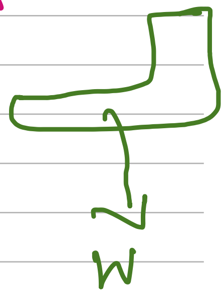
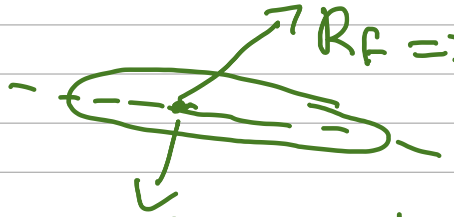
Clo 3. Theory of flight

Weight and lift

CG – center of gravity ⇒ in front of cp

W – weight of aircraft





* AoA change, also cp will change
* AoA ↑, Lift ↑, Drag ↑
* (AoA ↑ max, Lift reduce rapidly
  to the stalling point)
* Another factors that control Lift:

1. speed 2. AoA 3. Density of air 4. wing Area
   - ↳ pressure
   - ↳ Temp
   - ↳ humidity

Lift :

paragraph 3. explination

* if the aircraft move upward, AoA ↑,
  Lift ↑, speed ↑
* if the aircraft move downward, AoA ↓,

Lift ↓ , speed ↓.

* if the aircraft slow, V ↓, AoA ↑ to maintain lift

* warm humidity: less dense ↓ L ↓
  Dry humidity: high density ↑ L ↑

how the pilot control the density of air??

* by changing the altitude.

* Lift and Drag $\propto$ with density of air
* Density affected by: pressure, humidity and temperature
* warm air is less dense than cool air
* moist air is less dense than dry air
* which one is better when flying:
  cool air and dry air
* Aircraft must be flown in greater true airspeed for any given AoA than on cool dry day

* Density ↓, total lift = to total W to remain in flight

* Lift $\propto$ wing Area $\propto$ Drag

Thrust and drag :-

* thrust < the drag, aircraft travel more and more slowly
* if rpm of engine ↑, thrust become > drag, speed of aircraft ↑
* thrust > drag, the aircraft continuous to accelerate.
* when drag = thrust, aircraft flies at steady speed
  ثابتة
* when lift balance weight, and thrust balance drag, the aircraft in level flight never accelerating or slowing down.
* Thrust and drag ↑, AoA ↑ ∠ ↑.

Thrust = Drag
→ A/C still
→ A/C steady

in steady flight

T < D

Deceleration Thrust = Drag

L ↓ Lift fixed constant

T > D

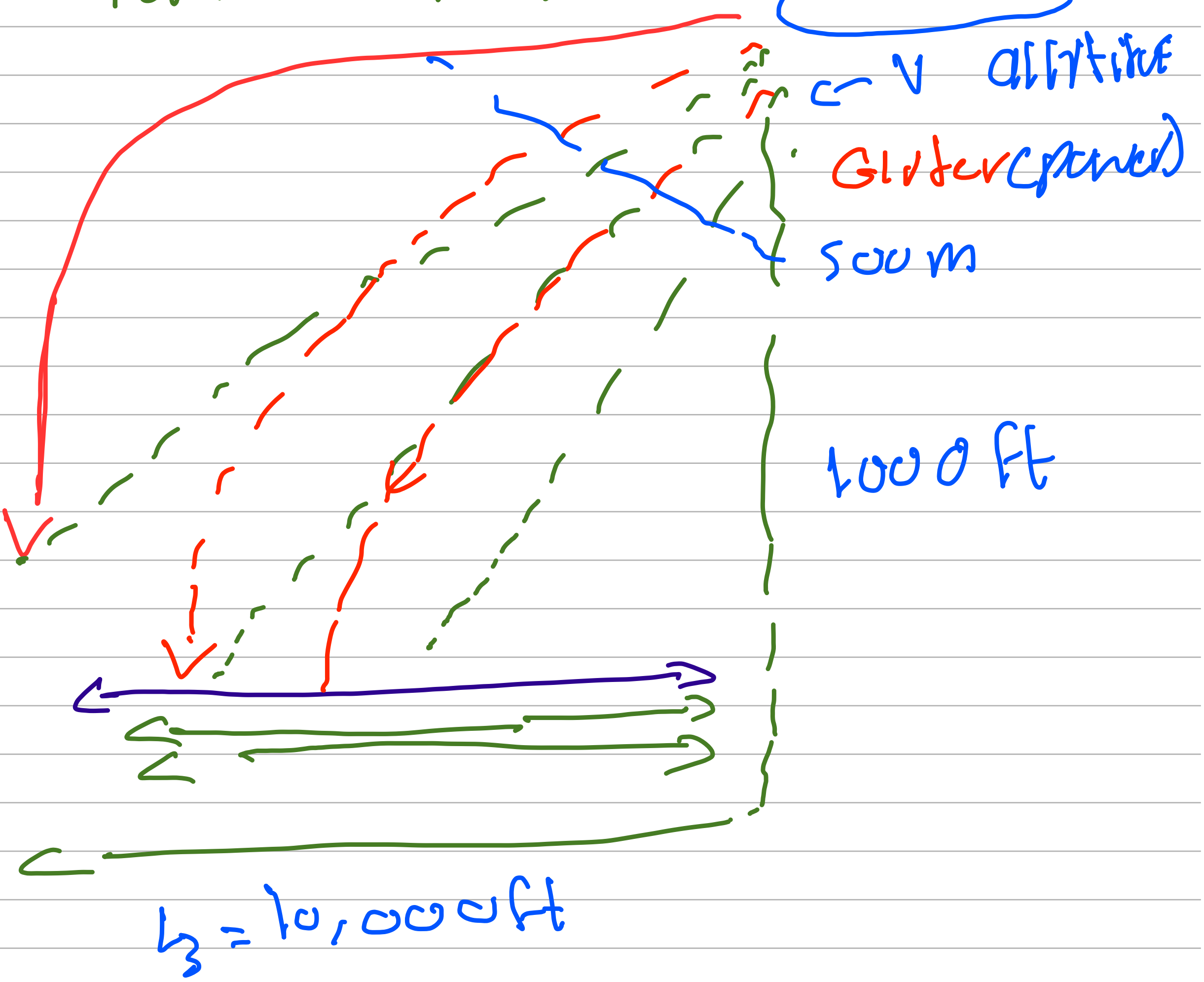
Acceleration L ↑

Glide Ratio :-

* distance moved forward / altitude it loses

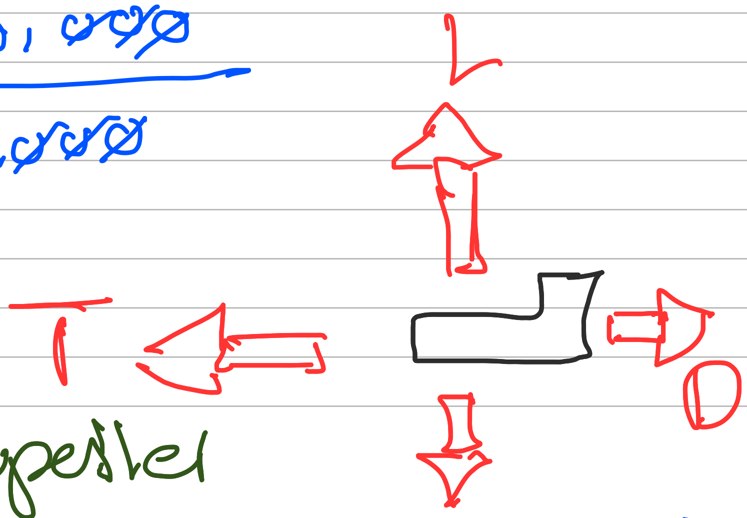
* Glide (without power)

* Glide ratio is proportional to the speed



Glider ratio = $\frac{10,000}{1000}$

10 : 1

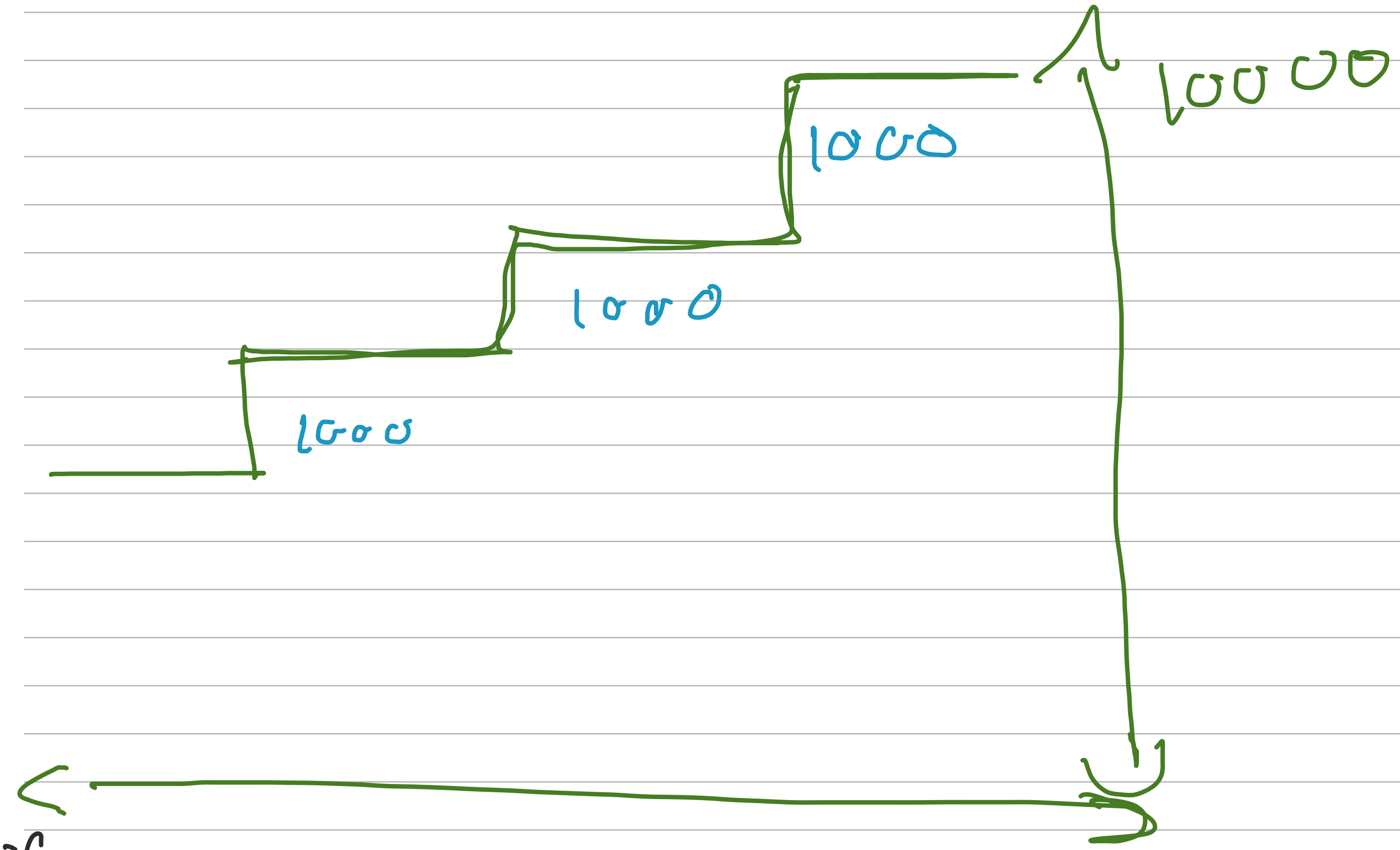


* wind milling propeller

(ω) → time

Equilibrium

Free rotation (?) was called windmilling propeller



if
$G/R = 10/1$

$100,000 \times 10 = 100,000$

if
$G/R = 70/1$

$100,000 \times 70 = 700,000$

if $G/R = 20/1$

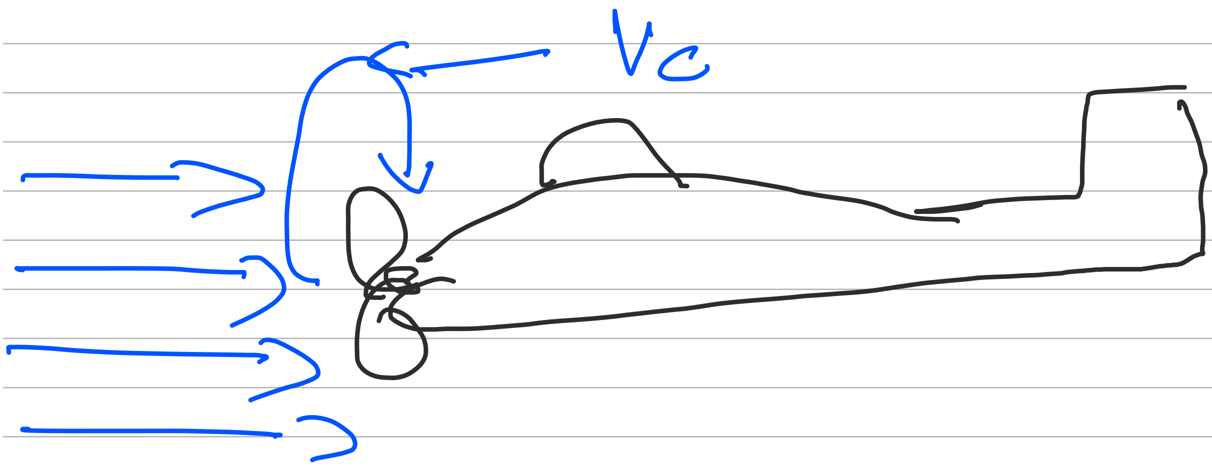
100,000 X 20 = 2000,000

Drag factor :

1. L/G flaps ↓G : R

2. pitch Adjusment

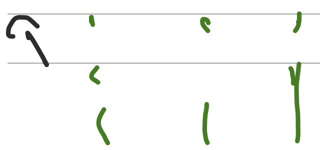
3. windmilling of propeller

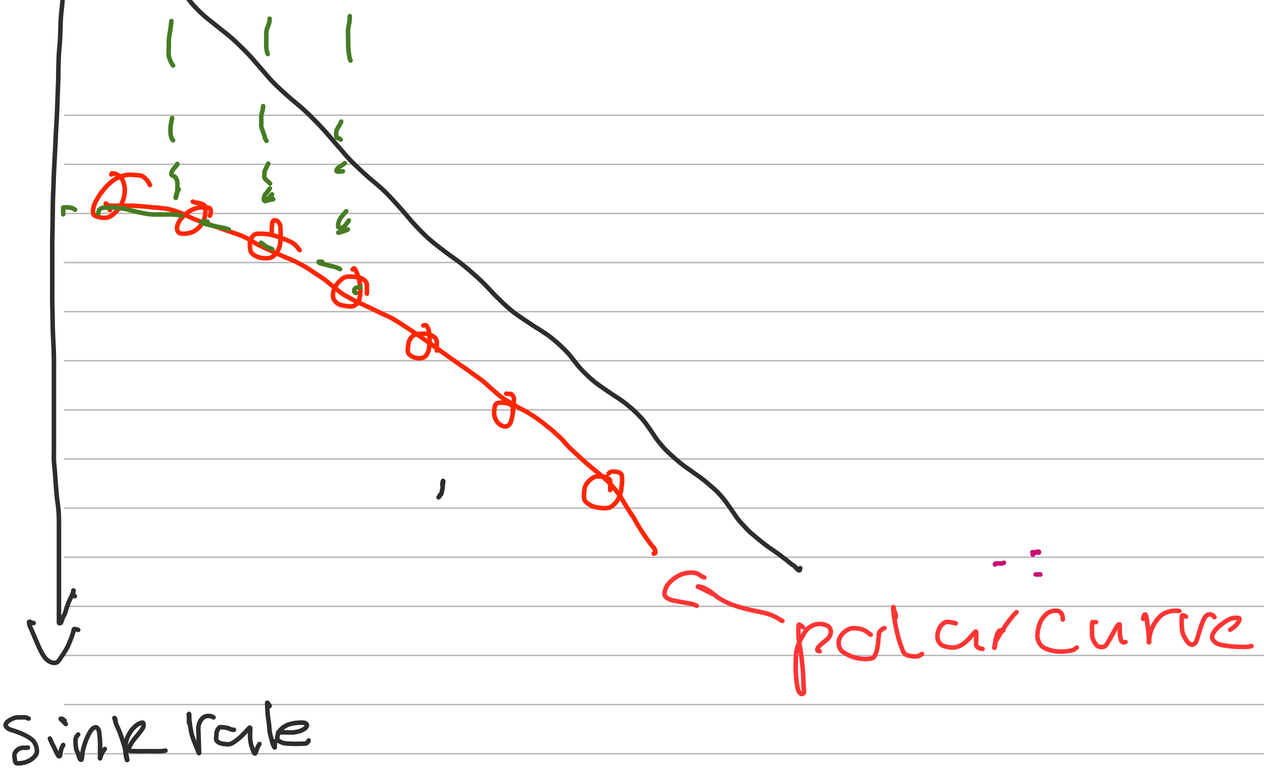


polar curve:

* is a graph which contrasts the sin rate of an aircraft with it horizontal → spe
→ air speed

400





* The key of measures of glider performance :

1. minimum sink rate
2. Air speed.

Aerodynamic force in turns :-

* figure 3-5

→ in level flight (Lift = weight

→ medium Banked
to increase the lift we should increase the AOA

increase speed.

→ steeply banked

important : CF / CP

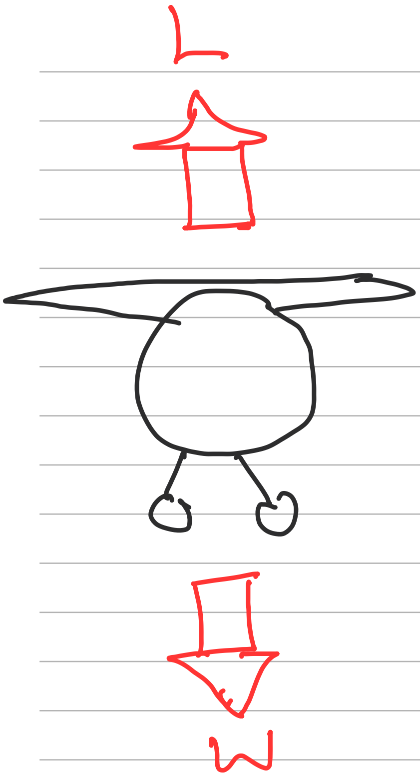
* The force of lift is speraled into two components :

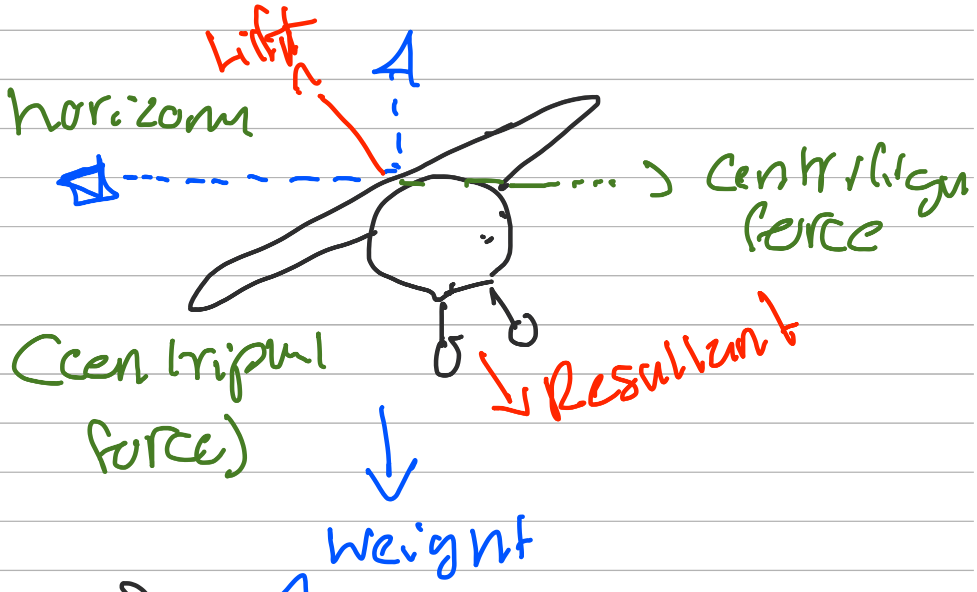
→ vertical component of lift (vertically and opposite to weight (gravity))

→ horizontal component of lift or centripetal force.

* each horizontally toward the center of turns.

* is the force that pulls the aircraft from straight flight path to make it turn.





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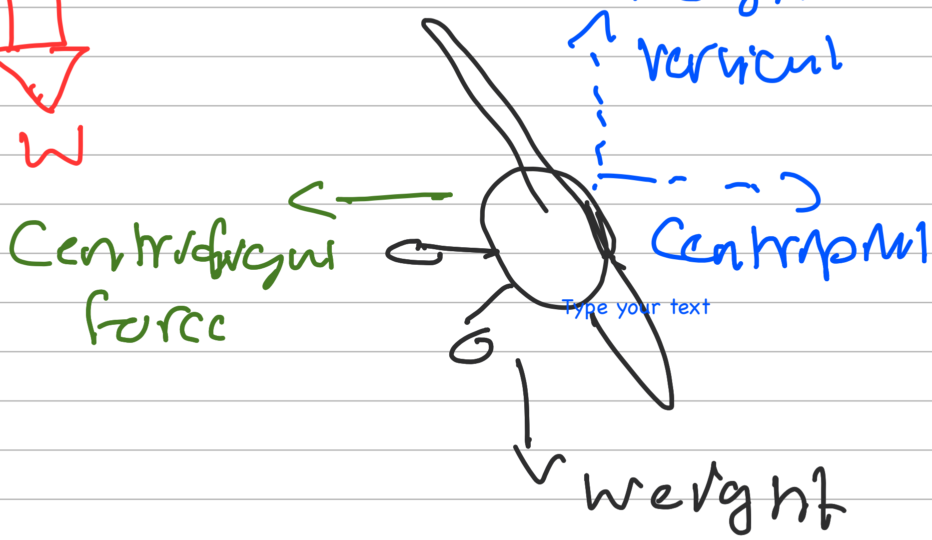
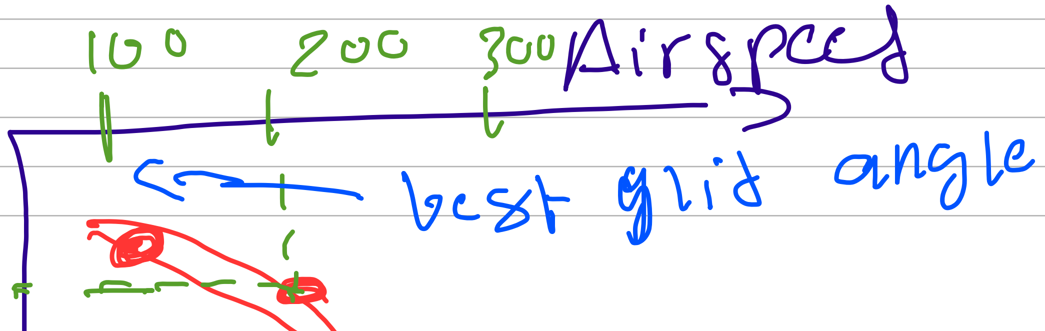
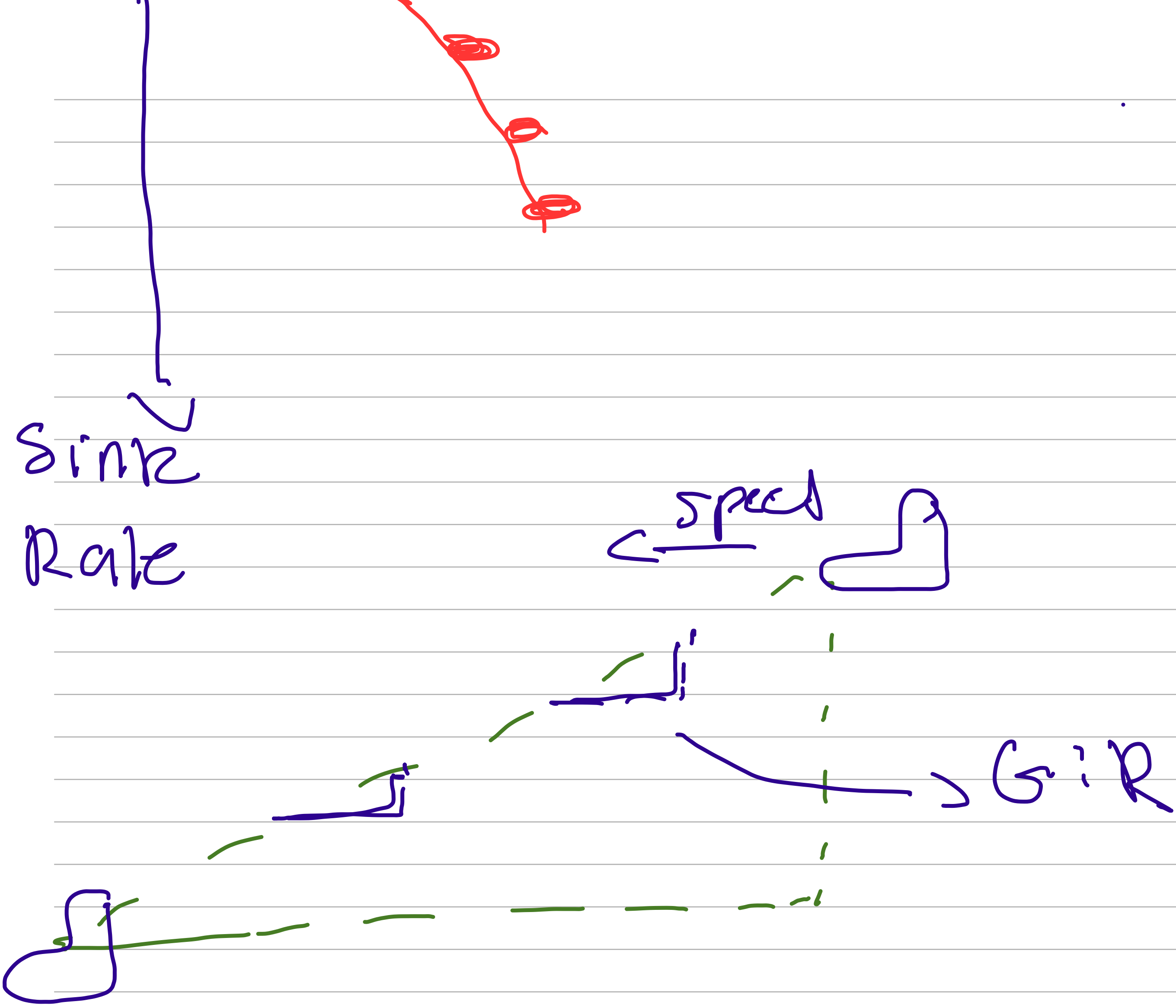


Explain the performance of a glide:

↳ sink rate minimum sink

↳ horizontal speed: best glide ratio





Glide speed

↑ ↑ Drag ↓ Distance

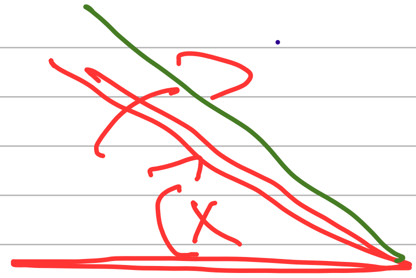
↓ ↓ Lift ↓ Distance

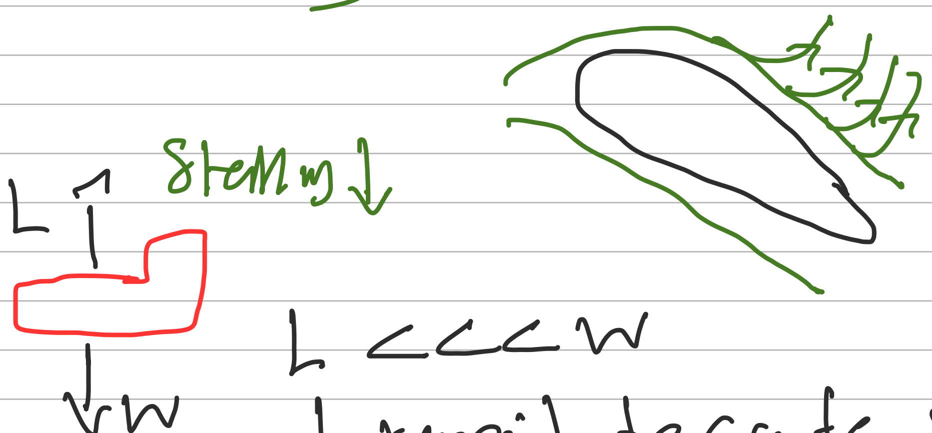
L/D

influnced of Load

Stall :

* rapid ↓ in lift caused by seperation of air flow.
* from wing surface brought on exceeding the "critical AoA"





L <<<< W

↓ rapid decade stall

1. Stalling of Aircraft

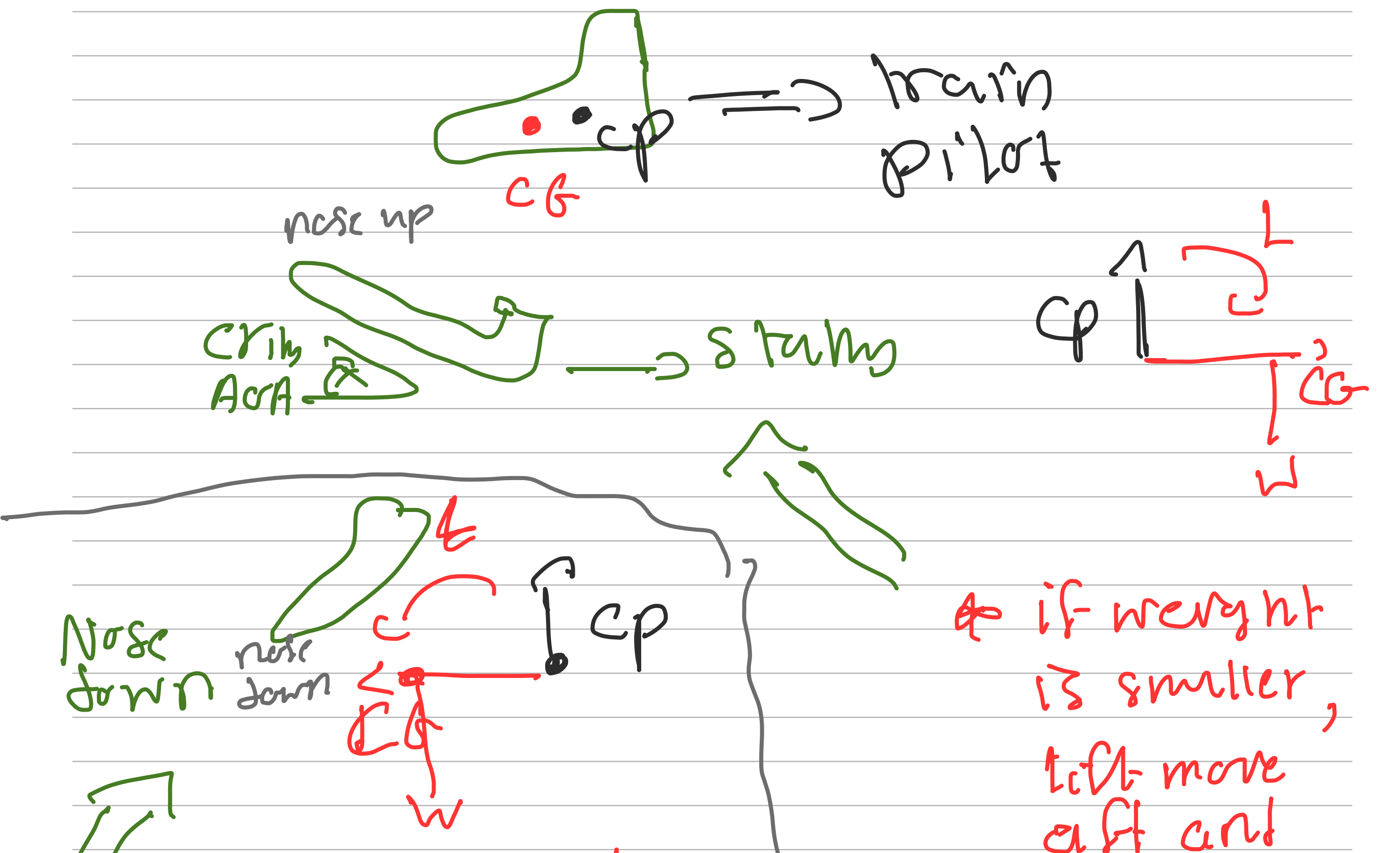
2. Critical AoA

3. Coefficient of lift (CL) CL ↑ AoA ↑

direct proportion

until CL max

4. post



* if W greater left will turn and nose will move down

* if weight is smaller, left move aft and nose will move up

* Centripetal force

* centrifugal force 

Flight Envelope :

1. Load factor
2. Acceleration of gravity (G)
3. factor of safety
4. gust load
5. critical mach number.

Category system :

1. normal
2. utility
3. acrobatic.

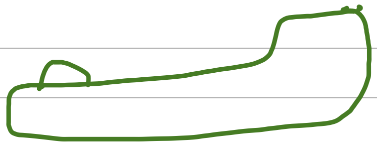
High speed flight

1. subsonic :

* The speed is less than speed of sound
* air is incompressible

* are negligible.

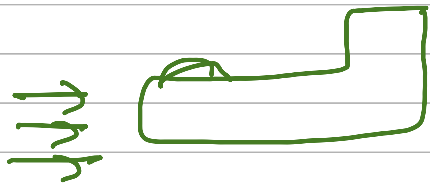
* incompressible
* non-viscous



subsonic

relative flow

* compressible
* viscous



supersonic

* speed above the speed of sound.

$V_1 > V_2$

$P_2 > P_1$ $= L\hat{}$

1.1 m

higher

0.7 1 m (supersonic)

0.8 m

0.77 m

(subsonic)

0.6 M also higher but less than the upper one.

0.8 m

Speed ranges:

- speed of sound varies with T

- in high speed flight and/or hight altitude flight, measurment of speed expressed in "Mach numberr".

Mach number Vs Airspeed

1 الصورة
upper ⇒ higher shear wave
below ⇒ lower shock wave

خطورة
dangrous

Shock waves:

[1] in subsonic speeds:

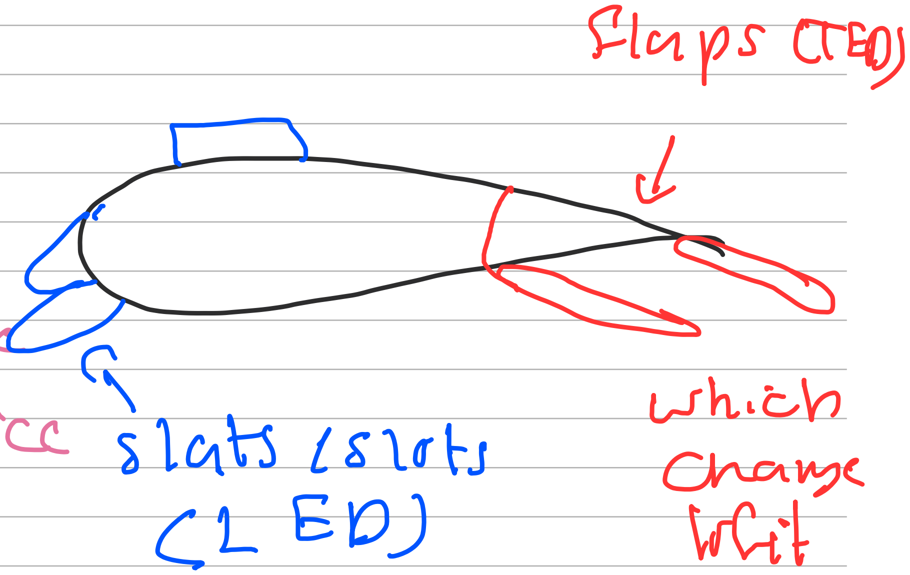
air ahead is 'warned'

to increase more thrust, we need more fuel.

Lift augmentation

is done by :

1. Leading edge
2. Trailing edge
3. Special device



Flaps :

1. high lift device
2. L and drag Both ↑
3. high cruising speed
   low landing speed
4. all Flaps increases the "cambers".

Types of Flaps :

plain, split, slotted and Flower Flaps

Plain :

1. Simplest types

2. airfoil camber ↑, results ↑ C_L,
in same time ↑ drag and more cp
aft on airfoil.
=> result : nose - down pitching moment

3. disadvantage :
=> ↑ drag => nose - down pitch

Split :

1. deflected from the lower surface of airfoil
2. produce slightly greater ↑ in L than plain
3. more drag is created, because :
Turbulent air pattern produced behind airfoil.
4. Both plain and split produce high drag with little additional L, when fully extended.

Slotted :

1. most popular

2. ↑ C_L more than plain and split

3. produces much greater ↑ in C_L-max than plain or split

4. Large aircraft often have Double and even triple slotted.

5. These allow the max ↑ in drag without the airflow over the flaps seperating
=> and destroying the L they produce.

flower 90

1. type of slotted flap

2. change the camber of wing

3. ↑ the wing area.

4. it is slides backward on tracks.

5. first portion of extension ;

⇒ ↑ drag very little, but

⇒ ↑ L agreat deal

⇒ as ↑ both area and camber

As extension continues;

flaps deflects downward.

last portion of travel;

flap ↑ drag with little additional

↑ in L.

Leading edge Devices

1. High-Lift Devices can be applied in leading edge

The most common type:

Fixed slots, moveable slots, leading edge, and cuffs

Fixed slot:

1. direct airflow to the upper wing surface and delay airflow separation at high AoA.

2. slot does not ↑ wing camber

3. allow higher max C_L, because stall is delayed until the wing reaches AoA.

⇒ Movable Slats
⇒ leading edge
⇒ cuffs

refers to the → Book and see the experimental page [3.16]

Fixed Airflow Devices

winglet

vortex

stall fence

gap seals

→ refer to the Book and see the explanation page 3.17 and 3.18