Aircraft Design

What is a glider?

- Heavier than air aircraft that derives its lift from their aerodynamic structure that are static and remain fixed in flight.

Aircraft composition and components

4 main components

- Fuselage
    - Truss type
        - Steel tubes welded together to form the outer frame of the aircraft, skin is then wrapped around it to form the shell
    - Monocoque or semi monocoque
        - Round or oval shaped formers held together by stringers. Skin is then wrapped around that takes some of the load and sometimes all of the load
    - Materials
        - Metal & metal alloys
            - Good strength to weight ratio
            - Durable and designed to prevent corrosion
        - Wood
            - Flexible, light and strong
            - Difficult to get good quality and long wood
        - Composite
            - Plastic, kevlar or carbon fiber
            - Light and strong
            - Very smooth
            - Very popular in high performance gliders
- Wings or lifting sections
    - Ailerons
        - Hinged on the trailing edge of each wing. Goes up and down and helps the plan roll or bank (left up → left wing down)
    - Flaps
        - Help aircraft increase lift and drag.
    - Spoilers & Dive breaks
        - Spoilers top of wing, when deployed, decreases lift
        - Dive breaks bottom of wing, when deployed, increases drag
    - Trim tabs
        - Located on elevators, rudders or ailerons.
        - Trim tab holds ailerons, rudders or elevators in a certain position so the pilot would not have to be controlling all the time
        - For ex Elevator up trim down to hold in position
    - Wing form
        - Usually similar method of internal construction
        - Changes planform (top down shape) to suit purpose of aircraft
        - Spars
            - Wing root to wing tip
            - Transmit load to fuselage
        - Ribs
            - Form the shape of the wing

        - Skin
            - Stretches over ribs and spars to form the wing
            - As smooth as possible
        - Swept Back wings
            - Increased stability
- The tail section (empennage)
    - Rudder
        - Hinged on the vertical stabilizer or fin
        - Goes left and right to help plane yaw (left → right, right → left)
    - Elevator
        - Hinged on the horizontal stabilizer
        - Goes up and down to help plane pitch (elevator up → nose up)
    - Fin
        - Stabilizes yaw and sometimes roll
    - Horizontal stabilizer
        - Stabilizes pitch and sometimes roll
- The undercarriage or landing gear
    - Nose wheel or tricycle
    - Conventional (tail dragger)
        - Less parasite drag
        - Less expensive
        - Easier to move on ground
        - Ground looping
    - Central single main wheel
        - Most training gliders
    - Tandem landing gear
        - Like central single main wheel but have wheels on wings to provide support
    - Fixed landing gears
        - Reduces weight and complexity
        - Increased drag
    - Retractable
        - Reduces drag but adds weight and complexity
            - More malfunctions like wheel up landing
        - Most high performance gliders have this

<u>Landing gear types</u>

- Single leaf cantilever spring steel gear
    - Like a spring so it absorbs shock
- Single strut gear
    - Has oleo (hydraulic that forces fluid out of hole to absorb shock)
    - Retractable gear
- Tripod
    - Fixed → Oleo → fixed to create a mechanical spring
- Split axle
    - Bungee cord or shock cord wound around a member of the fuselage

- Brake system

        - Mechanical
            - Simple and on early aircraft designs
        - Hydraulic
            - Uses hydraulics to press brake pads
            - Reliable
        - Electrical
            - Uses electrically driven screw drives to apply pressure on brake pads

Aircraft Design Lesson 2
Cockpit and flight controls
- Spoilers and dive brake handles are located on the upper left wall of the cockpit
    - 90 Degrees and a rearward pull extends surfaces

Tow hooks and release mechanisms
- Red knob, when pulled cable releases the hook and tow

Aircraft flight instruments
Six-pack
- Airspeed
- Attitude indicator
- Altimeter
- Turn and bank coordinator
- Heading indicator
- Vertical speed indicator

Pitot static system
- Uses basic physics to measure pressure differential
    - Static pressure is air pressure when nothing is moving
    - Dynamic pressure is air pressure when something is moving
- Instruments
    - Airspeed indicator
    - VSI or VSI
    - Altimeter
- Components
    - Pitot tube and static port
        - Pitot tube measures RAM air
            - Drain hole removes moisture and water from ice
        - Static port measures static pressure outside of the aircraft
            - Placed behind something to not get RAM air

Altimeter
- Measures air pressure
    - Aneroid capsule is sealed specifically to:
        - 29.92” Hg @ Sea level
        - 15 degrees Celsius
        - Air is perfectly dry
    - Higher pressure pushes down on the capsule to change needle (when we descend)
    - 3 Needles
        - Longest
            - 100s of feet

- Shorter
  - 1000s of feet
- Shortest
  - 10000s of feet
- Indicated and pressure altitude
  - Indicated is the indicated pressure on the altimeter
  - Pressure altitude is indicated pressure corrected for non-standard pressure
- Density altitude
  - Indicated pressure corrected for non-standard temperatures
- True altitude
  - Exact height ASL
  - True altitude = Indicated Altitude x [1+4/100 x (OAT - ISA temp)
- Absolute altitude
  - Actual height AGL
  - Absolute altitude = True altitude - Surface elevation
- Errors
  - We can counter this with the subscale
  - If we don't altimeter will over read
  - RAM enters the static port
  - If static port is frozen/blocked, altimeter wont function
- High to low… look out below

Vertical speed indicator/VSI

- Change in barometric pressure as you ascend and descend
  - Gives FPM
- Atmospheric pressure goes into the Aneroid capsule. Calibrated leak allows air to slowly leak into the casing around the capsule
- During stall, VSI could say it's in a descent, however, the attitude is actually up. VSI is not in relation with Attitude
- Errors
  - Lag
    - VSI takes 6-9 seconds to show accurate rate information
  - Reversal error
    - Abrupt pitch changes, VSI may momentarily show a change in the wrong direction
  - Static blockage
    - VSI connected to only static port
    - If it is slightly blocked, it will misread, if it is completely blocked, it will show 0
    - Air is trapped inside, therefore, no change
- Variometer
  - Measures variations in altitude
  - Connected to static system
  - Mirror the operation of a VSI

Aircraft flight instruments lesson 2

Airspeed indicator ASI

- Speed in relation of airflow outside, NOT in relation to the ground
- Connected to both pitot source and static source
    - Pitot tube measures both dynamic and static pressure
    - We subtract the static pressure to find the dynamic pressure only
- When there is RAM → Diaphragm is inflates and turns the needle
- ASI marking
    - V_{NE} → Never exceed
    - V_{NO} → Max structural cruise
    - V_S → Stall speed clean configuration
    - V_{FE} → Max flaps extended
    - V_{SO} → Stall speed landing configuration
- Errors
    - Apparent lag
        - Delay in indication
        - Friction
    - Position error
        - If the airflow does not go directly into the pitot tube, there is an error
    - Blockages
        - Block = malfunction
        - POCUD (Pitot blocked, over reads, in climb, under reads, in descent)
        - SUCOD (Static blocked, under reads, in climb, over reads, in descent)

Pitot static system errors

- Density error
    - Any standards not met, it will malfunction
- Position error
    - Disturbed airflow = malfunction
- Compressibility error
    - As air rams into tube, compressed air will give high pressure readings and high speed readings
- Hysteresis
    - Diaphragms and aneroid capsules can hold their shape, affecting the altimeter
- Reversal error
    - When the aircraft undergoes sudden pitch change, aircraft will mistake it for false static sensation, which will show an opposite indication of the actual direction

Airspeed definitions

IAS

- Indicated airspeed is the uncorrected air speed read directly from the airspeed indicator face

CAS

- The IAS corrected for position and instrument error

EAS

- CAS corrected for compressibility error

TAS

- EAS or CAS corrected for density or the real speed of the aircraft relative to air mass

Magnetic compass

- A compass using magnetic poles 0 to 360 degrees
- Compass filled with kerosene, clear alcohol to aid in movement and to dampen oscillations
- Errors
    - Magnetic dip
        - When close to magnetic pole, the magnet in the compass will try to point down
    - Turning error
        - Compass only correct when aircraft in equilibrium
    - Acceleration error
        - If the plane accelerates, the compass dips forward, decelerate, the compass dips backward, which will slightly turn the compass even when the aircraft isn't turning
    - Deviation
        - Since aircrafts are metal, there will be slight deviation in where the compass is pointing. There should be a deviation card that could help the pilot find their actual heading.

Aircraft Flight Instruments Lesson 3

1. Gyroscope
    a. Wheel that spins very fast, mounted on a gimbal that allows the wheel to spin in any direction
    b. INERTIA
        i. Once spinning, it will spin in the direction constantly. Rigidity in space.
    c. PROCESSION
        i. When a force is applied to the spinning wheel, the original force felt will be 90 degrees.
    d. Receive power from 3 ways
        i. Vacuum
            1. Air pressure differential drives the gyro
            2. Pilot receives info as soon as the aircraft has started
            3. Will not be found on gliders
        ii. Electrical
            1. AC power
            2. Effective in high altitudes
        iii. Venturi
            1. Cheaper
            2. Provides low pressure leading to a partial vacuum, powering the gyroscopic instruments
    e. Heading indicator
        i. More stable and reliable than the magnetic compass
        ii. Easier to use
        iii. Gyro mounted horizontally and spins up and dow
        iv. Mounted in space spinning freely while aircraft moves about the gyro
        v. Reset every 15 min in accordance to the magnetic compass
        vi. Remains constant, finds rate of turn and no northerly turning error
        vii. When the gyro upsets, fly straight until it erects itself using erecting motion
    f. Attitude indicator
        i. Spins horizontally while being mounted vertically
        ii. Gyro errors only happen when the gyro processing toward the inside of a turn due to centrifugal force
        iii. When gyro is tilted, it will alter the output of air from the veins to erect the instrument
    g. Turn and slip indicator
        i. Indicates rate and quality of turn
        ii. When the turn is not a coordinated turn, the ball of the indicator will move away from the center
        iii. Ball in the indicator is controlled by gravity and centrifugal forces
        iv. Needle is controlled by a gyro that is mounted horizontally and spins vertically
        v. Help the pilot indicate the rate of turn
        vi. Rate 1 turn → 2min to complete 360
    h. Slips and skids
        i. Try not to do skids
        ii. Slips help descend, therefore is sometimes allowed

i. Turn coordinator
    i. Same info as turn and slip indicator but also gives rate of roll
    ii. Both instruments not accurate when the ball isn't centered or past rate 1 turns
j.

Theory of flight

1. An object is at rest or maintains uniform motion, unless acted upon by an unbalanced external force
2. F = m*a
3. For every action, there is an equal and opposite reaction

Moment: M=F*d
Couple: Two parallel forces of the same magnitude acting in opposite directions and separated by distance

Definitions
- Airfoil
    - “Slice” of the wing, the shape of the wing
- Camber
    - Measure of the curvature of the airfoil
    - Mean camber line runs from LE to TE and has an equal distance between the upper and lower camber lines at all times
- Angle of incidence
    - The angle at which the wing is attached to the fuselage
    - Angle between chord and longitudinal axis on aircraft
- Relative airflow
    - Airflow over the wing. Parallel to the aircraft’s flight path
- Angle of attack
    - Angle between angle of incidence and relative airflow
- Center of pressure (COP)
    - Average of pressure on the airfoil
    - Moves forward when angle of attack increases
- Dead load
    - Weight on ground or smth
- Live load
    - Weight + loads like Gs and stuff

Bernoulli’s principle
Speed = decrease in pressure
Slow = increase in pressure
Upper is faster and lower is slower which means lower has higher pressure
Difference in pressure causes wing to move upward

Drag
Parasite
- Skin
    - Unsmoothness of the skin
- Form

    - Shape of aircraft (if the aircraft is shaped like a wall, there's more drag)

Induced
- Caused by things like lift
- Reduces with airspeed and increase in wing aspect ratio

Wing tip vortices
- Air on top of wing flows inward
- Air at bottom of wing flows outward

Load factor → n = *L/W*
N = 1 when in straight and level flight
N increases when performing maneuvers, gusts of wind, turbulence

Increased load factors require more lift
When critical angle of attack is exceeded, stall happens

Vertical lift causes aircraft to fly or climb, horizontal lift allows aircraft to turn
Centripetal force pulls into the aircraft's turn and its a genuine force
Centrifugal force pushes away from the aircrafts turn and is a fictitious force

Flutter
When at high speeds, if even slightly disturbed, the aircraft may vibrate and shutter. Control surfaces must be balanced to prevent flutter

Roll from yaw
When yawing right, the left wing goes faster, increasing lift so your right wing dips down
Adverse yaw
When you roll, the wing going down has more lift, but also gains more induced drag while the upper wing does the opposite, having the bottom wing travel slower while the upper wing travels faster, causing yaw.

Stability
Ability to go back to its original position after being disturbed

Pitch stability affected by horizontal stabilizer and C.O.G
Roll stability created by dihedral, keel effect and sweep
Yaw stability affected by vertical stabilizer size and position, sweep → aircraft is traveling, however, oriented diagonally, wing with more air going over it causes more drag, pulling it back and stabilizing the aircraft yaw wise (sweep)

Boundary layer: thin sheet of air over a wing
Laminar Flow: smooth flow over the wing
Turbulent Flow: non-smooth flow over the wing
Transition Point: location where airflow changes from laminar to turbulent
Separation Point: location where the airflow separates from the wing

COP moves forward as angle of attack increases. When a stall happens, COP moves backwards rapidly. Constant movement of COP causes instability.

COG too far forward, stall speed increases, COG too far aft, stall speed decreases
Weight: more lift
Turns: portion of lift used so need more lift
Turbulence: sudden changes to angle of attack and relative airflow
Wing contamination can decrease lift
Slip stream
Since propellor moving clockwise, air is going clockwise too, wraps around aircraft and pushes the fin, causing a slight yaw to the left

Air Law
15kt+ the air sock is horizontal
6kt 30 degrees below horizon
Fluttering: gusty
Indicates direction of wind

Definitions
Visibility
Ceiling
- Lowest height at which a broken or overcast condition exists or vertical visibility when bad weather like fog or snow

Flight visibility
Ground visibility
Clearance
Instruction

MAATE required instruments
(Magnetic compass, altimeter, airspeed indicator, tachometer [engine RPM measurer], Engine gauges, oil pressure, oil temp, fuel indicator, suction, manifold pressure)

Flight plan
Filed with ATC or FIC, provides cross country flight information, SAR notified after one hour overdue
Flight itinerary
Less formal, filed with a responsible person (Mom, friend)
SAR notified 24 hours after overdue

Right of way
More maneuverable = lower on the right of way
To overtake, must overtake on right side

1000’ from tallest structure vertically and 2000’ from any building horizontally
Rural areas: not 500’ from any building, car or person

Day VFR +30 min of reserve fuel
Night VFR + 45 min of reserve fuel
IFR + 45 min of reserve fuel

Class A
IFR Only, Class C Transponder, 18000’ ASL → 60000’ ASL, 2way
Class B
IFR and controlled VFR, Class C Transponder, 12500’ ASL → 17999’ ASL, 2way
Class C
IFR and VFR with clearance, Class C Transponder, Often around Airport, 0’ ASL to specific altitude, 2way
Class D
IFR and VFR with radio contact, Class C Transponder, oft around airport, 0’ ASL to specific altitude, 2way
Class E
IFR and VFR, used when not meeting class a b c and d but need controlled airspace. 2200 ft AGL to 12500 ft ASL
Class F
Unsafe and restricted CYA and CYR
Class G
Military and restricted (class ground)

Required documents on your aircraft
AROWJIL
Airworthiness, registration, POH, Weight & balance, Journey log, Insurance, Licenses

Flights longer than 30 min above 10k ft AGL require supplemental oxygen

Decoding METARS
Airport Identifier (ICAO Code)
Date and Time is in UTC (Zulu)
→ 201400Z -- 20th day of the month, 1400h zulu time
Surface winds
- 3 Digits represent true degrees
- 2 digits represent wind speed
- G with another 2 digits indicate gusty with the gust speed
- 00000KT 000 degrees T at 00 KT

Visibility
- 2 ½ → 2.5 statute miles of visibility

RVR Visibility 1 SM or less
- R36L/4000FT/D → Runway 36 Left has 4000 ft of visibility and decreasing

Intensity
- “-” indicates light
- “ ” indicates moderate
- “+” indicates heavy

METARS Weather
DESCRIPTORS:
SH → Showers
BL → Blowing
MI → Shallow
PR → Partial
FZ → Freezing
DR → Low Drifting
BC → Patches
PRECIPITATIONS:
TS → Thunderstorm
RA → Rain
DZ → Drizzle
IC → Ice Crystals
PL → Ice Pellets
SN → Snow
SG → Snow Grains
GR → Hail
GS → Snow Pellets
UP → Unknown Precipitation
OBSCURING PHENOMENONS:
HZ → Haze
SA → Sand
DU → Dust
FU → Smoke
FG → Fog
BR → Mist
VA → Volcanic Ash
+FC → Tornado or Water Sprout
FC → Funnel Cloud
SS → Sand Storm
+SS → Bigger Sand Storm
DS → Dust Storm
+DS → Bigger Dust Storm
SQ → Squalls

Clouds
CLR/SKC → 0/8 Cloud Coverage
FEW → 1-2/8 Cloud Coverage
SCT → 3-4/8 Cloud Coverage
BKN → 5-7/8 Cloud Coverage
OVC → 8/8 Cloud Coverage

Temp

KMIA 220853Z 13003KT 10SM FEW030 SCT060 23/16 A3010 RMK AO2 SLP194
Miami international airport
22nd day of the month at 853h UTC/Zulu
130 degrees 3 Knots of wind
10 statute miles of visibility
Few cloud coverage at 3000' AGL, scattered cloud coverage at 6000' AGL

Altimeter set at 30.1' Hg
RMK → Automated observation with discrimination, sea level pressure 109.4mbn

KDSM 220854Z 33007KT 10SM BKN021 OVC027 M04/M07 A3032 RMK AO2 SLP278
Des Moines International Airport
22nd day of the month at 854 zulu time
330 7 knots of wind
10 Statute miles of visibility
Broken cloud coverage at 2100 AGL
Overcast and 2700 AGL
Temperature 4 degree, dewpoint 7 degrees
- LN_Module-5a-Meteorology
- LN_Module-5b-Meteorology

Pelesys Theory of Flight

Bernoulli's Theorem:

$$P + (1/2\rho V^2) = \text{Constant}$$

or simplified

static pressure + dynamic pressure = Constant

- ***Air in motion will gain dynamic pressure, and more importantly, lose static pressure.***

The shape of the wing is designed to take advantage of another physics principle.

Law of Continuity

Area x Velocity = Constant

- If the area a fluid or gas flows through is restricted, its velocity will increase.
- The combination of the Law of Continuity and Bernouilli's Principle is commonly referred to as the "Venturi Effect"

1. Inertia

Objects in motion stay in motion; objects at rest stay at rest.

2. F = ma

A force must be applied to alter motion, the degree to which it changes depends on the force applied.

3. F = - F

For every action there is an equal and opposite reaction.

Let's learn some basic aerofoil terms.

- **Chord Line**
  - A line drawn from leading edge to trailing edge of a wing.
- **Camber**
  - The cross-sectional area of the wing. Divided into upper camber (above chord) and lower camber (below chord).
- **Relative Airflow**
  - Airflow that is always parallel to and opposite the direction of flight.
- **Angle of Attack**
  - The angle between the Chord Line of the wing and the relative airflow.
- **Stagnation Point**
  - The point where the airflow separates at the leading edge to either go above or below the wing.

FRICTION

Wet & Dry

- Wet is when something is in between two parts, dry is friction
- Friction → Resistance to movement between any two objects placed in contact with each other. There must be some movement to generate friction.
- Amount of friction depends on the pressure and the composition of the parts and relative movement of the parts
- Note → It is impossible to completely eliminate all friction. As friction is energy, we can however convert it to another form.
- The ICE is classified as a wet friction machine as it has an oil system built in to itself to provide lubrication to reduce friction to an acceptable level

OIL ADDITIVES

- The engines of today require more technical blend of chemicals
- Manufacturer's recommended engine oils that have additional additives to them.
- Direct result of engines having higher compression ratios.
    - Pour point depressants keep the oil from solidifying
    - Detergent dispersant additives used to prevent sludge and varnish formations, resulting in valves and tappets sticking
    - Foam inhibitors are designed to prevent foam
    - Oxidation inhibitors are used to prevent the possibility of the oil being oxidized
    - Viscosity index improver which help the oil flow at its specific temperature range
        - VISCOSITY IS THE RESISTANCE OF OIL TO FLOW
    - Corrosion and rust inhibitors are designed to help detergent prevent rust and corrosion from forming
    - Anti wear additives are the most important additives in the oil mixture as it has the ability to coat all the contacted parts with a strong and slippery film.

PROPERTIES OF ENGINE OIL

- Engine oil is available in different viscosities
    - Viscosity is considered to be the internal friction of a fluid
- An oil with a low viscosity will flow more easily
- Oils of different mixed oils have been assigned by numbers by the society of automotive engineers or the SAE
- There are single and multi viscosity oils. Single viscosity oils are used where the temperature is consistent. Multi viscosity oils are used where there are seasonal changes or extreme temperature differences within 24 hours.

AVIATION EXAM MAR 29th

<u>EO M431.01</u>

- Parts of the wing
    - Chord
        - Imaginary straight line connecting LE to TE
    - Mean Camber Line
        - Average curved line connecting LE to TE
        - Same distance between the upper camber and lower camber
- Types of airfoils
    - Conventional
        - Thick quarter chord (Front part) 25%
        - Stalls less violently
    - Laminar Flow
        - Faster moving aircraft
        - Moves transition point back, small to thick to small
        - Maximum chord occurs at around 50%
- Planforms
    - Elliptical
    - Delta/sweptback
    - Rectangular
    - Aspect Ratio
        - Length:Width
        - High Aspect Ratio = More lift and weak
        - Low Aspect Ratio = Little lift and strong
- Key terms
    - Angle of incidence
        - Angle the wing is **permanently** to the longitudinal axis
        - Affects takeoff and land as well as stall factors
    - Wash in & Wash out
        - Washout wings have a higher angle of incidence at WR and lower at WT
        - Vice versa
- Wingtip Designs
    - Tip fuel tanks
        - More fuel
    - Winglets
        - Reduces drag resulted from vortices
    - Drooping wing tips
        - Reduce induced drag
- Wing fences
    - Control the direction of airflow over the wing
    - Improves low speed and stall characteristics
- Slats, slots and LE Flaps
    - Things that move in and out from the wing, increases surface area to create more lift
- Flaps
    - Increases camber and wing surface area
    - Generates more lift
        - More camber = more lift = slower stall speed
        - More camber = more lift = more induced drag
    - Slow speed
        - Faster takeoff and better landing
    - Flaps increase lift and drag
- Spoilers

- Used to slow down and land, helps with braking at high speeds
- Dive brakes
    - Creates drag
    - Not a lot of effect on lift
    - Allow aircraft to slow without reducing thrust
    - On gliders

<u>EO M431.02</u>

- Systems
    - Pitot
        - Measures by pitot tube and measures the air going against the plane when flying
    - Static
        - Atmospheric pressure outside the aircraft
        - Not affected by plane’s speed or rotation
- Errors
    - Blockage
        - Ice builds up around pitot tube, making instruments look like 0
- Air speeds
    - IAS
        - Airspeed indicated by instrument
    - CAS
        - IAS after corrected for position and lag errors
    - EAS
        - Corrected for compressibility error
            - Happens when air gets compressed in the pitot tube, making it look faster
            - Important for high speed aircrafts
    - TAS
        - True airspeed relative to the ground
        - EAS after corrected for air density error
- Instruments
    - ASI
        - Measures speed by finding difference between pitot and static pressure
        - Density error
            - Higher altitude → Reduced temp and pressure → Lower speed reading
            - Calibrated at sea level pressure (29.92mmHg) and temp at 15
        - Positioning error
            - When the plane is tilted or falling, the air doesn't go straight into the pitot tube, it can also be fed into the static port
        - Lag error
            - Delay caused by friction
        - Icing error
            - Blockage on pitot port
        - Water error
            - Caused when water enters pitot system
    - Altimeter
        - Measures height from ground using static pressure (static pressure changes the higher you go)
        - Reading
            - Shortest = 1,000ft, longest = 10,000ft, medium = 100ft

                - Pressure error
                    - Pressure outside varies even at same altitude
                - Cold Temp
                    - Calibrated at 15C
                    - Colder temperature = Higher altimeter reading
        - VSI
            - Static port
                - Rate of change in static pressure
            - Lag
                - Yes lag
- Gyroscopic
    - Gyroscopic Inertia
        - Tendency for a rotating object to remain in the same plane of rotation
    - Precession
        - Change in orientation of a rotational axis
        - Basically if you spin the rod attached to the gyroscope the gyroscope will spin
    - Power sources
        - Vacuum
            - Venturi tube on outside of aircraft to suck in air
        - Electric
            - Electric motor
        - Engine driven
            - Vacuum pump powered by engine
    - Heading indicator
        - Basically a fancy compass
        - Precision Error
            - Friction causes gyroscope to drift
                - Must set degrees again every 15 min
        - Attitude indicator
            - Tells you your pitch
        - Turn and slip indicator
            - Tells you your role and the quality of your turn
                - If you're slipping, ball moves into the turn
                - If you're skidding, ball moves out of turn
                - Slips can be allowed for a better landing
- Angle of attack indicator
    - Certain plains have certain stall angles, when reach critical angle, the needle will be in the red
- Mach indicator
    - More fancy ASI measured in mach

<u>EO M432.01</u>

- Fuel system
    - Stores fuel for all phases of flight
    - Fuel tanks
    - Fuel selector valve
    - Fuel lines & filter
    - Fuel quantity gauge
    - Fuel primer
- Pressure fed system
    - A basic pump
    - Electric pumps for emergency

        - Pressure gauge & Pressure booster for startup
    - Gravity fed
        - Gravity
        - Bad bc cant go upside down
    - TYPES OF FUEL
        - Octane → Chemical with minimal boom
        - Heptane → Biggest explosion
        - Octane rating → Octane:Heptane
    - Carburetors
        - Fuel enters float valve into float chamber
        - Air enters filtered and sucks up some of the fuel, vaporizing it and making a 15:1 mix by weight
        - Rich mix
            - Higher power settings higher fuel consump
        - Lean mix
            - Lower power settings lower fuel consumption
        - Icing
            - -5 → 30 degrees and humid conditions = icing
    - Fuel injection
        - Two valves → Intake and exhaust
            - As camshaft spins, opens valves, lets in 15:1 mix, compress power exhaust opens exhaust valve piston pushes gasses out.

<u>EO M432.02</u>

- Propellor system
    - Blades are twisted to provide a better angle and taper, the hub has higher AOI
    - Thrust → Lift, torque → drag
    - Torque causes aircraft to roll bc of the air resistance
    - Coarse pitch → High pitch
    - Fine pitch → low pitch
- Pitch
    - Forward motion of a propellor measured in feet per revolution
    - Theoretical pitch
        - Perfect fluid made by propellor forward motion
    - Practical pitch
        - Distance covered by the propellor during one rotation
- Types of propellors
    - Fixed pitch
        - Blade angle is fixed and cannot be changed by the pilot
    - Variable pitch
        - The cooler one
        - Mechanical system
            - Connected to control
        - Hydraulic system
            - Pushed/pulled by hydraulics
        - Electric system
            - Electric motors
- Feathering & Reversing
    - Feathering
        - When one engine is damaged/turned off, at coarse-ist pitch and stops turning to prevent damage to engine
    - Reversing

        - Yes reversing to help brake (reverse thrust on jet)

<u>EO M437.01</u>

Longitude
    - Up down
    - Greenwich prime meridian when meridians are 0
- Latitude
    - Left right
    - Equator
- Time & Longitude
    - 24hrs = 360 degrees
    - 1hour = 15 longitude
    - 1min = 15 min of longitude
    - 1sec = 15 seconds of longitude
    - 1deg longitude = 4min
    - 1min of longitude = 4 seconds
    - 1sec of longitude = 1/15seconds
- Great circles and rhumb lines
    - Great circle is circle that cuts earth in **half**
    - Rhumb line is line that cuts each meridian at the same angle (shortest distance)
    - True north
        - Truest north (where earth spins)
    - Magnetic north
        - Earth's magnetic field causes magnetic north to be slightly off of true north
    - Course and heading
        - Course → direction intended to go
        - Heading → aircraft's direction rn

<u>EO M437.02</u>

- Earth's north and south poles are magnetic caused by earth's magnetic field
- Lines of force is the flow of force caused by magnetism
- Compass needle should point towards earth's magnetic north
- Components
    - Lubber line → Arrow of a compass, shows the aircraft's heading
    - Compass card → Helps with compass deviation
    - Compass bowl → The container the compass is in, made of brass to prevent deviation
    - Pivot → Axis
    - Magnetic needle → neeeedle
    - Liquid
        - Lubricates the pivot
        - Alcohol/kerosene for low freezing temp and clearness
- True & magnetic north variations
    - Maps are based on true north
    - Compass points to magnetic north
    - Variation is the angle in degrees between the true and magnetic north
    - Agonic lines → Joins places of zero variation
    - Isogonic lines → Joins places of equal variation
    - Maps have charts to help pilots convert true to magnetic headings
- Errors
    - Deviation → Cockpit made of metal make compass point weird
        - Compass card helps pilot convert this

- Magnetic dip → When you go towards magnetic pole, compass begins to point down, friction causes the compass to be weird
- Northerly turning error
    - Turn towards south you lag
    - Turn away from south you lead
- Acceleration & Deceleration
    - Accel = compass tips back, turning towards north
    - Decel = compass tips forward, turning towards south

<u>EO M437.02???</u>

- Types of projections
    - Lambert conformal conic projection
        - Slices one part of the globe, flattens it and puts it on a map, distance is consistent
        - VNC & World Aeronautical charts are examples
    - Mercator Transverse projection
        - Accurate scaling
        - Used in VFR Terminal areas (VTA)
- VNC vs WAC
    - VNC is used lower altitudes
        - 1:500000
    - WAC is used higher altitudes
        - 1:1000000
- VTA
    - Used for airports with high volume of air traffic, has radio communication and other information for flying through the region
    - 1:250000
- Enroute chart
    - Just information, no cities or anything

Electrical Power Generation

- Generator Power Output
    - Battery 12.6V if fully charged
    - When engine turning → Needle should be ~ 14.3V
    - 10.5V = Death of Electronics
    - Past 14.5V = Overcharge battery → Explode

Weather

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Exam Review
History of flight ; Balloons, Kites, Hot air, Hot Gases
Wright brothers - Dates, design issues, tech problems, major design issue
Fundamentals of flight - axes, wing angles, forces acting on the plane, control surfaces, flight controls
Wing Design - Shapes and design purpose, advantages/disadvantages
Wing Construction - All internal components, construction designs, truss design
Fuselage - All internal components, spars, bulk heads
Materials of construction - Composites, wood, paper
Spoilers/Air Brakes - Purpose and locations of components, designs and controls
ICE Engine - Four cycles, internal engine components ID and purpose, cooling system, lubrication system, ignition system, valve train, external engine parts, oil types and definitions
Weather - Cloud identification, precipitation descriptions, atmosphere ID, types of weather, wind descriptions
Landing Gear/Tires - purpose, types, designs, suspension designs, applications
Human factors

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