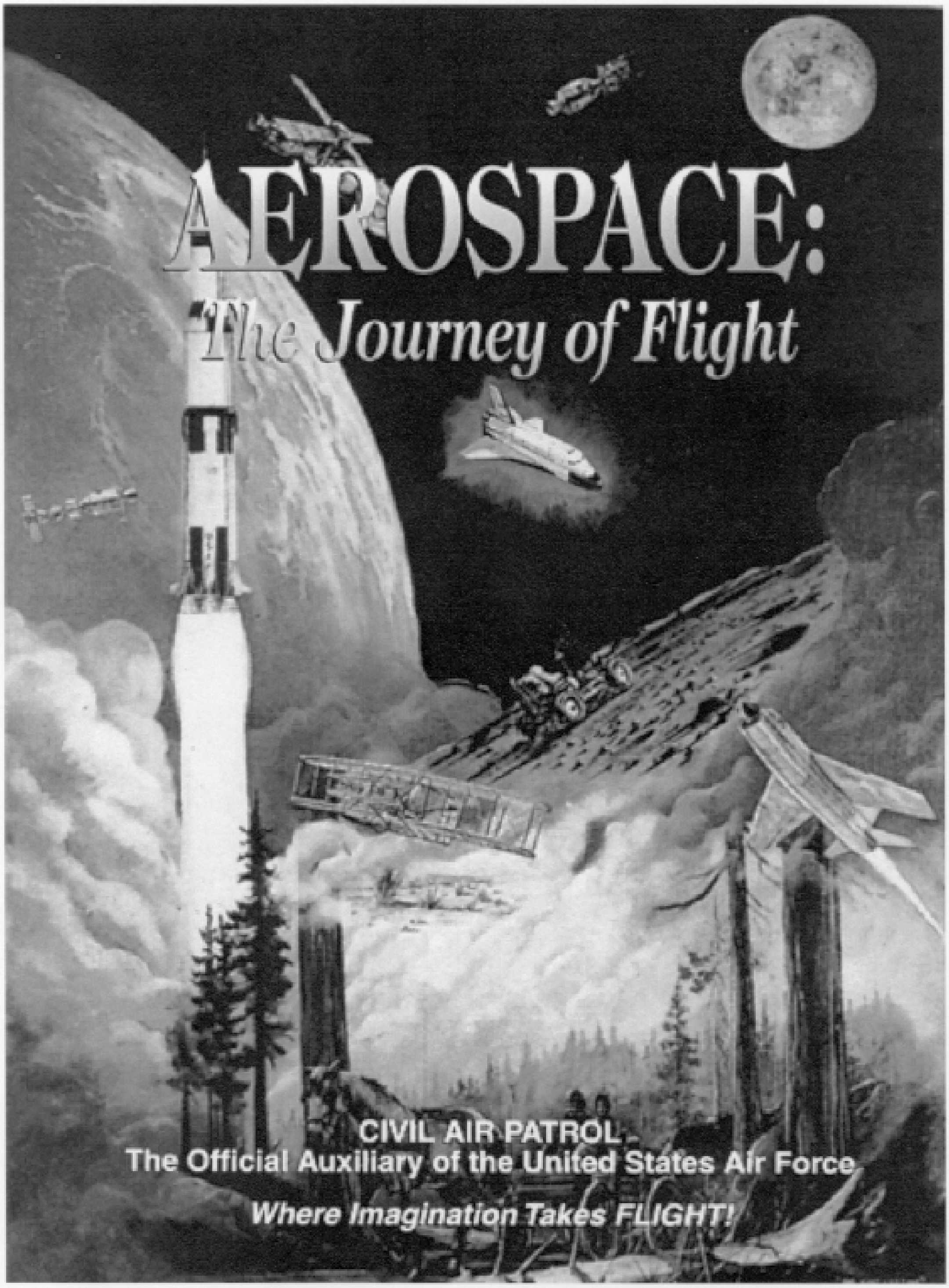
TEACHER'S GUIDE *for*



TEACHER'S GUIDE

For

AEROSPACE: THE JOURNEY OF FLIGHT

This document was prepared by Civil Air Patrol.

Contents

Multiple Choice Sample Test Bank

Preface

This guide was designed to help teachers use *Aerospace: The Journey of Flight* in their classrooms. It consists of detailed lesson plans for each chapter. The lesson plans include presentation steps, major points and supporting information. Each chapter also includes several objectives with descriptive verbs that should be easily verifiable and measurable.

Additionally, this guide contains a sample test for each chapter. The sample tests present multiple choice and true/false questions that could be used on a test. The sample tests are located at the end of each chapter.

Finally, this teacher's guide includes national standards. These are academic content standards that describe what every student should know and be able to do in the core academic areas (e.g., mathematics, science, English language arts, and social studies). These standards are criteria for judging quality and are important resources for providing a framework for curriculum design as well as criteria for school accountability.

National Standards

Aerospace: The Journey of Flight
Part One: The Rich History of Air Power
(Chapters 1-6)

Science Standards	Mathematics Standards	English Language Arts Standards	Social Studies Standards	Technology Standards
Physical Science: • Motions and Forces	1. Number and Operations Standard: • Understanding numbers, ways of representing numbers, and number systems.	1. Reading for Perspective	2. Time, Continuity, and Change	3. Understanding of the relationships among technologies and the connections between technology and other fields of study.
Science and Technology: • Abilities of technological design • Understandings about science and technology	9. Connections Standard: • Recognize and apply mathematics in contexts outside of mathematics.	2. Understanding the Human Experience	6. Power, Authority, and Governance	4. Understanding of the cultural, social, economic, and political effects of technology.
Unifying Concepts and Processes: • Evidence, models, and explanations • Form and function		3. Evaluation Strategies	8. Science, Technology, and Society	6. Understanding of the role of society in the development and use of technology.
		6. Applying Knowledge	9. Global Connections	7. Understanding of the influence of technology on history.
		12. Applying Language Skills		

Aerospace: The Journey of Flight
Part Two: Principles of Flight and Navigation
(Chapters 7-9)

Science Standards	Mathematics Standards	English Language Arts Standards	Social Studies Standards	Technology Standards
Physical Science: • Structure and properties of matter • Motions and forces • Conservation of energy	1. Number and Operations Standard: • Compute fluently and make reasonable estimates.	3. Evaluation Strategies	8. Science, Technology, and Society	1. Understanding of the characteristics and scope of technology.
Earth and Space Science: • Energy in the earth system	3. Geometry Standard: • Specify locations and describe spatial relationships using coordinate geometry and other representations system.	7. Applying Knowledge		3. Understanding of the relationships among technologies and the connections between technology and other fields of study.
Science and Technology: • Abilities of technological design • Understandings about science and technology	4. Measurement Standard: • Understand measurable attributes of objects and the units, systems, and processes of measurement	12. Applying Language Skills		6. Understanding of the role of society in the development and use of technology.
Science in Personal and Social Perspectives: • Science and technology in local, national, and global challenges	5. Data Analysis and Probability Standard: • Select and use appropriate statistical methods to analyze data. • Develop and evaluate inferences and predictions that are based on data.			8. Understanding of the attributes of design.

				9. Understanding of engineering design.
				10. Understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Aerospace: The Journey of Flight
Part Three: The Aerospace Community
(Chapters 10-17)

Science Standards	Mathematics Standards	English Language Arts Standards	Social Studies Standards	Technology Standards
Physical Science: • Motions and forces	1. Number and Operations Standard: • Understanding numbers, ways of representing numbers, relationships among numbers, and number systems.	1. Reading for Perspective	3. People, Places, and Environments	1. Understanding of the characteristics and scope of technology.
Science and Technology: • Abilities of technological design • Understandings about science and technology	5. Data Analysis and Probability Standard: • Develop and evaluate inferences and predictions that are based on data.	3. Evaluation Strategies	5. Individuals, Groups, and Institutions	3. Understanding of the relationships among technologies and the connections between technology and other fields of study.
Science in Personal and Social Perspectives: • Environmental quality • Natural and human-induced hazards • Science and technology in local, national and global challenges				4. Understanding of the cultural, social, economic, and political effects of technology.
History and Nature of Science: • Science as a human endeavor • Nature of scientific knowledge • Historical perspectives			10. Civic Ideals and Practices	5. Understanding of the effects of technology on the environment.

				6. Understanding of the role of society in the development and use of technology.
				8. Understanding of the attributes of design.
				10. Understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Aerospace: The Journey of Flight
Part Four: Air Environment
(Chapters 18-20)

Science Standards	Mathematics Standards	English Language Arts Standards	Social Studies Standards	Technology Standards
Physical Science: • Structure and properties of matter • Conservation of energy and the increase in disorder • Interactions of energy and matter	4. Measurement Standards: • Understand measurable attributes of objects and the units, systems, and processes of measurement. • Apply appropriate techniques, tools, and formulas to determine measurements.	3. Evaluation Strategies	3. People, Places, and Environments	3. Understanding of the relationships among technologies and the connections between technology and other fields of study.
Earth and Space Science: • Energy in the earth system	6. Problem Solving Standard: • Solve problems that arise in mathematics and in other contexts.	12. Applying Language Skills		
Science in Personal and Social Perspectives: • Natural and human-induced hazards • Science and technology in local, national, and global challenges	9. Connections Standard: • Recognize and apply mathematics in contexts outside of mathematics.			
History and Nature of Science: • Nature of scientific knowledge				

Aerospace: The Journey of Flight
Part Five: Rockets
(Chapters 21-23)

Science Standards	Mathematics Standards	English Language Arts Standards	Social Studies Standards	Technology Standards
Physical Science: • Structures and properties of matter • Chemical reactions • Motions and forces • Conservation of energy and increase in disorder • Interactions of energy and matter	3. Geometry Standards: • Use visualization, spatial reasoning, and geometric modeling to solve problems.	3. Evaluation Strategies	8. Science, Technology, and Society	8. Understanding of the attributes of design.
Science and Technology: • Abilities of technological design • Understandings about science and technology	5. Data Analysis and Probability Standards: • Develop and evaluate inferences and predictions that are based on data.	12. Applying Language Skills		9. Understanding of engineering design.
Science in Personal and Social Perspectives: • Science and technology in local, national, and global challenges	10. Representation Standard: • Use representations to model and interpret physical, social and mathematical phenomena.			10. Understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.
History and Nature of Science: • Nature of scientific knowledge				
Unifying Concepts and Processes: • Systems, order and organization				

Aerospace: The Journey of Flight
Part Six: Space
(Chapters 24 – 27)

Science Standards	Mathematics Standards	English Language Arts Standards	Social Studies Standards	Technology Standards
Life Science: • The interdependence of organisms • Matter, energy, and organization in living systems • The behavior of organisms	1. Number and Operations Standard: • Understand numbers, ways of representing numbers, relationships among numbers, and number systems	1. Reading for Perspective	1. Culture	3. Understanding of the relationships among technologies and the connections between technology and other fields of study.
Earth and Space Science: • The origin and evolution of the earth system • The origin and evolution of the universe	6. Data Analysis and Probability Standard: • Develop and evaluate inferences and predictions that are based on data.	2. Understanding the Human Experience	2. Time, Continuity, and Change	4. Understanding of the cultural, social, economic, and political effects of technology.
Science and Technology: • Abilities of technological design		3. Evaluation Strategies	3. People, Places, and Environments	6. Understanding of the role of society in the development and use of technology.
Science in Personal and Social Perspectives: • Natural and human-induced hazards • Science and technology in local, national, and global challenges		6. Applying Knowledge	5. Individuals, Groups, and Institutions	7. Understanding of the influence of technology on history.
History and Nature of Science: • Science as a human endeavor • Historical perspectives		12. Applying Language Skills	6. Power, Authority, and Governance	
			9. Global Connections	

Sources for National Standards and Web Sites

1. **National Science Standards – National Research Council**
   http://www.nap.edu/readingroom/books/nses/html

2. **National Mathematics Standards – National Council of Teachers of Mathematics**
   http://standards.nctm.org/document/index.htm

3. **National English Language Arts Standards – National Council of Teachers of English**
   http://www.ncte.org/standards/standards.shtml

4. **National Social Studies Standards - National Council for the Social Studies**
   http://www.ncss.org/standards/toc.html

5. **National Technology Standards – International Technology Education Association**
   http://www.iteawww.org/TAA/Listing.htm

Chapter 1

Introduction to Air Power (pages 2-21)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 50 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Describe** what makes air power unique.
- **Define** air and space power.
- **Recognize** the various legends of flight.
- **Identify** the Chinese invention that solved one of the major problems of air power.
- **Identify** the contributions the Chinese made to advance air and space power.
- **Identify** the significant contributions that advanced air and space power.
- **Recall** the individual scientists and researchers and their experiments.

Presentation

Attention: Air power has a distinctively rich history. It is fascinating to study the early pioneers and how their imaginations took flight. How did it all begin? That is what we want to talk about in this next hour.

Motivation: Going back to the beginning is so important because it gives us the opportunity to see what these men and women went through to learn and develop this new concept, air power. What were the circumstances? How did they prevail? Look around you today. Seems like so many take flying for granted. For instance, look at our space program. Don't we even take it for granted too? Studying these early pioneers and what they accomplished should be exciting for all of us, and help us appreciate even more this wonderful concept called flying.

Overview: This next hour we will take a look at some early legends of flight and discuss the early scientific research involving flight. Then we will get into the early airplane developments, ending with the Wright Brothers.

Evaluation: Time permitting, ask questions or go over the test your knowledge section.

Assignment: Review key terms and concepts on page 20 and test your knowledge with the questions.

Lesson Outline

1. Legends about Flight
   a. Chinese
      1) invented the kite
      2) invented gunpowder
      3) used gunpowder for rockets
      4) Wan Hoo
   b. Greece and Rome
      1) winged children
      2) Pegasus, winged horse
   c. Icarus and Daedalus
      1) escaped from prison
      2) wings made of feathers and wax
      3) flew too close to the sun
   d. Persian King and Alexander the Great
      1) Persian king supposedly had a flying throne
      2) Alexander flew in a cage drawn by winged griffins
   e. Man couldn't fly, but he wanted to invent machines that did.
2. Early and Basic Scientific Research
   a. Leonardo da Vinci – Italian artist, architect and man of science
      1) devoted life to mysteries of flying
      2) gave world descriptions and pictures of flying machines
      3) died in 1519, but his manuscripts were not found and published until 300 years later (could have changed history)
   b. Beginning with late 1500s and through the 1700s, there were many stories, books and research written about flight.
   c. In 1670, a Jesuit priest, Francesco de Lana wrote about an aerial ship.
   d. In 1709, another Jesuit priest, Laurenco de Gusmao invented the hot-air balloon.
   e. In 1766, English chemist, Henry Cavendish discovered flammable air (later called hydrogen).
   f. In 1783, Montgolfier brothers demonstrated a hot-air balloon.
      1) They worked with oxygen (Priestly discovered).
      2) They thought a new gas was being created by the burning fuel, so they called it Montgolfier gas.
      3) First two men to fly in a lighter-than-air craft rode in a Montgolfier balloon. They were Pilatre de Rozier and Marquis d'Arlandes.
      4) First flight lasted 25 minutes and covered 5 miles.
   g. Between 1783 and 1790, balloons became very popular in Europe
      1) In 1785, French balloonist, Jean Pierre Blanchard and his American passenger, Dr. John Jeffries, flew across the English Channel.
      2) In 1793, the first American balloon flight occurred in Philadelphia. President George Washington and thousands watched.
      3) In 1797, Andre-Jacques Garnerin made the first parachute jump from a balloon.
   h. First use of balloons by the United States military occurred during the Civil War.

i. Problem of changing a free balloon into a dirigible would stump people for almost one hundred years.
    1) In 1852, Henri Giffard built the first (generally credited) successful dirigible.
    2) In 1884, others credited the LaFrance as the first successful dirigible.
    3) Between 1898 and 1907, Santos-Dumont constructed and flew 14 gasoline-powered, non-rigid airships.
    4) In 1900, Ferdinand von Zeppelin built and flew the world's first successful rigid dirigible, the *LZ-1*.

3. Developing the Airplane
    a. Pioneers struggled with – developing lift, sustaining lift and controlling aircraft.
    b. George Cayley was the first 19^{th} century airplane pioneer.
        1) He constructed a whirling-arm device and tested types of wings.
        2) He built and flew small model gliders.
        3) In 1809, he laid the foundation for modern aeronautics with his published account of making a surface support a given weight by the application of power to the resistance of air.
        4) He identified the forces of lift, drag and thrust.
        5) He built the first successful full-sized, manned glider.
    c. John Montgomery built a 440-pound, man-carrying glider with wings like a sea gull.
        1) It carried him 600 feet aloft.
        2) From 1886-1892, he made thousands of experiments and studied birds.
        3) In 1905, he unveiled his new glider to the public. Glider stayed aloft for 20 minutes and was a success.
        4) Built five more gliders within the next year. Then in 1906 an Earthquake (the famous one that destroyed San Francisco) destroyed all of his work.
        5) He was unable to resume his work until 1911, and then was killed when a gust of wind flipped over the glider and threw him out.
    d. Otto Lilienthal – Father of Modern Aviation.
        1) He built single-winged and two-winged gliders.
        2) Between 1891-1896, he made over 2,000 glides; many covered over 700 feet.
        3) He built an engine to link the wingtips.
        4) He built a pilot control system.
        5) He wrote a book on aviation and created interest around the world.
    e. Octave Chanute read Lilienthal's works and improved them.
        1) He designed gliders but was too old to fly them.
        2) He is known mostly for his careful study of aviation history and collection and distribution of aviation information.
    f. In 1843, W.S. Henson and John Stringfellow received a patent for a man-carrying powered aircraft. They called it the *Ariel*.
        1) The Ariel was never built but was considered a masterpiece of engineering.
        2) In 1848, Stringfellow built a steam-driven model that did fly.
    g. Samuel Pierpont Langley attempted to add power to a glider.

1) In 1903, the Aerodrome was launched by catapult from a barge anchored in the Potomac River. It fell into the river. The same thing happened on the next try two months later.
2) Both attempts were widely covered by the press. The government dropped its support and Langley gave up his project.

h. The Wright Brothers – Orville and Wilbur
1) Achieved success in controlled, sustained and powered flight.
2) Their approach was to first develop an aircraft that would fly and then control it in flight.
3) They developed the wing-warping technique.
4) By October 1902, they had over 1,000 successful glider flights and had solved all of the major control problems. Now, they needed a suitable power plant.
5) December 17, 1903, the *Flyer* flew for 12 seconds and 120 feet.
6) Later that same day, a flight lasted 59 seconds and 852 feet.

Multiple–Choice and True/False Sample Test

1. Who is credited with inventing gunpowder?
   a. Americans
   b. Chinese
   c. Japanese
   d. Russians

2. Who was a great artist, architect, man of science and conducted the first scientific experiments in the field of aviation?
   a. J.A.C. Charles
   b. Francesco de Lana
   c. Leonardo da Vinci
   d. Joseph Montgolfier

3. The first use of balloons by the United States military occurred during
   a. the Civil War.
   b. the American Revolutionary War.
   c. the War of 1812.
   d. World War I.

4. Who built and flew the world's first successful rigid dirigible?
   a. Jean Pierre Blanchard
   b. Henry Cavendish
   c. Alberto Santos-Dumont
   d. Ferdinand von Zeppelin

5. Who has been called the "Father of Modern Aviation?"
   a. Octave Chanute
   b. Samuel Pierpont Langley
   c. Otto Lilienthal
   d. Wilbur Wright

6. Which one of the following statements about the Wright brothers is **not** true?
   a. They wanted to first develop an aircraft that would fly and could be controlled in flight, and then add a power plant.
   b. They felt they had to get into the air themselves to further test their wing-warping technique.
   c. On their first attempt to fly, Wilbur was at the controls. The Flyer became airborne but stalled and fell back into the sand. It was slightly damaged.
   d. On December 17, 1903, the Flyer flew for two minutes and 1200 feet.

7. **T**/F The first men to fly in a lighter-than-air craft rode a Montgolfier balloon into the air over Paris on November 21, 1783.

8. **T**/F In 1903, the *Aerodrome*, built by Samuel Pierpont Langley, was launched by catapult from a barge in the Potomac River. It did not fly and fell into the river.

9. T/**F** The first balloon flight in the United States took place in 1793 with President George Washington and Benjamin Franklin on board. The balloon ride lasted over one hour, and both Washington and Franklin landed safely.

10. T/**F** A dirigible is defined as a heavier-than-air craft that cannot be steered.

Chapter 2

The Adolescence of Air Power: 1904-1919 (pages 22-43)

Resource: ***Aerospace: The Journey of Flight,*** Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 45 minutes

Objectives: After completion of this chapter, the student should be able to:
- **List** significant aviation events occurring between 1904 and 1911.
- **Describe** the development of new aircraft engines.
- **Recall** Louis Bleriot's aviation contributions.
- **Discuss** early attempts at vertical flight.
- **Discuss** the story of the world's first regularly scheduled airline service.
- **Discuss** air power preparations towards World War I.
- **Discuss** the military role of the airplane in World War I.
- **Describe** the use of bomber and fighter aircraft in World War I.
- **Identify** several World War I aces.
- **Describe** the impact Billy Mitchell had on the development of air power.

Presentation

Attention: This chapter looks at the continued development of air power as it moves into its adolescence. The years of 1904-1919 mark a time when people were becoming interested in flying, but they didn't realize the uses of airplanes.

Motivation: It should be interesting to look at what was happening in the development of the airplane in the United States and then compare that to the progress occurring in Europe.

Overview: So, let's spend the next hour discussing this continuing development of the airplane and see how different countries handled this new invention.

Evaluation: Go over the questions at the end of the chapter.

Assignment: Review the key terms and concepts.

Lesson Outline

1. Developments in the United States
   a. In 1904-1905, the Wright brothers continued their experiments and perfected their aircraft. In October 1905, they flew 38 minutes and covered over 24 miles. The flight ended only when they ran out of fuel.
   b. In 1905, the Wright brothers offered to build an aircraft for the American government, but the government was afraid of another embarrassment like the Langley failures. After the government turned downed the Wright brothers three times, the Wrights gave up trying to sell their invention to the government.
   c. However, President Theodore Roosevelt directed the Secretary of War to ask the Wright brothers to test an airplane that could carry a plane, a passenger and fuel for 125 miles. Plus the plane had to fly at 36 mph.
   d. Orville began building the new plane and Wilbur went to France. Wilbur signed a $100,000 contract to form a French aircraft building company.
   e. In 1908, Orville Wright had completed 12 successful test flights when tragedy struck. On the 13th test, Army Lieutenant Thomas Selfridge, a passenger, died when a propeller broke and the plane crashed. Orville was seriously hurt but recovered. Selfridge was the first man to lose his life in a powered airplane.
   f. In 1909, the Army bought its first plane from the Wright brothers for $25,000 plus a $5,000 bonus for exceeding the speed requirements.
   g. In 1907, Glenn Curtiss became the fastest man on Earth when he set the motorcycle speed record of 136.3 mph. Then he switched his interest to airplanes.
   h. Also in 1907, Curtiss and Alexander Graham Bell founded the Aerial Experiment Association that designed and built several aircraft. One of them was the first American aircraft equipped with ailerons. Another aircraft was the first seaplane to be flown in the US.
   i. In 1908, Curtiss won the Scientific American Trophy in *June Bug*.
   j. In 1909, Curtiss won the Gordon Bennett Trophy in *Golden Flyer*.
   k. In 1910, both the Wrights and Curtiss opened flying schools.
   l. Also in 1910, former President Theodore Roosevelt became the first president to fly.
   m. In 1911, William Randolph Hearst offered $50,000 for flying across the US in 30 days. Calbraith Perry Rodgers on board the *Vin Fiz Flyer* completed the journey in 49 days and missed the prize money.
   n. In 1911, Harriet Quimby became America's first licensed female pilot.
2. Progress in Europe
   a. In 1904, Robert Esnault-Pelterie built a glider and used ailerons to replace the wing-warping technique.
   b. In 1906, Alberto Santos-Dumont flew the first powered airplane in Europe. Two weeks later he flew 722 feet and the press reported it in a positive manner. Europe was excited by the news.
   c. In 1907, Louis Bleroit built and flew the world's first powered monoplane.
   d. In 1909 Bleroit crossed the English Channel. Also in 1909, the first international air meet occurred in Rheims, France. Many speed and endurance records were broken.

e. In 1911, the Short brothers of England were granted patents for the world's first multiengine aircraft. It had two engines and three propellers and was called the *Triple Twin*.
f. In 1913, Igor Sikorsky built and flew the first four-engine aircraft. It was called the *LeGrand*.
g. Laurent and Gustav Seguin developed a lightweight rotary engine called the Gnome. Many World War I aircraft used this engine.

3. Moving Up – Flying Vertical
   a. Helicopter – the large propeller on top of a helicopter is made up of a number of blades. Each of these blades is like a wing. They move through the air causing lift.
   b. Helicopters are called rotary-wing aircraft because of the way the blades rotate.
   c. In 1907, Louis Breguet build and flew the first helicopter that lifted man into the air.
   d. In 1909, Emile and Henry Berliner became the first Americans to build and fly a helicopter.
4. Commercial Flying – The Beginning
   a. In 1914, the first regularly scheduled airline service using heavier-than-air craft started. This airline was called the St. Petersburg – Tampa Airboat Line.
   b. The airline flew 22 miles across Tampa Bay and cost $5 and took about 20 minutes.
5. Preparing for War
   a. By 1912, all of the major modern countries of the world had formed military flying services.
   b. The US military flying service was present in name only. By the end of 1913, the US Army had 19 aircraft and 29 pilots.
   c. In 1914, Germany had 200 aircraft; Britain and France possessed about 450.
   d. US entered the war in 1917, but didn't have any combat-worthy aircraft.
   e. Congress promised 263 American squadrons equipped with 22,625 aircraft would be in action by June 1918. However, when the war ended in November 1918, there were only 45 American squadrons, and they were all flying British and French aircraft.
   f. Not a single American-designed combat aircraft saw action in World War I.
6. World War I
   a. Military Role of the Airplane
      1) At the start of 1914, the average plane speed was 70-80 mph and could fly no higher than 10,000.
      2) When the war ended, the average speed was 140-150 and could fly up to 24,000 feet.
      3) The airplane was first used in war for observation.
      4) Next, it was used as a bomber with the pilot or an observer carrying bombs in their laps.
   b. Europe in World War I
      1) At the beginning of WWI, Germany had 20 large dirigibles and produced 88 more during the war.

2) Germany planned to use them as strategic bombers against French and English cities.
3) They were accurate bombers, but they were also highly flammable. So they were mainly flown at night.
4) British fighters were called back from the war in France to help protect the British cities from the dirigibles.

c. Fighter Development
1) There was a clear need for more fighters or pursuit aircraft to drive off the bombers.
2) In 1915, a French pilot, Roland Garros, mounted an automatic rifle on his aircraft and fired through the propeller.
3) The Germans captured Garros and his plane. Then, they asked a Dutch airplane designer, Anthony Fokker to improve on this design. Fokker designed a machine gun that fired through the spinning propeller. This gave the Germans almost total control of the air for about a year.
4) By 1916, the allies captured a German plane and were able to copy the machine gun design.
5) In May 1918, the German designer, Hugo Junkers, built the world's first all metal, low-wing monoplane fighter called the *Junkers D*1. It was too late to make much of a difference for this war, but it was the fighter of the future.

d. Fighter Aces
1) The French developed the method for recognizing pilots who shot down enemy aircraft. They used the term "ace" for a pilot who shot down five enemy aircraft.
2) The British and the Americans used the same criteria.
3) The Germans required 10 enemy aircraft downed for ace to be used.

e. The United States in World War I
1) US entered the war in 1917.
2) Lafayette Escadrille – American citizens who flew with the French Air Service before America entered the war.
3) Eddie Rickenbacker was the leading American ace of WWI with 26 kills in only five months of flying. He was the only living American to receive the Congressional Medal of Honor during WWI.
4) Billy Mitchell – American aviator who got his start in WWI. He later became the leading enthusiast for aviation, air power and the airplane's role as an offensive weapon.

Multiple-Choice and True/False Sample Test

1. In the early 1900s the Wright Brothers signed a contract with the US Army to build an airplane. While Orville was working in the contract, what was Wilbur doing?

a. Wilbur was working with him on the contract.
b. Wilbur was teaching President Roosevelt how to fly.
c. Wilbur was back home in Dayton, Ohio working on a more advanced airplane.
d. Wilbur was in France demonstrating the airplane for European governments.

2. The first powered dirigible in the United States used a __________ engine.
   a. Bell
   b. Curtiss
   c. Lahm
   d. Wright

3. Who won the 1908 Scientific American Trophy and the 1909 Gordon Bennett Trophy?
   a. Glenn Curtiss
   b. Calbraith Rodgers
   c. Harriet Quimby
   d. Wilbur Wright

4. In 1911, ________ _________ became America's first licensed female pilot.
   a. Bessie Coleman
   b. Amelia Earhart
   c. Phoebe Omlie
   d. Harriet Quimby

5. Who built the first powered monoplane and also built 11 planes before getting one that could cross the English Channel?
   a. Louis Bleriot
   b. Alberto Santos-Dumont
   c. Calbraith Rodgers
   d. Glenn Curtiss

6. Who designed and flew the first 4-engine aircraft?
   a. Glenn Curtiss
   b. Paul Cornu
   c. Alberto Santos-Dumont
   d. Igor Sikorsky

7. When World War I ended, the speed of aircraft had increased to ____ to ____ mph, and could operate up to about _______ feet.
   a. 50, 60 and 10,000
   b. 70, 80 and 10,000
   c. 100, 120 and 20,000
   d. 140, 150 and 24,000

8. Who were the Lafayette Escadrille group?
   a. They were a group of French men who flew in WWI.
   b. They were a group of Americans who flew for France in WWI.
   c. They were an elite group of the French Foreign Legion.
   d. They were a group of French men and women who led the resistance movement in WWI.

9. T/**F** Orville Wright was the first man to lose his life in a powered airplane.

10. **T**/F President Theodore Roosevelt was the first US President to fly.

Chapter 3

The Golden Age 1919-1939 (pages 44-75)

Resource: ***Aerospace: The Journey of Flight,*** Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 50 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Describe** the problems associated with the first attempts to cross the Atlantic Ocean.
- **Discuss** the successful crossings of the Atlantic Ocean in 1919.
- **Recall** how the United States cut back on investing in air power after World War I.
- **Describe** the impact that barnstorming had on the development of air power.
- **Recognize** the advantage air power has over ships.
- **Describe** the military's attempt to fly across the American continent.
- **Describe** the impact that the around-the-world flight had on the development of air power.
- **Identify** what led the Navy to develop the aircraft carrier.
- **Recall** the impact the National Air Races had on the development of air power.
- **Recall** the impact of airmail delivery on the development of commercial aviation.
- **Discuss** the importance of the Air Mail Act of 1925, the Air Commerce Act of 1926, the Air Mail Act of 1934, and the Air Mail Act of 1938.
- **Recognize** the importance Charles Lindbergh's historic flight had on the development of civil aviation.
- **Identify** the achievements of Amelia Earhart.
- **Explain** the importance of Jimmy Doolittle's blind takeoff and landing.
- **Discuss** the contributions Dr. Goddard made to the advancement of air and space power.
- **Discuss** the impact of the McNary-Watres Act on the development of commercial aviation.
- **Identify** the standard commercial airliner in 1938.
- **Identify** the aircraft that flew across the Atlantic with no fatal accidents in 1938.
- **Discuss** the most famous dirigible of all.

Presentation

Attention: The 20-year period between the end of World War I and the beginning of World War II has been called the Golden Age of Aviation. During this period, there were many exciting and dramatic exploits by daring aviators from many lands. New speed and altitude records were set and broken again and again. There were oceans and continents to cross and everyone wanted to do it faster. The airplane changed from a slow, wood-framed, fabric-covered biplane to a fast, sleek, all-metal monoplane.

Motivation: This is a critical period for studying aviation. Looking at the lessons learned from WWI, and which countries learned them are important facts that helped determine the outcome of WWII.

Overview: Let's take a look at the improvements in quality and quantity that accompany this period of time for aviation. Many individual achievements and accomplishments stand out during these years.

Activities: After the lesson, consider dividing your class into two or three groups and ask questions about the reading. See which team can answer the most questions correctly.

Evaluation: Dividing the class could be your evaluation, or you could just ask a few questions to get a feel for how well the class is learning the material and paying attention.

Assignment: Review the terms and concepts on page 73.

Lesson Outline

1. Flying the Atlantic
   a. Flying the Atlantic was conquered in 1919 by the United States Navy flying three new Curtiss flying boats.
   b. Two weeks later, June 1919, the first nonstop Atlantic crossing took place with a team of two; a pair of veterans of the Royal British Air Force.
2. Investing in Air Power
   a. France, Germany, Italy, England and the United States all built great aviation industries by the end of WWI. 177,000 aircraft were in service by the end of the war. That all changed when the war ended.
   b. Within 3 days after the war ended, the United States Government canceled $100 million in airplane contracts. Within 3 months, 175,000 factory workers had been laid off. Military aviation was cut back by 95 percent. Military airfields were closed, and pilots and other aviation personnel were unemployed.
   c. Aviation in the US almost died, except for two groups of people – barnstormers and Army aviators.
3. Barnstormers
   a. Ex-military pilots who flew war-surplus planes. They flew over small towns, then landed on nearby farms, and took people for rides.
   b. They put on flying exhibitions and wing-walking demonstrations.
   c. Some of the barnstormers were women pilots.
4. Army Air Power Develops
   a. General Billy Mitchell was trying to encourage investment in aviation. He thought the airplane could be used to bomb military and industrial targets.

b. Mitchell also advocated the air force as a separate service.
c. In 1921, Mitchell's pilots sank the battleship Ostfriesland proving Mitchell was right.
d. Mitchell planned the first round-the-world flight. It was completed in 1924.
e. Also in 1924, Army Lieutenant Russell Maughan flew coast-to-coast, 2850 miles in 21 hours and 47 minutes.

5. National Air Races
   a. When he noticed that Americans were making a poor showing in the European races, Ralph Pulitzer offered a trophy to promote high-speed flight.
   b. The first Pulitzer Trophy Race was held in New York in 1920. By 1924, it had grown to 10 separate events, and the name was changed to the National Air Races. 1925 was the last year that the Pulitzer was awarded at the National Air Races.
   c. In 1930, Charles Thompson established a trophy to encourage faster land-based aircraft. The Thompson Trophy Race became the feature event at the Nationals. It was awarded annually until WWII began.
   d. In 1931, the Bendix Trophy Race was added. It was a transcontinental speed race that began on the west coast and stopped at Cleveland, Ohio.
6. Women's Air Derby
   a. In 1929, the National Air Races were opened to women for the first time. The Women's Air Derby was the first cross-country competition for women.
   b. The Women's Air Derby led to the formation of an association of women fliers called the "Ninety-Nines". Amelia Earhart was the first president.
7. Air Mail Speeds Up Delivery
   a. The Post Office Department began airmail service in 1918.
   b. The first airmail route was between Washington DC and New York City.
   c. In 1919, Chicago was added, and in 1920 San Francisco was added.
   d. Regular airmail service did not truly begin until 1924.
   e. The Air Mail Act of 1925 authorized the Post Office Department to contract for air mail service.
   f. The Air Commerce Act of 1926 was the first attempt to standardize and regulate commercial aviation. It provided the first federal safety regulation of aviation for both pilots and aircraft.
   g. In 1934, the new Air Mail Act changed the economic and safety regulation arrangement of commercial air transportation. Commercial air carriers became responsible to three US Government agencies – 1) the Post Office Department; 2) the Aeronautics Branch of the Department of Commerce; and 3) the Interstate Commerce Commission's Bureau of Air Mail.
   h. In 1938, the Civil Aeronautics Act became law. It combined both economic and safety regulations into one independent agency called the Civil Aeronautics Authority.
8. Pioneers Contribute to the Development of Air Power
   a. Charles Lindbergh – first person to cross the Atlantic solo.
      1) In 1927, he took off in New York and landed in Paris.
      2) He took him thirty-three and one-half hours.
      3) He became a world hero and a promoter of civil aviation.

b. Amelia Earhart – first woman passenger to fly the Atlantic in 1928.
    1) In 1932, she was the first woman to make a transatlantic solo flight. She landed in Ireland.
    2) It took her twenty hours and 40 minutes.
    3) She disappeared in the Pacific in 1937 while trying to fly around the world.

9. Aviation Grows
    a. In 1920s, small companies were formed to build private aircraft.
    b. The earliest was the Travel Air Manufacturing Company in 1925 in Wichita, Kansas. The company was formed by Stearman, Cessna and Beech.
    c. Within the next few years, all three men broke away from Travel Air and started their own companies.
    d. Piper bought out Taylor Aircraft Company and renamed it Piper Aircraft Corporation. Then Taylor started another Taylor Aircraft Company.
    e. In 1915, President Woodrow Wilson formed the National Advisory Committee for Aeronautics. It directed scientific study of the problems of flight and provided valuable research in aeronautics.
    f. In 1926, Daniel Guggenheim founded the School of Aeronautics at New York University. It provided many colleges and universities with money for private flying clubs.
    g. In 1929, James Doolittle performed the first successful "blind" takeoff and landing. This paved the way for flight and navigation instruments to be installed in planes.
    h. During the 1920s and 1930s, helicopters made several advances too.
10. Commercial Aviation Matures
    a. Under the McNary-Watres Act, airmail carriers were paid according to the available cargo space. So, it was an incentive for larger aircraft.
    b. Boeing was flying the 247, and TWA was flying DC-2s. American was flying the DC-3, which became the standard commercial airliner by the late 1930s. The DC-3 carried 24 passengers or 5,000 pounds of cargo a distance of 1,200 miles.
11. Seaplanes Carry the Mail
    a. In 1927, Pan American Airways was formed to fly the first airmail route between Key West, Florida and Havana, Cuba. Pan American built a seaplane to handle this.
    b. The seaplane became known as the Pan American *Clipper*.
    c. Pan American also had six Boeing 314s, which were called *Yankee Clippers*. In the 6 ½ years they were flown, they made 596 Atlantic crossings and carried 42,042 passengers a total of 4,238,867 miles without a fatal accident.
12. What About the Dirigibles?
    a. Between WWI and WWII rigid airships rose to their peak in popularity and then completely disappear from the field of aviation.
    b. The Treaty of Versailles, at the end of WWI, allowed the Germans to build Zeppelins again and they built three – the *LZ-127 Graf Zeppelin*, *LZ-129 Hindenburg* and the *LZ-130 Graf Zeppelin II.*
    c. These three Zeppelins were very successful, but the *Hindenburg* is best remembered for its crash, which caused the first fatalities in the history of scheduled airship operations.

   d. The United States also had problems with airships and had two large crashes.
13. Military Air Power Developments During the Interwar Years
    a. Boeing developed the *Boeing 299*. Army designated it the *X1B-17*.
    b. The Army ordered over 50 of the *X1B-17*. This was their first long-range bomber.
14. The Possibility of War
    a. In January 1939, the President of US called for a buildup of our existing military forces.
    b. Army turned to civilian flying schools to train pilots and maintenance personnel.
    c. General Hap Arnold came up with the idea of civilian-operated, Army-supervised flight schools.
    d. Another source for pilots was the Civilian Pilot Training Program. One of these schools gave us the famous Tuskegee Airmen.

Multiple-Choice and True/False Sample Test

1. Within a few months of the end of WWI, which one of the following **did not** happen?
   a. US government canceled $100 million in airplane contracts.
   b. Aircraft production dropped 85 % and 175,000 factory workers were laid off.
   c. Military aviation was cut back by 95 %.
   d. The "barnstormers" contributed to the decline in aviation after the war.

2. Which one of the following statements is **not** true about General Billy Mitchell?
   a. General Mitchell was a vocal advocate for a separate air service, but equal to the Army and Navy.
   b. After WWI, General Mitchell believed that naval power would decide the winner of any future world wars.
   c. General Mitchell believed that the airplane could be used to bomb military and industrial targets inside an enemy's homeland.
   d. General Mitchell believed that air power could fly over the battlefield, attack the enemy's supplies, thus shorten the war and save lives.

3. In 1924, the US Army performed the first round-the-world flight using four aircraft. What were the names of the aircraft?
   a. Boston, Chicago Seattle and New Orleans
   b. Arkansas, Ohio, Nevada and Utah
   c. Dickey, Gehrig, Ruth and Wagner
   d. Doolittle, Lindbergh, Mitchell and Rickenbacker

4. In 1931, the Bendix Trophy Race was added to the National Air Races. Which of the following statements best describes the Bendix Trophy Race?
   a. It was a transcontinental race flown from the west coast to Cleveland, Ohio.
   b. It was a four-lap race around a 29-mile course.
   c. It was an intercontinental race flown from Paris to New York City.
   d. It was an international race flown from London to Paris.

5. The first air mail route in the United States was between
   a. New York City and Chicago.
   b. New York City and Washington DC.
   c. Chicago and Cleveland.
   d. Chicago and San Francisco.

6. Who was the first person to fly across the Atlantic Ocean solo?
   a. Amelia Earhart
   b. Bessie Coleman
   c. Charles Lindbergh
   d. Billy Mitchell

7. In 1915, President Woodrow Wilson formed an organization whose purpose was to supervise and direct the scientific study of the problems of flight, with a view of their practical solutions. What was the name of this organization?
   a. National Aeronautical Association (NAA)
   b. National Advisory Committee for Aeronautics (NACA)
   c. National Civil Aeronautics Authority (NCAA)
   d. Civil Aeronautics Administration (CAA)

8. T/**F** Phoebe Fairgrave Omlie was the first licensed black female pilot.

9. **T**/F The Women's Air Derby led to the formation of an association of women fliers called the "Ninety-Nines".

10. **T**/F The Tuskegee Airmen were a group of African-American pilots who flew in WWII.

Chapter 4

Air Power Goes to War (pages 76-111)

Resource*:* *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 90 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Discuss** German, Japanese and Italian air power preparations for World War II.
- **Discuss** US and British air power preparations for World War II.
- **Recognize** the German combined arms approach to warfare.
- **Recognize** the impact technology had on the Battle of Britain.
- **Describe** the lessons learned from the outcome of the Battle of Britain.
- **Describe** how the Germans used air power when they opened up a second front against the Russians.
- **Identify** the only country using women to fly combat sorties in 1941.
- **Discuss** why the Japanese plan for the attack on Pearl Harbor attacked American air power first.
- **Discuss** the impact the North African air campaign had on military air power.
- **Identify** the theories of the early air power theorists.
- **Describe** the early Royal Air force bombing experience before the start of the Combined bombing Offensive.
- **Describe** the effectiveness of the Army Air Corps bombing strategy at the beginning of World War II.
- **Discuss** what changes in strategy and tactics led to the Allies gaining air superiority over Europe.
- **Discuss** the impact air superiority had on the European campaign.
- **Identify** the first objective planned for by the Japanese during their advance through the Pacific.
- **Describe** how Allied air power stopped the Japanese advance.
- **Identify** the reasons the Japanese-held islands located in the southwest Pacific had to be captured by the Allies.
- **Identify** the most destructive air raid in history.
- **Identify** why the atom bomb was used against Japan.
- **Discuss** air power's role in war.
- **Discuss** the lessons learned in the European Air Campaign.
- **Discuss** the lessons learned in the Pacific Air Campaign.

Presentation

Attention: World War II has been called the "Air War" because for the United States it began with the Japanese air attack on Pearl Harbor and ended with the US aerial bombing of Japan. During this five-year period, the airplane developed faster than at any other time in history.

Motivation: Studying World War II from an air power perspective can really show how important the airplane is to the overall strategy of a country. Additionally, knowing how air power was used in the past is certainly vital to any future encounters.

Overview: With this chapter, we will take a look at many strategies and results for both the allies and the axis powers. This will also point out how close many of these battles were, and that many times, the results could have gone the other way.

Evaluation: Ask questions during the presentation and at the end.

Assignment: Review the key terms at the end of the chapter, and go back over the strategies of the important battles. ie. Battle of Britain.

Lesson Outline

1. World War II
   a. The Treaty of Versailles prevented Germany from building military aircraft after WWI. However, they were allowed to build civilian aircraft, which they did.
   b. This is how they built their air force for WWII. By 1935, the Luftwaffe, the German Air Force, was officially formed.
   c. Mussolini had built Italy's Air Force too. So, the Italians were ready for WWII.
   d. The Japanese had two air forces, the Army Air Force and the Navy, both were ready.
2. Allied Preparedness
   a. At the end of WWI, England, France and the United States had the most powerful air forces in the world. However, they all cut back after the war. So, while we were cutting back, the axis powers were expanding.
   b. When England saw Germany rebuilding her air power, England changed its strategy from an offensive one to a defensive posture (from bombers to smaller fighter aircraft). Their priority was to protect the homeland and hold off Germany.
   c. France spent its money on a ground defense.
   d. The US was almost completely disarmed. The US didn't start making great strides with airplane building until 1940-1941.
3. A New Type of War
   a. Germany – Blitzkrieg (lightning war). Blitzkrieg was also known as a combined arms operations.
   b. This strategy combined planes and tanks and moved fast, capturing land or personnel quickly.

   c. The *Messerschmitt 109* was the backbone fighter of the German Air Force.

4. War!
   a. Germany marched into and occupied Austria and Czechoslovakia in 1938 and 1939. Hitler invaded Poland in September 1940. Using its new Blitzkrieg strategy, Germany defeated Poland in 20 days.
   b. When Germany invaded Poland, Britain and France declared war on the Axis Powers.
5. Germany Takes Europe
   a. Germany parachuted airborne infantry into Norway and Denmark and captured them. That only left the Netherlands, Belgium and France free of German occupation.
   b. Germany went through the Netherlands and Belgium, and then France. With no air force to stop them, France was defeated in six weeks.
6. Battle of Britain
   a. After the victory in France, Hitler waited before invading Britain. He wanted the Luftwaffe to defeat the Royal Air Force (RAF) first.
   b. The problem was that the Luftwaffe was not designed to be a long-range bombing force.
   c. The RAF put up a heroic defense. The Luftwaffe was losing many more planes than the RAF.
7. War on Two Fronts
   a. While the Battle of Britain was going on so were battles in the Mediterranean and Northern Africa.
   b. Germany occupied all of south and southeastern Europe.
8. The Russian Front
   a. Germany was convinced Russia would fall very quickly. However, Russia threw everything they had at the Germans and stopped their advance.
   b. Germany was spread too thin, with battles in Britain, Eastern Europe, the Mediterranean and North Africa.
   c. Hitler backed off Britain to concentrate on Russia, but the Russian front was settling into a long land struggle.
9. The United States Enters the War
   a. Britain, Russia and the US agreed that defeating Germany was the number one priority for the allies.
   b. Japan would just be contained until Germany was defeated.
10. Japanese Territorial Strategy
    a. Japan needed to expand her territory to gain raw materials to become an industrial nation.
    b. After Japan moved into Manchuria and China in 1939, the US and Britain embargoed all trade with Japan.
    c. Rather than give up on expansion, Japan chose to fight.
11. Pearl Harbor
    a. December 7, 1941 Japan attacked Pearl Harbor, Hawaii.
    b. The primary purpose was to cripple the American fleet at Pearl Harbor.

c. The attack was a complete surprise and the losses were staggering. The US suffered heavy losses in ships, airplanes and personnel.

12. US Air Power Spins Up
    a. The contract schools increased their production of pilots.
    b. The Civilian Pilot Training Program became the CAA War Training Service. Over 300,000 pilots were trained by 1944.
    c. In 1942, the Women's Auxiliary Ferrying Squadron was established. These female pilots ferried aircraft to various locations.
13. European Campaign
    a. Grand strategy once US entered the war was to switch from defense to offense; recapture territory occupied by Germany; and finally force Germany and Japan into unconditional surrender.
    b. US air power would be used for supporting ground troops and conducting long-range bombing.
14. Learning in North Africa
    a. The Germans continually won the early battles in North Africa.
    b. The allies went to a centralized control of aircraft, which allowed more planes to come to the aid of an attacked army. This worked real well.
    c. By 1943, the Allies had gained air superiority in North Africa and won the ground war too. The Axis forces were defeated in Africa.
15. Developing a Strategy (for air power)
    a. Douhet said to gain air supremacy with a massive first strike; a surpise attack on the enemy's aircraft.
    b. Trenchard believed the proper force mix was two-thirds bomber aircraft and one-third fighter. He disagreed with Douhet on what targets to hit. Trenchard thought air power should knock out vital centers, like factories.
    c. Mitchell thought air power should take the war to the enemy's cities. He thought 20% should be bombers, 20% attack aircraft and 60% fighter aircraft.
    d. Chennault did not believe that the bomber could get through, however Chennault was ignored.
    e. US developed an unescorted high altitude, daylight, precision bombing, while the British bombed at night.
16. The Combined Bomber Offensive
    a. In the beginning, first priority targets were submarine factories, docks and ports.
    b. Second priority targets were aircraft factories and munitions plants.
    c. Third priority targets were communications and transportation systems.
    d. By late summer of 1943, the American bombers were getting chewed up by the Luftwaffe. The US decided to drop the unescorted, high-altitude, daylight, precision bombing.
    e. P-51 Mustangs began escorting the bombers and chased enemy fighters, too.
    f. This new strategy worked well.
17. The Normandy Invasion
    a. On June 6, 1944, the Allies landed in Normandy, France starting the invasion of Europe.
    b. For two months before the invasion, US and British planes bombed within 130-mile radius of the beaches. This gave the Allies air superiority for the invasion.

18. The Pacific Campaign
    a. Japanese/Allied Strength
        1) Militarily, Japan was stronger than Britain or the US. Britain was totally occupied with Germany, so they couldn't help in the Pacific.
        2) Japan had 2,400,000 well-trained men and 3,000,000 reserves. They had 7,500 aircraft and were making 400 more every month.
        3) Allies in the Far East consisted of 550,000 poorly equipped Army troops, 1,000 obsolete aircraft and 90 ships.
    b. Air Power Stops the Japanese Advance
        1) Allies finally stopped the Japanese advance by summer of 1942. Two air battles were critical to that stop.
        2) Battle of Coral Sea and the Battle of Midway were naval battles but were fought entirely by aircraft.
        3) Japanese lost over 100 of their best pilots, and this really hurt their war effort.
    c. On the Offensive: Island Hopping Through the Southwest Pacific
        1) War in Pacific involved fighting over several hundred separate islands scattered over millions of square miles.
        2) As islands were conquered, the US would build airfields and then use them to support flying and refueling missions.
        3) If the Allies could control the islands they could begin strategic bombing of the Japanese islands.
    d. The Flexibility of Air Power
        1) Gen. MacArthur was in charge of the island-hopping campaign. He had two goals: retain control of the Philippines and capture the islands necessary to launch a bombing campaign against Japan.
        2) The Pacific Campaign was a second priority behind the European Campaign, and MacArthur felt the elements of his command were inadequate.
        3) The air forces were in bad shape. There were only 150 American planes and 70 Australian aircraft that worked. Replacements and supplies were a problem and morale was low.
        4) Major General Kenney was MacArthur's air commander. He used a different strategy for the Pacific theater. He bombed from low altitudes and attached parachutes to the bombs so the airplane had time to get out of the way. He also had the bombs filled with white phosphorus, which caused streams of fire to shoot out from the bombs.
        5) Kenney's techniques and the cutting off of Japanese supplies contributed to the Allies' victories in the Pacific.
    e. The Bombing of Japan
        1) The first bombing of Japan took place in April 1942. It was highly successful. Japan no longer felt safe from Allied attack.
        2) The next bombing occurred in June 1944. This started the actual air campaign against the Japanese homeland.
        3) The US had gone back to high-altitude, unescorted, daylight precision bombing and it didn't work.

4) The US then began low level at night bombing. This was much more successful.
5) Japan's industries were scattered within cities, so this caused many civilian casualties. In March 1945, the US bombed Tokyo. More than 83,000 people were killed and over 100,000 were injured.
6) The Japanese fighters were not very successful at night. So, not very many US bombers were lost. This new strategy worked.

f. Atom Bomb Forces Surrender
1) In July 1945, there were still over 4 million Japanese soldiers fighting. President Truman feared that hand-to-hand combat would cost hundreds of thousands of lives for both the Japanese and the Americans.
2) So, he authorized use of the "ultimate weapon" to save lives. On July 27, 1945, Japan was warned to surrender or face complete destruction. Japan responded through the Soviet Union, but the Soviet Union did not relay the message. So, the US dropped the atomic bombs.
3) On August 6, 1945, the B-29, *Enola Gay* dropped an atom bomb on Hiroshima. On August 9, 1945, the US dropped an atom bomb on Nagasaki. The next day Japan communicated by radio that they were willing to surrender.
4) On September 2, 1945, Japan officially surrendered.

g. Lessons Learned
1) The flexibility of air power and the importance of it were prominently displayed during WWII.
2) WWII taught the futility of war in modern society. Twenty million people were killed and at least sixty million were injured or permanently disabled.

Multiple-Choice Sample Test

1. At the end of World War I, the Allied Nations (England, France and the United States) had the most powerful air forces in the world. What did each country do with these air forces after the war?

a. Each country retained approximately the same amount of planes.
b. Each country increased their air forces substantively.
c. Each country decreased their air forces and weakened them.
d. England and France cut back on theirs, but the US increased theirs dramatically.

2. Which of the following best describes Blitzkrieg?

a. It was the name the British gave for the German bombing of London.
b. It was the combined arms operations strategy that Germany used in WWII.
c. It was the lightning response Poland gave to the German invasion.
d. It was the US' strategy against Germany in WWII.

3. Which of the following statements is true concerning the Battle of Britain?
   a. The German Luftwaffe was designed to be a long-range bombing force.
   b. The Luftwaffe's short- and medium-range aircraft could takeoff from France, fly to England, fight the British RAF and strike their targets without refueling.
   c. During the Battle of Britain, the RAF's Bomber Command stood idly by waiting for a mission.
   d. The RAF had the right aircraft for this battle, but the Luftwaffe did not.

4. By 1941, who was the only major power of WWII to use women pilots in combat?
   a. England
   b. Germany
   c. Russia
   d. United States

5. What was the primary purpose for the Japanese attack on Pearl Harbor?
   a. to cripple the American fleet at Pearl Harbor
   b. to convince the Americans not to enter WWII
   c. to control all of the islands in the Pacific Theater
   d. to adhere to Hitler's request of Japan

6. Once the US entered WWII, all of the following were part of the overall allied strategy **except** which of these?
   a. The strategy switched from defense to offense.
   b. The strategy called for the recapture of territory occupied by Germany.
   c. The strategy was to force Germany and then Japan to unconditionally surrender.
   d. The strategy switched from a European focus to a Pacific focus.

7. Which one of the following people did **not** believe in unescorted high altitude, daylight, precision bombing?
   a. Claire Chennault
   b. Giulio Douhet
   c. Billy Mitchell
   d. Hugh Trenchard

8. What is significant about the Battles of the Coral Sea and Midway?
   a. The Japanese won both of these battles with superior air power.
   b. Both battles were fought entirely by aircraft without the surface ships seeing each other.
   c. Both battles were decided by the superior American submarine fleet.
   d. The battleship regained its predominance as the primary US naval weapon.

9. In which battle did the Japanese lose over 100 of their best pilots and served as a key to defeating Japan?

a. Battle of the Coral Sea
b. Battle of Iwo Jima
c. Battle of Midway
d. Battle of Tarawa

10. On August 6, 1945, what happened that devastated the Japanese and hastened the end of WWII?

a. The Soviet Union declared war on Japan.
b. The US troops captured Iwo Jima and the Marianas Islands.
c. US aircraft bombed Tokyo with incendiary bombs.
d. A US B-29 dropped an atom bomb on Hiroshima.

Chapter 5

Aviation: From the Cold War to Desert Storm

(pages 112-158)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 100 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Discuss** the political situation at the end of World War II.
- **Define** the "Cold War".
- **Identify** why the United States reduced its military forces after World War II.
- **Identify** the date the United States Air Force was formed.
- **Discuss** the first primary mission of the United States Air Force.
- **Identify** several aviation advances that were made during World War II.
- **Identify** the so-called German "vengeance" weapons that were used to terrorize Europe.
- **Discuss** the use of helicopters during World War II.
- **Discuss** air power's role in keeping Berlin from becoming a part of East Germany.
- **Discuss** how ready the United States air power was for a war in Korea.
- **Discuss** air power's role in stopping the North Korean army outside of Pusan.
- **Identify** the reason American fighter pilots were able to defeat the MiG-15.
- **Discuss** air power's lessons learned from the Korean War.
- **Identify** why the DC-4 was initially one of the most popular commercial airliners after WWII.
- **Identify** the first "pure" jet commercial airliner.
- **Identify** the "big three" in general aviation manufacturing.
- **Identify** the problems encountered when attempting to break the sound barrier.
- **Define** Mach 3.
- **Discuss** the advantages of variable swept-back wings.
- **Discuss** the potential impact new missile technology had on aircrews.
- **Identify** the primary reason the B-52 bomber was built.
- **Discuss** the impact television had on the Vietnam War.
- **Discuss** the results of the Tet Offensive.

Looking at the Thanh Hoa Bridge example:
- **Discuss** the impact technology has on air power.
- **Discuss** the difference in how air power was applied during Operation Rolling Thunder and Operation Linebacker.
- **Identify** aircraft built specifically for Strategic air command during the Cold War.
- **Discuss** Strategic Air Command's mission during the Cold War.

- Identify the contribution the Civil Reserve Air Fleet made to Operation Desert Shield.
- Identify the “key” air power capability that allows US air power to be a “global striking force”.
- Identify several of the lessons learned from previous air wars that were used to help develop the Desert Storm air campaign plan.
- Discuss why Iraq’s command and control was attacked first during the war.
- Discuss air power’s contribution to the defeat of Iraq’s counterattack into Saudi Arabia.
- Discuss air power’s contribution to the “100 Hour War”.
- Discuss the impact new technology had on the “War in the Desert”.

Presentation

Attention: After WWII, America’s main concern, militarily and politically, was the Soviet Union (Russia). America and Russia were the two super powers, yet their worldviews weren’t always in agreement. In fact, many times America and Russia had quite different views on political matters around the world. This time period is known as the Cold War, and we want to take a look at that today. What does it really mean? What transpired during this period of time?

Motivation: This was an important period of time in the world. Would there be a World War III? That was on the minds of many people in the 1950s, 1960s and 1970s.

Overview: Let’s look at this period of time in history, and then move into the Korean War, the Vietnam War and even the Desert Storm conflict.

Assignment: Using the terms and concepts in the back of the chapter, go back over these conflicts and wars. There is a lot of material in this chapter. Also review the objectives and see if you understand them and can answer them.

Evaluation: Since this lesson should take a couple of classes, it would be a good place for a pop quiz. Another option might be to assign students to make a presentation on some aspect of this chapter. You could also divide into teams and conduct a quiz bowl.

Lesson Outline

1. Setting the Stage: The Political Situation
    a. Cold War
        1) Between US and Soviet Union
        2) Didn’t share same ideas about freedom, economics and government.
        3) Soviet Union wanted to increase its influence in the world.
        4) US wanted to prevent the spread of communism.
        5) US and Soviet Union had an antagonistic relationship. They both wanted to influence the world, but they didn’t want to go to war.
    b. Cold War shaped many of the world’s developments including aviation.
2. Military Developments

a. After WWII, US military went from over 2 million to less than 900,000. A year later, the military was cut to 300,000.
b. US was certain, with the monopoly of the atomic bomb, no one would dare attack.
c. A Separate Air Force: Designed to Defend the Nation
    1) In July 1947 with the National Security Act, the Air Force became a separate branch of the military.
    2) The Air Force's primary mission was deterrence.
d. Wartime Advances
    1) Airplanes improved in design, instrumentation, navigation, and engines.
    2) Bombers grew in size, speed and bomb load capacity.
    3) *B-29* was the first to have pressurized crew compartments.
e. Jet Propulsion
    1) Frank Whittle designed the first turbojet engine in 1937, but England didn't fly her first jet aircraft until 1941.
    2) Germany flew the first jet aircraft in 1939.
    3) US flew its first jet in 1942 but didn't produce a jet fighter until 1944, the Lockheed *F-40, Shooting Star*.
    4) Before the end of the war, Germany had produced 22 different models of jet aircraft. The most famous jet of WWII was the Messerschmitt *ME-262A*. Fourteen hundred of them were produced during the war, but only 100 were ever used as fighters. A couple hundred more were used as tactical fighter-bombers. Germany could have changed the war if she would have used more of these.
f. "Vengeance" weapons
    1) Germany developed two, the *V-1*and the *V-2*.
    2) The V-1 was 26 feet long and weighed 3,000 pounds and carried 1,800 pounds of high explosives. It was called the buzz bomb. It was noisy and not very accurate.
    3) The V-2 was a rocket-propelled ballistic missile.
g. Helicopters
    1) The Sikorsky *R-4* was the first successful military helicopter. About 400 were used in Europe, the Pacific and in the US.
    2) In April 1944, the R-4 was used to rescue a downed pilot behind enemy lines for the first time.

3. The Cold War Heats Up
    a. The Berlin Airlift
        1) At the end of WWII, Berlin was divided into four sectors, each one controlled by one of the Allied Nations (US, Britain, France and the Soviet Union).
        2) Germany was divided into two parts – West Germany was controlled by the US, Britain and France; and East Germany was controlled by the Soviet Union.
        3) Soviet Union blocked supplies going into Berlin. The Soviets wanted to take over control of Berlin.
        4) The Allies answer to the blockade was the Berlin Airlift.
        5) Airlift grew to 12,940 tons delivered by 1,398 flights in one day.

6) The airlift went on for a year before Russia realized she couldn't blockade Berlin. So, the blockade was lifted. The airlift was a success.

b. The Korean War

1) In June 1950, North Korea, an ally of the Soviet Union, invaded South Korea.
2) After WWII, Korea had been divided into two parts – North Korea became an ally of the Soviet Union and also became a communist country; South Korea became an ally of the US and became a republic.
3) United Nations resolved to provide assistance to South Korea.
4) General MacArthur became the commander of the US forces and the UN forces.
5) The air battles were all-jet battles. The Russian *MiG*-15 was a little better than the US F-86, but American pilots were better trained than the enemy.
6) Nine *MiGs* were shot down for every one US aircraft.
7) UN troops eventually advanced to the 38th parallel, which was the original border between North and South Korea.
8) In July 1953, a cease-fire treaty was signed. Neither side was the outright victor, but the original objectives of the UN were accomplished.
9) Lessons learned
   a) US atomic arsenal alone was not enough to prevent involvement in war.
   b) US was not prepared for the Korean War.
   c) Military leaders had forgotten the lessons learned during the North African Air Campaign during WWII.

4. Aviation Continues to Develop: An Ongoing Process

a. Civil Aviation Developments

1) Because of WWII, millions of people were exposed to aviation and loved it.
2) Many veterans publicized the merits of aviation.

b. Commercial Airlines

1) Remarkable developments in aircraft design occurred during the war.
   a) better instrumentation, navigation
   b) increased safety
   c) radar was developed
2) More pilots were available and they were better.
3) New and better planes were developed.
   a) Douglas *DC-4*
   b) Lockheed *Constellation*

c. Commercial Airlines Adopt Jet Engines

1) First jet airliners were British
2) There were two types of propulsion, turboprop and pure jet; both used jet turbine engine.
3) World's first jet turboprop airliner was the Vickers *Viscount*.
4) DeHavilland *Comet I* was the world's first pure jet airliner. The Comet revolutionized commercial travel because it flew at 500 mph and at higher altitudes (25,000 – 30,000 feet).
5) In 1945, about 3 million passengers flew commercially in America.

6) By 1950, about 17 million did.
7) By 1958, when commercial jets were introduced, 30 million passengers flew.

d. General Aviation
1) Also fared well after WWII.
2) Thousands of American pilots flew in WWII. Thousands more got their pilot licenses using the GI Bill.
3) There was a great demand for general aviation so Cessna built the C-120 and the C-140.
4) By the end of the 1950s, Cessna was the number one general aviation manufacturer.
5) Piper and Beech joined Cessna to become the "big three" of general aviation.

5. Aviation Research and Development
a. Before and during WWII, most of the research and development was conducted by the National Advisory Committee on Aeronautics (NACA).
b. The NACA was joined by Boeing and Lockheed who also developed research facilities.
c. Airborne Research and Development – planes need to eventually be flown to test their capacities.
d. Breaking the Sound Barrier
1) In 1945, Bell Aircraft Company was contracted to explore the problems of high-speed flight. The aircraft, X-1, first flew in January 1946.
2) There were actually six X-1s built for test flights.
3) The X-1 was dropped from an airborne B-29.
4) In October 1947, Chuck Yeager penetrated the sound barrier. He flew at 670 mph at 42,000 feet.
5) In November 1953, Scott Crossfield reached Mach 2 (twice the speed of sound) or more than 1,320 mph.
6) At the end of WWII, the US captured plans for the German Messerschmitt *P-1101*. These designs gave us variable-angle wings. Swept-back wings produced higher speeds.
7) In 1953, the *F*-100 *Super Sabre* was produced. It was the first production supersonic fighter.

e. Bomber Developments
1) Presidents Truman and Eisenhower decided that US foreign policy would be backed by the strength of the atomic bomb. So, the best bombers needed to be built.
2) Three prototypes were built: North American XB-45, Convair XB-46 and Boeing Xs-47. All had straight wings.
3) Then US created XB-47 with sweptback wings. It became the US Air Force's first all-jet bomber. This plane had only one shortcoming, its range was only 3,000 miles.
4) So, Boeing developed the B-52. It was twice the size of the B-47 and had a range of 10,000 miles.

f. Smart Bombs: Advances in Guided Missile Research

1) After WWII, missile research was also making progress.
2) One of the first developments was a drone; called the Northrup *SM62 Snark*. The *Snark* had inertial and stellar guidance systems.

6. The Vietnam Conflict
   a. Phase I – July 1950 – July 1954
      1) In 1950, US gave France $15 million to fight the spread of communism in Vietnam.
      2) President Truman established a US Military Assistance Advisor Group (MAAG). This group consisted of 342 military advisors.
   b. Phase II – July 1954 – August 1964
      1) US involvement grew from advising to fighting. US was helping the South Vietnamese.
      2) French agreed to pull out of Vietnam. Laos, Cambodia and Vietnam became independent countries.
      3) Vietnam was divided into two parts, north and south. The division was meant to be only temporary, but elections had occurred because the communist north and the democratic south were both afraid they would lose the election. So, they remained divided.
      4) The new government of South Vietnam requested help from the US. President Eisenhower authorized help to organize, train and equip the South Vietnamese.
      5) By 1961, civil war was occurring and President Kennedy expanded our commitment. The goal was to help the South Vietnamese military. To do this Kennedy sent in US Special Forces and Air Force T-28 and B-26 aircraft. By February 1962, over 11,000 US forces were in Vietnam and fighting in combat.
      6) By the end of 1963, 17,000 US forces were in Vietnam, but the war was still going badly for the South Vietnamese.
   c. Phase III – August 1964 – June 1969
      1) In August 1964, a US destroyer was attacked by North Vietnamese torpedo boats. President Johnson ordered retaliatory naval air strikes. Congress passed the Tonkin Gulf Resolution, which gave Johnson the authority to take all-necessary actions to repel military actions against the US military and prevent further aggression.
      2) In 1964 and early in 1965, the North Vietnamese launched several attacks. Johnson called on the US Marines to protect American bases, and thus started the slow escalation of US involvement.
      3) By mid 1965, the war was still going badly for the US and the South Vietnamese. President Johnson did not trust his military advisors so he and the Secretary of Defense ran the Vietnam Conflict. They even picked out the targets for the air strikes.
      4) Operation Rolling Thunder began. It was another gradual escalation of the war. Johnson picked out targets, but made sure they weren't targets that might upset the Russians or the Chinese. Johnson was afraid they might join with the North Vietnamese and make this a world war.

5) Rolling Thunder lasted 3 years. It disrupted and destroyed ammunition depots, oil storage facilities, power plants and railroad yards, but it didn't destroy the North Vietnamese's will to resist.
6) Every time Johnson ordered a stop in the bombing, the North Vietnamese would repair and re-supply themselves.
7) US kept bombing, but the North Vietnamese were hiding and using hit-and-run tactics and resorting to guerrilla warfare.
8) The Tet Offensive
   a. In January 1968, the communists launched a large-scale surprise conventional attack on US and South Vietnamese forces.
   b. American air power won decisively over the North Vietnamese, but the Tet Offensive was seen every night on American television news stations. Johnson had over 500,000 American forces in Vietnam and the public didn't understand what was going on.

d. Phase IV – June 1969 – April 1975
   1) In January 1969, Nixon became president. His plan called for ending US involvement. The plan was called Vietnamization. The idea was to turn the fighting over to the Vietnamese. By the end of 1971, it appeared South Vietnam might be able to win the war. The US forces starting leaving.
   2) However, the North Vietnamese were building up forces along the border between North and South Vietnam.
   3) On Good Friday, March 30, 1972 North Vietnam invaded South Vietnam again. President Nixon reacted with B-52 strikes. This operation was called Operation Linebacker and was different from Operation Rolling Thunder because Nixon let his military advisors pick the targets. Operation Linebacker was aimed at bombing the North Vietnamese until they came to the negotiating table.
   4) By October 1972, US ground forces had withdrawn from Vietnam and negotiations had begun. However, negotiations did not go well, so Nixon ordered more bombing – Linebacker II. Twelve days later everyone was back at the table negotiating a cease-fire.
   5) US used air power as a foreign policy tool in Vietnam. Initially, it was used to raise the morale of the South Vietnamese troops and then to contain the advances of the communists. The gradualism policy restricted the use of air power.

7. Meanwhile: The Cold War continues
   a. By the early 1970s, the Soviet Union was still trying to spread communism and the US was trying to contain it.
   b. Both countries had atomic bombs and the world feared a war between them.
   c. Both countries created large defenses to deter the other.
   d. As the arms race continued, some analysts feared that the only way to win would be to use a preemptive first strike. This put emphasis on reconnaissance, surveillance and command and control.
   e. Also, put emphasis on space power, to monitor with satellites.
   f. Arms race produced better airplanes, missiles, radar and satellites.
   g. End of the Cold War

1) Ended in 1989 with the fall of the Berlin Wall and the collapse of the Soviet Union.
2) Soviet Union's economy couldn't keep up with the United States.
3) Despite lots of conflicts, a total world war never occurred.

8. War in the Desert
   a. On August 2, 1990, Iraq invaded Kuwait in a dispute over oil loans.
   b. Iraqis were in complete control by August 4th.
   c. Iraq had the 4th largest army in the world.
   d. Operation Desert Shield
      1) United Nations immediately passed Resolution 660 demanding an Iraqi withdrawal and President Bush ordered an immediate military deployment to defend Saudi Arabia.
      2) By August 21st, Americans had F-16s, F-15s, F-4s, F-117s, A-10, E-3Bs, C-130s, KC-135s and KC-10s in Saudi Arabia.
      3) In Kuwait, Iraqi troops looted and pillaged Kuwait. So, the United Nations passed Resolution 678 calling for UN Coalition Forces to use all means necessary if Iraqi troops did not withdraw from Kuwait by January 15, 1991.
      4) Desert Shield became the most massive airlift in the history of air power.
      5) For the first time in history, the Civil Reserve Air Fleet was activated.
      6) By December, only 4 months into Desert Shield, 16 different airfields were receiving up to 8,000 troops every day.
   e. The Plan
      1) President Bush set clear objectives: deter further Iraqi aggression and defend Saudi Arabia.
      2) UN Resolution 678 – expel Iraqi troops from Kuwait.
         Air Campaign called Instant Thunder was aimed at knocking out targets and keeping them out.
      3) Because of lessons learned from previous wars, the air campaign called for four phases: (a) target Iraq's command and control sites and facilities, (b) target enemy air defenses to ensure unhindered flying over Kuwait, (c) cut supply lines and target the enemy's main troops in Kuwait, (d) conduct close air support of friendly troops.
   f. Operation Desert Storm
      1) When the January 15 deadline passed and Iraqi troops were still in Kuwait, the war started.
      2) On January 17, several UN attacks took place. Air attacks were conducted on the largest number of separate targets in the shortest period of time in the history of war.
      3) Major damage occurred within the first 10 minutes. Saddam Hussein lost his ability to communicate. Within the next hour, Iraq lost its integrated air defense system.
      4) UN air superiority had been won within a few hours.
      5) Air attacks switched to enemy tanks, artillery, troops and supplies.
   g. Iraq Counterattacks
      1) On January 29, Iraq launched an attack into Saudi Arabia. Fortunately, the

Americans were ready. Iraq was moving its troops at night, but didn't realize that the Americans could see them.

2) Without the element of surprise, the Iraqi troops were at a disadvantage. Iraq actually invaded at two points but suffered heavy losses at both.

h. The 100-Hour War

1) On February 22, President Bush demanded Iraq withdraw from Kuwait or be forced out. They refused.

2) UN troops attacked from the west, south and southwest and reached Kuwait City on February 25th.

3) UN casualties were low – 95 killed, 368 wounded and 20 missing during this 100-hour war.

4) Iraq's losses were difficult to assess, but at least 30,000 to 60,000 were killed, 50,000 were wounded and 60,000 were captured.

i. Lessons Learned

1) Lessons learned from WWII, Korea and Vietnam were not wasted.

2) According to President Bush, "Gulf lesson number one, is the value of air power."

Multiple-Choice and True/False Sample Test

1. Who were the two major powers in the Cold War?
   a. The United States and England
   b. The Unites States and The Soviet Union
   c. The Soviet Union and China
   d. The Soviet Union and Poland

2. In 1947, the United States Air Force came into being with the passage of the
   a. National Aeronautical Act.
   b. Army-Air Force Separation Act.
   c. National Security Act.
   d. National Space Act.

3. Who designed the world's first turbojet engine for use in an airplane?
   a. Glenn Curtiss
   b. Billy Mitchell
   c. Carl Spaatz
   d. Frank Whittle

4. After WWII, Germany was divided into East and West Germany. Who controlled East Germany?
   a. England
   b. France
   c. United States
   d. Soviet Union

5. What was the US' first priority in the Korean War?
   a. bomb North Korea
   b. stop the advance of the North Korean troops
   c. send American troops to the 38^{th} parallel
   d. attack China and Russia for helping the North Koreans

6. What was the world's first "pure" jet airliner?
   a. DeHavilland *Comet 1*
   b. Lockheed *Constellation*
   c. Douglas *DC-4*
   d. Vickers *Viscount*

7. Who was the first man to penetrate the sound barrier and fly faster than the speed of sound?
   a. Scott Crossfield
   b. Mel Apt
   c. Kit Murray
   d. Chuck Yeager

8. What was the only true strategic bombing campaign of the Vietnam War, which resulted in the North Vietnamese coming back to the negotiating table?
   a. Rolling Thunder I
   b. Rolling Thunder II
   c. Linebacker I
   d. Linebacker II

9. **T**/F By 1990, Iraq had the fourth largest army in the world.

10. **T**/F In 1991, when discussing the Desert Storm victory, President Bush said that the number one lesson from the Gulf was the value of air power.

Chapter 6

Advances in Aeronautics (pages 159-171)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 30 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Discuss** the flights of the X-15.
- **Discuss** the XB-70.
- **Discuss** the importance of composite materials.
- **Discuss** solar aircraft.
- **Discuss** the advancements in military aerospace.
- **Discuss** the advancements in civil aviation and general aviation.

Presentation

Attention: Through the 1950s and 1960s important research was done in aeronautics and significant advances were made. From the late 1960s up to today, flight-testing has been accomplished by operational aircraft rather than research aircraft.

Motivation: We should take a few minutes and see where some of these improvements have taken us.

Overview: So, let's spend the next few minutes looking at the important research of the last 40 – 50 years.

Evaluation: Ask questions from the back of the chapter. This would be a good place for a slide presentation of the aircraft changes and improvements.

Assignments: Review key terms and read chapter 7. Some time could be spent on reviewing the first six chapters of the book.

Lesson Outline

1. Aeronautical Research
   a. The X-15
      1) Air Force, Navy and NACA joint project to build an airplane that would fly at 4,500 mph and reach 250,000 feet.

2) The X-15 was 50 feet long with a 22-foot wingspan. It weighed 33,000 pounds, of which 18,000 pounds was fuel. It was rocket powered and launched from a B-52.
3) The first flight was in September 1959 and reached a speed of 1,400 mph. The first eight flights were piloted by Scott Crossfield.
4) The flights continued through 1967 performing over 200 flights. Both goals were exceeded. It reached a speed of 4,534 mph (Mach 6.72), and reached an altitude of 314,750 feet.

b. XB-70
1) In 1954, the US wanted to build a supersonic replacement for the B-52. The result was the XB-70.
2) The XB-70 flew at 2,000 mph and reached an altitude of 70,000 feet. Its initial flight was in 1964.
3) Congress decided that the Air Force didn't need a supersonic bomber and canceled the program.

c. Other Research
1) In the 1970s, fuel efficiency and environmental considerations became the driving forces.
2) Advances in construction materials also overcame problems with weight and in-flight stresses.
3) Super-strong, lightweight, nonmetallic, epoxy graphite composite materials were developed.
4) Other research was conducted on airfoil design, which produced forward-swept wings, oblique wings, joined wings, mission-adaptive wings, winglets and canards.
5) The U-2 and the SR-71 were developed to fly at high altitudes over enemy territory.
6) The B-2 and the F-117A are stealth aircraft designed to be invisible to enemy radar.

d. Research and Development and Civil Aviation
1) In 1954, Boeing unveiled the 707, which revolutionized commercial aviation. The 707 also became the Air Force's C-135.
2) Shortly thereafter, Douglas introduced the DC-8, which was also very successful.
3) In 1963, Boeing introduced the 727, the most successful jet ever built.
4) In 1966, companies entered the jumbo jet field. Boeing announced the 747, Lockheed, the L-1011, and Douglas, the DC-10.
5) In 1962, British Aircraft Corporation and the Sud-Aviation agreed to build the supersonic Concorde. In 1976, the Concorde began flying from London and Paris to Washington DC. The flight takes less than 4 hours.

e. General Aviation
1) From 1958 to 1982, general aviation in the US grew at a faster rate than military or commercial aviation.
2) Generally not true in other parts of the world.
3) In the 1950s, manufacturers began building twin-engine aircraft.

Multiple-Choice and True/False Sample Test

1. The two X-series aircraft, which were flown during the 1950s and 1960s, were the
   a. X-15 and XB-70.
   b. X-10 and X-100
   c. XB-1 and XF-5
   d. X-52 and X-2

2. The X-29A was built to demonstrate the capabilities of
   a. adaptive-wing aircraft.
   b. forward-swept wing aircraft.
   c. oblique-winged aircraft.
   d. skewed-wing aircraft.

3. Which of the following is a stealth aircraft designed to be invisible to enemy radar?
   a. B-1
   b. B-2
   c. B-52
   d. X-15

4. Which of the following is a high-altitude reconnaissance aircraft?
   a. A-10
   b. F-4
   c. SR-71
   d. XB-70

5. Which jet revolutionized the commercial aviation industry and went on to become the standard long-range jet of the 1960s?
   a. Boeing 707
   b. Boeing 727
   c. Boeing 737
   d. Boeing 747

6. The Bristol Aeroplane Company and Sud-Aviation together built what aircraft?
   a. *Airbus*
   b. *Caravelle*
   c. *Concorde*
   d. *U-2*

7. **T**/F The first twin-engine aircraft was the Beechcraft *Twin Bonanza*.

8. **T**/F From 1958 to 1982, general aviation in the US grew at a faster rate than military or commercial aviation.

9. **T**/F The F-117A is a stealth aircraft.

10. T/**F** Carnards are vertical surfaces behind the main wings of an aircraft.

Chapter 7

Basic Aeronautics and Aerodynamics (pages 172-189)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 50 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Explain** the difference between Aeronautics and Aerodynamics. Understand the properties of air that are important to flight.
- **Describe** why scientists use simplifying assumptions during study.
- **Define** airfoil.
- **Recall** the parts of an airfoil.
- **Describe** the concepts of relative wind, angle of attack and streamlines.
- **Describe** Bernoulli"s Principle.
- **Give** examples of aircraft characteristics that can improve each force.
- **Explain** how the loss of one force affects the other three forces.
- **Describe** the real world effects of viscosity and compressible airflow.
- **Name** two effects wings have on airflow not accounted for by airfoils.

Presentation

Attention: Flying has fascinated people for a long time. How in the world does an airplane stay in the air?

Motivation: This chapter will talk about airfoil design and the forces of flight. You should come away from this chapter with a much better understanding of how planes fly.

Overview: We will begin this chapter with a discussion about the properties of air, and then move into airfoils and forces of flight. Then we will talk about that very important concept of lift.

Evaluation: Go over questions at the end of the chapter.

Assignment: Review key terms and concepts.

Lesson Outline

1. The Realm of Flight
   a. The composition and properties of air
      1) Our atmosphere is a mixture of gases, about 79% nitrogen, 21% oxygen and 1% of several other gases.
      2) The atmosphere extends to about 100 miles.
   b. Pressure
      1) At the top of our atmosphere, there is much less pressure. The pressure is greatest at the Earth's surface. So, pressure decreases with an increase in altitude.
      2) Standard pressure is 14.7 psi or 29.92 inches.
   c. Temperature
      1) Temperature is a measure of energy. The hotter the air, the more energy it has inside, and the faster the molecules move around.
      2) Temperature in the atmosphere decreases at a rate of 3 ½ degrees Fahrenheit for every 1,000 feet increase in altitude.
   d. Density
      1) The density of air means how many molecules are squeezed into a given volume. Higher density air is squeezed more tightly than lower density air.
      2) Because air at higher altitudes has less pressure, it is also less dense.
      3) Density is also related to temperature. As air is heated, the molecules move farther apart, which means there is a decrease in density.
   e. Viscosity
      1) Is defined as a fluid's resistance to flow. Honey is more viscous than water.
      2) The greater the density of air, the greater the resistance.
      3) Viscous drag occurs when an object is placed in the path of moving air.
   f. Laminar flow
      1) The flow pattern around a moving object is either smooth or turbulent.
      2) The smooth, and more desirable flow is called laminar.
      3) Laminar flow is given careful consideration when designing new aircraft.
   g. The Speed of Sound in Air
      1) Sound waves travel like ripples in water.
      2) Sound travels in all directions.
      3) Austrian physicist Ernst Mach determined the correct mathematical value for the speed of sound.
      4) Speed of sound varies with altitude because temperature decreases with an increase in height.
      5) The X-1 with Chuck Yeager exceeded the speed of sound on October 14, 1947.
2. Airfoil – Designs that Capture the Energy of the Wind
   a. Airfoil Design
      1) Leading Edge meets relative wind first.
      2) Camber can be either positive or negative.
      3) Trailing Edge is at the rear of the wing.
      4) Chord is an imaginary line that connects the leading with the trailing edge.
      5) The Relative Wind is opposite the flight path.

6) Angle of Attack is the angle between the chord line and the oncoming relative wind.

3. Who is Daniel Bernoulli?
   a. Dutch-born physicist, born in 1738
   b. Discovered a relationship between the pressure and speed of a fluid in motion
   c. Specifically – as the velocity of a fluid increases, the pressure decreases
4. The Forces of Flight
   a. The four forces are – lift, drag, thrust and weight
   b. Taking Flight – thrust balances drag and lift balances weight. More thrust than drag makes a plane accelerate, and more lift than weight makes a plane climb.
   c. Vectors are a graphical mathematical illustration showing both direction and magnitude.
   d. Lift Overcomes Weight – Lift can be increased by changing the camber, or curvature, of the airfoil shape of the wing. This is known as induced lift.
   e. Weight directly opposes lift and must be overcome. Light materials are used for building planes and a weight restriction on cargo is used as well.
   f. Thrust and Drag – The ultimate goal is to design a plane that produces a lot of thrust but weighs very little. Drag opposes all motion through the atmosphere.
5. Real World Lift and Weight
   a. Turbulence reduces the efficiency of the airfoil.
   b. Stalls – when the air next to a wing's surface separates, it flows more slowly and loses its lift capability.
   c. Weight Distribution – where the weight is placed in an airplane has a profound effect on the plane.
6. Real World Thrust and Drag
   a. Thrust Vectoring allows for a plane's thrust to be pointed in a particular direction.
   b. Induced Drag is a component of lift that adds to the drag.
7. Supersonic Aerodynamics
   a. Supersonic Flow – If an airplane travels at supersonic speeds, the air ahead receives no warning of the airplane's approach because the airplane is out speeding its own pressure wave.
   c. Wave Drag is the result of lost energy.

Multiple-Choice and True/False Sample Test

1. When an object is placed in the path of moving air the mutual attraction of the molecules slows the rate of flow. This is called

a. density drag.
b. laminar flow.
c. camber flow.
d. viscous drag.

2. Which one of the following is **not** part of an airfoil?
   a. leading edge
   b. camber
   c. chord
   d. vector

3. The angle between the chord line and the oncoming relative wind best defines
   a. angle of attack.
   b. angle of incidence.
   c. angle of descent.
   d. camber angle.

4. Bernoulli's Principle states that
   a. as the velocity of a fluid increases, the pressure increases.
   b. as the velocity of a fluid increases, the pressure decreases.
   c. as the density of a fluid increases, the pressure increases.
   d. as the density of a fluid decreases, the pressure decreases.

5. The four forces of flight are lift, ______, thrust and weight.
   a. drag
   b. gravity
   c. pressure
   d. volume

6. Running your hand over a piece of sandpaper would be an example of _______ drag.
   a. form
   b. friction
   c. induced
   d. wave

7. **T**/F Subtracting the empty weight from an airplane's maximum allowable weight defines useful load.

8. **T**/F Lift can be increased by changing the camber of the airfoil shape of the wing. This type of lift is called Induced Lift.

9. T/**F** The angle between the chord and the centerline of the aircraft is called the Angle of Attack.

10. T/**F** The trailing edge of an airfoil meets relative wind first.

Chapter 8

Aircraft in Motion (pages 190-228)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 50 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Identify** the basic parts of a conventional airplane.
- **Name** the three axes of rotation.
- **Describe** the locations of the three axes of rotation with regard to a conventional airplane.
- **Identify** the three different types of fuselage classification.
- **Explain** why box construction is better than wire support.
- **Describe** how the use of aluminum and composites in aircraft construction improve each force of flight.
- **Identify** the purpose of landing gear.
- **Describe** the three types of landing gear arrangements.
- **Describe** the typical functions of aircraft fuel systems.
- **Describe** the typical functions of aircraft hydraulic systems.
- **Describe** the typical functions of aircraft electrical systems.
- **Describe** the earliest aircraft instruments.
- **Classify** the three major groups of aircraft instruments by their uses.
- **Classify** the three major groups of aircraft instruments by their principles of operation.
- **Describe** any one new concept in aviation.

Presentation

Attention: Have you ever seen an airplane, in real life or in a movie, dive, roll or climb? Airplanes can move in any direction. They have freedom of motion. Unlike a car or a train that move over the Earth's surface only, airplanes or spacecraft are three-dimensional. They have so much more freedom than a car or train.

Motivation: Studying an aircraft in motion and studying how they move on the three axes of rotation should really increase your understanding of flight.

Overview: In this chapter, we will discuss the three axes of rotation, flight controls, flight instruments and engines.

Evaluation: Go over questions at the end of the chapter. Go over the basic airplane diagram and see if your students can name the different parts of a plane.
Assignment: Review key terms and concepts.

Lesson Outline

1. The Axes of an Aircraft
   a. Longitudinal (roll) axis runs from the tip of the nose to the tip of the tail of the plane. Roll is the motion about the longitudinal axis.
   b. Lateral (pitch) axis runs from one wingtip to the other wingtip. Pitch is the motion about the lateral axis.
   c. Vertical (yaw) axis passes vertically through the meeting point of the longitudinal and lateral axes. Yaw is the motion about the vertical axis.
2. Aircraft Structures and Components
   a. Engines – two common types are reciprocating and turbine
   b. Aircraft Reciprocating Engines power the conventional vehicles used for transportation, work and pleasure; such as cars, lawn mowers, motorcycles, boats, tractors and airplanes. Reciprocating means that certain parts move back and forth in straight-line motion. This is also known as internal-combustion engine.
      1) Principle of Operation – The cylinder is where fuel is converted into energy.
      2) The Intake Stroke – cycle begins with the piston at top center of the cylinder.
      3) Compression Stroke – As the crankshaft drives the piston upward in the cylinder, the fuel and air mixture is compressed.
      4) Ignition and Power Stroke – As the compression stroke is completed and just before the piston reaches its top position, the compressed mixture is ignited by the spark plug.
      5) Exhaust Stroke – On the second upward stroke, the exhaust valve is opened and the piston forces the burned gases out.
      6) Propeller is the action end of an aircraft's reciprocating engine because it converts the useful energy into thrust as it spins around and around.
3. Aircraft Turbine Engines
   a. Turbine means whirl and refers to any type of wheel device that has vanes attached to it. There are four basic types – turbojet, turbofan, turboprop and propfan.
   b. Principle of Operation – Turbines take a small amount of air at the intake and accelerate it to extremely high velocities through the exhaust nozzle.
4. Turbojet Engines
   a. Uses a series of fan-like compressor blades to bring air into the engine and compress it with a series of rotor and stator blades.
   b. Rotor blades perform somewhat like propellers in that they gather and push air backward into the engine.
   c. Hot gases strike the blades of the turbine and cause it to spin rapidly.
   d. The spinning turbine is what causes the compressor sections to turn.
5. Turbofan Engines
   a. One or more rows of compressor blades extend beyond the normal compressor blades.

b. Much more air is pulled into the turbofan engine than is pulled into the simple turbojet.
c. Turbofan is much quieter than turbojet and is more fuel-efficient.

6. Turboprop Engines
   a. Combines the best features of turbojet and propeller aircraft.
   b. Turboprop uses a gas turbine to turn a propeller. The gas turbine can turn a propeller with twice the power of a reciprocating engine.
7. Propfan Systems
   a. The thruster resembles a ship's screw more than it does an airplane propeller.
   b. The propfan combines the air-moving efficiency of the turbofan engine with the thrusting efficiency of the propeller.
8. Ramjet and Scramjet Engines
   a. This is the simplest type of all jet engines because it has no moving parts.
   b. The force of inertia rams air into a streamlined chamber of a fast-flying ramjet.
9. Flight Controls
   a. Wilbur and Orville Wright gave the aviation field **sustained, controlled** and **powered** flight of a heavier than air vehicle.
   b. Flaps are attached to the trailing edge of the wing. The flap increases the camber of the wing airfoil for that portion of the wing to which it is attached.
   c. Slats are protrusions from the leading edge of a wing. They add to the induced lift of a wing.
   d. Spoilers work to destroy lift. Spoilers are located somewhere on the top of the wing.
   e. Drag devices produce drag only. They may be located at the trailing edges of the wing or they may protrude from the craft's fuselage upon activation by the pilot.
10. The Fuselage Structure
    a. Fuselage means to shape like a spindle; to streamline.
    b. There are usually three classifications: truss, semimonocoque and monocoque.
11. Landing Gear
    a. There are three types of landing gear arrangements in common use today: conventional, tricycle and tandem.
    b. Conventional consists of two wheels forward and one small wheel in the rear.
    c. Tricycle has a nose wheel and two wheels, one on each side, underneath where the pilot sits.
    d. Tandem has two sets of wheels located one behind the other on the fuselage.
    e. Landing brakes must be used with caution because they move much faster than a car's brakes.
    f. Landing gear can be fixed or retractable. Smaller planes normally have fixed because they are less costly. Larger planes have retractable.
12. Systems
    a. Fuel Systems - includes everything that involves delivery of fuel to the engine.
    b. Fuel Tanks - can be located anywhere in the aircraft.
       1) There are two fuel-feed systems: gravity-feed and force-feed.
       2) Gravity feed uses gravity to cause the fuel to flow from the tanks downward to the engine.
       3) Force-feed uses a fuel pump to drive the fuel from the tanks to the engine.

c. Fuel Lines – lead from each tank to distribute the fuel throughout the aircraft.

13. Hydraulic and Electrical Systems
    a. Hydraulic Systems – means water tube. An aircraft's hydraulic system may operate the brakes, the landing gear, move the flight controls, and extend and lower the flaps.
    b. Electrical Systems – A generator mechanically attached to an aircraft's engine provides the electricity required to charge the battery, start the engine, operate the radios, and operate navigation and landing lights.
14. Aircraft Instruments
    a. Early Aircraft Instruments
       1) The first aviators relied on their senses because there were no instruments.
       2) Early instruments were adequate for "low and slow" aircraft.
    b. Instrument Classification
       1) Classification by Principle of Operation – mechanical instruments, pressure instruments and electrical instruments.
          a) Mechanical instruments work by means of direct mechanical linkage. An example would be gyroscopic stability, which means that a spinning flat weight tends to line up on one of its axes.
          b) Pressure instruments work on the idea that a fluid, such as air, exerts pressure.
          c) Electrical instruments operate on the principles of electricity, including magnetism.
       2) Classification by Use – performance and control
          a) Performance tells us how the aircraft has responded to our commands.
          b) Control tells us the current state of some aircraft devices, so that we are aware of their condition.
    c. Typical Instruments
       1) Engine Instruments
          a) Tachometer – measures speed; how fast the engine's crankshaft is turning.
          b) Oil Pressure and Temperature Gauges provide constant readings on the pressure and temperature of oil while the engine is operating.
       2) Flight Instruments
          a) Purpose – allow for safe flight and show pilot how well the airplane is performing.
          b) The Airspeed Indicator informs the pilot of the speed through the air.
          c) Aircraft Altimeters are aneroid barometers that read in feet of altitude and are calibrated to atmospheric pressure in inches of mercury.
          d) The Turn-and-Slip indicator does two things. The turn indicator, which is the needle, indicates the direction and rate of the turn. The ball in the glass tube, called the inclinometer, indicates the quality of the turn.
          e) The Vertical Velocity Indicator tells the pilot at what rate the airplane is climbing or descending. It is also known as the vertical speed indicator or the rate-of-climb indicator.
          f) The Attitude Indicator is a gyroscopic instrument that provides an artificial horizon to the pilot.
       3) Navigation Instruments are used to help the pilot find the way to the destination.

a) The most important navigation instrument is a magnetic compass.
b) Most planes have a heading indicator. It is a type of compass.

15. New Concepts
    a. V/STOL – stands for vertical/short takeoff and landing.
    b. Tilt-Rotor aircraft – these aircraft turn their rotors up to takeoff and land like helicopters, and down to fly like fixed-wing vehicles.
    c. Hypersonic transports – are designed to travel at Mach 5 and greater.

Multiple-Choice and True/False Sample Test

1. The __________ axis runs from the tip of the nose to the tip of the tail of a single-engine airplane.
   a. elevation
   b. lateral
   c. longitudinal
   d. vertical

2. Where is the central area of a reciprocating engine where fuel is converted into energy?
   a. crankshift
   b. cylinder
   c. pistons
   d. spark plugs

3. Which of the following is **not** one of the four basic types of turbine engines?
   a. turbojet
   b. turbofan
   c. turboprop
   d. turborod

4. Which of the following are protrusions from the leading edge of a wing?
   a. flaps
   b. rudders
   c. slats
   d. spoilers

5. Which of the following is **not** a type of fuselage?
   a. truss
   b. monocoque
   c. semimonocoque
   d. trimonocoque

6. Which of the following is **not** a common landing gear?
   a. conventional
   b. tandem
   c. tricycle
   d. unicycle

7. Aircraft instruments classified by their use fall into two major groups:
   a. performance and control.
   b. horizontal and vertical.
   c. flight and navigation.
   d. takeoff and landing.

8. **T**/F The vertical velocity indicator tells the pilot at what rate the airplane is climbing or descending.

9. **T**/F The attitude indicator is a gyroscopic instrument that provides an artificial horizon to the pilot.

10. T/**F** The modular air vehicle is a hypersonic or supersonic vehicle that has an attached shock wave along its leading fuselage edge.

Chapter 9

Flight Navigation (pages 229-261)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 50 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Explain** how a grid is constructed to provide a system of coordinates for use on a map.
- **Identify** the terms "small circle" and "great circle".
- **Describe** how the coordinates of a location are written.
- **Describe** which map projections are used for what purposes.
- **Define** prime meridian, equator, hemisphere, parallels, meridians and graticule.
- **Describe** the purposes served by sectional aeronautical charts.
- **Name** methods of showing relief on a sectional aeronautical chart.
- **Identify** symbols used to indicate cultural features on a sectional aeronautical chart.
- **Explain** why hydrographic features are a valuable navigational aid.
- **Name** the two broadest classifications of airports.
- **Describe** an airport using the symbols and data printed on a sectional aeronautical chart.
- **Define** joint-use airports.
- **Name** the agency responsible for regulating planes, pilots and airspace.
- **Describe** controlled airspace and its subdivisions.
- **Identify** special-use airspace categories.
- **Describe** the functions of specialized aeronautical charts.
- **Identify** the major factors influencing air navigation.
- **State** two causes of magnetic variation.
- **Explain** why compass deviation occurs.
- **Describe** the purpose of a wind triangle.
- **Define** true airspeed and ground speed.
- **Explain** pilotage navigation.
- **Describe** dead-reckoning navigation.
- **Identify** the basic steps involved in dead-reckoning navigation.
- **Describe** the use of the aircraft radio as a navigational aid.
- **Explain** the use of the VOR/TACAN receiver as a navigational aid.
- **Identify** limitations of the automatic direction finder (ADF) as a navigational aid.
- **Describe** the use of distance-measuring equipment (DME) as a navigational aid.
- **Name** the parts of the VOR System for navigation.
- **Describe** how to navigate using the VOR System.

- **Describe** how to plot a position on a LORAN chart.
- **Name** the two types of GOPS positioning systems and who might use each.
- **Describe** why the Inertial Navigation System is different than the other systems.
- **Describe** three types of landing systems.

Presentation

Attention: Navigation is the science of getting ships, planes and spacecraft from place to place. It is the method of determining position, course and distance traveled. Navigation is knowing where you are, where you are going and how you will get there.

Motivation: Navigation is part of all of our daily lives. We navigate to get to work or school. We have to know the streets that we must take and how long it will take to arrive on time. This chapter will help us understand reading maps better, and this should help us with our everyday travels.

Overview: We'll begin this chapter by talking about maps and aeronautical charts. Then we will move into basic navigational principles, techniques and systems.

Evaluation: Using a map, have students identify certain features on the map. Have some maps taped to the chalkboard. Have students come up front of the class and identify different features on the maps.

Assignment: Review key terms and concepts.

Lesson Outline

1. Maps and Map Projections
   a. Global Coordinate System
      1) Eighteen primary great circles going north-south are called lines of longitude.
      2) Parallel lines having 10 degrees spacing between them from the equator to the poles are called lines of latitude.
      3) The starting point for lines of longitude, or zero degrees, passes from the North Pole to the South Pole through Greenwich, England and is know as the prime meridian.
   b. Mercator and Conic Projections
      1)Mercator is a cylindrical projection of a map.
      2) Conic projection places a cone over the earth and projects the meridians and parallels.
2. Section Aeronautical Charts
   a. The most commonly used aeronautical chart is the sectional aeronautical chart.
   b. Sectionals give important information to pilots, particularly pilots who fly small aircraft over short distances.
   c. Relief charts describe elevations. They are depicted by color tints, contour lines and shading.
   d. Hydrographic Features refer to water. Streams and lakes are depicted in blue.

e. Cultural Features
    1) Cities or towns are featured in bright yellow.
    2) Small communities are shown in small black circles.
f. Airports – broadest definition is classifying them as civilian, military or joint-use.
    1) Civilian – unpaved is marked as a magenta circle. Near the name of the airport is the height above sea level and length of runway.
    2) Military – depicted the same as civilian; only distinguishing feature is the abbreviation for the owning military service. For instance Air Force Base is AFB.
    3) Joint-use airports are found where civilian and military share runways. Pilots can tell a joint-use airport by its name. Ex – Sheppard AFB/Wichita Falls.
g. Airspace and Airways
    1) Controlled airspace – is subject to control by FAA air traffic controllers.
        a. Largest area of controlled airspace is called the continental control area.
        b. Most control areas are around most airports.
    2) Airways – are three-dimensional highways in the sky.
    3) Special-use Airspace – pilots have to avoid; prohibited and restricted airspace.

3. Basic Navigation Principles
    a. The True-course Line – a line or series of lines that the navigator indicates the airplane will follow.
    b. Magnetic Courses – Magnetic north is different from true north because the magnetic north and south poles are not the same as the geographic north and south poles.
    c. Compass Deviation – occurs once the compass is mounted in a plane. It must be adjusted because of electrical power and metals in the aircraft.
    d. Altimeter is the only non-electronic means the pilot has of determining the airplane's distance over the surface.
    e. True Airspeed vs. Ground Speed – airspeed tells the pilot how fast the airplane is flying through the air. Ground speed is a measure of how fast your aircraft is going across the surface of the Earth.
    f. Wind and the Wind Triangle – The effect of wind on an airplane can either increase or decrease the ground speed depending on whether the plane is flying with or against the wind. Wind triangle is a tool pilots use to figure out where the wind drift will cause the aircraft to fly over the ground.
4. Navigation Techniques
    a. Pilotage means navigating by reference to visible landmarks.
    b. Dead Reckoning involves the systematic consideration of all factors that will and could affect the flight.
5. Electronic Aids
    a. The Aircraft Radio is an aid to navigation because it is the pilot's communication's link with FAA personnel.
    b. The Very-High-Frequency Omnidirectional Radio Range (VOR) Receiver is the second half of the aircraft radio. It must be tuned to the broadcast frequency of the VOR radio station just like the aircraft radio.
    c. The Automatic Direction Finder (ADF) is another type of radio receiver that is used to determine direction, but it does not provide as much information as the VOR.

   d. Distance-Measuring Equipment (DME). The DME sends a signal and measures the time it takes to go from the aircraft to the VORTAC and return.
   e. Weather and Ground Radar. Radar works on the principle of reflected radio energy. Weather radars show areas of precipitation and storms.
5. Navigation Systems
   a. The VOR System – the total system includes the airplane receivers and the ground stations working together to help the pilot navigate.
   b. Long-range Navigation (LORAN) – It is a complete navigation system that is used by large cargo ships and many small, privately owned sea craft. It is also used by aircraft as a means of navigation.
   c. The Global Positioning System (GPS) – consists of roughly 24 satellites in orbit around the Earth, several ground tracking stations and a receiver in the aircraft. The total number of satellites varies due to repairs and upgrades.
   d. Precise Positioning System (PPS) is the military's encoded signal.
   e. Standard Positioning System (SPS) is the civilian public's signal.
   f. Inertial Navigation is a self-contained unit located within the aircraft that needs only to be programmed for a starting point and a destination.
   g. The Area Navigation System (RNAV) is a computer-controlled navigation system that allows pilots to fly directly from the airport of origin to the destination airport without passing over a single VOR station.
6. Landing Navigation Systems
   a. The Instrument Landing System (ILS) is used only within a short distance from the airport and only when the purpose is to land the airplane.
   b. Microwave Landing System (MLS) – In Europe, this system is replacing the ILS. It is more efficient than the ILS.
   c. Differential GPS Landing Systems can be molded to the community's needs and still satisfy the aviator.

Multiple-Choice and True/False Sample Test

1. On a map, parallel lines are called lines of
   a. meridian.
   b. prime.
   c. latitude.
   d. longitude.

2. The prime meridian passes from the North Pole to the South Pole through
   a. Miami, Florida.
   b. Greenwich, England.
   c. Athens, Greece.
   d. Hong Kong, China.

3. What is the term used to describe elevations on maps?
   a. conic
   b. mercator
   c. meridian
   d. relief

4. On a map, the largest area of controlled airspace is called the __________control area.
   a. continental
   b. oceanic
   c. mountainous
   d. valley

5. Which of the following is a tool used by a pilot to determine where wind drift will cause the aircraft to fly over the ground?
   a. altimeter
   b. true-course line
   c. pilotage
   d. wind triangle

6. Which of the following is a technique of navigation that involves the systematic consideration of all factors that will and could affect a flight?
   a. dead reckoning
   b. pilotage
   c. true-course line
   d. compass deviation

7. **T**/F LORAN is an acronym for long-range navigation.

8. T/**F** The Global Positioning System (GPS) consists of one major satellite in orbit around the Earth and several ground tracking stations.

9. T/**F** The Standard Positioning System (SPS) is the military's encoded signal and its accuracy is controlled by a program called Selective Assignment (SA).

10. T/**F** The Instrument Landing System (ILS) is used only within a short distance from the airport, but is used for both takeoff and landings.

Chapter 10

The Airport (263-270)

Resource: ***Aerospace: The Journey of Flight,*** Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 20 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Identify** the different parts of a typical airport and describe their functions.
- **Describe** how runways are numbered.
- **Know** the difference between a controlled and uncontrolled airport.
- **Describe** the different lights and their meanings on an airport.
- **Describe** three concerns and challenges to a typical airport.

Presentation

Attention: How many of you have ever flown in a plane? How about, picked someone up at the airport? Many people find the airport to be a fascinating place and a fun place. Well, we are going to talk about airports for the next few minutes.

Motivation: This chapter should give you a little more understanding about airports.

Overview: So, let's begin. We'll talk about airports and then finish with some airport concerns.

Evaluation: Go over the questions at the end of the chapter.

Assignment: Review key terms and concepts. This is a good place to talk over some of the experiences students have had at airports. Also, chapters 10-13 can certainly be taught together in one or two lessons.

Lesson Outline

1. The Airport
    a. Runway – the most important part of the airport. The runway is needed for the planes to take off and land. Runways contain a dashed white light down the middle. At night, runways have steady white lights on the edges and sometimes down the middle.

b. Taxiways are the roads that aircraft use to get to the runway. Each airport has its own pattern of taxiways.
c. Ramps and Hangers are the parking lots for the aircraft.
d. Control Tower gives the aircraft permission for take off and landing.
e. Passenger Terminal is where the passengers check in with their airline tickets. It is also where luggage can be picked up. Passenger terminal also have restaurants, bookstores and places to sit and wait for planes.
f. Other Facilities – are a weather station and a fire station.

2. Airport Concerns and Challenges
   a. Wildlife – animals and especially birds, wander on the runway and cause accidents.
   b. Noise – airplanes are noisy. Airplanes try to take off and land more quickly.

Multiple-Choice and True/False Sample Test

1. At night, runways have steady _______ lights on the edges and sometimes down the middle.
   a. blue
   b. green
   c. red
   d. white

2. The most common taxiway is called the ________ taxiway.
   a. parallel
   b. ramp
   c. perpendicular
   d. vertical

3. **T**/F An airport without a control tower is called an uncontrolled airport.

4. **T**/F A fixed-base operation is basically a service station for airplanes.

5. T/**F** Taxiways are the parking spots for aircraft.

6. **T**/F The number of a runway is the first 2 digits of a compass direction rounded to the nearest 10 degrees.

7. T/**F** At the beginning of a runway, the lights are red.

8. **T**/F A hangar is really just a garage for airplanes.

9. T/**F** At civilian airports, a rotating beacon, which is used to help pilots locate an airport in bad weather, uses flashing red and white lights.

10. T/**F** Because of technology, birds are no longer a concern for airplanes.

Chapter 11

Air Carriers (271-283)

Resource: Aerospace: The Journey of Flight, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 20 minutes

Objectives: After completion of this chapter, the student should be able to:
- Define air carriers.
- Describe why the Airline Deregulation Act had more serious effects on the older airlines than on the newer ones.
- Define modern airliner, all-cargo carrier and regional/commuter carrier.

Presentation

Attention: Aviation is divided into separate categories with specific functions. This chapter covers the air carriers, both large and small.

Motivation: Studying this chapter will increase your knowledge of the modern airliners and their functions.

Overview: Although airliners come in different sizes, they all move people and cargo from one place to another. So, let's talk a closer look at the functions of these airliners.

Evaluation: Go over the questions at the end of this chapter.

Assignment: Review key terms and concepts. Give consideration to teaching chapters 11-13 as one lesson.

Lesson Outline

1. Major Air Carriers
    a. FAA regulates for safety.
    b. Airline Deregulation Act of 1978 gave the airlines free entry into the air routes of the US. The Civil Aeronautics Board (CAB) thought this would increase competition and reduce prices. It did in some areas. However, many airlines cut back on unprofitable routes and began flying only the profitable, big city routes.

c. Airliners can be categorized as
   1) Modern Airliners
   2) Cargo Carriers
   3) Regional-commuter Aircraft
d. Modern Airliners – most familiar to general population. They usually carry over 100 passengers and travel from large city to large city.
   1) Boeing 747 – largest commercial airliner ever built.
   2) McDonnell-Douglas DC-10/MD-11 – DC-10 is a little smaller than the 747. The DC-10 can carry between 255-380 passengers depending on configurations. The MD-11 is the world's only modern large, wide-cabin trijet.
   3) Lockheed L-1011 – is very similar to the DC-10. Both were originally designed to be profitable on high-density short-to-medium-length routes.
   4) Airbus A-300B – An international corporation builds these with industries in England, France, Germany, the Netherlands and Spain.
   5) Boeing 767 – uses the latest in technology in design.
   6) Boeing 777 – fills the gap between Boeing 767 and 747.
   7) Boeing 727 – the most successful airliner ever built in terms of numbers. The unique features are the three engines mounted in the rear of the plane and the T-tail.
   8) Boeing 737 – is a twin-engine, short-range jet transport.
   9) Boeing 757 – is a short to medium range aircraft; is a twin-engine aircraft.
   10) McDonnell-Douglas DC-9 – a twin-engine aircraft with a range of 1000-1500 miles.
e. Air Cargo Carriers – fly a variety of cargoes – from livestock and machinery to flowers and fruit. Their major market is medium or long routes where speed of delivery is very important.
   1) McDonnell-Douglas DC-10-30CF – a convertible passenger/freighter
   2) Boeing 747F – the giant of the airfreight world.
f. Regional/Commuter Carriers – serve very small cities or cities with little air traffic. The average trip is several hundred miles with about 20 passengers.
   1) Swearingen SA-266 Metro II – can carry up to 20 passengers
   2) Shorts SD-3-30 (England) – twin-turboprop engines and carries up to 30.
   3) Beechcraft 99 – twin-turboprop airliner that can carry up to 15.
   4) Dehavilland DHC-7 (Dash 7) (Canada) – a four-engine turboprop that carries 50 passengers.
   5) British Aerospace Company manufactures three aircraft that are used by regional carriers. They are: BAE *Jetstream* 31, ATF and the BAE 146. The 31 is the smallest and it carries 18-19 passengers. The 146 is the largest and it carries 82-93.
   6) Embraer (Brazil) – This company builds two twin-engine turboprop aircraft: the EMB 110 Bandeirante that carries 21 and the EMB 120 Brasilia that carries 30.
   7) Fokker (Netherlands) – This company is well known for its WWI contributions. However, they are also a leading builder of short-range commercial aircraft. For instance, the F-27, F-50, F-28 and the F-100.

Multiple-Choice and True/False Sample Test

1. Who is responsible for regulating the safety of the airlines and controlling the flights while flying over the United States?
   a. Civil Aeronautics Board (CAB)
   b. Federal Aviation Administration (FAA)
   c. Airline Safety Organization (ASO)
   d. National Aeronautical Association (NAA)

2. Boeing 747s and McDonnell-Douglas DC-10 fall into what category of major air carrier?
   a. cargo carrier
   b. modern airliner
   c. regional-commuter aircraft
   d. none of the above

3. The Airbus is built by an international corporation. Which of the following countries makes the engines for the Airbus?
   a. England
   b. France
   c. Germany
   d. United States

4. Which one of the following aircraft is used as an air cargo carrier?
   a. Boeing 777
   b. Lockheed L-1011
   c. McDonnell-Douglas DC-9
   d. McDonnell-Douglas DC-10-30CF

5. **T**/F The Airline Deregulation Act of 1978 allowed airlines free entry into the air routes of the nation.

6. T/**F** Regional-Commuter aircraft mainly carry freight.

7. **T**/F The Boeing 727 is the most successful airliner ever built in terms of numbers.

8. **T**/F The Boeing 747F is the giant of the air freight world.

9. T/**F** The Airbus best fits into the Regional/Commuter carrier category.

10. **T**/F The Boeing 777 was designed to fill the size gap between the 767 and 747.

Chapter 12

General Aviation (284-297)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 20 minutes

Objectives: After completion of this chapter, the student should be able to:
- Define general aviation.
- Name the five groups into which general aviation is separated.
- Describe the typical instructional aircraft.
- Discuss two basic trainer aircraft.
- Describe the process of getting a private pilot certificate.
- Describe the typical personal aircraft.
- Define sport aviation.
- List and describe the purposes of the seven divisions of sport aviation.

Presentation

Attention: General aviation is defined as all civil aviation other than the flying done by scheduled air carriers and government agencies. It is the largest segment of the aerospace industry. Very few people realize the size and importance of this branch of aerospace.

Motivation: Because general aviation is the largest segment of aerospace, it is a good idea to know more about it.

Overview: In this chapter, we will discuss general aviation and talk about the five categories of it.

Evaluation: Go over questions at the end of the chapter.

Assignment: Review key terms and concepts.

Lesson Outline

1. Instructional Aviation – deals with aircraft used to teach someone to fly.

   a. Pilot Certification – training includes both ground school and flight instruction. Prior to flying solo, a student must acquire an FAA student pilot certificate by passing an FAA Class III Medical Examination. At some point in the training, the student has to pass a written exam. After passing the exam, the student earns the private pilot certificate.
   b. Cessna 152 – many pilots received their basic flight training in this aircraft. Piper aircraft are also used a lot.
2. Personal Aviation – accounts for only 24 percent of general aviation flying.
   a. Is defined as flying for other than business or commercial use.
   b. Beech Aircraft Company built six aircraft that were used for personal aviation. All were all-metal, low-wing monoplanes. Only the *Bonanza* is still in production today.
   c. Cessna Aircraft Company built eight different models that were all-metal, high-wing aircraft. Cessna is the world's largest manufacturer of general aviation airplanes.
   d. Mooney Aircraft – the Mooney 201 is an all-metal, low-wing aircraft with a retractable tricycle landing gear.
   e. Piper Aircraft Company – is one of the big three of general aviation. It still offers the PA-18 Super Cub, which is the longest continuously produced airplane in American aviation history.
3. Sport Aviation – flying for fun.
   a. Flying for some purpose other than transportation or business.
   b. Has seven categories – homebuilts, ballooning, soaring and gliding, antique aviation, racing, aerobatics(stunt flying) and ultralights.
   c. Homebuilts combine flying with a hands-on hobby.
   d. Ballooning – refers to hot air ballooning.
   e. Soaring and Gliding – gliding is the controlled descent of a non-powered aircraft. Soaring is flying without engine power and without a loss of altitude.
   f. Antique Aviation involves either finding and restoring a vintage aircraft or building replicas of old airplanes from original plans.
   g. Racing – usually at low altitude and high speeds.
   h. Aerobatics – also called stunt flying; occurs at air shows.
   i. Ultralights – small, lightweight aircraft that began as powered hang gliders.

Multiple-Choice and True/False Sample Test

1. What is defined as all civil aviation other than flying done by scheduled air carriers and government agencies?
   a. business aviation
   b. commercial aviation
   c. general aviation
   d. personal aviation

2. Use of an aircraft for other than business or commercial use defines _______ aviation.
   a. instructional
   b. personal
   c. sport
   d. trainer

3. Who is the world's largest manufacturer of general aviation airplanes?
   a. Beech
   b. Cessna
   c. Mooney
   d. Piper

4. What city is sometimes referred to as the Air Capital of the World?
   a. Dayton, Ohio
   b. Lubbock, Texas
   c. Salt Lake City, Utah
   d. Wichita, Kansas

5. Which of the following is **not** considered as sport aviation?
   a. aerobatics
   b. crop dusting
   c. racing
   d. soaring and gliding

6. **T**/F Ultralight aircraft do not require FAA certification and pilots do not need a license.

7. **T**/F The Immelmann, the hammerhead stall and Cuban 8s are maneuvers seen during a typical aerobatic performance.

8. T/**F** The National Championship Air Races are held in Kitty Hawk, North Carolina.

9. T/**F** In order to qualify as an antique, an aircraft must be at least 50 years old.

10. **T**/F Gliding is the controlled descent of a non-powered aircraft.

Chapter 13

Business and Commercial Aviation (298-312)

Resource: ***Aerospace*: *The Journey of Flight***, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 20 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Define** business aviation.
- **Describe** the two categories of business aviation.
- **Describe** a typical business aircraft and a typical executive aircraft.
- **State** the importance of fuel efficiency, noise and cost effectiveness as they apply to business aviation.
- **Identify** at least two business aircraft.
- **Identify** at least two executive aircraft that are piston powered, two that are turboprop powered and two that are turbojet powered.
- **Define** commercial aviation.
- **Describe** the two subdivisions of commercial aviation.
- **Differentiate** between air taxis and rental aircraft.
- **Discuss** six different non–transportation areas of commercial aviation.

Presentation

Attention: This chapter is a continuation from the last chapter, so we are still talking about general aviation. We have two categories left to discuss: business and commercial.

Motivation: This chapter will give you the opportunity to learn all about business and commercial aviation. This chapter will definitely expand your understanding of these two categories of general aviation.

Overview: Let's begin with business aviation and the concerns in this area. Then, we will go into commercial aviation and explain the difference between this kind of commercial aviation and the main air carriers.

Evaluation: Go over questions at the end of the chapter.

Assignment: Review key terms and concepts. Summarize the last three chapters.

Lesson Outline

1. Business Aviation
   a. This is the use of a private- or company-owned general aviation aircraft for business purposes.
   b. Is usually divided into two categories: business and executive.
      1) business – if an individual personally pilots an aircraft used by a business in which the pilot is engaged.
      2) executive – if a professional pilot flies the company aircraft to transport employees.
   c. There are three main concerns:
      1) Fuel efficiency - The cost of aviation fuel has increased by 700 percent since 1973. Business airplanes are used to save time, not gas. However, the cost remains a concern, but the speed of travel is what saves the company money. If a business aircraft can get to a destination faster, the employees can accomplish more.
      2) Noise – the Federal Government places limitations on the amount of engine noise an aircraft can produce. Many communities close airports at night. Aircraft manufacturers are building quieter jets.
      3) Cost Effectiveness – companies are looking closer at how they use their planes and how far they normally travel. Then, this impacts on the type of plane or planes the company buys.
   d. Executive Aircraft – This market is very competitive. In 1996, it was reported that 335 of the Fortune 500 companies had at least one aircraft. Executive consists of:
      1) Multi-engine Piston Aircraft
      2) Turboprops
      3) Turbojets
   e. Business Aircraft – 78% of all business aircraft are single-and piston-engine aircraft and 21% are twin- and piston-engine aircraft.
      1) Business Twins
      2) Helicopters

2. Commercial Aviation – is a segment of general aviation. It deals with using general aviation aircraft for hire as a commercial (money making) business.
   a. Transportation – Air taxis and charter services provide transportation on a nonscheduled or demand basis.
   b. Nontransportation
      1) Agricultural Application – both fixed wing and rotary wing. They seed, fertilize and apply pesticides to almost 200 million acres of farmland annually.
      2) Aerial Advertising – banners over a sports stadium or a county fair.
      3) Aerial Photography – a single picture can cover a large area.
      4) Fire Fighting – dropping fire-retardant chemicals on a fire.
      5) Fish and Wildlife – planes stock fish in high mountain lakes and take census on deer and elk. Planes are also used to steer a herd of animals to prevent overgrazing.
      6) Patrol Aircraft – planes inspect power lines and pipelines.
      7) Industrial Uses – helicopters are used in construction and logging.

Multiple-Choice and True/False Sample Test

1. Business aviation is usually classified into two groups according to who is flying the aircraft:

    a. official and unofficial aircraft.
    b. civilian and military aircraft.
    c. business and non-business aircraft.
    d. business and executive aircraft.

2. There are three areas of concern in aviation today; fuel efficiency, cost effectiveness and

    a. air stability.
    b. storage capability.
    c. comfort.
    d. noise.

3. What is the largest turboprop executive aircraft?

    a. *Beech King Air* BE300
    b. *Piper Cheyenne* II
    c. *Swearingen Merlin* IVA
    d. *Turbo Seminole*

4. In the turbojet area, who leads all other manufacturers in numbers of aircraft?

    a. Gates *Learjet*
    b. Grumman *Gulfstream*
    c. Cessna *Citation*
    d. Israel *Westwind*

5. What is the only single-engine business aircraft built in the United States that is pressurized?

    a. Piper *Cub*
    b. Piper *Malibu*
    c. Gates *Learjet*
    d. Cessna *Citation*

6. Which of the following is **not** in the nontransportation area of commercial aviation?

    a. air taxis
    b. agricultural application
    c. aerial photography
    d. wildlife conservation

7. **T**/F Commercial aviation is a segment of general aviation.

8. **T**/F The Federal Government places limitations on the amount of engine noise an aircraft can produce.

9. T/**F** All of the Fortune 500 companies in the US have at least one company aircraft.

10. **T**/F Most of the helicopters used for business aviation are Bell 206 *Jet Rangers* and McDonnell-Douglas 500Ds.

Chapter 14

Military Aircraft (pages 313-330)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 30 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Describe** the functions of the major categories of military aviation.
- **Identify** at least two aircraft in each of the major categories of military aviation.
- **State** what the letter designation of specific military aircraft means.

Presentation

Attention: During World War II, aircraft became an important part of military strategy. It dominated all aspects of warfare, even naval battles. Since World War II, the airplane has proven its worth in every conflict there has been.

Motivation: In the Korean War, the Vietnam conflict and in Desert Storm, the airplane has shown that control of the air is crucial in wars. Studying this chapter will further illustrate that point and familiarize you with many different planes.

Overview: This chapter will divide airplanes into different categories, such as bombers and fighters. By learning the different categories, you will understand their functions better. Let's begin with combat aircraft.

Evaluation: Go over the questions at the end of the chapter. Quiz your students on some of the planes.

Assignment: Review key terms and concepts. Spend some time on the aircraft missions.

Lesson Outline

1. Combat Aircraft

a. Bombers are large, long-range aircraft whose mission to reach into the enemy's homeland and destroy the ability to wage war. Bombers drop bombs on factories, military bases, population centers and military troops. The US has three bombers.
1) B-52 – built in the 1940s; it has gone through 8 model changes. The current one is the B-52H. It has eight turbofan engines, goes about 660 mph, and has a range of up to 10,000 miles.
2) B-1 – The B-1B was approved by President Reagan in 1981. It goes at speeds of Mach 2.1 (1400 mph) at 50,000 feet.
3) B-2 – is the new Advanced Technology Bomber and often called the "stealth" bomber. The B-2 uses the latest technology to make it invisible to enemy radar and infrared detectors.

b. Fighters – basic mission is to destroy other aircraft. US has seven different fighters.
1) A-10 – primary mission is to support ground troops. It is slow, but is highly maneuverable and can operate at extremely low altitudes.
2) F-15 *Eagle* – is an all-weather, extremely maneuverable, tactical fighter designed to gain and maintain air superiority in aerial combat. It has a speed of more than Mach 2.
3) F-16 *Fighting Falcon* – lightweight fighter that goes Mach 2. It locates targets in all weather conditions and detects low-flying aircraft in radar ground clutter.
4) F-117 – The F-117A *Nighthawk* is the first operational aircraft designed to exploit low-observable stealth technology. The unique design provides exceptional combat capabilities.
5) F-14 *Tomcat* is a supersonic, twin-engine, variable sweep wing, two-place fighter designed to attack and destroy enemy aircraft at night and in all weather conditions.
6)F/A-18 is an all-weather fighter and attack aircraft. It was designed for traditional strike applications such as interdiction and close air support without compromising its fighter and self-defense capabilities.
7) F-22 was built to replace the F-15 and is called the Advanced Tactical Fighter. It is the only aircraft in the world that can travel at Mach 1 without using afterburners.

2. Noncombatant Aircraft

a. Reconnaissance and Observation Aircraft – used by the military to watch an enemy or potential enemy.
1) TR-1/U2 – built in the 1950s as a spy plane. It can fly at extremely high altitudes (90,000).
2) SR-71 *Blackbird* – the world's highest and fastest aircraft. It operates at altitudes of 80,000 – 100,000 feet at a speed in excess of Mach 3.
3) E-3A AWACS (Airborne Warning and Control System) is based on the Boeing 707. Serves as an airborne command and control center.
4) E-4B serves as the National Airborne Operations Center for the National Command Authorities.
5) E-8 J-STARS – The Joint Surveillance Target Attack Radar System (J-STARS) is an airborne platform equipped with a long-range, air-ground surveillance system designed to locate, classify and track ground targets in all weather conditions.

b. Noncombatant Navy Aircraft – for antisubmarine patrol, US Navy used the P-3C *Orien* and the S-3A.
c. Noncombatant Army Aircraft – observation is locating the enemy troops and calling for air or artillery strikes on their positions.
d. Transports and Tankers
   1) C-5 – USAF's largest aircraft, C-5 *Galaxy*, was built primarily to provide massive strategic (intercontinental) airlift for combat supplies. The C-5 is massive; nearly 248 feet long with a wingspan of more than 222 feet.
   2) C-141B *Starlifter* has been the backbone of our strategic airlift.
   3) C-130 *Hercules* is much smaller than the other two, but is considered one of the most successful aircraft of all time. It is also one of the most highly modeled airplanes with over 30 models having been produced, and with 52 foreign countries and the United States using the C-130.
   4) KC-135 – The military version of the Boeing 707 is the C-135. It has been produced in several models. The KC-135 tanker and the WC-135 weather aircraft are the best known.
   5) KC-10A *Extender* – an advanced tanker/cargo aircraft; selected to eventually replace some of the older KC-135 tankers.
   6) C-9 – The McDonnell-Douglas DC-9 has been modified into two models for the military, the Air Force C-9A *Nightingale* and the Navy C-9B *Skytrain*. The *Nightingale* is a medical airlift transport. The *Skytrain* is used as a personnel transport.
   7) C-17 *Globemaster* – It is the newest and most flexible cargo aircraft. It is capable of rapid delivery of troops and all types of cargo.
e. Trainers – all pilots must go through flight training.
   1) T-3 *Firefly* – some pilots receive their initial training in this.
   2) T-37B – comes after the T-3 and is a subsonic jet that seats the pilot and instructor beside each other.
   3) T-38 *Talon* – This comes after the T-37. The T-38 is supersonic and can fly at Mach 1.2. The student and instructor sit behind one another. This plane is used specifically for fighter pilot's training.
f. Utility Aircraft
   1) C-12A is the civilian version of the *Beechcraft Super King Air* 200 and is quickly converted for cargo missions. It carries a crew of two and eight passengers.
   2) C-20 – US Air Force has 11 and uses them for airlifting very important people. The aircraft carries a crew of five and 14-18 passengers.
   3) C-21A is the military version of the *Learjet* 35A and is used for operational support airlift. It has a crew of two and carries eight passengers.
   4) C-22B is the military version of the Boeing 727. The Air National Guard on operational-support airlift missions is operating four of these.

Multiple-Choice and True/False Sample Test

1. Which of the following is **not** in the US' current bomber inventory?
   a. B-1
   b. B-2
   c. B-25
   d. B-52

2. Which of the following is often called the "stealth" bomber?
   a. B-1
   b. B-2
   c. B-25
   d. B-52

3. Which category of military aircraft has the mission of destroying other aircraft?
   a. bombers
   b. fighters
   c. reconnaissance
   d. tankers

4. Which aircraft is **not** classified as a reconnaissance aircraft?
   a. TR-1
   b. SR-71
   c. E-3A
   d. C-9

5. What is the US Air Force's largest aircraft?
   a. C-5
   b. C-141
   c. B-52
   d. SR-71

6. The military version of the Boeing 707 is the
   a. C-5
   b. C-130
   c. C-135
   d. C-141

7. **T**/F The C-9A is used by the Air Force to transport medical patients.

8. T/**F** The T-1 *Jayhawk* is used in training for pilots who will be flying fighter aircraft.

9. **T**/F The C-141B *Starlifter* has been the backbone of our strategic airlift.

10. **T**/F The SR-71 *Blackbird* is the world's highest flying and fastest aircraft.

Chapter 15

Helicopters, STOL, VTOL and UAVs (pages 331-346)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 30 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Identify** at least two heavy-lift helicopters.
- **Identify** at least two light-lift helicopters.
- **Define** STOL and VSTOL.

Presentation

Attention: The last several chapters have been about aircraft, fixed-wing aircraft. Well, do you know what a rotor-winged aircraft is? That's right, helicopters!

Motivation: This chapter will give you a much better understanding of the role helicopters have played in the evolution of aircraft.

Overview: This chapter will cover helicopters and how we use them. It will also go into STOL and VTOL aircraft and what they can do for us.

Evaluation: Discuss the different helicopters and go over the questions at the end of the chapter.

Assignment: Review key terms.

Lesson Outline

1. Helicopters – have been used since the end of World War II. The latest push in civilian helicopters is into the executive/business aviation fields.
   a. Military – there are only two helicopters that are limited strictly to military use – the Bell AH-1 *Huey Cobra* and the AH-64 *Apache*.
      1) Bell AH-1 was designed specifically as an armed attack helicopter. The gunner sits in front of and below the pilot. The AH-1 is very fast for a helicopter (200 mph).

2) AH-64 – also designed and produced to be an attack helicopter. It is larger and slower than the AH-1.

b. Heavy-lift Helicopters – were designed for military use, but are now used by civilians too.

1) Boeing Vertol CH-47 – The CH-47 *Chinook* is a twin-rotor, heavy-lift helicopter powered by two turbine engines. It comes in three models, with the major differences being the power plants and rotor systems. The civilian version is called Model 234. It carries 44 passengers and is useful for carrying people and supplies to remote sites.

2) Boeing Vertol CH-46 – is a large twin-rotor helicopter used by the US Navy and the US Marine Corps as a transport helicopter for getting supplies from aboard ship to the troops on shore.

3) Sikorsky HH-3 – comes in two models; HH-3E *Jolly Green Giant* used by the US Air Force and the HH-3F *Pelican* used by the US Coast Guard. Both are used for search and rescue. The *Jolly Green Giant* won fame in the Vietnam War where it rescued downed pilots and performed emergency evacuation.

4) Sikorsky CH-53 – a very large, heavy-lift helicopter built for use by the US Navy, US Marine Corps and US Air Force. Navy and Marines used it for troop transport and cargo hauling. The Air Force used it for search and rescue.

5) Sikorsky CH-54 *Skycrane* – one of the largest helicopters in the world and holds several world's records for its lifting ability. This helicopter can lift bulldozers, road graders and armored personnel carriers.

6) Bell UH-1 – *Hueys* and *Iroquois* are the most common helicopters used by the military. Also used a lot in the civilian market. It is the right size for most transportation and hauling jobs.

7) Sikorsky UH-60A – This is the newest US Army helicopter. It was selected to replace the older *Hueys*. The UH-60A *Black Hawk* is used for transporting troops and supplies on the battlefield. It is much faster than the *Huey*.

c. Light-lift Helicopters – used in the military for observation and transportation of personnel. They are used in the civilian community for executive transport, crop dusting, construction and hauling personnel.

1) Bell 206 *Jet Ranger* – This is the most popular light-lift helicopter in the US. It comes in four models. They are used for supplying offshore oil platforms.

2) Bell 222 – It is a fast, quiet, long-range helicopter aimed at the executive aircraft marker and other commercial uses.

3) McDonnell-Douglas 500D – used as light observation helicopters. There are four models, with the E model used widely by law enforcement agencies.

4) Sikorsky S-76 – developed specifically for the civilian market. It uses the latest technology to be one of the smoothest and quietest helicopters ever built. It has many plush interiors from which to choose and is aimed at the executive market.

d. Foreign-built Helicopters

1) Aerospatiale – This is the national aerospace industry of France, and it is currently producing 10 different models of helicopters.

2) Agusta – This is an Italian company that markets one helicopter, the 109A *MkII*. This is a light-haul helicopter in competition with the Bell 222.

3) MBB – The MBB Helicopter, Inc. markets the MBB BO 105 CBS, which is imported from West Germany. It is very popular for use in the supply of offshore oilrigs.

e. Compound and Hybrid Helicopters – offered as improvements to the helicopter.
   1) Compound Helicopters – a conventional helicopter with extra forward thrust provided by either a jet or propeller unit.
   2) Hybrid Helicopters – a variety of advanced helicopter concepts lumped together. They are trying to solve the problem of using rotors for vertical takeoff and landing without impeding forward flight.

2. Short-takeoff-and-landing Airplanes – according to the US Air Force – the ability of an aircraft to clear a 50-foot obstacle within 1,500 feet of commencing takeoff and to stop within 1,500 feet after passing over a 50-foot obstacle when landing.

a. The Value of STOL – There are differences of opinion about the importance of STOL when VTOL (vertical takeoff and landing) is being pursued. Most people don't think that STOL will become obsolete because of VTOL.

b. Some STOL Characteristics and Problems
   1) Wings tend to be long in span.
   2) Engines are relatively powerful for the weight of the airplane and provide extra thrust for takeoffs and landings.
   3) Some have additional airfoil areas for additional lift.

3. Vertical-takeoff-and-landing Aircraft –the difference between STOL and VTOL is considerable.

a. VTOL Principles – Newton's 3rd Law of Motion applies. As the exhaust gas or air is directed downward toward the ground, the aircraft movement is upward.

b. Turboprop VTOL – the propellers tilt straight upward for VTOL and forward for level flight.

c. Jet VTOL – The jet engine can have a swiveling exhaust nozzle to provide vertical or horizontal thrust.
   1) Fan-in-wing VTOL Principle – is experimental.
   2) Combination Engines – The US Army and Air Force have experimented with six jet engines, four vertically mounted and two horizontally mounted.
   3) The Harrier – has VTOL and STOL capabilities.

4. Unmanned Air Vehicles (UAV) – are small, pilot-less aircraft that perform missions which do not require a pilot onboard or which is considered too dangerous or politically unwise for manned flight. The missions of UAVs are classified as either non-lethal or lethal.

Multiple-Choice and True/False Sample Test

1. There are only two US helicopters that are limited strictly to military use – the Bell AH-1 *HueyCobra* and the

   a. AH-64 *Apache*.
   b. CH-47 *Chinook*.
   c. HH-3F *Pelican.*
   d. UH-60A *Black Hawk.*

2. In 1967, what helicopters made the world's first nonstop transatlantic flight by helicopter?

   a. Two AH-1s
   b. Two AH-64s
   c. Two HH-3Es
   d. Two HH-53Bs

3. What is the most popular light-lift helicopter built in the US?

   a. Bell 206 Jet Ranger
   b. Bell 222
   c. McDonnell-Douglas 500D
   d. Sikorsky S-76

4. The ability of an aircraft to clear a 50-foot obstacle within 1,500 feet of commencing takeoff and to stop within 1,500 feet after passing over a 50-foot obstacle when landing best defines

   a. ATOL
   b. HTOL
   c. STOL
   d. VTOL

5. What is the only VTOL aircraft that has been put into common use in any county?

   a. 109A *Mk* II
   b. AV-8A *Harrier*
   c. OV-10 *Bronco*
   d. V-22 *Osprey*

6. **F**/T Aerospatiale is the national aerospace industry of Italy.

7. **T**/F The variety of advanced helicopter concepts can be lumped together as a category called hybrid helicopters.

8. T/**F** VTOL capability is achieved through the application of Newton's First Law of Motion.

9. **T**/F The missions of UAVs are classified as either non-lethal or lethal.

10. **T**/F A compound helicopter is a conventional helicopter with extra forward thrust provided by either a jet or propeller unit.

Chapter 16

Aerospace Organizations (pages 347-361)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 30 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Outline** the history of the Federal Aviation Administration (FAA).
- **Describe** the FAA air traffic control system.
- **Describe** the FAA system of flight standards.
- **Discuss** the FAA National Aviation Facilities Experiment Center and the FAA Aeronautical Center.
- **Explain** the responsibilities of the National Transportation Safety Board.
- **Describe** the function of NASA.
- **Describe** the function of the ICAO.
- **Discuss** the makeup and the role of the Civil Reserve Air Fleet.
- **Describe** the three missions of Civil Air Patrol.
- **Describe** the functions of AOPA and EAA.

Presentation

Attention: There are many aerospace organizations that promote aerospace functions. Some are governmental organizations and some are not. Most of the ones discussed in this chapter are well known.

Motivation: This chapter will give you the opportunity to learn a little more about some of the aerospace organizations that you have heard of, but know little about.

Overview: We will begin with governmental organizations and then move into a discussion about non-governmental organizations. We will talk about their functions and responsibilities.

Evaluation: Go over the questions at the end of the chapter. You could give them a few matching questions and have them match the organization with its function.

Assignment: Review key terms, especially the organizations. Ahead of time, you could request additional information from the organizations.

Lesson Outline

1. Governmental Organizations
   a. Federal Aviation Administration (FAA)
      1) Responsible for regulating air commerce.
      2) Helps improve aviation safety.
      3) Promotes civil aviation.
      4) Develops and operates a common system of air traffic control.
      5) Air Commerce Act of 1926 gave the FAA the responsibility for the operation and maintenance of the airway system over the US.
      6) Civil Aeronautics Act of 1938 placed all air transportation regulations under three separate agencies: the Civil Aeronautics Authority, the Office of the Administrator of Aviation and the Air Safety Board.
      7) In 1940, the three agencies were reduced to two: the Civil Aeronautics Board (CAB) and the Civil Aeronautics Administration (CAA).
      8) In 1958, the Federal Aviation Act changed the CAA to the Federal Aviation Agency (FAA).
      9) In 1966, it became the Federal Aviation Administration.
   b. National Transportation Safety Board
      1) A 5-member board appointed by the president of US.
      2) They are appointed to a 5-year term.
      3) They are responsible for determining the cause, or probable cause, of any transportation accident.
   c. National Aeronautics and Space Administration
      1) NASA's mission statement:
         a) To explore, use and enable the development of space for human enterprise.
         b) To advance scientific knowledge and understanding of the Earth, the solar system and the universe and use the environment of space for research.
         c) To research, develop, verify and transfer advanced aeronautics, space and related technologies.
      2) NASA promotes economic growth by conducting research in partnership with industry.
      3) It preserves the environment through studies of Earth as a planet.
      4) It supports education by encouraging learning through many educational endeavors.
      5) NASA research has created a large spin-off technology. Many developments stem from NASA research; such as pocket calculators or microwave ovens.
   d. International Civil Aviation Organization (ICAO) – standardizes aviation functions. Here are some examples of functions that are standardized: rules of the air, aeronautical meteorology, aeronautical charts and symbols and airport designations.
   e. Civil Reserve Air Fleet – is composed of commercial airliners, which have been designated by the Department of Defense for use in time of national emergency. It not only includes airplanes but also aircrews and maintenance crews.
   f. Civil Air Patrol (CAP) – is a federally charted, private, nonprofit corporation that is also the official civilian auxiliary of the USAF. CAP has three missions:

1) Emergency Services – helping downed aircraft and disaster relief missions.
2) Aerospace Education – developing an awareness of aerospace.
3) Cadet Programs – teaching and training young men and women who are interested in aerospace and community service. Cadets are taught leadership and management skills, moral leadership, physical fitness, aerospace and some flying.

2. Nongovernmental Organizations
   a. Aircraft Owners and Pilots Association (AOPA) – It was formed to support the rights and views of aircraft owners and pilots.
   b. Experimental Aircraft Association (EAA) - It was formed to help builders safely construct and fly their homebuilt aircraft.
   c. Industry Organizations – Aerospace industries involved in some form of manufacturing related to aircraft, missiles, spacecraft and their parts and accessories.

Multiple-Choice and True/False Sample Test

1. Who is responsible for regulating air commerce?
   a. AOPA (Aircraft Owners and pilots Association)
   b. EAA (Experimental Aircraft Association)
   c. FAA (Federal Aviation Administration)
   d. CAB (Civil Aeronautics Board)

2. What law gave the Federal Government the responsibility for the operation and maintenance of the airway system over the US?
   a. Air Commerce Act of 1926
   b. Civil Aeronautics Act of 1938
   c. Federal Airport Act of 1946
   d. Federal Airport Act of 1958

3. When an aircraft is in flight, who assigns the aircraft a certain altitude and a specific route to follow to its destination?
   a. Air Traffic Control Tower
   b. Air Route Traffic Control Center
   c. Federal Aviation Administration
   d. Flight Service Station

4. Where is FAA's Aeronautical Center, which trains FAA, military and foreign personnel to operate air traffic controllers, located?
   a. Kansas City, Kansas
   b. Little Rock, Arkansas
   c. Oklahoma City, Oklahoma
   d. Omaha, Nebraska

5. What group is responsible for determining the cause, or probable cause, of any transportation accident?

a. Civil Aeronautics Administration (CAA)
b. Bureau of Aviation Safety (BAS)
c. Federal Aviation Administration (FAA)
d. National Transportation Safety Board (NTSB)

6. **T**/F NASA's budget is under one percent of the federal budget.

7. **T**/F The Civil Reserve Air Fleet (CRAF) is composed of commercial airliners, which have been designated by the DoD for use in time of national emergency.

8. **T**/F The three main missions of Civil Air Patrol are: emergency services, aerospace education and cadet programs.

9. **T**/F The Experimental Aircraft Association was formed to help aircraft builders safely construct and fly their aircraft.

10. T/**F** The Aircraft Owners and Pilots Association is an international organization dedicated to standardizing aviation functions.

Chapter 17

Aerospace Careers and Training (pages 362-378)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 30 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Explain** how the aerospace age has affected education and training.
- **Describe** the relationship between aptitudes and careers.
- **List** several reasons why junior colleges are popular and serve the educational needs of many people.
- **Describe** the type of training available at technical/vocational schools.
- **Describe** how institutes differ from junior colleges and technical/vocational schools.
- **Describe** the types of aerospace courses taught in 4-year colleges and universities.
- **Compare** the type of education received in a 4-year college with that received in a junior college, a vocational/technical school or an institute.
- **List** four ways that the Air Force helps to train and educate their personnel.
- **Describe** the AFROTC program.
- **Discuss** the Air Force Academy's role in preparing officers for the US Air Force.
- **State** what service the Community College of the Air Force provides to Air Force personnel.

Presentation

Attention: Today's aerospace society is complex and dynamic, and it will continue that way as technology advances. With the beginning of space exploration, the quest for knowledge became more popular. The knowledge revolution or the information revolution increased people's awareness exponentially. New industries have sprung from this quest for information, new aerospace industries and new careers.

Motivation: This chapter addresses some of the aerospace careers and training that are available to anyone. If you have any interest at all in aerospace careers, this chapter should be of value to you.

Overview: Let's begin with the aptitudes necessary for these aerospace careers and then discuss some of the careers. After that, we will discuss some of the ways you can receive the necessary training for these careers.

Evaluation: Go over questions at the end of the chapter.

Assignment: Review key terms.

Lesson Outline:

1. Aptitudes and Aerospace Careers
   a. Aptitudes
      1) Special talents and natural abilities
      2) Aptitudes – strong aptitudes in mechanical, verbal, numerical, social and artistic are definitely beneficial for a successful aerospace career.
   b. Aerospace Careers
      1) See list on page 364
      2) List matches careers with aptitudes.
2. Community Colleges – also called junior colleges
   a. Very popular in recent years.
   b. Students can live at home and attend classes.
   c. Less costly than 4-year colleges.
   d. Community colleges usually have courses that help fulfill the needs of local employers.
   e. Offer basic courses that are transferable to 4-year schools.
3. Technical/Vocational Schools
   a. Provide the majority of formal technical educational courses.
   b. Students learn special trades and skills.
   c. Courses of study are about as long as those in community college; sometimes shorter.
   d. Graduates go directly to work for private industry or government.
4. Institutes
   a. They are special schools that offer only those courses and degrees that are designed for specific career fields.
   b. They place more emphasis on subjects that are essential to doing the job.
   c. Students can earn a bachelor's degree.
5. Four-year Colleges/Universities
   a. A much broader program than the others.
   b. Recommended for students who don't know how they will use their education.
   c. Could take longer than an institute due to more emphasis on humanities.
6. Air Force Schools
   a. Education and training is important to the Air Force.
   b. There is a broad range of courses open to officers and airmen to develop their skills and knowledge.
   c. These courses will help them with their careers and help them when they get out of the military.

7. Air Force Reserve Officer Training Corps (AFROTC)
    a. Is the primary source of commissioned officers for the Air Force.
    b. Is located on many colleges and universities across the country.
    c. AFROTC offers two-year and four-year programs to both men and women.
    d. Students take AFROTC classes like any other class on campus. There are some additional training requirements in the summers.
    e. Upon graduation from college, students receive their commission and enter the Air Force.
8. The US Air Force Academy
    a. Located in Colorado Springs, Colorado.
    b. Students receive a 4-year college education, plus military and physical training.
    c. US senators and representatives make most of the yearly appointments.
    d. Upon graduation, the students receive a commission in the US Air Force.
9. Community College of the Air Force (CCAF)
    a. Helps airmen and noncommissioned officers by translating what they have learned in the Air Force in technical training and on-the-job training into college-level semester hours.
    b. Air Force enlisted members can earn credit toward an associate degree.
    c. CCAF offers associate degrees in more than 70 programs.

Multiple-Choice and True/False Sample Test

1. Special talents and natural abilities are called
    a. attribute
    b. aptitude
    c. attitude
    d. feeling

2. In which of the following schools do people learn special trades and skills?
    a. community college
    b. junior college
    c. technical/vocational school
    d. 4-year college

3. Which of the following is the primary source of commissioned officers for the Air Force?
    a. Air Force Academy
    b. Community College of the Air Force
    c. Officer Training School
    d. Air Force Reserve Officer Training Corps

4. Which of the following is **not** a requirement for a prospective appointee to the Air Force Academy? A candidate must be

- **a.** at least 18 years old.
- b. unmarried and have no dependent children.
- c. in good physical condition.
- d. of good moral character.

5. **T**/F A college or university offers a much broader education than does a junior college.

6. **T**/F During the first two years of study at community colleges, they offer many of the same courses as 4-year colleges.

7. **T**/F There is a definite relationship between aptitudes and a person's success in certain occupations.

8. T/**F** The Community College of the Air Force is designed to help Air Force officers receive their masters degrees.

9. **T**/F AFROTC programs offer scholarships to qualified cadets.

10. **T**/F One reason community colleges are popular is because they are generally less expensive than 4-year schools.

Chapter 18

The Atmosphere (pages 380403)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 50 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Describe** atmosphere and space as one medium termed aerospace.
- **Identify** the atmospheric elements**.**
- **Recall** the four ways of describing atmospheric regions.
- **Define** the various atmospheric regions.
- **State** the general characteristics of atmospheric pressure.
- **Define** the atmospheric regions.
- **Describe** the evaporation cycle.
- **State** the difference between condensation and precipitation.
- **Identify** the role of particulate matter in the water cycle.
- **Define** water vapor, dew-point temperature, solar radiation, sublimation, humidity, relative humidity and condensation nuclei.
- **Classify** the four principal ways in which heat is transferred.
- **Define** insolation.
- **Describe** the importance of heat balance.
- **Explain** the Coriolis Effect.
- **Identify** the types of pressure patterns used to depict pressure gradients on weather maps.
- **Describe** the effect of gravity, friction and centrifugal effect (force) on the wind.
- **Explain** the land and sea breeze phenomena.
- **Describe** how turbulence can form around mountains.
- **Describe** the general characteristics of the jet stream.

Presentation

Attention: We are entering a new part of the book. This part is called the Air Environment. In this part, we will study the atmosphere and the weather. We'll start with the atmosphere. Have you ever given much thought to the atmosphere? What does it do for us?

Motivation: Our atmosphere surrounds the Earth. It contains the air that we breathe, and it gives us our weather, which helps us sustain life. Learning more about the atmosphere will help you better understand the world in which you live. Plus, it should give you a better appreciation for how our whole world interacts through our atmosphere.

Overview: We will begin by defining the atmosphere and describing its regions. We will look at its makeup, and we'll discuss the role of moisture in the atmosphere and how this effects the circulation of air.

Evaluation: Go over questions at the end of the chapter.

Assignment: Review the key terms.

Lesson Outline

1. What is the Atmosphere?
   a. It is the envelope of air surrounding the Earth.
   b. There is no distinct boundary line between the atmosphere and space.
   c. Describing the Atmosphere
      1) elements
      2) regions
      3) pressure
   d. Atmospheric Elements
      1) 78% nitrogen
      2) 21% oxygen
      3) 1% argon, neon, helium, methane, hydrogen, xenon, water vapor, carbon dioxide, ozone, carbon monoxide, sulfur dioxide and nitrogen dioxide.
   e. Atmospheric Regions – by temperature distribution
      1) Troposphere – is where people live and where most weather occurs. It extends to about 10 miles or 55,000 feet at the equator and to 28,000 feet at the poles. In the troposphere, temperature decreases with an increase in height. The tropopause is at the top of the troposphere and is the dividing line between the troposphere and the stratosphere.
      2) Stratosphere – temperature increases with an increase in altitude. This region begins at about 10 miles and extends to about 30 miles. At the base of the stratosphere, the temperature is about -60° C and at the top of the stratosphere is reaches -40° C. At about 30 miles, the warming trend stops and there is another dividing line called the stratopause.
      3) Mesosphere – This region starts at the top of the stratopause and at first shows a marked increase in temperature to 10° C, then it decreases until at about 50 miles altitude the temperature drops to as low as -90° C. The area at the top of the Mesosphere is called the mesopause.
      4) Thermosphere – This region starts at about 50 miles and goes to about 300 miles. Here, the temperature increases with height. How much it goes up depends on solar activity, but it is usually from 750° C to 1,250° C.
   f. Atmospheric Regions – by physicochemical processes

1) Ozonosphere – it extends from about 10 to 30 miles. The sun's radiation reacts with the oxygen molecules causing them to pick up a third atom creating ozone. This ozone shields us from ultraviolet and infrared radiation.
2) Ionosphere – begins at about 25 miles and extends to about 250 miles. Because of interactions between atmospheric particles and the sun's radiation there is a loss or gain of electrons, forming ions.
3) Neutrosphere – This is a region below the ionosphere that extends down to the surface of the Earth. Very little ionization takes place here.
4) Chemosphere – It begins at about the stratopause and overlaps into the ozonosphere and ionosphere. A number of important photochemical reactions take place here.

g. Atmospheric Regions – by Molecular Composition
1) Homosphere – from the Earth's surface to about 60 miles. Throughout this region, the gaseous composition and mixing are relatively constant.
2) Heterosphere – It begins at about 55-60 miles altitude. Molecules are farther apart and gravity influences them. So, the heavier nitrogen and oxygen molecules are found in the lower part of this region and the lighter ones in the upper part.

h. Atmospheric Regions – by Dynamic and Kinetic Processes
1) Exosphere is at the top of the atmosphere, above the heterosphere. The particles of the atmosphere move in free orbits subject only to the Earth's gravity.
2) The bottom of the Exosphere is somewhere between 310-621 miles above the Earth's surface.
3) The upper boundary extends into space without end.

i. Atmospheric Pressure
1) Pressure is the weight of molecules pressing down on molecules below them.
2) Pressure is greatest at the surface of the Earth and the gravitational influence is also the greatest.
3) Pressure decreases with an increase in altitude.

2. Roles of Water and Particulate Matter

a. Water in the Atmosphere
1) Water is found mostly in the troposphere. Some (with heavy thunderstorms), reaches into the stratosphere.
2) Water can be a liquid (rain, lakes), solid (ice, hail or snow), or a gas (water vapor). No matter how dry the air is, water vapor is always present.
3) Saturated means that the parcel of air is holding all the water vapor it can.
4) Dew-point is the temperature at which saturation occurs.
5) Condensation is when a gas is converted to a liquid. Clouds are a product of condensation.

b. Evaporation
1) This is the process by which liquid water molecules change to a gas or water vapor.
2) The main factor in evaporation is temperature.
3) Most of the water vapor in the atmosphere comes from the oceans.

c. Humidity and Relative Humidity
1) Humidity is the amount of water vapor or moisture in the air.

2) Relative Humidity is the amount of water vapor in the air compared to its total capacity at that temperature.

d. Condensation and Precipitation

1) Clouds, fog, dew and frost are forms of condensation.

2) Rain, sleet, snow and hail are forms of precipitation.

3) If visible water falls, it is precipitation.

e. Dew-Point Temperature

1) Dew-Point is defined as the temperature at which saturation occurs.

2) If you add a little bit of water to a parcel of air that is saturated, condensation will occur. Or if the temperature drops condensation will occur.

3) When the actual temperature and the dew-point temperature are the same, the relative humidity is 100%.

f. Particulate Matter

1) Small particles of dust, salt or soot stick to the water vapor in the atmosphere and are called condensation nuclei.

2) They represent the beginning of condensation and become small particles of the clouds.

3. Atmosphere in Motion – the atmosphere is in constant motion

a. Heat and Temperature

1) Heat is the total energy of all moving molecules within a substance.

2) Temperature is a measure that expresses the average energy of molecular motion.

b. Methods of Heat Transfer

1) Conduction – heating by direct contact.

2) Convection – heat transfer by vertical motion.

3) Advection – heat by lateral transfer.

4) Radiation – heat transferred by the Sun.

c. Insolation – The rate at which the Earth's surface is heated by solar radiation. The amount of insolation received at any point depends on the angle the Sun's rays make with the horizon(angle of incidence), the distance of the Earth from the Sun and the amount of radiation absorbed by the atmosphere. Insolation is greatest in the equatorial zone.

d. The Heat Balance – some of the insolation is radiated back into space or the atmosphere. It is estimated that only about 50% of the insolation reaches the Earth. The other 50% is reflected by the atmosphere and absorbed by the atmosphere.

e. Wind – Warm air rises. When this happens, cooler air flows in sideways to take its place. This lateral movement is referred to as wind. This happens on a larger scale too. Generally, the warm air rises from the equator and the cold air sinks from the poles. This, plus the rotation of the Earth complicates the simple concept of the wind.

f. Coriolis Effect – The Earth rotates in a counterclockwise direction. This rotation causes objects in the Northern Hemisphere to be deflected to the right. It is just the opposite in the Southern Hemisphere.

g. The Pressure Gradient – simply means a pressure change with distance. A pressure gradient exists whenever air pressure varies from one place to another.

h. Other Factors Affecting the Wind – include gravity, friction and centrifugal force. Gravity tends to pull the air downward. Friction tends to slow the air down. Centrifugal force slows down the air with a low-pressure system and speeds up the air with a high-pressure system.
i. Local and Surface Air Movements – land and sea breezes are good examples of this. These breezes are caused by temperature differences, which cause pressure differences, which cause air to move. During the afternoon, the air over the water is cooler and heavier and it flows toward land. During the evening, the air over the land is cooler and heavier, so the breeze flows back out to the water.
j. Jet Stream – a narrow current of air that moves across the Northern and Southern Hemispheres in wavelike patterns. It is usually 100-400 miles wide, 1-3 miles thick and is generally encountered at 30,000-35,000 feet. The wind speeds range from 150-300 mph, but speeds of 450 mph have been recorded. Its general motion to west to east.

Multiple-Choice and True/False Sample Test

1. Most of our weather occurs in the
   a. mesosphere
   b. stratosphere
   c. thermosphere
   d. troposphere

2. What is the standard lapse rate?
   a. 1° Celsius or 3° Fahrenheit
   b. 2° Celsius or 3.5° Fahrenheit
   c. 3° Celsius or 2° Fahrenheit
   d. 5° Celsius or 5° Fahrenheit

3. When a parcel of air cannot hold any more water vapor it is said to be
   a. evaporated.
   b. condensed.
   c. humidified.
   d. saturated.

4. The method of heat transfer by vertical motion is called
   a. conduction.
   b. convection.
   c. advection.
   d. radiation.

5. The rate at which the Earth's surface is heated by solar radiation is called
   a. advection.
   b. conduction.
   c. insolation.
   d. radiation.

6. On a weather map, lines of equal pressure are called
   a. gradients
   b. isobars.
   c. isotherms.
   d. troughs.

7. T/**F** A high is a center of high pressure surrounded by even higher pressure.

8. **T**/F The lateral movement of air is referred to as wind.

9. T/**F** Heating by direct contact is called convection.

10. **T**/F Jet streams have recorded winds as high as 450 mph.

Chapter 19

Weather Elements (pages404-422)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 50 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Define** weather.
- **Describe** the characteristics of air masses and fronts.
- **Classify** the four types of fronts.
- **Describe** the three general types of clouds.
- **Describe** various cloud types and weather associated with them.
- **Define** fracto and lenticular.
- **Classify** five types of fog.
- **Explain** how terrain affects weather.
- **Describe** the impact of terrain and wind on aviation.
- **Describe** the general characteristics of wind shear.
- **State** the danger of wind shear to aviation.
- **Define** temperature inversion and microburst.
- **Identify** causes of clear-air turbulence.
- **Classify** types of clear-air turbulence.
- **Define** wake turbulence.

Presentation

Attention: What is the weather going to be like today? I'll bet we have all heard that hundreds of times. How hot is it going to be? Will it rain? These are all very familiar questions about the weather and its elements.

Motivation: This chapter will help you understand weather a little better and maybe help you answer those questions about the weather.

Overview: We will begin by defining weather and then talk about air masses and fronts. Then we will discuss the various clouds and how they can affect the weather. We will end the chapter talking about winds.

Evaluation: Go over the questions at the end of the chapter. Quiz students on the different types of air masses and fronts.

Assignment: Review key terms.

Lesson Outline

1. Air Masses and Fronts
   a. An air mass is a huge body of air that generally has the same temperature and moisture content with the entire mass. It usually covers an area 1,000 or more miles across.
   b. Air Mass Type and Origination
      1) P – polar, cold
      2) T – tropical, hot
      3) m – maritime, humid
      4) c – continental, dry
   c. Characteristics of Air Masses – depend on 4 things
      1) surface over which it forms
      2) the season
      3) surface over which it travels
      4) length of time away from its source
   d. Fronts – the boundaries between air masses of different characteristics
      1) Cold Front – cold air comes in and pushes the warmer air aloft and out.
      2) Warm Front – warm air comes in and moves over the cooler air. The cooler air will slowly move out.
      3) Stationary Front – When there isn't much of a difference between the air masses neither one will replace the other for a while. They become stationary.
      4) Occluded Front – Occurs when a warm air mass lies between two cold air masses.
2. Clouds
   a. Cloud Types
      1) Three basic cloud types: cumulus, stratus and cirrus.
      2) Clouds have three general ranges: low, middle, and high.
         a) Low – from near the surface to about 6,500 ft.
         b) Middle - from 6,500 to about 20,000 ft.
         c) High – from 20,000 feet and up.
      3) Stratus, Altostratus and Cirrostratus
         a) Status has smooth appearance. Any precipitation will be light drizzle or light snow.
         b) Altostratus is relatively thin and is found in the middle range.
         c) Cirrostratus is very thin and appears in the high range. It is composed of ice crystals.
      4) Cumulus, Stratocumulus and Cumulonimbus
         a) Cumulus is puffy and looks like cotton balls. It is found in the low range.
         b) Stratocumulus is also found in the low range and is more gray and elongated than cumulus clouds.

c) Cumulonimbus (CB) is the thunderstorm cloud. A CB is a cumulus cloud with very strong vertical development.

b. Fog Types – a cloud that touches the ground

1) Radiation fog forms at night when the land radiates much of the heat absorbed from the Sun.

2) High-inversion fog is formed by the condensation of water vapor or near the top of cool air that is covered by a warmer air layer.

3) Advection fog is formed when wind blows moist air over a cold surface and the surface cools the air to its dew-point temperature.

4) Evaporation fog occurs when cold air moves over warm water; the water's normal evaporation process saturates the cooler air with water vapor, and the dew point is reached.

5) Upslope fog results when wind carries moist air up a mountain slope or sloping land until the air is cooled.

3. Wind Shear – Atmospheric condition in which changes in speed and direction of the wind occur. Can be dangerous for airplanes during takeoffs and landings. A microburst is a downdraft shear associated with a thunderstorm.

4. Clear-Air Turbulence (CAT) – is associated with convective currents, wind shears and obstructions (mountains). Can be classified as light, moderate, severe and extreme. Light may require airplane passengers to wear seat belts. Moderate means passengers must wear seat belts and unsecured objects move about. Severe means that aircraft may be out of control at times and occupants are thrown against seat belts. Extreme means the entire aircraft is tossed about and practically impossible to control. Structural damage may result.

5. Unique Weather Patterns

a. El Nino is the warming of the East Pacific Ocean temperature. It occurs when warm water moves in and displaces colder water for a longer than normal period of time.

b. La Nina is the opposite. La Nina occurs when the ocean temperature off the coast is colder than normal for a longer than normal period.

Multiple-Choice and True/False Sample Test

1. Which air mass classification refers to cold dry air?
   a. continental polar
   b. continental tropical
   c. maritime tropical
   d. maritime polar

2. What are the three basic cloud types?
   a. cumulus, stratus and cumulonimbus
   b. stratus, cirrus and stratocumulus
   c. stratus, altostratus and cirrostratus
   d. cumulus, stratus and cirrus

3. Which of the following clouds is composed entirely of ice crystals?
   a. cumulus
   b. cirrostratus
   c. nimbus
   d. stratus

4. Which cloud is associated with thunder and lightning?
   a. cirrus
   b. cumulonimbus
   c. nimbostratus
   d. stratocumulus

5. Which type of fog is formed when the wind blows moist air over a cold surface and the surface cools the air to its dew-point temperature?
   a. advection
   b. evaporation
   c. radiation
   d. upslope

6. **T**/F A microburst is a downdraft shear associated with thunderstorms.

7. T/**F** When air masses lose their punch and are not replacing one another, an occluded front develops.

8. T/**F** Moderate turbulence is defined as times when the aircraft may seem out of control, and occupants are thrown against seat belts.

9. **T**/F El Nino occurs when warm waters move in and displace the colder waters for a longer than normal period of time.

10. **T**/F The boundaries between air masses of different characteristics are called fronts.

Chapter 20

Aviation Weather (pages 423-442)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 50 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Describe** weather conditions that reduce visibility for aircraft.
- **Identify** the forms of turbulence hazardous to aircraft.
- **Classify** the types of icing hazardous to aircraft.
- **Define** CAVU, hydroplane, VFR, IFR, MVFR, and AGL.
- **Explain** the three stages in the development of a thunderstorm.
- **Describe** the general characteristics of a tornado.
- **Explain** the Fujita-Pearson Scale.
- **State** the general characteristics of a hurricane.
- **Explain** the Saffir-Simpson Scale.
- **Explain** the developmental stages of hail.
- **Describe** the hazards of severe weather to aviation.
- **Identify** the beneficial effects of severe weather.
- **Define** thunder, lightning, a tropical depression, a tropical storm, cyclone, and good and bad weather.
- **Describe** the characteristics of Arctic weather.
- **State** the classifications of tropic weather.
- **Identify** the hazards of Arctic and tropic weather to aviation.
- **Define** equatorial trough.

Presentation

Attention: The last couple of chapters we have been studying weather. So, it should be easy to see that weather can have a tremendous impact on flying. What does a pilot do when he sees lightning? Does he fly through it or does he try to go around it?

Motivation: This chapter will familiarize you with the weather elements that cause the most concern for flyers. All pilots should understand weather to some degree.

Overview: This chapter will talk about weather hazards, with a particular focus on severe weather.

Evaluation: Go over the questions at the end of the chapter.

Assignment: Review key terms and concepts.

Lesson Outline

1. Weather Hazards
   a. Reduced Visibility
      1) Visual Flight Rules (VFR) – the general flight conditions a pilot can expect at the surface. VFR criteria mean a cloud ceiling greater than 3,000 feet and visibility greater than 5 miles.
      2) Instrument Flight Rules (IFR) – weather conditions at an airport that cause a pilot to use his instruments to assist in takeoffs and landings. IFR means a cloud ceiling between 500-1000 feet. Visibility is greater than 1 but less than 3.
      3) Clouds, Rain, Snow, Fog and Obstructions – these weather conditions can pose hazards to flying depending on their intensity. If the rain is heavy it reduces the visibility. Snow can greatly reduce the visibility.
      4) Haze and Smoke – can also be an obstruction. If the winds stay calm, any haze and smoke will stay in the area, and because of pollution can become thicker.
      5) Blowing Dust, Blowing Sand and Blowing Snow – these all are picked up in strong winds and blow about causing visibility problems for planes.
      6) White Out – an optical phenomenon that requires a snow-covered surface. It causes a loss of any reference to the horizon and any other references needed for depth perception.
   b. Turbulence
      1) Unstable air – can be caused by cumulus clouds.
      2) Wake turbulence is caused by aircraft and can create swirling air currents.
   c. Icing
      1) Carburetor Ice – when water vapor condenses within the carburetor of an aircraft reciprocating engine.
      2) Glaze and Rime Ice – types of ice that form on the windshields of planes. Glaze is formed when super cooled rain droplets turn to ice when they strike the plane. Rime ice has that frosty appearance seen on the walls of frozen-food lockers.
      3) Frost – disturbs airflow and reduces lift efficiency. When frost gets on the wings of planes it makes it harder for the plane to takeoff.
2. Severe Weather
   a. Thunderstorms – any storm accompanied by thunder and lightning
      1) The Cumulus Stage – this is the first stage and it involves the updrafts of air currents. The water droplets are growing to raindrop size and the clouds are building into cumulonimbus clouds.
      2) The Mature Stage – This stage is marked by the beginning of rain. As the rain falls, it brings air with it, developing downdrafts.

3) The Dissipating Stage – The downdrafts produce heating and drying causing the raindrops to weaken and dissipate. This stage usually lasts the longest.

b. Tornadoes

1) Tornadoes consist of violently swirling winds. They occur with severe thunderstorms.

2) If a tornado touches ground, it destroys most things in its path. However, the path is erratic. It may destroy one house and skip over the next one.

3) Tornadoes consist of very low pressure.

4) Refer to page 432 for the Fujita-Pearson Tornado Intensity Scale.

c. Hurricanes

1) Hurricanes are strong tropical cyclones.

2) They contain strong winds, but not as strong as tornadoes.

3) Flooding causes most of the damage with hurricanes.

4) Hurricanes have a calm center. It is called the “eye”.

5) Refer to page 434 for the Saffir-Simpson Hurricane Damage Potential Scale.

6) Hail is frozen ice that can cause airplanes a lot of damage. Hail can put dents in a plane or car.

3. Arctic and Tropic Weather
   a. Arctic Weather – brings the coldest air masses.
   b. Tropic Weather – brings hot air masses and normally they contain lots of moisture.

Multiple-Choice and True/False Sample Test

1. Visual Flight Rules (VFR) apply when
   a. the ceiling is 1,000 feet or higher and the visibility is 1 mile or greater.
   b. the ceiling is 2,000 feet or higher and the visibility is 2 miles or greater.
   c. the ceiling is 3,000 feet or higher and the visibility is 5 miles or greater.
   d. the ceiling is 5,000 feet or higher and the visibility is 7 miles or greater.

2. What are the three stages of a thunderstorm?
   a. beginning, middle and end
   b. building, mature and dissipating
   c. calm, developing and violent
   d. rain, lightning and thunder

3. Where do tornadoes most often occur?
   a. North America and Central America
   b. South America and Africa
   c. Asia and Africa
   d. Australia and North America

4. Hurricane winds of 160 mph would cause the hurricane to be classified as a category
   a. 1
   b. 3
   c. 5
   d. 7

5. What distinguishes the "eye" of a hurricane?
   a. It is the most violent part of a storm.
   b. It is the leading edge of a storm.
   c. It is the calm center of a storm.
   d. It is the trailing edge of a storm.

6. **T**/F Flood damage is often a major problem associated with hurricanes.

7. T/**F** Hailstones, the size of baseballs, are estimated to occur in 1 out of every 100 thunderstorms.

8. **T**/F A tornado has been observed in every state in the continental US.

9. **T**/F Rime ice has that frosty appearance seen on the walls of frozen-food lockers.

10. **T**/F Blowing sand is seldom lifted more than 50 feet above the surface.

Chapter 21

Rocket Fundamentals (pages 443-459)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 30 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Explain** why a rocket engine is called a reaction engine.
- **Identify** the country that first used the rocket as a weapon.
- **Compare** the rocketry advancements made by Eichstadt, Congreve and Hale.
- **Name** the scientist who solved theoretically the means by which a rocket could escape the Earth's gravitational field.
- **Describe** the primary innovation in rocketry developed by Dr. Goddard and Dr. Oberth.
- **Explain** the difference between gravitation and gravity.
- **Describe** the contributions of Galileo and Newton.
- **Explain** Newton's law of universal gravitation.
- **State** Newton's three laws of motion.
- **Define** force, velocity, acceleration and momentum.
- **Apply** Newton's three laws of motion to rocketry.
- **Identify** two ways to increase the thrust of a rocket.
- **State** the function of the combustion chamber, the throat, and nozzle in a rocket engine.
- **Explain** which of Newton's laws of motion is most applicable to rocketry.
- **Name** the four major systems of a rocket.
- **Define** rocket payload.
- **Describe** the four major systems of a rocket.
- **List** the components of a rocket propulsion system.
- **Identify** the three types of rocket propulsion systems.
- **Name** the parts of a rocket guidance system. Name four types of rocket guidance systems.
- **Define** specific impulse.
- **Define** density impulse.

Presentation

Attention: There is an explanation for everything a rocket does. The explanation is usually based on the laws of physics and in the nature of rocket propellants.

Motivation: This chapter will help us understand Newton's laws and some other facts that will apply to rockets.

Overview: Let's begin with some history about rockets and then talk about Newton's Laws of Motion. We will finish the chapter talking about rocket systems.

Evaluation: Go over the questions at the end of the chapter.

Assignment: Review key terms.

Lesson Outline

1. History of Rockets
   a. The Chinese first used rockets in 1220. A few years later, they were also the first to use them as weapons.
   b. Between the 1400s and the 1700s, many rocket experiments were conducted.
   c. At the end of the 18th century, Colonel William Congreve added flight-stabilizing guide sticks to the rockets and built the first launching pad. He increased the range of a rocket from about 300 yards to several thousand yards.
   d. William Hale developed a technique called spin stabilization.
   e. In1903, Konstantin Tsiolkovsky, a Russian scientist, proposed the idea of using rockets for space exploration.
   f. Early in the 20th century, Dr. Robert Goddard conducted many rocket experiments. He was the first to use liquid propellants, which became the forerunner for today's rockets. He is known as the father of modern rocketry.
2. Newton's Laws
   a. Gravity is the force of attraction that exists between all matter within the universe.
   b. Newton believed that bodies in space were attracted to each other.
   c. Newton's Law of Universal Gravitation defines the relationship of force, weight and mass. This law states that two bodies attract each other with a force directly proportional to their mass and inversely proportional to the square of the distance between them. This means that as either or both of the masses increase, the force increases, but that as the distance increases, the force decreases.
   d. Newton's Laws of Motion
      1) First Law of Motion states that a body in a state of rest and a body in motion tend to remain at rest or in motion unless acted upon by an outside force.
      2) Second Law of Motion states that the rate of change in the momentum of a body is proportional to the force acting upon the body and is in the direction of the force.
      3) Third Law of Motion states that to every action, there is an equal and opposite reaction.
3. Application of Newton's Laws to Rocketry

a. 1st Law – when launching a rocket vertically, the propulsion system must produce enough force (thrust) to overcome the inertia of the launch vehicle.
b. 2nd Law – f=ma, or force equals mass times acceleration. The more mass, the more force required to accelerate it.
c. 3rd Law – The thrust produced is a reactive force acting in a direction opposite to the direction of the exhaust.

4. Rocket Systems – there are 4 major systems
   a. Airframe system – serves to contain the other systems and to provide the shape.
   b. Propulsion system – includes everything directly associated with propelling the rocket.
   c. Guidance system – is the brain of the rocket. Employs a computer that is programmed for the desired flight trajectory.
   d. Control system – steers the rocket to its destination and also keeps the rocket stable.
5. Specific Impulse and Density Impulse
   a. Impulse means thrust and is the measure of how much thrust will be obtained from a propellant.
   b. Specific impulse is the number of pounds of thrust delivered by consuming one pound of propellant in one second.
   c. Density impulse is a measurement of a propellant's thrust according to the volume involved.

Multiple-Choice and True/False Sample Test

1. What country first used rockets as a weapon of war?
   a. China
   b. England
   c. Japan
   d. Russia

2. Who added flight-stabilizing guide sticks to rockets and built the first viable launching pad?
   a. Christopher Geissler
   b. Konrad Kyeser
   c. William Congreve
   d. William Hale

3. Who was the first scientist to use liquid propellants and is known as the father of modern rocketry?
   a. William Congreve
   b. William Hale
   c. Robert Goddard
   d. Hermann Oberth

4. Who gave us the Law of Universal Gravitation that defines the relationship of force, weight and mass?

a. Galileo
b. Goddard
c. Hale
d. Newton

5. To every action, there is an equal and opposite reaction, is Newton's

a. First Law of Motion.
b. Second Law of Motion.
c. Third Law of Motion.
d. Fourth Law of Motion.

6. Which rocket system contains the other systems and provides the streamlined shape?

a. airframe system
b. propulsion system
c. guidance system
d. control system

7. **T**/F Specific impulse is the number of pounds of thrust delivered by consuming one pound of propellant in one second.

8. **T**/F The guidance system is the brain of a large sophisticated rocket.

9. T/**F** In Newton's Second Law of Motion, the M in his equation stands for motion.

10. **T**/F Konstantin Tsiolkovsky made the first computations for rocket flights into space.

Chapter 22

Chemical Propulsion (pages460-475)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 30 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Explain** oxidation.
- **State** the difference between an oxidizer and a reducer.
- **Define** cryogenics, hydrocarbons and a self-reacting compound.
- **State** the difference between a propellant, bipropellant and monopropellant.
- **List** the four qualities of a good propellant.
- **Explain** why a rocket propellant does not need air.
- **Explain** the difference between an air-breathing engine and a rocket engine.
- **Define** hypergolic propellants mass flow and low explosives.
- **Identify** a way to get more force from a load of propellant.
- **Describe** the purpose of the rocket engine.
- **Describe** the function of the rocket motor throat and nozzle.
- **Compare** the features of the liquid and solid propellant chemical systems.
- **Name** two systems that use solid propellants.
- **Describe** the solid propellant chemical system.
- **Explain** how the burning rate of solid propellants is controlled.
- **State** the purpose of a squib in a solid propellant rocket.
- **Describe** a liquid propellant engine system.
- **Discuss** the combustion chamber of a liquid propellant system.
- **Explain** the function of the coupled valve in a combustion chamber.
- **Explain** the function of the injector in a liquid propellant engine.
- **Describe** the hybrid propellant system.
- **State** the advantages of a hybrid propellant system.

Presentation

Attention: We have come a long way in the field of rocketry since Dr. Robert Goddard began using liquid propellants. However, liquid propellants are still a very popular choice for the rockets used with spacecraft.

Motivation: This chapter will delve a little deeper into the world of propellants. This chapter should greatly increase your knowledge of propellants and how we use them.

Overview: We will begin with the concepts of oxidation and combustion and then move into our discussion of propellants.

Evaluation: Go over questions at the end of the chapter.

Assignment: Review key terms and concepts.

Lesson Outline

1. Oxidation and Combustion – oxidation is the combining of oxygen with another substance. Combustion is very rapid oxidation.
   a. Oxidizers and Reducers – oxygen in its pure form, as two molecules is an oxidizer; rocket fuels are called reducers. Reducers contain hydrogen, carbon and nitrogen.
   b. Propellant Combinations – It takes both an oxidizer and a reducer to propel a rocket, so they can be called propellants. If the oxidizer and reducer are stored in different containers, the term bipropellant is used. If the same storage tank is used, the term monopropellant is used.

2. Combustion for Propulsion – the qualities of a good propellant are: 1) The propellant must contain oxidizer and fuel. 2) It must ignite correctly every time. 3) It must produce energy in the form of force. 4) The force produced must be controllable.
   a. Need for Packaged Oxidizers – must be placed in a concentrated package or it will burn.
   b. Ignition Characteristics – the propellant must start every time and must start easily.
   c. Energy for Force – the momentum of moving molecules.
   d. Controllable Force – the speed of the combustion should be fast but not too fast.
   e. Pressure and Mass Flow – the rocket engine provides a container that will increase the temperature which will increase the pressure.

3. Solid Propellants and the Solid-Propellant Engine
   a. Solid Propellants – the fuel and oxidizer are mixed together from the start.
   b. Chemical and Physical Properties – today's solid propellants are composites in which the fuel and oxidizer are two different compounds. Polyurethane fuel base is the most common solid-fuel mixture.
   c. Grain Design and Thrust Control – the grain of a skyrocket most likely is a solidly packed propellant, with a space for ignition between the charge and the nozzle.

The thrust control is also thought of as the burn rate. Using different propellant mixtures for the grain that have different burn rates can control it.

   d. Igniters – solid propellants are ignited by a composition that both heats the grain to ignition temperature and increases the pressure. Two igniter compositions frequently used are common gunpowder and a metal-oxidizer mixture such as magnesium and potassium perchlorate.

4. Liquid Propellants and the Liquid-propellant Engine
   a. Liquid Propellants – two classifications – bipropellant and monopropellant. When the oxidizers and fuels are separated they are bipropellants. When they are together they are monopropellants. Bipropellants are more stable and capable of better performance. A monopropellant only requires half the storage, pumping and controlling equipment, but it is sensitive to temperature and shock, therefore more unstable.
   b. The Liquid-propellant Engine – contains propellant tanks, a combustion chamber and a means of forcing propellants through the valves to the chamber.
   c. Combustion Chamber – is the heart of the liquid-propellant engine. Several combustion phases take place here: 1) atomizing, 2) mixing, 3) preheating to ignition temperature and 4) the reaction of the propellant
   d. Valves – they range in type and size depending on their specific functions.
   e. Injector – its function is similar to a carburetor; it atomizes and mixes fuel and oxidizer.

5.Hybrid Propellants – this term applies to rockets that use both liquid and solid propellants in combination within the same engine.

Multiple-Choice and True/False Sample Test

1. What is nothing more than very rapid oxidation?
   a. cryogenics
   b. hypergolics
   c. combustion
   d. thrust

2. The substance to be oxidized is known as the
   a. combuster.
   b. oxidizer.
   c. propellant.
   d. reducer.

3. If the oxidizer is stored in one container and the reducer in another, the term ___________ is used.
   a. bipropellant
   b. monopropellant
   c. propellant
   d. cryogenic propellant

4. Which of the following is **not** a characteristic of a good propellant?
   a. It must contain an oxidizer and fuel.
   b. It must produce energy in the form of force.
   c. It must ignite correctly at least every other time.
   d. The force it produces must be controllable.

5. Increase the temperature of a medium and its molecular activity and pressure will
   a. increase.
   b. decrease at first, then increase.
   c. decrease dramatically.
   d. not change.

6. The grain design that produces the most thrust shortly after ignition, and then diminishes thereafter is called
   a. progressive design.
   b. neutral design.
   c. regressive design.
   d. none of the above.

7. There are two general classifications of liquid propellants:
   a. hot and cold
   b. gas and solid
   c. oxidizer and reducer
   d. bipropellant and monopropellant

8. **T**/F The combustion chamber is the heart of the liquid-propellant engine.

9. **T**/F The polyurethane fuel base of the most common solid-fuel mixture is a type of synthetic rubber.

10. T/**F** Hybrid propellant systems use only liquid propellants within the same engine.

Chapter 23

Orbits and Trajectories (pages 476-495)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 50 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Describe** orbits and trajectories.
- **Define** inertia.
- **Explain** how a satellite remains in orbit.
- **Identify** the closest and farthest points of an object in orbit about Earth.
- **Identify** the closest and farthest points of an object in orbit about another planet and about the Sun.
- **Explain** what happens if the velocity of an object in orbit is increased.
- **Identify** the components that comprise the takeoff mass of a rocket.
- **Describe** escape velocity.
- **Define** burnout velocity.
- **Describe** the effect of Earth's rotational and orbital velocities on the launching of a satellite.
- **Define** total velocity requirement.
- **Describe** ballistic flight.
- **Describe** a sounding-rocket flight.
- **Name** the two basic types of orbits.
- **Describe** why lower velocities are required for satellites to stay in orbit at higher altitudes.
- **Describe** coplanar transfer.
- **Explain** a circular orbit.
- **Explain** the Hohmann transfer.
- **Explain** the fast transfer method for launching a vehicle.
- **Describe** a non–coplanar transfer.
- **Explain** a geostationary orbit.
- **Explain** why a satellite might be placed into polar orbit.
- **State** a reason for placing a satellite into sunsynchronous orbit.
- **Describe** the *Titan* IV launch vehicle.
- **Describe** the *Atlas* and *Delta* launch vehicles.

Presentation

Attention: Have you ever wondered how satellites stay out there in space?

Motivation: Well, this chapter should answer that question and help you understand more about how satellites are affected by orbits.

Overview: We will begin this chapter by defining some terms and then discuss the basic orbital trajectories.

Evaluation: Go over questions at the end of the chapter.

Assignment: Review key terms and concepts.

Lesson Outline

1. Orbit and Trajectory Defined – orbit means a path described by one body in its revolution about another body. Trajectory is a path of a body through space.
   a. Basic Orbital Trajectories – an orbit affects a balance between the gravitational and inertial forces. The farther away two objects are from each other, the less effect their mutual gravitation will have. The only way to keep an object from falling to Earth is to produce a force that is equal and opposite to the gravity and which balances the gravitational attraction. This is exactly what a satellite does, and the equal and opposite force is the inertial force or centrifugal effect.
   b. Circular orbit – an orbit that maintains a virtually constant altitude above the Earth's surface.
   c. Elliptical orbit – any closed orbit that is not circular. All elliptical orbits around Earth have an apogee and a perigee. Apogee is the point on the orbit where the object is the farthest away from the body being orbited. The perigee is the point where the object is the closest.
   d. Equatorial orbit – the satellite travels from west to east over the Earth's equator.
   e. Escape trajectory – In launching a spacecraft, it is necessary to accelerate the spacecraft to its escape velocity (about 25,000 mph).
2. Velocity Requirements – this means the velocity required in order to travel a certain path.
   a. Burnout Velocity - the velocity that is required to place a spacecraft on its intended trajectory in order to attain burnout.
   b. Total Velocity Requirement – adding all velocity requirements for all stages of the mission.
3. Ballistic Trajectories
   a. Ballistics is the study of the arc of a non-orbiting body.
   b. Ballistic flight is concerned with propelling an object from one place on Earth's surface to another place or target on Earth's surface.
   c. All ballistic trajectories behave as if they were going into an elliptical orbit around Earth's center of gravity.
4. Sounding-rocket Flights

a. The trajectory of a sounding rocket is straight up.
b. Rockets sent into the Earth's atmosphere and beyond, on a one-way trip, are called sounding rockets.

5. Types of Orbits
   a. For satellites, there are two basic orbits – elliptical and circular.
   b. The lowest orbit is an approximate circular one at 100 NM of altitude, with an injection velocity of 17, 454 mph required.
   c. For any higher orbits, higher velocities are needed to reach higher altitudes.

6. Circular Orbits and Transfers – to change from an elliptical orbit to a circular orbit required added thrust. Circular velocity minus apogee velocity gives the amount of kick needed to circularize an orbit at a given altitude.
   a. The Hohmann Transfer – is a practical method of space maneuver. The vehicle is placed into a low-elliptical parking orbit. When the vehicle swings around to perigee, sufficient thrust is applied to push the vehicle to apogee at the desired altitude. When the vehicle reaches the high point of this transfer, thrust is applied again and the vehicle moves out on a circle that is tangent to the transfer ellipse.
   b. Other Coplanar Transfers – a faster transfer can be accomplished by choosing a trajectory that intersects or crossed the two orbits.
   c. Non-coplanar Transfers – a vehicle is launched to its minimum angle and when the satellite passes the Equator, thrust is applied to get on an orbit coplanar with the Equator.

7. Special Orbits
   a. Geostationary Orbit – satellite is kept in an orbit stationed above one point on the Earth's surface.
   b. Polar Orbit – involves a path that crosses or nearly crosses the North and South Poles during each orbit.
   c. Sunsynchronous Orbit – it's a form of a polar orbit that keeps a satellite exposed to constant sunlight.

8 Launch Vehicles
   a. If the payload of a rocket is a satellite or a spacecraft rather than a warhead, the vehicle is called a launch vehicle or a booster.
   b. There are two categories of launch vehicles – expendable and reusable. Rockets that are only used once are considered expendable. The Space Shuttle is the only reusable vehicle we have.
   c. Refer to the launch vehicle chart on page 492.

Multiple-Choice and True/False Sample Test

1. An orbit that maintains a virtually constant altitude above the Earth's surface is a/an
   a. apogee orbit.
   b. circular orbit.
   c. elliptical orbit.
   d. escape orbit.

2. The point where the orbiting body is closest to the body being orbited is called
   a. apogee.
   b. burnout
   c. ellipticity
   d. perigee.

3. At the moment a rocket engine ceases to produce thrust, it is at
   a. apogee.
   b. burnout.
   c. ellipticity.
   d. perigee.

4. All ballistic trajectories behave as if they were going into an __________ orbit around Earth's center of gravity.
   a. apogeal
   b. elliptical
   c. equatorial
   d. escape

5. **T**/F Sounding is associated with measuring or sampling the depths of a body of water.

6. **T**/F Velocity requirement means the velocity required in order to travel a certain path.

7. T/**F** The adding together of all the velocity requirements for all stages of the mission is called maximum velocity requirements.

8. **T**/F The Hohmann transfer pertains to boosting a satellite into a chosen orbit.

9. **T**/F A form of polar orbit that keeps a satellite exposed to constant sunlight is called a sunsynchronous orbit.

10. **T**/F There are two basic categories of launch vehicles – expendable and reusable.

Chapter 24

Space Environment (pages 496-521)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 50 minutes

Objectives: After completion of this chapter, the student should be able to:
- **List** four reasons to explore and exploit space.
- **Define** the lower limits of space.
- **Define** cislunar space.
- **Describe** the contents of cislunar space.
- **Describe** interplanetary space.
- **Describe** interstellar space.
- **Describe** the characteristics of the Sun.
- **Describe** the solar magnetic field.
- **Identify** two solar cycles.
- **Identify** the divisions of the Sun's atmosphere.
- **Identify** three solar phenomena.
- **Define** solar wind.
- **Identify** three categories of solar emissions and their sources.
- **Describe** the Earth's ionosphere.
- **State** the causes of ionization.
- **Identify** types of ionospheric behavior.
- **Define** atom and ion.
- **Describe** the general characteristics of the magnetosphere.
- **Explain** the effect of solar wind on the magnetosphere.
- **Describe** cosmic rays.
- **Describe** the structure of the Van Allen radiation belts.
- **Identify** the content and cause of the belts.
- **State** the hazards identified with the belts.
- **Describe** the characteristics of magnetic storms.
- **Identify** the effects of the space environment of communications.
- **Identify** the effects of the Earth's atmosphere on spacecraft.
- **Identify** the effects of vacuum on spacecraft.
- **Describe** the electrostatic charging, which affects spacecraft.
- **Explain** the dangers from collisions in space.
- **Identify** the effects of the space environment on manned operations.

Presentation

Attention: Space, the final frontier. We have probably all seen science fiction movies about space. What is it really like? What is out there?

Motivation: This chapter should go a long way in answering some of the questions about space that you might have. The exploration of space should be important to you. Many scientists believe that many of us will one day have the opportunity to travel in space.

Overview: We will define space and talk about some of the fascinating facts about its environment.

Evaluation: Go over questions at the end of the chapter.

Assignment: Review key terms and concepts.

Lesson Outline

1. Definition of Space – it begins where the Earth's atmosphere leaves off. NASA says that at 50 miles a person earns astronaut wings. However, the altitude needs to be about 80 miles for an orbiting object to stay in orbit. Regardless of where it starts, it extends indefinitely.
2. Cislunar Space
   a. Description – the space between the Earth and the moon. This space varies with the seasons, but the average distance is 237,087 miles.
   b. Contents – part of the magnetosphere is found here. Meteoroids, asteroids and comets are also found here. Cislunar space is not void, but it isn't crowded either.
3. Interplanetary Space – is measured from the center of the Sun to the orbit of its outermost planet.
4. Interstellar Space – the distance between the extent of one solar system, and the beginning of another solar system.
5. Sun
   a. Characteristics of Our Sun – it is the center of our solar system. It is a medium-size star. The Sun's diameter is 864,000 miles. The Sun's magnetic field is at least 100 times stronger than Earth's. The Sun emits a tremendous amount of energy. It is generally accepted that the Sun is a giant thermonuclear reactor. The Sun is plasma, not a solid body.
   b. Solar Atmosphere – consists of photosphere, chromosphere and corona.
      1) photosphere – the portion of the Sun that gives off light. It is a very thin cell made of mostly hydrogen and helium. Sunspots are found here. Sunspots appear darker because they are cooler than the surrounding plasma.
      2) Chromosphere – a sphere of color that extends to about 15,000 miles. It is characterized by spicules. Spicules are hair-like projections that shoot up from the surface of the Sun.

3) Corona – is an enormous area of faint white light that extends for 3-4 million miles. Steady emissions from the Sun are called solar wind. These are extensions of the Sun's corona into interplanetary space.

6. Space Environment Around the Earth
   a. Ionosphere – a zone of electrically conductive layers in the upper atmosphere. In this region, the gas particles are ionized or charged.

      1) Characteristics of the Ionosphere

      2) The atom

      3) The ion – is an atom that carries a positive or negative electrical charge as a result of losing or gaining one or more electrons.

      4) Causes of Ionization – powerful ultraviolet radiation from the Sun and the ultra-high-frequency cosmic rays from the stars.

      5)Ionospheric Behavior – sunspots, solar flares, and other disturbances on the surface of the Sun produce fluctuations in the output of the Sun's rays. These, in turn, produce ionospheric disturbances.
   b. Magnetosphere and Solar Wind

      1) Magnetosphere is the region of the Earth's atmosphere where ionized gas plays a big part in the dynamics of the atmosphere and where the geomagnetic field plays an important role.

      2) The solar wind strikes the magnetosphere with considerable force and forms a bow shock wave where the magnetic lines of force of the magnetic field are struck by the solar plasma.
   c. Van Allen Radiation Belts

      1) Cosmic Rays – energetic charged particles from all over the galaxy that continuously rain down upon the Earth.

      2) Van Allen Radiation Belts – are filled with charged particles. They are the product of interaction between the Sun and the Earth.

         a) Structure of the Belts – crescent shaped in cross section and composed of two shells. The horns of the crescents dip toward Earth's magnetic poles.

         b) Content and Cause of the Belts – caused by the Sun constantly emitting charged particles. These particles are mainly protons and electrons traveling at a million miles per hour as a plasma.

         c) Radiation Hazards – sustained exposure to the radiation would kill humans.
   d. Effects of Solar Disturbances

      1) Magnetic Storms are characterized by a sudden onset of radiation bursts in which the magnetic field undergoes marked changes in less than an hour. This is followed by a gradual return to normalcy, which may take several days.

      2) Polar Magnetic Storms are solar disturbances observable only in the polar areas. These storms produce sporadic radiant emissions from the upper atmosphere over middle and high latitudes. These emissions are called aurora borealis in the northern latitudes and aurora australis in the southern latitudes.
7. Environmental Effects on Space Operations
   a. Communications – problems caused by environmental factors

      1) Not all radio frequencies are useable.

      2) Scintillation – electron density variations in the ionosphere cause rapid changes in radio signals.

3) Solar flares causes solar radio burst, which jams the radio for a few minutes.

b. Spacecraft – space environment can be hostile to spacecraft

   1) Atmosphere – can cause drag on the spacecraft and slow it down. It can also cause oxidation from the free oxygen atoms.

   2) Vacuum – materials used in the spacecraft can contain tiny bubbles of gas, which can escape when the pressure is removed.

   3) Electrostatic Charging – many parts of the spacecraft carry shock; therefore small parts of the craft can be shocked.

   4) Collisions – biggest worry about collisions is with space debris. NORAD currently tracks over 8,000 orbiting pieces of debris that are baseball size or larger. It is estimated that there are billions of much smaller pieces.

c. Manned Operations – man wasn't designed to live in space. So, a lot of weightlessness and psychological training must take place before humans go into space.

Multiple-Choice and True/False Sample Test

1. The space between the Earth and the Moon is called
   a. cislunar space.
   b. interplanetary space.
   c. interstellar space.
   d. solar space.

2. The portion of the sun that gives off light is a very thin shell called the
   a. corona.
   b. filament.
   c. chromosphere.
   d. photosphere.

3. The sun's diameter is almost ________ miles.
   a. 1,000
   b. 10,000
   c. 100,000
   d. 1,000,000

4. Aurora borealis is associated with what zone of electrically conductive layers in the upper atmosphere?
   a. chromosphere
   b. ionosphere
   c. magnetosphere
   d. plasmasphere

5. They are thought to be crescent-shaped in cross section and composed of two shells. The horns of these crescents dip toward Earth's magnetic poles. What does this describe?

a. cosmic rays
b. aurora australis
c. solar winds
d. Van Allen radiation belts

6. **T**/F Meteoroids, asteroids and comets can all be found in cislunar space.

7. **T**/F One parsec is 3.26 light years.

8. **T**/F Sunspots are enormous areas of the sun where the photosphere is dark.

9. T/**F** Solar winds are **not** affected by the Sun's 11-year cycle.

10. T/**F** An ion is an atom that carries only a negative electrical charge.

Chapter 25

Our Solar System (pages 522-550)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 50 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Describe** the characteristics of Mercury.
- **Describe** the characteristics of Venus.
- **Identify** the different programs that sent spacecraft to observe Venus.
- **Describe** some of Earth's characteristics.
- **State** basic Moon facts.
- **Describe** the physical features of the Moon.
- **Describe** the basic types of Moon rocks.
- **Describe** the results of the *Mariner* probes of Mars.
- **Describe** the results of the *Viking* probes of Mars.
- **Describe** the characteristics of the planet Jupiter.
- **Explain** the results of the *Pioneer* probes of Jupiter.
- **Describe** the results of the *Voyager* probes of Jupiter.
- **Describe** the characteristics of the planet Saturn.
- **Describe** the ring system around Saturn.
- **Describe** the characteristics of the planet Uranus.
- **Explain** the results of the *Voyager* 2 probe of Uranus.
- **Describe** the characteristics of the planet Neptune.
- **State** the characteristics of the planet Pluto.
- **Describe** the location of the asteroid belt.
- **Explain** the characteristics of an asteroid.
- **Describe** the characteristics of a comet.
- **Identify** the results of the probes of Comet Halley.
- **Describe** the characteristics of the Milky Way.
- **Define** nova, supernova, pulsar, Black Hole phenomenon, nebulae, light year and parsec.

Presentation

Attention: How many of the planets in our solar system can you name?

Motivation: Well, after studying this chapter you should be able to name them all. Plus you will learn something about them too.

Overview: We will go over them in the order of their distance from the Sun, starting with the closest one, Mercury. We will also talk about other phenomena in our solar system.

Evaluation: Go over questions at the end of the chapter.

Assignment: Review key terms.

Lesson Outline

1. Mercury
   a. Closest planet to the Sun, and revolves around it in 88 days.
   b. Mercury takes 59 Earth days to rotate on its axis.
   c. Mercury has a rocky, crusty surface with many craters. It has no atmosphere except for small amounts of helium and hydrogen.
   d. Daytime temperatures reach 750°F and at night temperatures reach -330°F.
2. Venus
   a. Is the nearest planet to Earth in both distance and size.
   b. Venus takes 225 Earth days to orbit the Sun and 240 Earth days to complete one rotation on its axis.
   c. It is the only planet known to rotate on its axis in a clockwise (east to west) direction.
   d. Venus is covered with a thick blanket of clouds made of water vapor and sulfuric acid. The clouds rotate every four days, much different than the planet.
   e. Venus is 96% carbon dioxide and 4% nitrogen.
   f. Because the clouds hold the heat in, the temperature on Venus doesn't change that much. Venus is the hottest planet with a temperature of almost 900°F.
   g. Venus is the easiest planet to see at night and the brightest too.
3. Earth
   a. Earth is 78% nitrogen and 21% oxygen.
   b. Earth revolves around the Sun in 365 days and rotates on its axis every 24 hours.
   c. Earth is covered with over 70% water; over 50% of that is the Pacific Ocean.
   d. As far as we know, Earth is the only planet that sustains life.
   e. Earth's Moon – average distance from Earth is about 235,000 miles.
   f. The Moon's orbit around the Earth is about 27 days.
   g. The Moon's temperature reaches about 270°F during the day and drops to about -250°F at night.
   h. A fine dust covers the surface of the Moon, along with many rocks and craters.
4. Mars

a. Is known as the Red Planet and appears as a small reddish light when viewed by the naked eye. The color comes from the reddish rusty-looking dust on Mars.
b. The surface is covered with deserts, high mountains, deep craters and huge volcanoes.
c. One day on Mars is 24 hours, 37 minutes. A Martian year lasts 687 Earth days.
d. *Mariner* and *Viking* probes have been flying by or landing on Mars for over 30 years. In 1997, the Mars Pathfinder with its rover Sojourner landed on Mars and analyzed its atmosphere and the composition of Mars.
e. Mars warms up to about -18°F during the day and gets as low as -130°F at night.

5. Jupiter
   a. Jupiter is by far the largest planet in our solar system.
   b. Jupiter rotates very quickly, about every 10 hours. This causes high winds and giant storms.
   c. Jupiter is a gas giant. Hydrogen is the most prominent gas, followed by helium, methane and ammonia.
   d. The outer core of Jupiter is composed of liquid hydrogen and helium, and these mix with the gaseous atmosphere to form colorful clouds. There is also a giant red spot in the lower half of Jupiter. This spot is a giant storm that is 30,000 miles long and 10,000 miles wide.
   e. Jupiter has 16 known moons. Jupiter revolves in about 11 Earth years.
   f. Its temperature ranges from 60,000°F at its center, to -220°F at the upper cloud layers.
   g. The *Pioneer* and *Voyager* probes have studied Jupiter for years.
6. Saturn
   a. Saturn is known for its rings. They are icy chunks of rock ranging from tiny particles to large boulders. The main rings are made of hundreds of narrow ringlets. The ring system is about 1 mile thick and extends about 250,000 miles from the planet.
   b. Saturn has an icy rock core surrounded by metallic hydrogen with an outer layer of hydrogen and helium.
   c. Saturn rotates in 10 hours, but it takes over 29 years to revolve around the Sun.
   d. Saturn has very strong winds. They have reached 1,100 miles per hour.
   e. Daytime temperatures get to 130°F, while at night they reach -330°F.
   f. Saturn has 18 known moons, one of them, Titan, has an atmosphere of its own.
   g. *Pioneer* and *Voyager* missions have explored Saturn since the late 1970s.
7. Uranus
   a. Uranus has a rocky core surrounded by water, ammonia and methane, in both ice and liquid form.
   b. The outer layer of Uranus consists of hydrogen and helium. Methane is also present in the upper atmosphere. This gives Uranus a bluish greenish color.
   c. Uranus rotates every 18 hours and spins sideways.
   d. Uranus takes 84 years to orbit the Sun. Uranus has 42 years of daylight, and then it has 42 years of darkness.
   e. The temperature is about -340°F on Uranus.
8. Neptune

a. Neptune is about 3 billion miles from the Sun, and it takes 165 Earth years to complete an orbit.
b. A Neptune day lasts about 19 hours.
c. It has a rocky core surrounded by water, ammonia and methane.
d. The atmosphere consists of hydrogen, helium and methane. The methane gives Neptune a bluish color.
e. Neptune is the windiest planet in our solar system. Winds blow about 1,500 miles per hour on Neptune.

9. Pluto
   a. Pluto is yellowish in color.
   b. It rotates on its axis in about 6.5 Earth days.
   c. It orbits the Sun in 249 years, however, for 20 of those years, its orbit is inside of Neptune's.
   d. Pluto is 50%-75% rock mixed with ice.
   e. Pluto's temperature varies widely because its orbit takes it as close to the Sun as 2,939 million miles and as far away as 4,583 million miles.
10. Other Bodies
    a. Asteroids – are rocky and metallic objects orbiting the Sun. They are too small to be considered planets. They range in size from a diameter of 623 miles, to the size of pebbles. The main belt of asteroids lies between the orbits of Mars and Jupiter.
    b. Comets – a small, irregularly shaped body whose tiny nucleus is composed of water, ice, rock and frozen gases. Comets travel in highly elliptical orbits that take them very close to the Sun and swing them into deep space. As comets move closer to the Sun, they develop an enormous tail that can extend for millions of miles from the head, away from the Sun.
    c. Meteoroids – bits and clumps of matter orbit the Sun. The very small, dust-particle size bits of matter are called micrometeorites. Anything larger is called a meteoroid. When a meteoroid enters the Earth's atmosphere it is called a meteor. Meteors are also called shooting stars.
11. The Milky Way and Beyond
    a. The Milky Way is the name of our galaxy. It is an enormous collection of stars arranged in a spiral shape.
    b. Nova and Supernova – Novas are stars that are not stable. They flare, subside, and flare again. A supernova occurs when a star gives up great mass in one giant explosion of light and energy.
    c. Quasars and the Formation of the Universe – A quasar is a very luminous body that is about the same size as our solar system. It emits 10,000 times the energy of our galaxy.
    d. Pulsar – also known as a pulsating star because it flashes electromagnetic emissions in a set pattern.
    e. Nebulae – can be dark or bright. A dark nebula is a vast cloud of matter, which has not yet formed into a star. The bright nebula may be studded with stars and sends forth brilliant arrays of color. Some bright nebulae are remnants of supernova.

f. Black Holes – probably was a large star that exhausted its nuclear fuel and collapsed inward upon it self. It cannot emit radiation.
g. Other Galaxies – scientists have found many other galaxies.

Multiple-Choice and True/False Sample Test

1. What is the closest planet to the Sun?
   a. Earth
   b. Mercury
   c. Pluto
   d. Uranus

2. What is the only planet known to rotate about its axis in a clockwise direction?
   a. Earth
   b. Jupiter
   c. Mars
   d. Venus

3. Which of the following planets has a reddish color even when viewed with the naked eye?
   a. Earth
   b. Jupiter
   c. Mars
   d. Saturn

4. On a recent Pathfinder mission, the small exploration rover called Sojourner investigated the atmosphere and composition of what planet?
   a. Jupiter
   b. Mars
   c. Saturn
   d. Venus

5. Which planet is by far the largest in our solar system?
   a. Jupiter
   b. Neptune
   c. Saturn
   d. Uranus

6. Which planet has recorded the strongest winds and is known as the most windy planet?
   a. Pluto
   b. Neptune
   c. Uranus
   d. Venus

7. When a meteoroid enters Earth's atmosphere it is called a/an

a. asteroid.
b. comet.
c. meteor.
d. meteorite.

8. T/**F** A quasar is also known as a pulsating star because it flashes electromagnetic emissions in a set pattern.

9. **T**/F A black hole probably began as a large star that exhausted its nuclear fuel and collapsed inward upon itself.

10. T/**F** Uranus is the smallest planet in our solar system and also is the farthest away from the sun.

Chapter 26

Unmanned Space Exploration (pages 551-582)

Resource*:* *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 50 minutes

Objectives: After completion of this chapter, the student should be able to:
- Discuss America's early space efforts.
- Discuss the Soviet Union's early space efforts.
- Describe America's reaction to the Soviet launch of Sputnik 1 in October 1957.
- State one of the biggest reasons for the space race between the United States and the Soviet Union.
- Discuss the establishment of the National Aeronautics and Space Administration.
- Describe the sources of space law.
- Describe the significance of Sputnik to space law.
- Describe the three principles of space law.
- Identify two significant provisions of the 1967 Outer Space Treaty.
- Explain the significance of the 1972 Anti-Ballistic Missile Treaty of space operations.
- Explain the significance of the National Aeronautics and Space Act.
- Explain the significance of the commercial Space Launch Act.
- Explain the significance of the Land Remote Sensing Commercialization Act.
- Describe the function of the International Telecommunications Union.
- Describe the 1976 Bogota Declaration.
- Describe the International Space Station Agreement.
- Identify three issues addressed by the International Space Station Agreement.
- Define a satellite.
- Identify four categories of satellites.
- Identify uses of communications satellites.
- Define an active communications satellite.
- Define a passive communications satellite.
- Describe the purpose of the Global Positioning system (GPS).
- Describe the elements required for global positioning.
- Identify GPS uses.
- Identify three types of observation satellites.
- Match examples of data to the satellite type most likely to observe and record it.
- Identify examples of weather satellites.

Presentation

Attention: At the end of WWII, German rocket scientists surrendered to American troops to avoid being captured by Russian troops. These German scientists formed the nucleus for rocket research in the US in the late 1940s and early 1950s. This marked the beginning of the space race between the US and Russia.

Motivation: This chapter will give you a basic understanding of how the space programs for the US and Russia began and progressed.

Overview: After a brief account of the beginnings of the space program of the US and Russia, we will discuss several of the series of unmanned satellites that have been rocketed into space.

Evaluation: Go over the questions at the end of the chapter.

Assignment: Review key terms and concepts.

Lesson Outline

1. The Space Race Begins
    a. Dr. Werner von Braun, a German scientist, headed a team of German scientists who lead the US' rocket research. The research was slowed by the lack of money.
    b. In 1949, the Soviet Union exploded its first atom bomb, and in 1950 the Korean War began. These two events changed national priorities, and the money for the Air Force Intercontinental ballistic program became available.
    c. In 1955, President Eisenhower announced the US would place several small satellites into orbit. This project was called *Vanguard*.
    d. In 1956, Premier Khrushchev, of the Soviet Union, announced that Russia had developed an ICBM. Then in August 1957, Russia successfully test-launched its ICBM. On October 4, 1957, using the same rocket, Russia launched *Sputnik* 1, the world's first artificial satellite. On November 3, they launched *Sputnik* 2, which carried a dog named Laika.
    e. On December 6, 1957, the US launched the *Vanguard*. It exploded. The Army had the *Redstone* missile, and it put the test rocket *Jupiter C* with this missile and successfully launched *Explorer* 1. This was the US' first satellite. The date was January 31, 1958.
    f. The Space Age – the Soviet Union had launched the first satellite and much heavier satellite into space. The *Sputnik* 2 weighed 2,926 pounds, while our *Explorer* 1 weighed 31 pounds. Our smaller satellite actually helped the US develop miniature electronics that eventually put the US far ahead of the Russians. The space race was occurring during the Cold War between the US and Russia. So in the beginning, one of the biggest reasons for the space race was international prestige.

g. NASA Established – On July 29, 1958, President Eisenhower signed the National Aeronautics and Space Act into law, creating the National Aeronautics and Space Administration (NASA). NASA was established to lead America's civilian space program.
h. Space Law – Space is an international concern. So, the most powerful source of international law is treaties. There are three principles for space law: 1) freedom of use, meaning all nations have access to space; 2) non-appropriation, the idea that no one owns any part of space; 3) common interests, which says that space belongs to all mankind and all should share in its benefits.

2. Treaties
   a. Outer Space Treaty
      1) Occurred in 1967. The United Nations General Assembly approved it and 90 nations signed it. It established the basic principles of space law.
      2) It said that nations, not organizations were responsible for the launched objects.
      3) It stated that space would be used for peaceful purposes, but allowed military personnel to conduct research.
   b. ABM Treaty – provided for only peaceful use of space.
3. National Space Law
   a. National Aeronautics and Space Act (NASA Act) – it is the legal basis for military and civil space activities in the US. It defines civil and military responsibilities.
   b. Commercial Space Launch Act (CSLA) – purpose was to promote private sector activity and investment in space. It sought to create a single agency to regulate commercial space. The Office of Commercial Space Transportation was created within DOT to manage the effort.
   c. Land Remote Sensing Commercialization Act (LANDSAT Act) – was designed to commercialize the government LANDSAT Program.
4. International Space Issues
   a. International Telecommunications Union (ITU) is a United Nations organization that regulates international communications. ITU was created to regulate radio frequencies and set standards. It operated on "first come, first served."
   b. Eight nations issued the Bogata Declaration in 1976, claiming sovereignty over geostationary orbits above their territories. No major space powers recognized their claim.
   c. The International Space Station Agreement was signed in 1988. The US managed the program. It was the combined effort of several nations.
5. Satellites – Unmanned Spacecraft
   a. A satellite is a natural or artificial object that orbits around the Earth. An example of a natural object in space is the Moon. It is Earth's only natural satellite. Artificial means man-made.
   b. Thousands of satellites now occupy various orbits. Many old satellites lasted longer than originally planned. So, they had to be silenced because of lack of money, but they are still out there.
   c. Satellites can be divided by their purpose. There are four broad categories: communication, navigation, observation and scientific.
6. Communications Satellites (SATCOM)
   a. Began in 1958 with the *Score* satellite. It operated for only 13 days.

b. *Echo* 1 was a large reflective balloon placed in orbit in 1960. It extended the range of line-of-sight signals.
c. *Courier* 1*B* also orbited in 1960; first of the repeater type communications satellites.
d. In 1962, *Telstar* 1was an active satellite that amplified and retransmitted as many as 60 two-way telephone conversations at one time.
e. A few months later, Relay 1added Italy and Brazil to the countries that were receiving broadcasts from space.
f. INTELSAT – is a series of satellites and an organization standing for International Telecommunications Satellite Organization. The organization has over 140-member nations. It links the world's telecommunications networks together via a global satellite system of geostationary satellites.
g. Galaxy Series – a series of satellites that relays video, voice, data and facsimile information worldwide. Galaxy 1 was dedicated to distributing cable television programming.
h. Tracking and Data Relay Satellite System (TDRSS) – designed to provide simultaneous full-time coverage for the Space Shuttle and up to 25 other NASA low-Earth-orbiting spacecraft.
i. Deep Space Network (DSN) – supports all deep space probes.

7. Navigation Satellites
   a. TRANSIT – was designed to update the inertial navigation system on Polaris submarines. It became operational in 1964.
   b. TIMATION – was a two-dimensional navigation system. It determines longitude and latitude.
   c. NAVSTAR Global Positioning System (GPS) – a space-based radio positioning system. It provides navigation and timing information. Position, velocity and time can be precisely determined. GPS is rapidly replacing all other navigational means.
8. Observations Satellites
   a. Weather Satellites – measure temperatures at the surface and in the atmosphere. They also measure cloud cover, moisture levels and even lightning strikes. *Tiros* 1 was the first weather satellite. The National Oceanic and Atmospheric Administration (NOAA) has a series of weather satellites.
   b. Multi-spectrum-imaging Satellites – observe radiant energy. Landsats locate natural resources and monitor other conditions on the Earth's surface.
   c. Reconnaissance Satellites – monitors the activities of people on the surface of the Earth. Generally, they serve military purposes. They provide early warning by detecting enemy missile launches, detecting nuclear explosions, electronic reconnaissance and photo-surveillance.

9. Scientific Satellites – used for gaining information; either orbital astronomy or environmental analysis.
   a. The Explorers – a series of satellites that studied the Van Allen radiation belts, micrometeoroids, and solar flares. The Explorers gave us the first photographs of Earth from space.
   b. Orbiting Solar Observatory (OSO) – studied the Sun and solar flares.

c. Orbiting Astronomical Observatory (OAO) – broadened scientists' understanding of the universe. It studied ultraviolet, infrared, gamma and x-ray wavelengths.
d. High-Energy Astronomy Observatory (HEAO) – investigated the sources and intensities of high-energy radiation at the very far end of the electromagnetic spectrum.
e. Rossi X-ray Timing Explorer (RXTE) – studying x-ray emissions.
f. The Hubble Space Telescope – operates at an altitude of 310 miles above the Earth. At this altitude, it is free of atmospheric interference. Astronomers' clarity is seven times better than for ground observations.
g. Solar Mesosphere Explorer (SME) – environmental analysis satellite. It studies the reactions between sunlight and Earth's atmosphere.
h. Earth Radiation Budget Satellite (ERBS) – studies Earth radiation and the interaction of the Earth with radiation energy received from the Sun.
i. Earth Observing System (EOS) – studies the Earth and how air, water, land and life interact.

10. Probes – spacecraft that fly by, orbit or land on a celestial body, other than Earth.
    a. The Rangers – investigated and took pictures of the Moon. Provided the first close-up pictures of the Moon.
    b. The Surveyors – probes landed on the Moon between 1964-1968. Five of these actually landed on the Moon and sent hundreds of pictures back to Earth.
    c. Lunar Orbiters – five of these took high-quality photographs of the Moon's entire surface. From these photos, maps of the Moon were made.
    d. The Mariners – used to investigate the inner planets. Gave us pictures of Venus and Mercury.
    e. The Pioneers – probed both the outer and inner planets. Gave us the first close-up pictures of Jupiter in 1973. Also, gave us the first pictures and data on Saturn in 1979.
    f. The Vikings – explored the environment of Mars. They analyzed the Martian atmosphere and photographed Mars' surface. Plus, searched for life.
    g. Voyagers 1 and 2 – gave us greatly improved pictures of Jupiter and Saturn.
    h. Giotto – explored Halley's Comet.
    i. Mars Global Surveyor – designed to orbit Mars for 2 years and collect data on Martian atmosphere, gravity and magnetic fields.
    j. Mars Pathfinder – primary objective was to prove the feasibility of low-cost landings on Mars.
    k. Galileo – 6-year journey to orbit Jupiter.
    l. Cassini – In 1997, it began its journey to reach Saturn. It will reach Saturn sometime after 2004.

Multiple-Choice and True/False Sample Test

1. What country launched the world's first artificial satellite, the *Sputnik*?
    a. China
    b. Germany
    c. Russia
    d. United States

2. Which of the following is **not** one of the three principles of space law?
   a. freedom of use
   b. non-appropriation
   c. common interest
   d. national customs

3. Which space treaty called space the province of all mankind, and also stated that exploration of space should benefit all countries?
   a. 1965 Moon Treaty
   b. 1967 Outer Space Treaty
   c. 1969 Outer Limits Treaty
   d. 1972 ABM Treaty

4. Which of the following is **not** one of the four broad categories of satellites?
   a. communication
   b. intelligence
   c. navigation
   d. scientific

5. What was the name of the US' first weather satellite?
   a. *Score* 1
   b. *Telestar* 1
   c. *Tiros* 1
   d. *Transit* 1

6. What family of probes gave us our first look at Jupiter?
   a. The Mariners
   b. The Rangers
   c. The Pioneers
   d. The Vikings

7. **T**/F GPS is rapidly replacing all other navigational means.

8. **T**/F Treaties are the most powerful source of international law.

9. **T**/F Explorer 1 discovered the Van Allen radiation belts.

10. T/**F** The Galaxy series is used to locate natural resources and monitor other conditions on the Earth's surface.

Chapter 27

Manned Spacecraft (pages 583-605)

Resource: *Aerospace: The Journey of Flight*, Civil Air Patrol, 2000

Lesson Method: Lecture

Time: 50 minutes

Objectives: After completion of this chapter, the student should be able to:
- **Identify** the contributions of the US manned space flights and their missions.
- **Describe** the Soviet manned space flights and their missions.
- **Identify** the American and Soviet joint manned spacecraft mission.
- **Describe** astronaut and cosmonaut individual accomplishments.
- **Identify** the three major parts of the Space Shuttle.
- **Describe** Spacelab and the Long-Duration Exposure Facility.
- **Describe** the living and working conditions in space.
- **Describe** the different space suits.

Presentation

Attention: Just a few years after the space race began, the US and Russia were ready for manned space flights.

Motivation: This chapter will outline all of the major developments of the US and Soviet manned space operations. This will definitely increase your knowledge of both countries' space programs.

Overview: This chapter will begin with the US space program, but it will also include information about the Soviet's space program.

Evaluation: Go over the questions at the end of this chapter.

Assignment: Review key terms.

Lesson Outline

1. US Manned Space Program
   a. Project *Mercury* – America's first manned space flight program. Its mission was to find out if a human could survive space travel and what, if any effects would

space travel have on the human body. It lasted 2 years and six manned flights. The first flight was sub-orbital and lasted for only 15 minutes. May 5, 1961, astronaut Alan Shepard became the first American in space. Astronaut John Glenn became the first American to orbit the Earth. He remained in orbit for 4 hours and 55 minutes, while orbiting the Earth three times.

   b. Project *Gemini* – had several objectives; improve techniques needed for a lunar mission, put two persons in space, rendezvous and dock with another spacecraft, and achieve the first walk in space. *Gemini* was the first two-man capsule, and it did achieve the first American walk in space. Enough information was gathered that scientists were convinced that humans could last in space for several weeks or even months safely.
   c. Project *Apollo* – its mission was to put a man on the Moon. Several of the early Apollo flights traveled to the Moon, orbited it and returned to Earth. *Apollo* 11 landed on the Moon on July 20, 1969. Neil Armstrong was the first man to walk on the Moon. A few minutes later, Buzz Aldrin joined Armstrong on the Moon. Five more Apollo flights landed on the Moon.
   d. Project *Skylab* – used left over equipment from the Apollo flights to put a laboratory in space. Scientists continued their studies of long-duration space flights. The final *Skylab* mission lasted 84 days in space and showed that people could live and work in space with no ill effects.
   e. Project Apollo-Soyuz – the linkup in space of an American and a Soviet manned spacecraft.
2. US Second Era
   a. Space Shuttle – launched in 1981, also called the Space Transportation System (STS). It provides a system for transportation into space and a return back to Earth. The shuttle can be used again and again. It consists of three main parts: the orbiter, the solid rocket boosters and the external tank. There have been over 100 shuttle launches, and our knowledge has increased tremendously because of them.
   b. The Crew – The shuttle has many diversified missions. So, the pool of astronauts contains many individuals with special skills. Knowledge and skills from several scientific fields are needed. The astronauts are assigned as mission pilots, mission specialists and payload specialists.
   c. The Craft – the orbiter has a wingspan of 78 feet; its length is 122 feet. The orbiter's payloads can weigh a total of 65,000 pounds on a single flight. The orbiter carries the crew and payload to and from space. There are three major sections: the forward fuselage, the mid-fuselage and the aft-fuselage. Astronauts and payload specialists occupy the forward fuselage. The mid-fuselage houses the payload bay; therefore, it contains the purpose of each mission. The aft-fuselage contains units for orbital propulsion and aerodynamic flight control.
   d. Payloads – The shuttle can carry a variety of payloads into space. Most shuttle missions are geared toward those that need onboard specialists.

3. Soviet Manned Space Program – developed along the same lines as the American space programs, however, the Soviets had several "firsts" in the space race.

a. Vostok – On April 12, 1961, the Soviets put the first man in space, Major Yuri Gagarin, who was abroad *Vostok* 1. In June 1963, *Vostok* 6 carried the first woman in space, Valentina Tereshkova.
b. Voskhod – The first Voskhod was launched in 1964 and was a 3-man capsule. On March 18, 1965, aboard the *Voskhod* 2, Alexei Leonov became the first person to walk in space.
c. Soyuz – means union and was designed for docking in space. Forty Soyuz spacecraft were launched between 1967 and 1981, including the 1975 *Apollo-Soyuz* rendezvous.

4. Space Stations
   a. Soviet Space Stations
      1) *Salyut* – The Soviets launched *Salyut* 1 in April 1971, and three days later, Soyuz 10 docked with the world's first space laboratory. By 1976, the Soviets had put up six *Salyut* space stations. By the early 1980s, several modifications had been made and a Soviet crew set an endurance record for 234 days in space.
      2) *Mir* – was the next space station model. *Mir* was launched in 1986 and stayed in space until the spring of 2001. It conducted many experiments over the years and docked many spacecraft. In fact, the US sent several Space Shuttles to *Mir*.
   b. American Space Station – *Skylab* – On May 14, 1973, Skylab 1 was placed in orbit. *Skylab* was NASA's only orbited space station. Three different crews lived there at different times. The longest stay was 84 days. *Skylab* came back to Earth after six years in space.
   c. European Space Station – *Spacelab* – was designed to be flown in the Space Shuttle's cargo bay. *Spacelab*'s environment allowed specialists to work in short-sleeve shirts and not space suits. Missions included astronomy, microgravity, life sciences and biomedicine.
   d. *Long-duration Exposure Facility* (LDEF) - was designed to provide long-term data on the space environment and its effects on space systems and operations. The facility remained in space for 69 months before it was retrieved by *Space Shuttle Columbia* in 1990.
   e. Living and Working in Space Stations – creation of the *International Space Station* will provide a permanent laboratory where gravity, temperature and pressure can be manipulated to achieve a variety of scientific and engineering pursuits that are impossible in ground-based laboratories. Astronauts have learned how to function effectively in weightlessness. Food will still be dehydrated because it saves weight and storage. Sleeping will be either restrained in bunks or sleeping bags tethered to a wall.

5. Future Manned Spacecraft – *International Space Station* is scheduled for completion in the 2005-2006 timeframe. The space station will be permanently manned. Beyond the space station, space colonies are a serious consideration. Committees are still working on where the best locations would be.

Multiple-Choice and True/False Sample Test

1. What was the name of America's first manned space flight program?
   a. Apollo
   b. Gemini
   c. Mercury
   d. Redstone

2. Which of the following was America's first astronaut in space?
   a. John Glenn
   b. Scott Carpenter
   c. Alan Shepard
   d. Chuck Yeager

3. Which Apollo flight was the first to land on the Moon?
   a. Apollo 5
   b. Apollo 11
   c. Apollo 13
   d. Apollo 15

4. John Glenn accomplished which of the following?
   a. He was the first human in space.
   b. He was the first American to walk in space.
   c. He was the first American to orbit the Earth.
   d. He was the first American to walk on the Moon.

5. Which of the following is **not** a name of one of the space shuttles?
   a. Atlantis
   b. Challenger
   c. Endeavour
   d. Voyager

6. In space terms, what does EVA stand for?
   a. Environmental Vehicular Association
   b. Extra Vehicular Activity
   c. Electrical Voltage Allowance
   d. Extraterrestrial Visitor Act

7. **T**/F Skylab was NASA's only orbited space station.

8. T/**F** Sally Ride was the first woman in space.

9. **T**/F Yuri Gagarin was the first human in space.

10. T/**F** Project Gemini's mission was to land on the Moon.