{lapse rate 1}}$$

   (in 1000 feet)

   h. Discuss the cause of Chinook winds.

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

1. *Air has weight and mass.*
   a. Blow up a paper bag and burst it.
   b. Push inverted glass with dry paper in the bottom of a pan of water.
   c. Pour air from one beaker to another under water.
   d. Measure the volume of a balloon by releasing its air into a graduate cylinder inverted in a pan of water.
   e. Compute the weight of air in a room.
   f. Determine the density of air.

3. *Films:*
   a. *What Makes Clouds?*, 19 minutes, color, Encyclopedia Britannica Films, 1965.
   b. *Clouds Above*, 9 minutes, color, Bailey, 1964.

P. *Basic Causes of Weather*

1. *Air has weight and mass*

   Films:
   a. *Winds and Their Causes*, 10 minutes, black and white, Coronet Films.
   b. *Nothing But Air*, 11 minutes black and white, Encyclopedia Britannica Films, 1949.

g. Compute the force with which air tends to crush your body.
h. Discuss the meaning and effects of pneumothorax.

2. *Air is a mixture of gases.*
   a. Review the nature of solids, liquids and gases.
   b. Discuss the possibilities of air becoming liquid.
   c. Graph the composition of air.
   d. Place iron filings in a bottle of oxygen.
   e. Conduct tests for the presence of oxygen.
   f. Discuss the properties of nitrogen in the air.
   g. Report on the oxygen-nitrogen cycle in nature.
   h. Demonstrate the production of, and tests for, carbon dioxide.
   i. Review the three states of water.
   j. Demonstrate the presence of water vapor in the air.
   k. Explain why water vapor content of the air varies.
   l. Observe the presence of dust in the air.
   m. Discuss rare gases in the air.
   n. Locate gases on the periodic table.
3. *Air is constantly in motion.*
   a. Observe anemometer.
   b. Study the action of gliders and kites.
   c. Release helium filled balloons tied to a post card with name, address and request for return.
4. *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.
5. *Air's ability to hold water vapor lessens as it cools.*
   a. Determine the "dew point" temperature of the atmosphere.
   b. Observe "clouds" at end of spout of boiling tea kettle.
   c. Build hygrometer and psychrometer.
6. *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.

2. *Air is a mixture of gases*
   Films:
   a. *Learning About Air,* 11 min., color, Paramount Films, 1972.
   b. *Climate and the World We Live In,* 14 min., color, Coronet Films, 1957.
3. *Air is constantly in motion*
   Films:
   a. *Inconstant Air,* 27 minutes color, McGraw, 1961.
   b. *Learning About Air,* 11 minutes, color, Paramount Films, 1972.
4. *Weight and pressure difference*
   Film:
   a. *Gas Pressures and Molecular Collisions,* 21 minutes, black and white, Encyclopedia Britannica Films, 1962.
6. *Clouds*
   Films:
   a. *Clouds Above,* 9 minutes, color, Bailey Films, 1964.
   b. *What Makes Clouds,* 19 minutes, color, Encyclopedia Britannica Films, 1965.

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b. Observe and record types of clouds in the area for several successive days or weeks.
c. Discuss cloud seeding.

Q. *Atmospheric conditions have great influence on aviation.*
1. *The Airplane.*
   a. Discuss factors to be considered in taking off in thin air:
      i. ground speed to achieve lift.
      ii. rate of climb
      iii. distance to gain altitude
   b. List methods used by pilots and runway designers to compensate for the effects of thin air.
   c. Discuss factors to be considered in landing in thin air.
   d. Demonstrate the effects of lift by the use of a small wind tunnel constructed by pupils.
2. *The Engine.*
   a. Locate information and discuss effects of thin air on the:
      i. propeller
      ii. fuels (mixtures)
      iii. engine.

R. *All basic principles of electricity are involved in the operation of the aircraft.*
1. Conduct a general laboratory demonstration and discussion of the principles of electricity.
2. A very good source of DC electricity for the average high school or junior high school laboratory may be cheaply had by securing a 24-volt aircraft generator and gearing it to a 2 H.P. electric motor. There is no limit to its versatility with the use of proper rheostats, buss bars, shunts and imagination.

Q. *Atmospheric influences aviation*
1. *Filmstrip:*
   a. *Safety in Flight,* Jim Handy, 1960.

R. *Principles of electricity*
1. *Films:*
   a. *Electronics,* 11 minutes, black and white, Encyclopedia Britannica Films.
   b. *Electrons on Parade,* 21 minutes, black and white, R.C.A.
   c. *Plane Without a Pilot,* Bell Aircraft Corporation, Buffalo, NY.
2. *Readings:*
   a. *Experiments with Magnetism and Electricity,* NSTA Publication.
   b. *Radio Direction Finder,* Sperry Gyroscope Company, Great Neck, NY.

SOCIAL STUDIES

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OVERVIEW

The study of aviation from the social studies viewpoint illustrates the extensive, essential contribution of aviation to man's progress. The course of this progress and its consequential effects upon our lives may be integrated into the teaching of social studies at the various grade levels to good advantage.

A correlation with the science and math sections of this guide will be noticed in the lessons on maps and globes and the methods used in aerial navigation. The social studies teacher will find the material readily adaptable to use in providing extensive experiences in these areas.

While the treatment of aviation careers has been included in this section of the guide, it can also be effectively used as an independent series of lessons. It should be emphasized that the occupations listed are of a general nature and are not meant to be an exhaustive list of aviation and aviation-related careers. Individual or group study on careers in military aviation, the air transport industry, utility aviation, etc., would be appropriate extensions of this topic.

SOCIAL STUDIES

Specific Learnings

- To develop an awareness of the role of aviation in man's history.
- To gain an understanding of the early history and spectacular growth of aviation.
- To develop skill in reading and interpreting maps and globes and locating places on the earth's surface.
- To learn the fundamentals of methods used in aerial navigation.
- To gain insight into the social, economic and physical changes resulting from the discovery and development of air transportation.
- To recognize vocational opportunities in aviation.
- To learn strategies and techniques useful in gaining employment.

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 and his Roc.
   d. Arabs and their flying carpets.
   e. Simon, the Magician in the time of Nero, who tried to fly from a tower.
   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. Display pictures of early designs for flying machines 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 of fantasy concerning the Greek mythology of aviation.
5. Read and illustrate ideas of flying related to Indian legend.
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. Plan to 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 on flight records made in the past with more recent ones.
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. Make a "Current Events in Aviation" notebook or bulletin board.
16. Make reports on the latest development in rockets.

Materials and Resources

1. Wall Chart: *Chronology of Aerospace Events*, Civil Air Patrol, Maxwell AFB, AL 36112.
2. Pictures and free materials from airline companies and airplane manufacturers.
3. *Learning packets:*
   a. Aerospace Personality Series.
   b. History of General Aviation Series.
   Both from Civil Air Patrol, 1980.
4. *Films:*
   a. *Icarus and Daedalus*, 6 minutes, animated, color. Sterling Productions, N.Y., 1964.
   b. *The Early Days*, 30 minutes, color. Air Power Series, CBS-TV, 1958.
   c. *Time Flies*, Association Films, Inc., Executive Offices, 866 Third Avenue, NY 10022. Free loan.
   d. *Oh, How We Flew*, Western Airlines, P.O. Box 92005, World Way Postal Center, Los Angeles, CA 90009. Free loan.
   e. *A Trip to Chicago*, Modern Talking Picture Service, Inc., 5000 Park Street, N., St. Petersburg, FL 33709. Free loan.
   f. *In Celebration of Flight*, FAA Film Service, c/o Modern Talking Picture Service, Inc., 5000 Park Street, N., St. Petersburg, FL 33709.
   g. *A Man's Reach Should Exceed His Grasp*, NASA Lyndon B. Johnson Space Center, Education Office, Houston, TX 77058.
   h. *Kites to Capsules*, 5 minutes, black and white. FAA Film Service, c/o Modern Talking Picture Service, 5000 Park Street, N., St. Petersburg, FL 33709. Free loan.

i. *Spaceship Earth*, 17 minutes, documentary. Lockheed-Georgia Company, Motion Picture Service, 5000 Park Street, N., St. Petersburg, Florida 33709. Free loan.

5. *Readings:*

a. *Bullfinch's Mythology*, Harper and Row, 1970.

b. Gibbs-Smith, Howard. *Aviation, A Historical Survey From Its Origins to the End of World War II*, Wm. Clausen and Sonds, Ltd., 1970.

c. *Great Adventures That Changed Our World*, Reader's Digest Association, 1978.

d. McMullen, David and Susan. *First Into the Air*, Silver Burdett, 1978.

e. Hartcup, Guy. *The Achievement of the Airship*, David E. Charles, 1975.

f. Cook, Graeme. *Air Adventures*, St. Martin's, 1975.

g. Galleo, Alma. *Air Travel From The Beginning*, Children's Press, 1978.

h. C. Burton Cosgrove. *Fantasy in Flight*, Aviation Book Co., 1975.

i. Leary, Wm., *The Dragon's Wings*, University of Georgia Press, 1976.

j. Mrajck, James E., *The Glider War*, St. Martin's, 1976.

k. Hatfield, David D., *Pioneers of Aviation*, Aviation Book Co., 1976.

l. Ault, Phil, *By The Seat of Their Pants: The Story of Early Aviation*, Dodd, Mead, 1978.

m. Norman, Bruce. *The Inventing of America*, Taplinger, 1976.

n. *Aerospace: The Challenge*, Civil Air Patrol, 1980.

o. Boyne and Lopez. *The Jet Age: Forty Years of Jet Aviation*, Smithsonian Institution Press, 1979.

II. 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 art. (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 map of your state: put in cities, highways, railroads, airports, etc.
17. Draw maps of air routes [illegible] 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° = 24 hours   10° = 40 minutes
    15° = 1 hour   1° = 4 minutes

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.

Materials and Resources

1. *Readings:*
   a. Bauer, H.A. *Globes, Maps and Skyways,* 1969.
   b. Baxter and Stephens, *Introduction to Global Geography,* 1968.
   c. Towers, Merrill E., *A Student Guide for Aeronautics,* 1963.
   d. Beiser, Arthur, *Our Earth,* E.P. Dutton, 1959.
   e. Jeffreys, Arhold, *The Earth,* (4th ed.) Cambridge University Press.
   f. Brown, Lloyd A., *The Story of Maps,* Little-Brown, 1949.
   g. Gurney and Elliott, *Pilot's Handbook of Navigation,* Aero, 1977.
   h. Keen, Martin L., *How It Works: Volume 2,* Grossett and Dunlap, 1976.
   i. Reithmaier, L.W., *Private Pilot's Guide,* Aero, 1978.
   j. *Navigation and The Weather,* Civil Air Patrol.
   k. *Air Navigation: Introduction to Navigation,* McGraw-Hill.
   l. *Aerospace: The Challenge,* Civil Air Patrol.
   m. Budlong, John P., *Sky and Sextant,* Van Nostrand Reinhold, 1978.
2. *Films:*
   a. *Maps are Fun,* 10 minutes, color, Coronet Films.
   b. *Longitude and Latitude,* 11 minutes, black and white, United World Films.
   c. *Using a Compass,* 10 minutes, color, Moreland-Latchford.
   d. *Aerial Navigation: Maps and the Compass,* 13 minutes, black and white, United World Films.
   e. *Global Concepts in Maps,* 11 minutes, color, Coronet Films.
   f. *Celestial Navigation: The Earth,* 16 minutes, black and white, Castle Films.
   g. *Celestial Navigation: Charts,* 20 minutes, Castle Films.
3. Maps and Free Materials are often available from airline companies.
4. *Charts:*
   a. Available from National Ocean Survey, Distribution Division (C-44), 66501 Lafayette Avenue, Riverdale, MD 20840: *Catalog of Aeronautical Charts and Related Publications.*

III. Methods Used in Aerial Navigation

Suggested Activities

A. Dead Reckoning:

1. Describe the route taken to get to school.
2. Define "on course" in terms of getting to school.
3. Plan a flight using map and chart made by the student.
4. Use a sectional chart to plan a flight course to be followed to the nearest airport.
5. Discuss the effects of wind changes upon a flight path.
6. Locate the prime meridian and review meridians: locate the equator and review parallels. Discuss coordinates.
7. Determine the locations of true north and magnetic north. Explain how the differences between these affects flight planning.
8. Make a compass.
9. Use a compass to determine directions.
10. Make a chart showing compass variations in the U.S.
11. Examine an automobile compass.
12. Write some problems in determining the true heading required in making a flight plan to a nearby location. Make the required course corrections.
13. Display pictures showing various navigational aids.
14. Identify all the instruments required for flight by dead reckoning and describe the function of each.
15. List the advantages and disadvantages of dead reckoning.
16. Obtain and discuss an FAA Flight Plan Form.

B. Celestial Navigation:

1. Examine a sextant and discuss its function.
2. Make a simple sextant and describe the operation of it.
3. Make a study of the relative positions of heavenly bodies.
4. Draw a series of pictures to illustrate the changes in position of the Big and Little Dippers.
5. Study a celestial globe to find the relative position of the stars in comparison with the north pole, south pole, equator and your city.
6. Draw a map showing major constellations or stars used in celestial navigation.

Materials and Resources

A. *Dead Reckoning*

1. *Readings:*
   a. Brown, Lloyd A. *The Story of Maps.* Little-Brown, 1949.
   b. Bauer, H.O. *Globes, Maps and Skyways,* Dodd-Mead, 1969.
   c. *Air Navigation: An Introduction to Navigation,* McGraw-Hill.
   d. Keen, Martin L. *How It Works, Volume 2.* Grossett and Dunlap, 1976.
   e. Beiser, Arthur. *Our Earth,* E.P. Dutton, 1959.
   f. Jeffries, Harold. *Our Earth (4th ed.),* Cambridge University Press.
   g. *Aerospace: The Challenge.* Civil Air Patrol.
   h. *Navigation and the Weather,* Civil Air Patrol.
   i. Towers, Merrill E. *A Student Guide for Aeronautics,* 1963.
   j. Gurney and Elliott, *Pilot's Handbook of Navigation,* Aero, 1977.
   k. *Aeronautics, The First Step to Space,* NASA.
   l. Budlong, John P., *Sky and Sextant,* Van Nostrand Reinhold, 1978.
2. *Filmstrip:*
   a. *Dead Reckoning,* b/w, University of Illinois.
3. *Films:*
   a. *Using a Compass,* 10 min., color, Moreland-Latchford.
   b. *Aerial Navigation: Maps and the Compass,* 13 min., b/w, United World Films.
   c. *The Sport of Orienteering,* 24 min., color, Siva Film.

B. *Celestial Navigation*

1. *Readings:*
   a. *Aerospace: The Challenge.* Civil Air Patrol.
   b. *Aeronautics, The First Step to Space,* NASA.
   c. Gurney and Elliott, *Pilot's Handbook of Navigation,* Aero, 1977.
   d. Keen, Martin L., *How It Works, Volume 2.* Grossett and Dunlap, 1976.
2. *Films:*
   a. *Celestial Navigation: Introduction and Location of Celestial Points,* 18 min., b/w, Castle Films.

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7. Explain what is meant by:
   a. Prime celestial meridan
   b. Parallels of declination
   c. Right ascension
8. Discuss improvements in celestial navigation since the ancient times.

C. Radio Navigation:
1. Demonstrate on the chalkboard the radio quadrants at the airport.
2. Make a drawing to show radio quadrants, radio markers, cone of silence, etc.
3. Practice sending radio code signals.
4. Visit the control tower at an airport.
5. Explain how the radio compass works.
6. Report on the method a pilot uses to orient himself to the position of an airport by means of the radio signals received.
7. Illustrate, with explanations, the instruments used in radio navigation.
8. Discuss factors which interfere with a radio reception.
9. Report on radar devices used for radio navigation.
10. Invite a speaker from a radio station to speak on radio navigation.
11. Discuss other uses made of radio instruments.
12. List advantages and disavantages of radio navigation.
13. Report on LORAN (Long Range Navigation).
14. Discuss the Very High Frequency Omnidirectional Range (VOR).

   b. *Celestial Navigation: The Earth,* 16 min., b/w, Castle Films.
   c. *Celestial Navigation: Charts,* 20 min., b/w, Castle Films.
   d. *Celestial Navigation: Position Finding on the Earth,* 15 min., b/w, Castle Films.

C. *Radio Navigation*
1. *Readings*
   a. *Navigation and the Weather,* Civil Air Patrol.
   b. *Aerospace '81,* Civil Air Patrol.
   c. Elliott and Gurney. *Pilot's Handbook of Navigation,* Aero, 1977.
   d. Webb, William L. *Flying with VHF Navigation and Communication,* Bendix Corporation.
   e. Letcher, John S., *Self-Contained Celestial Navigation,* International Marine Publications, 1978.
2. *Films:*
   a. *Area Navigation,* 25 minutes, FAA Film Service, c/o Modern Talking Picture Service, Inc., 5000 Park Street, N., St. Petersburg, FL 33709.

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IV. 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 school. 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 Indian 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.

Materials and Resources

1. Films:
   a. *There Will Be a Slight Delay*, Modern Talking Picture Service, Inc., 5000 Park Street, N., St. Petersburg, FL 33709. Free Loan.
   b. Available on a free loan basis from NASA Lyndon B. Johnson Space Center, Education Office, Houston , TX 77058:
      1. *Survival*, 17½ min., color.
      2. *Five Minutes to Live*, 18 min., color.
      3. *Partners with Industry*, 12 min., color.
      4. *David's World*, 11 min., color.
   c. *Rapid Transit in the Sky*, Air Transport Association of America, 1709 New York Avenue, N.W., Washington, D.C., 20006. Free Loan.
2. Charts:
   a. Available from National Ocean Survey, Distribution Division (C-44), 65501 Lafayette Avenue, Riverdale, MD 20840:
      1. Sectional and VFR terminal charts.
      2. Enroute low altitude charts.
3. Readings:
   a. *10001 Sources for Free Travel Information*, Box 105, Kings Park, NY, 11754.
   b. Knight, Geoffrey. *Concorde*, Stein & Day, 1976.
   c. Kane and Vose. *Air Transportation*, Kendall/Hunt, 1977.
   d. *Air Travel Answers*, P.O. Box 11347, Las Vegas, NV 89111.
4. *Filmstrips:*
   a. *Great Spacecraft and Their Accomplishments*
   b. *Social Impact of Flight*
   Both available from National Air and Space Museum, Washington, D.C. 20560.

V. 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 positions.
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 or occupationally) one might take to get into a particular career, including training, licensing, certification, and other special requirements.

Materials and Resources

1. Films:
   a. Films available on free loan from FAA Film Service, c/o Modern Talking Picture Service, Inc., 5000 Park Street N, St. Petersburg, FL 33709:
      Looking Up To Your Aviation Career;
      Put Wings On Your Career;
      These Special People;
      Brother.
   b. *Just a Flight,* 15 minutes, black and white,

Association Films, Inc., Executive Offices, 866 Third Avenue, New York, NY 10022. Free loan.

2. Booklets:
   a. FAA career guidance materials are distributed to the public free of charge by: Superintendent of Documents, Retail Distribution Division, Consigned Branch, 8610 Cherry Lane, Laurel, MD 20707:
      Career Pilots and Engineers;
      Airport Careers;
      Aviation Maintenance;
      Flight Attendants;
      Airline Careers.
3. Readings:
   a. Scribner, Kimball. *Your Future In Aviation Careers In The Air*, 1979.
   b. Scribner, Kimball, *Your Future In Aviation Careers On The Ground*, 1979.
   c. *Transport Career Opportunities*, National Defense Transportation.
   d. *Guide to Aerospace Occupations*, The Boeing Company.
   e. *Your Future at Graumann*, Graumann Aerospace Corporation.
   f. Blicq, Ron. *On the Move: Communication for Employees*, Prentiss-Hall, 1976.
   g. *Collegiate Aviation Directory*, University Aviation Association, P.O. Box 2321, Auburn, AL 36830.
4. Publications and personnel inquiries about aerospace career opportunities will be provided by writing to:
   U.S. Air Force
   Air Force Opportunity Center
   P. O. Box 1776
   Valley Forge, PA. 19481 OR
   Air Force ROTC
   Center of Information
   Maxwell Air Force Base, AL 36112
5. A list of some aerospace careers is provided at the end of this section.

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

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

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

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

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

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Answers Sheet

Answers for Page 14

	Distance On:			
Scale	Chart		Ground	
1. 1 IN = 16 MI	4 IN	=	64 MI	(16 × 4 = 64)
2. 1 IN = 16 MI	$3\frac{1}{2}$ IN	=	56 MI	(16 × $3\frac{1}{2}$ = 56)
3. 1 IN = 80 MI	$4\frac{3}{4}$ IN	=	380 MI	(80 × $4\frac{3}{4}$ = 380)
4. 1 IN = 32 MI	$3\frac{1}{8}$ IN	=	100 MI	(100 + 32 = $3\frac{1}{8}$
5. 1 IN = 8 MI	$9\frac{3}{8}$ IN	=	75 MI	(75 + 8 = $9\frac{3}{8}$
6. 1 IN = 32 MI	$9\frac{1}{2}$ IN	=	304 MI	(304 + $9\frac{1}{2}$ = 32)
7. 1 IN = 16 MI	$7\frac{1}{8}$ IN	=	114 MI	(114 + $7\frac{1}{8}$ = 16)
8. 1 IN = 32 MI	$5\frac{11}{16}$ IN	=	182 MI	(32 × $5\frac{11}{16}$ = 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 + 12 + 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, 32 × 12 × 5280 = 2,027,520 or about 2,000,000.

Answers for Page 15

Scale 1 IN = 32 MI (Distance in inches × 32 =)

1. $2\frac{5}{8}$ IN = 84 MI
2. $2\frac{3}{4}$ IN = 88 MI
3. $1\frac{3}{8}$ IN = 44 MI
4. 1 IN = 32 MI
5. $1\frac{3}{4}$ IN = 56 MI

Scale 1 IN = 80 MI (Distance in inches × 80 =)

6. $2\frac{1}{8}$ IN = 170 MI
7. $2\frac{1}{2}$ IN = 200 MI
8. $2\frac{11}{16}$ IN = 215 MI
9. $\frac{5}{16}$ IN = 25 MI
10. $2\frac{9}{16}$ IN = 205 MI

Scale 1 IN = 64 MI (Distance in inches × 64 =)

11. $1\frac{1}{4}$ IN = 80 MI

Scale 1 IN = 16 MI (Distance in inches × 16 =)

12. $1\frac{7}{16}$ IN = 23 MI

Answers for Page 16

Direction	Degrees (Compass Heading)
1. North (N)	0°
2. East (E)	90°
3. South (S)	180°
4. West (W)	270°
5. Northeast (NE)	45°
6. Southeast (SE)	135°
7. Southwest (SW)	225°
8. Northwest (NW)	315°
9. 360° is also 0° and is North	
10. Clockwise	332.5°
11. Counterclockwise	157.5°

Answers for Page 17

Ground Temperature	Altitude	Ambient Temperature
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. 74.5°	11,000 FT	36°
8. 65°	12,000 FT	23°
9. 95.5°	21,000 FT	22°
10. 92°	17,000 FT	35.5°

Answers for Page 18

	Engine Speed	Propeller Speed	Ratio	
1.	3160	1580	2:1	(3160 ÷ 2 =)
2.	3400	1360	5:2	(3400 ÷ 5 × 2 =)
3.	2175	1450	3:2	(1450 × 3 ÷ 2 =)
4.	3750	1250	3:1	(1250 ÷ 3 =)
5.	3150	1575	2:1	(3150 ÷ 1575 =)
6.	2800	1680	1.7:1	(2800 ÷ 1680 =)
7.	1800	1350	4:3	(1800 ÷ 4 × 3 =)
8.	3360	1470	16:7	(1470 × 16 ÷ 7 =)
9.	2910	1940	1.5:1 (3:2)	(2910 ÷ 1940 =)
10.	1920	1120	12:7	(1120 × 12 ÷ 7 =)

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

Answers for Page 19

A.

1. 0140 HRS	6. 1230 HRS
2. 1716 HRS	7. 2349 HRS
3. 1939 HRS	8. 1432 HRS
4. 1847 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	[illegible] 1:03 AM
5. 9:48 PM	10. 3:08 PM

B.

	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 7½ 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.

	Distance	Time	Average GS
1.	285 miles	3 HRS	95 MPH
2.	780 miles	6½ HRS	120 MPH
3.	800 miles	5⅓ HRS	150 MPH
4.	1260 miles	4 HRS 40 MIN	270 MPH
5.	2875 miles	6 HRS 15 MIN	460 MPH
6.	675 miles	4½ HRS	150 MPH
7.	594 miles	3 HRS 18 MIN	180 MPH
8.	245 miles	2 HRS 27 MIN	100 MPH
9.	595 miles	[illegible]½ HRS	170 MPH
10.	1104 miles	4 HRS 36 MIN	240 MPH

Answers for Page 20

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.	4.375 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)

Answers for Page 21

B. True Airspeed Computations

	Altitude (FT)	IAS (MPH)	TAS (MHP)	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)

	IAS (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

Answers for Page 22

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

Answers for Page 23

Sample Problems:

1. Area of Wing is 105 ⅜ FT²
   Change fraction of FT² to IN²
   1 FT² = 144 IN²   144 × ⅜ = 54 IN²

2. Departs 9:30 AM + 7 HRS 55 MIN
   Arrives 5:25 PM Eastern Time
   Arrives 2:25 PM Pacific Time (– 3 HRS)

Answers for Page 24

Fractions, Decimals and Percent

Sample Problems:

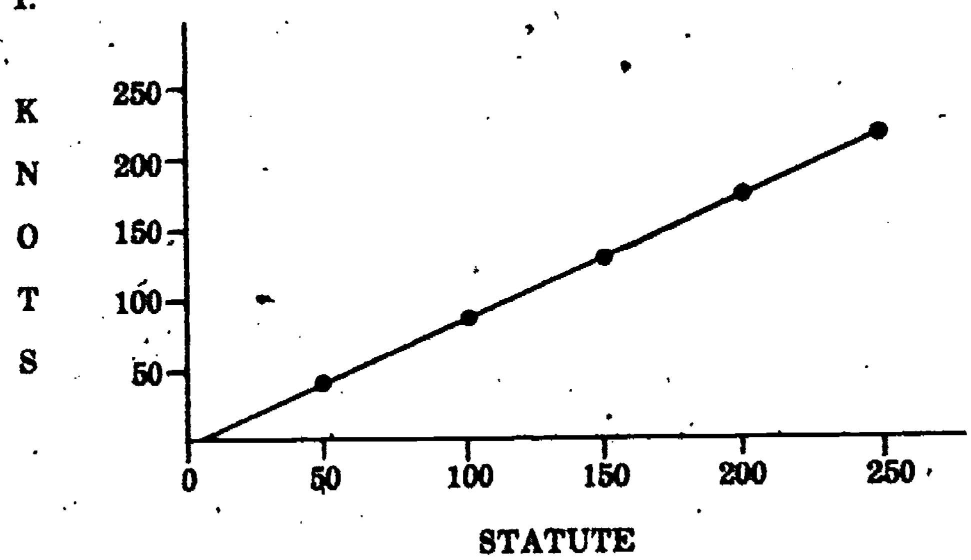
1.	MPH	1	8	200	158½	87.25
	FPS	1.467	11.736	293.4	232.52	127.99

FPS = MPH × 1.467 inversly MPH = FPS × .682

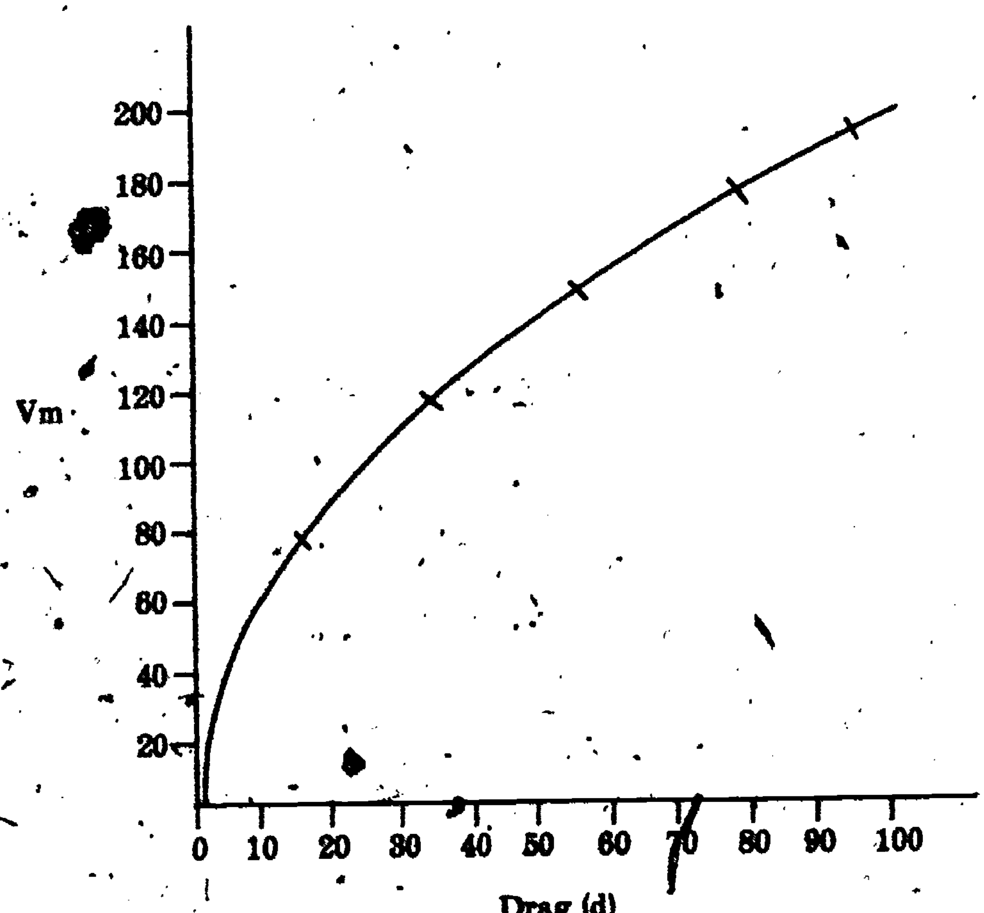
2. 3278 US Gallons × .8327 = 2729.6 British Gallons
U.S. GAL × .8327 = British Gallons inversly British Gallons × 1.2009 = US Gallons

Answers for Page 25

GRAPHS:
1.



Kts = .86845 × Statute MPH
× 50 = 43.42 Kts
× 100 = 86.85 Kts
× 150 = 130.27 Kts
× 200 = 173.69 Kts
× 250 = 217.11 Kts



$Vm = 19.76(d)^{1/2} = 19.76$ d

d = 16 then Vm = 4(19.76) = 79
35 = 118
56 = 148
78 = 174
95 = 192

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Answers for Page 26

Angles and Triangles

Sample Problems:

1. 130° measured clockwise from 065°
   230° measured clockwise from 195°

The generally accepted answer to this question would be 130°.

2. 027° – 050° = 337° (0° – 360°)

3.

TH	VAR	MH	DEV	CH
325°	– 10°	315°	+ 5°	320°
165°	– 14°	151°	– 4°	147°
355°	+ 15°	010°	– 3°	007°