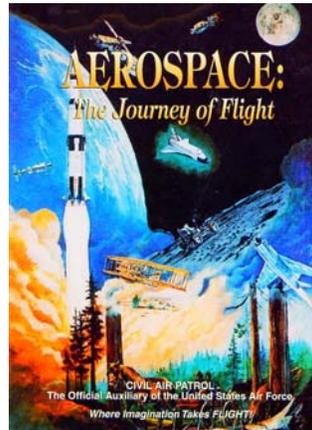




## Aerospace Education Program for Senior Members (AEPSM)



Page 1



## Overview

- AEPSM is a self-paced, independent-study program based upon CAP's *Aerospace: The Journey of Flight*.
- Your unit might have a copy of this superb book.
- Or you could order it from NHQ for \$17.50.
- Or you can download it at no cost from:  
<https://www.capnhq.gov/jofdownload/index.asp?SID=AAD7E887-E47B-4E95-895A-800C608FE2EC&AC=SELF&AppName=/eServices.aspx>

Page 2



## Why Take the Exam?

- Preparing for the test is an excellent way to learn about aerospace history and concepts in a short period of time.
- You will receive the Brigadier General Charles E. "Chuck" Yeager Aerospace Education Achievement Award and may wear the AE ribbon.
- If you finish the program before completing Level II of the senior program, you will receive a special seal on your Certificate of Proficiency.
- The AEPSM satisfies the activity requirement for Level IV training.

Page 3



## About the Exam

- The exam is 100-questions and tests your knowledge of the material contained in book.
- It can be taken at your unit in the traditional pencil-and-paper format.
- The exam is also on-line:  
<https://tests.cap.af.mil/ops/tests/default.cfm?grp=ae>
  - *There are two tests on-line; however, you need to take only one.*
- The passing score is 70%; members who take the pencil-and-paper version open-book must correct to 100%.

Page 4



## Online Exam Hints...

- You may find it useful to print this file and use it as a guide when taking the on-line exam.
- Or you may find it useful to print the exam before taking it – this can help avoid issues with the website “timing-out.”

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## Very Important!

- Once you pass the AEPSM exam your unit AEO completes a CAPF 126, *Unit AE Examination Administration Record and Report Form* and sends it to the Wing Director of Aerospace Education, (DAE), who adds the information to the monthly report to National.
- If you take the online exam, be sure to print the certificate of completion and give it to your unit AEO for processing!

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# Outline



- **Part 1 - The Rich History of Air Power**
- **Part 2 - Principles of Flight & Navigation**
- **Part 3 - The Aerospace Community**
- **Part 4 - Air Environment**
- **Part 5 - Rockets**
- **Part 6 - Space**

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## Part 1 The Rich History of Air Power



- Chap. 1- Introduction to Air Power**
- Chap. 2- Adolescence of Air Power: 1904-1919**
- Chap. 3- The Golden Age: 1919-1939**
- Chap. 4- Air Power Goes to War**
- Chap. 5- Aviation: From the Cold War to Desert Storm**
- Chap. 6- Advances in Aviation**

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# Introduction to Air Power



- Desire to fly dates back 4000 years - China
  - Invented kite 100 BC, Gun Powder 900 AD, Rockets 1100 AD
- Leonardo da Vinci (1452-1519) Artist, Architect, Man of Science
  - First scientific experiments in field of aviation
  - 160 pages of descriptions & sketches of flying machines
  - 1st design of parachute and helicopter
  - Wrote about principles of CG, CP, Streamlining
- Lighter-than-air: Balloons
  - 1783 Montgolfier brothers first balloon experiment with sheep, rooster, duck
  - Nov 21, 1783 - Pilatre de Rozier & Marquis d'Arlandes were first humans to fly lighter-than-air. Flight lasted 25 minutes and 5 miles.
  - First balloon flight in US: Jan 9, 1793 in Philadelphia
  - 1st US military use in Civil War-observation, aerial reporting



# Introduction to Air Power

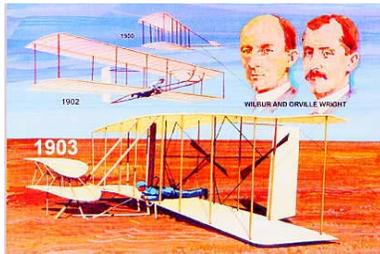


Dirigible: Lighter-than-air craft that can be propelled and steered

- Paul Haenlein - 1st dirigible powered by an internal combustion engine
- Ferdinand von Zeppelin - built and flew the world's first rigid dirigible LZ-1.



## Wright Brothers



- First to achieve controlled, sustained, powered heavier than air flight.
- Learned from previous pioneers an observing birds in flight
- Utilized "wing-warping technique" for control
- Utilized gas powered engine; built gliders
- December 17, 1903-1st powered flight: flew 120 feet over 12 seconds at Kitty Hawk, N.C.
- Completed 3 flights that day, longest 852 feet, 59 seconds.



## Adolescence of Air Power: 1904-1919



### Wright Brothers

- Poor press, No enthusiasm
- Contracted w/ Board of Ordinance & Fortifications to train 2 pilots
- Demonstrations in France to European governments
- Sept 17, 1908- Lt. Thomas Selfridge, 1st death in powered aircraft

### Aviation Gains Recognition

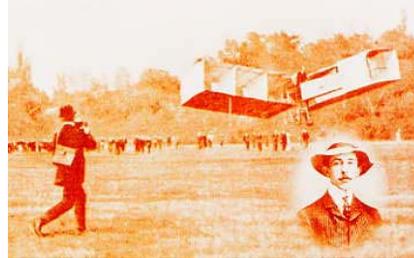
- Vin Fiz Flyer - 1st to fly coast to coast
- Harriet Quimby - 1st licensed female pilot in US.
- Louis Breguet - 1st helicopter to lift man
- World's 1st regularly scheduled airline - St. Petersburg - Tampa Airboat, 1914

### Study of Flight Problems

- Wilson (1915) creates Natl Advisory Committee for Aeronautics (NACA)

### Europe

- Frenchman Robert Esnault-Pelterie 1st aileron application and enclosed fuselage
- Alberto Santos-Dumont-flew 1st powered airplane in Europe 1906.



- Louis Bleriot-Built/flew 1st powered monoplane.

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## Adolescence of Air Power: 1904-1919



### World War I

- Airplane not recognized as important at beginning WW1
- Germans had dirigibles as bombers (filled w/ hydrogen)
- Germans developed bombers
- Fighters developed to shoot down bombers
- Eddie Rickenbacker - American WW1 ace-16 kills in 5 months. Only living American to receive Medal of Honor in WW1
- US didn't recognize aircraft as "game changer" - used English/French built aircraft
- Lafayette Escadrille - American group of flyers serving the French

### Gen. Billy Mitchell

- Recognized that the airplane is an offensive weapon
- Air service should be separate service than Army
- Air power can be effective against ground troops



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# Golden Age 1919-1939



## US Aviation after WW I

- US had built 15,000 airplanes during war - front-line strength: 750 combat aircraft, 800 pilots
- 3 days after war ended, US gov't cancelled \$100M airplane contracts
- US and allies (England, France) decreased and weakened air forces
- 175,000 workers laid off, production dropped 85%, military aviation cut 95%

## Barnstormers

- Ex-military pilots, flew to attract attention
- Most people in US had not seen an airplane
- 1st licensed African-American pilot - Bessie Coleman



## Billy Mitchell and airpower

- Air power could strike industrial targets, attack troop supply routes, decide winner of war
- Stressed importance of airpower in strategic warfare
- Ostfriesland "unsinkable" battleship
- Demolished by 200 lb. bombs
- Navy recognized importance and within 8 months had first aircraft carrier
- Organized 1st around the world flight with 4 Douglas World Cruisers - *Boston, Chicago, Seattle, New Orleans*



# Golden Age 1919-1939



## National Air Races

- Pulitzer Trophy - 29 mile closed course
- Bendix Trophy Race - West coast to Cleveland, OH - 1931

## Air Mail

- First service by US Post Office May 15, 1918 between Washington DC and New York City.
- May 20, 1926 - Air Commerce Act, first attempt to regulate commercial aviation
- President Roosevelt signed Civil Aeronautics Act of 1938 creating Civil Aeronautics Authority (CAA) - one independent agency to regulate law and safety



## 1st non-stop Atlantic crossing

- July 1919-John Alcock and Arthur Brown
- St. Johns Newfoundland to Ireland 16 hrs, 1880 miles.

## 1st solo non-stop Atlantic crossing

- May 20, 1927 - Charles Lindbergh in the Spirit of St. Louis, built by Ryan





# Air Power Goes to War



## New Type of War

- Germany had terrible losses in WWI from trench warfare
- Blitzkrieg - "lightning war" combination of army and air forces
- Germany focused on small/medium sized aircraft to support Blitzkrieg tactics

## Battle of Britain August 1940

- Luftwaffe focused on gaining control of air over Britain
- Germany did not have long range bombers
- Britain focused on defensive warfare with fighters
- Britain used radar
- Britain won by having the right aircraft for battle

## Germany Advances

- 1940 - Italy & Germany declared war on Great Britain
- Italy & Germany attacked western Africa
- Axis invaded Greece, Russia
- Russia used heavy defenses including woman pilots for combat sorties.
- Germany forces spread too thin on 3 fronts



# Air Power Goes to War



## US Enters WWII

- December 7, 1941 - Japanese attack Pear Harbor, Hawaii. Purpose was to cripple the US naval fleet.
- Allied strategy -
  - Defensive to offensive
  - Recapture territory occupied by Germany & Japan
  - Force both Germany & Japan to unconditional surrender
  - European campaign had priority over Pacific
  - Focus on strategic bombing



## Lessons in North Africa

- Centralize control of air forces
- Gain air superiority - attack airfields, aircraft
- Interdiction - cripple enemy supplies
- Close ground support - bomb enemy troops
- Hitler defeated in North Africa



# Air Power Goes to War



## Europe

- US declared war on Germany/Axis 12/11/41
- 8th Air Force formed in 1/42, 8/42 1st bombing mission
- US strategy-precision daytime bombing
- RAF strategy-Night blanket operations
- 6/6/44 - Normandy invasion
- 5/7/45 - Germany surrenders
- Russia – only major power to use women pilots in combat

## Pacific

- Japan rapidly advancing throughout the Pacific
- 1942 -Battle of Coral Sea & Midway-entirely by airpower, no surface ship engagement
- Established strategy for subsequent naval battles
- Stopped advance of Japan
- 4/42 Doolittle Raid on Tokyo
- 8/6/45 Atomic bombing of Hiroshima - B-29
- 8/9/45 Atomic bombing of Nagasaki
- 9/2/45 Japan surrenders

## Lessons Learned

- Airplane became prominent weapon of war
- Aircraft carrier became primary naval weapon
- 20 Million killed, 4 million civilians
- Warfare-no one wins or loses
- Sensible solution is to prevent war rather than fight one.



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# Aviation: Cold War to Desert Storm



## Political Climate

- Postwar years (after WWII) were called "Cold War".
- Soviet Union tried to spread communism, US tried to stop it.
- Antagonistic relationship, not a "hot" war.
- Cold War shaped many developments in aviation.
- 7/26/47 - National Security Act - USAF was formed.
- Primary mission - deterrence with atomic bombs by Strategic Air Command



## Korean War

- 6/25/50 North Korea invaded S. Korea-ended 7/53
- 1st Priority to stop advance of N. Korean Army
- 1st all jet battle-F-80 shot down MiG-15
- Lessons learned: atomic arsenal not enough to prevent war, multiple levels of conflict

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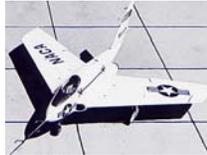
# Aviation: Cold War to Desert Storm



## Research & Development



- Bell X-1 exceed Mach 1
- 10/14/47 Chuck Yeager



- Northrop X-4
- Tailless research
- Led to XB-35, YB-49 and B-2 stealth bomber



- Douglas D558-II
- Exceed Mach 2
- 11/20/53 Scott Crossfield



- Bell X-2
- Swept wing research
- Exceed Mach 3
- 9/27/56 Milburn Apt



- Douglas X-3
- High speed flight materials & aerodynamics testing
- Never exceeded speed of sound



- Bell X-5
- Variable geometry wing research
- Led to F-111, F-14, B-1

The X-Planes: X-1 to X-45  
Jay Miller



# Aviation: Cold War to Desert Storm



## Vietnam Conflict

- Americas Longest War - 25 years
- Phase I-1950-1954-Aid and advisors for French
- Phase II 1954-1964-French defeated, troops sent to train S. Vietnamese
- Phase III-1964-1969-US Naval ships attacked. 8/64 Tonkin Gulf Resolution- empowered Johnson "take all necessary measures to repel armed attack against forces of US an prevent further aggression."
- Operation Rolling Thunder: 1965-1968
  - 3 year bombing campaign to force N. Vietnam to surrender. Limited targets
- Operation Linebacker I & II
  - President Nixon's strategy to force N. Vietnam to negotiate. Linebacker II was the only true strategic bombing campaign of Vietnam War
- Phase IV-1969-1975-Nixon withdrew troops, Saigon captured by N. Vietnamese in 1975.



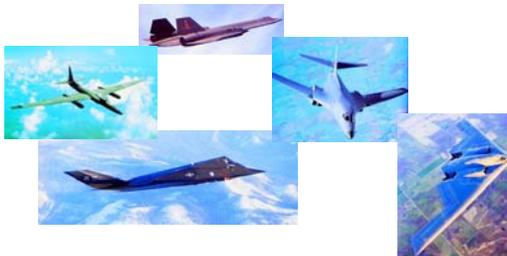


# Advances In Aeronautics



## Aeronautical Research

- X-15 joint USAF, Navy, NASA program to build aircraft to fly 4500 mph at 250k feet.
- XB-70-Mach 3 high altitude supersonic bomber prototype to replace B-52
- Composite materials-Strong, lightweight, non-metallic
- Oblique wing-Pivoting wing-optimum lift under different circumstances
- Winglets-Reduce vortices off wingtips reducing drag
- Canards-Horizontal surfaces forward of main wing
- Supercritical wing-Delay point at which air reaches supersonic speeds, delaying increased drag.
- Forward-swept wing: X-29



## Military Advancements

- U-2: High altitude reconnaissance
- SR-71: Mach 3+ high altitude reconnaissance
- B-1B: Low altitude, high speed strategic bomber
- F-117 Nighthawk: 1st stealth fighter-bomber
- B-2: Stealth bomber



# Advances In Aeronautics



## Civil Jet Aviation-the Beginning

- 1st commercial jet Boeing 707, 1957
- Revolutionized commercial aviation
- Douglas' answer to 707, the DC-8



- Short/medium range: 727, DC-9, 737
- 737 most produced jetliner in history



# Advances In Aeronautics



## Civil Aviation-The Wide body's

- 1st wide-body and largest commercial aircraft in service - Boeing 747, 1968
- Douglas entered with DC-10 trijet
- Lockheed entered with L-1011 trijet
- Airbus enters with A-300 twinjet



- First supersonic transport: Concorde
- The advanced twins: 757, 767
- DC-9 grows into MD-80
- Airbus enters the narrow body market with A320



# Advances In Aeronautics



## Civil Aviation-Modern Transports of the 1990's

- Boeing MD-11, 777, 737-700 series
- Airbus A330, A340



## Civil Aviation-The Future....

- Boeing Sonic Cruiser
- Airbus A380





## Part 2 Principles of Flight & Navigation



**Chap. 7- Basic Aeronautics & Aerodynamics**

**Chap. 8- Aircraft in Motion**

**Chap. 9- Flight Navigation**

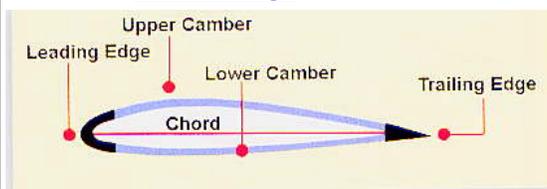
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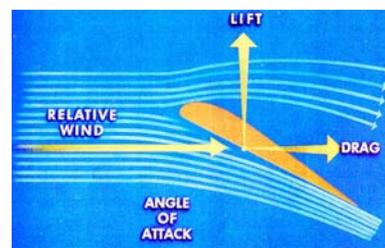
## Basic Aeronautics & Aerodynamics



### Airfoil Design



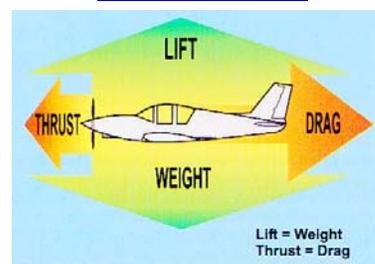
### Lift & Angle of Attack



### Daniel Bernoulli

- Dutch physicist, 1738
- Discovered relationship between the pressure and speed of fluid in motion
- Bernoulli's Principle: "As the velocity of a fluid increases, the pressure decreases"

### 4 Forces of Flight



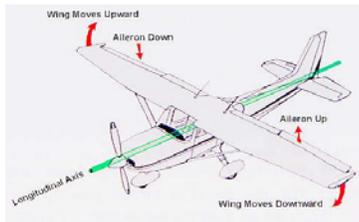
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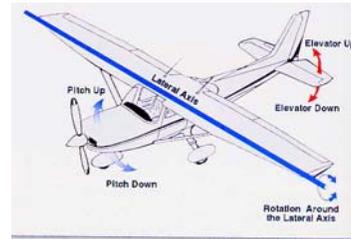
# Aircraft in Motion

## The Axes of An Aircraft

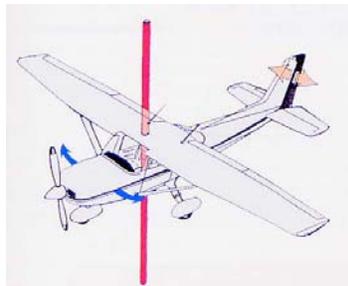
### Longitudinal Axis (Roll)



### Lateral Axis (Pitch)



### Vertical Axis (Yaw)



### Center of Gravity

Point where the three axes converge and all weight is concentrated

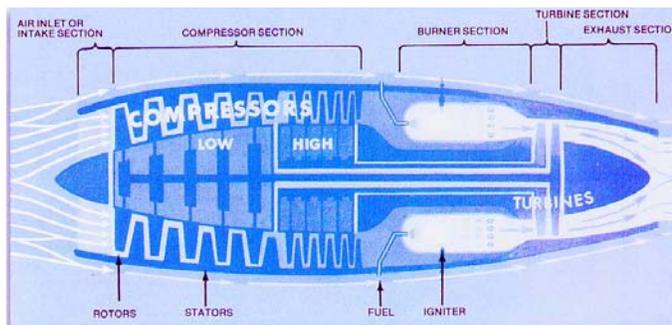
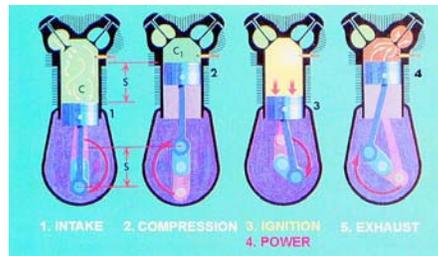


# Aircraft in Motion

## Engines

### Reciprocating

- Fuel converted to energy in cylinder



### Turbine

- Turbojet
- Turbofan
- Turboprop
- Turboshift



# Aircraft in Motion

## Aircraft Instruments

- Performance - How aircraft responds to our commands
- Control - Current state of aircraft devices

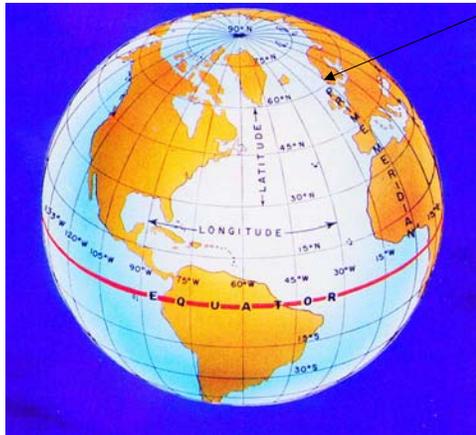
### Instrument Types

<u>Engine</u>	<u>Flight</u>	<u>Navigational</u>
Tachometer	Airspeed Indicator	Magnetic Compass
Oil Press.	Altimeter	Heading Ind.
Oil Temp.	Turn/slip Indicator	VOR Ind.
Manif. Press.	Vertical Speed Indicator	
Carb. Temp.	Attitude Indicator (Artificial Horizon)	
Exhaust Gas Temp.		



# Flight Navigation

## Global Coordinate System



Greenwich, England

## Sectional Charts

- Most common general aviation map
- Relief - Elevations
- Hydrographic - Bodies of water
- Cultural - Cities, towns
- Airports - Civil & Military
- Airspace & Airways - Navigation



## Basic Navigation Techniques

- Pilotage - Reference to visible landmarks
- Dead Reckoning - Systematic consideration of all factors that could effect the flight



## Part 3 The Aerospace Community



- Chap. 10- The Airport**
- Chap. 11- Air Carriers**
- Chap. 12- General Aviation**
- Chap. 13- Business & Commercial Aviation**
- Chap. 14- Military Aircraft**
- Chap. 15- Helicopters, STOL, VTOL, UAVs**
- Chap. 16- Aerospace Organizations**
- Chap. 17- Aerospace Careers & Training**

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## The Airport



### Runway

- Most important part of an airport.
- Can be made of grass, gravel, concrete, or asphalt.
- Identified by number corresponding to compass direction
  - 90 degrees "09", opposite end 270 degrees "27"
- White lights at edges and sometimes in middle at night, during day are dashed white line down middle
- End of runway are red lights

### Control Tower

- Primary function to control runway
- Controls movement of aircraft on ground
- Most airports are uncontrolled (no control tower)

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# Air Carriers



## Major Air Carriers

- Regularly scheduled service (commercial airlines, cargo carriers, regional air carriers - All regulated by FAA)

## Modern Airliners

- Boeing 707-1st commercial jet used in US. Flew 1958, built until 1979
- Douglas DC-8-Entered service 1 yr after 707, ended 1972
- DC-9-Twin jet short/medium range competitor to 737. MD-80/MD-90 are new versions.
- Boeing 727-Most successful tri-jet
- 737-Twin engine, short/medium haul, most successful jetliner
- Boeing 747-Largest commercial jet produced, 1st wide-body, Series 400-heaviest commercial aircraft 892K lbs (Antonov An-225-1,322K lbs)
- Douglas DC-10-2nd jumbo jet-3 engines, MD-11 next generation version
- Lockheed L-1011-1st commercial aircraft since Electra.
- Airbus A-300-1st commercial aircraft by Airbus; engine made in US
- 767-1980's technology small wide-body

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# Air Carriers



## Major Airliners Continued

- 757-Designed with 767, standard body, same fuselage diameter as 707, 727, 737, intended to replace 727 however created its own market.
- A320 - Airbus entry into narrowbody market
- MD-11 - 1990's version of DC-10
- 777-1990's technology twin-engine long range
- A330/A340-1990's technology medium/long range
- A380-New double deck 600 passenger long range - service 2006
- Boeing Sonic Cruiser - Near supersonic long range medium sized (767) twin engine transport. Probable service 2008

## Air Cargo Carriers

- Only carry cargo, no passengers
- Boeing 747F ("Giant"), DC-10, MD-11, A300, 757, 727, DC-8

## Regional Aircraft

- Metro III, Beech 99, ATR 72, Dash 8- all turboprops
- Regional Jets
- Bombardier CRJ, Embraer 145, Dornier 328



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# General Aviation

General Aviation - All civil aviation other than flying by scheduled air carriers and government agencies

Instructional Aviation

- Aircraft specifically use to teach someone to fly. C-152, Piper Tomahawk, Beech Skipper



Personal Aviation

- Use of aircraft other than business or commercial use, 24% all hours flown.
- Beech - Sundowner, Sierra, Bonanza



- Cessna - largest builder of GA planes - 172 Skyhawk, 182 Skylane, 185 Skywagon, 210 Centurion



# General Aviation

- Mooney - Mooney 201
- Piper - Malibu, Cherokee, Cruiser, Arrow, Super Cub, Archer



Sport Aviation

- Home builds, ballooning, soaring, antique aviation, racing, aerobatics, ultralight
- First unrefueled nonstop flight around the world - December 14-23, 1986, Dick Rutan & Jeana Yeager





# Business & Commercial Aviation



**Business Aviation** - Major areas of concern in aviation today: 1) Fuel efficiency; 2) Noise; 3) Cost effectiveness

## Executive Aircraft

Multi-engine piston



Turboprops



Turbofans



## Business Aircraft

Transportation (air taxi, charter), agricultural, aerial Advertising, aerial Photography, fire fighting, fish & wildlife, patrol, industrial uses



# Military Aircraft



## Combat Aircraft

**Bombers** - Reach enemy's homeland and destroy ability to wage war

- Boeing B-52, B-1, Northrop Grumman B-2 Stealth Bomber



**Fighters** - Destroys other aircraft, small ground targets

- Boeing F-15, F/A-18, Northrop Grumman F-14, Lockheed Martin A-10, F-22, F-35 (JSF), F-16, F-117





# Military Aircraft



## Noncombat Aircraft

Reconnaissance & Observation - Watch an enemy to keep track of what they are doing

- Lockheed U-2, SR-71, Boeing E-3A AWACS, E-4B, E-8 J-STARS, Lockheed P-3C, S-3A, Northrop Grumman E-2C



Transports & Tankers - Unarmed to support combat aircraft & military assets

- Lockheed C-5, C-141, C130, Boeing C-17, KC-135, KC-10, VC-25, C-9A (Medical)



# Military Aircraft



## Training Aircraft

### US Air Force

- Raytheon T-6 Texan II, Cessna T-37 Tweet, Northrop T-38 Talon, Raytheon T-1 Jayhawk



### US Navy

- Raytheon T-34C Mentor, Boeing T-45 Goshawk, Raytheon T-44 Pegasus





# Helicopters, STOLs, VTOLs, UAVs



**Helicopters** - In use since end of WWII, very resourceful with limitations: high maintenance costs, vibrations, high noise levels. Turbine engines, composite materials advanced helicopter development

### Attack

- Bell AH-1 Cobra (Army & Marines), Boeing AH-64 Apache (Army)



### Heavy-Lift

- Boeing CH-47 (Army), CH-46 (Navy, Marines), Sikorsky CH-53 (USAF, Navy, Marines), Bell/Boeing V-22 Osprey (Hybrid), Sikorsky H-3 - 1st nonstop flight across Atlantic Ocean 1967



### Utility

- Bell UH-1 Huey, Sikorsky UH-60 Blackhawk (Army, Navy, AF)



### Civilian

- Bell 206 Jetranger, Bell 222, MD 500, Sikorsky S-76

### Foreign

- Aerospatiale Puma, Dauphin, Agusta 109, MBB 105



# Helicopters, STOLs, VTOLs, UAVs



**Short-takeoff-and-landing (STOL)** - Defined as ability of an aircraft to clear a 50-foot obstacle within 1500 feet after takeoff and to stop within 1500 feet after passing over a 50-foot obstacle when landing.

**Vertical-takeoff-and-landing (VTOL)** - Significant design differences to achieve VTOL from STOL. V-22 Osprey is propeller VTOL. AV-8B Harrier only VTOL aircraft put to common use in multiple countries. F-35 JSF Marines VTOL version to replace Harrier.



**Unmanned Air Vehicles (UAVs)** - Pilotless aircraft used for reconnaissance, electronic warfare, or combat operations. Used during WWII, widely used in Vietnam. Computer technology has renewed significant interest today.



RQ-1A Predator



RQ-5A Hunter



RQ-4A Global Hawk



# Aerospace Organizations



## Federal Aviation Administration

- Air traffic regulation began with Air Commerce act of 1926. Bureau of Air Commerce formed within Dept. of Commerce
- Civil Aeronautics Act 1938 - Regulation placed under Civil Aeronautics Authority (established safety & economic policies), Administrator of Aviation (execute safety policies), and Air Safety Board (investigated accidents).
- Federal Aviation Act 1958 - FAA formed
  - Air Traffic Control
  - Airway Facilities
  - Flight Standards
  - Research & Development
  - Aeronautical Center

## National Transportation Safety Board (NTSB)

- 5 member board appointed by President
- Responsible for determining cause of any transportation accident.

## National Aeronautics & Space Administration

- Earth Science, Aero-Space Technology, Space Science, Human Exploration & Development of Space

## International Civil Aviation Organization (ICAO)

- 1947 - International organization dedicated to standardization of aviation functions.

## Civil Reserve Air fleet (CRAF)

- Commercial airliners which have been designated by DoD for use in time of emergency.

## Aircraft Owners & Pilots Association (AOPA)

- Supports the views and rights of aircraft owners and pilots.

## Experimental Aircraft Association (EAA)

- Formed to help builders safely construct and fly homebuilt aircraft.

## Industry Organizations

- Aerospace Industries Association (AIA)
- General Aviation Manufacturers Association (GAMA)



# Aerospace Careers & Training



## Aptitudes and Aerospace Careers

- Special talents and natural abilities which a person possesses are called aptitudes.
- Mechanical, verbal, scientific, manipulative, numerical, administrative, social, artistic.

## Academic Institutions

- Junior or community colleges - Associate degree
- Technical/Vocational School - technical education courses
- Four year college/University - BA, BS, MS, PhD
- Air Force Schools
  - Air Force Reserve Officer Training Corps. (ROTC)-Bachelors
  - Air Force Academy-Bachelors, Masters
    - Must be 17
    - US Citizen
    - Good moral character, physical condition, scholastic record
    - Unmarried and no dependent children
    - Demonstrated potential for leadership, desire to become a cadet
  - Community College of the Air Force - Associate Degrees



## Part 4 Air Environment



**Chap. 18- The Atmosphere**

**Chap. 19- Weather Elements**

**Chap. 20- Aviation Weather**

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## The Atmosphere



### Atmospheric Regions

- Troposphere - Region where we live. "Tropo" means change "sphere" means layer. Temperature decreases with altitude, region where weather occurs.
- Stratosphere - Stable weather region, temperature increases with altitude
- Mesosphere - Temperature increase then decrease to -130F
- Thermosphere - 50 miles to 300 miles, temperature increases

### Water in Atmosphere

- Evaporation - liquid molecules turn to gas or vapor state.
- Humidity - amount of water in air
- Relative Humidity - indicates amount of water vapor that can still enter air mass
- Saturation - Air can not hold any more water vapor
- Dew Point Temperature - Temperature at or below which water vapor will be saturated and condense.

### Methods of Heat Transfer

- Conduction - Heating by direct contact
- Convection - Heating by vertical motion of fluid (thermals)
- Advection - Heating by horizontal motion of fluid (wind)
- Radiation - Method of heating without changing temperature of medium in between (sun)
- Insolation - Rate Earth's surface is heated by solar radiation

### Pressure Gradient

- Pressure gradient - slope of high-pressure mountain
- Isobars - lines of constant pressure
- Jet Stream - "River" of high speed air moving from West to East at speeds up to 450MPH

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# Weather Elements



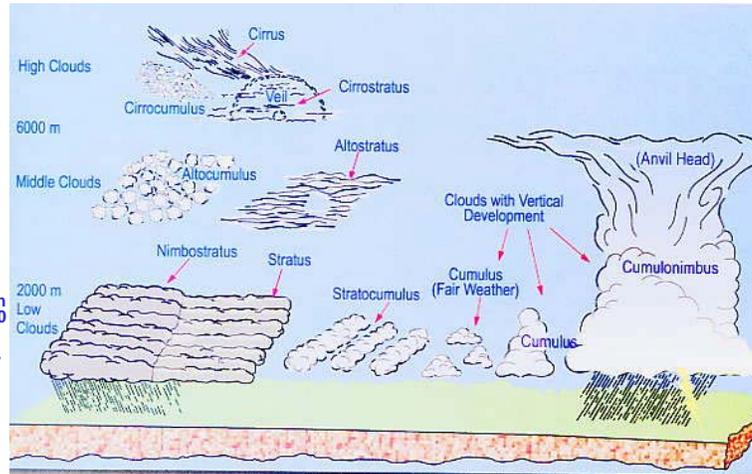
## Air Masses & Fronts

- Cold Front - Pushes warm air upward and can create thunderstorms
- Warm Front - Warm air covers cold air, usually high, thin wispy clouds develop
- Stationary Front - When air masses lose their "punch" and do not replace each other
- Occluded Front - Warm air mass, lying between two cold masses is lifted by cold mass behind

- Polar - Cold
- Tropical - Hot
- Maritime - Humid
- Continental - Dry

## Clouds

- Cumulus - Piled up
- Stratus - Layered
- Cirrus - High, thin appearance
- Low - 300-6500 ft, stratus, cumulus, stratocumulus, cumulonimbus, nimbostratus
- Medium - "Alto" high but not highest, 6500 - 20000 ft
- High - Cirrus - wispy



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# Weather Elements

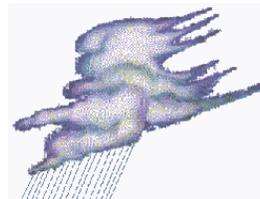


- Severe Weather
  - Cumulonimbus clouds are a sign of Severe Weather, which could be a Thunderstorm, Tornado or Hurricane
  - Thunderstorms
    - Heavy Winds, Strong Rain, Sometimes Hail
    - Lightning - Electric Discharge, which can heat the air to 60,000°F!



### Do's and Don'ts:

- Don't use electric appliances, telephones, or take a shower
- DO Stay away from Windows and Doors
- If Outdoors, DO go Inside
- If in a car, DO stay there
- If in a boat, DO get ashore
- DO Move away from Water and Metal objects
- Don't stand in open space, or under a tree
- DO Stay Low, and Don't huddle in a group



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# Aviation Weather

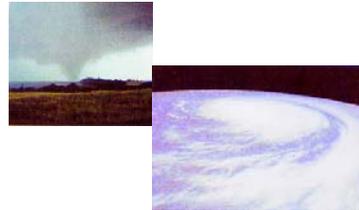
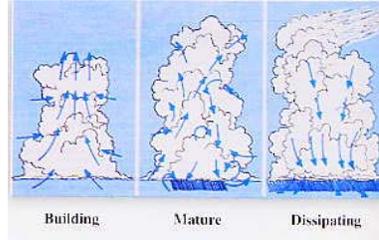


## Weather Hazards

- Visual Flt Rules (VFR) – Apply when Cloud ceiling > 3000 ft and visibility > 5 miles
- Instrument Flt Rules (IFR) - Cloud ceiling >500 and <1000 ft and visibility >1 mile and <3miles
- Clouds, rain, snow, fog, haze, smoke, blowing dust, sand, snow
- Icing - Carburetor, glaze, rime, frost

## Severe Weather

- Thunderstorms
  - Cumulus stage - updraft of warm moist air
  - Mature stage - Rain, strong downdrafts
  - Dissipating stage - Downdrafts produce heating, drying, ceasing rain
- Tornadoes
  - Funnel cloud that touches ground - violent energy in small area
  - Occur most often in N. America & Australia
- Hurricane
  - Strong tropical cyclone that occur around world
  - Eye of hurricane is calm center
- Hail
  - Frozen rain pellets that circulate in thunderstorm



# Aviation Weather



- Tornadoes
  - Fujita Wind Damage Scale - F0 to F5, with wind speed range and expected scale of damage for each
    - F5 is over 261 MPH, with 'Incredible' Damage resulting
    - Do's and Don'ts:
      - » DO Get to a Basement (or lie down in low ground)
      - » DO, If above ground, move at 90° to the Tornado
      - » DO, if indoors, stay away from windows, got to the interior, or into a closet or bathroom
- Hurricanes
  - Saffir-Simpson Hurricane Damage Potential Scale - Category 1 (75-95 MPH), to 5 (155+ MPH!), with Pressure Range, Wind Speeds, and Storm Surge (Sea Level increase)
    - Do's and Don'ts:
      - same as Thunderstorms & Tornadoes, since they can produce BOTH Worse, they can be HUGE, and can continue for more than a week! But, Hurricanes have a 'Eye' at the center which is calm





## Part 5 Rockets



**Chap. 21- Rocket Fundamentals**

**Chap. 22- Chemical Propulsion**

**Chap. 23- Orbits & Trajectories**

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## Rocket Fundamentals



### History of Rocketry

- Rocketry is based on the propelling of a vehicle by a reactive force.
- Chinese developed rockets in 1220 and were first to use in war.
- 1405 - German engineer Konrad Kyeser von Eichstadt devised rocket propelled by gunpowder
- 1800 - Britain's William Congreve developed flight-stabilizing guide sticks and built first viable launching pad.
- William Hale (English) developed spin-stabilization with angled exhaust tubes.
- WW I - rockets used as signal flares and to carry messages, not used as primary weapon.
- Dr. Robert H. Goddard - Developed and launched first liquid propelled rocket. Recognized as the "Father of Modern Rocketry".
- Germany developed liquid rocket as weapon in WW II know as the V-2.

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# Rocket Fundamentals

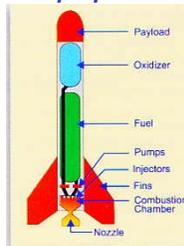
## Fundamental Physics

- Gravitation-Force of attraction between all matter within the universe
  - Gravity- Gravitation force with a body or mass on or near the Earth (Galileo)
  - Newton's Law of Universal Gravitation:  $F = \frac{Gm_1m_2}{d^2}$
  - Newton's Three Law's of Motion:
    - 1) Inertia
    - 2)  $F=ma$
    - 3) Action=Reaction
- Momentum = m x V**  
**Acceleration = rate of change of velocity**

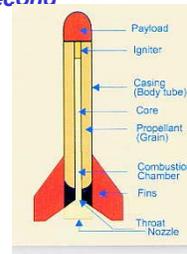
## Rocket Systems

*Specific Impulse (Isp) = lbs of thrust delivered by consuming 1 lb of propellant in 1 second*

- Airframe – Structure & Shape
- Propulsion
  - Engines - Liquid Propellant
  - Motors- Solid Propellant
- Guidance Systems - “Brain”, inertial platform, star tracking
- Control Systems - “Steering”, thrust vector control, reaction control



Liquid Fuel Propulsion System



Solid Fuel Propulsion System



# Chemical Propulsion

## Oxidizers & Reducers

- Oxidation - combination of oxygen with another substance. Time it takes for this process determines if substance rusts, corrodes, burns, or explodes
- Combustion - Rapid oxidation
- Oxidizer - Chemical element of Oxygen used to facilitate oxidation
- Reducers - Fuel used to combine with Oxygen to produce combustion.
- Propellant - Common reference to both oxidizer and fuel
  - Bipropellant - Propellant with separate storage of oxidizer and fuel.
  - Monopropellant - Oxidizer and fuel stored in same container.

Solid Motors-Oxidizer and fuel are mixed together in solid state

- Storable
- No thrust control
- Cannot stop or throttle

Liquid Propellant

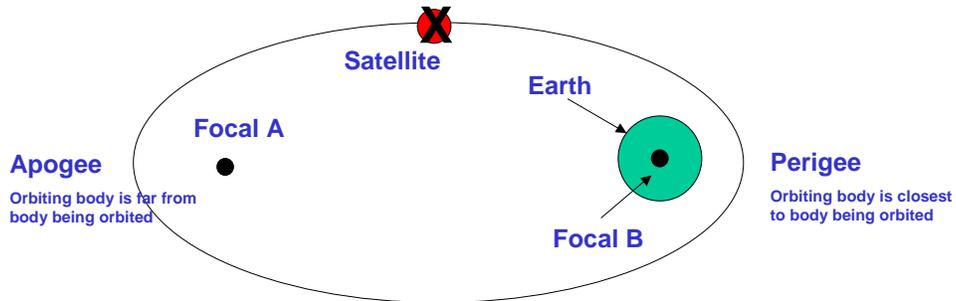
- Hard to store/handle
- Can stop or throttle



# Orbits & Trajectories



**Orbit** - Path described by one body in its revolution about another body.



- Circular Orbit - Constant altitude above Earth's surface
- Elliptical Orbit - Not circular
- Equatorial - West to East over Equator
- Geostationary Orbit - Equatorial orbit of period of 24 hours
- Polar Orbit - Crosses North and South poles
- Sunsynchronous Orbit - Constant exposure to sunlight
- Sounding Rocket - Straight up trajectory, never reaches orbit



# Orbits & Trajectories



## Velocity Requirements

- Burnout - Moment a rocket engine ceases to produce thrust.
- Satellite in circular Earth orbit - 17,856 MPH
- Minimum velocity to Moon - 24,409 MPH
- Escape velocity of Earth - 25,560 MPH
- Escape velocity of Solar System - 36,000 MPH

## Launch Vehicles

- Rocket - Power plant used to propel a payload.
- Missile - Rocket propelled vehicle used to deliver a weapon.
- Launch Vehicle - Rocket propelled vehicle use to deliver payload other than a weapon.
  - Expendable - Vehicles used only once and do not return to Earth.
  - Reusable - Space Shuttle is only reusable launch vehicle.



## Part 6 Space



**Chap. 24- Space Environment**

**Chap. 25- Our Solar System**

**Chap. 26- Unmanned Space Exploration**

**Chap. 27- Manned Spacecraft**

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## Space Environment



### Space

- Definition - Altitude of 50 miles and beyond Earth's surface.
- Cislunar Space - Space between Earth & Moon.
- Interplanetary Space - Center of Sun to outermost planet, Pluto.
- Interstellar Space - Distance between solar systems.

### Sun

- Strongest gravitational force in the solar system.
- 864,000 Miles in diameter, surface is plasma, fusion process
- Photosphere - Thin shell that gives light.
- Chromosphere - Sphere of Color.
- Corona - "Crown" outermost part of sun's atmosphere



### Environmental Effects on Space Operations

- Communications - Magnetic storms, ionosphere, solar flares
- Radiation, Electrostatic charging, vacuum
- Weightlessness - Damaging physical effects on Human body.
- Astronauts use NASA's "Vomit Comet" to train for weightlessness or free fall.

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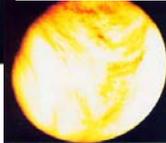


# Our Solar System



## Mercury

- Closest planet to Sun; 36 million miles
- Temperature ranges from -350F to 750F



## Venus

- Second planet from Sun; 67 million miles
- Nearest to Earth in size and distance
- Only planet to rotate about its axis in a clockwise (east to west) direction
- Hottest planet of 900F, 240 days to complete one rotation



## Mars

- Fourth planet, the Red Planet, slightly longer than 1 Earth day
- Highest mountain in solar system: 400 miles wide 17 miles high
- Pathfinder mission landed 1997. Small rover called Sojourner analyzed rocks and soil.



## Jupiter

- Fifth planet, largest in solar system
- Gas giant, hydrogen, helium, methane, ammonia
- 11 times larger than Earth
- Rotates every 10 hours



# Our Solar System



## Saturn

- 2nd largest planet and sixth from Sun
- Rotates every 10 hours



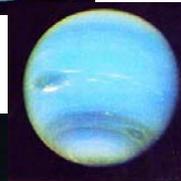
## Uranus

- 3rd largest planet in solar system
- Rotates on side every 18 hours.
- 2 billion miles from Sun, -340F on surface



## Neptune

- Outermost of gas planets, 4th largest in solar system
- Rotates every 19 hours
- Most windy planet, up to 1500 MPH



## Pluto

- About size of Mars
- Rotates every 6.4 Earth days
- Ranges from 2.9 to 4.6 billion miles from Sun





# Our Solar System



## The Asteroids

- Rocky and metallic objects orbiting the Sun too small to be planets
- Over 15,000 asteroids have been found



## Comets

- Small irregular shaped body with nucleus made of water, ice, rock, and frozen gas
- Identified by a coma (diffuse material surrounding nucleus) with a long trailing tail
- Highly elliptical orbit around the Sun



## Meteoroids

- Bits and clumps of matter that orbit the Sun and cross cislunar space
- Meteor - meteoroid that enters Earth's atmosphere
- Meteorite - meteor that collides with Earth's surface
- Most meteorites are size of basketball or smaller

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# Unmanned Exploration



## The Space Race Begins

- Former German scientists worked with V-2 rocket derivatives to explore rocket research for US and Russia.
- Soviet Union launched first successful artificial satellite, Sputnik 1 on Oct. 4, 1957



- Explorer I - US first satellite launched Jan 31, 1958.
- October 1, 1958 - National Aeronautics & Space Administration (NASA) developed.

## Space Treaties

- 1967 Outer Space Treaty - Approved in UN General Assembly states that space is providence of all mankind and space exploration should benefit all countries.
- AMB Treaty - 1972, Anti-Ballistic Missile Systems - agreement not to develop systems to defend against ballistic missiles.
- Commercial Space Launch Act (CSLA) - Single regulatory agency for commercial space in US.

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# Unmanned Exploration



## Satellites - Unmanned Spacecraft

- Communications Satellites - relay and amplify signals
  - Echo 1, Telstar, INTELSAT, TDRSS, Milstar
- Navigation Satellites - Send positional data to specific receivers
  - Transit, NAVSTAR (GPS)
- Observation Satellites - Look at Earth and relay information.
  - Weather (Tiros 1960), multi-spectrum imaging, reconnaissance
- Scientific Satellites - Orbit for sole purpose of gaining information
  - Explorers - first of series to orbit Earth
  - Orbiting Solar Observatory (OSO)
  - Orbiting Astronomical Observatory (OAO)
  - Hubble Space Telescope
- Probes
  - Rangers - first probes to investigate the Moon
  - Surveyors - landed on Moon's surface

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# Unmanned Exploration



- Probes
  - Mariners - flyby of Venus, Mercury, and Mars
  - Pioneers - Outer planet probes, first look at Jupiter and Saturn
  - Vikings - Two probes that landed on Mars
  - Voyagers - explored Jupiter, Saturn, Uranus, Neptune
  - Mars Pathfinder - 1997 landing of rover Sojourner
  - Galileo - Inserted probe into Jupiter
  - Cassini - To reach Saturn in 2004



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# Manned Space Explorations



## Project Mercury - First American Manned Space Program

- Determine if man can survive in space and effects on human body.
- Original Seven: Carpenter, Cooper, Glenn, Grissom, Schirra, Shepard, Slayton
- 1961-1963: 6 flights
- May 5, 1961 - First American in space, Alan Shepard, suborbital flight
- February 20, 1962 - First American to Orbit Earth, John Glenn



## Project Gemini

- Improve techniques needed for lunar mission: 2 people in space, rendezvous, and docking with another spacecraft, walk in space.
- June 3, 1965 - Ed White first American to walk in space.
- 1965-1966: 10 flights



# Manned Space Explorations



## Project Apollo - The Moon Missions

- 1968-1972: 11 missions, 6 landed on Moon
- Apollo 8 - December 24, 1968 - First Moon orbit
- Apollo 11 - July 20, 1969 - First Moon landing.

Neil Armstrong & Edwin Aldrin



## Project Skylab - Our First Space Station

- 1973-1974: 3 Missions, longest mission 84 days

## Space Shuttle

- April 12, 1981 - first flight with John Young & Bob Crippen, Columbia
- Vehicles built: Enterprise (atmospheric test vehicle), Columbia, Challenger (lost Jan 28, 1986), Discovery, Atlantis, Endeavour
- June 18, 1983 - first American woman in space





# Manned Space Explorations



## Soviet Manned Space Program

- April 12, 1961 - First human enter space and orbit Earth - Yuri Gagarin
- June 1963 - First woman in space - Valentina Tereshkova
- March 1965 - First human to walk in space - Alexei Leonov
- July 1975 - Apollo-Soyuz Test Project - docking in space
- Mir - 1986-2001

