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ABSTRACT

This syllabus has been designed to provide the classroom teacher with a capsulized view and understanding of a one-year course at the high school level. This course is designed to be an integral part of the existing general educational program of the school and is general and introductory in nature, rather than inclusive. This syllabus is to be used with, and as a part of, the Civil Air Patrol High School Program and is keyed to the CAP textbooks, instructor guides, and student workbooks. The seven topics included are: (1) Introduction to Aerospace, (2) The Challenge of Aerospace Power, (3) Aircraft in Flight, (4) Power for Aircraft, (5) Navigation and the Weather, (6) Airports, and Electronics, and (7) The Dawning Space Age. The basic format for this guide is as follows: Lesson Outline, Behavioral Objectives to Measure Understanding, Lesson Overview, and Bibliography/Sources for the teacher. (Author/TS)

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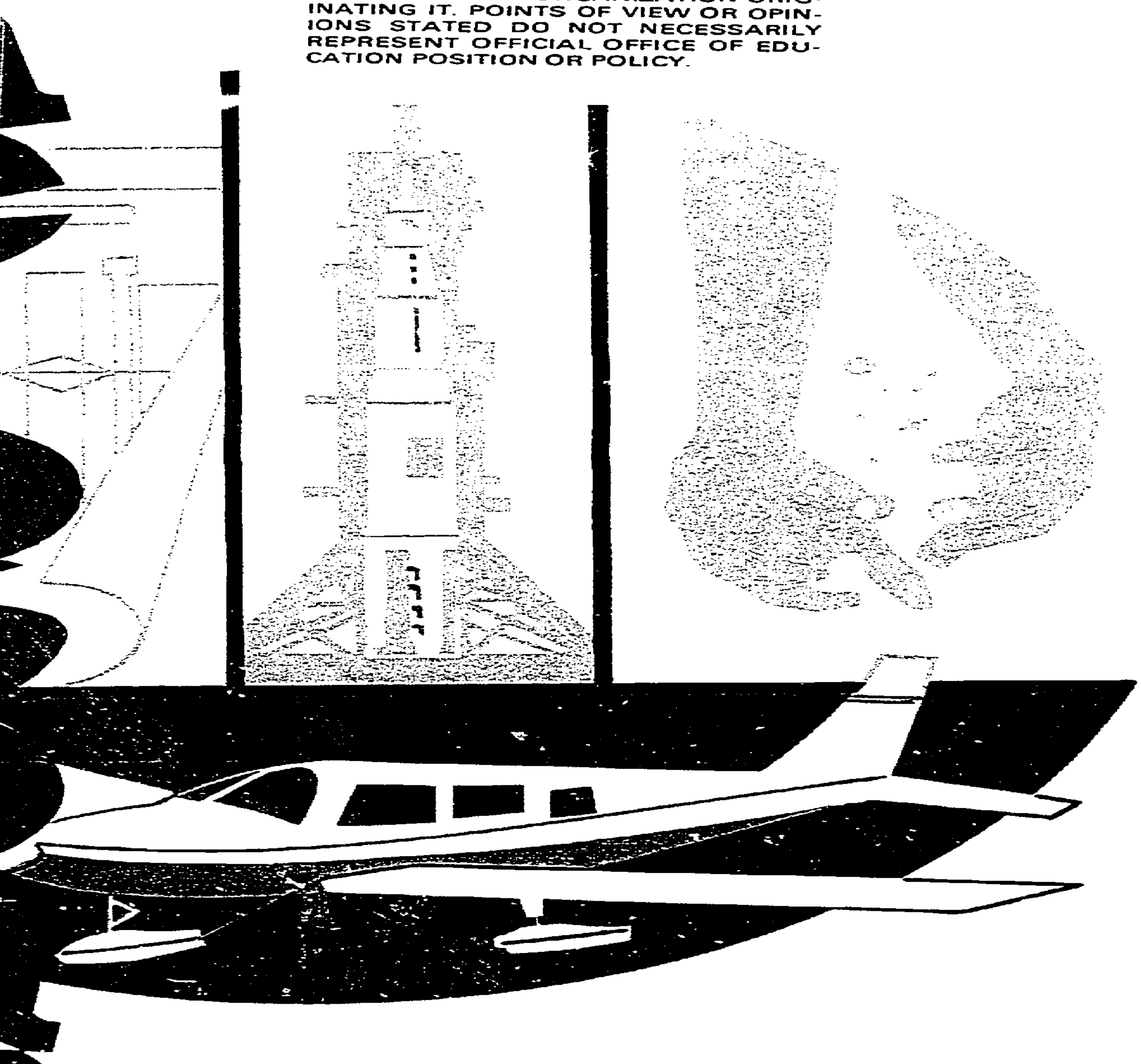

EDUCATION COURSE SYLLABUS

CIVIL AIR PATROL MAXWELL AIR FORCE BASE, ALABAMA

AEROSPACE EDUCATION COURSE SYLLABUS*

A Guide for an Elective,
Two-Semester (One-Year) High School Course
in
Aerospace Education

*From time to time, CAP Aerospace Education texts are updated or revised. As a result, the order of subject presentation in the texts may not agree with the charts in this syllabus.

BOOK I

INTRODUCTION TO AEROSPACE

AEROSPACE EDUCATION COURSE SYLLABUS

A Guide for an Elective, Two-Semester (One-Year) High School Course in Aerospace Education

INTRODUCTION

Long before the landing on the moon by the crew of Apollo 11, mankind's discovery of how to make use of aerospace and the series of events this discovery has brought about have effected innumerable changes in the social, economic, and political environment of the entire world. Each day the impact of aerospace activities modifies the climate of modern living. It is, therefore, important that we learn something of the circumstances surrounding aerospace developments.

Aerospace, a combined form of the words "air" and "space," is the term used to denote the region extending from the earth's surface through the total expanse beyond. The elective aerospace education course should provide information and/or experiences designed to help the student attain general aerospace understandings. The program of instruction should encompass the significant uses, effects, nature, underlying principles, and problems of aerospace vehicles, both aircraft and spacecraft. A carefully planned course of study will create interest for the student in science, physics, mathematics, and the humanities.

At the same time, the academically talented student should be inspired to undertake specialized professional education in the science and engineering areas of aerospace vehicle development, manufacture, and operation. The broad nature of the problems to be faced will require not only specialists, but also minds trained to cut across and exploit the various classical disciplines.

Through safe and practical means, the instructor must be certain that initiative, intellectual curiosity, and scientific insight are encouraged in our youth. Since the United States is in the Aerospace Age, it is mandatory that young people with special ability and ingenuity be sought. It is also mandatory that the general public be informed. Education must, therefore, accept its responsibility to provide study in the field of aerospace education, ever mindful that "humanistic values" are important and that "technology without character" is suicide.

I. USE OF SYLLABUS

This syllabus has been designed to provide the classroom teacher with a capsulized view and understanding of a one-year course curriculum in aerospace education at the high school level. This course is designed to be an integral part of the existing general educational program of the school. It is general and introductory, or exploratory, in nature, and not intended to be all-inclusive. This syllabus is to be used with, and as a part of, the Civil Air Patrol High School Program keyed to the CAP textbooks, instructor guides, and student workbooks. The lessons may be presented in the sequential order shown or in a different order if desired. The individual teacher is encouraged to use this outline guide and other CAP materials to meet the requirements and needs of his own particular situation and student population. Visual aids such as slides, filmstrips, and additional textual materials are available from Civil Air Patrol to help the instructor introduce, teach, and summarize each lesson. It is suggested that the teacher use local resources and that he obtain materials listed in the appended bibliography to enrich course content and relate it to the local situation. By expanding or contracting the allotted time limits, this outline can be used as the instructor desires--for review, special activities, guest speakers, field trips, library book reports, or other such special interest work.

The basic format for this guide is as follows:

Lesson Outline
Behavioral Objectives to Measure Understanding
Lesson Overview
Bibliography/Sources for the Teacher

II. OBJECTIVES OF THE COURSE are to give the student:

1. An adequate reading and speaking vocabulary of things both aeronautic and astronautic.

2. An understanding of the importance of weather and climate to flight operations.

3. An understanding of the importance of the physical and biological sciences to space operations.

4. A general knowledge and understanding of the structural requirements for terrestrial and extra-terrestrial vehicles.

5. An understanding of aerospace industry in peace and war.

6. An understanding of the effects of the Aerospace Age on international relationships.

7. An introduction to the social, economic, and political implications of current and future aerospace developments.

8. An appreciation of the services rendered by airports and their associated personnel.

9. Familiarity with existing and needed basic governmental services and regulations.

10. A knowledge of available aerospace education resources in materials, personnel, and equipment.

11. An understanding of problems--political, economic, international, and social--that have been created by the Aerospace Age.

12. A realization of how the aerospace vehicle has changed not only geographic relationships, particularly concepts of time, place, and distance, but also attitudes toward land masses, water barriers, and space travel.

13. A knowledge of the career potential in the science and engineering areas of aerospace vehicle development, manufacture, and operation.

14. An understanding of the underlying scientific principles basic to aerospace vehicle development and operation.

To accomplish these broad course objectives, instructors and students are encouraged to become thoroughly familiar with the specific behavioral objectives appropriate to each of the seven CAP textbooks.

III. INSTRUCTIONAL AIDS

While this course is prepared to be used with Civil Air Patrol publications, other reference materials, experiments, films, field trips, resource people, and related instructional aids should be used to enrich the program. Lectures must be held to a minimum. Student activity and participation should be the rule. Variety and flexibility of content add to the enjoyment and value of the course.

Civil Air Patrol examinations are recommended, but locally-prepared examinations may be used. Because of the limited classroom hours available it may be necessary for the student to complete a certain amount of the required workbook assignments as homework. Additional time should be allotted for field trips and special activities.

a. Materials. Civil Air Patrol books, instructor guides, workbooks, and slides may be ordered from National Headquarters, Civil Air Patrol, Maxwell Air Force Base, Alabama 36112. Use CAP's "Catalog of Aerospace Education and Training Materials" to obtain costs of materials.

Note: Numerous teaching aids can be found at the local level. Available and waiting for the teacher who makes the effort to search them out, in addition to the library and the laboratory, are resource people from community enterprises; local, state, and national organizations associated with aviation; military organizations; and Civil Air Patrol units.

b. Testing Service. CAP provides free testing service to educators who conduct its aerospace education course. To obtain this service, use the school letterhead and write to National Headquarters, Civil Air Patrol (Attn: EDAE), Maxwell Air Force Base, Alabama 36112.

c. Bibliography. This syllabus includes a guide to some of the textual and visual references available to the teacher in the field of aerospace education. Use these materials fully for maximum teaching effectiveness. A separate bibliographic source document has been published to accompany this syllabus and is available upon request from HQ CAP-USAF (ED), Maxwell AFB, Alabama 36112.

LESSON I - THE AEROSPACE AGE

A. Lesson I (Chapter 1). At the end of this unit of instruction, the student should be able to:

1. Give the exact date which marked the "birth of aviation."
2. Name the two men who first flew a powered aircraft.
3. Give the duration of flight and distance flown by the first powered aircraft.
4. Give the date of the first successful launching of an earth satellite.
5. Name at least three men who, through research, contributed to the development of powered aircraft.
6. Name the person who pioneered America's development of rocketry.
7. Give the difference in time it took Lindbergh to fly across the Atlantic as compared to a U.S. F-100 jet aircraft.
8. Name the type of aircraft which first flew nonstop around the world.
9. Name the rocket, or missile, which made the first intercontinental distance flight of 9,000 miles.
10. Name the person who made the first manned orbital flight, and give the date of the launch.
11. Identify the country which launched the first manually controlled spacecraft and name the person who piloted it.

B. Overview.

Historians will refer to our period of history as the Aerospace Age. In 1903 the Wright brothers marked the birth of aviation by making a 120-foot, controlled flight in a powered aircraft at Kitty Hawk, North Carolina. Man reached the threshold of space in 1957 with the successful orbit of the first manmade satellite.

More than any other technological developments, the perfection of airfoils, reciprocating aircraft engines, jets, rockets, and space vehicles are profoundly affecting our lives. Mythology and history record man's early attempts to fly, but practical solutions to the problems of flight were not found until research became a tool of science. Scientists and engineers of many nations contributed directly or indirectly to the first flight of a heavier-than-air aircraft and to the successful orbit of the first manmade satellite. Each year significant achievements in aviation and astronautics demonstrate man's increasing ability to improve the performance of air and space vehicles.

Aviation and astronautics have created an expanding industry, with jobs for approximately one million people. Aircraft, rockets, missiles, and space vehicles represent practical applications of the arts, crafts, and sciences that are providing diversified, stimulating careers for persons with appropriate training. Applications of the aerospace sciences are making a tremendous impact on the conduct of human affairs.

LESSON II - AVIATION AND ASTRONAUTICS

A. Lesson II (Chapters 2 and 3). At the end of this unit of instruction, the student should be able to:

1. Discuss the meaning of aviation to the following:
   a. Pilots
   b. Military personnel
   c. Industrialists
   d. Airline managers
   e. Teachers

2. Compare the speed of travel in the "horse and buggy" days to today, giving at least two examples of the contrasting speeds.

3. Give the approximate number of calendar years, at the speed of light, required to reach the star nearest our sun.

4. Define astronautics.

5. In miles, give the depth of 99% of the earth's atmosphere.

6. State the distance of Venus from Earth, to the nearest one million miles.

B. Overview.

Aviation is the art or practice of operating heavier-than-air aircraft. The term aviation has different meanings to different people, for it includes the activity of flight and all of its impacts. Aviation and its effects have become important in a relatively short time. Air travel knows few obstacles and greatly increases the speed of transportation. The boat facilitated man's travel over the surface of the water, and the use of the wheel made possible convenient travel over the surface of the land. The development of the airplane made it possible for men to travel through the air and over natural obstacles to surface transportation. Modern aircraft, missiles, and communications have eliminated the time and distance barriers between nations. Commercial jet aircraft now travel from coast to coast in 4 hours and fly around the world in 48 hours. Achievements in aviation are still so spectacular that newspapers each day feature aviation stories.

Astronautics is the art and science of designing, building, and operating space vehicles. More than 99 percent of the earth's atmosphere lies within 20 miles of the earth's surface, but it is not man's nature to relinquish his interest in the space beyond this altitude. Air and space constitute an indivisible area of human activity.

Industries experienced in building aircraft have contributed significantly to the development of missiles and space vehicles. Airframes, powerplants, and guidance systems are common to both aircraft and space vehicles. As the exploration of space continues, radical changes and refinements in these components will be necessary. Today's satellites and space vehicles represent only the first of significant scientific achievements in space exploration. Our earth is the fifth largest planet in a solar system that represents only a very minute part of the universe. Achievements in the first half-century of powered flight demonstrate that man is accepting successfully the challenge of space. In the next decade, astronautics promises to bring about a number of spectacular achievements in space exploration. Ultimately, the rocket and space vehicles, which have already taken man to the moon, will take him to the planets and the stars.

LESSON III - INDUSTRY AND AEROSPACE PROGRESS

A. Lesson III (Chapters 4 and 5). At the end of this unit of instruction, the student should be able to:

1. List the three types of U.S. military aerospace forces.
2. Tell why the Allies were able to win WW II.
3. Identify the two major industries which have developed from aerospace activities.
4. List the steps involved in manufacturing an airplane.
5. Select the reason for the drop in production of military aircraft.
6. Name the four basic parts of a ballistic missile.
7. Identify the roles of computers and television in the manufacture of space vehicles.

B. Overview.

Aviation and astronautics are important because they are changing significantly the way in which all people work and live. Progress in the aerospace sciences has brought producers, distributors, and consumers into close association; new business and industry have been created; human migration has been encouraged; and a greater appreciation for foreign customs has developed. Isolationism as a national policy is no longer given serious consideration. Aerospace progress has given man his most formidable weapons and his strongest deterrent to aggression. Aviation and astronautics have created two great industries--air transportation and aerospace manufacturing. Together, these two industries employ more people than any other industrial group. The maintenance of aerospace supremacy provides the nation's youth with significant responsibilities and opportunities. Aviation and astronautics offer stimulating careers that provide for both patriotic service and satisfying employment.

Approximately 100 primary manufacturing firms in the United States make airplanes, aircraft engines, missiles, spacecraft, and their components. The aerospace manufacturing industry employs about 735,000 people. In the 35-year period between 1903 and 1938, only 50,000 airplanes were built. During the 20-year period between 1939 and 1959, more than 500,000 were built. Civil aircraft production today is stimulated by increasing requirements for modern jet transports, commercial helicopters, and small business and industrial aircraft. The shift in emphasis from manned aircraft to missiles and space vehicles as our primary aerospace weapons has annually decreased the production of military aircraft and sharply increased the development of missiles and space vehicles. Essentially, ballistic missiles are refinements of manned aircraft. Their production has brought about many refinements in aerospace manufacturing techniques including flexible, low-volume production. The conception, design, testing, improvement, and production of high-performance aircraft, missiles, and space vehicles offer new, intriguing vocational experiences for young men and women with appropriate training.

LESSON IV - THE AIR TRANSPORT AND AEROSPACE INDUSTRIES

A. Lesson IV (Chapters 6 and 7). At the end of this unit of instruction, the student should be able to:

1. Name the three categories of airlines.
2. Name the three departments that airlines maintain at airports.
3. Given the description of a job associated with the airline industry, supply the title of the person who does the job.
4. Give the ratio of hours flown by an airline to the hours spent on maintenance.
5. Define "turn-around inspection."
6. Name the Federal Government unit which regulates the repair aspects of airline flight operations.
7. Given a particular airline "job," select the aptitude that best fits the job.
8. State the approximate number of new companies that have evolved just to serve the manufacturers of aircraft and missiles.
9. In billions, give the approximate annual turnover of dollars generated by the U.S. air transport industry.

B. Overview.

The nation's airlines include domestic trunk airlines, local service lines, international carriers, and helicopter lines. The air transport industry is big business. It carries passengers, mail, express, and freight on both scheduled and nonscheduled flights. The growth of air transportation has been spectacular. Since 1939, scheduled air carriers have increased from 23 to 56. Seats available daily have increased from 5,100 to more than 121,000. The number of cities served has leaped from 296 to 721, and the maximum cruising speed of airline transports has increased from 220 miles per hour in 1939 to more than 600 miles per hour today. Since 1939, the air transport industry has increased the size of its payroll almost 50 times.

To assure the safety of the industry's more than 58 million passengers each year, airlines conduct careful preflight checks of each airplane before flight. Additional scheduled checks and overhauls insure the safe operation of every part of each airplane and its installed equipment. Airline operations require the services of thousands of skilled employees to perform flight operations, communications, maintenance, professional, and administrative duties. To assure that each airline enforces necessary safety rules, the Federal Aviation Administration has established standards and requirements for airline aircraft and for personnel with duties affecting safety in flight. These standards are frequently surpassed by the airlines to insure still greater operational safety. Flight aboard U.S. scheduled airlines is three times safer than travel in private automobiles.

All major industries in the United States are vitally affected by aviation and astronautics. Precious jewels, furs, fruit, critically needed tools and parts, and even horses are transported by air. The aerospace industries have thousands of subcontractors. Fabric, rug, plastic, paint, concrete, and even grass seed companies have felt the impact of aerospace progress. The $3 billion the airlines are investing in jet transports provides work for 5,000 different factories and jobs for more than 100,000 men and women. An annual dollar turnover of more than $5 billion is generated by the U.S. air transport industry alone.

LESSON V - GENERAL AVIATION AND MILITARY AEROSPACE POWER

A. Lesson V (Chapters 8, 9, and 10). At the end of this unit of instruction, the student should be able to:

1. Define general aviation.

2. Given an enterprise, such as farming or mining, select the uses that the enterprise can make of aircraft in its operations.

3. Give the year in which Congress officially recognized the importance of military aerospace power.

4. Give the reason for U.S. military emphasis on aerospace forces.

5. Name the U.S. military force which has the largest role in space research and development.

6. Given the number and/or name designation of an aircraft or rocket, provide either its speed in miles per hour, thrust in pounds, or payload capability.

7. Define: ICBM, VTOL, STOL.

B. Overview.

The term general aviation refers to general uses of the airplane, such as those made by industry, agriculture, and business. It includes all civil aviation enterprises, except aerospace manufacturing and the air transportation services provided by the airlines. Many varied uses are made of general aviation aircraft. Farmers, ranchers, foresters, fishermen, miners, petroleum workers, and government employees join photographers, newsmen, executives, salesmen, and technicians in making extensive use of the airplane in their work. In 1970 the fleet of general aviation aircraft was in excess of 124,000 -- 92 percent of all civil aviation aircraft.

Early in the history of powered flight, air superiority was recognized a , essential to successful military operations on the surface. Today, it has been demonstrated that unrestricted aerospace operations are essential to military superiority in the earth's atmosphere and on its surface. The national strategy of the United States attempts to deter aggression and to prevent war through the maintenance of powerful aerospace forces. These forces consist primarily of ballistic missiles and high-performance manned aircraft. In its role as the nation's primary military agency for space research and development, the U.S Air Force conducts an extensive program of rocket research,

missile development, satellite launching, and manned space exploration. The training and skills required by our aerospace forces are frequently similar to those required in civil aviation and in our nonmilitary space program.

Progress in increasing the speed, range, and usefulness of aircraft, missiles, and space vehicles is the result of painstaking research in many arts, crafts, and sciences. In addition to the almost limitless opportunities for the development of new knowledge in exploring space, many challenges exist in atmospheric flight. There is a need for better and faster interceptors, more efficient cargo planes, supersonic multipurpose aircraft, and commercial airplanes with higher cruising and lower landing speeds. Increasing the complexities and capabilities of modern aircraft, missiles, and space vehicles requires continuing achievements in increasingly more branches of science and technology.

LESSON VI - AEROSPACE EDUCATION AND CAREERS

A. Lesson VI (Chapters 11 and 12). At the end of this unit of instruction, the student should be able to:

1. List the six major groups of job classifications found in an airline system.
2. Name the four "jobs" that may be found in the main cabin area of a large airliner.
3. Identify jobs that are considered in the specialized service category--in regard to aircraft.
4. Give at least two occupations found in each of the three broad categories of aerospace manufacturing.
5. Given several manufacturing industries, select the one which employs the most people.
6. Identify the methods by which young people may obtain commissions as Air Force officers.
7. Name four U.S. Government agencies which provide "aerospace" careers.
8. In billions of dollars, give the approximate amount of money spent by the Federal Government on aerospace research and development programs.
9. List some of the advantages that a Civil Air Patrol cadet has in obtaining information about aerospace careers.

B. Overview.

Education must provide the highly skilled personnel required in Aerospace Age occupations. It must also interpret the impact of aerospace technology for the benefit of all of our people. There are now 49 colleges which confer degrees in aeronautical engineering; 25 colleges offer programs in aeronautical administration or aerospace services; and more than 100 colleges now teach astronautics. Aviation trade schools have been established in every state of the Union. The aerospace industries conduct more than 1,500 training courses in job-related subjects, and the U.S. Air Force operates a training and education program that is more extensive than the combined programs of the public schools, trade schools, and airlines. Many scientific and engineering skills are necessary to maintain aerospace superiority. The production of today's intricate aerospace weapons and research vehicles requires increasingly more engineering and scientific manhours. As a result, many institutions, agencies, and corporations are providing significant assistance to young people with aptitudes for specialized training and higher education in engineering and the sciences.

More than 200,000 occupational skills contribute to our aerospace progress. Personnel with appropriate training and education have extensive vocational opportunities in air transportation, aerospace manufacturing, general aviation, military aviation and astronautics, civil government, research and development, and in hundreds of supporting industries. There are definite relationships between vocational success and individual aptitudes. Frequently, there are meaningful associations between aptitudes and school subjects that are liked or disliked, easy or difficult. Valuable assistance in selecting an appropriate occupation may be secured from educators, guidance services, professional counselors, employment offices, and other individuals and services in or near each community. General ability, special aptitudes, health, learned skills, family status, and many other factors require complex decisions in the selection of an appropriate vocation.

BOOK II

CHALLENGE OF AEROSPACE POWER

<u>Lesson</u>

1 INTRODUCTION
- The Nature of Aerospace Power
- The Elements of Aerospace Strength

2 MILITARY AEROSPACE POWER
- The Capabilities of Aerospace Power
- The Threat of Military Aerospace Power
- The Problem of Maintaining Peace
- Aerospace Power for Peace

3 THE AEROSPACE INDUSTRY
- Historical Background
- Importance of Aerospace Superiority
- Industry and National Survival
- The Space Program

4 AIRLINE TRANSPORTATION
- The Beginning of the Airlines
- The Beginning of Federal Supervision
- The Federal Aviation Administration
- Civil and Military Air Transport Cooperation
- Civil Reserve Air Fleet

5 AIRPORTS AND THE COMMUNITY
- The Need for a National Airport Program
- Airports and Aircraft
- The Metropolitan Airport Problem

6 RESEARCH AND DEVELOPMENT
- The Importance of Aerospace Research
- Our Supersonic Air Force
- Our Missile Forces
- Astronauts in Space
- The Problems of Supersonic Flight
- Space Medicine
- Problems of Space Law

BOOK II Continued

<u>Lesson</u>

7	EDUCATION AND AEROSPACE POWER The Challenge of Aerospace Education The Role of Formal Education in Aerospace Education
	SUMMARY
	OPEN TIME
	CAP or Local Examination

LESSON I - INTRODUCTION

A. Lesson I (Chapter 1). At the end of this unit of instruction, the student should be able to:

1. Define "aerospace power" in terms of capabilities.
2. List the five components of U.S. military aerospace capabilities.
3. Give the two major reasons why we need large military aerospace forces.
4. Identify the six elements of a strong modern aerospace force in being.
5. Discuss the factors which influence our nation's aerospace power.

B. Overview.

It is believed by the nation's leaders that in order to preserve peace we must be prepared for war. In general, our leadership is convinced that until a better way for achieving peace is discovered, aerospace power is our principal instrument of defense. The nation's aerospace strength depends not only upon the strength of its military aerospace force but also upon superiority of its aircraft and missile manufacturing industries, its air transportation system, its airports, and its research and development facilities (both civil and military), as well as upon the creation of an aerospace-minded public through aerospace education.

The challenges of aerospace power are numerous, and many of them have international implications. Our military aerospace force includes not only the United States Air Force but also the Army, Navy, and Marine Corps aerospace operations. The military element of our aerospace power must be strong enough to accomplish two things: (1) to make a potential aggressor hesitate to attack us and seek peaceful ways to settle differences and (2) to enable us, in case of attack, to launch an immediate and violent counterattack against an aggressor. To achieve either of these objectives presents problems, not the least of which is continued high taxes. Other problems stem from the need to achieve superiority of weapons, to effect technological changes, and to avoid concentration upon the production of a particular model or models.

All of the elements of aerospace power play a part in the solution of the problems of maintaining military strength. We need a strong aerospace industry; a strong civil air transport system; modern and plentiful airports, air bases, and missile bases; and a continuing program of research and development. Before the elements of aerospace power can play their roles successfully, still other conditions must be achieved. The success of these roles depends upon a strong national economy, wise government regulation, and a reservoir of skilled personnel.

Many disturbing questions about our aerospace power now confront us. Is it strong enough? Is it ready to do the task required of it? If it is not ready, what needs to be done to get it ready? Do we have time enough to prepare it to do the tasks we require of it?

LESSON II - MILITARY AEROSPACE POWER

A. Lesson II (Chapter 2). At the end of this unit of instruction, the student should be able to:

1. List the three primary systems of our nation's aerospace forces.
2. Tell what the following initials stand for, in relation to missiles:
   a. AAM
   b. SAM
   c. SSM
   d. ASM
3. Identify the four elements of our aerospace readiness and defense program.
4. The slogan "Aerospace Power for Peace" is called the keystone of our military policy. Discuss the following points with relation to this slogan:
   a. Prevention of war.
   b. Its general cost in terms of aircraft and budget.
   c. Relative cost of early models of Atlas missiles.
   d. Overall objective.
   e. Aerospace education.

B. Overview.

Today's aerospace weapons include the intercontinental ballistic missile (ICBM), fleets of supersonic bombers and fighter planes and a variety of tactical and strategic missiles, including those which are launched by the far-ranging nuclear submarine. The destructive capability of these forces is of such magnitude that the weapons of past wars seem almost trivial by comparison.

The modern development of rocket-powered vehicles has expanded the potential environment for warfare to include the total expanse beyond the earth's surface. Aerospace power depends upon an adequate balance of aircraft, ballistic missiles, and space vehicles.

Aerospace readiness and defense are maintained by vast detection installations, such as the Ballistic Missile Early Warning System (BMEWS), and by "ground alert" crews of the U.S. Air Force, which remain vigilant at all times. Our policy is to maintain a formidable deterrent force which will insure peace because of its superior strength.

"Aerospace Power for Peace" is the slogan which defines our military attitude.

Maintaining aerospace power is a costly operation. However, it is much more economical to maintain superiority in aerospace weapons than it is to wage a war. If it takes such superiority to keep the peace, it is well worth the cost, both in terms of money spent and effort expended.

LESSON III - THE AEROSPACE INDUSTRY

A. Lesson III (Chapter 3). At the end of this unit of instruction, the student should be able to:

1. Give the reason for the irregular development of the aircraft industry.
2. Provide the letter-number designation of the rocket and name of the country responsible for making rocketry a major element in aerospace endeavors.
3. Recognize the three changes in the aerospace industry that have been brought about by emphases on jet aircraft development, missile development, and space technology.
4. List the six divisions of "lead time."
5. Give an example of why we need engineers and research scientists in the aerospace industry.
6. Give the mission of the Alarm satellite project.
7. Place the "generations" of ballistic missiles in chronological order.
8. Name the Federal Government unit which supervises our civilian space efforts.

B. Overview.

Thousands of manufacturers and industrial organizations are devoting their skills and production capacities to the creation of aerospace vehicles and their components. Aerospace power could not be achieved without this great industrial effort. The aerospace industry employs the skills of our best scientists, engineers, and trained workmen in producing a variety of advanced types of aircraft, missiles, and space-probe vehicles.

In its early days the aircraft industry was very unstable. World War I brought into being the first great period of aircraft manufacturing. Afterwards, however, production dropped sharply, and it was not until World War II that another upsurge in aircraft manufacturing was stimulated. Again, at the end of war, the industry suffered cutbacks and contract cancellations. When the Korean War broke out in June of 1950, industry was called upon a third time to tool up in order to meet the need for late-model military aircraft.

Through these experiences we have learned of the great cost, as well as the extreme risk, of allowing our industrial potential in this field to decline or collapse. Modern achievements in space technology and the rapid development of jet-powered flight are drastically changing this unstable pattern. Never, again, perhaps, will public apathy cause production to decline.

Because aerospace power will not grow overnight, the aerospace industry must be geared to a long-range plan. It takes 7 to 10 years to develop a new weapon system from drawing board to production. This "lead time" is perhaps the most important factor in a sound program of production which will guarantee aerospace superiority.

LESSON IV - AIRLINE TRANSPORTATION

A. Lesson IV (Chapter 4). At the end of this unit of instruction, the student should be able to:

1. Tell what each of the following Bills did and its general importance to aviation industry growth:

   a. Kelly Bill, 1925
   b. McNary-Watres Bill, 1930

2. Explain how the Air Commerce Act of 1926 aided in the growth of air-passenger traffic.

3. List the two main functions of the Civil Aeronautics Act of 1938.

4. Tell what act was passed in 1957 to improve the control of airways. Discuss briefly the role of the agency which this act specified should be established.

5. Describe the U.S. military air transportation situation at the start of World War II. Give number and types of airplanes available at that time.

6. List some of the contributions made to airlines by the WW II Air Transport Service after the war ended.

7. State the purpose and composition of the Civil Reserve Air Fleet.

8. Identify the main cause of the 1946-1947 airlines slump.

9. Give the two main reasons for government subsidy to airlines.

B. Overview.

Like the aircraft manufacturing industry, the air transport industry, in its early beginning, experienced periods of difficulty. However, with the introduction of federal supervision of air commerce, which paralleled the enactment of the Air Commerce Act of 1926, the airlines began a period of substantial progress. Subsequent aviation legislation helped them to become a stable industry. At the outbreak of World War II, the importance of air transportation to successful military operations was realized. Through the assistance of both the domestic and international air carriers, the military air transport service grew, in a period of three and one-half years, into the mightiest air transport system ever developed. Its network of intercontinental airways embraced the world. Its air bases were well equipped and completely manned for all-weather flying. Commercial air transportation fell heir not only to this network of intercontinental airways but also to an accumulation of information concerning long-distance flight which was painfully gathered by the Air Transport Command during a comparatively brief period of airlift performance.

The commercial airlines today are tied closely to military aviation through a task force known as Civil Reserve Air Fleet. CRAF is currently made up of civil passenger and transport aircraft. All are in commercial operation but earmarked for military use when needed. As a potential auxiliary of the military services, the civil air transport industry saves the American taxpayer a considerable amount of money.

Although the United States Government recognizes the importance of air transportation to the nation's commerce, industry, and economy, it regards civil aviation as a business to be operated by businessmen. However, because of the economic and military importance of aviation, it is the practice of the government to assist airlines by means of subsidies until they can become self-sustaining.

LESSON V - AIRPORTS AND THE COMMUNITY

A. Lesson V (Chapter 5). At the end of this unit of instruction, the student should be able to:

1. Give three reasons why a national airport program is needed.

2. State the length and weight-bearing capability of runways which can accommodate large jet aircraft--such as the Boeing 707.

3. Give the two big differences in airway operations of jet and reciprocating engine aircraft.

4. Name three developments that will improve air traffic control.

5. Give the percentage of Federal funds that can be used in the construction of a "local" airport.

6. List at least two community-type obstacles to airport construction and modernization.

7. List at least four advantages that airport construction can provide to a community.

8. Give several actions that metropolitan centers can take to help solve their "airport problems."

B. Overview.

Airports are evolving from the older cow pastures, upon which light single-engine aircraft could land, into areas bisected by 10,000-foot heavy-concrete runways. In view of current aircraft developments, all too few of the nation's airports have completed this process of change. This is true in spite of the fact that since 1946 a national airport program has been in operation. Very likely, the lag in airport development stems from a lack of general understanding of the need for modern airports.

Jet-powered air transports entered commercial service in the late fifties. They are now in large-scale use, and the runway situation for domestic and international air activities has become crucial. The growth of air traffic has created airspace congestion at many of our major airports, particularly during periods of low-visibility weather. Programs of federal support for both construction and modernization of airports and installation of air traffic control facilities have been authorized. The Federal Airport Act of 1946 authorized the use of federal money for airport development. The Act of 1946 provided that funds should be apportioned to the several states on a population-area basis to be matched 50-50 by local sponsoring agencies. The National Airport Plan established in 1959 by FAA, under authority of the Act of 1946, is constantly being reviewed and revised to anticipate future developments. The Congress continues to appropriate matching funds, but failure of community leaders to provide their share of funds explains the apparent inadequacies of our present airport system. Were communities to realize fully the advantages resulting from an adequate municipal airport, the airport problem would be well on the way to solution.

The airport problems of large municipal centers are quite critical. At large metropolitan centers the available airspace over the airport has reached the point of saturation. Airport engineers are concluding that a municipal area needs several specialized airports, such as one for short-haul traffic, another for cargo traffic, another for international operations, and another for domestic trunkline traffic.

It appears imperative that, for the nation's security and economic welfare, all necessary effort must be expended in the interest of an adequate national airport system. The Airport and Airway Development and Revenue Acts of 1970, are the most significant acts ever passed to develop and finance a long-range, nation-wide airport and airways system.

LESSON VI - RESEARCH AND DEVELOPMENT

A. Lesson VI (Chapter 6). At the end of this unit of instruction, the student should be able to:

1. List four or more organizations that are involved in aerospace research.

2. Briefly describe the functions of the USAF Office of Aerospace Research, Air Force Systems Command, and the USAF Air Proving Ground Center.

3. Name at least five space projects which are, or have been, conducted by NASA.

4. Define supersonic.

5. Give the performance characteristics of the SR-71.

6. Name at least one cargo aircraft developed specifically for military use.

7. Given the name of a missile, select its classification according to usage.

8. Match U.S. "firsts" in space with the astronauts who accomplished the feats.

9. Give the letter-number designation of the aerospace plane used in hypersonic flight research.

10. Give the name of the pilot who first flew faster than sound, and the date of the flight.

11. Name the scientist who discovered the "area rule" concept of aircraft design.

12. Identify at least four developments that have resulted from research in supersonic aerodynamics.

13. Describe how the BMEWS provides data for predicting the point of launch, impact area, and impact time of a missile fired toward the United States.

14. State the purposes of projects Rover, Pluto, and SNAP.

15. Define "closed ecological system."

16. List some of the factors that must be considered when setting a course for interplanetary travel.

B. Overview.

Research has revolutionized aerospace science. It has made possible the historic first flights of men into space. It has developed jet and rocket engines and made possible a wide variety of supersonic aircraft and guided missiles. We have built an arsenal of ballistic missiles, ranging from small air-to-air weapons to powerful ICBM's, such as the Atlas, Titan, Polaris, and Minuteman. Space research vehicles, such as the X-15, have pointed the way to new potentialities in manned flight. Future developments in the aerospace field depend upon research. Our nation's position as a leader in aerospace technology rests upon the success of research and development.

Aerospace research in the United States is conducted by industry, the military services, the National Aeronautics and Space Administration, the National Bureau of Standards, the nation's colleges and universities, and many private agencies. The United States Air Force monitors many research projects through its Air Force Systems Command. The chief task of the National Aeronautics and Space Administration is the development of a comprehensive program for the study of peaceful uses of space.

The first successful flights in space vehicles, accomplished by Gagarin and Shepard, marked the beginning of man's actual conquest of outer space. The many new frontier areas of research in the aerospace field include space medicine, nuclear propulsion, space law, interplanetary navigation, and countless other important areas. Future research promises to revolutionize our lives and the world in which we live.

LESSON VII - EDUCATION AND AEROSPACE POWER

A. Lesson VII (Chapter 7). At the end of this unit of instruction, the student should be able to:

1. State the factor which will be most likely to determine the outcome of the struggle for air and space supremacy.

2. Given any one of the three major areas of education, state its purpose--what it produces.

3. Give one reason why our nation needs to expand aerospace education.

B. Overview.

The outcome of the struggle for aerospace supremacy depends upon the quality of our aircraft and space vehicles and upon their successful operation. However, the quality of our vehicles and the skill of those who design, fly, service, and maintain them depend upon the quality of the education and training they receive. To a great degree, the outcome of the struggle for aerospace supremacy also depends upon the education of the general public. For without general public understanding of the relationship of a strong aerospace force to the nation's defense, adequate aerospace power can never be established.

It takes several years to bring an aircraft from the drawing-board stage to the testing stage of its development. It takes 18 years for a young man or young woman to reach maturity. An aerospace age demands, during this period of growth, an education quite different from that of the horse and buggy era. Without proper general education, the success of future training in special aeronautical and space science fields could well be affected. Scientists, research specialists, aerospace technicians, pilots, and flight engineers all need a substantial, general-education foundation upon which to build their special skills and understandings. Moreover, both these specialists and the general public must, through an adequate program of general education, become oriented to the Aerospace Age to the extent that they develop socially desirable attitudes toward aerospace and its importance.

Education relates to every element of aerospace power. It is important to the aircraft and missile manufacturing industries, to the air transport industry, to the United States Air Force, and to Army, Navy, and Marine Corps aerospace operations. Schools and colleges generally recognize a responsibility toward the special education requirements of aerospace technology. It is just as important, however, that appropriate understandings and proper attitudes toward the Aerospace Age be ingrained in the average citizen as it is that pilots be taught to fly aerospace vehicles and engineers be taught to design them.

BOOK III

AIRCRAFT IN FLIGHT

Lesson

1 THE ATMOSPHERE AND THEORIES OF FLIGHT
The Atmosphere
Theories of Flight

2 FORCES OF FLIGHT
Lift; Angle of Attack; Lift and Velocity of the Relative Wind; Air Density and Lift; Wing Area and Lift; Flaps, Slots, and Spoilers; The Boundary Layer; Drag; Thrust; and Weight.

3 STABILITY AND CONTROLS
The Axes of Rotation; Stability; and Flight Controls

4 AIRCRAFT DESIGN AND STRUCTURE
Locating the Center of Gravity (C.G.)
Stresses; Fuselages; Wings; The Tail Assembly (Empennage); Construction Materials; and Hydraulic Systems

5 AIRCRAFT INSTRUMENTS
Engine, Aircraft, Navigation, and Flight Instruments
Classification by Operating Principle

6 HIGH SPEED FLIGHT
The Nature of Sound
The Sonic Barrier and Shock Waves
Design for Transonic Speeds and Beyond
Thrust Requirements for High Speed Flight
The Thermal Thicket

7 MAN IN FLIGHT
Very High Altitude Emergency Equipment
Vision in Flight
The Effects of Acceleration
Illusions in Flight

SUMMARY

OPEN TIME

CAP or Local Examination

LESSON I - THE ATMOSPHERE AND THEORIES OF FLIGHT

A. Lesson I (Chapter 1). At the end of this unit of instruction, the student should be able to:

1. Describe the composition and behavior of the atmosphere with special reference to:

   a. Pressure
   b. Weight and density
   c. Temperature
   d. Humidity
   e. Winds and air currents
   f. Effects of altitude

2. Define "relative wind."

3. Explain the theories of flight based on Bernoulli's Theory and Newton's Action and Reaction Theory.

B. Overview.

The atmosphere is a sea of air extending hundreds of miles upward, and composed primarily of nitrogen (78%) and oxygen (21%). Like all gases, air has pressure, density, weight, and temperature. The value of these varies on the earth's surface, but the most important point for flight is that they all decrease with altitude.

The velocity of the air passing over the aircraft is the velocity of the relative wind. To really understand relative wind, one must understand the velocity relationship between the air, the aircraft, and the ground.

There are two popular theories of how an aircraft gets its lift. The simplest is based on Newton's Third Law of Motion, or the action-reaction principle. It is simply that the wing or airfoil leading edge is higher than the trailing edge, and the relative wind strikes the undersurface, forcing the aircraft up.

Another more common theory, which explains how most of the lift is provided, is called the Bernoulli Principle. It is based on the relationship and variation of the velocity and pressure of the air (which comprise the total energy of the air) moving over the wing surfaces. The upper curved surface requires the air to travel farther to rejoin the undersurface air at the trailing edge. When the velocity on the upper surface increases, the air pressure decreases--but the total energy remains constant. The pressure differential results in lift.

LESSON II - FORCES OF FLIGHT

A. Lesson II (Chapter 2). At the end of this unit of instruction, the student should be able to:

1. Describe airfoil design with reference to the leading edge, trailing edge, chord, and camber.

2. Discuss the effects of the following on the amount of lift generated, and explain or define associated terms:

   a. Angle of attack
   b. Velocity of the relative wind
   c. Air density
   d. Wing area
   e. Flaps, slots, and spoilers
   f. The boundary layer

3. Explain the relationship of drag to lift and thrust, define the types of drag, and discuss drag with reference to:

   a. Angle of attack
   b. The boundary layer
   c. Aspect ratio
   d. Velocity

4. Define thrust and weight, and explain their relationship to lift and drag.

B. Overview.

Four primary forces act on an aircraft in flight: lift, thrust, drag, and weight. For constant speed in level flight, lift must equal weight, and thrust must equal drag.

LESSON III - STABILITY AND CONTROLS

A. Lesson III (Chapter 3). At the end of this unit of instruction, the student should be able to:

1. Name and explain the three axes about which an aircraft can move, and state the term used for each type of movement.

2. Discuss the term "stability" with reference to the following:

   a. Positive, neutral, and negative
   b. Sensitivity of controls
   c. Static and dynamic

3. Explain how longitudinal stability is obtained with reference to:

   a. Location of center of gravity and center of lift
   b. Horizontal stabilizer design and action
   c. Relative wind
   d. Unbalanced alignment of thrust and drag forces

4. Explain how lateral stability is obtained with reference to:

   a. Dihedral
   b. Keel effect
   c. Sweepback

5. Explain how directional stability is obtained with reference to:

   a. Vertical tail surface
   b. Location of center of gravity

6. Discuss the location and theory of operation of the following flight controls: ailerons, elevators, rudder, and trim tabs.

7. Describe the use of the throttle, ailerons, elevators, and rudder in turns.

8. Describe the use of throttle and elevators in climbs, and define:

   a. Climbing angle
   b. Rate of climb
   c. Ceiling

9. Define the variety of conditions which can lead to a stall.

B. Overview.

An aircraft can rotate on three axes: rotation on the longitudinal axis is called roll; rotation on the lateral axis is pitch; and rotation on the vertical axis is yaw.

The function of flight controls is to control the lift and drag forces of various parts of the aircraft about a specific axis.

LESSON IV - AIRCRAFT DESIGN AND STRUCTURE

A. Lesson IV (Chapter 4). At the end of this unit of instruction, the student should be able to:

1. Explain what is meant by "load factor," and what causes it to vary.

2. Explain what is meant by the following terms: center of gravity, center of gravity range, maximum allowable gross weight, datum, and mean aerodynamic chord.

3. Given appropriate statistical data, compute an aircraft's maximum allowable gross weight, and determine whether its load is appropriately balanced.

4. Explain what "stresses" are, and give examples of tension, compression, bending, shearing, and torsion.

5. Describe the design and characteristics of truss and semi-monocoque fuselages, and the advantage and present use of each.

6. Describe wing design with reference to the four major components and their purposes, the differences in braced and cantilever wings, and the differences between light and heavy subsonic aircraft.

7. Describe the component parts and structure of the tail assembly and nacelles.

8. Discuss the design of landing gear with reference to:

   a. Fixed and retractable
   b. Conventional, tricycle, and bicycle
   c. Shock absorption
   d. Landing gear footprint
   e. Ganged wheels
   f. Brakes

9. Discuss the qualities and uses of the following materials, separately and as alloys, in today's aircraft: wood, aluminum, steel, titanium, nickel, magnesium, ceramics, and plastics.

10. Discuss hydraulic systems with reference to the following:

    a. Uses in aircraft
    b. Basic principles of hydraulics, including Pascal's Law and mechanical advantages.
    c. The design of a hydraulic system, and the function of the following component parts:

       (1) Hydraulic pump and actuating cylinder
       (2) Reservoir
       (3) Selector valve and return line
       (4) Power pump and relief valve
       (5) Pressure regulator and check valves

B. Overview.

An aircraft must be aerodynamically efficient; that is, its design characteristics must permit desirable lift without too much drag. An aircraft must also be structurally efficient; that is, its construction must give it its designed strength with as little weight as possible. But increased strength means increased weight; therefore, designers of ever-improving aircraft compromise between strength and weight.

LESSON V - AIRCRAFT INSTRUMENTS

A. Lesson V (Chapter 5). At the end of this unit of instruction, the student should be able to:

1. List the ways aircraft instruments can be classified either (1) according to use, or (2) according to construction or operating principle.

2. Discuss the purpose and use of the following engine instruments: tachometer, engine temperature gauges, oil pressure gauge, fuel gauge, manifold pressure gauge, and carburetor temperature gauge.

3. List aircraft safety instruments usually available.

4. Discuss the design and use of the following flight instruments: altimeter, turn-and-bank indicator, rate-of-climb indicator, and artificial horizon.

5. Discuss the design principles of the airspeed indicator and magnetic compass.

6. Discuss the operating principles of mechanical instruments (including gyroscopic instruments), pressure instruments (including bourdon tube and diaphragm), and electrical instruments (including Wheatstone Bridge, thermocouples, generator, tachometer, and remote indication systems).

B. Overview.

When classified by use, there are three main types of instruments: flight, engine, and navigation. Some instruments may be classified in more than one of these categories.

LESSON VI - HIGH SPEED FLIGHT

A. Lesson VI (Chapter 6). At the end of this unit of instruction, the student should be able to:

1. Discuss the nature of sound, and explain how sound is transmitted in the atmosphere and what causes variations in its speed in the atmosphere.

2. Define the terms Mach number, subsonic, transonic, supersonic, and hypersonic.

3. Discuss the transonic zone with reference to:

a. The compressibility of air
b. Variations in pressure and velocity of the airstream on aircraft surfaces
c. Shock wave formation
d. Effects on flight

4. Define "critical Mach," and explain design changes in the following areas which became desirable with supersonic flight:

a. Fuselages
b. Wings

(1) Thickness-to-chord ratio
(2) Aspect ratio
(3) Structural strength
(4) Drag-lift considerations
(5) Effects of sweptback and delta planforms
(6) Variable geometry wings

5. Define "thermal thicket;" discuss the nature of heat and the heat problem at high speeds; and explain methods that are used, or being considered for use, to deal with this problem.

B. <u>Overview.</u>

Since World War II, aircraft designers have been concerned with the problems of supersonic flight. Today, such flight is routine in military aircraft, and soon will be in commercial travel. For flight at supersonic speed, designers had to consider air's compressibility, a characteristic they had largely ignored for subsonic flight.

LESSON VII - MAN IN FLIGHT

A. <u>Lesson VII (Chapter 7).</u> At the end of this unit of instruction, the student should be able to:

1. Discuss man's ability to adapt to altitude on the ground and in the air with specific reference to how this ability is affected by changing atmospheric density and pressure at varying altitudes.

2. Define hypoxia, and discuss its symptoms and methods for its prevention at altitude, including how lower pressure and density affect breathing and associated body functions.

3. Explain the effects of altitude on undissolved body gases in the gastro-intestinal tract, the middle ear and Eustachian tube, and the sinuses, including how problems can be relieved.

4. Explain what decompression sickness is, what causes it, what its effects are, and what can be done about it.

5. Discuss the oxygen and pressure problem between 45,000 and 65,000 feet, and describe the emergency equipment needed by man at these altitudes.

6. Discuss vision in flight with reference to the following:

a. Illuminated and night vision
b. Central and peripheral vision
c. Facts a pilot should know to improve visual perception

7. Define "acceleration," and discuss the effects of "G's" and factors affecting man's tolerance to them.

8. Discuss "equilibrium" with reference to the role of eyes, muscles, and the inner ear.

9. List and explain some of the illusions to which pilots are subject when betrayed by their senses.

B. <u>Overview.</u>

Man is adapted to live on the ground; therefore, as he has proceeded into the air at higher and higher altitudes, he has encountered problems to which he must adjust and for which he has had to develop equipment to assist him.

BOOK IV

POWER FOR AIRCRAFT

Lesson	
1	INTRODUCTION TO AIRCRAFT POWERPLANTS The Three Main Types of Engines The Seven Components of a Powerplant
2	RECIPROCATING ENGINES Early Development of the Internal Combustion Engine How the Reciprocating Engine Works Reciprocating Engine Design
3	FUEL SYSTEMS FOR RECIPROCATING ENGINES Design and Operating Principles of the Carburetor Fuel Injection Fuels and Their Use
4	RECIPROCATING POWERPLANT ELECTRICAL SYSTEMS Principles of Electricity The Ignition System Sparkplugs
5	COOLING AND LUBRICATING SYSTEMS FOR RECIPROCATING ENGINES Cooling Systems The Lubrication System
6 (Chap 6 & 7)	RECIPROCATING ENGINE INSTRUMENTS AND CONTROLS; PROPELLERS
7 (Chap 8)	JET ENGINES Jet Engine Operating Principles Ramjets; Turbojets; The Turboprop Engine; and The Turbofan Engine
8 (Chap 9)	TURBINE ENGINE ACCESSORIES AND SUBSYSTEMS Thrust Reversers; Noise Suppressors; and The Fuel System The Lubrication System The Cooling System Engine Instruments

BOOK IV Continued

Lesson

9 (Chap 10) POWERPLANTS OF THE FUTURE
- Reciprocating Engines
- The Rotary Combustion or Wankel Engine
- The Rocket Engine
- The Gas Turbine Engine
- Composite Engines

SUMMARY

OPEN TIME

CAP or Local Examination

LESSON I - INTRODUCTION TO AIRCRAFT POWERPLANTS

A. Lesson I (Chapter I). At the end of this unit of instruction, the student should be able to:

1. Identify and briefly discuss the following three main problems encountered in early reciprocating powerplant development:

   a. Weight/power output ratio
   b. Reliability
   c. Economy

2. List the three major categories of engines now in use in the sequence of their development for aircraft operational use, and state approximately the speed, power, and altitude limitations of present-day versions of each.

3. List the seven main parts of an aircraft powerplant, and briefly describe the role of each.

4. Define or explain the following in his own words and give examples of each with reference to aircraft operation:

   a. Kinetic and potential energy
   b. Boyle's Law
   c. Charles' Law
   d. Newton's Second and Third Laws of Motion

5. Define horsepower and thrust in general terms, explain the context in which each term is used, and state a "rule of thumb" for conversion of thrust to horsepower.

B. Overview.

In the early stages of aircraft powerplant development, the main problems were the weight/power output problem, the need for reliable operation, and the need for economy of construction, operation, and maintenance. In differing degrees, these problems continued to be of prime importance, but the desire to fly higher and faster became the motivating factor which led to the improvement of reciprocating engines, and subsequently to the airstream jet and rocket engines.

The operation of internal combustion engines and aircraft is based on principles known as Charles' Law, Boyle's Law, and Newton's Second and Third Laws of Motion. These must be understood to thoroughly understand how reciprocating and reaction engines convert potential energy into kinetic energy.

The force exerted by, or the work done by, reciprocating engines is stated in terms of horsepower. Jet aircraft force is stated in terms of pounds of thrust. To really understand the fantastic thrust in modern jets, it is enlightening to convert the pounds into the more familiar horsepower unit. When the horsepower of a modern jet is compared to the horsepower of the Wright Brothers' engine, the progress in the field can really be appreciated.

LESSON II - RECIPROCATING ENGINES DEVELOPMENT, DESIGN, AND OPERATION

A. Lesson II (Chapter 2). At the end of this unit of instruction, the student should be able to:

1. Define the term "reciprocating" as it applies to engines, and define the general area of continued use of reciprocating aircraft in view of jet development.

2. Describe briefly the early history of the development of internal combustion reciprocating engines with reference to the contribution of the following individuals: W. Cecil, William Barnett, de Rochas, Nickolaus Otto, Wright Brothers, and Charles Manly.

3. Given an appropriate cross-section illustration, label the following main parts of the reciprocating engine: Cylinder, piston, connecting rod, crankshaft, valves, sparkplug, and valve operating mechanism.

4. List the five events of an Otto engine, and briefly describe what happens during each of the four strokes of an Otto engine cycle, with specific reference to the above main parts.

5. Describe how rotary motion is converted to straight line motion in the in-line and rotary engines, with reference only to the movement of pistons, connecting rods, and crankshaft.

6. Describe the operation of a cylinder in terms of Charles' and Boyle's Laws.

7. Depict the piston-connecting rod-crankshaft arrangements of the following engines with simple, front-view line drawings: upright in-line, inverted in-line, V type upright, opposed, and radial.

8. Describe the primary advantage (s) of the:

a. Inverted design over the upright engine
b. The radial design over the in-line engine
c. The opposed design over the other in-line engines

9. Given the stroke, the bore, the mean effective pressure, the engine rpm's, and the number of cylinders, compute the horsepower of an engine.

B. Overview.

Reciprocating engines continue to be the most economical and efficient at relatively low altitudes and low speed, especially for small, low-powered aircraft.

LESSON III - FUEL SYSTEMS FOR RECIPROCATING ENGINES

A. Lesson III (Chapter 3). At the end of this unit of instruction, the student should be able to:

1. Define the purpose and list the main components of a fuel system; and discuss the major difference in the design and use of gravity-feed and force-feed systems.

2. Describe the design and explain how a venturi tube operates with reference to the pressure and velocity of fluid moving through it.

3. Given a cross-section drawing, identify the six major parts of a simple float carburetor, and briefly describe the functions of each.

4. Explain the essential design and operation of internal and external superchargers, and list the advantages of this system over a simple float carburetor.

5. Explain the advantages of downdraft over updraft carburetors.

6. Describe the basic design and operating differences between float and diaphragm carburetors.

7. Briefly explain "fuel injection" and compare its operation to a carburetor system.

8. Explain the desirable characteristics of an aviation fuel, specifically considering volatility, flash point, freezing point, and stability.

9. Explain "lean" and "rich" air/fuel mixtures with reference to the operational characteristics of each.

10. Explain what the following are and the causes and remedies for each:

a. Vapor lock.
b. Carburetor icing.
c. Fuel knock.
d. Detonation.
e. Pre-ignition.

11. Explain the term "octane rating."

B. Overview.

The purpose of a fuel system is to deliver to the carburetor a steady flow of clean fuel at a constant pressure. To do this, it is comprised of a series of tanks, fuel lines, pumps, and strainers. The carburetor, which may also be considered to be a part of the system, delivers a proper mixture of fuel and air to the cylinders. The two basic types of fuel systems are gravity-feed and force-feed. The reliance on gravity for even fuel flow was very unsatisfactory for modern aircraft for a number of reasons. Fuel tanks had to be located in relation to the engine so that the fuel would flow down, thus causing serious aircraft design limitations. Also, modern high pressure engines required fuel under greater than atmospheric pressure to develop high power, as you know. Also, with higher altitudes and significant changes in atmospheric pressures on the system during a flight, as well as increased maneuvering, the enclosed pressurized system became increasingly necessary.

LESSON IV - RECIPROCATING POWERPLANT ELECTRICAL SYSTEMS

A. Lesson IV (Chapter 4). At the end of this unit of instruction, the student should be able to:

1. Briefly explain in his own words the basic operating principles of an electric generator and a transformer.

2. Draw a schematic diagram of an ignition system, and identify and briefly explain the operation of each of the following parts: armature, the primary and secondary windings, the breaker points and condenser, the distributor, sparkplugs, and the ignition switch.

3. List three methods for starting reciprocating engines, and explain how direct and inertia starters work.

B. Overview.

At this point, you have a general idea of how an engine operates, but we have not considered how to get it started. How do we get the fuel into the cylinder and ignite it so the engine will start and continue operating? For this, we need a starter to turn the motor over and draw a fuel mixture into the cylinder, and an ignition system or source of timed electricity to feed a spark to the sparkplug(s) for each cylinder at the proper time. The heart of an ignition system is the magneto. To understand how it works, you must first know a little about some basic principles of electricity--particularly how a simple generator and transformer work.

LESSON V - COOLING AND LUBRICATION SYSTEMS FOR RECIPROCATING ENGINES

A. Lesson V (Chapter 5). At the end of this unit of instruction, the student should be able to:

1. List four ways in which engine heat is used or dissipated, and the approximate amount of engine heat handled in each way.

2. Briefly explain how a liquid cooling system works by tracing the cooling agent from the radiator through a complete cycle until the agent is again ready to enter the engine, specifically explaining the transfer of heat.

3. List the advantages and disadvantages of liquid and air cooling systems, with specific reference to the effort to improve air cooling by the use of fins, baffles, and cowling flaps.

4. List at least three different functions of a lubricating system in a reciprocating engine.

5. Briefly discuss the effects of friction, and explain the three main ways in which it is reduced.

6. Define viscosity, flash point, and pour point with reference to oil.

7. Given illustrations, identify the following parts of a typical wet and dry sump lubricating system and explain the function of each: storage tank, pressure pump, sump, filter, scavenger pump, and radiator.

B. Overview.

The purpose of the reciprocating engine is to convert the heat energy from the fuel into mechanical energy. However, only about 30 or 35% of the heat goes directly into this task and produces useful work on the propeller shaft. Perhaps 5 to 10% is used in overcoming friction on the piston, and over 40% is expelled through the exhaust system. This leaves 20 to 25% which must be dissipated in another way if it is not to cause damage to the engine. For this a cooling system is necessary. To prevent even more inefficient heat from being generated, a lubrication system is used, and this serves a secondary purpose of carrying off some excess heat.

Friction between two surfaces moving against each other in an engine causes heat to be generated. The combination of friction and heat causes deterioration of parts and the loss of mechanical efficiency. These undesirable effects are reduced by using ball bearings and roller bearings as well as by using different metals when two parts come into contact with each other, such as bearings and the journals (spindles or shafts) which turn within the bearings. Oil, of course, reduces friction between two moving surfaces, and all engines must have a lubricating system.

LESSON VI - RECIPROCATING ENGINE INSTRUMENTS AND CONTROLS; PROPELLERS

A. Lesson VI (Chapters 6 and 7). At the end of this unit of instruction, the student should be able to:

1. List the three most basic temperature instruments and the three most basic pressure instruments, and explain the importance to the pilot of each.

2. Explain the value of the tachometer to the pilot as an indicator of how the engine is operating.

3. List five of the most important engine controls, and describe what each does, referring to specific instrument indications which require their use.

4. List the two most common types of controls according to construction and the three types according to method of operation.

5. Briefly describe a control quadrant or pedestal.

6. Compare the design of a propeller with that of a wing, with particular reference to the following peculiarities of propellers: tip design and variations in chord length, variations in pitch and effect on thrust, and difference in pattern of the propeller's motion.

7. Define the following terms and/or explain the advantages and disadvantages of the following types of propellers or propeller capabilities: fixed and variable pitch, adjustable and controllable pitch, constant speed propellers, full-feathering, and negative pitch.

B. Overview.

Engine instruments inform pilots of the operating conditions of aircraft engines. Most engine instruments are pressure or temperature gauges. For example, modern engines have gauges that indicate oil, cylinder head, and carburetor temperatures. Acceptable operating limits are usually indicated right on the instruments.

A propeller is an airfoil just as is a wing, except that the "lift" it provides is in a forward rather than an upward direction.

LESSON VII - JET ENGINES

A. Lesson VII (Chapter 8). At the end of this unit of instruction, the student should be able to:

1. Briefly explain the application of Newton's Second and Third Laws of Motion to jet propulsion.

2. In the most simple terms, explain the design and operation of the ramjet, stressing its limitations in practical use.

3. Name the four main sections of the turbojet engine, and compare the function of these sections to the five events of the reciprocating engine Otto cycle.

4. Name the two types of compressors used. Explain their differences in terms of design and operation of the stator and rotor, and compare the efficiency of the two types.

5. Briefly explain the design and operation of the can and the annular types of combustion chambers.

6. Compare the design and operation of the turbine with the compressor; state the purpose of the turbine; and discuss the stresses on the operating turbine.

7. Briefly explain the design and purpose of the exhaust section, including reference to the afterburner function.

8. Briefly compare and contrast the design and operation of turboprop and turbofan engines with conventional turbojet and reciprocating engines, stressing the advantages of the turboprop and turbofan.

B. Overview.

The altitude, speed, and power limitations of reciprocating engines led to the development of jet engines. The first successful jet flight in the United States was in 1942, and it employed a version of Frank Whittle's engine. Whittle had worked on this development for two decades prior to his first successful jet engine in England in 1941.

Jet engine operation is based primarily on Sir Issac Newton's Second and Third Laws of Motion. According to the Second Law, force (thrust) is equal to mass times acceleration. In other words, the thrust of a jet is equal to the amount of air moved by the engine times the amount of acceleration the air is given.

LESSON VIII - TURBINE ENGINE ACCESSORIES AND SUBSYSTEMS

A. Lesson VIII (Chapter 9). At the end of this unit of instruction, the student should be able to:

1. Briefly discuss the purpose and design of thrust reversers.

2. Explain the operation of noise suppressors with reference to the size of an engine and the amount of thrust, the mass and acceleration of exhaust gases, and the characteristics of high frequency sound.

3. Describe the pressure-driven and mechanically-driven accessory systems.

4. Briefly explain the operating principles of air turbine (pneumatic) and combustion starters.

5. Describe how thrust is controlled by fuel control, with specific reference to the relationship to turbine rpm's in centrifugal and axial compressor engines.

6. Describe briefly the major differences in lubrication requirements between the turbine and the reciprocating engine.

7. Describe briefly how turbine engines are cooled.

8. Discuss the purpose of liquid injection and how it is done.

9. List eight basic instruments for monitoring turbine engine performance and tell what each one does.

B. Overview.

Accessories and subsystems for the jet engine are powered in two ways: either by high pressure air bled from the rear of the compressor or by an accessory shaft geared to the main compressor shaft. Much high pressure air is available to drive small turbines which are independent of the main engine. They are used to operate air conditioning units, hydraulic pumps, generators, pressuring units, heating units, etc. Accessory shafts drive such things as tachometers, pumps, generators, alternators, etc.

LESSON IX - POWERPLANTS OF THE FUTURE

A. Lesson IX (Chapter 10). At the end of this unit of instruction, the student should be able to:

1. Briefly explain the rotary combustion (RC) engine with specific references to:

   a. Mainshaft and rotor operational relationships
   b. The five events of the Otto cycle
   c. Comparison with other types of engines

2. Describe the most critical problem areas to be dealt with in future improvements of gas-turbine-powered aircraft.

B. Overview.

Reciprocating engines serve a continuing purpose for relatively low speed, low altitude economical flight. More advanced propulsion systems include the rotary combustion engine, the gas turbine, and composite engine types.

BOOK V

NAVIGATION AND THE WEATHER

Lesson	
1 (Chapters 1 & 2)	THE IMPORTANCE OF WEATHER AND OF MEASURING TIME, DISTANCE, AND DIRECTION Introduction Aeronautical Charts and Publications, and Weather Information and Charts Types of Navigation Measuring Time, Distance, and Direction Meridians of Longitude and Parallels of Latitude The Time Zones Map Projections and Aeronautical Charts Variation, Deviation, and Compass Courses Basic Navigation Instruments
2 (Chapters 3 & 4)	PILOTAGE AND DEAD RECKONING Pilotage "Before Takeoff" Navigation Procedures A Flight by Pilotage Dead Reckoning Six Basic Dead Reckoning Factors
3 (Chapter 5)	RADIO AND ELECTRONIC NAVIGATION The Low-Frequency/Medium-Frequency Radio Range The Automatic Direction Finder Radio Direction-Finding Stations
4 (Chapter 6)	CELESTIAL NAVIGATION The Celestial Sphere and Celestial Coordinates Hour Angles: Sidereal, Greenwich, Local
5 (Chapter 7)	INERTIAL NAVIGATION Inertial Navigation Theory
6 (Chapter 8)	THE WEATHER The Atmosphere Local and Surface Air Movements The Jet Stream Humidity; Condensation; Temperature; and Altitude

BOOK V Continued

Lesson

7 (Chapter 9)	AIR MASSES, FRONTS, AND WEATHER HAZARDS	
		Temperature Classification and Characteristics of Air Masses
		Fronts: Cold; Warm; Occluded; Stationary
	SUMMARY	
	OPEN TIME	
	CAP or Local Examination	

LESSON I - THE IMPORTANCE OF WEATHER AND OF MEASURING TIME, DISTANCE, AND DIRECTION

A. Lesson I (Chapters 1 and 2). At the end of this unit of instruction, the student should be able to:

1. List six things which a pilot should do before preflighting his aircraft for a cross-country flight.

2. List four types of aeronautical charts used by pilots.

3. Given the title of an aeronautical publication, tell what type information a pilot may get from the publication.

4. Give the reasons why a pilot must be familiar with prevailing and forecast weather along his flight path.

5. List and define briefly the five different methods of air navigation.

6. State the times, names, and distances involved with radio broadcasts of weather information which are available to pilots in flight.

7. List and describe the four methods of map making.

8. Interpret symbols used on aeronautical charts.

9. List and describe the functions of the four instruments basic to navigation.

10. Name the four weather charts which are important to pilots, and tell what information each provides.

11. Explain the scheme of meridians of longitude and parallels of latitude, and tell how it is used to locate any point on earth.

12. When provided a reference time zone, give the correct standard time of any time zone in the U.S.

13. Given the time as read from a 12-hour clock, convert the time to a 24-hour clock reading.

B. Overview.

Air navagation is the process of establishing the position of an aircraft and directing it from one place to another. One way to keep an aircraft on its course is by visual reference to landmarks that are known to mark the desired flight path. This type of navigation is called pilotage. Dead reckoning navigation requires the pilot to calculate a compass heading in advance of the flight and to keep a careful record of direction, distance, and the elapsed time between positions. Radio and electronic navigation is a third type that may be used if the aircraft is properly equipped. Pilots using celestial navigation determine their position by reference to the sun, stars, or planets. Inertial navigation systems react to inertial forces and measure motion to guide an aircraft along a desired flight path. Pilots are likely to use several different types of navigation during a single flight.

The equator is an imaginary line around the earth midway between the North and South Poles. Imaginary lines drawn parallel to the equator are called parallels of latitude. Lines perpendicular to the plane of the equator are called meridians of longitude. The meridian running from pole to pole and which passes through Greenwich, England, is called the prime meridian. Meridians and parallels form coordinates which make it easy to locate any position on the earth's surface north or south of the equator and east or west of the prime meridian in degrees, minutes, and seconds of latitude and longitude.

Pilots usually plan their flights in advance. Charting a course and determining the weather require first attention. General purpose air navigation charts include Local Aeronautical Charts, Sectional Aeronautical Charts, World Aeronautical Charts, and Aeronautical Planning Charts. Surface Weather Charts, Winds-Aloft Charts, Constant-Pressure Charts, and Prognostic Charts are among the weather charts of importance to airmen. Pilots must know and understand weather signs and symbols so they can avoid weather dangers, such as thunderstorms, fog, and icing conditions, and plan their flights accordingly.

Basic navigation instruments include the clock, magnetic compass, airspeed indicator, and altimeter.

LESSON II - PILOTAGE AND DEAD RECKONING

A. Lesson II (Chapters 3 and 4). At the end of this unit of instruction, the student should be able to:

1. Define pilotage.

2. Identify the two major factors which govern flights according to Visual Flight Rules (VFR).

3. List the six factors basic to flights by dead reckoning navigation.

4. Given the necessary information, a ruler, and a protractor, solve an air navigation problem by constructing a wind triangle.

B. Overview.

There are six steps in planning a pilotage flight: (1) Draw a true course line between departure point and destination, (2) Measure the angular direction of the true course line at the midmeridian, (3) Mark off the course line in segments appropriate for the speed and range of the airplane, (4) Select landmarks to use as checkpoints along or near the route to check heading and determine groundspeed, (5) Select prominent terrain features along either side of the course and at the destination for use as brackets, and (6) Determine compass course.

There are five in-flight procedures required in pilotage: (1) First, fly direct to the first checkpoint and take up compass heading, (2) Check wind drift, (3) Correct heading, if necessary, to keep aircraft on true course line, (4) Note elapsed time between checkpoints and determine groundspeed, (5) Maintain continuous check on the course by observing checkpoints and brackets.

To plan a flight by dead reckoning, follow the same before-takeoff procedures used in pilotage. Anticipate the effect of wind speed and direction upon the aircraft during flight. Information about wind speed and direction is obtained from weather services. Theoretically, if the effects of all the factors involved in dead reckoning are accurately computed, the pilot should be able to fly from point to point and pass over his destination precisely at the time of arrival estimated before takeoff.

The effect of the wind is determined by solving a wind triangle problem--a vector problem. A vector line represents force (or velocity) and direction. In a simple wind triangle problem, the magnitude and direction of two vectors are used to find a resultant. When the aircraft's true course and airspeed and the wind's direction and velocity are known, it is possible, by means of the wind triangle, to find the aircraft's true heading and groundspeed. When the aircraft's airspeed, true heading, groundspeed, and true course are known, the wind's velocity and direction can be found. A heading is a course corrected for wind effect. Several types of dead reckoning problems may be solved by the wind triangle method.

LESSON III - RADIO AND ELECTRONIC NAVIGATION

A. Lesson III (Chapter 5). At the end of this unit of instruction, the student should be able to:

1. Describe briefly the following types of radio/electronic navigation aids: LF/MF radio range, ADF, VOR, DME, TACAN, VORTAC, and LORAN.

2. List the three types of landing assistance provided by radio/electronic systems, and describe how each aids the pilot.

3. Given the description of a route to be flown, select the best type of radio/electronic navigation system.

B. Overview.

New and improved radio and electronic aids to navigation continue to make flying safer and easier. A pilot may now use one or a combination of radio and electronic aids. These include (1) LF/MF Radio Range Stations, (2) the Automatic Direction Finder (ADF), (3) Radio Direction-Finding Stations, (4) VHF Omnirange Stations (VOR), (5) Distance-Measuring Equipment (DME), and (6) VOR-Tactical Air Navigation Stations (VORTAC). Depending upon the area over which a flight is made, the pilot may also use LORAN (Long-Range Navigation) or Doppler radar navigation systems. Ground Controlled Approach Radar (GCA), the Instrument Landing System (ILS), and Automatic Landing Systems (ALS) assist the pilot in landing his aircraft.

A pilot can fly the "hum" or "beam" broadcast by an LF/MF radiorange station directly to the station. The Automatic Direction Finder (ADF) indicates the direction of a station being received.

Radio direction-finding stations are used chiefly for emergency "homing." An omnirange station (VOR) is a VHF radio station that transmits radio beams called radials in all directions. Distance-Measuring Equipment (DME) continually measures the slant distance of an aircraft from a known point on the ground. The need for a common radio and electronic navigation system providing bearing and distance information to both military and civilian pilots has resulted in a combination of VOR-DME with TACAN (Tactical Air Navigation). The combined VOR and TACAN systems is called VORTAC. LORAN (Long-Range Navigation) is used chiefly by aircraft flying heavily traveled ocean routes. Doppler radar navigation systems are essentially self-sufficient and do not rely on ground navigation aids.

Additional radio and electronic navigation aids assist the pilot in flying from place to place, improve flying safety and air traffic control, and provide landing assistance.

LESSON IV - CELESTIAL NAVIGATION

A. Lesson IV(Chapter 6). At the end of this unit of instruction, the student should be able to:

1. List the three items essential to celestial navigation.
2. Give the reason why there exists the Plane of the Ecliptic.
3. Define sidereal hour angle (SHA), Greenwich hour angle (GHA), and local hour angle (LHA).
4. Write the formula for determining the SHA and LHA of a star.
5. Given the observed altitude of a star, determine the number of nautical miles distance to the star's subpoint.
6. Explain why a star's subpoint will not be located at the same point at the same time each day.
7. Tell why correct time is essential to accurate celestial navigation.
8. Give the roles played by "hack" watches, master watches, and chronometers in celestial navigation.

B. Overview.

The navigator begins by observing the altitude of a star with a sextant. An assumed position is selected close to the aircraft's best known position. The "computed altitude" and bearing of the star are found in celestial navigation tables. This gives the navigator the computed altitude of the star measured from his assumed position at an exact instant of time, and the bearing of the star from true north.

When the computed altitude of the star obtained from the tables is the same as the observed altitude of the star indicated by the sextant, the observer is on a line of position passing through his assumed position. In actual practice, the computed altitude and the observed altitude of a star rarely agree. The difference between the two equals the number of nautical miles the aircraft is away from its assumed position. This difference, measured in nautical miles along the bearing of the star, is called the intercept.

A line of position is drawn on the chart at right angles to the bearing of the star. The line of position is drawn at the intercept distance, measured in nautical miles from the assumed position. The aircraft is known to be located along this line, which is a segment of a circle of position. The intersection of two or more lines of position obtained by "shooting" different stars indicates the position of the aircraft. Essentially, the navigator simply selects the point where he thinks he is and then uses the stars or other celestial bodies to find out how far away he is from this assumed position.

LESSON V - INERTIAL NAVIGATION

A. Lesson V (Chapter 7). At the end of this unit of instruction, the student should be able to:

1. List the four primary parts of an inertial guidance system.
2. Define acceleration.
3. Compare and contrast accelerometers to gyroscopes.

4. Given the rate of acceleration of a body, give its speed and the distance traveled at the end of a unit of time.

5. Explain how accelerometers are mounted to obtain the true acceleration of a body.

6. Show why "torquers" are essential components of inertial guidance systems.

7. Give three advantages of inertial navigation systems over other systems.

B. Overview.

The word "inertia" refers to the property of matter which requires that a force act on a body to change its motion. Inertial navigation systems react to inertial forces and measure motion. They convert these measurements into velocity and distance, and display heading information to guide an aircraft along a desired flight path. A pure inertial navigation system determines an aircraft's position and directs it along its course without outside assistance. It observes no checkpoints or stars, follows no compass, and senses no radio or radar signals. It is the only navigation system that is entirely self-contained.

An inertial navigation system "remembers" its travels through the atmosphere. Simply stated, it knows where it is because it remembers where it started from and how it has traveled since then. The system measures inertial forces; converts the measured data to velocity, direction, and distance; and then calculates continuously the aircraft's position.

A typical inertial navigation system has four primary parts. These are (1) an inertial (stabilized) platform containing accelerometers and gyroscopes; (2) a computer, which makes all of the mathematical calculations virtually instantaneously; (3) a power supply to operate the system; and (4) electrical and mechanical devices such as those used to preset the latitude and longitude of the takeoff point and destination.

Most future military aircraft are expected to use inertial navigation systems.

LESSON VI - THE WEATHER

A. Lesson VI (Chapter 8). At the end of this unit of instruction, the student should be able to:

1. By percentages of gases, state the composition of our near-earth atmosphere.
2. Given the names of the various layers of our atmosphere, arrange them in proper sequence.
3. Define density.
4. Explain how the actions of local air currents cause clouds to form.
5. Identify the three methods of heat transfer.
6. Explain how violent storms obtain their energy.
7. Define insolation.
8. Explain why summers are hotter in the Southern Hemisphere.
9. Give a brief description of what happens to the sun's rays as they contact our atmosphere.
10. Compare atmospheric pressure systems to terrain features.
11. List the effects that gravity and friction have upon winds.
12. Define isobar.
13. Explain why and how surface features affect local and surface air movements.
14. Describe jet streams, and tell how pilots of high flying aircraft may use them.
15. Define relative humidity.
16. List the forms of water vapor condensation, and identify those which are normally considered precipitation.
17. Define adiabatic lapse rate.

B. Overview.

Restrictions to visibility and the effects of wind direction and velocity complicate the task of air navigation. These weather phenomena occur in the first layer of the atmosphere--the troposphere.

The air of the atmosphere has temperature, volume, and density. The behavior of these three characteristics of air, in relation to each other, causes clouds, rain, snow, fog, vertical and horizontal winds, and other weather phenomena. A change in any one characteristic causes a change in the other two. Changes are brought about when heat from the sun reaches the earth through the process of radiation.

Radiant heat energy is absorbed when water from the earth's surface evaporates. When water condenses, this heat is then released, causing a change in the temperature of the surrounding air. Insolation is the rate at which the earth's surface is heated. Insolation is greatest at the equator where the sun's rays are nearly perpendicular.

The coriolis force modifies the direction of flow of air currents caused by insolation. This force results from the earth's rotation.

Air moves from high-pressure areas to low-pressure areas. The slope from a high- to a low-pressure area is called a pressure gradient and is shown on a weather map by lines of equal pressure called isobars. The strength of the wind depends upon the slope of the pressure gradient. Gravity, friction, mountains, large bodies of water, deserts, and cultivated areas all affect the speed and direction of the wind.

Dry air contains no water vapor. Humid air does. The ratio of the water vapor that air contains to the amount it can hold when saturated is called relative humidity. An adiabatic process occurs when, without heat, the expansion or compression of an air mass brings about a temperature change. A nonadiabatic process occurs when the expansion or compression of an air mass is a function of heat. Both the adiabatic and the nonadiabatic processes are important factors in weather changes.

LESSON VII - AIR MASSES, FRONTS, AND WEATHER HAZARDS

A. Lesson VII (Chapter 9). At the end of this unit of instruction, the student should be able to:

1. Identify the origins of air masses, and list the characteristics of a given air mass.
2. Given an abbreviation of an air mass, provide its long title.
3. Define front.
4. Describe the types of clouds and weather associated with a given front.
5. Explain how an occluded front is formed.
6. Given the name of a cloud, describe its shape, how it might affect a pilot or his aircraft, and give the altitude range of the cloud.
7. List the ten weather characteristics that are "measured" for forecasting weather.
8. In their proper order, list the items of information shown on a weather sequence report.
9. State the time intervals of winds-aloft forecasts, regional forecasts, area forecasts, and terminal forecasts.
10. Define SIGMET and PIREP.
11. Name the three weather hazards to aircraft in flight.

B. Overview.

A mass of air acquires the characteristics of the area with which it has been in contact for a considerable period of time. For example, a continental polar air mass is cold and dry. A maritime tropical air mass is warm and humid. Although a moving air mass takes on some of the characteristics of the surface over which it passes, it never loses all of its original characteristics. The temperature classification of an air mass is based upon its temperature in relation to the surface over which it passes.

When the movement of a cold air mass brings it into contact with a warm air mass, a cold front is formed. When the movement of a warm air mass brings it into contact with a cold air mass, a warm front is formed. Under certain conditions there is a tendency for a horizontal wave motion to occur along a front. The frontal bend so formed then develops into an occluded front; i.e., a warm air mass is forced upward by two converging cold air masses.

Certain types of weather are associated with cold air masses; others with warm air masses. Within a cold air mass, cumulus and cumulonimbus clouds may form. Local thunderstorms, showers,

hail, sleet, or snow flurries may occur. In a warm air mass, haze, fog, stratus clouds, and drizzle may be manifest.

Cold air is denser and heavier than warm air. Because of this fact, the warm air ahead of a moving cold front is lifted. Consequently, cumulonimbus clouds form and thunderstorms occur along a rapidly moving cold front. The air of a moving warm front overrides the cold air ahead of it. As a result, nimbostratus clouds form along a warm front. Drizzle and rain are likely to occur.

BOOK VI

AIRPORTS, AIRWAYS, AND ELECTRONICS

<u>Lesson</u>

1 GROWTH AND DEVELOPMENT
- The Need for Airports
- Airport Growth and Federal Aid

2 THE CHARTING OF AIRPORTS AND AIRWAYS
- The Importance of Chart Symbols
- Classification of Airports

3 ELECTRONICS
- The Radio in Modern Aviation
- Controlling the Nature of Radio-Frequency Waves
- The Stages of Sound Transmission
- Radar

4 WHY AIRPORTS ARE NECESSARY
- Commercial Fixed Base Operations
- Airport Administration
- Airline and Government Airport Operations
- Air Traffic Management
- Air Route Traffic Control Centers

5 AIRWAYS AND THE FACILITIES OF AIR TRAFFIC MANAGEMENT
- All Weather Flights
- Types of Control Radar

6 THE REGULATION OF AIR TRAFFIC, I
- The Need for Air Traffic Control
- Airport Traffic Patterns

7 THE REGULATION OF AIR TRAFFIC, II
- Flight Rules: General, Visual, and Instrument
- Approach Control
- The Language of Air Traffic Control
- Good Operating Practices

SUMMARY

OPEN TIME

CAP or Local Examination

LESSON I - GROWTH AND DEVELOPMENT

A. Lesson I (Chapter 1). At the end of this unit of instruction, the student should be able to:

1. State the reason for changing from airports with sod runways to those with more durable runways.
2. Give the title and date of the first Federal Government act intended to improve airports.
3. Provide the date and the name of the pilot who made the first scheduled night flight.
4. Identify the method used to mark airways in 1926.
5. Name three types of VHF/UHF radio facilities used as navigational aids.

B. Overview.

In the days of aviation's barnstorming pioneers, aircraft were small, light, and uncomplicated, and any "cow pasture" served as a flying field. Development of larger, heavier, and faster airplanes created a need for larger fields with improved landing surfaces. Cinder and gravel runways up to 1,500 feet in length became commonplace. But this type of field soon proved inadequate. Reinforced concrete replaced the cinder and gravel, and by 1940 runway lengths of 5,000 to 6,000 feet were the rule. Airports are again proving inadequate for tomorrow's airplane and, in many instances, for today's airplane. To handle the airplanes coming off the engineer's drawing boards today, airport operators find that they must provide landing surfaces with lengths up to 10,000 feet that will withstand loads of over half a million pounds. The Dulles International Airport at Chantilly, Virginia, is the world's first civil airport designed especially for jet aircraft.

Runways, taxi and approach lights, control towers, maintenance hangars, passenger and freight terminal buildings, and aviation gasoline pumps are only a few of the modern airport facility requirements.

Airports have grown in quantity as well as quality. In 1928 there were 1,300 airports of all types in the United States. In 1930 there were 1,800. In 1962 there were about 7,000 airports of all types serving the cities and towns of this country, and in 1970, there were more than 11,000.

In 1921 Jack Knight made the first scheduled night flight, carrying mail from North Platte, Nebraska, to Chicago, Illinois. His flight path was marked by bonfires on the ground. Lighting of airways by powerful beacons was begun the next year.

LESSON II - THE CHARTING OF AIRPORTS AND AIRWAYS

A. Lesson II (Chapter 2). At the end of this unit of instruction, the student should be able to:

1. Explain why a pilot needs to know how to read aeronautical charts.
2. Interpret symbols used on aeronautical charts.
3. Given an altitude in feet, provide its flight level.
4. State the reason why the need for designated airways is increasing.

B. Overview.

Information about airports and airways is found in symbol form on aeronautical charts. These charts show whether or not an airport (1) is operated by civil, military, or joint authority; (2) is a land or water facility; (3) is for heavier-and/or lighter-than-air aircraft; and (4) has traffic control and service facilities available.

Standardized chart symbols also give information about field elevation, field lighting, nature of runways (whether or not they are hard surfaced), and length of the longest runway. Charts also indicate whether or not low-visibility approach and direction-finding systems are available. They also show control tower transmitting and receiving frequencies.

Designated airways, radio ranges, beacons, communication stations, and certain commercial broadcasting stations are also shown on aeronautical charts. From such charts, the specific designation of an airway can be determined, as well as whether or not it is an LF/MF or VOR airway. The exact location, frequency, designation, call sign, range legs (if applicable), and voice information relative to the various navigation aids along the airways are depicted upon these charts in symbol form.

LESSON III - ELECTRONICS

A. Lesson III (Chapter 3). At the end of this unit of instruction, the student should be able to:

1. List at least three services provided to pilots through the principles of radio.
2. Define: Columb, Ampere, Volt, and Flux.
3. Name the two major methods of producing electricity.
4. Identify the functions (in a circuit) of resistors, induction coils, condensers, transformers, and electron tubes.
5. Name at least two persons who pioneered the development of electron tubes.
6. Identify components within a diode tube and a triode tube.
7. Explain the basic operation of a carbon microphone.
8. Given any one of the three types of radar, tell how it is used.
9. Give the reason why MTI radar is such an improvement over older radar systems.
10. Define kilocycle and megacycle.
11. Given the abbreviation for a frequency, select the correct range in kilocycles or megacycles for the frequency.
12. Name an electronic device which can be replaced by a transistor.

B. Overview.

Radio plays an important role in modern aviation. Radio provides pilots and communicators with a means of ground-to-air and air-to-ground communications. Also, the electronic devices of airport and airway operations which make possible air traffic control.

An electronic circuit is an electrical circuit that employs vacuum tubes. The electronic flow through this circuit can be controlled through special kinds of controlling devices. Among these are resistors, induction coils, condensers, transformers, electron tubes, and, perhaps, transistors. By controlling the nature of an electronic circuit, a radio transmitter can be made to change sound waves into audio waves and audio waves into radio-frequency waves whose shape corresponds to the shape of the audio waves. Through this same controlled circuit, a radio receiver can change the modulated radio-frequency waves back into audio waves. The diaphragm of the pilot's headphone then converts audio waves into sound waves.

From the study of magnetos, you will recall that opening and closing a switch in a primary circuit causes a magnetic field to build up and then to collapse around the primary coil of this circuit. The movement of the magnetic field across a secondary circuit causes a flow of electrons through the circuit. If the flow of the electrons is through a linear conductor, such as the antenna of a radio transmitter, the build-up and collapse of the magnetic field, which occurs as the switch is closed and opened, causes lines of force to radiate outward in the form of circular waves. When these waves contact the antenna of a receiver, a circuit is established in the receiver which corresponds to that of the transmitter.

The controlling devices mentioned above control the nature of the original circuit. The resistor offers resistance to the flow of electrons in a circuit. The induction coil tends to oppose a change in the direction of an existing current. The condenser enables the circuit to store up an electrical charge. A transformer serves to increase the voltage of the circuit. The electron tube both generates a flow of electrons and changes alternating electrical currents to direct electrical currents.

Radar has become increasingly important in air traffic applications. New developments include Moving Target Indicator (MTI) radar, which will not reflect unwanted signals from stationary objects, and three-dimensional radar, which gives an indication of altitude as well as bearing. Radar techniques will become the primary tool of air traffic management in the coming era of supersonic air carriers.

LESSON IV - WHY AIRPORTS ARE NECESSARY

A. Lesson IV (Chapter 4). At the end of this unit of instruction, the student should be able to:

1. Describe the facilities normally found at a modern airline terminal, and list four or five functions that are directly connected with the primary purpose of the terminal and four or five that are in related areas.

2. List the two governmental agencies, or bureaus, that are available to assist all types of aviation.

3. Name at least two services provided to pilots by Flight Service Stations.

4. Identify the two major divisions of Air Traffic Management.

5. Describe an airway, according to height and width.

B. Overview.

The basic need served by airports is that of providing aircraft with safe landing and takeoff areas. However, since commercial airline operation has as its principal function the transportation of passengers, it is necessary that airline passenger facilities be provided. The nature of these facilities differs from airport to airport.

The departing passenger becomes aware of many airport activities. He hears announcements of incoming and departing flights. He sees many airline workers busy at their tasks. What he does not observe are those individuals who employ electronic devices in the interest of safe operation of aircraft. The behind-the-scenes operations include those provided by the government, by the airlines themselves, and perhaps, by local aviation services.

Airline operations include providing not only passenger reservations, ticket sales, and similar passenger services, but they also include maintaining the aircraft, rebuilding and reconditioning aircraft and their component parts, and dispatching air transport aircraft on their flight routes.

The government operations include National Weather Service reports, pilot and flight assistance service, and control of incoming and departing aircraft. Flight assistance service is made use of by pilots other than air transport pilots. It answers questions about the weather, about obstacles that might affect a proposed flight, about the radio facilities along a proposed route, and about runway conditions existing at the airport of destination. Flight assistance service provides all pilots with weather information. Weather reports are broadcast all day long, twice each hour, at 15 and 45 minutes past the hour. The Air Traffic Control Tower is staffed by government employees. Approach control radar provides the controller with a means of observing the position of aircraft when clouds cover the sky.

LESSON V - AIRWAYS AND THE FACILITIES OF AIR TRAFFIC MANAGEMENT

A. Lesson V (Chapter 5). At the end of this unit of instruction, the student should be able to:

1. Name the Federal unit that is responsible for maintaining the electronic devices that are used to aid in the management of air traffic.

2. Compare the advantages/disadvantages of low frequency and high frequency radio navigation aids.

3. State the purpose of marker beacons.

4. Demonstrate how a pilot can use his VOR receiver to find his position.

5. Explain in simple terms how the Course Line Computer and the Nonstandard Measuring Equipment operate.

6. Name the three major components of an Instrument Landing System and describe what each does.

7. Identify the uses of ARSR, ASR, PAR, and ASDE.

B. Overview.

An aircraft pilot often must fly his aircraft when he can see nothing ahead or below except clouds or fog. Radio and electronic aids make such flight possible. Moreover, the growth of aviation and the

increased number of aircraft in operation have stimulated the development of such electronic devices. Air-to-ground communication, made possible by two-way radio, for a good many years has been indispensable to aviation. Radio ranges, also for a number of years, have indicated to pilots where the airways are located.

The radio ranges first installed broadcast low frequency/medium frequency signals. By means of special antennas, these range stations directionally broadcast the Morse code for the letter A (.-) into two opposing quadrants of the range, and the Morse code for the letter N (-.) into the other two quadrants. Where these signals overlap along the quadrant boundaries, a steady tone defines the course. A pilot hearing this tone through his earphones knows that he is "on the beam." Each range station is given a three-letter identification signal which is broadcast at 30-second intervals so that the pilot in flight can identify the broadcasting station. LF/MF range stations are already partially obsolete. Among their disadvantages are "multiple courses," "bent beams," false cones of silence, and the so-called "night effect." These disadvantages are inherent in the use of low and medium frequencies.

A new type of range station, called a very high frequency omnidirectiona' range (commonly called omnirange) station is replacing the four-course low frequency range station. A pilot of an aircraft equipped with a VOR receiver can find his direction from a range station whether or not he is on a designated airway. If the aircraft also is equipped with distance measuring equipment (DME), the pilot can discover his distance from such a station. Another device, called the course line computer, makes it possible, through the use of VOR/DME, for a pilot to maintain his aircraft on a path that does not pass directly over a VOR station.

Electronic devices are truly versatile servants of aviation. They not only mark the airways but help aircraft effect safe landings during low-visibility weather conditions. Localizers give the pilot of an incoming aircraft lateral guidance during his landing approach. The glide slope indicator gives him vertical (up-and-down) guidance during his landing approach.

LESSON VI - THE REGULATION OF AIR TRAFFIC, I

A. Lesson VI (Chapter 6). At the end of this unit of instruction, the student should be able to:

1. Give two reasons why the regulation of air traffic is necessary.
2. Provide the four classifications of air traffic regulations.
3. Give two conditions under which aircraft must be flown according to Instrument Flight Rules (IFR).
4. Name a circumstance that would warrant a control area extension.
5. Interpret the light signals received by a pilot when he has no radio in his aircraft.
6. Name three devices used to show pilots wind directions.

B. Overview.

Safe operation of modern aircraft requires stringent regulation of air traffic. Such regulation cannot be exercised without the use of ground-to-air communication facilities. Although radio signals provide aircraft with their best communication media, light signals also are used to convey air traffic information from gound communicators to pilots. Through the means of light signals, pilots of light aircraft not equipped with radio are given traffic instructions. Regardless of the means used to communicate traffic information, the bases of air regulation are always the same. Air traffic regulation employs a system founded upon the following: (1) air regulations formulated by the Federal Aviation Administration, (2) a service which communicates advice, instruction, and information to pilots in flight, and (3) the exercise by the pilot of good operating practices.

An aircraft's position in the airspace above certain kinds of surface areas governs the air traffic rules under which the aircraft operates. Air traffic areas are called control zones; control areas; the continental control area; and elsewhere, which is sometimes referred to as outside controlled airspace. A control zone is a designated airspace extending upward from the surface of the earth; it includes at least one airport and the airspace over land adjacent to the airport in which aircraft must maneuver for landings. A control area is an airspace extending upward from an altitude 1,200 feet above the earth. A control area extension is the airspace within which aircraft fly a circular course at a designated altitude while awaiting landing instructions. The continental control area is the airspace extending upward from 14,500 feet within the continental limits of the United States. The term elsewhere refers to the remaining airspace.

A pilot of an aircraft not equipped with radio, landing at a strange airport, should observe the flow of traffic to determine the runway in use. In the absence of traffic, he should use the runway which will enable him to land his aircraft into the wind. A wind tee, tetrahedron, or other wind indicators will show him the wind direction. A segmented circle on the airport will indicate to him the proper traffic pattern if the "left-turn landing" rule is not enforced.

LESSON VII - THE REGULATION OF AIR TRAFFIC, II

A. Lesson VII (Chapter 7). At the end of this unit of instruction, the student should be able to:

1. Given a direction of flight, select the proper altitude for the flight on a VFR flight plan.

2. Give one reason why VFR flight plans should be filed.

3. In feet and miles, give the clearance from obstacles a pilot must maintain while on an IFR flight.

4. Name the three directions of aircraft separation that are maintained in controlled zones and areas.

5. Describe the cruising altitudes, or flight levels, of aircraft on IFR flights--above and below 29,000 feet.

6. Explain the purpose of air traffic clearances, and identify the one situation which makes them effective.

7. Give at least three things that a pilot is expected to report when flying under an Air Traffic Clearance.

8. State the service provided by an Approach Control System.

9. Given a series of letters from the alphabet, convert them to the phonetic alphabet.

10. List at least four good operating practices for pilots.

B. Overview.

All aircraft operate under General Flight Rules which regulate pre-flight actions of pilots, avoidance of prohibited and restricted areas, right-of-way, proximity of aircraft, acrobatic flying, and many other flight operations. The set of rules under which aircraft operate depends in great part upon the weather. One set of rules is called Visual Flight Rules (VFR); the other, Instrument Flight Rules (IFR). The pilot of an aircraft operating in accordance with Visual Flight Rules must be able to see objects 3 miles away when flying in a control zone or in a control area and 1 mile away when flying elsewhere. For example, when flying in a control zone, a pilot must operate his aircraft to fly clear of clouds in accordance with the following distances: 500 feet under, 1,000 feet over, and 2,000 feet horizontally. Similar minimums apply when he operates an aircraft in a control area or elsewhere. VFR rules prohibit aircraft operation in control zones when the ceiling is under 1,000 feet. Aircraft operated on airways in accordance with VFR altitude rules cruise at specific altitudes, depending upon the type of airway and the direction of flight.

Pilots flying under Visual Flight Rules are given ground support by more than 400 Flight Service Stations maintained throughout the United States by the Federal Aviation Administration. These centers are manned by flight service specialists who broadcast weather and airway information and provide briefings and a radio follow-up of each aircraft along the route of flight.

Aircraft operating on Instrument Flight Rules (IFR) are required to file flight plans with the nearest airway communication station, Airport Traffic Control Tower, or Air Route Traffic Control Center. A flight plan may be filed by person, telephone, or radio. Such plan indicates the route to be followed, the cruising altitude or altitudes, the proposed true airspeed at cruising, the radio frequencies to be used, the point of the first intended landing, and an estimate of the time which will elapse between departure and arrival over the airport of the first intended landing. Within control zones and areas, air traffic control (ATC) keeps aircraft a certain distance one from another--vertically, laterally, and longitudinally.

BOOK VII

THE DAWNING SPACE AGE

<u>Lesson</u>

1 THE DAWN OF SPACE TRAVEL
- Setting the Stage for Space Travel
- The Story of the Rocket
- Beginnings of the Science of Space Travel

2 GUIDED MISSILES
- Ballistic and Aerodynamic Missiles

3 ROCKET ENGINES AND MISSILE PROPULSION
- The Basis of Rocket Propulsion

4 MISSILE GUIDANCE SYSTEMS
- The General Nature of Missile Guidance Systems

5 RESEARCH, ROCKETS, AND SATELLITES
- Early Research Vehicles
- Rocket-Powered Aircraft
- Rockets and Satellites
- The Manned Space Flight Network
- The Deep Space Tracking Network

6 FLIGHT INTO SPACE
- Early Manned Flights into Terrestrial and Cislunar Space: Mercury, Gemini, Apollo
- Apollo Lunar Explorations
- Manned Space Stations
- Deep Space and Planetary Probes

SUMMARY

OPEN TIME

CAP or Local Examination

LESSON I - THE DAWN OF SPACE TRAVEL

A. Lesson I (Chapter I). At the end of this unit of instruction, the student should be able to:

1. Give one reason why he should learn and keep informed about rocket, missile, and space developments.

2. Tell which country first used rockets, and give the year.

3. Name the war and give the date when rockets were first used as weapons.

4. Tell why military forces lost their interest in rockets, for a time.

5. Name one peaceful employment of rockets during the mid-19th century.

6. List the ingredients of gunpowder, as described by Roger Bacon.

7. Identify the following men, places, publications, or events that were important to the development of space travel:

a. Dr. Robert H. Goddard
b. Capt. Iven C. Kincheloe, Jr.
c. Major Robert M. White
d. Major David G. Simons
e. Dr. Jacques Charles
f. Battle of Kai-Feng-Fu, AD 1232
g. Colonel William Congreve
h. Vera Historia
i. Wan Hoo
j. From the Earth to the Moon
k. Professor Hermann Oberth
l. Peenemunde
m. A-4 (V-2) missile
n. FZG-76 (V-1) missile
o. Dr. Wernher von Braun
p. "Bazooka" and "Tiny Tim"
q. James H. Wyld
r. Pulsejet engine
s. Aberdeen wind tunnel
t. "Wac Corporal"

8. List the purposes of the National Aeronautics and Space Administration.

9. Name the four Department of Defense agencies which are involved with the development of rocketry.

B. Overview.

Although aviation, as we know, plays significant roles in our nation's transportation and defense systems, the influence of rocketry is growing steadily. The rocket has provided the means for advanced defense systems, and is essential for placing satellites in orbit, sending probes to other planets, and for manned space travel.

LESSON II - GUIDED MISSILES

A. Lesson II (Chapter 2). At the end of this unit of instruction the student should be able to:

1. Interpret: JATO, SPR, LPR, IFTA, and ATO.

2. Define missile.

3. Name the four major components of guided missiles.

4. Distinguish between a ballistic missile and an aerodynamic missile.

5. Describe two methods used for directional control of ballistic missiles.

6. Classify missiles according to their launch and target areas.

B. Overview.

Military rocketry developments have speeded the development of space flight and have provided many helpful devices to assist takeoffs and in-flight thrust augmentation of more conventional aircraft. The most significant military application of rocketry has been in the field of the guided missile—a sophisticated, complex projectile that is either aerodynamic or ballistic. The aerodynamic missile, equipped with wings and tail, obtains lift for flight from the atmosphere. The ballistic missile may travel into space where there is little or no atmosphere; therefore, its lift comes from rocket power. Whereas the aerodynamic missile is kept on course by deflections of controls on its wing and tail surfaces, the ballistic missile is kept on course by deflections of jet vanes, the sporadic firing of gas jets, or some other force-producing device which maneuvers the missile according to guidance commands. It depends upon thrust and momentum, rather than upon aerodynamic lift.

Missiles consist of four major components or systems: The airframe, the propulsion system, the guidance system, and the control system. The purpose of these four components is to deliver what may be considered the fifth component — the payload — to its target, if it is a military missile, or to its planned destination, if it is a scientific or research missile. In a military missile, the payload is an explosive warhead which must hit a distant target from a point of comparative safety. In a research missile, the payload consists of scientific instruments.

LESSON III - ROCKET ENGINES AND MISSILE PROPULSION

A. Lesson III (Chapter 3). At the end of this unit of instruction the student should be able to:

1. State Newton's three laws of motion.
2. Explain why a jet or rocket will fly faster at higher altitudes.
3. List the four rocket propulsion systems.
4. Define hybrid propulsion system.
5. Name any one of the four methods used for structural cooling of propulsion systems.
6. Provide a basic description of nuclear use in gas-heating propulsion systems.
7. Describe solar sail propulsion.
8. Distinguish between nuclear fusion and nuclear fission propulsion principles.
9. Give one reason why electric propulsion systems can be more efficient than other types of propulsion systems.
10. List two problems associated with the development of a photon propulsion system.
11. List three materials that are used in the construction of solid propellant rocket engines.
12. Give an advantageous characteristic of thixotropic propellants.
13. Distinguish between progressive, regressive, and neutral designs of solid fuel charges.
14. Name the three essential elements of a liquid propellant rocket engine.
15. Name the three "sections" of a liquid propellant combustion chamber.
16. List the four phases of the liquid propellant combustion process.
17. Give an advantage of bipropellants over monopropellants.

B. Overview.

Both the rocket engine and the air-breathing jet engine accomplish their work in accordance with Sir Isaac Newton's three laws of motion. In general terms, beginning with the third law, the force of gasses escaping from a rocket engine's nozzle causes an equal reaction in the form of movement of the rocket. In accordance with the second law, the rocket will continue to move faster, or accelerate, until its speed is in proportion to the rearward thrust force of the engine's escaping gasses. Finally, in accordance with the first law, the rocket will continue in flight after the engine stops. How long the flight will continue depends upon forces acting against the rocket.

As a jet- or rocket-propelled vehicle gains altitude, the thrust value of its engine is increased. This is because of the lessened pressure exerted by the atmosphere on the vehicle. Of course, the jet engine's altitude limit is dependent upon atmospheric oxygen, but the rocket's thrust value is highest in the vacuum of space.

There are four classifications of rocket propulsion, or fuel systems: The chemical, now in widest use; the gas-heating system; the electrical system; and the photon system.

The chemical system is further divided into three subsystems: The solid, the liquid, and the hybrid, the latter using a combination of solid and liquid propellants.

Much basic research remains to be done before the photon propulsion system is developed. Briefly, the idea behind photon propulsion is to convert matter--the fuel--directly into light or radiant energy. (Photons are the separate particles that make up light.)

Two "pure" nuclear propulsion proposals are the fusion system and the fission system. The fusion process would unite light atomic nuclei into heavier nuclei, producing extremely hot gasses which would be channeled by magnetic fields to become thrust-producing jets. The fission system would consist of small atomic "bombs" exploded behind a large pusher surface attached to the spaceship. The force of the explosions would push the spaceship in the desired direction.

Until several scientific breakthroughs occur, however, the chemical systems will continue to be the major propulsion systems.

LESSON IV - MISSILE GUIDANCE SYSTEMS

A. Lesson IV (Chapter 4). At the end of this unit of instruction the student should be able to:

1. List the types of guidance systems used for both short range and long range missiles, and describe briefly the principle of each.
2. List and describe the flight phases of guided missiles.
3. Identify the four basic requirements of an automatic guidance control system.
4. List the advantages of inertial guidance systems.
5. Describe gyroscopic inertia and gyroscopic precession.
6. Explain how accelerometers assist in keeping an inertial guidance platform in proper alinement.
7. In regard to major factors which complicate matters for the designing of inertial guidance systems, explain oblateness, coriolis effect, and centripetal force.
8. Identify characteristics of the following guidance systems:
   a. Automatic Celestial
   b. Stellar Supervised Inertial
   c. Circular (Radio)
   d. Hyperbolic (Radio)
9. In regard to aerodynamic missiles, compare the control effects of spoilers and ailerons.
10. Give three examples of directional control devices used with ballistic missiles.

B. Overview.

All guided missiles, by definition, require guidance systems.

Four basic requirements govern automatic guidance systems: First, the controllable item – the flight path. Second, a sensor, or sensors, to obtain data needed to keep the missile on the proper flight path. Third, the control equipment which converts electronic impulses into the mechanical energy needed to operate the fourth requirement--the control devices.

Directional control devices on missiles vary considerably: The aerodynamic missile probably will use ailerons, elevators, and rudders as primary control devices, and will have tabs, spoilers, and slots as secondary control devices. The ballistic missile must have control devices that produce force or change the direction of force. These devices are exhaust vanes, deflection charge controls, and gimbaled engines.

There are four general types of guidance systems: The preset (of which the inertial is most important); the command; the beam-rider; and the homing. (The hybrid system, using a combination of these, can be considered a fifth type.)

LESSON V - RESEARCH, ROCKETS, AND SATELLITES

A. Lesson V (Chapter 5). At the end of this unit of instruction the student should be able to:

1. Identify the two general functions of research rockets.

2. Define sounding rocket.

3. Name the first two-stage rocket used in the U.S., and name the two rockets which were used in its assembly. Also, identify the contributions this experiment made to rocketry science.

4. Identify the contributions made by the following rocket-powered aircraft: X-1, X-2, and X-15.

5. Name at least three scientific accomplishments of the Jupiter C Project.

6. State the "first" achieved by Project Score.

7. In statute miles per hour, give the exact maximum velocity produced by earth's gravity on a falling body.

8. Identify the primary function of each of the following satellites or satellite series:

   a. Nimbus
   b. Tiros
   c. Transit
   d. Midas
   e. Echo
   f. Courier
   g. Samos
   h. Discoverer

9. Name the four disciplines of scientific research that can be studied with instruments taken aloft in rockets and satellites.

10. Give a brief explanation of how radio telemetry functions.

11. Describe the instrumentation found at a typical tracking station.

12. Explain how Kepler's and Newton's observations contributed to the placing of manmade satellites into orbit.

B. Overview.

Were it not for the development and sophistication of rocketry, our society would never have achieved the present advanced state of aerospace technology and knowledge of aerospace phenomena. Some rockets serve in pure research roles. On the one hand, rockets serve to advance knowledge of rocketry itself--new and better engines, structural materials, propellants, and so forth. Other rockets are used as instruments for scientists to obtain scientific data not obtainable in any other way.

Newton's laws provided the basis for sophisticated rocketry development and orbital computations, and Kepler discovered the laws of celestial motion. Both these men, whose discoveries took place about 400 years ago, have profoundly influenced aerospace technology. It is challenging to wonder what influences our present day aerospace discoveries will have on scientists 400 years hence.

LESSON VI - FLIGHT INTO SPACE

A. Lesson VI (Chapter 6). At the end of this unit of instruction the student should be able to:

1. Identify desirable and necessary characteristics of manned space vehicles.

2. Describe the structure of our solar system with regard to:

   a. Distances of the various planets from the sun.
   b. Number of natural satellites possessed by any given planet.
   c. Atmospheric composition of any given planet.
   d. Period and direction of rotation of any given planet.
   e. Escape velocity of any given planet in either miles per hour or miles per second.
   f. Peculiarities of orbit or axial rotation.

3. Describe the various categories of space.

4. List and discuss at least three problems of manned space flight which have been or must be solved through research in space medicine.

5. Define Terrella.

6. With regard to U.S. manned space flights, name the astronaut(s) who:

a. First made a flight into space.
b. Made the first orbital flight.
c. Made the first two-man flight.
d. Made the first circumlunar flight.
e. Made the first footprints on the moon's surface.

7. Given any of the major components of a Saturn booster/Apollo spacecraft, describe it according to size, weight, and function.

8. In their proper sequence, list the steps of a typical Apollo mission.

B. Overview.

Manned space flights to the moon and even those planned to Mars are but elementary steps in comparison to what is possible. If man is to venture farther into space, there are many more problems to be solved. Propulsion systems will have to be more sophisticated and efficient, and special attention will have to be given to life support systems provided future astronauts.

While manned space flight programs--including such projects as Skylab--are progressing, we will continue to send unmanned vehicles into deep space to study the other planets of our solar system.

Present and future activities by this country and other countries will in all probability result in the establishment of some form of international space law.

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