TECHNOLOGY EDUCATION

Grades 9-12

PROGRAM/COURSE Aerospace

Draft for field test and orientation use

PHASE: CONCENTRATION   ELEMENT: TECHNOLOGY

MODULE: AEROSPACE

SUBMODULES:

Aerospace Overview
- A. Historical Evolution of Aerospace
- B. Fundamentals of Flight
- C. Navigation/Communications
- D. Meteorology/Flight Physiology
- E. Propulsion Systems
- F. Space Technology - Unmanned
- G. Space Technology - Manned
- H. Aerospace Careers and Occupations

$$PREPARED BY
$$AEROSPACE CURRICULUM TEAM
$$FUTURING PROJECT FOR THE PRACTICAL ARTS

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TOTAL TEACHING TIME: 60 hours   DATE: September 15, 1984

TOPIC: Aerospace Overview   MODULE: AEROSPACE

$$AEROSPACE MODULE OVERVIEW

Aerospace education is that branch of general education concerned with communicating knowledge, skills and attitudes about aerospace activities and the total impact of air and space vehicles upon our society. The aerospace curriculum has been identified by the following submodules:

A. Historical Evolution of Aerospace
B. Fundamentals of Flight
C. Navigation/Communications
D. Meteorology/Flight Physiology
E. Propulsion Systems
F. Space Technology - Unmanned
G. Space Technology - Manned
H. Aerospace Careers and Occupations

The Historical Evolution of Aerospace involves the origins of flight, the formative years, World War II and the Aerospace age.

The Fundamentals of Flight to be investigated include: laws and principles, aircraft components/mechanics of motion, and the four forces.

The Navigation/Communications submodule investigates "the earth", map and chart reading, methods of navigation, and radio communications.

Meteorology and Flight Physiology investigates the composition of our planet's atmosphere, the large and small scale motions that it undergoes, the surface weather map and local weather conditions, the atmosphere as a flight instrument, and the effects that the flight environment can have on the human body.

Propulsion Systems concerns itself with the engines available for air and space travel, the historical development of these systems, the scientific and technological study of these systems, and the application of propulsion systems.

Space Technology - Unmanned involves the study determining what constitutes the unmanned space program, the historical achievements of the program, the delivery systems, structures, and projected goals for future missions.

Space Technology - Manned considers the following: the historical development, the mechanics needed to achieve orbital space flight, stress causing conditions of space flight, the challenge of taking a living environment into space, implications of human space exploration for present and future generations, the contributions that space exploration programs have made in creating career fields, and ideas for future development of space through human spaceflight and habitation in space.

Aerospace Careers and Occupations investigates general aviation, military aerospace and aerospace education and training.

TOPICS: Aerospace Overview MODULE: AEROSPACE

$$SPECIAL NOTE TO TEACHERS

1. Please note that this Aerospace Curriculum is a SUGGESTED curriculum.

2. Primary areas to cover are left to the discretion of the teacher, who is most familiar with both the extent of laboratory facilities available to teach this curriculum and the ability levels of the students enrolled in the course.

3. It is the responsibility of the teacher to develop the lesson plans, presentation methods and evaluation tools necessary to utilize this curriculum.

4. Time factors indicated are to be considered as a SUGGESTED framework within which to work, and teachers should feel free to adapt these guidelines to fit individual teaching styles and learning styles.

5. A bibliography is provided at the end of each submodule. Titled: "Suggested Submodule Resources", full bibliographic information for any items mentioned in the submodule will be found there.

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INSTRUCTIONS (NOTES)

PHASE: CONCENTRATION ELEMENT: TECHNOLOGY

MODULE: AEROSPACE

SUBMODULE: A. HISTORICAL EVOLUTION OF AEROSPACE

TOPICS:
1. Origins of Flight
2. Formative Years
3. World War II
4. Aerospace Age

PREREQUISITES: None

$$PREPARED BY
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$$CLIFTON PARK, NEW YORK

TOTAL TEACHING TIME: DATE: July 19, 1984

SUBMODULE A: 7 hours

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TOPICS: 1 - 4

MODULE: AEROSPACE
SUBMODULE A

$$OVERVIEW OF SUBMODULE

GOALS:

The purpose of this submodule is to present the historical evolution of aerospace technology to the students as evidence of the creativity and ingenuity of humanity in the realization of the dream and the application of the reality of flight. Evolution of aerospace technology from the dreams, superstitions, and fears of primitive humans to the projection of aerospace technology beyond the future will be investigated. Areas of evolutionary aerospace development to be investigated will include:

1. Origins of Flight
2. Formative Years
3. World War II
4. Aerospace Age

The investigation of the evolution of aerospace technology will trace flight from early origins, through technological development and adaptation of aerospace systems to the social, economic and political needs of humanity.

DESCRIPTION:

The dream of flight has existed for thousands of years from early observations of birds in flight to the legends and myths describing the substitution of humans in the achievement of the goals of controlled flight. Significant studies and research into the actual accomplishment of flight did not begin to occur until approximately five hundred years ago. In the 15th century, Leonardo da Vinci made detailed sketches of his analysis of birds and proposed a design for a man-powered "ornithopter". DaVinci also proposed ideas for a helicopter and the parachute. It must be noted that none of daVinci's machines were ever built, and the theory that humans could fly simulating the muscle-power of birds was proved to be ill-founded in 1680. The first ventures of humans into the atmosphere were made with lighter-than-air hot air balloons, with early models being demonstrated in Portugal in 1709. Actual human flight occurred as a result of the demonstrations of the Mongolfier brothers, near Paris on November 21, 1783. The Montgolfier's demonstrated that humans could fly, using a lighter-than-air vehicle. A French engineer, Henri Giffard, flew the first practical steerable airship in 1852. Humans still believed in the idea that heavier-than-air flight could be achieved by the "flapping wing" principle.

In 1799, Sir George Cayley, an Englishman, understood the need to balance the forces of flight (lift, drag and thrust). Cayley's theories provided the foundations for modern aeronautics. Cayley applied his theories to full-size gliders and his design approach achieved the first genuine human glider flight in history in 1853.

Research into controlled flight was conducted in Germany by Otto Lilienthal in the 1890's, and by Octave Chanute in the United States in 1896. Both men tested the principles of aerodynamics and controlled flight, which set the stage for later successes. Lilienthal and Chanute conducted exhaustive experiments with the design of hang glider configurations.

A number of research efforts by Samuel Langley and other early pioneers of aeronautics sought a solution to a means of propulsion for aircraft through the use of steam engines. Langley recognized the importance of using an internal combustion engine in place of a cumbersome steam engine, but failed in his attempts to launch a powered aircraft. The date was October 7, 1903.

Building upon the knowledge gained through the failures and limited successes of earlier flight researchers, two brothers from Dayton, Ohio embarked upon a systematic approach to the realization of the dream of heavier-than-air, powered, controlled flight. Using the data of Cayley, Lilienthal, Chanute and others, Wilbur and Orville Wright applied aeronautical engineering principles to glider and powered flight experiments and achieved sustained, controlled, powered flight at Kill Devil Hill, near Kitty Hawk, North Carolina, on December 17, 1903. Ironically, the accomplishment of the Wright brothers went unnoticed for several years.

Simultaneous development of aircraft in Europe and in the United States began slowly, and it was several years before the principle of controlled flight received public acceptance. Aviation pioneers such as Glenn Curtiss, Santos-DuMont, Henri Farman, Louis Bleriot, the Wright's and others were making independent contributions to aviation during the period from 1903-1909. Between 1909 and 1914, many daring advances were made in aviation in the United States, Europe and Russia. In 1914, World War I began in Europe with the airplane and avaition playing a key role in the outcome of the war and the future of humanity.

The design capabilities of the airplane developed rapidly during World War I. The airplane evolved from a curiosity to a device capable of performing a number of functions with a high degree of speed and efficiency. Lessons learned during World War I made it possible for rapid advances in avaiation and aircraft design during the "inter-war years" (1919-1939). Experimentation and aeronautical design research made it possible for advances in such areas as: airships, helicopters, autogyros, rockets, jets, and advanced aircraft design capabilities. Major contributors to aviation advances during this period included names such as: Fokker, Lindbergh, Ford, Doolittle, Sikorsky, Dornier, Goddard, Oberth and others. Speed, distance and altitude records fell by the wayside during these inter-war years. Advances gained during the period 1919-1939 were applied to more efficient and faster aeronautical designs, which accelerated during World War II.

World War II was used as a proving ground for advanced aeronautical designs, which included: long-distance capabilities, guided rockets, jet aircraft, and increased aircraft performance. The end result of World War II was to drive home the fact that the advances made in aviation and aerospace had caused the world to shrink, and no longer were nations able to enjoy the privilege of isolation from each other.

~~Early advan~~ces in jet aircraft development made it possible for humans to achieve greater heights and to cover greater distances faster and more efficiently. Post war experiments in the area of rocket propulsion brought humanity to the threshold of space. Rocket propelled vehicles made it possible for aeronautical designers to probe the fringes of space. Rapid advances in the area of aerospace design occurred in the United States and the Soviet Union after World War II. Aerospace achievements became a source of national pride. Competition between super powers resulted in accomplishments which included: orbital satellites, human orbital flight, lunar exploration, orbital space stations, communications and weather satellites, and interplanetary exploration. Advances made through the accomplishments of aerospace research have benefitted the economic, social and political needs of humanity.

The achievements of aviation and aerospace in the 20th century have drastically changed the traditional direction of civilization. The future of aerospace beyond the 20th century will yield developments in technology comparable to the incomprehensible dreams envisioned by early humans.

SKILLS, KNOWLEDGE, BEHAVIORS TO BE DEVELOPED:

Upon completion of the submodule, the student will be able to:

1. Identify early legends, myths and experiments related to flight.
2. Identify the early pioneers and investigations into the origins of flight.
3. Evaluate early investigations into the origins of flight.
4. Recognize the contributions of early researchers during the developmental years of flight.
5. Identify the milestones of the evolution of flight of controlled, heavier-than-air devices during the developmental years of aviation.
6. Trace the development of flight to applications and advancements in design during the war years.
7. Identify the advancements made in aviation during the "inter-war years".
8. Relate the advances made during World War II to post war applications.
9. Trace the development achieved during the "jet age" to commercial and military applications.
10. Recognize the development of rocket design and experimentation to "space age" applications.
11. Identify the major historical developments associated with exploration and research in space.

TOPIC: 1 Origins of Flight

MODULE: AEROSPACE
SUBMODULE A

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Provide the students with detailed graphic descriptions and time-lines related to early mythology, superstitions and legends dealing with flight. Each student will be required to relate early attempts at flight, legends and mythology to historical time-lines.

Suggested topics for consideration:

Chinese legends
Greek, Roman and Persian mythology
Winged Gods
Gunpowder/Early rockets
Leonardo da Vinci
de Lana

Materials needed:

Library resources, photographs, time-lines, models, posters, bird skeletons (obtained from the Biology laboratory)

Suggested references:

Aerospace: the Challenge. Civil Air Patrol.
Introduction to Flight. John D. Anderson, Jr.
History of Aviation. John W. Taylor and Kenneth Munson

2. Provide the students with detailed descriptions, library resources, graphics, simple demonstrations and supporting written information describing early attempts at placing humans in flight. Each student will be required to develop lists of earlier contributions to human flight, citing the contribution of each event or person. Students will apply research findings to a scaled historical time-line.

Suggested events and individuals for consideration:

Montgolfier brothers
Professor Charles
Henri Giffard
Sir George Cayley
William Henson
John Stringfellow

Materials needed:

Library reference materials, photographs, time-lines, models, demonstration materials (heat source, plastic bags, Helium source, paper supply, scissors, tape)

TOPIC: 1 Origins of Flight

MODULE: AEROSPACE
SUBMODULE A

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been given detailed written descriptions, supporting audio-visual materials (movies, slides and posters), library resources and verbal descriptions, will be able to recognize the origins of flight as visualized by early humans. The students will display their understanding through oral and written analyses.

   In order to do this, the student must be able to:

   A. Read and understand basic time-lines and supporting audio-visual materials.
   B. Identify and relate early mythology and legends to early desires to fly.
   C. Recognize misconceptions related to evaluation of early flight principles.

2. Senior high school students, having been presented with detailed visual and verbal descriptions, will be able to recognize early developments and accomplishments of research involving the elevation of humans into the atmosphere.

   In order to do this, the student must be able to:

   A. Evaluate early theories of flight.
   B. Relate early flight experiments to practical applications.
   C. Recognize the contributions of early flight research.

3. Senior high school students, having been exposed to detailed written information, verbal descriptions, demonstrations and supporting audio-visual materials, will demonstrate an understanding of the application of early aeronautical design and research to controlled, powered, heavier-than-air flight.

   In order to do this, the student must be able to:

   A. Identify the contributions of early aeronautical research to controlled, powered, heavier-than-air flight.
   B. Relate photographs, diagrams and models to the evolutionary accomplishments of aeronautical design.
   C. Develop verbal and graphic presentations for analysis.
   D. Interact with group members in the gathering of research materials.
   E. Read basic photographs, drawings and illustrations.

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INSTRUCTIONS (NOTES)

Sample demonstrations (Basic concepts):

A. Hot air balloon (lighter-than-air principle)
B. Gas-filled balloon (Helium) - use plastic bags
C. Cayley's theories (lift, drag, thrust)- use paper models

Suggested references:

Illustrated History of Aircraft. B. Gallagher
Introduction to flight. J.D. Anderson, Jr.
Aerospace: the Challenge. Civil Air Patrol.

3. Present detailed descriptive information to the class relating the development of research and experimentation in order to achieve controlled, powered, heavier-than-air flight. Supplement written materials with supporting slides, photographs, library resources, models, and historical information relating the contributions of early aeronautical research to achievement of controlled, powered, heavier-than-air flight. Students, working in teams, are assigned a specific person or event to be researched. Groups will prepare graphic and written presentations for class evaluation and display.

Individuals for consideration:

Sir George Cayley
Otto Lilienthal
Octave Chanute
Samuel Langley
Wilbur and Orville Wright

Sources of information and free materials:

National Air and Space Museum
Smithsonian Institution
Education Services Division
Washington, D.C. 20560

Director of Aerospace Education
NASA - Goddard Space Flight Center
Public Affairs Office
Code 202
Greenbelt, MD 20771

Film resource:

Antique Airplane Association, Inc.
New York Chapter
1785 Hannington Avenue
Wantagh, NY 11793

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INSTRUCTIONS (NOTES)

Suggested references:

A. National Air and Space Museum Publications:

Otto Lilienthal and Octave Chanute: pioneers of Gliding

Langley's Aerodrome

The Wright Brothers

B. History of Aviation. John W. Taylor and Kenneth Munson

Materials needed:

Library resources, information sheets, teacher prepared slides, models*

* Demonstration models can be constructed by students from many fine kits available at local hobby stores.

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INSTRUCTIONS (NOTES)

~~TOPIC: 1~~ Origins of Flight

MODULE: AEROSPACE
SUBMODULE A

$$SUPPLEMENTAL ACTIVITIES

1. Assign teams of students the responsibility of constructing models of examples of historical achievements in heavier-than-air research. The demonstration models can be constructed from available kits or can be "scratch-built" from drawings and photographs available in the classroom aerospace laboratory. Models can be used as teaching aids and also to stimulate student interest in aerospace activities both within and outside the classroom.

Materials needed:

Basic hobbyist's modeling tools, kits (where available), supporting historical photographs and drawings, assorted adhesives, paints, etc., safety information sheets.

SAFETY: All laboratory and shop modeling and construction activities must be in compliance with existing safety procedures for "hands-on" activities. All activities should be preceded by appropriate operational instruction.

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INSTRUCTIONS (NOTES)

TOPIC: 2 Formative Years MODULE: AEROSPACE
SUBMODULE A

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been presented detailed descriptive information, models, photographs and supporting audio-visual materials, will display an understanding of the status of aviation at the start of World War I.

In order to do this, the student must be able to:

A. Follow the evolution of the airplane from the first practical powered controlled flight to the start of World War I.
B. Recognize the contributions of international aviation development before World War I.
C. Present graphic and oral analyses of aviation evolution before World War I.
D. Identify the type of incentives existing for developments in aviation prior to World War I.
E. Develop a chronological listing of aviation events from 1903-1914.

2. Senior high school students, having been given detailed models, descriptive information, and supporting audio-visual materials, will analyze the evolution of aviation during the period 1914-1919. The students will present oral, written and graphic summaries of findings for class discussion and review.

In order to do this, the student must be able to:

A. Identify the major roles played by aircraft in World War I.
B. Relate scale models to historical time-lines.
C. Recognize the evolution of aircraft design during World War I.
D. Develop oral, written and graphic summaries of research findings.

3. Senior high school students, having been provided with graphic descriptions, historical time-lines, and supporting audio-visual materials, will be able to recognize the contribution of aviation research, experimentation, and events as related to social, economic, and political circumstances during the "inter-war years". Students will summarize findings through oral and graphic analyses, and present materials to the class.

In order to do this, the student must be able to:

A. Recognize the contribution of individuals to the evolution of aviation during this time period.

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INSTRUCTIONS (NOTES)

B. Identify major events occurring in aviation research and experimentation during the period 1919-1939.

C. Relate written, verbal abd descriptive models to aviation events and personalities during the period 1919-1939.

D. Evaluate aviation accomplishments through resource research investigations.

E. Relate aviation achievements to social, economic and political climates during the period 1919-1939.

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INSTRUCTIONS (NOTES)

TOPIC: 2 Formative Years — MODULE: AEROSPACE, SUBMODULE A

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Present detailed, descriptive historical information to the class outlining the development of aviation from the first powered, heavier-than-air flight of the Wright brothers to the start of World War I. Students are to be divided into groups in order to present historical research findings to the class for discussion and evaluation. Individual students will be responsible for maintaining chronological lists of aviation achievements during the period 1903-1914.

Suggested research topics/individuals:

Wright brothers
Louis Bleriot
"Vin Fiz"
Glenn Curtiss
Igor Sikorsky
Lavasseur
Santos-DuMont
Henri Farman
Schneider Trophy

Materials needed:

Library resources, information sheets, photographs, time-lines, supporting audio-visual materials, worksheets, models, graphic display materials

Suggested film: America's Wings. NASA. Washington D.C.

Order from: Antique Airplane Association, Inc.
New York State Chapter
5936 48th Avenue
Woodside, NY 11377

Information sources:

National Air and Space Museum
Education Services Division
Washington, D.C. 20560

Glenn Curtiss Museum of Local History
Hammondsport, NY 14840

Suggested references:

Illustrated History of Aircraft. Brendan Gallagher. National Air and Space Museum.
Conquerors of the Air: The Evolution of the Aircraft (1903-1945). Heiner Emde and Carlo Demand.

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INSTRUCTIONS (NOTES)

2. * Present detailed graphic descriptions, slides and library resources to the class, describing the role of aviation at the beginning of World War I. Instruct the students to investigate the change in philosophy related to the role of aviation in the conduct of war. Divide the class into small groups, with each group assigned the responsibility of a role played by aviation during World War I. Each group will present oral and graphic summaries to the class for discussion and review.

Suggested topics:

A. Aviation design evolution (aircraft types)
B. Aircraft utilization (strategic applications)
C. Individual and national roles

Materials needed:

Photographs, drawings, scale models, library resources.

Suggested references:

History of Aviation. J.W. Taylor and K. Munson
Conquerors of the Air: the Evolution of Aircraft (1903-1945). H. Emde and C. Demand.
Aerospace: the Challenge. Civil Air Patrol.
Illustrated History of Aircraft. B. Gallagher.
Air Classics magazine
Scale Modeller magazine

*See supplemental activity in this topic section.

3. Present audio visual and graphic descriptions to the class indicating the progress of aviation during the "inter-war" years. Each student will be required to report on an individual or an event significant to the development of aviation and aerospace during the period 1919-1939.

Sample individuals and events: (1919-1939)

U.S. Air Mail
Atlantic crossing (NC-4)
Charles Lindbergh
Amelia Earhart
Wiley Post
Grover Loening
Lockheed "Vega"
Schneider Trophy
Richard Byrd
DC-3
China Clipper
Ford Tri-motor
National Air Race
Hindenburg/Graf Zeppelin
Robert Goddard

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Billy Mitchell
Igor Sikorsky
Jimmy Doolittle
Howard Hughes
Autogyro

Materials needed:

Library resources, photographs, models, memorabilia, worksheets, notebooks, time-lines.

Sample references:

History of Aviation. J.W. Taylor and K. Munson.
Illustrated History of Aviation. B. Gallagher.
Conquerors of the Air...
Spirit of St. Louis. C. Lindbergh.
"WE" C. Lindbergh.
Sixty Years of Aeronautical Research, 1917-1977. NASA.
New York State Aerospace Resources Guide. R.J. Ullery (ed.)

Resource contacts:

National Air and Space Museum
Washington, D.C. 20560

NASA Goddard Space Flight Center.
Greenbelt, MD. 20771

4. Invite a guest speaker to address the class on the subject of "The Formative Years of Aviation/Aerospace (1919-1939)". Seek input from the class members concerning potential guest speakers since the students may know of a relative or a friend connected with aviation during the 1919-1939 period. Students will be responsible for taking notes and incorporating accumulated data into individual aerospace notebooks. Encourage the students to question the speakers after their presentations.

Potential sources of guest speakers:

1. Local fixed base operator (airport).
2. Aircraft companies (ie. Grumman, Cessna, Boeing).
3. National Air and Space Museum.
4. Civil Air Patrol - Regional representative.
5. FAA regional representative.
6. Antique Aircraft Association.
7. Local public library speakers bank.

Materials needed:

Notebooks, resource contact list, models, photographs, tape recorder.

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INSTRUCTIONS (NOTES)

Suggested reference:

New York State Aerospace Resources Guide. R.J. Ullery.

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INSTRUCTIONS (NOTES)

TOPIC: 2 Formative Years MODULE: AEROSPACE SUBMODULE A

$$SUPPLEMENTAL ACTIVITIES

1. The area covered in Instructional Strategy #2 (Topic #2) is an excellent point to relate scale models of historically significant design to the activity. Encourage students to display any models that they may have illustrating examples of the World War I period. Advise students that many excellent scale model kits are available through local hobby stores.

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INSTRUCTIONS (NOTES)

TOPIC: 3 World War II   MODULE: AEROSPACE
SUBMODULE A

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been given detailed descriptions, historical time-lines, library resources and supporting audio-visual materials, will be able to recognize the role played by aviation in the events leading up to and occurring during World War II. The students will develop observations and conclusions through oral and graphic presentations to the class.

In order to do this, the student must be able to:

A. Read and analyze basic descriptive information.
B. Identify the roles played by aviation at the start of World War II.
C. Relate the application of advanced aviation and aerospace technology to the conduct of World War II.
D. Analyze the evolution of aviation and aircraft design through scale model and graphic review activities.
E. Present oral and graphic analyses to the class for evaluation and review.
F. Construct scale models based upon historical research.

2. Senior high school students, having been provided with descriptive information and examples of types of aircraft which evolved during World War II, will evaluate and recognize the application of aviation design to post-war civilian and military uses. The students will present evaluations to the class through oral and graphic presentation of research findings.

In order to do this, the student must be able to:

A. Relate military aviation development to civilian applications.
B. Develop graphic presentations based upon evaluation of models, photographs, time-lines and drawings.
C. Manipulate basic modeling tools in construction activities.
D. Relate aircraft proportions and performance to civilian and military applications.

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TOPIC: 3 World War II   MODULE: AEROSPACE
SUBMODULE A

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Present detailed verbal, graphic and audio-visual information to the class, relating the strength of individual countries at the start of World War II in the area of aviation. Emphasize the initial role of aviation in the early events leading to the involvement of a majority of the nations of the world in World War II. Students will be required to identify the role played by aviation as it related to geographic interests and individual applications of nations.

Suggested topics for consideration:

- Versailles Treaty
- Expansionism in Asia
- Spanish Civil War
- Pearl Harbor
- German Re-Armament
- Invasion of Poland
- Blitzkreig
- Battle of Britain
- Atlantic War

Materials needed:

Information sheets, library resources, maps, supporting audio-visual materials (slides, movies), notebooks, models.

Suggested resources:

A. Guest speakers: Veterans organizations
Civil Air Patrol representative
Social Studies teachers

B. Museum resources: National Air and Space Museum
Military Archives
Local Historical Museums

References:

Aerospace: the Challenge. Civil Air Patrol.
The History of Aviation. J.W. Taylor and K. Munson.
New York State Aerospace Resources Guide. R.J. Ullery.

2. Provide the students with detailed information relating to the evolution of aviation during World War II. The students will analyze specific types of aircraft and relate the roles of the aircraft to wartime application and post-war use. The students are assigned the responsibility of evaluating the intent and capabilities of aircraft types. Findings will be recorded in student notebooks and materials will be displayed in the class Aerospace Resource Center.

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INSTRUCTIONS (NOTES)

TOPIC: 4 The Aerospace Age

MODULE: AEROSPACE
SUBMODULE A

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been given detailed oral, written and graphic descriptions, will be able to trace the evolution of jets from experimental stages to applications in civilian and military aviation sectors. The students will give written and oral descriptions of basic definitions and supporting illustrations.

In order to do this, the student must be able to:

A. Trace the historical development of jet powered experimentation and research.
B. Compare the research of individual in different countries.
C. Identify the first practical applications of jet aircraft.
D. Recognize the role played by jet aircraft in commercial and military applications.
E. Evaluate charts, models and diagrams of jet aircraft and propulsion systems. (See submodule E)

2. Senior high school students, having been provided descriptive information and graphic examples of the evolution of rockets as a viable aerospace system, will trace the evolution of rockets to present and future applications. The students will give verbal and graphic presentations to the class for evaluation.

In order to do this, the student must be able to:

A. Trace the historical evolution of rockets.
B. Identify individuals responsible for modern rocket research and development.
C. Evaluate models and diagrams of rocket evolution.
D. Conduct basic research in the area of rocket technology development.

3. Senior high school students, having been given detailed written, oral and graphic information illustrating the development of rocket power, will identify the historic milestones related to the entrance of humanity into the space age. The students will present findings and conclusions through group analyses of library resources, working models and graphic descriptions.

In order to do this, the student must be able to:

A. Read basic charts, diagrams and graphic materials.
B. Evaluate conceptual diagrams and models.
C. Identify milestones of space technology.
D. Construct graphic displays and working models.

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Suggested areas for consideration:

- Naval aircraft
- Helicopters/autogyros
- Medium-range aircraft
- Fighter aircraft
- Long-range heavy aircraft
- Gliders and airships
- Jets and rockets
- Post-war applications

Materials needed:

Drawings, photographs, models, maps, library resources, basic modeling tools.

Suggested references:

- The History of Aviation. J.W. Taylor and K. Munson.
- Conquerors of the Air... H. Emde and C. Demand.
- Aerospace: the Challenge. Civil Air Patrol.
- The United States Navy in World War II. S.E. Smith.
- Incredible Victory. W. Lord.
- Illustrated History of Aircraft. B. Gallagher.
- Scale Modeller magazine
- Air Classics magazine

Information sources:

History Center
Grumman Aerospace Corporation
Bethpage, NY 11714

National Air and Space Museum
Smithsonian Institution
Washington, D.C. 20560

Resource guide:

New York State Aerospace Resources Guide. R.J. Ullery.

TOPIC: 4 The Aerospace Age

MODULE: AEROSPACE
SUBMODULE A

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Provide the students with detailed oral and graphic descriptions of the evolution of jet aircraft from early experimental efforts to applications for civilian and military use. Support descriptions and illustrations with photographs, models and demonstrations. (See Submodules E and H).

Instruct the students to identify and recognize the importance of the evolution of jet aircraft in military and civilian applications. Students will present research to the class in the form of verbal descriptions and graphic presentations relating to the evolution of the "Jet Age". Information will be recorded in student notebooks. Graphic presentations will be incorporated into the classroom Aerospace Resource Center.

Sample events and personalities to be investigated:

Coanda Jet Aircraft - 1910
F-80 "Shooting Star" - Lockheed
Me 262
Boeing 700 series
Commercial aviation
Heinkel Jet Aircraft - 1938
Glouster Jet Fighter - 1941
British Comet
Military aviation
General aviation

Materials needed: Library resources, information sheets, scale models, photographs, supporting audio-visual materials.

Potential guest speakers:

Commercial airline representative
FAA regional representative
CAP regional representative
Local Veterans groups

Resources:

National Air and Space Museum
Air Force Museum
NASA - Goddard Space Flight Center

E. Describe the evolution of space technology and the benefits of the advances of aerospace technology to humanity.

4. Senior high school students, having been given detailed graphic descriptions and written information, will identify contemporary attempts to develop research in the area of aerospace technology by private enterprise and individual research efforts. The students will present verbal and graphic presentations for class evaluation and review.

In order to do this, the student must be able to:

A. Identify types of contemporary aerospace research.
B. Recognize individuals and events relating to contemporary aerospace research.
C. Relate contemporary independent research to large-scale aerospace applications.

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INSTRUCTIONS (NOTES)

<u>Suggested activities:</u>

A. Library research
B. Model construction (kits and simluators)
C. Information gathering (FAA, NASA, CAP)
D. Field trips
E. Slide presentations (student prepared)
F. Bulletin board displays
G. Postage stamp display (USPS)

<u>Sample topics for consideration:</u>

A. Early orbital exploration (Sputnik, Explorer, Echo)
B. Manned exploration (Vostok, Mercury, Gemini, Apollo, Skylab, Space shuttle)
C. Unmanned exploration (Viking, Pioneer, Tiros, Landsat)
D. Space personalities (Gagarin, Sheppard, Glenn, Armstrong, von Braun)

<u>References:</u>

<u>NASA Publications.</u> Washington, D.C.
<u>History of Aviation.</u> J.W. Taylor and K. Munson.
<u>National Air and Space Museum.</u> CBS Publications.
<u>U.S. Postal Service: Topical Collector Packages.</u> USPS.

Aerospace submodules - Manned and Unmanned Space.

<u>Materials needed:</u>

Access to school mailing services, list of resource contacts, photographs, drawings, posters, models (kits), modeling materials (cardboard, paint, etc.) basic hand and power tools, graphic display materials.

<u>Suggested films:</u> (from NASA)

<u>The World was There</u>
<u>The Eagle has Landed</u>
<u>Space Shuttle: Mission to the Future</u>

<u>SAFETY:</u> All modeling and construction activities must be done in compliance with existing safety procedures for laboratory and shop "hands-on" activities. All construction activities are to be preceded by appropriate operational instruction.

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References:

Young Scientists Book of Jets. M. Hewish.
History of Aviation. J.W. Taylor and K. Munson.
Conquerors of the Air... H. Emde and C. Demand.
Illustrated History of Aircraft. B. Gallagher.
New York State Aerospace Resource Guide. R.J. Ullery.

2. Provide students with access to library resources, supporting audio-visual materials, models, photographs and drawings. The students will be responsible for evaluating resource material and for developing oral and graphic descriptions of the historical evolution of rockets, as related to technological development of aerospace.

Students will present findings to the class in the form of oral and graphic presentations. Graphic materials will be incorporated into a display as part of the class Aerospace Museum and Resource Center.

Materials needed:

Library resources, models, posters, time-lines, diagrams, movies.

Individuals and events for consideration:

Robert Goddard
Charles Yeager
Herman Oberth
Bell X-1
Werner von Braun
Scott Crossfield
X-15 (North American)

Resources: NASA - Goddard Space Flight Center
National Air and Space Museum

Suggested films: (from NASA)

A Man's Reach Should Exceed His Grasp
Research Project X-15

3. Provide the students with detailed posters, diagrams and supporting audio-visual materials depicting the evolution of space technology from the first orbital satellites to present space exploration and research efforts. Display written and graphic materials for student review. Divide the class into small groups, each assigned the task of developing graphic presentations depicting specific areas of space technology evolution. Final research findings will be incorporated into the classroom Space Technology Resource Center.

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INSTRUCTIONS (NOTES)

4. Provide students with detailed information regarding the benefits realized by the research and exploration of space to society. Students are to develop lists of direct and indirect benefits to humanity of the achievements of space technology programs.

Materials needed:

Library resources, posters, movies.

Suggested films: (from NASA)

4 RMS - Earth View
The Age of Space Transportation
Images of Life
New View of Space

References:

NASA Publications. Washington, D.C.

5. Provide the students with an overview relating independent contemporary experimentation and research efforts in the field of aviation and aerospace. Students are assigned the responsibility of investigating at least one contemporary independent aviation/aerospace experiment or research effort. Students will give an oral report citing the effort, the individuals and the implications for application of the effort.

Sample areas for investigation:

A. Trans-oceanic ballon flights
B. Human-powered aircraft designs
C. Private rocket experiments
D. Ultra-light aircraft
E. Non-stop around-the-world flights
F. Hot air ballooning

Resources:

Guest speakers (sport pilots, researchers)

References:

Illustrated History of Aircraft. B. Gallagher.
History of Aviation. J.W. Taylor and K. Munson.
New York State Aerospace Resources Guide. R.J. Ullery.

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INSTRUCTIONS (NOTES)

TOPICS: 1-4

MODULE: AEROSPACE
SUBMODULE A

$$SUGGESTED SUBMODULE RESOURCES - ADDRESSES FOR FURTHER INFORMATION

AEROSPACE EDUCATION PROGRAMS
NASA - Goddard Space Flight Center
Greenbelt, MD 20771

AMERICAN SOCIETY FOR AEROSPACE EDUCATION
1910 Association Drive
Reston, VA 22091

DIRECTOR - AEROSPACE EDUCATION
U.S. Air Force - Civil Air Patrol
Northeast Region
Building 29-01
McGuire AFB, NJ 08641

FEDERAL AVIATION ADMINISTRATION
Aviation Education Office
Fitzgeral Federal Building
JFK International Airport
Jamaica, NY 11430

HISTORY CENTER
Grumman Aerospace Corporation
Bethpage, NY 11714

SMITHSONIAN INSTITUTION
National Air and Space Museum
Education Services Division
NASM, Room P-700
Washington, DC. 20560

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TOPICS: 1-4

MODULE: AEROSPACE
SUBMODULE A

$$SUGGESTED SUBMODULE RESOURCES - MUSEUM RESOURCES

Museums located within New York State:

The Cradle of Aviation Museum
Davis Avenue
Hempstead, New York
(1-516-222-1190)

The Glenn H. Curtiss Museum of Local History
Lake and Main Streets
Hammondsport, New York 14840
(1-607-569-2160)

Long Island Early Flyers Club
Box 221
Bethpage, New York 11714
(1-516-369-8610)

National Soaring Museum
RD#3, Harris Hill
Elmira, New York 14093
(1-607-734-3128)

Old Rhinebeck Aerodrome
Box 89
Rhinebeck, New York 12572
(1-914-758-8610)

Museums located outside New York State:

The Franklin Institute of Science Museum
Benjamin Franklin Parkway at 20th Street
Philadelphia, PA. 19103
(1-215-448-1200)

Paul E. Garber, Restoration Facility
Suitland, MD

Contact: Educational Services Division
National Air and Space Museum
Smithsonian Institution
Washington, D.C. 20560
(1-202-357-1400)

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INSTRUCTIONS (NOTES)

Marine Corps Aviation Museum
Brown Field
Quantico, VA. 22134
(1-703-640-2606)

National Air and Space Museum
Educational Services Division
Smithsonian Instution
Washington, D.C. 20560
(1-202-357-1400)

NOTE: This museum's library facilities are among the most complete on the subject of aviation and space. Of particular note is its photograph collection and its rare book department. Teachers needing copies of particular photographs and illistrations of crafts should contact this resource for information.

Tucson Air Museum Foundation
Pima Air Museum
P.O. Box 17298
Tucson, AZ 85731
(1-602-889-0462)

U.S. Air Force Museum
Wright-Patterson Air Force Base
Ohio 45433
(1-513-255-3284)

U.S. Army Aviation Museum
Fort Rucker, Alabama
(1-205-255-4507)

The United States Naval Aviation Museum
Naval Air Station
Pensacola, FL

NOTE: Additional museum resources may be located in the New York State Aerospace Resources Guide.

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INSTRUCTIONS (NOTES)

TOPICS: 1-4 MODULE: AEROSPACE SUBMODULE A

$$SUGGESTED SUBMODULE RESOURCES - RESOURCE GUIDES

Aviation books of all publishers. (catalog). Glendale, CA. Aviation Book Co. 1984.

Bibliography of reference books for selected technology fields. Albany, NY. New York State Education Department. 1984

The directory of aerospace education. Reston, VA. American Society for Aerospace Education. 1984.

Guide to federal aviation administration publications. Washington, D.C. FAA. U.S. Department of Transportation. 1984.

Information leaflets - Aviation history. Washington, D.C. Smithsonian Institution. National Air and Space Museum. n.d.

NASA publications. Washington, D.C. NASA. 1984.

National Air and Space Museum publications. Washington, D.C. NASM. Special Projects and Publications Division. n.d.

New York State aerospace resources guide. (R.J. Ullery, ed.) Albany, NY. New York State Education Department. 1982.

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INSTRUCTIONS (NOTES)

TOPICS: 1-4

MODULE: AEROSPACE
SUBMODULE A

$$SUGGESTED SUBMODULE RESOURCES - NON-PRINT (AUDIO VISUAL) MATERIALS

Film titles:

The Eagle has landed: the flight of Apollo 11
The age of space transportation
Images of life
A man's reach should exceed his grasp
New view of space
Research project X-15
Space shuttle: mission to the future
The world was there
America's wings

Available from:

National Aeronautics and Space Administration
Goddard Space Flight Center
Public Affairs Office
Code 202
Greenbelt, MD 20771

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TOPICS: 1-4

MODULE: AEROSPACE
SUBMODULE A

$$SUGGESTED SUBMODULE RESOURCES - PRINT MATERIALS

Anderson, John D. Introduction to flight. NY. McGraw-Hill Book Co. 1978.

CBS Publications. The National Air and Space Museum. NY. Harry N. Abrams Co. 1982.

Civil Air Patrol. Aerospace: the challenge. Maxwell AFB, AL. CAP. 1983.

Emde, Heiner and C. Demand. Conquerors of the air: evolution of aircraft, 1903-1945. NY Viking Press. 1968.

Gallagher, Brendan. Illustrated history of aircraft. NY. W.H. Smith Publishers, Inc. 1984.

Hewish, Mark. Young scientist's book of jets. St. Paul, MN. EMC Corporation. 1978.

Lindbergh, Charles A. Spirit of St. Louis. NY. Charles Scribner's and Sons. 1953.

Lord, Walter. Incredible victory. NY. Harper and Row. 1967. (out of print)

Mosley, Leonard. Lindbergh: a biography. Garden City, NY. Doubleday Books. 1976.

NASA. Sixty years of aeronautical research. Washington, D.C. NASA. 1977.

Ross, Frank. Flying windmills: the story of the helicopter. NY. Lothrop, Lee and Shepard Co., Inc. 1953.

Smith, S.E. The United States Navy in World War II. NY. William Morrow Co., 1966.

Taylor, John W. and Kenneth Munson. History of aviation. NY. Crown Publishers, Inc. 1978.

Wilding-White. Jane's pocket book of space exploration. NY. Macmillan. 1978.

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STRUCTIONS (NOTES)

TOPICS: 1 - 4

MODULE: AEROSPACE
SUBMODULE A

$$SUGGESTED SUBMODULE RESOURCES - PERIODICALS OF INTEREST

AIR CLASSICS
Challenge Publications, Inc.
7950 Deering Avenue
Canoga Park, CA 91304

AVIATION SPACE
Aerospace Education Association
1910 Association Drive
Reston, VA 22091

NASA FACTS
NASA
Washington, D.C.

SCALE MODELLER
Challenge Publications, Inc.
7950 Deering Avenue
Canoga Park, CA 91304

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The principles utilized in the venturi directly apply to an airfoil to create lift. The shape of an airfoil is used to create a pressure differential in the air. As complex as this may sound, the same principle is in force upon a spinning baseball, to create a "curve", "fastball", or "sinking ball". If a baseball is spinning downward in relationship to the direction of its flight, the seams allow air to pass at a higher velocity under the ball than over the top. The lower pressure under the ball causes it to drop. By adding Bernoulli's Principle to gravity, a baseball making its revolutions on its way to home plate will drop as much as 17-1/2 inches! The concept, applied to aircraft, will lift and support many tons at over 100,000 feet of altitude.

An airfoil is any shape which is designed to produce lift. Although the wing is the primary part of the aircraft that produces lift, other airfoils such as the fuselage, empennage, landing gear, propeller and experimental devices all add to the concept. The entire goal of NASA's Aircraft Energy Efficiency (ACEE) program is to make possible the most efficient use of energy for aircraft propulsion and lift.

An aircraft in straight-and-level flight is acted upon by four forces: lift, gravity, thrust and drag. Lift is the upward acting force; gravity, or weight, is the downward acting force; thrust acts in a forward direction; and drag is the backward, or retarding force produced by air resistance. Extensive research is directed toward designing airfoils with maximum lift and minimum drag in order to produce more efficient and economical aircraft and transitional space vehicles.

"Aeroplane" was first used in England in 1866 to describe a wing or (geometric) plane in the air. Then in 1873, it was used to refer to the entire craft. In the U.S., the spelling was changed to "airplane" in the late 1870's. Thus, though the Wright Brothers patented the "flying machine" some Americans immediately called it an airplane. The study of what makes an aircraft fly became "aeronautics" in the 1900's and the study of the concepts became known as "aerodynamics".

SKILLS, KNOWLEDGE, BEHAVIORS TO BE DEVELOPED:

Upon completion of the submodule, the student will be able to:

1. Investigate Newton's Laws of Motion, Bernoulli's Principle, and the properties of air.
2. Identify the components of an aircraft associated with motion.
3. Identify and compare the various airfoil designs and the nomenclature associated with each.
4. Identify "high lift" devices and their use.
5. Investigate the four forces of lift, drag, thrust, weight (gravity) and investigate the concepts in a glide.

TOPIC: 1. Laws and Principles

MODULE: AEROSPACE
SUBMODULE B

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been given detailed descriptions, audio visual materials, drawings and illustrations, written explanations and verbal clarifications, will be able to demonstrate an understanding of Newton's physical Laws of Motion and display their understanding through oral and written analyses.

   In order to do this, the student must be able to:

   A. Read and understand Newton's First Law of Motion.
   B. Compute the force acting upon a body with the simple mathematical formula of Force = mass x acceleration.
   C. Read and understand Newton's Third Law of Motion.

2. Senior high school students, having been given written information, demonstrations using models, verbal descriptions, illustrations and library resources will be able to demonstrate an understanding of Bernoulli's Principle and its application to practical purposes.

   In order to do this, the student must be able to:

   A. Understand the concept of air pressure and pressure differential.
   B. Understand the concept of air velocity and density.
   C. Recognize and identify the principles of a venturi tube.

TOPIC: 1. Laws and Principles — MODULE: AEROSPACE, SUBMODULE B

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Provide the students with detailed descriptions and experiments to support the law that a body remains at rest or in motion with a constant velocity unless an external force acts on the body.

   Materials needed:

   Elementary texts on physical properties, models, illustrations, two different size and weight balls, model cars.

   Suggested resources:

   Making Things Move. 11 min. Color film. Britannica Films, 1963.

   Demonstration Aids for Aviation Education. FAA.

2. Provide students with detailed descriptions and verbal explanations of Newton's Law of Acceleration. Discuss "G" forces on a body in flight and discuss how the law accounts for centrifugal and centripetal forces. Discuss and illustrate the action of freely falling bodies and the action of air resistance on these bodies.

   Suggested experiments:

   - Roll a ball down an inclined plane and observe it gaining speed. Determine the rate of acceleration.
   - Discuss why water stays in a bucket while swinging it in a vertical circle.
   - Push a small model car with varying amounts of force to show that speed of movement is related to thrust.
   - Calculate force given weight, acceleration and gravity in: Force = mass x acceleration, where mass is weight divided by gravity.

   Materials needed: (see resource list at the end of this submodule)

   Suggested films:

   How an Airplane Flies. 56 min. color. 1976.
   High Speed Flight. 20 min. B&W. 1976.
   Force and Motion. 10 min. B&W.

   Suggested references:

   Basic Sciences for Aerospace Vehicles.
   McGraw-Hill Encyclopedia of Science and Technology.

3. Provide students with illustrations, descriptions and suggested experiments to explain <u>Newton's Third Law of Motion</u> (to every action, there is an equal and opposite reaction). Explain the relationship between thrust and weight in view of this law.

<u>Materials needed:</u>

Library resources, information sheets, experimental models.

<u>Sources of information:</u>

National Air and Space Museum
NASA - Goddard Space Flight Center

<u>Suggested filmstrips:</u>

<u>Jet Power.</u> From: Scott Educational Division
Lower Westfield Road
Holyoke, MA 01040

<u>How the Jet Engine Works.</u> From: American Gas Assn.
1515 Wilson Ave.
Arlington, VA 22209

4. Present detailed descriptions, illustrations and models along with experiments for evaluation and discussion to support <u>Bernoulli's Principle.</u> The students will be responsible for reproducing graphic illustrations of a venturi tube and the relationship of this concept to the motion of air over an airfoil. Illustrations, readings and verbal explanations will be given on air pressure, velocity and density.

<u>Materials needed:</u>

Library resources, information sheets, filmstrips, supporting audio visuals, experimental models, worksheets, graphic display materials.

<u>Suggested references:</u>

<u>Basic Sciences for Aerospace Vehicles.</u>
<u>Introduction to the Aerodynamics of Flight.</u> T. Talay.
<u>Aeronautical Dictionary.</u> F.D. Adams.
<u>Theory of Aircraft Flight.</u> J.D. Elmer.

<u>SAFETY:</u> All laboratory activities must be in compliance with existing safety procedures, especially when working with materials that may move at high velocities. All activities should be carefully supervised.

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INSTRUCTIONS (NOTES)

TOPIC: 1. Laws and Principles

MODULE: AEROSPACE
SUBMODULE B

$$SUPPLEMENTAL ENRICHMENT AREAS

1. Study of inertia
2. Study of moments of force and resultant forces
3. Archimede's Principle
4. Speed of sound
5. Pascal's Law
6. Boyle's Law
7. Charle's Law

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TOPIC: 2. Aircraft Components/ Mechanics of Motion

MODULE: AEROSPACE
SUBMODULE B

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been given detailed models, descriptive information, illustrations, photographs and supporting audio visual materials, will be able to recognize the components of an aircraft and their associated function in the flight of the vehicle. The students will present oral and written descriptions of each component and how it is utilized in flight.

   In order to do this, the student must be able to:

   A. Recognize the components in the structure of an aircraft.
   B. Discuss the function of each component.
   C. Recognize the sub-component types in the structure of an aircraft and discuss the use of each.

2. Senior high school students, having been given detailed models, descriptive information, experimental design drawings, audio visual presentations and verbal and graphic explanations, will be able to identify and compare various airfoil designs and will be able to discuss and illustrate the utilization of these designs. The students will be able to discuss the latest experiments and research in the area of airfoil construction.

   In order to do this, the student must be able to:

   A. Identify airframe components as an airfoil.
   B. Recognize the control surfaces of an aircraft and their associated use.
   C. Identify various wing designs and be able to discuss aspect ratio, angle of incidence, chord and camber.

3. Senior high school students, having been given detailed models, audio visual displays, illustrations and descriptions, will be able to identify and discuss "high lift" devices and their use. The students will be able to discuss the current research and development of these devices.

   In order to do this, the student must be able to:

   A. Identify the various types of flaps in use.
   B. Manipulate the components of an airframe to illustrate the use of high lift devices.

~~TOPIC: 2.~~ Aircraft Components/Mechanics of Motion

MODULE: AEROSPACE
SUBMODULE B

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Present pictures of aircraft, illustrations, drawings and general models of various aircraft, along with drawings depicting the basic parts of the airframe (fuselage, empennage, landing gear, wings, flaps and power plant) to the students, Discuss the function of each. The concepts of lift, thrust, drag, and gravity can be discussed in detail in Topic #3. The students will be required to identify not only the component parts, but also the sub-types under each. The items to be discussed under each are as follows:

   A. Fuselage:

      1. Truss-type
      2. Semi-monocoque
      3. Experimental

   B. Empennage:

      1. Vertical stabilizer
      2. Rudder
      3. Horizontal stabilizer
      4. Elevator
      5. Stabilator
      6. Trim tabs

   C. Landing Gear Types
   D. Power Plant Types
   E. Wings:

      1. Straight
      2. Tapered
      3. Elliptical
      4. Sweptback
      5. Delta
      6. Experimental "supercritical"

   F. Flaps/Spoilers (see Strategy #3)

   G. Ailgrons

Materials needed:

Suggested films:

How an Airplane Flies. Shell.

Suggested references:

How It Works. M.L. Keem
Basic Sciences for Aerospace Vehicles.

(see resource list at the end of this submodule)

2. Provide students with detailed information, illustrations, drawings and models depicting various airfoils and their function. Relate Bernoulli's Principle through illustrations and experiments. Discuss aspect ratio and angle of incidence.

Introduce and reinforce concepts of:

airfoil
leading edge/trailing edge/root/tip
chord line
camber
relative wind
angle of attack

Materials needed:

Model of an aircraft and models of various airfoils, graphic illustrations and audio visual materials (slides, movies), notebooks and information sheets, NASA publications.

Suggested references:

Introduction to the Aerodynamics of Flight. T. Talay.
Aerospace: the Challenge. CAP.

3. Provide students with illustrations, drawings, models, audio visual presentations, information sheets, NASA publications depicting "high lift" devices and their use.

Materials needed:

Graphic illustrations and drawings of flaps:

plain
split
Fowler
zap
slotted and double slotted
droop snoot

Illustrations and drawings or photographs of:

winglets
slats

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INSTRUCTIONS (NOTES)

Suggested sources of information:

NASA - Goddard Space Flight Center
FAA (Demonstration Aids for Aviation Education)

Suggested references:

Advanced Pilot Manual.

(see resource list at the end of this submodule)

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TOPIC: 3. The Four Forces

MODULE: AEROSPACE
SUBMODULE B

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been given detailed descriptions, audio visual presentations, drawings and illustrations, written and verbal explanations, lectures/demonstration experiments, a complete review on preceding materials, will be able to identify and demonstrate an understanding of the four forces of lift, drag, thrust and weight (gravity), and display this understanding through oral and written analyses.

   In order to do this, the student must be able to:

   A. Identify the factors producing lift.
   B. Recognize laminar airflow illustrations.
   C. Explain:

      effective lift
      coefficient of lift
      angle of attack
      boundary layer control/laminar air flow
      wing tip vortex control

   D. Explain gravity (weight) and its implications.
   E. Identify the types of drag and the factors affecting:

      - parasite drag (form drag, skin friction, interference drag
      - induced drag (by-product of lift)

   F. Explain and calculate lift-to-drag ratio.
   G. Explain downwash and ground effect.
   H. Explain thrust.
   I. Recognize propeller design.

2. Senior high school students, having been given detailed descriptions, illustrations, audio visual presentations, NASA briefs, drawings, and model glider demonstrations, will be able to identify the aerodynamic forces in a steady state glide and explain the relationship of these forces through written and oral evaluation.

   In order to do this, the student must be able to:

   A. Explain the forces in a glide.
   B. Analyze the rate of sink of a glider.
   C. Identify the forces in a level turn of a glider.

TOPIC: 3. The Four Forces

MODULE: AEROSPACE
SUBMODULE B

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Provide the students with detailed drawings and illustrations, model airplane and glider demonstration models, and worksheets depicting the four forces: lift, drag, thrust and weight. Discuss weight. Discuss different gravitational effects. Compute the weights of objects on the earth. Draw an airfoil and the lines showing the airstream over and under it. Discuss how air lifts kites. Identify lift as the force opposing gravity. Have students make a report on why an airplane flies.

   Materials needed:

   Model airplane, model glider, pictures of aircrafts, illustrations, paper airplane, funnel and ping pong ball, films, slides, worksheets.

   Suggested films: Gravity: How It Affects Us.
   The Force of Gravity.

   Suggested references:

   Any good encyclopedia article.
   Basic Science For Aerospace Vehicles.

2. Provide students with detailed drawings, audio visual materials, descriptions, graphic illustrations, publications, demonstration models and worksheets depicting the concept of drag and drag versus thrust. Discuss the types of drag and the factors affecting each. Illustrate and discuss ground effect, lift to drag ratio and downwash. Discuss and illustrate propeller design.

   Materials needed:

   Illustrations of airfoils, effect of speed on drag; NASA briefs of experiments with wind tunnels, materials and drag, model airplane, model glider, pictures of aircraft, films, filmstrips, readings and illustrative hand-outs.

   Suggested references:

   Advanced Pilot Manual.

   Sources of Information:

   NASA - Goddard Space Flight Center
   FAA

(see resource list at the end of this submodule)

3. Provide students with graphic illustrations, descriptions, demonstrations, models and news briefs depicting the history of, the flight characteristics of and the concepts of flight for the steady state glide of the space shuttle. Discuss and illustrate the forces in the glide through demonstrations and experiments. Have the students prepare a complete report on the space shuttle and the aerodynamic characteristics, experimentation and forces related to the launch and re-entry of the vehicle.

Materials needed:

Space shuttle model, illustrations, library resources.

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INSTRUCTIONS (NOTES)

TOPICS: 1 - 3

MODULE: AEROSPACE
SUBMODULE B

$$SUGGESTED SUBMODULE RESOURCES - ADDRESSES FOR FURTHER INFORMATION

AMERICAN SOCIETY FOR AEROSPACE EDUCATION
1910 Association Drive
Reston, VA. 22901

CENTER FOR AEROSPACE EDUCATION DEVELOPMENT
Civil Air Patrol
National Headquarters
Maxwell AFB,
Alabama 36112

DIRECTOR OF AEROSPACE EDUCATION
NASA - Goddard Space Flight Center
Public Affairs Office
Code 202
Greenbelt, MD 20771

EDUCATORS' PROGRESS SERVICE
214 Center Street
Randolph, WI 53956

FAA
U.S. Government Printing Office
Library and Statutory Distributing Service
5208 Eisenhower Avenue
Arlington, VA 22304
(Send a self-addressed mailing label and request Aviation Education Materials)

NASA
Educational Programs
LFG-11
Washington, D.C. 20546

NATIONAL AIR AND SPACE MUSEUM
Smithsonian Institution
Educational Services Division
Washington, D.C. 20560

NATIONAL SOARING MUSEUM
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INSTRUCTIONS (NOTES)

TOPICS 1 - 3

MODULE: AEROSPACE
SUBMODULE B

$$SUGGESTED SUBMODULE RESOURCES - NON-PRINT (AUDIO VISUAL) MATERIALS

Basic principles of flight. Holyoke, MA. Scott Educational Division. n.d.

Controlling an airplane. Holyoke, MA. Scott Educational Division. n.d.

Flight technology. Washington, D.C. National Air and Space Museum. n.d.

Force and motion. (10 min. B&W) n.p. Coronet Films. n.d.

The force of gravity. (10 min. B&W) NY. Young America Films. 1963.

Gas pressure and molecular collisions. NY. Encyclopedia Britannica Films. n.d.

Gravity: how it affects us. (14 min. color) NY. Encyclopedia Britannica Films. 1960.

High speed flight. (20 min. B&W) Indianapolis, IN. Shell Film Library. 1976. (1433 Sadler Circle, west Dr.; free loan)

How an airplane flies. Holyoke, MA. Scott Educational Division. n.d.

How an airplane flies. Indianapolis, IN. Shell Films Library. n.d. (free loan)

An introduction to vectors: coplaner concurrent forces. NY United World, Inc. n.d. (1445 Park Avenue)

Learning about air. Falls Church, VA. Paramount Pictures, Inc. n.d. (107 Park Place)

Making things move. (11 min. color) NY. Encyclopedia Britannica Films. 1963.

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INSTRUCTIONS (NOTES)

TOPICS: 1 - 3

MODULE: AEROSPACE
SUBMODULE B

$$SUGGESTED SUBMODULE RESOURCES - PRINT MATERIALS

Adams, Frank D. Aeronautical dictionary. Washington, D.C. NASA. 1969.

Ames, Lee J. Draw 50 airplanes, aircraft and spacecraft. NY. Doubleday. 1977

Aviation Education Catalog. Englewood, CO. Jeppeson-Sanderson Co. n.d. (55 Inverness Drive, East, 1-303-799-9090).

Basic sciences for aerospace vehicles. 4th ed. NY. McGraw-Hill Book Co. 1972.

Bauer, Frances. Supercritical wing sections. n.p. Springer-Verlag. 1975.

Civil Air Patrol. Aerospace: the challenge. Washington, D.C. CAP. 1983.

Demonstration aids for aviation education. Washington, D.C. FAA. n.d.

Elmer, James D. Theory of aircraft flight. Washington, D.C. Air Force Junior ROTC. 1974.

FAA. Pilot's handbook of aeronautical knowledge. Washington, D.C. U.S. Dept. of Transportation. 1979.

Jeppeson-Sanderson. Advanced pilot manual. Englewood, CO. Jeppeson-Sanderson, Inc. 1977.

Keem, Martin L. How it works. (volume 1 and 2) NY. Grossett and Dunlap Co. 1974.

Martin, Elizabeth F. Aerospace activities for learning and fun. n.p. n.d.

McGraw-Hill encyclopedia of science and technology. NY McGraw-Hill Book Co. 1984.

Momdey, David. The international encyclopedia of aviation. n.p. 1977.

Krajck, James E. The glider war. NY. St. Martin's Press. 1976.

Philpott, Bryan. Making a model aircraft. NY. Scribner's. 1978.

Talay, Theodore A. Introduction to the aerodynamics of flight. Washington, D.C. NASA. 1976.

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INSTRUCTIONS (NOTES)

PHASE: CONCENTRATION ELEMENT: TECHNOLOGY

MODULE: AEROSPACE

SUBMODULE: C. NAVIGATION/COMMUNICATIONS

TOPICS:
1. The Earth
2. Chart Reading
3. Methods of Navigation
4. Radio Communications

PREREQUISITES:
Aerospace Overview
Submodule A: Historical Evolution of Aerospace
Submodule B: Fundamentals of Flight

$$PREPARED BY
$$G. EDWARD McILHENNY
$$DEPARTMENT CHAIRPERSON - INDUSTRIAL ARTS
$$PAUL D. SCHREIBER HIGH SCHOOL
$$PORT WASHINGTON, NEW YORK 11050

TOTAL TEACHING TIME:
SUBMODULE C: 6 hours

DATE: August 31, 1984

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TOPICS: 1 - 4

MODULE: AEROSPACE
SUBMODULE C

$$OVERVIEW OF SUBMODULE

GOALS:

The purpose of this submodule is to present the normal evolution and development of a safe and satisfactory means of traversing the earth while fulfilling human needs and desires to extend their horizons. Areas of aerospace development to be investigated and discussed in this segment will include:

1. The Earth
2. Chart and Map Reading
3. Methods of Navigation
4. Radio Communications

DESCRIPTION:

During humans' early quest for knowledge, strength and power, people walked the countryside, but always around mountains they could not climb. People sailed, but always around protruding land masses. Humans flew over land and sea to any and all points beyond. To find their way, they looked at landmarks. They gazed into the sky and found stars to guide them. Later, humans also developed highly complex mechanical and electronic devices and systems to provide guidance throughout their travels.

To make an airplane truly useful, it was evident that some further means would have to be devised and perfected to aid the pilot in finding his way, particularly at night and during other adverse conditions. A primitive system consisted of bonfires lighted at predetermined times. Another system consisted of lighted beacons, but they were only effective when the visibility was good, at night. The first radio aid, introduced in 1925, was an aural system, "A" and "N" was transmitted to the plane receiver in Morse Code. This developed into airways and was quite successful. It was known as the Adcock Low Frequency Radio Range. Some may still be in use in foreign countries today. This system phased out gradually in the United States with the coming of the many and varied visual radio nav-aids.

SKILLS, KNOWLEDGE, BEHAVIORS TO BE DEVELOPED:

Upon completion of this submodule, it is intended that the student will have sufficient knowledge to be able to:

1. Develop and understand map and chart reading skills.
2. Increase his/her scientific knowledge of the laws and principles which apply to navigation.
3. Improve mathematical skills through the solution of navigational problems.
4. Understand the international significance of great circle routes.

5. Improve language skills through the use of radio transmission techniques, phraseology, and an enlarged vocabulary (practiced in trainer).

And, for the student who becomes involved in pilot training, this unit is intended to help him/her:

6. Understand basic principles of cross country (x-c) flying.
7. Know basic flight planning procedures.

If an orientation flight is to be a part of aerospace technology, it is recommended that one or more short "cross country" flights be scheduled at or near the completion of this submodule. Any of the local fixed base operators should be able to assist with this phase.

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INSTRUCTIONS (NOTES)

TOPIC: 1. The Earth

MODULE: AEROSPACE
SUBMODULE C

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been presented with detailed visual and verbal descriptions, will be able to recognize the origin of travel needs as visualized by the pioneers of the aviation industry.

   In order to do this, the student must be able to:

   A. Recognize the earth and its size, shape and location relative to the sun.
   B. Understand the basic movements of the earth (rotation).

2. Senior high school students, having been exposed to demonstrations, verbal descriptions, discussions, and audio visual materials, will be able to understand the early development and need for maps and charts.

   In order to do this, the student must be able to:

   A. Understand the following:

      1. Latitude - Temperature:

         a. That latitude is measured North and South of the equator to the poles (0 to 90 degrees).
         b. The major lines of latitude.

      2. Longitude - Time:

         a. That longitude is measured East and West from the Prime Meridian to the International Date Line. (Monday in the United States is Tuesday in Japan.)
         b. That there are four time zones in the continental United States.
         c. That Greenwich Mean Time (GMT/ZULU) is standard internationally.

      3. Great Circle Routes:

         a. The comparison to Rhomb Line Routes.

      4. Projections:

         a. Distortion of shape and size (flattening of grapefruit peel).
         b. Types of projections, such as the Lambert Conformal conical and the Mercator.

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TOPIC: 1. The Earth

MODULE: AEROSPACE
SUBMODULE C

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Have the students compute the time of day in major cities of the world, indicating the day of the week and daylight or night, for a given time of day in their hometown.

Materials needed:

World globe, various maps and projections, navigation kit #JS257023 - Jeppeson Sanderson, overhead projector, screen, charts, information sheets, models and mock ups prepared by the teacher or students.

Suggested references:

Aviation Fundamentals. Jeppeson-Sanderson

2. Have the students compare different seasons North and South of the equator.

Materials needed:

Items listed in #1 plus library research materials.

3. Prepare a demonstration using an orange or grapefruit peel with some common shape sketched on its surface and slowly flatten to illustrate the distortion associated with "projections".

Materials needed:

Items listed in #1, plus a grapefruit or orange peel (one-half).

~~TOPIC: 2.~~ Chart Reading

MODULE: AEROSPACE
SUBMODULE C

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been presented with detailed descriptive information, charts, and supporting audio visual materials, will be able to read and understand the many varied charts used by the pilot in order to take off, navigate and land safely at all times (day or night), including under adverse weather conditions.

In order to do this, the student must be able to:

A. Read, understand and use the following aeronautical charts:

1. Sectionals: 1:500,000 (approximately eight statute miles to the inch)
2. World Aeronautical Charts (WAC): half of sectional scale, 1:1,000,000 (approximately 16 statute miles to the inch).
3. Terminal Area Charts (TCA) for Visual Flight Rules (VFR): 1:250,000 scale
4. VFR/IFR Planning Charts (IFR - Instrument Flight Rules): 1:2,333,232 scale. (Very large charts, often affixed to the wall in briefing rooms and fixed base operator (FBO) flight planning areas.)
5. IFR Low Altitude Enroute Charts: made with various scales.
6. IFR Approach Plates, including:
   a. VOR (very high frequency OMNI)
   b. TACAN (tactical air navigation)
   c. ADF/NDB (automatic direction finding or non-directional beacon)
   d. ILS (instrument landing system)
   e. Microwave landing system
7. Topographic information and aeronautical data that must be learned from varied charts, including:
   a. the area
   b. the date
   c. the colors
   d. the symbols (legend)
   e. the radio NAV-AIDS, facility and frequency, such as: NDB (non-directional radio beacon), ADF (automatic direction finding), VHF (very high frequency OMNI), vector airways and miscellaneous frequencies displayed, FSS (flight service stations), CT (control towers), UNICOM, etc.

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INSTRUCTIONS (NOTES)

TOPIC: 2. Chart Reading

MODULE: AEROSPACE
SUBMODULE C

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Select the charts (VFR/IFR) in the proximity of the geographic location of the high school. Show and discuss known points of interest.

Materials needed:

Various charts, sectional and low altitude enroute. (preferably of the local area), supporting audio visual materials and references, filmstrip projector and screen.

Suggested filmstrip and cassette:

Aeronautical Charts. Jeppeson-Sanderson. (Catalog #JS200238) 22 min.

Suggested references:

Aviation Fundamentals. Jeppeson-Sanderson
Pilot's Handbook of Aeronautical Knowledge. U.S. GPO.
Airman's Information Manual. U.S. GPO.
various Advisory Circulars (AC's). U.S. GPO.
New York State Aerospace Resources Guide. R.J. Ullery.

2. Measure and record distances, altitude, magnetic directions, etc. to places commonly visited.

Materials needed:

See #1.

3. Compare aeronautical charts with road maps.

Materials needed:

Items in #1, plus road maps and atlases.

4. Develop an awareness of the topographical features in the student's own community.

Materials needed:

See #1.

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INSTRUCTIONS (NOTES)

~~TOPIC: 3.~~ Methods of Navigation   MODULE: AEROSPACE
SUBMODULE C

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having completed Topic #2 (Chart Reading) and being exposed to continued detailed descriptions and supporting audio visual materials concerning the methods of navigation, will be able to understand the evolution and development of the various systems and nav-aids available to the pilot from the very basic to the highly complex electronic systems used today.

In order to do this, the student must be able to:

A. Use charts previously studied to plan local and cross country flights.

B. Plan and present detailed flights to the class, such as:

   1. Pilotage - (landmark to landmark)
   2. Dead reckoning - (point to point), including details such as:

      a. true course
      b. magnetic heading
      c. magnetic variation
      d. deviation (compass error)
      e. wind correction
      f. ground speed (GS)

C. Identify and utilize the following "tools":

   1. Plotter
      a. protractor portion (course direction)
      b. straight edge (course line and distance)
      c. scales (WAC and Sectional)
   2. Mechanical Flight Computer (calculator and wind faces)
      a. time, speed and distance
      b. fuel consumption
      c. true airspeed (TAS)
      d. density altitude
      e. conversions
      f. wind triangle
   3. Electronic Flight Computer (including arithmetic computations, conversions and navigation modes)
      a. addition and subtraction
      b. multiplication and division
      c. lb. to kg/kg to lb.
      d. ft. to m/m to ft.
      e. NT (knots) to KM/KM to NT
      f. gallons to liters/liters to

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gallons
g. Fahrenheit to Centigrade/ Centigrade to Fahrenheit
h. density altitude
i. standard temperature
j. true airspeed (TAS)
k. wind correction
l. ground speed (GS)
m. time and distance
n. fuel consumption

2. Senior high school students, having been given detailed descriptions, participated in discussion periods, using appropriate audio visual materials (including selected references), will be able to understand many of the nav-aids utilized in flight today.

In order to do this, the student must be able to:

A. List and describe the following nav-aids: (The ability to use the nav-aids studied can be demonstrated on an instrument procedural trainer, if available.)

1. Very high frequency omni directional range (VOR) VHF omni is the most popular and easiest to use.
    a. frequencies
    b. directional advantages
    c. line of sight
    d. accuracy
    e. VHF omni receiver components including: course deviation indicator (CDI); omni bearing selector (OBS); and the "to" - "from" indicator
    f. VOR radials- labeled 0-360 degrees like the spokes of a wheel and are always "out from". They form vector (V) airways, are used in position fixing and are also used as test signals (VOT's).

2. TACAN System (tactical air navigation)
    a. used largely by the military
    b. used by general aviation when incorporated with distance measuring equipment (DME)
    c. includes also the VORTAC system VOR and TACAN integrated on the same sight

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INSTRUCTIONS (NOTES)

3. Distance measuring equipment (DME)
   a. aircraft tranceiver, including VHF and UHF frequencies
   b. distance and ground speed are displayed in nautical miles and knots
   c. slant distance error must be accounted for

4. Area Navigation System (RNAV)
   a. permits better use of airspace due to more lateral freedom (safer)
   b. relieves heavily used enroute nav-aids
   c. provides direct routes

5. Doppler Radar
   a. is used to determine direction and rate of movement
   b. relates on a visual display, through use of a computer, the aircraft's position and desired course

6. Inertial Navigation System (INS)
   a. a long range, highly efficient system used largely by scheduled airlines, corporate aircraft and the military
   b. a complex "stable table" consisting of two gyroscopes and three accelerometers, sensing all directional changes and acceleration
   c. with the aid of a computer, all inputs give course information, distance, time, etc.

7. LORAN C - long range navigation system primarily designed for marine use

   a. presents present position (lat/long.), bearing, distance, ground speed, time to waypoint

8. Automatic direction finding system (ADF)
   a. covers frequencies 20 KHz through 415 KHz
   b. includes amplitude modulation (AM) broadcast band
   c. provides means for tracking, homing "to and from" the station

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INSTRUCTIONS (NOTES)

9. <u>Transponder/Airborne Interrogator</u> (RADAR)
   a. modes A and C - position and altitude
   b. codes include - VFR/IFR procedures emergencies, radio failure, etc.

10. <u>Instrument Approaches</u>
   a. VFR - visual and contact
   b. IFR - VOR, ILS, ADF, etc.

TOPIC: 3. Methods of Navigation MODULE: AEROSPACE
SUBMODULE C

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Present detailed flight planning techniques to the class using appropriate charts and teaching aids. Have the class members (individually) plan separate cross country (x-c) flights within close proximity of the local airport.

Materials needed:

Various aeronautical charts, supporting audio visual materials, VOR/ADF magnetic trainer (available from Jeppeson/Sanderson), student plotters, bicycle wheel weighted and balanced, and a toy gyroscope, filmstrip projector and screen, trainer ATC 610 or GAT I.

Suggested audiovisual materials:

DME, AREA NAV, and ADF. (Catalog #JS200246)
Basic Radar and Transponder (Catalog #JS200248)

Suggested references:

Aviation Fundamentals. Jeppeson-Sanderson
Pilot's Handbook of Aeronautical Knowledge. U.S. GPO.
Various manufacturers' advertising literature,
ie. Texas Instruments
NARCO
ARNAV
Morrow
Century
Cessna
Beech
Mooney
New York State Aerospace Resources Guide. R.J. Ullery.

2. Take the class on field trips to an air traffic control center, control tower, flight service station or other locally available facilities.

3. Invite guest speakers, professionals in the aviation industry, such as pilots, FAA inspectors, air traffic controllers and avionic manufacturer representatives to address the class on the area of navigation. Have the class take notes of the lecture for their notebooks. Tape the lectures, if possible.

Materials needed:

Student notebooks, video tape equipment.

TOPIC: 4. Radio Communications MODULE: AEROSPACE
SUBMODULE C

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been given detailed oral and written descriptions, supported by audio visual presentations, will be able to understand that the major portion of air traffic control is based on voice communications.

In order to do this, the student must be able to:

A. Demonstrate a mastery of the following subject areas to the teacher's satisfaction:

1. Aircraft transceivers:
   a. communication frequencies
   b. navigation frequencies
   c. Simplex or Multiplex operation

2. Correct use of the microphone:
   a. position
   b. normal level voice transmission
   c. keying

3. Radio phraseology:
   a. International Civil Aviation Organization (ICAO) - established English as the international language to be used
   b. phonetic alphabet
   c. radio phrases to aid in decreasing transmission time
   d. frequency limitations -L/MF 30-300KHz/300-3000KHz, HF 3000-30,000KHz, VHF 30MHz - 300MHz, UHF 300-3000MHz
   e. characteristics and limitation of procedures used

TOPIC: 4. Radio Communications

MODULE: AEROSPACE
SUBMODULE C

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Instruct the students to recognize the importance of correct usage of the aircraft radio by presenting to them both written and audio visual materials to enable them to practice correct voice procedures. If an appropriate instrument procedural trainer is available, have each student act as pilot in command or as an FAA air traffic controller.

Materials needed:

Information sheets, radio panel mock ups, supporting audio visual materials, projector and screen.

Suggested filmstrip and audio tape:

Radio Communications and ATC. (Catalog #JS200304)
Jeppeson/Sanderson

Suggested guest speakers:

professional pilot
air traffic controller
FAA flight instructor

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INSTRUCTIONS (NOTES)

TOPICS: 1 - 4

MODULE: AEROSPACE
SUBMODULE C

$$SUGGESTED SUBMODULE RESOURCES - ADDRESSES FOR FURTHER INFORMATION

ARNAV SYSTEMS, INC.
Mr. Dennis Nichols
4740 Ridge Drive, NE
P.O. Box 7078
Salem, OR 97303-0012

BEECH AIRCRAFT CORPORATION
Wichita, KS 67201

CENTURY FLIGHT SYSTEMS, INC.
P.O. Box 610
Municipal Airport
Mineral Wells, TX 76067

CESSNA AIRCRAFT CORPORATION
Wichita, KS 67201

KING RADIO CORPORATION
400 North Rogers Road
Olathe, KS 66062

MOONEY AIRCRAFT CORPORATION
Box 72
Kerrville, TX 78028

MORROW, INC.
P.O. Box 13549
Salem, OR 97309

NARCO AVIONICS, INC.
Fort Washington, PA 19034

NASA AUDIO VISUAL, LFD.
NASA Headquarters
Washington, D.C. 20546

TEXAS INSTRUMENTS, INC.
Avionic Products
P.O. Box 405, M/S 3438
Lewisville, TX 75067

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INSTRUCTIONS (NOTES)

TOPICS: 1 - 4

MODULE: AEROSPACE
SUBMODULE C

$$SUGGESTED SUBMODULE RESOURCES - NON-PRINT (AUDIO VISUAL) MATERIALS

Filmstrip titles:

Aeronautical Charts. (1978, 22 min.) Catalog #JS200238
Basic Radar and Transponder. (1984, 27 min.) Catalog #JS200248
DME, Area Nav, and ADF. (1978, 18 min.) Catalog #JS200246
Flight Computer - AVSTAR Electronic. (2) (1980, 57 min.) Catalog #JS200468
Flight Computer EGB. (2) (1972, 47 min.) Catalog #JS200220
Plotter and the Wind. (1972, 25 min.) Catalog #JS200240
Radio Communications and ATC. (1981, 21 min.) Catalog #JS200304

Available from:

Jeppeson/Sanderson
55 Inverness Drive, East.
Englewood, Colorado 80112-5498

Films:

Films of interest (16mm, color, sound) are available on free loan from:

Grumman Aerospace Corporation
Bethpage, New York 11714

These films have to do with the history and development of all aircraft manufactured by Grumman, and their roles in the military. Some examples are:

Sea Legs. (15 min., color, 1977) - carrier aircraft.
One of a Kind. (14 min., color, n.d.) - weapon control system of the F-14.
Five Tactical Aircraft. (13 min., color, n.d.) - F-14, E-2C, A-6E, EA-6B, and EF111.

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INSTRUCTIONS (NOTES)

TOPICS: 1 - 4

MODULE: AEROSPACE
SUBMODULE C

$$SUGGESTED SUBMODULE RESOURCES - PRINT MATERIALS

Advisory circulars. (AC61-27C and AC00-6A). Washington, D.C. U.S. GPO. n.d.

Airman's information manual. Washington, D.C. U.S. GPO. n.d.

Aviation fundamentals. Englewood, CO. Jeppeson/Sanderson. 1983. (Catalog #JS315334)

New York State aerospace resources guide. (R.J. Ullery, ed.) Albany, NY. New York State Education Department. 1982.

Pilot's handbook of aeronautical knowledge. Washington, D.C. U.S. GPO. n.d.

Periodicals of Interest:

AIR TRANSPORT WORLD
P.O. Box 95759
Cleveland, OH 44101

AOPA PILOT
Aircraft Owners and Pilots Association
421 Aviation Way
Frederick, MD 21701

AVIATION AND SPACE MAGAZINE
Aerospace Education Association
1910 Association Drive
Reston, VA 22091

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INSTRUCTIONS (NOTES)

PHASE: CONCENTRATION ELEMENT: TECHNOLOGY

MODULE: AEROSPACE

SUBMODULE: D. METEOROLOGY/FLIGHT PHYSIOLOGY

TOPICS:
1. The Atmosphere
2. Weather Phenomina
3. Flight Physiology

PREREQUISITES: Aerospace Overview

$$PREPARED BY
$$THOMAS W. NORTON
$$LINTON HIGH SCHOOL
$$SCHENECTADY, NEW YORK 12308

TOTAL TEACHING TIME:
SUBMODULE D: 6 hours

DATE: September 7, 1984

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INSTRUCTIONS (NOTES)

TOPICS: 1 - 3

MODULE: AEROSPACE
SUBMODULE D

$$OVERVIEW OF SUBMODULE

GOALS:

Upon completion of this submodule, students will be able to:

1. Know the composition of our planet's atmosphere and its physical properties.
2. Describe the large scale and small scale motions that it undergoes and understand their basic causes.
3. Analyze the weather elements presented on a surface weather map, and state the local weather conditions depicted.
4. Examine the atmosphere as a flight environment.
5. Understand the effects that the flight environment can have on the human body.

DESCRIPTION:

The atmosphere is a uniquely constructed, very thin shell of gases and particles surrounding the solid and liquid portions of our earth. It is subject to constant changes, yet within limits, remains sufficiently uniform to sustain life for long times. When viewed on the global scale, its behavior demonstrates the majesty and power of nature, causing us to appear as insignificant specks on our planet, in the same way one would feel in the middle of the ocean or desert. When viewed on the smaller scale, its power frequently appears awesome because of the disruptions to our dailiy living by such distrubances as hurricanes, typhoons, etc., which can be devastating. On a personal level, its rain can spoil our picnic plans.

The atmosphere's influence on us is much greater than ours is on it, but we can maintain our sense of personal significance by understanding the basic principles that control its motions in response to our innate sense of curiosity. It is really intriguing to understand what is going on and why. Thus, it is appropriate for us to study in detail the properties and and dynamics of this flight environment. We can understand the laws and principles which govern its motions and actions, even though we cannot control them. The topic is one of the most important areas of knowledge for the aviator if he or she expects to fly from here to there safely. We ignore this great power at our peril.

SKILLS, KNOWLEDGE, BEHAVIORS TO BE DEVELOPED:

SKILLS: Perform measurements and calculations related to the weather elements, monitor and record data, identify cloud types and weather patterns, read weather maps and charts.

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INSTRUCTIONS (NOTES)

KNOWLEDGE:

1. The composition, physical quantities, properties, circulation patterns and dynamics of the atmosphere.
2. Weather data collection and depiction techniques.
3. Weather elements and their relationships to air masses, fronts and cyclonic storms.
4. Special weather-related hazards to flight.
5. Physiological limitations of humans in the flight environment.

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INSTRUCTIONS (NOTES)

TOPIC: 1. The Atmosphere

MODULE: AEROSPACE
SUBMODULE D

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been given detailed lectures, written descriptions and supporting audio visual materials, will be able to state the composition and extent of the atmosphere, understand the causes of its motions and the changes it undergoes.

In order to do this, the student must be able to:

A. Identify the fixed and variable components of the atmosphere and their amounts, and define the physical quantities that are used to describe their single and collective behavior.

Examples:

1. Fixed Components (and volume, by percentage):

Nitrogen	78.09%
Oxygen	20.95%
Argon	0.93%
Carbon dioxide	0.03%
Neon	0.0018%
Helium	0.00052%
Krypton	0.0001%
Hydrogen	0.00005%
Xenon	0.000008%
Ozone	0.000001%

2. Variable Components:

Water vapor
Particulates
Hydrocarbons
Pollutants
Pollen
etc.

3. Quantities:

mass
density
pressure
temperature
moisture
winds
insolation altitude
latitude
time
gradients

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B. Describe the global and local circulation patterns and their causes.

Examples:

1. Examine the flow of air vertically and horizontally.
2. One cell, non-rotating earth model (due to temperature differences only).
3. Three cell pattern (showing trade winds, prevailing westerlies, doldrums, polar fronts, convergence and divergence zones, etc.) (See reference: Earth Science: the World We Live In, page 532.)

C. List the major types of air masses, their characteristics and origins, and relate their motions and changes to the global circulation patterns.

Examples:

See reference: Aerospace: the Challenge, page 2-20, figure 2-18.

D. List and define the various types of fronts and state their properties, motions and effects.

Examples:

1. Cold, warm, stationary, occluded...
2. See reference: Aerospace: the Challenge, page 2-22, figure 2-23.

E. Characterize the four stages in the life cycle of a cyclonic storm from origin, youth, maturity and old age, and show the frontal system and weather conditions associated with each.

Example:

See reference: Meteorology. page 220, figure 9-6.

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INSTRUCTIONS (NOTES)

TOPIC: 1. The Atmosphere

MODULE: AEROSPACE
SUBMODULE D

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Provide the students with written, oral and graphical descriptions of the kinds of atoms and molecules which make up the atmosphere.

Suggested class exercises:

A. Plot a graph illustrating the vertical distributions of these components individually. (See reference: Meteorology, page 15, figure 1-8.)

B. Plot graphs showing the collective behavior by showing pressure, temperature, density, etc. variations with altitude.

Materials needed:

Graph paper, library resources, or standard meteorology text.

Suggested references:

U.S. Standard Atmosphere - 1984
Handbook of Physics and Chemistry

Examples:

See reference: Meteorology, page 50, figure 3-8.

2. Having prepared a large scale diagram ahead of time, have the students make a similar diagram showing the vertical extent of the atmosphere, labeling the major zones and their altitudes. Have them determine the variations in altitude that occur depending upon latitude and season.

Materials needed: Graph paper

Suggested reference:

U.S. Standard Atmosphere - 1984, or other reference.

Example:

See reference: Aerospace: the Challenge, pages 2-4 and 2-5, figures 2-2 and 2-3.

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3. Have the students list and give the technically correct definitions of the quantities that determine the condition of the atmosphere. NOTE: Be sure that they include the correct units for each.

Examples:

Temperature: wet bulb, dry bulb, maximum, minimum, mean, dew point
Temperature gradient
Density
Pressure
Pressure gradient
Wind: direction, velocity, gusts
Visibility
Absolute humidity
Relative humidity
Precipitation: various types and amounts

Materials needed:

Library resources, worksheets, meteorology textbook.

4. Have the students list and describe the principle of operation of the instruments used to measure these quantities, such as thermometers of various types, thermographs, barometers of various types, barographs, altimeters, wind vane, anemometer, hygrometer, rain gauge, ceilometer, rawinsonde, weather radar, rocket soundings, psychrometer, nephelometer, etc.

Materials needed:

Standard meteorology text, weather instrument supply company catalogs (ie. Weathertronics, Federal Meteorological Handbook), worksheets, library resources.

5. Have the students research and actually construct meteorological instruments, calibrate them and then use them to obtain routine weather data over weeks or months. Have them make oral presentations to the class regarding the instrument features, their calibrations results and the data they have collected.

Examples:

Instrument shelter: Why does it have the following features: four feet above the ground, white, double roof, louvred sides, vented floor, lock and key, anchored to the ground, sloping roof, door hinged on the bottom? The standard enclosure size is 30" x 20" x 32".

Turbidity meter: related to visibility. For construction details, see reference: Solar Energy Experiments, pp. 37-51.

Sling psychrometer: constructed from two standard thermometers, one with a 1-1/2 inch wick attached to its base, and mounted securely so that they may be twirled rapidly to evaporate water from the wick. From the dry bulb and the wet bulb (lowest possible reading) temperatures, the dew point temperature can be determined from suitable tables. Use the Earth Science Reference Tables, available from the Bureau of Secondary Science, NYS Education Department.

Example: "The Home Weatherman", one student's project, is summarized in: Weather. (Life Science Library). Time-Life Co. 1965. pp.160-71.

6. Following detailed written,oral and graphic presentations, have the students:

   A. Describe the idealized single cell global circulation patterns (horizontal and vertical) which would occur if the earth were not rotating.
   B. Explain the cause of horizontal and vertical air movements, including pressure gradients and temperature differences which give rise to density differences. NOTE: Make sure they understand that the cold, more dense air (not heavier) pushes up the warmer air against gravity. Warm air doesn't just rise, it is pushed up.
   C. Show how the spin of the earth causes deflection of the moving air to the right in the Northern hemisphere, resulting in the three-celled circulation pattern. (see Instructional Strategy #7)
   D. Relate the horizontal flow of air to the prevailing winds and the zones of convergence and divergence, as well as the resulting pressure patterns. Have them tell how these zones shift in latitude during the various seasons. (See reference: Earth Science: the World We Live In, pages 532, 536 - diagrams)

Materials needed:

Student notebooks, library resources, textbooks, worksheets.

7. Have the students draw a diagram of the global circulation pattern, showing both the North-South motion and the upward and downward vertical motions.

Materials needed:

See reference: Aerospace: the Challenge, page 2-15, figures 2-11 and 2-12.

8. Following detailed written and oral explanations, with appropriate visual aids and charts, have the students:

   A. Analyze the global heat balance showing how the earth transfers the insolation by conduction, convection and radiation.
   B. Show how the heat flow is affected by the horizontal and vertical motions of the air.
   C. Explain how temperature inversions are formed.
   D. Discuss the stability of the air based upon temperature and density differences, and show the influence that the moisture content of the air has on it as a result of it being pushed upward, cooled to its dew point, and then condensed. Have them list the major causes of the upward motion of the air (ie. air mass instability, frontal passage, passing over mountains).

<u>Materials needed:</u>

Charts, worksheets, notebooks, library resources.

9. Invite a meteorologist from your area to discuss with the class the kind of information that he/she must have in order to prepare a forecast. Contact the nearest National Weather Service Office, NOAA, Meteorology Department of a local college, or the local television meteorologist.

<u>Materials needed:</u>

Audio or video tape, to record the guest speaker.

10. After having given detailed oral, written and graphic presentations, have the students:

   A. Explain how air masses are classified. (According to temperature and moisture content.)
   B. List six (6) main types of air masses.
   C. Describe the source regions for each and locate those found in North America. (<u>See reference</u>: <u>Aerospace: the Challenge</u>, page 2-20, figure 2-18)
   D. Explain how temperature and moisture conditions of an air mass change as the air mass moves over:

      continents
      water
      mountains
      other air masses

<u>Materials needed:</u>

Student notebooks, charts, textbooks.

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INSTRUCTIONS (NOTES)

Suggested references:

Aviation Weather.
Aerospace: the Challenge
any standard Earth Science textbook

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INSTRUCTIONS (NOTES)

TOPIC: 1. The Atmosphere

MODULE: AEROSPACE
SUBMODULE D

$$EXTENDED AREAS OF STUDY

1. Study the chemistry of each of the components of the atmosphere and their reactions. Study the properties of the gases and particulates that are present in trace amounts, yet have a great influence on us and the weather, such as:

    condensation nuclei
    nitrogen and sufur oxides
    lead
    ozone
    contaminents
    photochemical smog
    excess carbon dioxide

2. Assign a student to research and report to the class the various types of weather satellites that are currently being used, their names, instrumentation, data collected, mission, etc. Have them write to NOAA and NASA for up-to-date information.

3. Have students study some of the upper air characteristics, including:

    pressure ridges
    troughs
    jet streams
    inversions

TOPIC: 2. Weather Phenomina   MODULE: AEROSPACE
SUBMODULE D

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been given detailed lectures, written descriptions, and supporting audio visual materials, will be able to relate the everyday weather phenomina to the local and global circulation patterns studied in the previous topic.

In order to do this, the student must be able to:

A. Identify the major quantities displayed in a weather map station model and list the names of the instruments used to collect these data.
B. Locate and explain the major features presented on a surface weather map.
C. Tell how clouds are classified, list 10 major cloud types and relate the typical weather conditions or systems associated with each.
D. List the types of severe weather and weather-related hazards to flight.

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INSTRUCTIONS (NOTES)

TOPIC: 2. Weather Phenomina

MODULE: AEROSPACE
SUBMODULE D

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Provide the students with detailed descriptions of the stational model, explaining how it summarizes a lot of data in a small space.

   A. Have the students list the appropriate data in the proper position. Include wind direction and speed, cloud cover, temperature, dew point, pressure, visibility, restrictions to visibility, precipitation and pressure trend.

   Materials needed:

   Library resources, stational model, worksheets.

2. Obtain from a scientific educational supply company, local weather bureau, meteorology department of a nearby college or other source, a set of weather maps for individual study. Have the students identify:

   high and low pressure centers
   significant wind change boundaries
   temperature boundaries
   isotherms
   isobars
   areas of precipitation
   fronts
   overcast cloud cover areas

   Materials needed:

   Information sheets, weather maps, worksheets.

3. Provide students with detailed written and visual descriptions showing how clouds are classified according to altitude and structure. Have them relate these to the various frontal systems. (See also, Instructional Strategy #4.)

   Materials needed:

   Information sheets, cloud chart, worksheets.

   Cloud chart available from many weather equipment supply companies, such as: Weathertronics. Distributed by C.C. Marketing, P.O. Box 1122, Glen Allen, VA 23060.

4. Class Activity: Every day, for several weeks, spend ten minutes with the class outdoors, observing the local cloud cover and cloud types. Collect additional weather data (listed in other strategies) routinely. See if students can relate the present weather and cloud conditions to predict future weather.

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INSTRUCTIONS (NOTES)

5. Have the students prepare a list of various severe weather phenomina and hazards to flight. Next to each, have them tell how a pilot, while making pre-flight preparations and decisions, might be able to overcome them and make a safe, successful flight.

Examples to consider:

- thunderstorms
- tornadoes
- cyclones
- typhoons
- hurricanes
- precipitation of various types (snow, rain, fog, hail, sleet, freezing rain, rime ice)
- wind
- turbulence
- wake turbulence
- wind shear
- runway conditions
- icing on the air frame
- density altitude
- carbureator icing

Materials needed:

Sources of information:

National Weather Service
(contact the local branch in your area)

Films:

A variety of free loan films are available through:

Modern Talking Picture Service
Film Scheduling Center
5000 Park Street
St. Petersburg, FL 33709
(1-813-541-5763)

Slide lectures:

Order Section
National Audiovisual Center
General Services Administration
Washington, D.C. 20409
(1-301-763-1869)

Information regarding NOAA/NWS Hazard Awareness publications and audio visuals can be obtained from:

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National Weather Service Disaster Preparedness
Staff (W/OM11x1)
Attn: Dick Wood
8060 13th Street
Silver Springs, MD 20910
(1-301-427-8090)

<u>Free materials:</u>

<u>FAA Adivsory Circulars:</u>

00-30	Clear air turbulence
00-50A	Low level wind shear
20-73	Aircraft icing protection
20-117	Ground deicing and ground operations
90-23D	Wake turbulence
91-13C	Cold weather operation of aircraft
150/5200-23	Airport snow and ice control
00-2XX	Advisory circular checklist

<u>FAA Accident Prevention Program pamphlets:</u>

FAA P-8140-2	Density altitude
-12	Thunderstorms
-24	Winter flying
-40	Wind shear

<u>Send requests to:</u> Department of Transportation
Subsequent Distribution Unit
Washington, D.C. 20590

JOB NO.

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INSTRUCTIONS (NOTES)

TOPIC: 2. Weather Phenomina

MODULE: AEROSPACE
SUBMODULE D

$$EXTENDED AREAS OF STUDY

1. From a surface weather map, prepare a blank map showing only the station model locations and their data. Have the students draw from these:

   isobars
   fronts
   cloud cover
   isotherms
   etc.

   Be sure to have them label the centers of high and low pressures.

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TOPIC: 3. Flight Physiology MODULE: AEROSPACE
SUBMODULE D

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been given detailed lectures, written and audio visual materials and descriptions, will be able to understand the limitations imposed by the human body as it functions in the flight environment.

In order to do this, the student must be able to:

A. List the physiological phenomina which are of concern to the aviator, state their impact on the body and on human performance, and tell how these limitations can be overcome to make flying safe.

Examples:

Effects of altitude, including hypoxia
ear and sinus blocks
decompression after scuba diving
vertigo
g-forces
disorientation
illusions in flight
effects of diet
medication
alcohol
fatigue
stress
emotion
illness

TOPIC: 3. Flight Physiology

MODULE: AEROSPACE
SUBMODULE D

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Present detailed descriptive information to the class outlining the physiological problems of hypoxia, vertigo, g-forces, disorientation and effect of diet, including drugs and alcohol. Assign each student one of these problems to research in detail and report to the class.

Materials needed:

Library resources, information sheets, audio visual materials.

Suggested films:

Hypoxia (16 min.)
Medical Facts for Pilots (25 min.)

Available from: Ward Shandoff
Accident Prevention Specialist
FAA
Albany GADO
Albany Airport
Albany, NY 12211

Free information:

Accident prevention pamphlets:
FAA-P-8740-41 - Medical facts for pilots
-38 - Human behavior: the #1 cause of accidents
FAA-APA-PG7 Guide to FAA publications

Advisory circulars:
00-52 Ozone irritation during high altitude flight
20-32B-CO Contamination in aircraft
20-68B Recommended radiation safety precautions for airborn western radar
36-2A Measured or estimated airplane noise levels
36-3C Estimated airplane noise levels in A-weighted decibels
60-4 Pilots spatial disorientation
91-35 Noise, hearing damage and fatigue in general aviation pilots
91-36B-VFR flight near noise sensitive areas

Order from: U.S. DOT
M-494.3
Washington, D.C. 20590

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INSTRUCTIONS (NOTES)

FAA Film Catalog:

37 color motion picture films on 16mm are described, along with order information.

Write to: Public Inquiry Center
APA-430
FAA
Washington, D.C. 20591

Additional information:

1. Aeromedical Reports (555 reports listed in the Index to FAA AAM Reports, 1961-82),available from:

   FAA Aeronautical Center, AAC-140
   P.O. Box 25082
   Oklahoma City, OK 73125
   (cost: $11.50)

2. Airman's Information Manual (medical facts for pilot's section gives summaries of physiological phenomina of flight). Topics include:

   fitness for flight
   effects of altitude
   hyperventilation in flight
   carbon monoxide poisoning in flight
   illusions in flight
   vision in flight
   aerobatic flight

   Available by quarterly subscription from:

   Superintendent of Documents
   U.S. GPO
   Washington, D.C.

3. Instrument Flying Handbook AC61-27
   FAA Flight Standards Service

   Chapter 2 gives excellent descriptions and explanations of the physiological factors related to instrument flying.

4. Contact person:
   (1-212-667-1019)
   George W. Briskey, Aviation Ed. Office
   FAA Eastern Region, AEA4
   Public Affairs and Planning Staff
   Fitzgerald Federal Building
   JFK International Airport
   Jamaica, NY 11430

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INSTRUCTIONS (NOTES)

TOPICS: 1 - 3

MODULE: AEROSPACE
SUBMODULE D

$$SUGGESTED SUBMODULE RESOURCES - PRINT MATERIALS

Aerospace: the challenge. Maxwell AFB, AL. CAP, 1983.

Airman's information manual (quarterly). Washington, D.C. U.S. GPO. n.d.

American weather observer (monthly) Belvidere, IL. American Assn. of Weather Observers. n.d.

Anthes, Richard. Weather around us. n.p. Bobbs-Merrill, 1976.

Aviation Weather (AC-00-6) Washington, D.C. U.S. GPO. n.d.

Critchfield, H.J. General climatology. 3rd ed. NY. Prentice-Hall. 1974.

Donn, W.L. Meteorology. 4th ed. NY. McGraw-Hill. 1975.

Namowitz and Stone. Earth science: the world we live in. 5th ed. n.p. American Book Co. n.d.

Federal meteorological handbook (Series #1-10). Silver Springs, MD. National Weather Service. n.d.

Handbook of physics and chemistry. 65th ed. Boca Raton, FL. CRC Press. 1984.

Instrument flying handbook (AC61-27) Washington, D.C. U.S. GPO. n.d.

This island earth. (NASA SP-250) Washington, D.C. NASA. U.S. GPO. 1970.

Ludlum, D.M. The American weather book. MA. Houghton-Mifflin Co. 1982.

Norton, T.W. Solar energy experiments for high school and college students. Emmaus, PA. Rodale Press. 1976.

Schaefer, V.J. and John A. Day. Field guide to the atmosphere. Boston, MA. Houghton-Mifflin. 1981.

U.S. standard atmosphere-1976 (or later ed). Washington, D.C. U.S. GPO. annual.

Weather. (Life Science Library). NY. Time, Inc. 1965.

Wood, E.A. Science from your airplane window. n.p. Dover. 1975.

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INSTRUCTIONS (NOTES)

PHASE: CONCENTRATION ELEMENT: TECHNOLOGY

MODULE: AEROSPACE

SUBMODULE: E. PROPULSION SYSTEMS

TOPICS:
1. Combustion Engines with Rotary Shaft Output
2. Combustion Engines with Reaction Thrust Output
3. Non-Combustion Systems Which Operate Within the Atmosphere
4. Non-Combustion Systems Which Operate in Space

PREREQUISITES: Aerospace Overview

$$PREPARED BY
$$C. DAVID GIERKE
$$ENERGY TECHNOLOGY LABORATORY
$$WEST SENECA EAST SENIOR HIGH SCHOOL
$$WEST SENECA, NEW YORK

TOTAL TEACHING TIME:
SUBMODULE E: 8 hours

DATE: August 3, 1984

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TOPICS: 1 - 4

MODULE: AEROSPACE

E

$$OVERVIEW OF SUBMODULE

GOALS:

Upon completion of this submodule, students will be able to:

1. Appraise the propulsion systems available to people.
2. Recognize the historical development of propulsion systems.
3. Compare and contrast specific types of propulsion systems from a scientific and technical context.
4. Identify the applications of propulsion systems.

DESCRIPTION:

The failure of humans in their early attempts at flight were due primarily to two obstacles: insufficient knowledge of the basic principles of aerodynamics and the lack of a suitable source of power. The second obstacle was the last to be overcome. Several pioneers attempted to fly by using only muscle power, but their crafts were too heavy for the propulsion system available. To propel themselves in flight, the early experimenters needed to develop a powerplant that was portable, powerful, lightweight and controlable.

At the turn of the century, there was only one successful example of an aero engine that satisfied all of the needs for flight. The design was years ahead of its time in many respect. It featured a radial cylinder configuration of an odd number of cylinders (5), the four stroke cycle, spark plug ignition, air cooling and external geared propeller drive. This engine powered a one-quarter sized model of a craft called the Aerodrome, which was intended to solve the mysteries of powered, man-carrying flight, by its inventor, Samuel Pierpont Langley, third Secretary of the Smithsonian Institution. Langley's capable assistant, Charles Matthew Manley, is credited for the engine's development, which contributed to the success of the Aerodrome model. The model achieved sustained "free flight" in 1901 and again in 1903, before trials were begun on the full-sized machine. The engine Manley produced for the full scale Aerodrome was also a remarkable piece of machinery for its day. The five cylinder engine weighed only 125 pounds and produced 53 horsepower!

Today, the Wright brothers' "Kitty Hawk Flyer" is credited by most people with being the first machine to successfully solve the problems of manned, powered flight. The Wrights' engine, although not as powerful or as light as the Manley design performed adequately and ultimately achieved success. Since these early days of barely successful airplane engines, they have more than kept pace with the changes in airplane structures necessary in providing ever increasing speeds and load carrying capacity.

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INSTRUCTIONS (NOTES)

Presently, the United States air transportation system represents a multi-billion dollar industry, employing nearly a million Americans. Air transportation accounts for more than six times as many passenger miles as its nearest competitor in public transportation - the inter city bus.

Propulsion is also the key which opens the door to all pioneering achievements in space. The "muscle" of the space program is the rocket engine. In it resides peoples basic capacity to hurl instrumented, unmanned and manned payloads out beyond the restricting influences of the earth's atmosphere and gravitational field.

Students of Aerospace Education must be made aware that propulsion systems are in a continual state of evolution, designed to meet the ever changing needs of our air and space transportation needs. Energy requirements for these needs places a great burden upon science and technology in order to provide systems which not only do the job, but do it efficiently.

Topics #1-4 provide the essentials for such an understanding of today's and tomorrow's propulsion systems.

SKILLS, KNOWLEDGE AND BEHAVIORS TO BE DEVELOPED:

SKILLS: Disassemble, measure and perform calculations related to aerospace propulsion systems.

KNOWLEDGE: The history, energy requirements, requirements for combustion, engine terminology, types, components, mechanical operation, advantages and disadvantages, application, and physical concepts associated with combustion and non-combustion engines operating within the atmosphere and space for the purpose of transportation.

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TOPIC: 1. Combustion Engines with Rotary Shaft Output (piston, Wankel, gas turbine, and reciprocating steam engines)

MODULE: AEROSPACE
SUBMODULE E

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having worked through an activity packet while observing transparencies and other audio visual materials, plus having prepared a short written report, will be able to trace the history of the internal combustion engine from the late 17th century through the beginning of the 20th centruy.

In order to do this, the student must be able to:

A. List the major inventions, along with their inventors and dates, in chronological order during this period, at an achievement level acceptable to the instructor.

2. Senior high school students, having worked through an activity packet while observing transparencies, plus having identified and experimented with various chemical fuels, will be able to determine the requirements for combustion, the energy content of chemicals within fuels, and the methods of measuring the energy content of chemical fuels.

In order to do this, the student must be able to:

A. Identify the three components which are necessary for combustion to take place.
B. Explain the role of Hydrogen and Carbon in providing thermal energy within a chemical fuel.
C. Compare and apply the English and Metric systems of measuring the energy content of a chemical fuel.

3. Senior high school students, having observed demonstrations, audio-visual presentations, plus having filled in "follow along" sheets from instructor lectures, will be able to define and compare introductory terminology related to the rotary shaft internal combustion engine, and explain key concepts associated with each.

In order to do this, the student must be able to:

A. Define:

internal combustion engines
energy converters
Charles' Law (gas law)

B. Explain:

internal combustion, as it relates to Charles' Law
how pressure differential provides motion
energy form changes within the engine

C. Compare:

energy converters and engines

4. Senior high school students, having observed demonstrations along with transparencies and slides associated with instructor lectures, will be able to identify the types of internal combustion ignition systems and concepts associated with each.

In order to do this, the student must be able to:

A. Identify:

flame ignition
spark ignition (three types)
compression ignition
glo ignition

B. Explain:

induction principle for high voltage spark ignition
Boyle's Law, related to compression engines
alcohol-platinum, catalytic ignition for glo plugs

5. Senior high school students, having observed a film, transparencies, and actual components, will be able to identify the basic 4-stroke cycle engine components.

In order to do this, the student must be able to:

A. List the 4-stroke cycle engine components, at an achievement level acceptable to the instructor.

6. Senior high school students, having observed a film, transparencies, and witnessed an engine disassembly, will be able to explain the mechanical operation and analyze the flow of energy through the 4-stroke cycle engine.

In order to do this, the student must be able to:

A. Explain terminology, such as:

cycle
stroke
reciprocating
cycle events

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INSTRUCTIONS (NOTES)

B. Compare mechanical motions of various engine components, such as:

piston, connecting rod and crankshaft
crankshaft and camshaft
piston and valves

C. Analyze, on a molecular level, the energy flow for each cycle event, such as:

- the formation of a partial vacuum and the resultant pressure differential on the intake event
- the increased molecular activity and proximity of the air and fuel molecules on the compression event

7. Senior high school students, having worked through a teacher prepared activity packet which included follow along sheets, example problem sheets and problem solving worksheets, will, with the aid of a textbook, audio visual materials, lecture/demonstrations and student measurement exercises, be able to identify, measure and perform calculations related to internal combustion, rotary shaft engine performance factors.

In order to do this, the student must be able to:

A. List the important engine performance factors, such as:

displacement
compression ratio
valve timing

B. Demonstrate the ability to use precision measuring instruments and other special equipment, such as:

outside micrometers
telescoping gauges
depth micrometers
dial indicators
laboratory buret
degree wheel

C. Measure the essential components necessary to determine each of the performance factors, such as:

cylinder bore
crankshaft stroke
clearance volume
intake and exhaust valve opening and closing

D. Calculate, using the measurements obtained, the desired performance factors.

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8. Senior high school students, having observed a film, transparencies, and actual engine examples, will be able to recognize and compare factors necessary for identification of internal combustion, rotary shaft output engines.

In order to do this, the student must be able to:

A. List the engine identification methods:

1. cylinder arrangement
2. valve arrangement
3. cooling system types
4. ignition system types

B. Compare the components of each method:

1. Cylinder arrangement

   a. in-line
   b. V-type
   c. radial
   d. opposed

2. Valve arrangement

   a. L-head
   b. I-head
   c. F-head
   d. T-head

3. Cooling system

   a. air
   b. water

9. Senior high school students, having observed transparencies and actual engine components, will be able to identify the components of a two stroke cycle internal combustion rotary shaft engine.

In order to do this, the student must be able to:

A. List the 2-stroke cycle engine components, at an achievement level acceptable to the instructor.

10. Senior high school students, having observed a film, transparencies, and witnessed an engnie disassembly, will be able to explain the mechanical operation and analyze the flow of energy through the 2-stroke cycle internal combustion, rotary shaft engine.

In order to do this, the student must be able to:

A. Explain terminology, such as:

induction process
primary and secondary compression
cycle events overlap
crankcase and cylinder scavenging
exhaust blowdown
exhaust lead

B. Compare the mechanical motions of various engine components to engine operations, such as:

- crankshaft rotation to induction valve opening and closing
- piston movement to transfer and exhaust port opening and closing

C. Appraise, on a molecular level, the energy flow for the cycle events, such as:

- induction (intake) and compression (secondary) events which occur simultaneously on the up stroke
- power (expansion) and exhaust events which occur simultaneously on the down stroke

11. Senior high school students, having observed transparencies and actual engine examples, will be able to recognize and compare factors necessary for identification of 2-stroke cycle, internal combustion, rotary shaft engines.

In order to do this, the student must be able to:

A. List the identification methods:

1. Induction systems
2. Scavenging systems

B. Compare the components of each system:

1. Induction systems

a. shaft value
b. disk value
c. drum value
d. piston value
e. reed value

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INSTRUCTIONS (NOTES)

2. Scavenging systems

a. cross
b. loop
c. Curtiss
d. Schneurle
e. Schneurle (with boost)

12. Senior high school students, having observed transparencies and actual engine components, will be able to identify the components of a rotary combustion (Wankel) internal combustion, rotary shaft engine.

In order to do this, the student must be able to:

A. List the rotary combustion (Wankel) engine components, such as:

rotor
housing
stationary gear
intake and exhaust ports, etc.

at a level of competency acceptable to the instructor.

13. Senior high school students, having observed transparencies and witnessed an engine disassembly, will be able to explain the mechanical operation and analyze the flow of energy through the rotary combustion (Wankel) internal combustion, rotary shaft engine.

In order to do this, the student must be able to:

A. Explain terminology, such as:

Epitochoidal design (shape)
cycle events

B. Compare the mechanical motions of various engine components to engine operations, such as:

rotor RPM's the crankshaft RPM's
power impulses per rotor revolution
impulses per crankshaft revolution with internal rotor gear to the stationary gear

C. Analyze, on a molecular level, the energy flow for the cycle events of the rotary combustion (Wankel) engine, such as:

- the increase in volume during the intake event, with ports and pressure differential
- compression being controlled by each rotor face being disked out, forming the combustion chamber

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INSTRUCTIONS (NOTES)

14. Senior high school students, having observed transparencies and witnessed engine disassembly (film), will be able to identify the components of a continuous combustion gas turbine internal combustion, rotary shaft engine.

In order to do this, the student must be able to:

A. List the components of the gas turbine engine, such as:

combustion chamber
regenerator
burner
compressor turbine
power turbine

15. Senior high school students, having observed transparencies and witnessed engine disassembly (film), will be able to explain the mechanical operation and analyze the flow of energy through the continuous combustion gas turbine, internal combustion, rotary shaft engine.

In order to do this, the student must be able to:

A. Explain terminology, such as:

gasifier
centrifical and axial compressor
impeller and diffuser
closed and open cycle

B. Compare the mechanical motions of various engine components to engine operation, such as:

- how some compressors are turned by power turbines
- power turbines and geared output shaft
- power turbine speed vs. regenerator speed
- compressor speed vs. power turbine speed in a two shaft system

C. Analyze, on a molecular level, the energy flow for the cycle events of the continuous combustion gas turbine, internal combustion, rotary shaft engine, such as:

- the effect of the compressor on the temperature and pressure of the incoming air
- the process of adding waste heat to the air from the regenerator
- the processes occurring within the combustion chamber (burner)
- the energy form changes taking place within the engine

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16. Senior high school students, having observed audio visual presentations and participated in classroom discussion, plus having written a short paper, will be able to trace the history of the external combustion engine from Hero's steam turbine about 2000 years ago, to the present day, identifying where it had been applied to aeronautical projects.

In order to do this, the student must be able to:

A. List the major inventions, along with their inventors and dates, in chronological order during this period.

Example:

1. Aeoliple - Hero of Alexandria - 130 BC
2. Steam gun - Leonardo - 1495
3. Steam cylinder - Papin - 1690
4. "Fire engine" - Savery - 1698
5. Atmospheric steam engine - Newcomen - 1712
6. Separate condenser - Watt - 1769

B. List the inventors who tried to use the steam engine for aeronautical purposes.

Example:

Sir George Cayley - 1819
Henson and Stringfellow - 1842
Sir Hiram Maxam - 1896

17. Senior high school students, having completed a study of atmospheric engines, and by utilizing the multiple techniques of audio visual presentations, library research, instructor lecture/demonstration and classroom discussions, will be able to identify the important advances of reciprocating steam engines after Watt's single acting atmospheric engine.

In order to do this, the student must be able to:

A. List the important advances in reciprocating steam engines after Watt's single acting atmospheric engine.

1. rotary motion output
2. the double acting engine (using steam pressure and vacuum)
3. the governor
4. slide valves
5. the compound engine
6. the steam locomotive
7. the horizontal, reversing, vertical and oscillating engine

18. Senior high school students, having viewed transparencies, color slides and films, plus having participated in classroom discussions and an actual disassembly of a reciprocating steam engine, will be able to identify the mechanical components, describe their relationships and analyze the energy flow through these units.

In order to do this, the student must be able to:

A. List the mechanical components of a typical reciprocating steam engine, including:

1. pistons and cylinders
2. steam passages
3. steam chest
4. eccentric rod and valve rod
5. stuffing box
6. crosshead
7. connecting rod and crankshaft
8. lubricator
9. frame and cylinder head
10. governors

B. Describe the mechanical motions of:

1. crankshaft, connecting rod, crosshead, piston rod and piston in converting reciprocating to rotary motion
2. eccentric, eccentric strap, crosshead slide and slide valve in alternately directing steam to opposite sides of the piston in a double acting engine
3. exhaust port, slide valve, steam port and piston motions

C. Analyze the energy form changes which occur within the reciprocating steam engine.

- thermal to mechanical

D. Describe the flow of thermal energy (steam) within the reciprocating steam engine:

- through passages, valves
- into steam chest and cylinder
- out exhaust ports and passages

E. Describe the flow of mechanical energy within the reciprocating steam engine:

- piston to piston rod to crosshead and connecting rod to crankshaft and flywheel

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INSTRUCTIONS (NOTES)

F. Analyze the function of the flywheel in terms of potential and kinetic energy for providing smooth engine operation.

19. Senior high school students, having prepared a short written report after observing transparencies and other audio-visual materials, will be able to identify how various rotary shaft internal combustion engines are used in aerospace vehicles.

In order to do this, the student must be able to:

A. List several aerospace uses for each of the following engines:

- spark ignition, reciprocating
- spark ignition, rotary
- compression ignition
- gas turbine

20. Senior high school students, having participated in class discussions and observed color slides and transparencies, will be able to analyze and compare the effect the rotary shaft internal combustion engine has had upon our society and individual lifestyles, when applied to the airplane.

In order to do this, the student must be able to:

A. Compare society before and after the implementation of the rotary shaft internal combustion engine to airplanes, by writing a short paper (200-400 words) itemizing the changes which took place.

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INSTRUCTIONS (NOTES)

TOPIC: 1. Combustion Engines with Rotary Shaft Output (piston, Wankel, gas turbine and reciprocating steam engines)

MODULE: AEROSPACE
SUBMODULE E

$$SUGGESTED INSTRUCTION STRATEGIES

1. Direct students to "fill in the blanks" on the prepared follow along sheet while the teacher narrates 35mm color slides of actual early examples of internal combustion engines, paying close attention to:

   A. The type of engine
   B. The name of the inventor
   C. The date of the invention

   Materials needed:

   A. 35 mm color slides of antique internal combustion engines which may be found in museums (ie. the Ontario Science Center, in Canada). Slides may also be made from textbook illustrations and photos, with the publisher's permission.

   B. Spirit duplication of the follow along sheet, which contains either dates, inventor's name or the engine identification. Leave space to identify the fuel used for each engine.

2. DEMONSTRATION: To show that oxygen is required for combustion, place a watch glass full of ditto fluid along with a spark plug and its wires into a bell jar and pump the air out (vacuum pump). Allow the liquid alcohol to partially evaporate and actuate the spark across the plug's electrodes. Combustion will not occur.

   Materials needed:

   Bell jar, vacuum pump, alcohol, watch glass, spark plug and wires, model T spark coil or other high voltage power supply.

   CAUTION: This experiment can be dangerous if air should leak into the bell jar at the time of ignition. The apparatus must be placed behind a protective barrier with all students wearing eye protection.

3. STUDENT ACTIVITY: From the Handbook of Physics and Chemistry, have the students identify common fuels and list their heat energy content in English and Metric units.

   Materials needed:

   Use this as an out of class activity which can be performed in the school library. Have the librarian provide the reference

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in the library's reserve section.

4. DEMONSTRATION: To show the results of having the three necessary combustion components, drill or punch a hole in the side of a large coffee can, which will accept a spark plug. Using an eyedropper, place approximately 5cc of gasoline into the bottom of the can. Place the plastic lid onto the can. Tip the can at various angles, allowing the gasoline to evaporate into the can's air space. After about 30 seconds of this, stand back and actuate the high voltage to the spark plug. Combustion will take place (rapidly) and the lid will fly off. Be sure to ask the students:

   A. What components of combustion were present?
   B. What were the energy changes (form changes) that took place?
   C. How did pressure differential make the car's lid fly off? Was this mechanical energy?
   D. The walls of the can are warm. Did this thermal energy provide any help in popping the lid? (Here the idea of efficiency and the law of Conservation of Energy might be introduced or reviewed.)

Materials needed:

Coffee can with plastic lid, spark plug, gasoline, eye dropper, high voltage power supply

CAUTION: All students should stand at least 15 feet away from this demonstration. The lid sometimes pops violently, along with producing considerable flame.

5. 35mm COLOR SLIDES - ENGINES AND ENERGY CONVERTERS: Color slides provide a visual comparison of why engines are energy converters but not all energy converters are engines. The following are examples:

Engines (mechanical output)

waterwheel
windmill
diesel

Energy converter (any output energy form)

solar cell
fuel cell
furnace

Materials needed:

35mm color slides of various engines and energy converters. May copy from textbook illustrations and photos with publisher's permission.

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INSTRUCTIONS (NOTES)

6. DEMONSTRATION: Spark ignition systems, including:

A. Model T spark coil
B. Battery ignition system
C. Magneto

Materials needed:

Model T spark coil and spark plug, battery ignition system from motorcycle or car, magneto from small engine such as a chain saw or lawn mower.

7. DEMONSTRATION: Compression ignition concept. Pump up a bicycle or auto tire and have the students feel its temperature rise. Carefully touch the pump cylinder. Be sure to reinforce this with Boyle's Law (gas law) emphasizing that temperature increases proportionally with pressure, as gasses are reduced in volume.

Materials needed:

Tire pump, tire

CAUTION: Warn students about the potentially high temperatures of the pump cylinder (150 degrees F) after vigorous pumping.

8. STUDENT ACTIVITY: Prepare students to measure important engine performance factors, such as: displacement, compression ratio and valve timing by having them practice using the appropriate instruments after instructor demonstrations have been completed.

Materials needed:

Example small engine short blocks with cylinder heads and valve trains provide excellent equipment for this exercise.

9. STUDENT ACTIVITY: Set-up and operation of a representative example of a 4-stroke cycle internal combustion rotary shaft engine.

Materials needed:

4-stroke cycle engine
fuel
lubrication
student procedure sheet
exhaust gas removal capability
secure engine mounting

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10. STUDENT ACTIVITY: Set-up and operation of a representative example of a 2-stroke cycle internal combustion, rotary shaft engine.

    Materials needed:

    2 stroke cycle engine, fuel, student procedure sheet, exhaust gas removal capability, secure engine mount

11. DEMONSTRATION: Illustrate the mechanical interrelationships existing within the rotary combustion (Wankel) engine. Utilize a transparent plastic model with moving opaque components. It is most effective for this engine type.

    Materials needed:

    RC Wankel plastic engine kit, available from the local hobby shop

12. STUDENT ACTIVITY: Set-up and operation of a representative example of a RC Wankel internal combustion, rotary shaft engine.

    Materials needed:

    RC Wankel engine, fuel, student procedure sheet, exhaust removal capability,secure engine mount

    NOTE: A .30 cubic inch RC Wankel engine (model airplane type) can be purchased from a local hobby dealer.

13. STUDENT ACTIVITY: Using a small group of students (no more than 3), have them perform an experiment designed to accurately determine the performance factors of a 4-stroke cycle internal combustion, rotary shaft engine, using English and Metric systems of measure.

    Materials needed:

    A complete and operational 4-stroke cycle engine, tools for partial disassembly of the engine, measuring instruments, student laboratory procedure and data collection sheet

14. STUDENT ACTIVITY: By labeling examples of various types of 4-stroke cycle engines in the lab, have students identify them by cylinder arrangement, cooling and ignition system.

    Materials needed:

    Representative examples of various types of 4-stroke cycle engines

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INSTRUCTIONS (NOTES)

15. STUDENT ACTIVITY: Using a small group of students (no more than 3), have them perform an experiment designed to accurately determine the performance factors of a 2-stroke cycle internal combustion, rotary shaft engine, using English and Metric systems of measure.

Materials needed:

A complete and operational 2-stroke cycle engine, tools for partial disassembly of the engine, measuring instruments, student laboratory procedure and data collection sheets.

16. STUDENT ACTIVITY: Label examples of various types of 2-stroke cycle engines in the lab. Have students identify them by induction and scavenging systems.

Materials needed:

Representative examples of 2-stroke cycle engines

17. Construct a simple atmospheric experiment where a fluid is displaced from a flask at a lower level to one at a higher level. Use condensed steam from the third flask to provide the partial vacuum. Refer to an example of the Savery atmospheric engine for further details.

Materials needed:

3 250ml flasks, bunsen burner, colored water in two of the flasks (for visibility), 3 rubber stoppers and glass tubes, rubber tubing

18. Demonstrate the power of the atmosphere by placing water (50ml) in an empty and clean gallon can. Boil the water with the cap removed. When steam is venting from the can, quickly replace the cap tightly. Place the can under the cold water tap. The condensing steam produces a partial vacuum within the can, and the atmospheric pressure collapses it very dramatically.

Materials needed:

Gallon can with cap, approximately 50ml of water, bunsen burner, access to cold water tap

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TOPIC: 1. Combustion Engines with Rotary Shaft Output (piston, Wankel, gas turbine and reciprocating steam engines)

MODULE: AEROSPACE
SUBMODULE E

$$ALTERNATE INSTRUCTIONAL STRATEGIES

The following student activities center around independent library research, where many varied references are utilized. Complete bibliographic information related to these references can be found at the end of this submodule.

1. List 10 uses for each engine type.
   REFERENCES: card catalog; encyclopedia index
   (SUBJECTS: internal combustion engine, inventions)

2. A. Compare society before and after the invention of the internal combustion engine.
   REFERENCES: card catalog; encyclopedia index
   (SUBJECTS: United States - History; Industrial Revolution; transportation)

   B. List factors responsible for altered lifestyles in the transportation sector.
   REFERENCES AND SUBJECTS: see #2A.

3. Identify industries associated with the internal combustion engine and aircraft.
   REFERENCES: card catalog; encyclopedia index
   (SUBJECTS: Industrial Revolution; industry; economic growth; aircraft)

4. Look up the amount of fuel used per year by the internal combustion engine in aircraft.
   REFERENCE: Energy Fact Book; U.S. Fact Book; almanac

5. Construct an operational model of the Savery atmospheric engine. The engine should have two active chambers constructed from 500ml graduated cylinders. The steam boiler consists of one 250ml flask. One-way valves may be purchased from scientific supply houses. Engine valving may be accomplished by using simple rubber tubing clamps. The operation of the engine sees one cylinder being filled with water by the force of the atmosphere, while the other cylinder is being emptied by steam boiler pressure, giving a continuous water pumping action. The Savery engine and its operation can be found in any technical publication concerning the history of heat engines.

   Materials needed:

   2 500ml graduated cylinders, 2 rubber stoppers for graduated cylinders (2 hole), 1 250ml flask, 1 bunsen burner, 4 one-way valves, 3' glass tubing, 6' rubber tubing, 1 two-way valve (manual) or 2 rubber tubing clamps, 2 cooling fans.

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INSTRUCTIONS (NOTES)

TOPIC: 1. Combustion Engines with Rotary Shaft Output (piston, Wnakel, gas turbine and reciprocating steam engines)

MODULE: AEROSPACE
SUBMODULE E

Suggested references for Topic #1:

The Energy Fact Book, R.C. Dorf
Energy Technology Handbook. McGraw-Hill
McGraw-Hill Encyclopedia of Science and Technology.
New York Times School Microfilm Collection. Microfilming Corporation of America.
Smithsonian Book of Invention. Smithsonian Institution.
Social Issues Resource Series. Energy. SIRS, Inc.
Thomas Register of American Manufacturers.
Those Inventive Americans. National Geographic.
The U.S. Fact Book. B.J. Wattenberg.

Complete detailed bibliographic information on these sources is available at the end of this submodule.

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INSTRUCTIONS (NOTES)

TOPIC: 2. Combustion Engines with Reaction Thrust Output (Jets, rockets)

MODULE: AEROSPACE
SUBMODULE E

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having worked through an activity packet while observing transparencies and other audio visual materials, will be able to trace the history of the internal combustion thrust reaction engine (rockets and jets) from earliest account through the present.

   In order to do this, the student must be able to:

   A. List the major inventions along with their inventors and dates in chronological order during this period, at an achievement level acceptable to the instructor.

2. Senior high school students, having observed a film, transparencies and actual engines, will be able to define the function of a jet engine and list at least four of its design criteria.

   In order to do this, the student must be able to:

   A. Define the jet engine as an air consuming device.
   B. List four design criteria:

      1. Burns liquid or gaseous fuel.
      2. Breathes surrounding air.
      3. Air functions as a "working fluid" and a coolant for the engine.
      4. Thrust levels from a few pounds to many thousands.

3. Senior high school students, having observed a film, transparencies and actual engines, will be able to identify the two categories of jet engines and define how they are classified.

   In order to do this, the student must be able to:

   A. Identify the categories:

      1. ATHODYD (aero thermodynamic du
      2. turbojets

   B. Define how jets are classified:

      -according to the function of the component parts, as they relate to the entry of air, fuel, the combustion and exhausting of gases.

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INSTRUCTIONS (NOTES)

4. Senior high school students, having observed audio visual presentations and actual engines, will be able to identify the two examples of ATHODYD engines and list several alternative names given to each.

In order to do this, the student must be able to:

A. Identify the two ATHODYD examples:

- Ramjet
- Pulse jet

B. List alternative names for each example:

Ramjet: aerodynamic duct; flying stovepipe
Pulse jet: stuttering stovepipe; resojet; resonant jet; buss engine; aeroresonator

5. Senior high school students, having observed audio visual presentations, actual engines, instructor lectures and demonstrations, will be able to list operational phases of the ramjet and pulse jet, while also identifying the combustion process exhibited by each.

In order to do this, the student must be able to:

A. List the operational phases and combustion process for:

1. Ramjet:

a. intake
b. compression
c. combustion
d. exhaust

The engine has a continuous combustion process.

2. Pulse jet:

a. starting intake
b. compression
c. combustion
d. exhaust
e. recharging intake

The engine has an intermittent combustion process.

6. Senior high school students, having observed many instructor initiated presentations concerning the internal combustion, air breathing thrust reaction (jet) engine, will be able to identify the major components of the two ATHODYD examples.

In order to do this, the student must be able to:

A. List the major components of the Ramjet:

1. diffuser
2. fuel injectors
3. flame holder
4. convergent or convergent-divergent nozzle
5. spark ignition

B. List the major components of the Pulse jet:

1. a duct, consisting of:
   a. venturi
   b. diffuser
2. a reed valve inlet system
3. combustion chamber
4. exhaust or resonance tube
5. spark ignition

7. Senior high school students, having participated in classroom discussions, disassembly of actual and model jet propulsion devices, plus the operation of a miniature pulse jet engine, will be able to explain the flow of energy through the ATHODYD examples.

In order to do this, the student must be able to:

A. Relate scientific & technical concepts to the operation of the ramjet and the pulse jet.

1. Newton's Third Law: thrust
2. Bernoulli's Principle: velocity and pressure
3. Resonance: recharging phase (pulse jet)
4. Energy form changes: chemical to thermal to mechanical
5. Sub-sonic, sonic, super sonic: convergent-divergent exhaust nozzle (deLaval)
6. Newton's Second Law: the change of momentum of masses of fuel and air
7. Horsepower and thrust: HP depends on speed produced
8. Weight to horsepower: comparison of piston engine with ATHODYDs.

Analyze on a molecular level, the energy flow for each section of the ATHODYD in terms of:

1. temperature
2. pressure
3. velocity of gases

~~8.~~ ~~Senior hi~~gh school students, having completed all of the other activites concerning operation of the internal combustion, air-breathing, thrust reaction ATHODYD, will be able to contrast and compare the advantages, disadvantages and applications of the two types: ramjets and pulse jets.

In order to do this, the student must be able to:

A. List the advantages of the ramjet:

1. simple, no moving parts
2. extermely high operational speeds

B. List the disadvantages of the ramjet:

1. inefficient use of fuel
2. high drag at operational speeds, because of large inlet area
3. will not accelerate from a static position to a desired speed

C. List applications of the ramjet:

1. supersonic flight, where light weight is important

D. List the advantages of the pulse jet:

1. low weight (compared to other jets)
2. relatively inexpensive to construct
3. highly dependable

E. List the disadvantages of the pulse jet:

1. very loud device
2. limited to sub-sonic speeds

F. List the applications for the pulse jet:

1. target drones
2. model airplane engines
3. educational demonstrations

9. Senior high school students, having studied the ATHODYD type of internal combustion, airstream reaction engines and a film concerning turbojets, will be able to relate general facts unique to the turbine of turbojet engine.

In order to do this, the student must be able to:

A. List turbojet facts unique to that engine type:

1. the most sophisticated jet engine

A. Explain:

1. how much the compressor is driven
2. how much combustion force is required to drive the compressor-turbine
3. the difference between an impulse and a reaction turbine
4. the difference between an axial and centrifical flow compressor
5. on a molecular level, the energy flow for each cycle event, for each section of the engine

   a. temperature
   b. pressure
   c. velocity

13. Senior high school students, having observed a film, transparencies and actual engines, will be able to define the function of a rocket engine, and list at least three of its design criteria.

In order to do this, the student must be able to:

A. Define the rocket as a self-contained propulsion system.
B. List design criteria:

   1. burns propellants (fuel and oxidizer)
   2. single or multiple stage
   3. used for military, orbiting satellites and launching planetary probes outside the atmosphere

14. Senior high school students, having observed a film, transparencies and actual engines, will be able to identify the two categories of rocket engines and define each.

In order to do this, the student must be able to:

A. Identify and define the rocket engine categories:

   1. Liquid propellant: uses fuels and oxidizers in a liquid state. Chemicals are stored in remote containers, are injected into the combustion chamber and burned.

   2. Solid propellant: uses propellants in a solid state. Consists of either: Composite propellants - different chemicals for fuel and oxidizer, or monolithic propellant - one chemical for both the fuel and oxidizer.

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INSTRUCTIONS (NOTES)

15. Senior high school students, having observed audio visual presentations, actual examples of engines, instructor lectures and demonstrations, will be able to identify the components of the solid and liquid propellant rocket engine.

In order to do this, the student must be able to:

A. List the components of the solid propellant rocket engine:

1. case
2. propellant (solid)
3. core
4. exhaust nozzle (C-D)

B. List the major components of the liqud propellant rocket engine:

1. exhaust nozzle (C-D)
2. combustion chamber
3. propellant pumps/valves
4. oxidzier and fuel tanks

16. Senior high school students, having been provided many learning experiences associated with the internal combustion, thrust reaction rocket engine, will be able to describe several applications for both the solid and liquid propellant engine.

In order to do this, the student must be able to:

A. List the applications of the solid propellant rocket engine.

1. bazooka
2. air to air missles
3. air to ground missles
4. RATO units (Rocket Assisted Take Off)
5. model rocket

B. List the applications of the liquid propellant rocket engine.

1. ballistic missles
2. launching space probes
3. retro-rockets
4. RATO units
5. control rockets (thrusters)

17. Senior high school students, having participated in classroom discussions, disassembly of model and actual rocket propulsion devices, plus the operation of a miniature rocket engine, will be able to explain the operation of the device from a conceptual point of view.

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15. Senior high school students, having observed audio visual presentations, actual examples of engines, instructor lectures and demonstrations, will be able to identify the components of the solid and liquid propellant rocket engine.

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3. core
4. exhaust nozzle (C-D)

B. List the major components of the liqud propellant rocket engine:

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2. combustion chamber
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B. List the applications of the liquid propellant rocket engine.

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2. launching space probes
3. retro-rockets
4. RATO units
5. control rockets (thrusters)

17. Senior high school students, having participated in classroom discussions, disassembly of model and actual rocket propulsion devices, plus the operation of a miniature rocket engine, will be able to explain the operation of the device from a conceptual point of view.

In order to do this, the student must be able to:

A. Explain thrust from Newton's Third Law of Motion.

B. Explain why thrust increases when either the mass flow rate or the velocity of the exhausting particles increases...in terms of Newton's Second Law of Motion.

C. List the energy conversions which occur within the rocket engine. Which are examples of potential and kinetic energy?

D. Explain how the deLaval nozzle accelerates the exhaust gases from subsonic to supersonic velocities. Relate why this is important, in terms of momentum.

18. Senior high school students, having completed all of the other activities concerning the operation of the internal combustion, thrust reaction rocket engine, will be able to contrast and compare the advantages and disadvantages of the solid and liquid categories.

In order to do this, the student must be able to:

A. List the advantages of the solid propellant rocket:

1. simple system, with few components
2. compact
3. lends itself to longtime propellant storage
4. ease of handling
5. low toxicity
6. economical

B. List the disadvantages of the solid propellant rocket:

1. inability to change the burning rate once ignited
2. cracking of the charge, or grain

C. Advantages of the liquid propellant rocket:

1. thrust can be controlled (throttled)
2. restart capability

Disadvantages of the liquid propellant rocket:

1. complicated plumbing system
2. highly corrosive toxic propellants

19. Senior high school students, having prepared a short, written report after observing a variety of audio visual materials, will be able to identify specific uses for the internal combustion, thrust reaction engine, within our society.

In order to do this, the student must be able to:

TOPIC: 2. Combustion Engines with Reaction Thrust Output (Jets, rockets)

MODULE: AEROSPACE
SUBMODULE E

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Direct students to "fill in the blanks" on the prepared "follow along sheet" while the teacher narrates 35mm color slides of actual early examples of internal combustion, thrust reaction engines (rockets and jets), paying close attention to:

   A. The type of invention
   B. The name of the inventor
   C. The date of the invention

   Materials needed:

   A. 35mm color slides of antique and modern internal combustion, thrust reaction engines, which may be found in museums (ie. the Ontario Science Center, in Toronto, Canada). Slides may also be made from textbook illustrations and photos, with the publisher's permission.

   B. Spirit duplication of the follow along sheet, which contains either dates, inventor's name or the engine identification. Leave space to identify the fuel used for each engine.

2. Obtain an operational model of the pulse jet. Set it up with adequate cooling, along with a fuel and ignition system. Compressed air is needed for starting. A force scale may be mounted to the engine stand for thrust measurement. By using a laboratory buret, fuel consumption may be measured. (See items 1, 2, 3 under "Sources of Materials" at the end of this topic section.)

   Materials needed:

   Model pulse jet engine (Dyna jet), fabricated simple thrust stand, spring scale (0-5 lb), fuel tank (50ml laboratory buret), fuel (Coleman's lantern fuel - white gas), regulated 40 PSI compressed air for starting, ignition - 6v DC input (2A) 20,000v output, Model T spark coil, stop watch - used in conjunction with the buret, for fuel consumption determination

3. Design, construct and operate a pulse jet powered tether-vehicle. The vehicle would operate from the school parking lot, on a 70 foot steel cable tether.

A. List three uses for each of the following engines:

pulse jet
ramjet
turbojet
solid propellant rocket
liquid propellant rocket

20. Senior high school students, having participated in class discussions based upon previous instructor initiated presentations, will be able to <u>analyze and compare the effect the internal combustion, thrust reaction engine has had upon our society and individual lifestyles.</u>

In order to do this, the student must be able to:

A. Compare society before and after the commercial and military application of the jet and rocket engine, in respect to transportation and national security.

B. Write a short paper (200-400 words) concerning one of the following applications of liquid propellant engines:

in aircraft
in missles
in space flight

C. The dawn of the 20th century saw three pioneers spear-head enthusiasm and serious thought toward the science and technology of rocketry. Describe how they were to influence the course of events through their work. Identify which one was called "the father of rocket theory"; the "father of practical astronautics; and the "father of modern rocketry". These three individuals are:

Robert H. Goddard
Konstantin Tsialovski
Herman Oberth

Materials needed:

Steel tether cable - .024 single strand music wire (hobby shop supplied), balsa wood, aircraft plywood, various cements, model airplane wheels 94-6" dia.), model airplane fuel tank (12 oz.), pulse jet engine (Dyna jet)

CAUTION: Precautions must be taken against accidents. Strong protective barriers must be constructed to protect students and onlookers.

4. Construct a simple static test stand to obtain time-thrust curve information for comparisons of various types of model rocket engines.

Contact: ESTES INDUSTRIES
Penrose, Colorado 81240

Beside being able to obtain their latest model rocketry catalog, be sure to ask for the Educator's Kit, which includes a free rocket kit plus many informative bits of literature concerning experiments, teaching units, technical reports, projects and much more. (For information on construction of the test stand, see items #5, 6, 7 and 8 under "Sources of Materials", at the end of this topic section.)

5. There are many spectacular demonstrations of basic concepts related to the airstream reaction, internal combustion engine. Some of these are listed below, with included materials.

A. BERNOULLI'S PRINCIPLE:

1. Attempt to blow a ping pong ball out of a glass funnel. Start with the mouth of the funnel up, and turn the funnel gradually through 180 degrees. If the demonstrator has enough breath to maintain the air stream, the ball will remain in the funnel in the inverted position.

2. Support a ping pong ball on a vertical air jet. This can be done by blowing through a piece of rubber tubing, if compressed air is not available. It is expecially interesting to reduce the flow of air until the ball is wobbling back and forth immediately on top of the air outlet. As it starts to fall off on one side the air moving past it on the other side quickly provides a force to return it to the air stream.

There is a real danger that, in seeing an unexpected outcome, the basic reasons for the demonstration may be lost. Remember, the experiments relate to the fact that in a fluid, the pressure decreases as the velocity increases.

B. NEWTON'S THIRD LAW:

A laboratory version of Hero's famous reaction steam engine can be made by using ordinary equipment. Two 4-inch pieces of glass tubing, each with two right-angle bends, are used as jets. The bends of each piece cause the steam to emerge in the same direction (clockwise or counterclockwise). The boiler is a laboratory flask, stoppered with a two hole rubber stopper, into which the glass jets have been inserted (use glycerine or WD-40). The whole assembly hangs by a piece of string from a support. Include a swivel (bead chain) to prevent tangles.

After the water in the flask boils from being heated with a bunsen burner, steam emerges from the ends of the tubes. The resultant thrust is enough to spin the flask.

6. Construct model rockets from inexpensive kits. Launch these models and perform simple experiments designed to reinforce concepts previously discussed in the classroom. (Items listed in A-E are contained in the Estes Educator's Kit.)

A. Altitude tracking:

Model Rocketry Technical Manual, pp. 78-79.
Model Rocket News, Vol. 9, No. 3, pp. 8-9, "How high did it go?"
Technical Report, TR-3 - "Altitude Tracking"

B. Beginning in model rocketry:

Technical Report, TR-8 - "Model Rocket Study Guide"

Design of Rockets:

Technical Report, TR-9 - "Designing Stable Rockets"

Launch Problems:

Model Rocket Launch Systems

C. Velocity:

Model Rocket News, Vol. 10, No. 1, pp.8-9, "How fast did it go?"

D. Concepts:

- Newton's Laws of Motion
- Model Rocket News, Vol. 8, No. 1, pp. 8-9, "What rockets push against in space"
- Model Rocket News, Vol. 9, No. 1, pp. 8-9, "Why are rockets staged?"

E. "How to make your own launching system" (Estes Construction Paper)

~~TOPIC: 2.~~ Combustion Engines with Reaction Thrust Output (Jets, rockets)

MODULE: AEROSPACE
SUBMODULE E

$$ALTERNATE INSTRUCTIONAL STRATEGIES

The following student activites center around independent library research, where many references are utilized. A number of these references are suggested for each supporting competency. Complete bibliograpic information related to these references can be found at the end of this topic section.

1. List three uses for each thrust reaction, internal combustion engine.
   REFERENCES: card catalog, encyclopedia index
   (SUBJECTS: reaction engines; rockets; jets; inventions)

2. A. Compare society before and after the commercial and military application of the jet and rocket engine, in reference to transportation and national security.
   REFERENCES: card catalog; encyclopedia index
   (SUBJECTS: United States - History; Industrial Revolution; transportation; rockets; jets; United States - Foreign policy; United States - Security)

   B. Write a short paper (200-400 words) concerning either aircraft, missles or space flight as an application of liquid propellant rocket engines.
   REFERENCES: card catalog; encyclopedia index
   (SUBJECTS: rockets; inventions; aircraft, missles, space flight)

   C. Describe how Robert H. Goddard, Konstantin Tsialokovski and Herman Oberth influenced space flight through rocketry study and experimentation.
   REFERENCES AND SUBJECTS: see #1.

3. Have students perform a search for the actual applications of the ATHODYD engines. The vehicle's name, date of production and design function should be listed. Offer a small reward to the student who finds the greatest number of historical applications, for each of your classes.

Materials needed:

Consult your school librarian and arrange for materials in the area of Inventions, Space, Weapons and Aircraft to be reserved for your students' use, in addition to the general encyclopedias and the McGraw-Hill Encyclopedia of Science and Technology. (This can be handled as a class assignment or out of class assigned activity.)

4. Have the class view one or all of the following films:

Power for BOMARC. This is the story behind the BOMARC missle's unique ramjet power plant. This is what the Air Force refers to as a "historical" film. Although old (late 1950's), it describes the ram jet very effectively through graphics and actual static and vehicle test firings. (See item #4 under "Sources of Materials" at the end of this topic section.)

ABC's of the Gas Turbine. The principles of the gas turbine engine are explained through the use of animation and colorful graphics. The basic engine is shown, as well as some of the specialized engine forms, such as turbojet, fanjet, turboprop and turboshaft. (Formerly available through the General Motors Corporation, this film may be obtained through many of our BOCES Centers.)

Research Project X-15. Shows the development of the experimental X-15 rocket-powered research airplane. 1966. color. 27 min.

Within this Decade: America in Space. Traces the principal accomplishments of NASA in aerospace research and aeronautics from 1959 until the eve of the first lunar landing. 1969. color. 28 min.

Ordering information in item #9 under "Sources of Materials" at the end of this topic section.

TOPIC: 2. Combustion Engines with Reaction Thrust Output (Jets, rockets)

MODULE: AEROSPACE
SUBMODULE E

$$SOURCES OF MATERIALS

1. Karwatka, Dennis. "Operating and Testing a Simple Pulse Jet Engine". School Shop. February, 1973.

2. "A Jet You Can Build in Your Own Shop". Mechanix Illustrated. January, 1975.

3. Dyna Jet Pulse Engine (Cost: approx. $125.00)
   Curtis Dyna-Products Corp.
   P.O. Box 297
   Westfield, Indiana 46074

4. USAF CENTRAL AUDIO VISUAL LIBRARY
   Aerospace Audio Visual Service
   Norton AFB
   California 92409

   Request: Air Force Audiovisual Directory
   AF Regulation 95-2 Vol. II

   Confirmation or denial of request forms
   AF-2014 (Free Films)

5. For Static Thrust Test Stand:
   Model Rocket News, Vol. 3, No. 1, pp. 1, 10-12.
   "Model Rocketry and the Science Fair"

6. For Time Thrust Curves:
   Model Rocketry Technical Manual, pp. 84-85.
   "Rocket Engine Design"

7. For Total Impulse:
   Model Rocket News, Vol. 4, no. 2, pp. 3, 5, 6.
   "Rocket Math"

8. For Model Rocket Engines:
   Technical Note, TN-1 - "Rocket Engines"
   Technical Note, TN-2 - "Model Rocket Engine Performance"

9. Films available from:

   National Aeronautics and Space Administration
   Washington, D.C. 20546

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INSTRUCTIONS (NOTES)

TOPIC: 2. Combustion Engines with Reaction Thrust Output (Jets, rockets)

MODULE: AEROSPACE
SUBMODULE E

Suggested references for Topic #2:

The Energy Fact Book. R.C. Dorf.
The U.S. Fact Book: the American Almanac. B.J. Wattenberg.

Complete detailed bibliographic information on these sources is available at the end of this submodule.

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TOPIC: 3. Non-combustion Engines which Operate within the Atmosphere (gravity and wind, human power, electric)

MODULE: AEROSPACE
SUBMODULE E

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having had structured lessons concerning introductory aerodynamics, will be able to recognize gravity as a force used for propulsion with gliders.

   In order to do this, the student must be able to:

   A. List the four forces acting upon an airplane:

      thrust
      drag
      lift
      gravity

   B. Describe how gravity provides thrust for a glider.

      - by flying "down hill" providing lift

2. Senior high school students, having discussed the force of gravity as a propulsion system capable of providing forward thrust, will now be able to compare and contrast the various methods used by early experimenters to meet this objective.

   In order to do this, the student must be able to:

   A. List at least three pre-Wright brothers glider experimenters and their techniques for providing thrust by gravity.

      1. George Cayley (1799) - floating gliders down a hill
      2. John J. Mongomery (1884) - down a gently sloping, mile long hill and released from a hot air balloon
      3. Otto Lilienthal (1871) - running down the slopes of steep hills
      4. Octave Chanute (1896) - launched down slopes

3. Senior high school students, having researched the methods of providing thrust for gliders through the use of gravity by early pre-Wright brothers experimenters, will be able to identify techniques used by modern gliders to attain this result.

In order to do this, the student must be able to:

A. Describe at least two common techniques:

1. Aerotow (powered aircraft cable tow)
2. Winch (electric motor or gasoline engine cable tow)
3. Bungee cord (elastic cord catapult from cliff)
4. Run off slope (hang glider)
5. Balloon drop

4. Senior high school students, having studied how gliders use gravity as a propulsion system, will now be able to identify the vehicles, which depend upon the wind for propulsion.

In order to do this, the student must be able to:

A. Identify the types of early airships (lighter than air) that were propelled only by the wind.

1. hot air balloon
2. gas filled balloon

B. List at least three early lighter than air experimentors, along with their nationality, date of experimentation and type of ship.

1. Montgolfier brothers (French) - June 5, 1783; hot air balloon
2. J.A.C. Charles (English) - August 27, 1783; Hydrogen filled balloon
3. Dr. John Jeffries (American) - 1785; Hydrogen balloon, flew across the English Channel
4. Charles Green (English) - 1821; gas balloon filled with coal gas

C. List two modern lighter than air vehicles which are propelled by the wind, and their applications.

1. Gas filled weather balloons - meteorological studies
2. Propane fired hot air balloons - lighter than air sport aviation
3. Gas filled sport and long distance balloons - Double Eagle II (1978)

C. Explain the second Kremer competiton, the amount of prize money and its winner.

1. For the first successful controlled flight of a man powered aircraft from the mainland of the United Kingdom to the mainland of France.

2. Prize money - 100,000 pounds (about $176,000).

3. <u>GOSSAMER ALBATROSS</u> (Paul MacCready - USA, July 12, 1979); flight time 2 hours and 49 minutes; actual flight distance 35 miles; aircraft is similar to the Gossamer Condor, with a slightly decreased wing span.

7. Senior high school students, having investigated the modern attempts by many inventors to solve the problems of human powered flight, will now be <u>able to analyze the power requirements of successful designs.</u>

In order to do this, the student must be able to:

A. Explain the method of measuring human power (HP).

- muscle power dynamometer (ergometer)

B. Describe the factors which produce human power (HP).

- torque (twisting force)
- RPM (revolutions per minute)

C. Analyze the horsepower potentials of physically fit average sized humans who have trained over a period of time for prolonged strenuous peddling activity.

1. <u>Bryan Allen</u>, pilot/power plant for both successful Gossamer flights is 6 ft. tall and 137 pounds. Bryan learned he could sustain .35HP for 30 minutes, .45 HP for 7 minutes, and 1.2HP for short bursts.

2. For the English Channel crossing, Allen had to pedal at a rate producing .35 hp for 169 minutes!

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INSTRUCTIONS (NOTES)

8. Senior high school students, having studied the many scientific and technical aspects of human powered flight, will now be able to <u>compare and contrast the possible practical applications of these accomplishments.</u>

In order to do this, the student must be able to:

A. List the benefits, both scientific and technical, resulting from the human powered flight experience.

1. Knowledge of factors affecting low speed flight, such as turbulence from air currents or erratic control motion, which increase induced and parasitic drag.

2. The application of modern high technology materials to provide essential simple and lightweight airframe structures.

3. The potential of combining the concepts of human powered airplanes and hang gliders, as well as other slow-flying ultralight vehicles, as an eventual basis for very light, inexpensive gliders of spans between 35 and 50 feet, able to take off from foot-launch, climb to altitudes using motors in the 2 to 6 horsepower range, and then outsoar the hawks.

B. Describe the prestigious trophy won by Dr. Paul MacCready in recognition of his human powered flight successes.

- <u>The Collier Trophy</u> (America): For the greatest achievement in aeronautics or astronautics in America, with respect to improving the performance, efficiency and safety of air or space vehicles, the value of which has been thoroughly demonstrated by actual use during the preceding year.

9. Senior high school students, having completed a comprehensive study of human powered flying machines and their intricacies, including the science, technology, history and modern developments, will now be able <u>to identify the historical attempts to solve problems associated with electric propulsion systems.</u>

In order to do this, the student must be able to:

A. List at least three electric powered aircraft, their inventors, date of experimentation, airframe and motor specifications and any performance data available.

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(INSTRUCTIONS / NOTES)

5. Senior high school students, having studied other non-combustion propulsion systems used in atmospheric vehicles, such as gravity and the wind, will now be able to identify the contributions of early inventors to the solution of heavier-than-air flight by human muscle power.

... to:

A. List the ideas of Leonardo for human powered flight (1483-1499).

- He sketched at least 14 human powered aircraft designs, including:

  a. Flapping wings by pulling with arms and treading with legs.
  b. A double set of wings, operated by foot stirrups, levers and pulleys, in a standing position.
  c. The vertical airscrew operated by human power (helicopter).

B. Identify at least three 19th century inventors of human powered aircraft, describing the machine and the proposed method of propulsion.

1. Charles Spenser (1868 - Great Britain) Two wings (rigid) of 15 square feet, each with flapping tips, weighing 24 pounds was said to have moved along the ground for distances up to 130 feet.
2. Dandrieux (1879). Built an ornithopter (flapping wings) which was designed to attain a figure 8 motion by muscle power (unsuccessful).
3. Cayley (1808 - Great Britain) Tried a muscle powered set of umbrella shaped wings, unsuccessfully.

6. Senior high school students, having had the opportunity to investigate some of the early pioneers and their human powered flying machines, will now be able to identify, compare and analyze some of the modern efforts to produce successful, sustained human powered flight, through the incentive of the Kremer Competitions.

In order to do this, the student must be able to:

A. Explain the first Kremer Competition and the amount of its prize.

1. The course was laid out as a figure - eight around two markers, half a mile apart. Power for takeoff and during

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INSTRUCTIONS (NOTES)

flight had to be muscle-power alone, without the use of stored energy or lighter than air gases. The aircraft had to cross the start and finish lines at a height of at least ten feet.

2. By 1973, the Kremer prize was raised to 50,000 pounds (about $88,000 U.S. dollars at that time).

B. List the Kremer competiton entries (at least 5) along with names, dates and machine specifications from 1961 through the successful completion of the problem

1. PUFFIN Mark I (Hatfield Club - English, 1962); wing span 84 feet; wing area 330 square feet; pusher propeller behind the tail; flew 3,000 feet (straight line).

2. SUMPAC (Southampton University Man Powered Aircract - English, 1962); wing span 80 feet; wing area 300 square feet; pusher type pylon mounted propeller; flew better than 1800 feet (straight line).

3. TOUCAN (Hertfordshire Pedal Aeronauts - English, 1972); wing span 123 feet; wing area 600 square feet; pusher propeller mounted behind the empanage; two person power; flew more than 1000 feet (straight line).

4. JUPITER MPA (Halton RAF College - English, 1972); wing span 80 feet; pylon mounted pusher propeller; single person; flew 1.23 kilometers (straight line).

5. BURD I MPA (Massachusetts Institute of Technology - USA, 1970); wing area 625 square feet, biplane; pusher propeller; canard (tail first) design; 450 lb. gross weight; first flight resulted in nearly complete structure collapse.

6. GOSSAMER CONDOR (Paul MacCready - USA, July 1977); WINNER OF THE KREMER COMPETITION; wing span 96 feet; weight 70 lbs. - gross; pusher propeller, canard design; 7-1/2 minute flight.

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INSTRUCTIONS (NOTES)

1. Airship LaFRANCE: (C. Renard and A.C. Krebs - 1880's) - gas filled non-rigid airship; carried a nine horsepower electric motor that operated from specially designed batteries and drove a tractor propeller (pulls rather than pushes an airplane through the air) 23 feet in diameter. The complete power plant weighed 130 pounds per horsepower. The LaFRANCE reached speeds of 14 miles per hour. Although a definitie improvement in performance over the steam engine, the vehicle was limited by battery weight and short operating time.

2. GOSSAMER PENGUIN: (Dr. Paul MacCready - 1980) - fixed wing, heavier than air; generated electricity from silicon photovoltaic cells (solar cells) to drive an electric motor directly, without energy storage. The first airplane to fly by the direct power of the sun.

3. SOLAR CHALLENGER: (Dr. Paul MacCready - 1981) - electricity generated from photovoltaic cells operated an electric motor which drove a geared down propeller, without energy storage; the fixed wing, heavier than air craft flew 163 miles from Paris to England at an altitude of 11,000 feet.

4. BIONIC BAT (Bionic - for muscle power, Bat - for the battery used to store the pilot's energy): (Dr. Paul MacCready - 1984) - the aircraft was designed to compete in the latest Kremer Competition; a speed prize to be awarded for achieving an average speed of more than 20 mph around a 1,500 meter course (triangluar) with two turning points, 750 meters apart. Required to fly the course in opposite directions, the Bionic Bat employed two special, high efficiency electric motors, which assisted the pedaling pilot. The 10 minute energy storage was achieved by pedaling a specially wound electric generator to charge a 3 pound NiCd (Nickel-Cadmium) battery pack. The airframe has a wingspan of 45 ft., weighs 84 pounds, and has unofficially broken the 20 mph speed limit in practice runs at Shafter, CA. $30,000 prize

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INSTRUCTIONS (NOTES)

TOPIC: 3. Non-combustion Engines which Operate within the Atmosphere (gravity and wind, human power, electric)

MODULE: AEROSPACE
SUBMODULE E

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Purchase, build and fly a simple glider, from a hobby shop, mail order house or direct from the manufacturer. (See resource list at the end of this submodule.)

2. Visit a local radio control club (RC), check with your local hobby shop. Meet some of the people who fly RC gliders by attending a club meeting or going out to their flying field. See RC gliders in action.

3. Visit a local "full scale" glider club. Meet these people and watch gliders in action...go for a ride!

4. Purchase, build and fly a simple airship from a kit. (See resource list at the end of this submodule.)

5. Construct a hot air balloon.

Materials needed:

plastic dry cleaner's bag, piece of scotch tape 1/2" wide x 30" long, 2 pieces balsa 3/16" wide x 1/16" thick x 16" long, 9 wax birthday candles - length cut to 1-1/2" (leave the wick intact - cut bottom), 4 straight pins

Procedure - Construction:

A. Carefully tape the perforated holes in the top of the plastic cleaners bag with scotch tape (magic mending tape works best). Make sure the bag doesn't have any air leaks.

B. Adhere the two balsa strips together forming an X (90 degrees) by first positioning a drop of hot wax from a candle at the center of one of the balsa strips (on the flat side). Place the middle of the other balsa strip onto the first strip and hold until the wax solidifies.

C. Equally distribute the birthday candles onto the flat surfaces of the balsa "X" with a drop of hot liquid wax to hold each.

D. When everything has solidified, place the balsa cross with the attached candles into the open end of the plastic dry cleaner's bag. Have an assistant hold the bag in an upright position, open end down.

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INSTRUCTIONS (NOTES)

E. Pin from the outside of the bag through the plastic and carefully into each of the four balsa ends. NOTE: The cross of balsa with the candles should be located about 4-6 inches from the bottom of the open plastic bag (inside the bag).

Flying your hot air balloon:

A. Choose a calm evening, preferably after dark (so you can follow the progress of your hot air balloon at high altitudes).

B. Have your assistant hold the plastic bag by its two "ears" at the top of the bag.

C. With care, light all nine candles, using another candle, from the bottom of the bag. Be careful not to melt a hole in the plastic, or burn the balsa cross!

D. Allow about 10-20 seconds for the plastic bag to completely fill with hot air before launching. When you feel a gentle tug upward, simply release your grip... no sudden motions, please! The object is to have the balloon rise straight up, without wild oscillations and possible burn-outs because of an unsteady release.

The balloon will rise rapidly to a great altitude where it will be affected by the slightest breeze or gust of wind. The birthday candles will burn surprisingly long, (about 5 minutes), despite the fact that they have been shortened (they must be shortened in order to reduce the launch weight, which is marginal). The candles burn longer because they are operating in an atmosphere of reduced oxygen (inside the plastic bag).

SAFETY NOTE:

1. Do not launch this hot air balloon in an area which will allow it to pass over other structures such as houses or buildings, because of the possible fire hazard.

2. Do not launch hot air balloons during the dry season, when grass and forest fires are more likely.

3. Students should only operate this vehicle under the supervision of an adult.

4. Caution should always be exercised when working with fire or flame.

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INSTRUCTIONS (NOTES)

6. Build a display model of the Gossamer Condor or Albatross.

7. Construct a simple human power dynamometer (ergometer) and determine your horsepower potential.

NOTE: The machine can be constructed by belt driving an automobile alternator from the rear wheel of a bicycle which has had the tire removed. Load may be controlled by a variable resistor in the output circuit of the alternator. The horsepower can be accurately measured by reading the voltmeter (in parallel circuit with the alternator's output) and the ampmeter (in series with the alternator's output. Of course, volts (v) times amps (A) equals Watts (W). Since Watts is the electrical unit of power and the mechanical equivalent of one horsepower (HP) is 746 Watts, the measurement of human horsepower becomes simplified.

A typical test would require the test subject to exert maximum effort for a short period of time (10 seconds ?), while the maximum meter readings (v and A) are recorded simultaneously. These efforts would begin at low loads (mild work on the part of the test subject), or high electrical resistance, and continue in gradual steps to high loads (hard work), or low electrical resistance. The results would be graphed as RPM versus calculated horsepower. A standard mechanical or electrical tachometer may be used with a range of from 0 - 1000 RPM.

8. Purchase, construct and fly a rubber band powered ornithopter (wing flapper) and conduct flight tests for duration.

Materials needed:

Ornithopter kit, basic hobbyist tools and glues

9. Purchase construct and fly an electric powered model airplane from a kit.

Materials needed:

Kit, basic hobbyist supplies and tools

10. Obtain samples of modern high strength/low weight materials from representative industries and incorporate small amounts of these into your model building activities (ie. carbon fiber laminates for wing spars, Boron filaments for wing bracing, Kevlar for landing gear strength.

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INSTRUCTIONS (NOTES)

~~TOPIC: 3. Non~~-combustion Engines which Operate within the Atmosphere (gravity and wind, human power, electric)

MODULE: AEROSPACE
SUBMODULE E

$$<u>ALTERNATE INSTRUCTIONAL STRATEGIES</u>

1. 35mm Color Slides: These provide a visual impact unsurpassed by few of any other technique. Included in this presentation should be slides of:

   - historical gliders
   - modern gliders
   - historical human powered aircraft
   - modern human powered aircraft
   - modern electrical powered aircraft
   - historical lighter than air vehicles
   - modern lighter than air vehicles

   Many slides can be created by photographing pictures contained in magazines and texts. Be sure to secure the publisher's <u>permission</u> to copy these illustrations so you will not violate copyright laws.

2. The following <u>student activities</u> center around <u>independent library research</u>, where many <u>references</u> are utilized. Bibliographic information on these references can be found at the end of this submodule.

   A. List <u>three uses</u> for the modern lighter than air, gas filled vehicle.
   REFERENCES: card catalog; encyclopedia index
   SUBJECTS: aircraft; lighter than air vehicles; balloons, inventions; transportation

   B. Write a short paper of the development of the glider after World War II, describing the scientific and technical milestones through the modern era.
   REFERENCES: card catalog; encyclopedia index
   SUBJECTS: gliders; aircraft; heavier than air vehicles; transportation

   C. Develop a list of practical uses for the human powered, heavier than air flying machine. Don't limit yourself to actual historical vehicles, but speculate upon potential future uses and spinoffs.
   REFERENCES: card catalog; encyclopedia index
   SUBJECTS: human powered vehicles; muscle power; inventions; aircraft; transportation

   D. Determine the <u>number of solar cells</u> that are needed to produce one horsepower in bright sunshine for the purpose of providing propulsion for a heavier than air vehicle. Describe how such vehicles might sustain flight 24 hours a day.

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REFERENCES: card catalog; enyclopedia index

SUBJECTS: solar cells; photovoltaic cells; aircraft; transportation

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INSTRUCTIONS (NOTES)

TOPIC: 4. Non-combustion Systems which Operate in Space (Nuclear and Electric Propulsion)

MODULE: AEROSPACE
SUBMODULE E

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

A. NUCLEAR PROPULSION

1. Senior high school students, having viewed audio visual presentations, introductory lessons and a guest speaker, will be able to list and explain the reasons for and the goals of our nuclear propulsion system research.

In order to do this, the student must be able to:

A. State the reason for our interest in nuclear propulsion research.

- In 1960, the AEC-NASA (Atomic Energy Commission - National Aeronautics and Space Administration) Space-Nuclear Office (SNPO) was formed to push toward an operational nuclear engine that would aid the U.S. in the race to the moon and other planets. The new agency was formed because of the Russian Sputnik I and other orbiting space successes.

B. List the goals of our newly formed nuclear propulsion research program.

1. Provide basic design concepts for nuclear rockets.
2. Extend reactor technology to improve efficiency and increase power.
3. Provide technology for flight reactors.
4. Provide nuclear rocket engine system technology.

B. Senior high school students, having absorbed the introductory material concerning advanced propulsion systems, will now be able to trace the history of nuclear propulsion by identifying the various projects, the system involved, the performance obtained and problems encountered. Dates should be listed.

In order to do this, the student must be able to:

A. List the projects

ROVER
CONDOR
KIWI

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INSTRUCTIONS (NOTES)

NERVA
PHOEBUS

B. Describe the systems involved with each project:

<u>ROVER:</u> overall project name for rocket research (1960)

<u>CONDOR:</u> a huge nuclear powered airplane (never built)

<u>KIWI:</u> non-flying test reactors that were fired nozzle up. Power level obtained - about 100 megawatts. KIWI A operated on gaseous hydrogen while KIWI B advanced to liquid hydrogen working fluid. KIWI B operated at about 1100 MW (July 1959 -64)

<u>NERVA:</u> (Nuclear Engine for Rocket Vehicle Application). Engines were redesigned to operate at about 1-1/2 times the power level of the KIWI B (1,500 megawatts - thermal). This is enough to generate about 37.5 tons of thrust in space. The program began in the fall of 1960 and continued through 1969.

<u>NRX:</u> (NERVA Reactor Experiment) Engine systems test (all major engine components were assembled into a breadboard configuration). A major milestone was achieved in December 1967 when the NRX was operated at full power for 60 minutes. This series of tests showed that a complete nuclear rocket system could start on its own power and operate stabily over a wide range of conditions.

<u>PHOEBUS:</u> This project might best be thought of as a tool to advance the nuclear rocket technology. The project advanced the areas of higher exhaust gas temperatures

- higher power levels
- longer component life

Project tests were performed with system components arranged in a configuration which would be used in an actual flight. Tests were concluded in August 1969.

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INSTRUCTIONS (NOTES)

C. Identify project problems:

1. KIWI B - internal vibrations caused extensive reactor damage to the internal garphite core.

2. Remote dis-assembly because of radio-activity.

D. Identify the location for propulsion systems testing:

- The Nuclear Rocket Development Station (NRDS) located in Jackass Flats, Nevada.

3. Senior high school students, having been exposed to basic nuclear propulsion technology through audio visual presentations, lectuures and discussions, will now be able to list the major segments of a nuclear propulsion system and their use.

In order to do this, the student must be able to:

A. List the five segments of a nuclear propulsion system, and their basic functions.

1. The reactor - heat source
2. The pump - pulls liquid Hydrogen from its tanks and forces it through the reactor.
3. The nozzle - device that transforms heat energy to mechanical thrust
4. The structure - holds all the pieces together
5. The controls - force all engine components to march in step at the command of the spacecraft pilot

B. Describe the primary operation of the nuclear propulsion engine.

1. Nuclear rocket engines work in the same manner as conventional chemical rocket engines, except that that nuclear reactor heats the Hydrogen into a high velocity gas that exits from the throat of the rocket nozzle.

4. Senior high school Students, having participated in class discussions, will be able to identify the advantages and disadvantages of nuclear rockets plus establish ideal role models for their applications.

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In order to do this, the student must be able to:

A. List the advantages and disadvantages of nuclear rockets:

Advantages:

1. The nuclear rocket has exhaust velocities that are about double that of conventional chemical rockets. This high velocity translates into high fuel economy, or specific impulses up to about 900 seconds. Stated another way: nuclear rockets use only about half the propellant (weight) for each second of operation as a comparable thrust chemical rocket.

2. Combustion is not required for providing thrust.

3. The reactor fuel has a great deal of energy packed in it, and is therefore suited for long distance flights.

Disadvantages:

1. Nuclear propulsion systems are heavier and more costly than a chemical rocket of similar performance capabilities.

2. NERVA's thrust capability is considerably smaller than the largest chemical engines, (ie. NERVA: 37.5 tons; chemical rocket engines: up to 750 tons).

3. Nuclear propulsion systems are highly radioactive, which causes great problems in the areas of crew shielding; component maintenance and service; component recycling, etc.

B. Identify and explain the ideal role(s) of nuclear propulsion systems:

Nuclear propulsion systems are not ideally suited for launch vehicles because of their relatively low thrust levels. Their use in outer space where high exhaust gas velocity translates into high efficiency is a great asset. Examples are:

a. Operations from earth orbit, moving outward toward a higher earth orbit, the moon and other planets.

b. Perhaps the real significance of the nuclear rocket lies in the fact that it represents a true advance in our overall propulsion capability.

B. ELECTRIC PROPULSION

5. Senior high school students, having seen and discussed several audio visual presentations along with an introductory lecture, will be able to describe the purpose for having electric propulsion systems, the energy sources required and the essential component categories.

In order to do this, the student must be able to:

A. Describe the purpose of electric propulsion:

Highly efficient propulsion systems are needed for space travel of the future. These systems are required especially for manned trips from earth to other planets, which will take months or even years.

B. List the possible energy sources which may be used for electric propulsion.

- nuclear fission
- concentrated solar energy

C. List the essential components of an electric propulsion system:

- source of heat
- unit to convert heat to electricity
- an electric thruster unit

6. Senior high school students, having participated in class discussions after a presentation by a guest lecturer, and a formal lecture concerning the technical merits of these systems, will be able to identify and describe the major types of electrical propulsion systems and list the primary advantages and disadvantages of each.

In order to do this, the student must be able to:

A. List and describe the three major types of electric propulsion systems:

1. ELECTROTHERMAL PROPULSION (arcjet). Electric power is used to heat a propellant to a high temperature. The heat transfer may be accomplished by flowing the propellant gas through an electric arc or over a resistance-heated surface. The expanded gas is expanded through a nozzle, similar to that of a chemical rocket engine.

2. ELECTROMAGNETIC PROPULSION (plasma jet). In this engine, the propellant gas is ionized to form a plasma that is accelerated rearward by electrical and magnetic fields to produce thrust. A plasma conducts electric current just as a copper wire does. No exhaust nozzle is needed with this system. It is this characteristic that allows a plasma to be accelerated. When an electric current is passed through a plasma that is in a magnetic field, a force is exterted on the plasma in a rearward direction at a high velocity, producing thrust.

3. ELECTROSTATIC PROPULSION (ion). This propulsion system is often referred to as ion propulsion. As in the plasma system, propellant atoms are ionized by removal of electrons. The electron removal is at the same rate as the ions are accelerated rearward. The system component that accomplishes this ionization and separation is called the emitter. No exhaust nozzle needed with this system. Electric fields are required to accelerate ions. Ion acceleration is produced by an accelerator that takes the ions from the emitter and electrostatically accelerates them to high velocity.

B. Itemize the main advantages and disadvantages of each propulsion system:

Advantages:

ELECTROTHERMAL (arcjet) - has a relatively high efficiency (approximately 40%). It has a specific impulse of between 1500-2000 seconds and the potential for producing the high thrusts of any electric propulsion system.

ELECTROMAGNETIC (plasma) - has very high efficiency (approximately 90%). It has very high specific impulse of between 5000-20,000 seconds.

ELECTROSTATIC (ion) - the engine has very high efficiency (approximately 90%). It has a very high specific impulse of between 5000-20,000 seconds.

Disadvantages:

ELECTROTHERMAL (arcjet) - limits to increased exhaust velocity seem to be associated with the breakdown of the Hydrogen molecule (dissociation) at high temperatures (3000 degrees K). Dissociation absorbs energy. Another problem with this type is exhaust nozzle materials failure and arc erosion at elevated levels of exhaust gas velocity, low thrust levels, high system weight, high power per pound of thrust.

ELECTROMAGNETIC (plasma) - technology of producing and maintaining a plasma is at an elementary level. Proposed engines will have a low thrust, high weight and high power requirement per pound of thrust produced.

ELECTROSTATIC (ion) - have the same types of problems that plasma engines encounter, including high weight and power requirements plus a low level of technical development.

Disadvantages common to all electric propulsion systems include:

a. System reliability for the weeks or months of continuous operation required.
b. Heavy, bulky radiator equipment necessary to cool and condense the high temperature vapor, after it leaves the turbine, before it returns (pumped) to the heat exchanger.

7. Senior high school students, having studied the various technical system from the text, plus having already evaluated chemical rocket systems, will now be able to list the components of a typical electric propulsion system, and be able to compare its performance with that of the chemical rocket and list the performance capabilities of each electric type.

In order to do this, the student must be able to:

A. List the components of a typical nuclear fission turbo electric generating system:

reactor
neutron shield
heat exchanger
gamma shield
liquid vapor separator
electric cable
generator
turbine
radiator
electric rocket engine
propellant storage

B. Compare electric propulsion systems with chemical propulsion systems for a proposed manned trip to Mars:

For an eight man crew, taking 500 days round trip, the following would be true:

a. Weight of the electric propulsion system - 450,000 lb.
b. Weight of the chemical propulsion system - 8,000,000 lb.
c. Both systems would have to be assembled in orbit.
d. Two boosters would be required for the electric propulsion system's components.
e. Forty boosters would be required for the chemical propulsion system's components.

C. Itemize the performance capabilities of the three electric propulsion types:

ELECTROTHERMAL

thrust range - 0.1 - 10 lb.
specific impulse - 1,000 - 2,000 sec.
power/pound of thrust - 500 KW
weight of system/pound of thrust - 500 lb.
operation time - weeks
efficiency - approx. 40%

ELECTROMAGNETIC

thrust range - .001-1.0 lb.
specific impulse- 5,000-20,000 sec.
power/pound of thrust - 250 KW
weight of system/pound of thrust - 6,000 - 20,000 lb.
operation time - months
efficiency - approx. 90%

ELECTROSTATIC

thrust range - .001-1 lb
specific impulse - 5000-20,000 sec.
power/pound of thrust - 50KW
weight of system/pound of thrust - 5,000-15,000 lb
operation time - months
efficiency - greater than 90%

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INSTRUCTIONS (NOTES)

TOPIC: 4. Non-combustion Systems which Operate in Space (Nuclear and Electric Propulsion)

MODULE: AEROSPACE
SUBMODULE E

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Model building:

A. Nuclear powered airplane - from project CONDOR which was to use the nuclear powered ramjet from project PLUTO (part of the ANP - Aircraft Nuclear Propulsion - program).

B. Construct a model of the nuclear engines KIWI or NERVA

C. Research, design and build a model of a proposed (by the student) nuclear powered space ship for interplanetary travel.

D. Build a model of an ARC, PLASMA and ION engine.

E. Research, design and build a model of a proposed (by the student) electric propulsion spaceship and its necessary componenets (ie. radiators).

Materials needed:

Model building tools, etc, balsa wood, pins, cement, bass wood, styrene plastic sheeting 1/16" thick, flat paint

2. Direct students to "fill in the blanks" on the prepared follow along sheet while the teacher narrates 35mm color slides of actual examples and illustrations of nuclear and electric propulsion systems.

Materials needed:

35mm color slides available from NASA, DOE and the NRC, spirit duplication of a follow along sheet, which includes dates names engine identification and a space for comments

3. Have the class veiw one or more of the following films:

Atomic Energy for Space
Electric Propulsion
Nuclear propulsion for Space
Power for Propulsion
Project Rover
Rocket Propulsion

NOTE: See bibliography at the end of this submodule for film descriptions, production dates, running time, and sources.

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INSTRUCTIONS (NOTES)

TOPIC: 4. Non-combustion Systems which Operate in Space (Nuclear and Electric Propulsion)

MODULE: AEROSPACE
SUBMODULE E

$$ALTERNATE INSTRUCTIONAL STRATEGIES

1. The following student activity centers around independent library research, where many varied references are utilized.

   A. Compare society today with that of a future date (ie. 2025), when massive exploration of the planets and other galaxies will probably be in progress, using advanced propulsion systems such as nuclear and electric technologies.
   REFERENCES: card catalog; encyclopedia index
   SUBJECTS: future, civilization, transportation, space, invention

   Suggested readings: Future Shock. A. Toffler.
   Megatrends.
   The Third Wave. A Toffler.

2. Using technical drawing instruments, draw a flow diagram of a complete electric or nuclear propulsion system, including all necessary components for a proposed spacecraft vehicle.

3. Assemble aerospace technology students for a panel discussion/debate where the pros and cons of nuclear propulsion for space travel are discussed in relation to other propulsion systems.

4. Write the various government agencies (NASA, DOE, NRC) requesting information concerning recent developments in the areas of nuclear and electric propulsion.

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INSTRUCTIONS (NOTES)

~~TOPICS: 1 - 4~~

MODULE: AEROSPACE
SUBMODULE E

$$SUGGESTED SUBMODULE RESOURCES - NON-PRINT (AUDIO VISUAL) MATERIALS

ATOMIC ENERGY FOR SPACE - 1967 (17 min)

This film explains the two basic ways in which nuclear energy for space is being developed: The nuclear rocket and nuclear generators to produce electricity for spacecraft use. Project ROVER is covered through animation.

Free film loan from NRC or Audience Planners, NY, NY.

ELECTRIC PROPULSION - 1960 (24 min)

Film describes the operation and applications of electric propulsion units. Extensive use of animation.

Free loan from Audience Planners, NY, NY.

NUCLEAR PROPULSION FOR SPACE - 1969 (19 min)

This film was produced by NASA and the AEC (now NRC). The film presents the story of the development of a nuclear rocket engine for space exploration.

Free film loan from NRC or Audience Planners, N.Y., N.Y.

POWER FOR PROPULSION - 1965 (15 min).

Shows the operation of nuclear rockets, NERVA's first test firing. Developments for deep space missions are shown.

Free film loan from NRC and Audience Planners, NY, NY.

PROJECT ROVER - 1962 (21-1/2 min)

This historical film is a progress report on the design, fabrication and testing of KIWI.

Free film loan from NRC or Audience Planners, NY, NY.

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INSTRUCTIONS (NOTES)

ROCKET PROPULSION - 1960 (28 min)

A technical film describing the performance criteria associated with all thrust reaction engines (total and specific impulse, mass ratio, etc.).

Free film loan from:

USAF Central Audio Visual Library
Aerospace Audio Visual Service
Norton AFB
California 92409

Request: Air Force Audio Visual Directory
AF Regulation 95-2 Vol. II

Confirmation or denial of request forms AF-2014 (free films loan)

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TOPICS: 1 - 4

MODULE: AEROSPACE
SUBMODULE E

$$SOURCES OF MODELING SUPPLIES

F.A.I. MODEL SUPPLY CO.
P.O. Box 3957
Torrance, CA 90510

Model airplane kits and supplies.

INDOOR MODEL SUPPLY
Box C
Garberville, CA 95440

Model airplane kits and supplies.

MICRO X, INC.
P.O. Box 1063
Lorain, OH 44055

Model airplane kits and supplies

TOPICS: 1 - 4

MODULE: AEROSPACE
SUBMODULE E

$$SUGGESTED SUBMODULE RESOURCES - PRINT MATERIALS

Bilstein, Roger E. Fundamentals of aviation and space technology. Savoy, Ill. University of Illinois - NASA. 1974.

Coard, E.A. Spacecraft and their boosters. Maxwell AFB, AL. Air Force Junior ROTC. 1972.

Conway, Carle. The joy of soaring: a training manual. Los Angeles, CA. The Soaring Society of America, Inc. 1969.

Corliss, William R. Nuclear propulsion for space. Oak Ridge, TN. U.S. Department of Energy. 1971.

Dorf, Richard C. The energy fact book. NY. McGraw-Hill. 1981.

Dwiggins, Don. Man-powered aircraft. Blue Ridge Summit, PA. TAB Books, 1979.

Energy technology handbook. NY. McGraw-Hill. 1977.

Finney, R.T. Pioneers of flight. Maxwell AFB, AL. Air Force Junior ROTC. 1975.

Gentle, Ernest J. Aviation space dictionary. Fallbrook, CA. Aero Publishers, Inc. 1980.

Goodger, E.M. Principles of spaceflight propulsion. Elmsford, NY. Pergamon Press, Inc. 1970.

Grosser, Morton. Gossamer Odyssey. Boston. Houghton-Mifflin Co. 1981.

McGraw-Hill encyclopedia of science and technology. NY. McGraw-Hill. 1982.

Martin, Ralph C. Rocket and space science series. Volume I: Propulsion. NY. Howard Sams & Co., Inc. 1967.

Meyer, Robert B. Langley's (full scale) aero engine of 1903. Washington, D.C. Smithsonian Institution Press. 1971.

Meyer, Robert B. Langley's model aero engine of 1903. Washington, D.C. Airplanes and Engines Publishers, Inc. 1976.

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INSTRUCTIONS (NOTES)

New York Times school microfilm collection. (1878-1980). NC. Microfilming Corporation of America. (Superceded by: _New York Times current events edition_, 1980 -).

Smithsonian book of invention. 1st. ed. NY. Smithsonian Institution Press. 1978.

Space technology. (Illustrated Encyclopedia, 1 vol.) NY. Crown Publishers. 1981.

Sutton, George P. _Rocket propulsion elements._ NY. John Wiley & Sons. 1967.

Thomas register of American manufacturers. NY. Thomas Publishing Co. annual.

Those inventive Americans. Washington, D.C. National Geographic Society. 1971.

Toffler, Alvin. _Future shock._ NY. NAL 1973.

Toffler, Alvin. _The third wave._ NY MacMillan. 1983.

Wattenberg, Ben J. _The U.S. fact book: the American almanac._ NY. Grosset and Dunlap. annual.

Winter, Frank H. _Prelude to the space age._ Washington, D.C. Smithsonian Institution Press. 1983.

$$PERIODICALS OF INTEREST

MODEL AIRPLANE NEWS
Air age, Inc.
837 Post Road
Darien, CT 06820

MODEL AVIATION
Academy of Model Aeronautics
1810 Samuel Morse Drive
Reston, VA. 22090

MODEL BUILDER
621 West Nineteenth Street
Box 10335
Costa Mesa, CA 92627-0132

AEROMODELLER (British)
Argus Press, Ltd.
23/27 Tudor Street
London, E.C.4. ENGLAND

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INSTRUCTIONS (NOTES)

PHASE: CONCENTRATION   ELEMENT: TECHNOLOGY

MODULE: AEROSPACE

SUBMODULE: F. SPACE TECHNOLOGY - UNMANNED

TOPICS:
1. Space Technology - Unmanned: Overview
2. Unmanned Space Vehicle Delivery Systems
3. Space Vehicle Concepts

PREREQUISITES: Submodule E: Propulsion Systems

$$PREPARED BY
$$CHARLES H. GOODWIN
$$UNION-ENDICOTT HIGH SCHOOL
$$ENDICOTT, NEW YORK

TOTAL TEACHING TIME:
SUBMODULE F: 7 hours

DATE: September 2, 1984

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TOPICS: 1 - 3

MODULE: AEROSPACE
SUBMODULE F

$$OVERVIEW OF SUBMODULE

GOALS:

Upon completion of this submodule, students will be able to:

1. Isolate delimiting parameters of the unmanned space program.
2. Establish the historical achievements of consistent unmanned space projects.
3. Characterize the delivery systems for unmanned programs.
4. Compare the taxonomic elements and structures of unmanned space vehicles.
5. Identify realistic projected goals involving future unmanned space missions.

DESCRIPTION:

Outer space (the so-called black void, or last frontier) exists beyond the limits of our earth's atmosphere or any celestial body's immediate influence. This region has, for ages, been a romantic ideal for so many writers like Voltaire, Edgar Allen Poe, Jules Verne, H.G. Wells, and Arthur C. Clarke. One only has to look to the stars, planets and moon at night and the imagination can run wild with the thought of what lies out there in the abyss of outer space.

In the latter part of the nineteenth century, one man lacked the technological means for space travel, but he remarkably managed to come up with all of the right theories for making space travel adventure achievable. This visionary individual was Konstantin Tsiolkovsky (1857-1935), of Russia. Inspired by Jules Verne's stories, Tsiolkovsky conceived laws of motion of bodies in cosmic space, the velocities required for both earth orbit and earth escape, the use of multistage rockets for space travel, the need for heat shields in re-entry from space, the use of liquid hydrogen and liquid oxygen as rocket fuels and the creation of space stations in orbit with self-contained environments. Unfortunately, Tsiolkovsky's works remained in obscurity in Russia while America's Robert Goddard and Germany's Hermann Oberth separately laid the ground work for modern rocketry.

Working an ocean apart, Goddard and Oberth believed liquid fueled rockets were the answer to efficiently lifting payloads from the earth's surface and allowing them to perform in outer space. In 1919, Robert Goddard stimulated everyone's interest with his famous paper, A Method of Reaching Extreme Altitudes. Hermann Oberth, in 1923, influenced the establishment of the German Society for Space Travel with his paper, Rocket Into Inter-Planetary Space.

Modern rocketry saw its real beginning with Robert Goddard's designs, constructions and launches in the late 1920's and early 1930's. Further refinements of Goddard's work, which thrust the world into the Space Age in short order, were those carried on by the German rocket specialists at Peenemunde while creating the A-4 (V-2) and the A-9/A-10 project during World War II.

Unmanned space technology came into being on October 4, 1957, when the Russians shocked the modern world by placing Sputnik 1 into earth orbit. By placing this first artificial 184 pound satellite into orbit, the Russians created a resounding political and scientific victory for themselves, and a bitter pill for the Americans to swallow. Almost one month after Sputnik 1, the Russians orbited a much larger Sputnik 2, which contained a dog, named Laika. The Sputniks caused the Americans to scramble and rework their space program. Certainly the races for space, space technology and space supremacy were placed into full swing.

Today, the outer space arena is not limited to two powerful nations. our space environs are open to an international space effort. Beyond the National Aeronautics and Space Administration (NASA) and the Soviet Academy of Sciences (USSR), we have the European Space Agency (ESA), the United Kingdom (UK), Japan's National Space Development Agency (NASDA), India's Indian Space Research Organization (ISRO) and France's Centre Nationale d'Etudes Spatiale (CNES), all striving towards a greater understanding of our place in the universe through space exploration.

Since the space race's inception, the citizenry of earth has been introduced to countless new vistas of information never before enjoyed or even thought possible. Satellites provide instant communication anywhere on earth, up to the minute weather information, worldwide news coverage, the management of crops and population centers, the monitoring of pollution elements, observation of military developments, geological surveys, the mapping of our oceans, air and sea navigation and the tremendous enhancement of search and rescue efforts. Informational production of this scope allows the earth's inhabitants to better understand each other, to realize their effect on the earth's environment and the environmental effect on all of us.

Turning away from earth, our focus settles on the multitude of heavenly bodies that have always tantalized our imagination. Through the use of spacecraft, we have created a method whereby we can reach these celestial objects for first-hand exploration and analysis. These scientific vehicles go by several classifications, depending on their intended mission and on-board hardware. Spacecraft classes include: orbiters, landers, orbiter/landers, surface rovers, atmospheric rovers, probes, orbiter/probes, comet chasers, and a wide array of earthbound satellites and earth-based telescopes designed to study our sun, the solar system and interstellar space. No matter where we turn, we have the technological capacity to go in that chosen direction. Our horizons are unlimited.

The unmanned space program, over the past three decades, has provided more knowledge about ourselves, our planet, and about the universe than all of the cumulative information attained prior to the launch of Sputnik. Space science has become a respected exacting science. Space related technology has affected the workplace at every level and has made tremendous influences in our modern homes and lifestyles. Practical benefits from space technology and space exploration are firmly established with every new insight and useable spin-off. Continual advances are being made in medicine, transportation, electronics, manufacturing and nearly every aspect of human endeavor. World economics are stimulated through the development of new and improved products and processes. Benefits from outer space have made our earth smaller and more vulnerable, planting the seed towards greater international understanding and cooperation.

Continued exploration, analysis and observation of our earth, sun, moons, planets, asteroids, belts of influence, comets, the Milky Way galaxy and the far reaches of the universe is essential. By obtaining a growing body of information on the heavenly occupants found within the void of space, we can more readily verify our roots of origin, pinpoint where extraterrestrial life might be found and provide a foundation on which we can grasp a part of our own destiny.

<u>SKILLS, KNOWLEDGE, BEHAVIORS TO BE DEVELOPED:</u>

<u>SKILLS:</u> Design, measure, construct, refine, prepare and launch a payload with a rocket launcher.

<u>KNOWLEDGE:</u> The design, limitations, history, classifications, spin-offs, future prospects, delivery systems, guidance systems, communication systems, and power systems of unmanned space technology.

<u>BEHAVIORS:</u> Develop resourcefulness, cooperation, organization, safe attitudes, concern for others, appreciation for materials, processes, procedures and unmanned space technology.

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INSTRUCTIONS (NOTES)

TOPIC: 1. Space Technology - Unmanned: Overview   MODULE: AEROSPACE
SUBMODULE F

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been given detailed descriptions, supportive audio visual information (movies, slides, posters, overheads), and verbal descriptions, will be able to determine the delimiting constraints of unmanned space technology through objective tests, oral and written analysis.

In order to do this, the student must be able to:

A. Define unmanned space technology.

- the development of a man-made vehicle, with all of its component parts, which is designed to operate unmanned, outside the earth's atmosphere for any purpose.

B. Relate the importance of national political support towards the existence of space agency ventures.
C. Recognize the importance of international law.
D. Recognize the importance of international cooperative space efforts.
E. Determine the advantages and disadvantages of unmanned space vehicles, such as:

1. Advantages:
   a. lower costs
   b. mission flexibility
   c. lighter payloads
   d. less complexity
   e. expendable
   f. tireless reporters
   g. very adaptable

2. Disadvantages:
   a. few in-mission maintenance possibilities
   b. lack of inherent intelligence
   c. lack of spontaneous judgement
   d. must be preprogrammed for the unknown
   e. limited corrective measures

2. Senior high school students, having been exposed to classroom presentations, prepared written descriptions, audio visual resources and textbook assignments, will be able to categorize and discuss unmanned space vehicles according to accepted international classifications. The student will demonstrate comprehension of this subject matter through class discussion, class assigned work sheets, and essay writing.

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In order to do this, the student must be able to:

A. Read and understand space agency definitions and supporting audio visual materials.

B. Determine the international classifications for unmanned spacecraft:

1. satellites
2. orbiters
3. probes
4. orbiter/probe
5. orbiter/lander
6. atmospheric probe
7. surface rovers
8. sample return vehicle
9. lander

C. Organize spacecraft into their proper classifications:

1. Communications satellites (examples):

Telstar	USA
Intelstat	USA
Molniya	USSR
Marots	ESA
ECS	NASDA
Sirio	Italy

2. Meteorology satellites (examples):

Tiros	USA
Nimbus	USA
Meteosat	ESA
GMS	NASDA
Eole	France

3. Military satellites (examples):

Velva 11/12	USA
Big Bird	USA
Navstar	USA
IMEWS	USA

4. Scientific satellites (examples):

GEOS	USA
Exosat	ESA
Helios	Germany
Intercosmos	USSR
Prognoz	USSR

5. Planetary orbiter/lander (examples):

Mars 3	USSR
Viking	USA

6. Planetary orbital survey (examples):

Mars	USSR
Mariner	USA

7. Space probes (examples):

Mariner	USA
Pioneer	USA
Voyager	USA
Galileo	USA

D. Identify space vehicle configurations through photographs, models and illustrations.

E. Write an essay about the mission profile of one spacecraft.

3. Senior high school students, having been exposed to textbook references, audio visual materials, written descriptions, duplicated illustrations, prepared worksheets and library resources, will be able to establish notable historical developments of unmanned space technology.

In order to do this, the student must be able to:

A. Observe movies and filmstrips on historical growth.

B. Research unmanned space program achievements through prepared worksheets and text materials.

C. Relate chronological developments of unmanned space projects through photos, illustrations and models.

D. Compare the early American space program to the early Russian program.

E. Identify space achievements of Japan, the European nations, India and others.

F. Indicate the contributions obtained from the founding fathers of modern day space programs:

1. Robert Goddard
2. Konstantin Tsiolkovsky
3. Hermann Oberth

4. Senior high school students, having been given access to library resources, audio visual materials, and actual examples, will be able to determine twenty or more different spin-offs made possible through the unmanned space program.

In order to do this, the student must be able to:

A. Explain the meaning of spin-off or space dividend:

- Any resultant space program technological innovation that can benefit the workplace, and/or become incorporated, either directly or indirectly, into consumer products and resources.

B. List numerous space program spin-offs that provide conveniences and advantages for the individual:

1. accurate weather information
2. noise abatement
3. automobile components
4. environmental control of buildings
5. worldwide communications
6. computer technology

C. Develop charts or graphs showing spin-off impacts on the American work force.

D. Select five spin-offs and realize the technological growth of each, such as:

1. microminiaturization
2. new materials
3. health and medicine
4. the monitoring of the earth
5. solar powered products

5. Senior high school students, having been presented current space agency literature, library resources, photographs and supportive audio visual materials, will be able to designate and describe future unmanned space ventures.

In order to do this, the student must be able to:

A. Describe the celestial inhabitants of our solar system, galaxy, and universe.

1. Solar system:

sun
planets
moons
comets
asteriods
meteorites
outer space

2. <u>Galaxy system:</u>

   100 billion stars
   black holes
   planetary systems
   pulsars
   nebulas
   interstellar space

3. <u>The Universe:</u>

   galaxies
   quasars
   galaxy clusters
   intergalactic space

B. Isolate reasonably close celestial bodies, having the greatest potential for the return of scientific information:

   Mercury
   Mars
   Venus
   Jupiter
   Saturn
   Uranus
   Titan
   Europa
   Granymede
   Triton
   The Sun

C. Draw detailed trajectory illustrations of intended space exploration missions.

D. Problem solve space flight format computer programs.

E. Illustrate the future unmanned role for lensed and radio telescopes, such as:

   1. Earth based
   2. orbiting space telescope
   3. SETI (search for extraterrestrial intelligence)
   4. SIRTF (shuttle infrared telescope facility)
   5. AXAF (advanced X-ray astrophysics facility)
   6. COBE (cosmic background explorer)
   7. IRAS (infrared telescope facility)

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INSTRUCTIONS (NOTES)

F. Identify examples of possible military earth orbital endeavors, such as:

1. ASAT (anti-satellite system)
2. High Frontier
3. Laser Weapons

G. Discuss probable and possible space ventures covering the next two decades, such as:

1. Galileo - Jupiter exploration - USA
2. VELA 1 and 2 - Halley's Comet & Venus - USSR
3. Project Huygens - Titan
4. Project Herschel - Uranus
5. TSS - tethered satellite system

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INSTRUCTIONS (NOTES)

TOPIC: 1. Space Technology - Unmanned: Overview

MODULE: AEROSPACE
SUBMODULE F

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Intorduce students into the realm of unmanned space technology by providing detailed audio visual materials, oral and written descriptions related to legal and political limitations. Students will be expected to articulate legal and political factors through written class assignments and class discussions.

Suggested topics for consideration:

international space agreements
space motivations and goals - USA
space motivations and goals - USSR
the goals of peace and international cooperation
justification of national space program initiatives

Materials needed:

Library resources, audio visual materials, information sheets, student notebooks, written descriptions.

Suggested films: International Cooperation in Space
Partnership Into Space Mission: Helios

(see resource list at the end of Submodule F)

Suggested references: The Politics of Space. Wm. Schauer
Satellite Spies. S. Hochman

2. Organize the class into a functional school-based space agency. Describe the necessary organizational structure and allow the class to determine who will fill leadership posts through Parlimentary Procedure. Have the newly formed space agency investigate and adhere to:

The model rocketry safety code
NYS laws governing rocket launches
Local restrictions
School-approved launch sites
Goals of the agency's space program
Classroom safety requirements

Materials needed:

Library resource materials, information sheets, audio visual materials and equipment.

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Suggested film: Model Rocketry: the Last Frontier

(see resource list at the end of Submodule F)

Suggested references: Industrial Arts Teacher's Manual for Model Rocketry. H. Smith and H.J. Warden
The Model Rocketry Manual. G.H. Stine
Handbook of Model Rocketry - NAR. G.H. Stine.

3. Exhibit a model of a satellite, an unmanned vehicle or use an overhead transparency showing an accurate, easy to follow space vehicle illustration. Have students equipped with prepared follow along sheets. Discuss the advantages and disadvantages of unmanned vehicles.

Materials needed:

Space vehicle model, overhead transparency, information sheets, student notebooks, textbooks, library resources, follow along sheets.

Suggested references:

NASA Spacecraft. Wm. Corliss
Planetary Encounters: the Future of Unmanned Spaceflight. R. Powers
"Unmanned Probes on a Comeback". M. Lemonick

(see resource list at the end of Submodule F)

4. Clarify to students the classification and class member breakdown of unmanned spacecraft, using models, overhead transparencies, mission profiles, and library materials. Students will be able to identify notable spacecraft configurations and place them into a proper classification format.

Materials needed:

Student notebooks, models, information sheets, photographs, illustrations, follow along sheets,

Suggested films: Exploration of the Planets.
Trial Balance.

(see resource list at the end of Submodule F)

Suggested sources of information:

Aerospace Education Association of America
NASA, Goddard Space Flight Center
Jet Propulsion Laboratory - Teacher Resource Center
(see resource list at the end of Submodule F)

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INSTRUCTIONS (NOTES)

Suggested references:

Planetary Encounters: the Future of Unmanned Spacecraft. R. Powers
Jane's Pocket Book of Space Exploration. T.M. Wilding-White
The Observer's Spacecraft Directory. R. Turnill.

5. Assign an essay covering the mission profile of one unmanned spacecraft. Utilize this assignment as an outside library research exercize, which will include the following:

- classification of spacecraft
- spacecraft type
- on-board experiments
- successes and failures
- labeled spacecraft illustration
- mission goals
- current expectations

Materials needed:

Suggested references:

Jane's Pocket Book of Space Exploration. T.M. Wilding-White
The Observer's Spacecraft Directory. R. Turnill
NASA, Spacecraft. Wm. Corliss.

6. Construct a scale model of a selected spacecraft (ex. Mariner, Pioneer Space Telescope) out of wood, plastic or any combination of materials. The student will accompany his model project with a written report containing the following supportive facts:

- missions performed
- specifications
- launch vehicles
- evaluation of vehicle
- projected vehicle use

Materials needed:

Kit materials, plastic, wood glue, x-acto knives, scroll saw, drill press, vise, paints, sandpaper

SAFETY: All modeling and construction will be done in accordance with existing safety procedures for laboratory and shop "hands on" activities.

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7. Establish for students, the chronological development of the unmanned space program, using films, Propulsion and Aerospace History submodule information (Submodules E and A, respectively), library resources, written descriptions. Students will be expected to conceptualize the evolutionary development, international impacts, international contributions and major achievements of the unmanned program.

Suggested topics for consideration:

- founding fathers
- Werner von Braun
- The Space Race - USA vs. Russia
- aerospace contractors
- communications advancement
- meteorology enhancement
- earth resources
- major findings in outer space
- military involvement
- NASDA/ISRO/ESA, and others

Materials needed:

Library resources, overhead transparencies, written descriptions, student notebooks, workbook assignments, textbooks.

Suggested films: Portrait of Earth
Exploration of the Planets

(see resource list at the end of Submodule F)

Suggested sources of information:

NASA, Goddard Space Flight Center
Smithsonian National Air and Space Museum
Roswell Museum

(see resource list at the end of Submodule F)

Suggested references:

Planetary Encounters: the Future of Unmanned Spaceflight. R. Powers.
Jane's Pocket Book of Space Exploration. T.M. Wilding-White
The Observer's Spacecraft Directory. R. Turnill
Aviation/Aerospace Fundamentals. Sanderson

8. Develop a history-related question/answer computer program for student use and reinforcement. Include major, more noteworthy historical developments, allowing for updating and expansion of the existing material. Students will use this system to reinforce class materials, in their free time.

Materials needed:

Up to date library resources, written descriptions, school compatable personal computers, discs, etc., material format and master for programming.

9. Identify and illustrate examples of space-related spin-offs to students. Describe how spin-offs evolve and how omnipresent these innovations are in commodities, all phases of American society, and the world at large. Students will identify, analyze, investigate and realize the technological advancements of spin-offs.

Materials needed:

Physical examples of spin-offs, written descriptions, supportive audio visual materials, follow along sheets, student notebooks and library resources.

Suggested sources:

NASA, Goddard Space Flight Center
Director - Aerospace Education - USAF/CAP

(see resource list at the end of Submodule F)

Suggested references:

For All Mankind. L.B. Taylor
Dividends From Outer Space. Ordway and Adams
The Satellite Spin-Off. G. Paul
Spin-Off 1983. NASA

(see resource list at the end of Submodule F)

10. Review science class exposure to the structure and elements of outer space systems. In order to appreciate vehicles researching outer space, students must understand what objects of interest are found throughout this black void and for what purposes these objects serve.

Suggested topics for discussion:

- structure of the solar system/galaxy/universe
- reasons for outer space study
- outer space environment
- future military operations
- space ship earth
- near future, feasible unmanned space ventures
- celestial bodies of strongest, immediate interest
- growth of telescope technology

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INSTRUCTIONS (NOTES)

Materials needed:

Photographs, NASA 35mm slide packages of outer space and heavenly bodies, posters, overhead transparencies, models, information sheets and follow along sheets.

Suggested sources:

NASA, Goddard Space Flight Center
Space Photographs - NASA
Director - Aerospace Education - USAF/CAP
U.S. Government Printing Office, Washington, D.C.

(see resource list at the end of Submodule F)

Suggested references:

Planetary Encounters: the Future of Unmanned Spaceflight. R. Powers
Aviation/Aerospace Fundamentals. Sanderson
The Science of Astronomy.
Search the Solar System. J. Strong
"Exploring the Solar System Primeval." T. Simpson
"Planets of Rock and Ice." C. Chapman

(see resource list at the end of Submodule F)

Suggested films: Radio Astronomy Explorer
Jupiter Odyssey
Earth-Sun Relationship

(see resource list at the end of Submodule F)

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TOPIC: 2. Unmanned Space Vehicle Delivery Systems

MODULE: AEROSPACE
SUBMODULE F

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been exposed to working models, library resources, audio visual materials, prepared worksheets and descriptive materials, will identify and describe current and future earth launched delivery systems.

In order to do this, the student must be able to:

A. Interpret illustrations, audio visual materials, models and diagrams.

B. Describe the major components of earth launched delivery systems:

1. Nose cone or nose shroud
2. Payload compartment
3. Payload
4. Bulkhead
5. Fuel tanks
6. Booster stage
7. Upper stages
8. Booster engines
9. Sustainer engines
10. Vernier engines
11. Stage engines
12. Propellents

C. Identify earth launched delivery systems according to the participating country or space agency, such as:

1. United States NASA:

a. Atlas/Agena
b. Atlas-Centaur
c. Delta
d. Titan III (A,B,C,D, and E)
e. Scout
f. Titan IIB-Agena

2. USSR:

a. A-1
b. A-2
c. B-1
d. D
e. D-i-e

3. Japan - NASDA:

   a. MU-4S-2
   b. Lamda L-4S
   c. Q Launcher

4. ESA:

   a. Diamont (A,B, BP4)
   b. Black Arrow
   c. Ariane L-3S

D. Associate earth launch systems with specific missions, which would include:

   1. A-1: Sputnik/Cosmos/Luna
   2. Atlas-Centaur: Surveyor/Intelstat/Pioneer
   3. A-2e: Zond/Venera/Molniya
   4. Delta: Tiros/Pioneer/Early Bird/Landsat
   5. Titan: DOD-Big Bird/Viking/Mariner
   6. Lamda-4S: Tansei/Shinsei/Denpa

E. Utilize tools safely and effectively, while performing modeling activities.

F. Construct a working scale model launch system from available resources.

2. Senior high school students, having been exposed to working models, library resources, prepared worksheets, class discussions, and teacher planned presentations, will be able to discuss and identify shuttle orbiter launch systems of unmanned vehicles. The students will make valuable system comparisons and determine mission roles, through objective tests and summary work materials.

In order to do this, the student must be able to:

A. Research current articles and space agency reports.

B. Identify and describe the potential types of propulsion systems expected to be involved in outer space launched projects:

   SEPS - solar electric propulsion system
   Solar sail
   Gravity assist
   Liquid propellent
   Nuclear propulsion (terminated indefinitely)
   Hybrid engines (solid and liquid)
   Photon rocket (futuristic)
   Plasma accelerator (futuristic)

C. Compare orbital transfer vehicles to interim upper stage vehicles.

D. Establish vehicle payload carrying capacities.

JOB NO. PAGE NO. F-19

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ISTRUCTIONS (NOTES)

E. Research the mission time frames each vehicle provides.

F. Categorize shuttle launch systems as they develop, including:

1. Orbiter transfer vehicle
2. Interim upper stage vehicle

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~~TOPIC: 2.~~ Unmanned Space Vehicle Delivery Systems

MODULE: AEROSPACE
SUBMODULE F

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Display and discuss a multistaged rocket, used in conjunction with a large poster or an informative overhead transparency of an actual rocket launch system. Provide students a follow along sheet, to fill in while you identify major parts, staging aspects, streamlining considerations and control devices.

Materials needed:

A well labeled, uncomplicated overhead transparency, large descriptive poster, information sheets, follow along sheets, multistaged rocket model with a payload section (ex. Estes Hercules).

Suggested film: All About Our Missles

(see resource list at the end of Submodule F)

Suggested references:

Missles and Rockets. K. Gatland
The Observer's Spaceflight Directory. R. Turnill
Model Rocketry. Estes Industries

2. Take the existing class Space Agency and break it down into two and three member rocket launch teams. Have students in these groups select a payload and a rocket launch system with a payload compartment. Determine if the payload and rocket are compatible. The Student launch teams will construct and prepare their vehicles for actual launch and recovery activity. Insure that selected kits or scratch designs are simple and functional.

Suggested topics for discussion:

model rocket construction techniques
laboratory safety standards
payload possibilities: living, active and passive
rocket design*

*NOTE: Designing and planning should be done outside of class.

Materials needed:

Model rocket kits or plans, basic hobbyists tools, paints, etc.

SAFETY: All modeling and construction activity will be done in accordance with existing safety procedures for labora-

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INSTRUCTIONS (NOTES)

tory and shop "hands on" activities.

Suggested film: Model Rocketry: the Last Frontier. Estes

Suggested references:

Handbook of Model Rocketry. G.H. Stine
Model Rocketry Manual. G.H. Stine
Model Rocketry. Estes Industries
Model Rocketry Catalog. Estes Industries

(see resource list at the end of Submodule F)

3. Use 35mm slides, overhead transparencies, and actual models to distinguish major multinational earth launch systems. Then categorize these systems under their country or designated space agency.

Materials needed:

35mm slides, transparencies, models, follow along sheets, notebooks, library resources.

Suggested references:

Jane's Pocket Book of Space Exploration. T.M. Wilding-White
The Observer's Spacecraft Directory. R. Turnill

(see resource list at the end of Submodule F)

4. Have students research five earth launch systems (2 USA, 2 USSR, 1 ESA), to find the following information:

mission applications (payload or vehicle)
configuration
height
diameter
launch weight
propulsion thrust for each stage
guidance and control systems
operational record
prime contractor

Materials needed:

Suggested references:

Jane's Pocket Book of Space Exploration. T.M. Wilding-White
The Observer's Spaceflight Directory. R. Turnill

(see resource list at the end of Submodule F)

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5. Review all propulsion systems adaptable to shuttle launch assemblies and associate each system to their implementation for earth orbit, inner planet, outer planet, and interstellar space exploration.

Suggested topics for discussion:

- current and expected propulsion systems
- orbital transfer vehicles
- interim upper stage vehicles
- potential maximum thrust
- system flexibility
- system potential
- payload capacities
- operation time frames

Materials needed:

Library resources, current NASA data, models, audio visual materials, notebooks, written descriptions.

Suggested film: Nuclear Propulsion in Space

Suggested sources of information:

Jet Propulsion Laboratory - Teacher Resources
Lewis Research Center - Teacher Resource Center
NASA, Goddard Space Flight Center

Suggested references:

Planetary Encounters: the Future of Unmanned Spaceflight. R. Powers
NASA Facts. NASA
Frontiers of Space. K. Gatland

(see resource list at the end of Submodule F)

6. Set up model construction activities, providing plans, designs, photographs and slides of each kind of shuttle launched propulsion system. Emphasis should be placed on the exterior vehicle configuration (ie. reactor compartment). Students will be relatively accurate in capturing each type of propulsion system constructed.

Materials needed:

Balsa wood, plastic, cardboard, styrofoam, glue, razor knives, dowels, paper, paint.

SAFETY: All modeling and construction will be done in accordance with existing safety procedures for laboratory and shop "hands on" activities.

7. Have students draw color coded, labeled, detailed, descriptive posters of any of the following unmanned space technology propulsion systems:

    Solar sail
    Orbiter transfer vehicle
    Gravity assist
    SEPS
    Nuclear
    Liquid propellent
    Solid propellent
    Hybrid engines

   Materials needed:

   Paper, posterboard, felt tip pens, pencils, pens, photographs, plans, illustrations, library resources, information sheets, student notebooks

   Suggested references:

   The Frontiers of Space. K. Gatland
   Propulsion For Deep Space. NASA
   Interstellar Travel: Past, Present and Future. J. MacVey
   Spaceships of the Mind. Nigel Calder.

   (see resource list at the end of Submodule F)

8. Demonstrate how a spacecraft's progress can be changed by the gravitational force of a planet (gravity assist). To accomplish this, fold cardboard along its length (launcher for a spaceship marble). Obtain approximately a 4 x 4" cardboard box or larger, and tightly place cellophane or mylar over the open end of the box. Place a lead "planet" sinker in the middle of the sheet. Launch the marble onto any edge of the box and point out the marble's movement as the launcher is raised and lowered at different points. Students will notice and record an orbital type action or a flinging action.

   Materials needed:

   Cardboard box, thin plastic, lead sinker, 1"x 12" strip of cardboard, tape, marbles.

9. Demonstrate the solar sail action by devising a small kite (solar sail) and running a fan to serve as the solar wind.

   Materials needed:

   Thin plastic, paper, glue, fan, thread or fishing line, small pieces of wood.

TOPIC: 3. Space Vehicle Concepts   MODULE: AEROSPACE
SUBMODULE F

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been introduced to audio visual materials, class demonstrations, charts, illustrations and written descriptions, will demonstrate knowledge and understanding of missle and aircraft guidance methods. The students will actively participate in all phases of classroom experiences to complete experiments, worksheets and projects reflecting their understanding.

In order to do this, the student must be able to:

A. Organize guidance systems into five major categories:

1. Preset guidance
2. Command guidance
3. Target seeking
4. Inertial
5. Celestial

B. Relate the important role guidance systems play in the movement of unmanned vehicles through space.

C. Complete experiments demonstrating basic guidance principles.

D. Establish the capabilities that each guidance system should provide to a spacecraft or missle:

1. Measure the vehicle's velocity and position.
2. Compute the correction requirements needed to maintain a desired flight path.
3. Deliver corrective commands to the vehicle's control system.

E. Define each type of guidance system:

1. Preset: is characterized by a predetermined flight path set into the vehicle's internal guidance system. Variable factors such as wind, evasive maneuvers, and target locations are evaluated and programmed into the system.

2. Command guidance: can be controlled either manually or by automatic means. Computers are constantly comparing incoming information with the actual flight profile versus the intended flight profile and commands the necessary corrective action.

3. Target seeking: utilizes infrared or heat radiation to perceive the target and compute its own control signals.

4. Inertial: is made up of three accelerometers for each plane of rotation, and a computer. The accelerometers sense a change and feed the computers, which, in turn, provides necessary corrections.

5. Celestial guidance: is performed by an automatic sextant which locks onto light (radiation) emanating from preselected natural celestial bodies. The sextant then measures the angle between the actual space vehicle path and the path to a celestial reference. The computer evaluates the data and makes changes if needed.

2. Senior high school students, having been informed through space agency information, class discussion, audio visual and teacher demonstration, will convey and illustrate concepts associated with spacecraft trajectories.

In order to do this, the student must be able to:

A. Describe orbital mechanics utilized to accomplish orbital mode for satellites and spacecraft, including:

1. Predetermine the orbital height and path.
2. Accelerate the spacecraft to the required orbital velocity to offset gravity.
3. Utilize Newton's Laws of Gravity and Motion.
4. Utilize Kepler's Laws of Planetary Motion.
5. Calculate required thrust and fuel needs to accomodate the payload's weight.

B. Explain the types of orbital flight paths taken by various types of spacecraft missions.

circular
elliptical
polar
geosynchronous
solar synchronous
sub-orbital
eccentric

C. Establish methods of in-flight adjustments, such as:

1. Vernier engines
2. Controllable aerodynamic surfaces
3. Retrorockets
4. Accelerometers on each axis

D. Compute a spacecraft trajectory problem.

E. Interpret trajectories taken by Pioneer and Voyager.

3. Senior high school students, following exposure to radio equipment, audio visual materials, classroom instruction and written descriptions will be able to describe and participate in telemetry operations. The students will demonstrate knowledge through successful receipt and transmission of information and through objective tests and completion of worksheets.

In order to do this, the student must be able to:

A. Interpret telemetric processes.

B. Compare spacecraft telemetry power requirements to the power requirements of earthbound commercial radio and television stations.

C. Participate in experiments that illustrate the principles of telemetry.

D. Utilize a transmitter and receiver for communication and data collection.

E. Explain the changes which might take place in a wave as it travels through the atmosphere to earth from a satellite.

4. Senior high school students, having participated in classroom demonstrations, audio visual presentations, related experimentation, will demonstrate and discuss spacecraft attitude control methods.

In order to do this, the student must be able to:

A. Define the following two main tasks of attitude control:

1. stabilization
2. pointing

B. Determine the natural forces acting for or against a spacecraft's equilibrium, such as:

gravity
solar pressure
earth's magnetic field
Law of Conservation of Angular Momentum
meteoroids

C. Identify and explain the methods used to counter spacecraft destabilizing forces, such as:

- long booms, or pendulums
- magnetizing the spacecraft
- spin stabilizing
- retrorockets
- gyroscopes
- inertia wheels

D. Gain conclusions from experiments convering attitude control principles.

5. Senior high school students, having been exposed to the unit on propulsion systems (Submodule E), audio visual materials, class demonstrations, written descriptions, will explain propulsion systems as they relate to the unmanned space vehicles.

In order to do this, the student must be able to:

A. Review the material on propulsion systems relating to space operations.

B. Associate the types of propulsion systems to the kinds of vehicles that utilize them, such as:

1. Solid propellents (examples):

- submarine missles
- ICBM's
- Titan boosters
- Delta boosters
- Scout

2. Liquid propellents (examples):

- Delta
- Titan
- V-5V
- Type G
- Diamant
- Ariane

3. Gravity assist (examples):

- Pioneer 10
- Voyager

C. Research data on a specific power plant, including:

- thrust in a vacuum
- specific impulse
- total impulse
- combustion chamber pressure

pressure ratio
developer
applications
propellents
time in service

D. Complete an experiment on rocket propulsion principles utilizing a model rocket engine.

6. Senior high school students, having been exposed to class experiments and discussions, written descriptions, audio visual materials and library resources, will <u>interpret spacecraft environmental dangers and associate combatant environmental control systems.</u>

In order to do this, the student must be able to:

A. Create a controlled environment project.

B. Identify and describe the environmental hazards encountered by spacecraft, such as:

the vacuum of space
ultraviolet rays from the sun
micrometeoroid impacts
radiation
high "G" forces during launch
extremes of hot and cold

C. Explain the hostile environment countermeasures incorporated into spacecraft to maintain a safe, workable balance for all onboard systems:

radiate heat into cold space
special heaters for cold spots
thermostatically controlled louvers
radiation shielding
passive paints
methods of insulation
aero shell (heat shield for re-entry)

7. Senior high school students, having had exposure to electrical demonstrations, electrical experiments, audio visual materials and prepared worksheets, will <u>identify and explain the power systems found on unmanned spacecraft.</u>

In order to do this, the student must be able to:

A. Compare the power needs for the following types of missions:

outer planet - deep space probes
sounding rockets
short mission satellites
long mission satellites
inner planet and solar probes

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INSTRUCTIONS (NOTES)

B. List and describe the power sources found in unmanned spacecraft:

chemical cells/batteries
solar cells/solar arrays
RTG:radioisotope thermoelectric generators
fission reactors (future)

C. Identify the instrument packages and devices requiring power to obtain their valuable information, such as:

Geiger counters
transmitters
pressure gauges
recorders
spectrometers
sensors
cameras

D. Analyze, through experimentation, the power output characteristics of solar cells and chemical cells.

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INSTRUCTIONS (NOTES)

TOPIC: 3. Space Vehicle Concepts

MODULE: AEROSPACE
SUBMODULE F

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Demonstrate, with a bow and arrow, the three primary objectives of a guidance system controlling missles and spacecraft. The arrow is a missle in its own right, The primary guidance system objectives are:

   1. The object's velocity and position
   2. Correction requirements
   3. Needed corrective commands

   Materials needed:

   Bow and arrow, target, or an improvised teaching aid, supporting audio visual materials.

2. Discuss factors that would alter the course of a vehicle's movement through the atmosphere or through the vacuum of space. These factors would include:

   turbulence
   wind
   solar wind
   micrometeorites
   target location and speed
   propulsion forces
   gravity
   magnetic disturbance

   Materials needed:

   Suggested references:

   NASA Spacecraft. Wm. Corliss
   Aviation/Aerospace Fundamentals. Sanderson

   (see resource list at the end of Submodule F)

3. Demonstrate a command guidance system (wire rider-beam rider) by attaching a straw to an inflated balloon and running the balloon on a wire or string track to the point of destination. Point out that the wire or string serve as an example of the radar or light beam source, which would guide a vehicle to its target.

   Materials needed:

   Wire, string, balloon, straw.

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INSTRUCTIONS (NOTES)

4. Discuss preset, command, target seeking, inertial and celestial guidance systems with your students. Provide audio visual materials, written descriptions and follow along sheets. Emphasize inertial guidance systems, because of their primary use in unmanned spacecraft. Point out inertial system characteristics with the following:

   independent of radio signals
   independent of outside references
   dependent on accelerometers, memory devices and gyroscopes

5. Demonstrate gyroscopic action with a bicycle wheel and a gyroscope (if available). Explain how gyroscopes are activated and retain momentum. Discuss where gyroscopes are incorporated into unmanned spacecraft. Continue demonstration by showing gyroscopic control of each of the spacecraft's three axis.

   Materials needed:

   Wooden frame, bicycle wheel, gyroscope, pivotal metal frame.

   Suggested sources of information:

   NASA - Goddard Space Flight Center
   Aerospace Education Director - USAF/CAP

   (see resource list at the end of Submodule F)

6. Provide students with written descriptions, audio visual materials and worksheets relating to the factors controlling trajectory. The students will analyze scientific principles, engineering design and planning affecting the flight path of a spacecraft. Findings will be recorded in student notebooks.

   Suggested topics for discussion:

   orbital mechanics
   escape velocity
   Newton's Laws of Gravity and Motion
   Kepler's Laws of Planetary Motion
   orbital path configurations
   trajectory control methods
   trajectory determining launch considerations

   Materials needed:

   Information sheets, library resources, teaching aids, NASA illustrations.

   Suggested sources:

   NASA - Goddard Space Flight Center
   Aerospace Education Director - USAF/CAP
   Jet Propulsion Laboratory - Teacher Resources

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INSTRUCTIONS (NOTES)

Suggested references:

Aviation/Aerospace Fundamentals. Sanderson
NASA Educational Topic #ET-78-5. NASA
Orbits and Revolutions. NASA

(see resource list at the end of Submodule F)

7. Demonstrate basic trajectory principles simply in the classroom with materials you can easily find. Experiments can show: gravity assist, orbital action, escape velocity, centrifugal and gravitational forces. Set up the following experiments:

launch a marble satellite
why do satellites stay in orbit?
spinning satellites
the great escape

Materials needed:

All materials are listed each developed experiment.

Source: Office of Public Affairs
Aviation Education, APA-5
Washington, D.C. 20591

Request: Demonstration Aids for Aviation Education. (NL-1 through NL-6). U.S. Department of Transportation.

8. Obtain or program a spacecraft trajectory sequential problem. Students will gain sound understandings in trajectory principles and spaceflight considerations. Introduction of the program should be made in class. Students will work the program during their free time.

Materials needed:

Personal computer, monitor, disc, program text, etc.

Suggested source: U.S. Government Printing Office
Washington, D.C. 20402
(Write for information and listing)

9. Have students study the trajectories taken by previous spacecraft and space probes. Provide illustrations, written descriptions and worksheets where students can interpret the mechanics involved.

Suggested topics for discussion:

Ranger missions
Pioneer
Voyager
Mariner

DO NOT TYPE BELOW THIS LINE

Materials needed:

Suggested references:

Exploring the Moon and Planets. W. Corliss.
Distant Encounters. M. Washburn
Planetary Encounters: the Future of Unmanned Spaceflight. R. Powers
Voyage to Jupiter. D. Morrison and J. Samz

10. Set up basic radio equipment (transmitter and receiver) to demonstrate analogically, telemetry to the class. Use analogies with your equipment to show collection of data, the conversion of data into electrical transmissions, transferral to another location, reception of transmissions, decoding for analysis and use.

Suggested topics for discussion:

- instrument sensors
- raw data
- real time
- transducer
- coding box
- frequency
- carrier wave
- power requirements
- STADAN/NASCOM

Materials needed:

Transmitter, receiver, microphone, FM or AM oscillator, audio visual materials, written descriptions, student notebooks, worksheets.

Suggested sources:

NASA - Goddard Space Flight Center
Director - Aerospace Education - USAF/CAP

Suggested references:

Spacecraft Tracking and Communication. NASA
Telemetry. NASA
Spacecraft Tracking. W. Corliss
Aerospace Communications. DOT

(see resource list at the end of Submodule F)

11. Demonstrate by using a model spacecraft depicting an unstabilized attitude. Detail the specific forces affecting spacecraft: gravity, solar pressure, magnetic fields, meteoroids and angular momentum. Demonstrate, using audio visuals, models, teaching aids and illustrations, the methods designed into spacecraft to counteract destabili-

zing forces. Provide for student involvement, so they can experience the examples first-hand.

Materials needed:

Models, bicycle wheel, gyroscope, magnet, needle, string, dowels, model rocket enginer.

Suggested sources:

NASA - Goddard Space Flight Center
Director - Aerospace Education - USAF/CAP

Suggested references:
NASA Spacecraft. W. Corliss.

(see resource list at the end of Submodule F)

12. Develop rocket engine mock-ups, illustrative charts, slides and transparencies covering current and feasible propulsion systems. Students will be able to recognize, describe and discuss major understandings as covered in the propulsion submodule (Submodule E). Students will also be able to delineate propulsion system applications to the launching and delivery of unmanned space vehicles.

Materials needed:

Suggested references:

Aviation/Aerospace Fundamentals. Sanderson
The Observer's Syaceflight Directory. R. Turnill
Jane's Pocket Book of Space Exploration. T.M. Wilding-White
Missles and Rockets. K. Gatland
Model Rocketry. Estes Industries

Suggested film: Rocket Propulsion

(see resource list at the end of Submodule F)

13. Present an itemized list of data typically included for propulsion systems. Use a well developed set of slides and illustrations on propulsion systems for easy reference and understanding. Students will research data on their own concerning one type of unmanned power plant. The class will then share their findings for comparison.

Materials needed:

Data list, slides, library resource materials.

14. Organize a model rocket launch day for your class to culminate submodule activities. Obtain proper clearance to use school board or local community fields. The launch teams should have their selected payloads completed and rockets prepared for launch. Break the class up into safety engineers, launch control officers, tracking team, communicators, down range tracking, data recorders and timers. Students will rotate their responsibilities during the launches. Evaluation will be determined by:

adherence to all safety rules
payload construction and care
rocket construction and design
successful launch and recovery
quality of flight (evaluation form)
payload operation and survival
duration of flight
a launch team mission data report

Materials needed:

Launch site, launch stands, launch system, battery, stop watch, tranceivers (hand held), alitscope, binoculars, tool kit, wadding, fire extinguisher, charts, safety check list, rope, tables, chairs.

Suggested references:

Model Rocketry Handbook. G.H. Stine
Model Rocketry Manual. G.H. Stine
Model Rocketry. Estes Industries

(see resource list at the end of Submodule F)

15. Develop an airtight box with access openings for the provision of air inlets and outlets. When desired, show how you can control the environment of the enclosure. Demonstrate the kinds of hostile elements strongly threatening to the environmental balance. Design into your environmental enclosure countermeasures methods and devices. Associate your environmental box with the engineered checks and balances found in unmanned spacecraft, for environmental control.

Materials needed:

Air pump, vacuum pump, electric lights (low and high wattages), buzzers, insulation, metal plates, wooden or clear plastic box, marbles, lazy susan, switches, rubber plugs, temperature activated switches or circuits.

16. Demonstrate how electrical power is generated through solar cells and chemical cells. Allow students to benefit from your experiments by providing a follow along sheet. Relate what devices on board a spacecraft require electrical power, and explain why different kinds

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INSTRUCTIONS (NOTES)

of missions require totally different power generating systems.

Materials needed:

Audio visual materials, detailed illustrations, water and vinegar, silicon solar cells, chemical cell, meters, small demonstration motors, wire, information sheets, follow along experiment sheet, light source.

Suggested film: Electric Power Generation in Space

Suggested references:

NASA Spacecraft. W. Corliss
Understanding Electricity and Electronics. P. Buban and M. Schmitt
Missles and Rockets. K. Gatland

(see resource list at the end of Submodule F)

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INSTRUCTIONS (NOTES)

TOPICS: 1 - 3

MODULE: AEROSPACE
SUBMODULE F

$$SUGGESTED SUBMODULE RESOURCES - ADDRESSES FOR FURTHER INFORMATION

AEROSPACE EDUCATION PROGRAMS
NASA - Goddard Space Flight Center
Greenbelt, MD 20771

AEROSPACE EDUCATION ASSOCIATION OF AMERICA
National Center for Aerospace Education
1910 Association Drive
Reston, VA 22091
(Write for membership information)

ALABAMA SPACE AND ROCKET CENTER
Tranquility Base
Huntsville, AL 35807
(1-205-337-3400)

DEFENSE DOCUMENTATION CENTER
Attn: DDC-TSR
Cameron Station
Alexandria, VA 22314
(Write for DDC Digest - Unclassified Research and Development Periodical - free)

DIRECTOR - AEROSPACE EDUCATION
U.S. Air Force - Civil Air Patrol
Northeast Region
Building 29-01
McGuire AFB, NJ 08641

ESTES INDUSTRIES, INC.
Penrose, CO 81240
(Write for model rocket information and teacher guides/technical information)

JET PROPULSION LABORATORY
Teacher's Resource Center
4800 Oak Grove Drive
Pasadena, CA 91103
(1-818-354-2423)

KANSAS COMOSPHERE AND DISCOVERY CENTER
1100 N. Plum Street
Hutchinson, KA 67501
(1-316-662-2305)

LEWIS RESEARCH CENTER
Teacher Resources
21000 Brookpark Road
Cleveland, OH 44135
(1-216-433-4000, ex. 731)

NATIONAL SPACE INSTITUTE
Membership Department
P.O. Box 7535
Ben Franklin Station
Washington, D.C. 20044
(Publishes Space World Magazine)

NEW YORK STATE AEROSPACE RESOURCES GUIDE
Robert J. Ullery, Editor
New York State Education Department
Technology Education
99 Washington Avenue
Albany, NY 12234

RECORDS OF ACHIEVEMENT
NASA - Special publication #SP-470 - free
Box 8757
BWI Airport, MD 21240

ROSWELL MUSEUM (Robert Goddard)
North Main and 11th Streets
Roswell, NM 88201

SMITHSONIAN INSTITUTION
National Air and Space Museum
Education Services
NASM Room P-700
Washington, D.C. 20560

SPACE PHOTOGRAPHS- NASA
Room 6035
400 Maryland Avenue, SW
Washington, D.C. 20546
(1-202-755-8366)
(Write for listing. cost, information)

UNION OF CONCERNED SCIENTISTS
Publication Department
26 Church Street
Cambridge, MA 02238
(Inquire about Space Warfare slide show, ASAT Weapons #3 Briefing Paper -free, Star Wars Weapons #5 Briefing Paper - free)

TOPICS: 1 - 3

MODULE: AEROSPACE
SUBMODULE F

$$SUGGESTED SUBMODULE RESOURCES - NON-PRINT (AUDIO VISUAL) MATERIALS

Film titles:

Assignment: shoot the moon. (HQ 167). 1967. 28 min.
Presents Ranger, Surveyor and lunar orbiter spacecraft.

Earth-Sun relationship. (HQ 235). 1973. 6 min.
Animated depiction of how the sun and planets were formed.

Jupiter odyssey. (HQa 243). 1974. 28 min.
Story about Pioneer 10's mission.

Life beyond earth and the mind of man. (HQ 245). 1975. 25 min
Excerpts from a Boston held symposium on the possible existence of extraterrestrial life in our galaxy and universe.

Mars: the search begins. (HQ 236). 1974. 28-1/2 min.
Shows many of Mariner 9's 7,000 pictures of Mars.

Partnership into space: Mission Helios. 1975. 27-1/2 min.
Follows the development and launch of spacecraft Helios, a US-German venture.

19 minutes to earth. (HQ 292) 14-1/2 min.
Discusses scientific findings of the Viking missions to Mars.

Planet Mars. (HQ 283). 1979. 28-1/2 min.
Follows early telescope Martian investigation through to the Viking missions.

Portrait of earth. (HQ 299). 1981. 27 min.
Explains the function of satellites in detail and how they perform their missions in orbit.

Radio astronomy explorer. (HQa 186). 1968. 30 min.
Discusses radio astronomy satellite and its mission to detect radio waves from space.

Remote possibilities. (HQ 280). 14 min.
Covers Landsat and its visual imagery for helping the study of the environment, geology, land use and agriculture.

Viking (HQ 266). 1976. 28 min.
Comprehensive look at the Viking Mars landing.

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INSTRUCTIONS (NOTES)

The wet look. (HQ 271). 14-1/2 min.
Presents Landsat's ability to help resolve water resource problems.

Available from: NASA - Goddard Space Flight Center
Public Affairs Office
Code 202
Greenbelt, MD 20771

Film titles:

Electric power generation in space. (HQ 155). 1967. 27 min.
Presents current and future methods of developing electrical power for space missions.

Electric propulsion. (HQ 96). 1965. 23-1/2 min.
Shows and discusses electric propulsion for outer space.

Exploration of the planets. (HQ 212). 1971. 25 min.
Presents Mercury-Venus fly-bys/Mars orbiters and landers.

International cooperation in space. 1965. 23 min.
Shows the world-wide tracking stations, Telstar/Tiros satellites and US-USSR cooperation.

Nuclear propulsion in space. (HQ 152). 1968. 16 min.
Shows nuclear rocket propulsion and comparisons to other propulsion systems.

Satellites of Hughes - 1980. 1980. 14 min.
Covers synchronous satellites from the first syncom to Intelstat IV.

Trial balance. (HQ 123). 1965. 28 min.
Covers communications, study of planets, search for extraterrestrial life, meteorology.

Available from: Audience Planners, Inc.
875 Avenue of the Americas
Suite 1911
New York, New York 10001

Film titles:

About our missles. (26602). 1970. 15 min.
Covers spectacular launches and actual Air Force launch sites.

Aerospace technology. (26488). 1965. 12-1/2 min.
Shows many devices and tools developed for the space age.

DO NOT TYPE BELOW THIS LINE

Rocket propulsion. (27685). 1964. 30 min.
Discusses specific impulse, thrust and mass ratio. Explains fundamentals of liquid, solid, nuclear and electric propulsion systems.

Titan III: research and development for today and tomorrow. (20693). 1967. 14 min.
Shows the Titan III under assembly and its preparation for launch.

Available from: Department of the Air Force
DAVA-N-LDS
Norton Air Force Base, CA 92404
(Request form #2018 and please book 1 month in advance)

Film titles:

Model rocketry: the last frontier. 1975. 15 min.
With William Shatner ("Captain Kirk") as narrator, this film captures the excitement of model rocketry and includes a great deal of information.

Available from: Modern Talking Picture Service
Box 33002
St. Petersburg, FL 33733
(Allow 1 month for booking. State day desired and 2 alternate play dates.)

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INSTRUCTIONS (NOTES)

TOPICS: 1 - 3

MODULE: AEROSPACE
SUBMODULE F

$$SUGGESTED SUBMODULE RESOURCES - PRINT MATERIALS

AIAA. Exploration of the Solar System. Washington, D.C. U.S. GPO. 1973. (EP-122).

Beggs, James. "A new era in space." Aviation Space. Summer. 1984. p. 32.

Bennett, Gary L. "Ion engines for our mission to Neptune." Popular Science. Vol. 224. June 1984. p.83.

Boyd, Mary Jo. "Glimpse of infinity." Science Digest. Vol. 91. July 1983. p.70.

Brownlee, Shannon. "Visions from Viking." Discover. Vol. 5. September 1984. p. 20.

Bussard, Robert. "A starship is born." Science Digest. Vol. 91. May 1983. p. 61.

Calder, Nigel. Spaceships of the mind. NY. The Viking Press. 1978.

Chapman, Clarke R. Planets of rock and Ice: from Mercury to the moons of Saturn. NY. Scribners. 1982.

Corliss, William. Exploring the moon and planets. Washington, D.C. NASA. U.S. GPO. 1968. (EP-52).

Corliss, William. NASA spacecraft. Washington, D.C. NASA. U.S. GPO. 1968. (ED-54).

Corliss, William. Spacecraft tracking. Washington, D.C. NASA. U.S. GPO. 1968. (EP-55).

Corliss, William. Space physics and astronomy. Washington, D.C. U.S. GPO. 1968.

Covault, Craig. "Triple satellite payload to study Van Allen Belts." Aviation Week and Space Technology. Vol. 121. August 6, 1984. p. 54.

Dooling, Dave. "Saving TDRS-1." Space World. Vol. 244. April 1984. p. 14.

Elson, Benjamin. "Venus project team finds extensive volcanic activity." Aviation Week and Space Technology. Vol. 120. February 27, 1984. p. 44.

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INSTRUCTIONS (NOTES)

Ferris, Timothy. "Space shots." Science '84. Vol. 5. September 1984. p. 60.

French, Bevan M. Mars: the Viking discoveries. Washington, D.C. NASA. U.S. GPO. 1977. (EP-146).

"French, Soviets define observation platform." Aviation Week and Space Technology. Vol. 120. February 20, 1984. p. 55.

Gatland, Kenneth. Frontiers of space. NY. MacMillan Publishing Co. 1976.

Gatland, Kenneth. Missles and rockets. NY MacMillan Publishing Co. 1975.

Gunter, Paul. The satellite spin-off: the achievements of space flight. NY. Robert B. Luce, Inc. 1975.

Haggerty, James. Spinoff 1983. Washington, D.C. NASA. U.S. GPO. 1983.

Hajek, Stanley M. and Raymond L. Schuette. A four week unit in space age technology. Penrose, CO. Estes Industries. 1970.

Hochman, Sandra. Satellite spies: the frightening impact of a new technology. NY. Bobbs-Merill Co., Inc. 1976.

"Intelstat launch on Ariane I scheduled for early March." Aviation Week and Space Technology. Vol. 120. February 1984. p. 65.

Lemonick, Michael. "Unmanned probes on a comeback." Science Digest. Vol. 92. June 1984. p. 26.

Lewis Research Center. Propulsion for deep space. Cleveland, OH. NASA. U.S. GPO. 1966. (EP-41).

MacVey, John. Interstellar travel: past, present and future. NY. Stein and Day. 1977.

Marsh, Alton K. "Space services pushing conestoga launch vehicle." Aviation Week and Space Technology. Vol. 120. June 25, 1984. p. 163.

Morrison, David and Jane Samz. Voyage to Jupiter. Washington, D.C. NASA. U.S. GPO. 1980. (SP-439).

Morrison, David. Voyages to Saturn. Washington, D.C. U.S. GPO. 1982. (SP-451).

NASA. A new dimension in space experimentation: LDEF. Washington, D.C. U.S. GPO. 1983. (NF-140).

DO NOT TYPE BELOW THIS LINE

NASA. Explorer 1. Washington, D.C. U.S. GPO. 1982.

NASA. IRAS-infrared astronomical satellite. Washington, D.C. U.S. GPO. 1983.

NASA. Liquid propellent rockets. Washington, D.C. U.S. GPO. 1982. (EB-82-6).

NASA. NASA's Landsat to monitor timber resources. Washington, D.C. U.S. GPO. n.d. (ET-78-3).

NASA. Orbits and revolutions. Washington, D.C. U.S. GPO. 1968.

NASA. Pioneer encounter with Saturn. Washington, D.C. U.S. GPO. n.d. (NF-114).

NASA. Pioneer 11 provides new data about the sun's magnetic field. Washington, D.C. U.S. GPO. n.d. (ET-78-7).

NASA. Pioneer Venus. Washington, D.C. U.S. GPO. 1978.

NASA. Planet earth through the eyes of Landsat 4. Washington, D.C. U.S. GPO. 1982. (NF-138).

NASA. Repairing solar max: the solar maximum repair mission. Washington, D.C. U.S. GPO. 1984. (EP-205).

NASA. Robotics in space. Washington, D.C. U.S. GPO. 1982. (EB-82-9).

NASA. Some gravity effects on spacecraft trajectories: a useful classroom topic. Washington, D.C. U.S. GPO. n.d. (ET-78-5).

NASA. Spacecraft tracking and communications. Washington, D.C. U.S. GPO. 1967.

NASA. Space resources for the high school: industrial arts resource unit. Washington, D.C. U.S. GPO. 1967.

NASA. Telemetry. Washington, D.C. U.S. GPO. 1971.

NASA. Voyager 2 at Saturn: early findings. Washington, D.C. U.S. GPO. 1981. (Report to educators, Vol. 9, no. 3).

Oberg, Alcestis. "Race to the red planet." Science Digest. Vol. 89. October 1981. p. 34.

Oberg, Alcestis. "Space robots." OMNI. Vol. 6. August 1984. p. 26.

Oberg, James. Red star in orbit. NY Random House. 1981.

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INSTRUCTIONS (NOTES)

Oberg, James. "Weapons in orbit." Science Digest. Vol. 92. April 1984. p. 41.

Ordway, Frederich, Carsbie Adams and Mitchell Sharpe. Dividends from space. NY. Crowell. 1971.

Powers, Robert M. Planetary encounters: the future of unmanned spaceflight. Harrisburg, PA. Stackpole Books. 1978.

"Probing the heavens: any real value?" U.S. News and World Report. Vol. 91. November 16, 1981. p.76.

Randolph, Anne. "JPL set to integrate Galileo Jupiter probe with orbiter." Aviation Week and Space Technology. Vol. 120. February 27, 1984. p. 41.

Reichardt, Tony. "The Halley armada." Space World. Vol. U-6-246. June 1984. p. 20.

Riabchikov, Evgeny. Russians in space. Garden City, NY Doubleday and Co., Inc. 1971.

Sagan, Carl. "The case for Mars." Discover. Vol. 5. September 1984. p. 26.

Sagan, Carl, Louis Friedman. "Missions to the asteroids." Science Digest. Vol. 92. March 1984. P. 58.

Sanderson. Aviation/aerospace fundamentals. Denver, CO. Jeppeson and Co. 1974. pp. 14-1 to 15-54.

Schauer, William. The politics of space: a comparison of the Soviet and American space programs. NY Holmes and Meier Publishers, Inc. 1976.

Schefter, James. "Orbiting telescope maps an infrared universe." Popular Science. vol. 223. December 1983. p. 88.

Service, Robert and John M. Williams. Space exploration. Irving, TX. Boy Scouts of America. 1983.

Simpson, Theodore. "Exploring the solar system primeval." Space World. Vol. U-3-243. March 1984. p. 4.

Simpson, Theodore and Lt. Col. Roger Dekok. "Into the wild black yonder (ASAT-DOD)." Space World. Vol. U-4-244. April 1984. p. 9.

Smith, Harry T. and Henry J. Warden. Industrial arts teacher's manual for model rocketry. Penrose, CO. Estes Industries, Inc. 1980.

DO NOT TYPE BELOW THIS LINE

"Soviets strive to outpace U.S. technology in space." Aviation Week and Space Technology. Vol. 120. March 1984. p. 111.

Stine, G. Harry. The model rocketry manual. NY. Sentinel Books Publishers, Inc. 1970.

Sternbach, Richard. "Journey to the stars." Science Digest. Vol. 91. May 1983. p.52.

Strand, Linda. "The dirty Jupiter space probe." Science Digest. Vol. 92. August 1984. p. 68.

Strong, James. Search the solar system. NY. Crane, Russak, and Co., Inc. 1973.

Taylor, L.B. For all mankind: America's space programs of the '70's and beyond. NY. E.P. Dutton and Co., Inc. 1974.

Tindal, Margaret. Educator's guide for mission to earth: Landsat views the world. Washington, D.C. NASA. U.S. GPO. 1978. (SP-360).

Turnill, Reginald. The observer's spaceflight directory. London. Frederick Warne Publishers, Ltd. 1978.

Wake, William H. and Garth Hull. Field study for remote sensing: an instruments manual. Washington, D.C. NASA. U.S. GPO. 1978.

Washburn, Mark. Distant encounters: the exploration of Jupiter and Saturn. NY. Harcourt, Brace, Jovonovich Publishers. 1983.

Washburn, Mark. Mars at last. NY. G.P. Putnam and Sons. 1977.

Whipple, Fred. Orbiting the sun: planets and satellites of the solar system. Cambridge. Harvard U. Press. 1981.

Wilding-White, T.M. Jane's pocket book of space explorarion. NY. Collier Books. 1976.

Woods, John A. The science of astronomy. NY. Harper and Row. 1974.

Yulsman, Thomas. "Experiments in space." Science Digest. Vol. 92. July 1984. p. 39.

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INSTRUCTIONS (NOTES)

TOPICS: 1 - 3

MODULE: AEROSPACE
SUBMODULE F

$$SUGGESTED SUBMODULE RESOURCES - PERIODICALS OF INTEREST

AEROSPACE (free)
Aerospace Industries Association
1725 DeSales Street, NW
Washington, D.C. 20036
(1-202-429-4600)

ASTRONOMY
Circulation Services
P.O. Box 186
Westchester, IL 60153

AVIATION SPACE
Aerospace Education Association of America
1910 Association Drive
Reston, VA 22091

AVIATION WEEK AND SPACE TECHNOLOGY
Fulfillment Manager
P.O. Box 1022
Manasquan, NJ 08736
(Make requests on school letterhead, through the school library)

DISCOVER
Subscription Department
Time-Life Building
Chicago, IL 60611
(1-800-621-4800)

GALAXY
Universal Publishing and Distributing Corp.
P.O. Box 418
Planetarium Station
New York, NY 10024

HIGH TECHNOLOGY
Subscription Service
P.O. Box 2810
Boulder, CO 80322
(1-800-525-0643)

NASA PERIODICALS:
a. NASA Educational Briefs
b. NASA Educational Topics
c. NASA Facts
d. NASA Mission Reports
e. NASA Report to Educators

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Available from: Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

OMNI
Subscription Service
P.O. Box 5700
Bergenfield, NJ 07621
(1-800-247-5470)

POPULAR SCIENCE
Subscription Department
Boulder, CO 80322

SCIENCE DIGEST
Subscription Service
P.O. Box 10076
DesMoines, Iowa 50350
(1-800-274-5470)

SCIENCE (year) '84
Subscription Department
P.O. Box 10790
DesMoines, Iowa 50340
(1-800-247-5470)

SKY AND TELESCOPE
Subscription Service
49 Bay State Road
Cambridge, MA 02238-1290

SPACE WORLD
Subscription Department
Palmer Publications, Inc.
Amherst, WI 54406

TECHNOLOGY REVIEW
Subscription Service
Room 10-140
MIT
Cambridge, MA 02139
(1-617-253-8292)

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INSTRUCTIONS (NOTES)

PHASE: CONCENTRATION

ELEMENT: TECHNOLOGY

MODULE: AEROSPACE

SUBMODULE: G. SPACE TECHNOLOGY - MANNED

TOPICS:

1. History of Manned Spaceflight
2. Living in the Space Environment
3. Earthly Advantages/Disadvantages of Space Utilization
4. The Extraterrestrial Future

PREREQUISITES: None

$$PREPARED BY
$$ROBERT N. JONES
$$AMSDELL HEIGHTS JUNIOR HIGH SCHOOL
$$HAMBURG, NEW YORK

TOTAL TEACHING TIME:
SUBMODULE G: 5 hours

DATE: September 8, 1984

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TOPICS: 1 - 4

MODULE: AEROSPACE
SUBMODULE G

$$OVERVIEW OF SUBMODULE

GOALS:

Upon completion of this submodule, the student will be able to:

1. Trace the historical development of the human quest to conquer and travel space.
2. Describe the mechanics needed to achieve orbital space flight and apply physical laws to problematic situations (Newton's Laws to rocket engine thrust).
3. Describe the various stress causing conditions of space flight that must be adapted to or overcome for an earth dweller to make space flights.
4. Appraise the challenge of taking a living environment into space in order to survive.
5. Recognize the accomplishments in manned space exploration, since its reality.
6. Appraise the impacts that human space exploration has had for present generations and project future implications.
7. Describe the contributions that space exploration programs have made in creating career fields.
8. Speculate, and project ideas for the future development of space through human spaceflight and habitation in space.

DESCRIPTION:

The earliest recorded thoughts of humans indicate a fascination with the heavens. They "explored" space through a systematic observation of celestial bodies. The mysticism that developed through astrologers' interpretation of the heavens had real impacts on the development of civilization. The beginning of religiious observations, starting of wars, planting times, etc. were often determined by interpretations of "star" patterns. Today, many humans still put varying degrees of faith in the stars for making their earthly decisions.

Early civilizations had myths and legends about human efforts to conquer the heavens. The Greeks had stories such as "Vera History", about flights to the moon. Daedalus and Icarus, in legend, flew too close to the sun; Mercury is pictured having winged feet; and the Pegasus could move through the heavens. In other parts of the ancient world, Wan Hu, in China, (it is told in legend) attempted "space flight" in a rocket-equipped chair, never to be heard from again.

The awakening of scientific discovery through technology only a relatively few centuries ago set the groundwork for the final human push into space in this century. The telescope, developed by Galileo in 1609, became

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INSTRUCTIONS (NOTES)

~~the tool for adv~~anced study of the stars and planets, and in advanced form is more important today.

Rockets, the propulsion system that took people beyond the grips of earthly gravity, are usually thought of as 20th century developments. However, it is known that the Mongols used rockets as weapons as early as 1232 in the siege of Kaifeng, in China. The knowledge of rockets spread throughout the civilized world, and applications were developed that ranged from war, and commerce to entertainment.

In 1405, Joanes deFontana, an Italian engineer, wrote a description of a rocket car designed to be used as a battering ram. William Congreve is credited with helping the British develop reliable rockets after a decisive battle won against them in India was credited to this self-propelled weapon. His rocket designs were the victorious edge in later battles in Denmark, France and Prussia. In this country, during the War of 1812, "the rockets' red glare" of our national anthem was penned by Francis Scott Key as he observed the bombardment of Fort McHenry by Congreve's rockets. In the mid-1800's, the use of artillery became more important for bombardment, due to greater accuracy.

The early commercial uses of rocket power were in the propelling of harpoons for whalers and in sea rescues for throwing lines and buoys. Fascination with rockets in fireworks displays has been around since the 18th century, and continues today as exhibited in gigantic displays celebrating our nation's independence and many other occasions for public celebration. In 1865, Jules Verne was writing fiction which foretold of the exploration of space. His books, From the Earth to the Moon and Around the Moon, predicted many of the technologies that have become realities in this century. The public's facsination with his stories stimulated an interest in space invention and travel.

Modern rocketry, man's vehicle into space, had its birth at the begining of this century through the work of four pioneers: Tsiolovsky, a Russian; Goddard, an American; and two Germans, Oberth and Von Braun. When the scientists at the German Rocket Research Center at Peenemunde recognized that the German war effort was lost, a sizable number of them decided to surrender to the American forces before the facility was overtaken by the Russian allies. Their object in doing this was a hope that they would be more "free" to continue the rocket research in America. The V-2 rocket, which was used against England towards the close of World War II became the basis for the United States' rocket research program. The German rocket scientists, led by Dr. Wernher von Braun, shipped 300 train car loads of equipment from the Peenemunde rocket works to the United States just a few days before the advancing Russian forces captured that research center. They too recovered a great amount of V-2 materials which had been abandoned.

In 1945, the German scientists joined with American rocket scientists in White Sands, New Mexico, which became the test center for our early rocket developments using salvaged V-2 parts. Dr. Robert Goddard, the "father of rocketry" in the United States, died that year. It was Goddard's contributions to the science of liquid propulsion rockets which was teamed up with a large scale test vehicle in the V-2, which served as a direct model for the

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Army's Redstone rocket that put Alan Shepard and Gus Grissom into suborbital flight in 1961. This was essentially the development of the original Peenemunde team, and the launch vehicles from the Atlas to the moon mission's Saturn, though larger, were of the same basic type and used similar technology.

Early missions were neccessarily developmental in testing the engineering needed to get astronauts into space and back without undue risk. The Saturn V proved to be both powerful and reliable enough to accomplish the Apollo Moon missions. The engineering goals set for this project and the resulting generation of space vehicles had been accomplished.

To answer the Soviet challenge of October 4, 1957, when Sputnik I became the first artificial satellite, NASA was formed to mobilize industrial research and development, and to coordinate science and technology into problem solving units which could operate as a productive entity. The objective was to try to overtake the Soviet lead in space accomplishment. On April 12, 1961, when the Soviet Vostok I pushed Yuri Gagarin into orbit, it was realized that the U.S. program was far behind in the lifting power of rockets. On May 5th, 1961, astronaut Alan B. Shepard became the first American in space.

The United States had suffered an embarassment at the "Bay of Pigs", the race for space was lagging, and we needed some challenge to revive the American spirit. President John F. Kennedy gave that direction by proposing to Congress in August of 1961 that we needed as a national goal the putting of a man on the moon before 1970. Even with the estimated costs running into the billions of dollars, the American public wholeheartedly supported the program, and great steps in technological development were ready to begin. The systems approach was used to deal with the multitude of technological problems of attaining manned space flight. This model, of setting objectives and breaking complex problems down into more workable subsystems that can be systematically solved or circumvented and designing a timetable to bring the bits and pieces back into a workable whole has proved a viable model for many other endeavors. This systems model has been used to develop several curricula, such as the one you are following in Aerospace Education in New York state.

The volume of knowledge continues to grow on how to best maintain people in space in a condition of comfort and productivity that rivals the best conditions found on earth. The experience of weightlessness and need to provide a living environment in the austere environment of space opened a whole new field of investigation - space biology. From the early missions of Vostok I and II and our Mercury missions, it was found that humans could function in space, even when subjected to the multiple environmental stresses that are simultaneuously experienced during space flight. Weightlessness, noise, vibration, acceleration, temperature and humidity extremes, ionizing radiation, circadian rhythm disruption, motion sickness, and altered atmospheric gas concentrations are some of the conditions that needed answers. Each new program added to the understandings and development of solutions to the human problems in space environment. Most problems have been solved so that the Shuttle Program can take "average citizens" into space and back.

SKILLS, KNOWLEDGE, BEHAVIORS TO BE DEVELOPED:

SKILLS: Experiment and observe laws of physics as they pertain to rocket propulsion, by doing static and thrust tests on model rocket engines. Construct model rockets and run stability and controlled flight tests. Brainstorm ideas, examine parameters, select "best" solution from alternatives, construct model solutions for a space habitat, evaluate results

KNOWLEDGE: Trace the history of human desire for conquest of space. Recognize the contributions of early space experimenters and the technological spinoffs that have contributed to a better quality of life.

TOPIC: 1. History of Manned Spaceflight

MODULE: AEROSPACE
SUBMODULE G

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been given instruction, handout time lines, viewing films and filmstrips and accomplishing reading assignments, will be able to trace the history of manned spaceflight from the earliest accounts to the most recent activity.

In order to do this, the student must be able to:

A. Fill in a time line with significant events of human endeavors in efforts to conquer space, to a degree acceptable to the instructor.

B. List four major contributors to space knowledge in the early 20th century and describe the significance of their work to space flight, at a level acceptable to the instructor.

C. Fill in a chart, or keep a log of manned space flights from 1961 to the present day, at a level acceptable to the instructor.

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INSTRUCTIONS (NOTES)

TOPIC: 1. History of Manned Spaceflight

MODULE: AEROSPACE
SUBMODULE G

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Assign students reading assignments related to the history of manned space flight. After reviewing the readings, as a group project, students will construct a scaled bulletin board time line on which to contribute their bit of information. When the time line is complete, they will enter data on a handout sheet with the instructor through discussion, filling in the voids.

   Materials needed:

   Resource materials, readings, filmstrips, bulletin board, chalk, long newsprint, markers, prepared handout sheets.

2. Assign students to research the persons credited with the early research and development programs that formed the basis for modern rocketry. These will take the form of written reports, with selected reports being given orally to the class.

   Materials needed:

   Library resources on space history, a teacher-prepared bibliography for student use, audio visual equipment for presentations.

3. Assign students the responsibility of keeping current with happenings pertaining to human space flight by maintaining a log of events. This can take the form of a scrap book. Students will be provided with a handout data recording chart on which to capsulize events (ie. date, place, purpose, people, etc.).

   Materials needed:

   Handout chart, old magazines and newspapers, subscription to Aviation Week and other magazines of like nature.

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INSTRUCTIONS (NOTES)

~~TOPIC: 1.~~ History of Manned Spaceflight

MODULE: AEROSPACE
SUBMODULE G

$$SUPPLEMENTAL ACTIVITIES.

1. Simulate a "countdown to liftoff" using NASA'a sheet with a number of student teams coordinating systems and keeping the count on schedule.

2. Take a photo view from space with the Estes Astro Cam.

3. Study and identify land masses as shown in NASA - Eros photos. (Try to obtain low orbit photos of the school area, 550 miles.)

4. Design the minimum size package to protect a raw egg in a three story free fall.

5. Given newspaper and masking tape, design a free fall protection for a raw egg.

6. Experiment with a night launch using "Cylume" chemical lights as payload tracers.

7. Design a soft landing device for a payload, other than a parachute.

8. Sponsor a NASA Spacemobile assembly program for the school.

9. Visit a local manufacturer that has a NASA contract/or invite a local engineer in the talk about local contributions to the space program (ie. Scott Aviation, Calspan, Bell Aerosystems, etc.).

TOPIC: 2. Living in the Space Environment

MODULE: AEROSPACE
SUBMODULE G

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, given instruction, handout materials, viewing audio visual materials and doing reading assignments, will be able to explain some of the basic technology needed to travel to space.

   In order to do this, the student must be able to:

   A. State and apply Newton's Laws of Motion (3rd), to problems dealing with rocket propulsion.
   B. List the advantages and disadvantages of solid fuel propulsion systems compared to liquid fuel systems.
   C. Describe the balance between inertial velocity and gravity and the meaning of "escape" velocity.
   D. Describe factors that must be considered in planning the trajectory of a spacecraft being launched from earth to the moon.

2. Senior high school students, given instruction, handout materials, audio visual presentations and reading assignments, will be able to discuss the physiological and psychological stress of humans living in a weightless environment.

   In order to do this, the student must be able to:

   A. Outline factors which may prove stressful to humans living/working/playing in a weightless environment.

3. Senior high school students, given instruction, handout materials, audio visual presentations and reading assignments, will be able to outline the necessary biological conditions needed to sustain human life in the hostile environment of outer space.

   In order to do this, the student must be able to:

   A. List the conditions found in space:

      1. no atmosphere
      2. no gravity - weightlessness
      3. relative gravity of bodies in space
      4. no air drag
      5. extremes of heat and cold
      6. high radiation
      7. possibility of collision with space debris

   B. Discuss psychological/social implications of living conditions imposed by weight and storage limitations during extended human space travel/living.

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INSTRUCTIONS (NOTES)

4. Senior high school students, given instruction, handout materials, audio visual presentations and reading assignments, will be able to propose "optimum designs" for human habitation of spacecraft/space habitats, given a specified mission in space exploration/living/working.

In order to do this, the student must be able to:

A. Develop the optimum requirements of a space craft/space habitat, given specified conditions.

B. Appraise a given design for a futuristic extraterrestrial vehicle, or a long term habitat or space colony.

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INSTRUCTIONS (NOTES)

TOPIC: 2. Living in the Space Environment

MODULE: AEROSPACE
SUBMODULE G

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Direct students to fill in the blanks on a handout sheet that has been prepared to record Newton's Laws and apply formula for calculation of thrust of reaction engines. Use segments of film or filmstrips dealing with Newton's Laws. Help students through initial application of math for solving problems.

Materials needed:

Films, projector, duplicated worksheet.

2. Assign students a library research task to complete a comparison sheet that would suggest advantages/disadvantages of solid rocket fuel versus liquid fuel. Ask for a conclusion on why the Space Shuttle program uses both. (Option: write to the Propulsion Contractors - Public Relations Department of NASA.)

Materials needed:

Library research materials, audio visual materials.

3. Develop a demonstration to help understand what forces keep a space craft in orbit. Use the classic ball, weight, string and spool demo. Put an eyescrew in an old baseball, attach a heavy, 6 ft. piece of string to the eyescrew. Run the string through the spool and attach a weight equal to the baseball's weight. Holding the spool, swing the baseball until its speed counterbalances the weight's mass. Swing ball at various speeds. Observe what happens. Record on a work sheet, the results of different inputs. Ask: The ball's pull on the cord represents what force? What force does the weight represent? What is the relationship of velocity to "height of orbit"? What will happen if the string breaks? (etc.)

Materials needed:

Baseball, eye screw, 6 ft. string, spool or tube, 2.2 lb. counter weight, data recording chart.

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INSTRUCTIONS (NOTES)

TOPIC: 2. Living in the Space Environment

MODULE: AEROSPACE
SUBMODULE G

$$SUPPLEMENTAL ACTIVITIES

1. Build a large scale model of the Space Shuttle vehicle.

2. Construct a model of a space colony on a heavenly body with a specified environment. Teams will deal with technical problems.

3. Demonstrate the growing of plants without soil, for an orbiting space station.

4. Process some foodstuff for potential use on a space station, using freeze drying and solar drying.

5. Design a process for recycling "grey water" in the spacecraft.

6. Do a spinning stool simulation as a demonstration of the workings of the inner ear and balance/air sickness feeling.

7. Modify a snap shot camera so that it can be operated while wearing heavy gloves to simulate space suit restrictions.

8. Calculate the best possible loading scheme for a space canister designed to be carried in a Shuttle "bay". Have team competitions to justify their schemes.

9. Simulate construction of a structure in space. The largest structure to weight ratio wins. (Could be longest bridged gap, or tallest structure.) Materials limited to newspaper, masking tape/tagboard and staples/toothpicks and glue. Divide the class into teams of 3-4.

10. Select the best astronaut in your class for an extended space flight, by determining body fat by water displacement method.

11. Simulate difficulty of working in space environment by using a student suspension system with "work piece" also suspended.

12. Design a space tool that would be helpful in zero gravity.

13. Have a contest of sorting "space" hardware while wearing bulky gloves. (Sort, passed relay fashion to the next team member, team competition)

14. Experimentally determine the optimum color to paint a space craft. Study heat absorption/reflection and co[illegible]

15. Make an animated film/video using space models, space sets and student character actors.

16. Construct a full scale Shuttle control module in a corner of the room; a class continuing project used for simulations, research and refine from available data.

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INSTRUCTIONS (NOTES)

~~TOPIC: 3.~~ Earthly Advantages/Disadvantages of Space Utilization

MODULE: AEROSPACE
SUBMODULE G

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, given instruction, handout materials, audio visual presentations and reading assignments, will be able to explain some of the advantages and disadvantages that could develop due to the human utilization of space for technological/industrial/commercial and recreational purposes.

   In order to do this, the student must be able to:

   A. List possible applications for space use for technological/industrial/commercial and recreation purposes.
   B. List advantages of space utilization.
   C. List disadvantages of space use and/or space development.

2. Senior high school students, given instruction, handout materials, audio visual presentations and reading assignments, will be able to explain the use of space as a military base, and discuss/propose the governing of space through international agreements, laws and regulations.

   In order to do this, the student must be able to:

   A. Speculate on the possible military uses of space.
   B. Discuss and formulate regulations and laws for future development/use of space through international agreement/treaty.

3. Senior high school students, given instruction, handout materials, audio visual presentations and reading assignments, will be able to identify several "spinoffs" which have benefitted humans through space research and development to present time, and will describe cultural and social impacts the advancing technology may hold for the future.

   In order to do this, the student must be able to:

   A. List and describe several spinoffs from the space exploration program that have benefitted mankind:

      1. environmental management
      2. weather survey and studies
      3. dehydrated/irradiated foodstuffs
      4. miniaturization of electronics
      5. fuel cell development
      6. solar cell development
      7. laser technology
      8. air bearing techniques

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INSTRUCTIONS (NOTES)

9. remote sensing devices
10. long range photo devices/electronic
11. earth and sea observations
12. communication and navigation devices
13. medical advances
14. metallurgical research and development
15. ceramic research and development
16. composite research and development

B. List several impacts culturally and socially, that expanding space research and utilization may have on future generations:

1. Social:

   a. reappraisal of social concepts in space
   b. possible population redistribution
   c. aerospace education as a teaching area
   d. reappraisal of religious beliefs

2. Economic:

   a. number and variety of jobs
   b. manufacturing:

      research
      development
      fabrication
      assembly
      accessories
      maintenance

3. Political
4. Legal
5. Educational
6. Career opportunities

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TOPIC: 3. Earthly Advantages/Disadvantages of Space Utilization

MODULE: AEROSPACE
SUBMODULE G

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Distribute copies of NASA's annual "Spinoff" to the class and NASA technical briefs. Small groups will make a comparative list of benefits/advantages and possible disadvantages that the space program has brought about. The groups will contribute their findings in a class discussion. A bulletin board listing of findings could be used to continue the project over several weeks, as the teams would find or draw illustrations of examples of the contributions.

Materials needed:

Newspapers, several issues of "Spinoff" (available from the U.S. GPO), bulletin board.

2. Have students view several NASA films/videotapes on the utilization of space technology in our everyday lives. Using a checkoff handout sheet, students will note as many benefits and problems related to the space program. A class discussion or debate of their points of interest should follow.

Materials needed:

Film projector or VCR, NASA film/videocassette catalog, checkoff sheet.

3. Assign students reading in current periodicals (last 5 years) which deal with the militarization of space. Also provide a bulletin board of current clippings and articles on the topic of arms in space. To facilitate students finding assigned articles, the teacher or librarian may compile a photocopied collection to be used by students.

Brainstorm the used/possible/projected military use of space. List these on newsprint for future reference. In a later session, a future wheels analysis will be done to project consequences of developments in space militarization.

Materials needed:

Library resources, article collection, photocopying facilities, newsprint and markers.

4. Divide the class into small groups to represent "world space powers" (ie. U.S., Russia, France, England, China). After some research and planning time, have the powers "bargain" for rights and regulations of space, presenting their cases. Proposals will be recorded on video and paper copy, which will be used in social studies classes to get a peer reaction. Discussion would follow. The instructor should move from group to group to facilitate planning.

Materials needed:

"Problem sheet" spelling out what the groups are to do, video recording equipment.

5. Students will pick, or be assigned, a topic which as a spinoff from the space program has had an impact on the way we live. This could be a "term study", which would be presented to the class as an abstract (paper for a course/module requirement). A running list (on bulletin board) would be kept of those spinoffs presented. The teacher would help complete the list through class discussion of those areas not selected by students.

Materials needed:

Library resources.

6. Students will pick or be assigned a topic reflecting the social and cultural impacts the "space age" is having on our lives. This could focus on: social, religious, economic, career, political, educational or other factors. This would be done as an outside reading/research paper. The instructor would serve as a resource/ facilitator by holding individual conferences with students, during class lab work periods. Good papers would be selected to share with the class.

Materials needed:

Library resources, lists of association addresses and resource information, film catalogs.

NOTE: Strategies #5 and #6 are viewed as possible interdisciplinary links between school departments, as suggested by the Regents Action Plan.

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~~TOPIC: 3.~~ Earthly Advantages/Disadvantages of Space Utilization

MODULE: AEROSPACE
SUBMODULE G

$$SUPPLEMENTAL ACTIVITIES

1. Do a "Houston, we've got a problem" simulation. Have ground teams design a fix and then discuss best alternatives.

2. Build a kit model rocket of a more difficult level and modify it for a special experiment (ie. "Night Fire" - lighted nose cone, or "Flash at apogee" - mercury switch and flash cube.)

3. Design an "ideal government " for your proposed space colony.

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TOPIC: 4. The Extraterrestrial Future

MODULE: AEROSPACE
SUBMODULE G

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, given instruction, handout materials, audio visual presentations and reading assignments, will be able to conceive probable scenarios for future space exploration.

In order to do this, the student must be able to:

A. Identify probable goals for space exploration programs:

1. heavy lifting transport rockets
2. reusable "flyable" spacecraft - take off and land
3. orbiting space command/deployment base
4. modular space building units
5. intra space propulsion units - space tugs
6. mass drivers/material transporters

2. Senior high school students, given instruction, handout materials, audio visual presentations, and reading assignments, will be able to explain the resources needed for space colonization, speculate on problems of development and project implications for mankind in extra-terrestrial environments.

In order to do this, the student must be able to:

A. Explain factors to be considered in the developing of the physical structure (spacecraft/space station/lunar base).

1. mission statement
2. facilities description
3. construction modules
4. construction organization
5. population to be served
6. socialization and control of facility

B. Appraise the needs of humanization of space facilities for optimum utilization and fulfillment of mission statements.

1. crew/habitant safety
2. physical conditioning and exercise in space
3. health and phy[illegible] for space hygiene.
4. interpersonal behavior in confined environment
5. sexual factors in space
6. social organization

7. social control and deviance
8. earth dependency

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INSTRUCTIONS (NOTES)

TOPIC: 4. The Extraterrestrial Future

MODULE: AEROSPACE
SUBMODULE G

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Students could send letters to the top aerospace industries, as listed in Fortune magazine, or the Thomas Register. They would ask for a copy of their Annual Report and publicity releases of future planning for space utilization. Magazines such as Aviation Week are as current as security permits. From these, students will make bulletin board picture collections. A teacher-facilitated discussion will bring out possible uses of space in the future (how to read between the lines).

   As a group, the class could produce a space mural of wall size to depict their projections.

   Materials needed:

   School letterhead, mailing facilities, Annual Reports and publicity releases, library resources, bulletin boards.

2. Have a representative of the local L-5 Society make a presentation to the class on the goals of the organization, or attend and L-5 Society meeting and report to the class on it.

3. Assign students reading/reports on the future of space technology.

   Materials needed:

   Library resources.

4. Construct simple models of future spacecraft/bases for display, based on research findings. This would be a good small group activity.

   Materials needed:

   Basic modeling supplies, balsa/basswood, glue, hand tools, abrasive paper, etc.

   NOTE: All modeling activities will be in conjunction with standard safety practices for laboratory activities, as explained by the teacher.

Following instruction, films, and reading assignments, conduct a brainstorming session with the class on the factors and requirements needed to be considered in the physical facility of a specified space project (ie. space station or lunar colony). Facilitate combining and refining their ideas. Come to a consensus on the features needed. Have the students sketch their interpretations of the facility. Post these on bulletin boards and conduct a "critique/defense" of their designs.

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Materials needed:

Library resources, L-5 Society slide series on space settlement, drawing materials.

6. Students could use modeling techniques instead of drawing in the above strategy.

7. Present a panel discussion to summarize what the space program has done for humanity, and how it may affect future societies. This could be approached from the "new frontier" and compared to the U.S. Western frontier of the 1800's, or "where we are in space explorarion compared with early steps in aviation".

7. Form a class "world court" to rule on topics of human government while on space missions/space colonies. Teacher would toss out a problem (ie. What should the social order be in space? Are all crew members equal or not? Should the commander rule on life/death decisions, or should the crew vote? What about mutiny? Should marriage be required for space crews? What about deviance from social mores? Students would be asked to describe in writing their proposals for the ideal socioculture for the new "high frontier".

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INSTRUCTIONS (NOTES)

TOPIC: 4. The Extraterrestrial Future

MODULE: AEROSPACE
SUBMODULE G

$$SUPPLEMENTAL ACTIVITIES

1. Build an original scratch built model of a proposed manned space vehicle.

2. Design and build a prototype of a futuristic rocket launched vehicle that will "glide land" and is resuable.

3. Use recycled 2 litre plastic bottles to build a design for a space colony ala Gerard O'Neil. Use a scale of 1" = 1000'.

4. Experimentally compare the outputs of solar panels and calculate the square footage needed to sustain one person's needs in a space colony.

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INSTRUCTIONS (NOTES)

TOPICS: 1 - 4

MODULE: AEROSPACE
SUBMODULE G

$$SUGGESTED SUBMODULE RESOURCES - PRINT MATERIALS

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JOB NO. PAGE NO. H-1

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INSTRUCTIONS (NOTES)

PHASE: CONCENTRATION ELEMENT: TECHNOLOGY

MODULE: AEROSPACE

SUBMODULE: H. AEROSPACE CAREERS AND OCCUPATIONS

TOPICS:
1. General Aviation
2. Military Aerospace
3. Education and Training

PREREQUISITES: Aerospace Overview

$$PREPARED BY
$$DANIEL A. NELSON
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$$CLIFTON PARK, NEW YORK

TOTAL TEACHING TIME:
SUBMODULE H: 2.5 hours

DATE: July 28, 1984

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$$OVERVIEW OF SUBMODULE

GOALS:

The purpose of this submodule is to offer information to the students in order that evaluations and conclusions can be made relating aerospace careers and occupations to the career and vocational objectives and capabilities of individual students. Careers and occupations directly and indirectly related to the aerospace industry will be correlated to the political, economic and social needs of our society.

In order to evaluate aerospace careers and occupations, investigations will be conducted in areas directly and indirectly related to the aerospace society and economy, which will include:

General Aviation
Military Aerospace
Aerospace Education and Training

DESCRIPTION:

Aerospace industries and supporting entities within the United States serve a key role in the maintenance of an economic, social and political system of standards in our society. As our present students prepare for future careers and occupations, the fact that aerospace offers unlimited opportunities for a wide range of skills and aptitudes poses exciting challenges for future participants in our technological growth.

Aerospace industries in the United States include all organizations involved in the production of aerospace vehicles and the provision of support materials and services for the aerospace industry. Much of the high technology of our nationa is tied directly or indirectly to the maintenance of a complex system of engineering design, communication, transportation, electronics, energy, environmental and supporting systems. Opportunities in aerospace exist for careers and occupations in a variety of civilian and military fields ranging from areas which include: engineering, commercial aviation, pilot training, air traffic control, space medicine, facilities management, meteorology, navigation, research and development, military aviation, space technology, aerospace aviation support services, and many other technical and vocational skill areas.

All areas related to aerospace occupations and careers require a specialized level of training and orientation that will require potential participants in the aerospace industry to be well versed in order that individuals can function at high levels of skill and proficiency. Aerospace education provides a valuable service by providing future participants in an aerospace economy with exposure to the many career and occupation options which are available. The service provided by aerospace career awareness is to present current and future career and occupational requirements to the students in order that a proper direction can be established for the students to meet aerospace industry needs. A key to successful exposure of aerospace career requirements and demands is direct contact with resources and members of the aerospace community. General aviation, military aerospace and educational experts will be utilized with supporting resources in order to present aerospace careers and occupations to the students for consideration.

SKILLS, KNOWLEDGE, BEHAVIORS TO BE DEVELOPED:

Upon completion of this submodule, the student will be able to:

1. Identify three major aerospace career and occupation categories.
2. Recognize the role of the aerospace industry related to the economic, social and political functions of our society.
3. Relate aerospace careers and occupations to the economy of New York State.
4. Differentiate between direct and indirect aerospace careers and occupations.
5. Recognize the requirements for specialized training and education related to specific aerospace careers.
6. Identify general aviation and military aerospace education and training opportunities.
7. Interact with fellow students and aerospace career and occupational representatives in the definition of career goals and objectives.

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INSTRUCTIONS (NOTES)

TOPIC: 1. General Aviation

MODULE: AEROSPACE
SUBMODULE H

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been given detailed descriptions, definitions and exposure to experts and resources related to general aviation programs, will recognize the role played by general aviation careers and occupations in the aerospace environment. The students will demonstrate an understanding through discussions and written outlines relating to career and occupational opportunities available in the general aviation sector.

In order to do this, the student must be able to:

A. Follow descriptive presentations and discussions related to general aviation careers and occupations.
B. Maintain notes and outlines related to general aviation careers and occupations.
C. Identify types of direct general aviation careers.
D. Identify types of indirect general aviation careers.
E. Conduct basic interviews and analyses of general aviation careers presentations.
F. Read and evaluate general aviation career and occupational resource materials.

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INSTRUCTIONS (NOTES)

~~TOPIC: 1.~~ General Aviation

MODULE: AEROSPACE
SUBMODULE H

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Provide the students with access to detailed lists and descriptive materials directed toward careers and occupations in general aviation industries and supporting fields. Instruct the students to develop lists of job titles with related aptitudes and job descriptions, using the Dictionary of Occupational Titles and the Occupational Outlook Handbook. Have them also list the numerical code given for each job title they are researching. Lists and outlines will be developed and shared with the class members, with materials being incorporated into the classroom Aerospace Resource Center - Careers Section.

Sample careers for investigation:

Aircraft and engine mechanic
Flight operations inspector
Flight surgeon
Airplane pilot, commercial
Airplane pilot, agricultural
Drafter, aeronautical
Passenger service agent
Airport director
Flight instructor
Test engineer, aircraft
Meteorologist
Aerospace engineer
Airport engineer
Air traffic control specialist

Materials needed:

Library and Guidance Department resources, access to Guidance career computer, supporting aerospace career materials, Dictionary of Occupational Titles, Occupational Outlook Handbook.

Suggested films: (available from NASA)

The Weather Watchers
Moonflights and Medicine
Partners with Industry
Where Dreams Come True

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References:

Dictionary of Occupational Titles. 1984.
Occupational Outlook Handbook. 1983
New York State Aerospace Resources Guide. NYSED. 1982.
Occupational Brief - Aerospace Careers. NYS-OICC. New York State Department of Labor.
Aviation Education (career guides). FAA. Washington.
Careers in Aerospace (pamphlets). NASA. Washington.
Aerospace: We're Career Minded People. NASA.
NASA Career Opportunities. (NASA kit 101). Washington.
Official Guide to Airline Careers. A.C. Norton.
Space Careers. C. Sheffield amd C. Rosin. 1984.
Aerospace: the Challenge. CAP. 1983.

2. Invite a guest speaker to address the class on the topic of "General Aviation Careers and Occupations". Instruct the students to take notes of the presentation materials and encourage them to interview the guest speaker and discuss general aviation careers after the presentation. Each student will be responsible for summarizing the presentation in the form of a written outline to be incorporated into notebook aerospace career materials.

Potential guest speakers:

- FAA regional education representative
- Local fixed base operator
- Commercial airline personnel representative
- Charter airline representative
- Regional weather service
- Aircraft manufacturing/support services
- Civilian space industry representative

Materials needed:

Tape recorder, career outline worksheets, notebooks, supporting audio visual materials.

References:

New York State Aerospace Resources Guide. R.J. Ullery.

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INSTRUCTIONS (NOTES)

TOPIC: 2. Military Aerospace MODULE: AEROSPACE
SUBMODULE H

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been provided with descriptive information relating careers and occupations available through military training programs, guest speakers in the area of military aerospace careers and other information, will be able to recognize the variety of military aerospace careers and occupations available and will demonstrate their understanding through involvement in classroom discussions and written outlines relating military aerospace opportunities to career objectives.

In order to do this, the student must be able to:

A. Evaluate descriptive written and graphic military aerospace career resource materials.
B. Recognize the variety of careers and occupations available through military aerospace training.
C. Identify basic entry requirements for military aerospace careers.
D. Relate military aerospace careers to general aviation occupations.
E. Listen to and evaluate presentations given by military aerospace personnel.

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INSTRUCTIONS (NOTES)

TOPIC: 2. Military Aerospace MODULE: AEROSPACE
SUBMODULE H

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Invite representatives of military aerospace entities to the classroom to address your students on the topic of "Military Aerospace Careers and Occupations". Students are required to take outline notes during the presentations for notebook reference. Encourage the students to interview the guest speaker and obtain as much resource information as can be supplied. Students will incorporate free materials and findings into the resource collection located in the classroom Aerospace Resource Center - Careers Section.

Potential guest speakers:

Civil Air Patrol educational representative
Military recruiters (Army, Navy, Air Force, Marines)
Regional Air Force base aerospace education director
United States Senator, or Representative

Materials needed:

Career worksheets, tape recorder, access to school mailing facility, lists of military aerospace resource contacts, supporting audio visual materials.

References:

Job Opportunities in the Air Force. USAF - ROTC
Space Careers. C. Sheffield and C. Rosin.
Aerospace: the Challenge. CAP
New York State Aerospace Resources Guide. R.J. Ullery.

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INSTRUCTIONS (NOTES)

TOPIC: 3. Aerospace Education and Training

MODULE: AEROSPACE
SUBMODULE H

$$PERFORMANCE OBJECTIVES/SUPPORTING COMPETENCIES

1. Senior high school students, having been provided with detailed definitions and descriptions of aerospace education and training programs, will recognize the need for application of both education and training of aerospace in our society. The students will develop conclusions through oral discussions and written analyses.

In order to do this, the student must be able to:

A. Differentiate between aerospace education and training.
B. Identify the importance of aerospace education to our society.
C. Relate aerospace training to civilian and to military applications.
D. Analyze supporting aerospace education and training resource materials.

2. Senior high school students, having been given detailed oral and written descriptions of levels of aerospace education and training, will identify specific programs leading to aerospace careers and occupations. The students will form conclusions and identify programs through interviews and discussions with aerospace related education and training personnel.

In order to do this, the student must be able to:

A. Read basic career charts and diagrams.
B. Understand levels of education and training required for aerospace careers and occupations.
C. Identify major types of aerospace education and training programs.
D. Discuss aerospace education and training programs with representatives of such programs.
E. Identify direct and indirect aerospace related education and career related training programs.

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INSTRUCTIONS (NOTES)

Materials needed:

Access to school mailing facilities and telephone facilities, tape recorder, supporting audio visual materials, notebooks, outline worksheets.

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TOPIC: 3 Aerospace Education and Training

MODULE: AEROSPACE
SUBMODULE H

$$SUGGESTED INSTRUCTIONAL STRATEGIES

1. Describe, in detail, the importance of aerospace education to the general public, and the need for aerospace training in careers directly and indirectly related to the functions of the aerospace industry. Students will be required to differentiate between aerospace education and training, through analysis of oral and written aerospace resource materials. Students will be required to furnish oral and written outline descriptions of aerospace education and training programs in both general avaiation and military applications.

   Materials needed:

   Guidance department resources, aerospace education and training resource materials, information sheets, access to the Guidance career computer.

   References:

   Dicitionary of Occupational Titles. 1984.
   Occupational Outlook Handbook. 1983.
   New York State Aerospace Resources Guide. R.J. Ullery.
   Space Careers. C. Sheffield and C. Rosin.
   Job Opportunities in the Air Force. USAF-ROTC
   Guide to FAA Publications. FAA.
   Directory of Aerospace Education. ASAE
   Aviation Books of All Publishers. Aviation Book Co.

2. Invite representatives of aerospace education and training entities to the class, in order to address the students in the area of "Preparation for Careers and Occupations in the Aerospace Industry". The speakers will address the subject of prerequisites and special requirements needed for entry into careers and occupations directly and indirectly related to aerospace industries and supporting services. Students are required to maintain notebooks and are encouraged to interview the speakers. Materials accumulated by the class will be incorporated for student review and evaluation in the classroom Aerospace Resource Center - Careers Section.

   Potential guest speakers:

   Local community college representative
   Vocational/technical training representative
   Aerospace industry training representative
   Military aerospace training specialist (ROTC)
   University representative
   FFA regional education specialist
   CAP education specialist

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INSTRUCTIONS (NOTES)

TOPICS: 1-3

MODULE: AEROSPACE
SUBMODULE H

$$SUGGESTED SUBMODULE RESOURCES - NON-PRINT (AUDIO VISUAL) MATERIALS

Film titles:

Age of Space Transportation	(HQa262)
Adventures in Research	(HQa255)
David's World	(HQa297)
Seeds of Discovery	(HQ 196)
The Weather Watchers	(HQa290)
Space for Women	(HQ 301)
Space Navigation	(HQ 116)
Where Dreams Come True	(HQ 296)

Available from:

National Aeronautics and Space Administration
Goddard Space Flight Center
Public Affairs Office
Code 202
Greenbelt, MD 20771

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INSTRUCTIONS (NOTES)

~~TOPICS: 1-3~~

MODULE: AEROSPACE
SUBMODULE H

$$SUGGESTED SUBMODULE RESOURCES - ADDRESSES FOR FURTHER INFORMATION

AEROSPACE EDUCATION PROGRAMS
NASA - Goddard Space Flight Center
Greenbelt, MD 20771

AEROSPACE INDUSTRIES ASSOCIATION
1725 DeSales Street, NW
Washington, D.C. 20036

AMERICAN SOCIETY FOR AEROSPACE EDUCATION
806 15th Street, NW
Washington, D.C. 20005

FEDERAL AVIATION ADMINISTRATION
Aviation Education Office
Fitzgerald Federal Building
JFK International Airport
Jamaica, NY 11430

HELICOPTER ASSOCIATION INTERNATIONAL
1110 Vermont Avenue, NW, Suite 430
Washington, D.C. 20005

NEW YORK STATE DEPARTMENT OF TRANSPORTATION
State Office Building Campus
Albany, NY 12240

NEW YORK STATE OCCUPATIONAL INFORMATION COORDINATING COMMITTEE
New York State Department of Labor
Building 12 - Room 559A
State Office Building Campus
Albany, NY 12240

Director - Aerospace Education
UNITED STATES AIR FORCE ACADEMY
Colorado Springs, CO 80840

Director - Aerospace Education
USAF - CIVIL AIR PATROL, Northeast Region
Building 29-01
McGuire AFB, NJ 08641

U.S. DEPARTMENT OF TRANSPORTATION
Office of General Aviation
Washington, D.C. 20591

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INSTRUCTIONS (NOTES)

TOPICS: 1-3

MODULE: AEROSPACE
SUBMODULE H

$$SUGGESTED SUBMODULE RESOURCES - PRINT MATERIALS

Aerospace: the Challenge. Maxwell AFB, AL. Civil Air Patrol. 1983.

Aviation books of all publishers. (catalog). Glendale, CA. Aviation Book Co. 1984.

Aviation education. Washington, D.C. U.S. DOT-FAA. Office of General Aviation. n.d.

Dictionary of Occupational Titles. Washington, D.C. USGPO. bienniel.

Directory of Aerospace Education. Washington, D.C. American Society for Aerospace Education. 1984.

Guide to Federal Aviation Administration Publications. Washington, D.C. U.S. DOT. 1984.

Job Opportunities in the Air Force. USAF. ROTC. n.d.

NASA. Career series:
Aerospace: W're Tomorrow Minded People. 1981.
Careers in Aerospace. n.d.
NASA Career Opportunities. (Kit 101) n.d.
Greenbelt, MD. NASA - Goddard Space Flight Center.

Norton, Alexander C. Official Guide to Airlines Careers. Miami Springs, FL. Airlines Careers. 1981.

New York State Aerospace Resources Guide. (R.J. Ullery, Ed.) Albany, N.Y. NYSED. 1982.

NYS-OICC. Occupational Brief (Aerospace/Aviation). Albany, N.Y. NYS Department of Labor. 1980.

Occupational Outlook Handbook. Washington, D.C. USGPO. Bienniel.

Sheffield, Charles and Carol Rosin. Space Careers. NY. William Morrow Co. 1984.

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