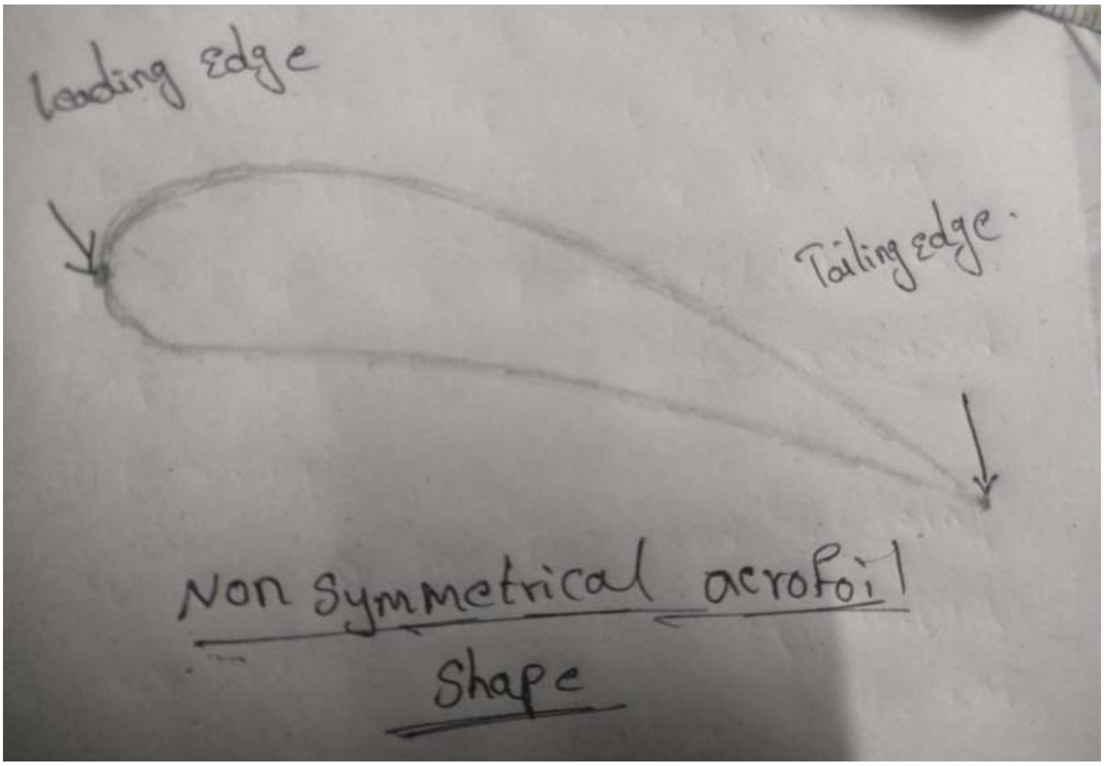
Question 1: Aerodynamics of Aerofoil

Aerofoil Shape Diagram

• Illustrate a typical aerofoil shape.

Answer:-

In the below image the aerofoil shape is asymmetric shape or it is also called as non - symmetrical
A non-symmetric airfoil also known as a positive cambered airfoil has an asymmetrical shape when viewed from the front.



NON -SYMMETRICAL IS THE TYPE I HAVE CONSIDERED

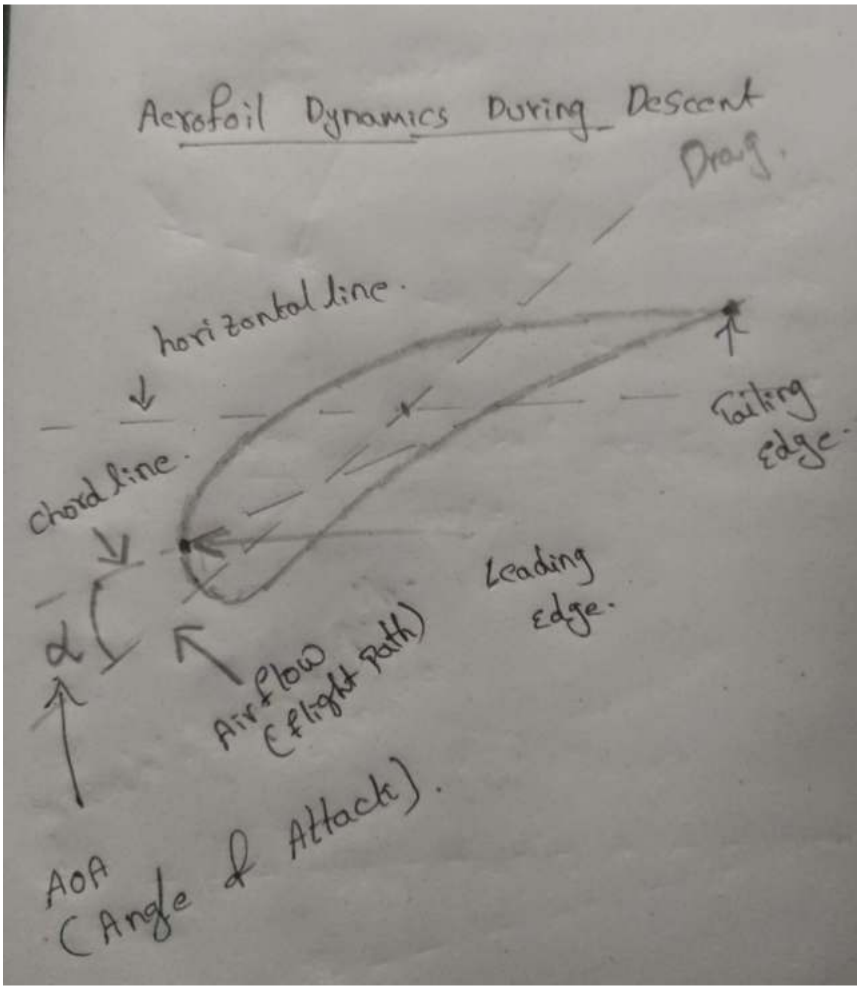
b) Aerofoil Dynamics During Descent

I have drawn the chord line using the references of relative wind and leading edge and trailing edge

2. Depict the relative airflow as if the aircraft is descending.

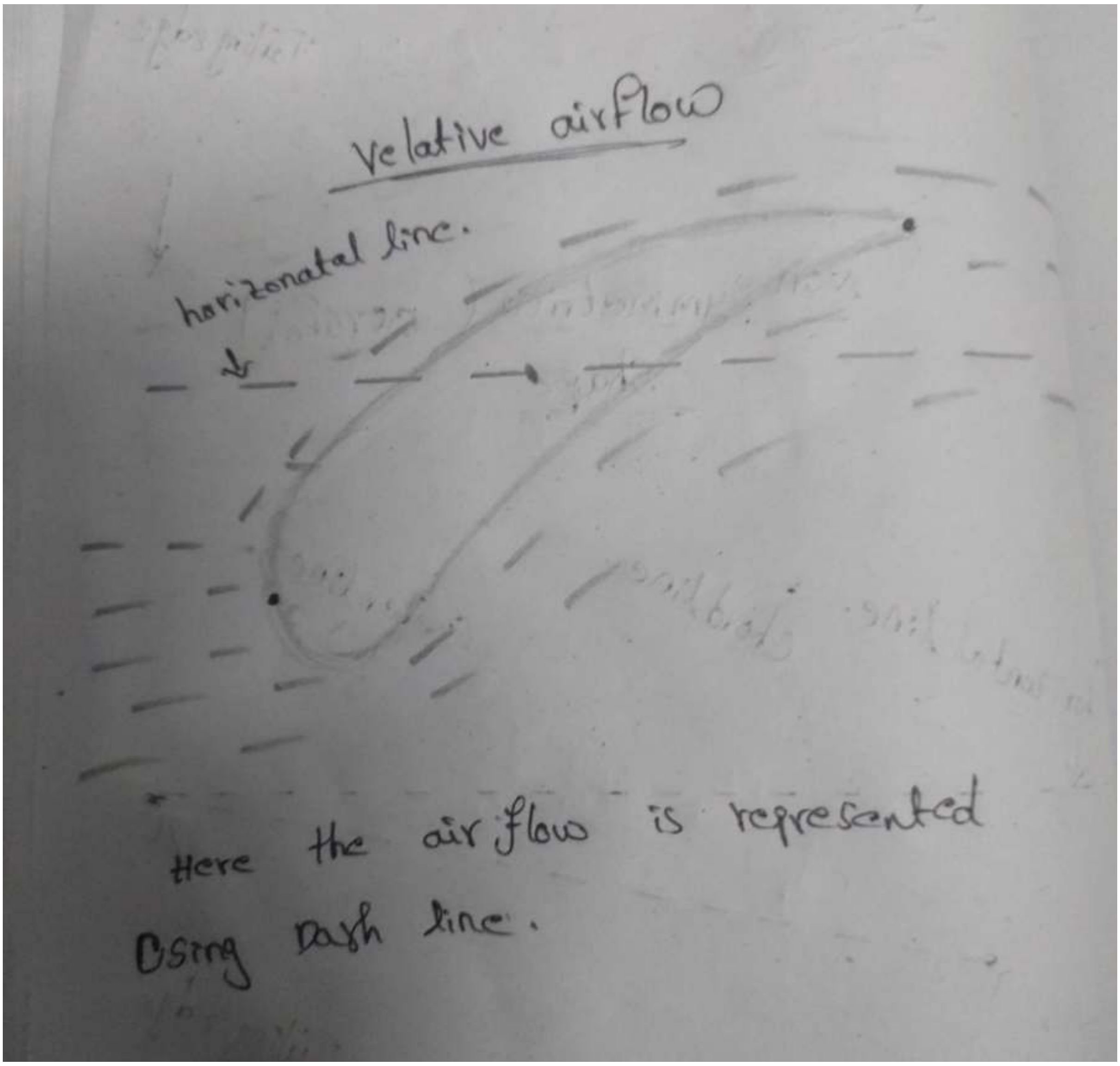
Answer :- if the aircraft is descending the relative airflow has a slightly upwards component compared to level flight

In below image we can see the flight is in decent level

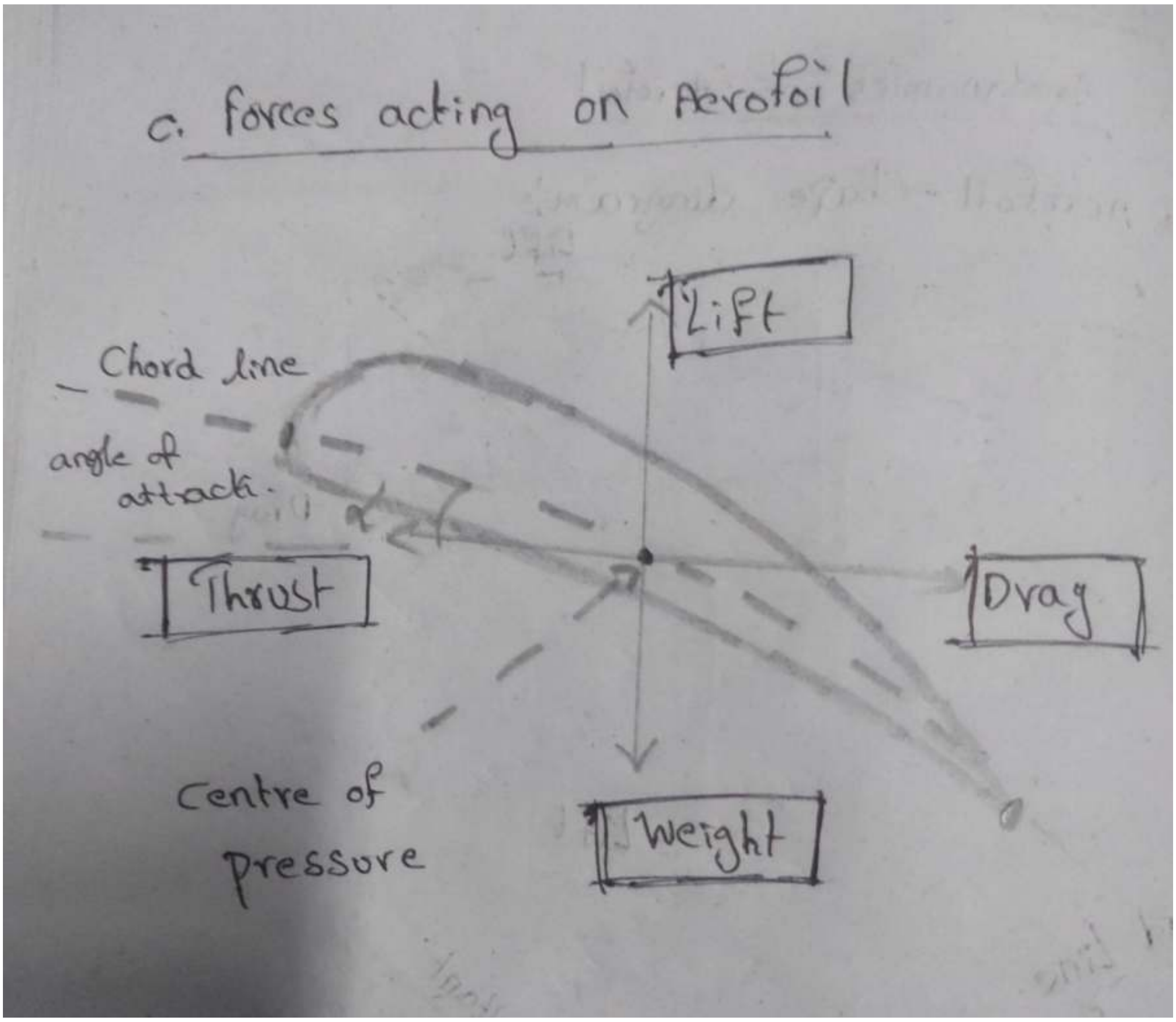


We can observer that flight path is forward and downward then the relative wind is backward and upward

If the flight path is forward and downward then the relative wind is backward and upward



Forces Acting on Aerofoil:



Question 2: Lift Equation and Aircraft Performance

a) Lift Equation Definition

Ans:- lift equation helps us understand how an aircraft generates lift.

Formula ➖ $L = \frac{1}{2}$ x $CL \times P \times A \times V2$

Here

L: Lift force generated by the wings

CL :-Coefficient of Lift a dimensionless number representing the efficiency of the wings in generating lift.

p: Air density is a measure of how tightly packed the air molecules are.

A: Wing area is the total surface area of the wings.

V: Velocity of the aircraft through the air.

b) Altitude Maintenance and Speed Variation:

1. Identify properties that must change to maintain altitude while altering speed.

Answer:- we have 5 properties that must change to maintain the altitude while altering the speed

These are that 5 properties

Angle of Attack : The angle at which the wings meet the oncoming air. Adjusting the angle of attack helps in balancing lift and maintaining altitude when altering speed.

Lift: Lift is the force that opposes gravity and keeps the aircraft in the air. To maintain altitude the lift generated by the wings must match the aircraft's weight. As speed changes the lift needs to be adjusted accordingly.

Thrust: The forward force provided by the engines. When altering speed thrust may need to be increased or decreased to balance with drag and maintain a stable flight.

Weight: The force exerted by gravity on the aircraft. To maintain altitude the lift generated must equal the weight of the aircraft. Adjustments may be needed if speed changes affect the balance.

Airspeed: The speed of the aircraft through the air. Changes in airspeed affect lift and drag. Pilots must manage these changes to maintain a stable flight.

2. Discuss the visual perception of the aircraft at slow and high speeds.

visual perception of the aircraft at slow

Using an example we will answer these question

Imagine the aircraft is in level flight stage then four forces will be as

Lift equals to weight (in order to prevent vertical acceleration

Thrust equals to drag (To maintain a constant forward speed)

Let assume that at level fight

1.if thrust is less than drag then these say that aircraft is at slow speed and these cause increase of angle of attack

If the angle of attack is greater than 18 degrees then it cause the stall and will not produce the lift

2. if lift is less than weight this causes flight to descent

If these 2 cases are happen then there's chances of slow speed in aircraft

1. Airfoil's Angle of Attack and Lift: This diagram would show an airfoil (cross-section of a wing) with the oncoming air and the angle it makes with the airfoil. This angle is the angle of attack. You could also show how lift is generated perpendicular to the oncoming air.
2. Flaps and Slats: This diagram would show a wing from the side with the flaps and slats in their retracted (normal) positions. Then show another diagram with the flaps and slats extended demonstrating how they increase the camber of the wing and thus change the angle of attack.

These are the 2 things that we will visualise

Visual Perception of Aircraft at Slow and High Speeds:

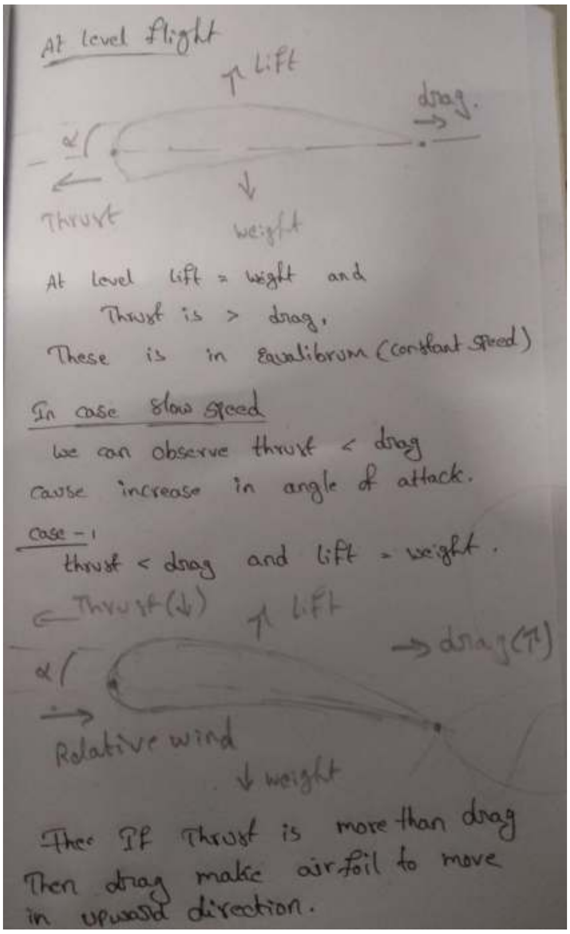
At Slow Speeds:

- Lift Generation: At low speeds the visual perception of the aircraft involves a noticeable increase in the angle of attack. Pilots adjust control surfaces to enhance lift as depicted by the upward arrow in the diagram. The wings work hard to generate sufficient lift to counteract the gravitational force (weight).
- Thrust Management: The horizontal arrow for thrust in the diagram indicates that at slow speeds the need for forward force is present but comparatively less than at high speeds. Pilots carefully manage thrust to maintain controlled movement.

- Balancing Forces: The diagram illustrates a delicate balance between lift   weight   thrust   and drag. The challenge at slow speeds is to manage these forces effectively to ensure stable flight and controlled descent or ascent.

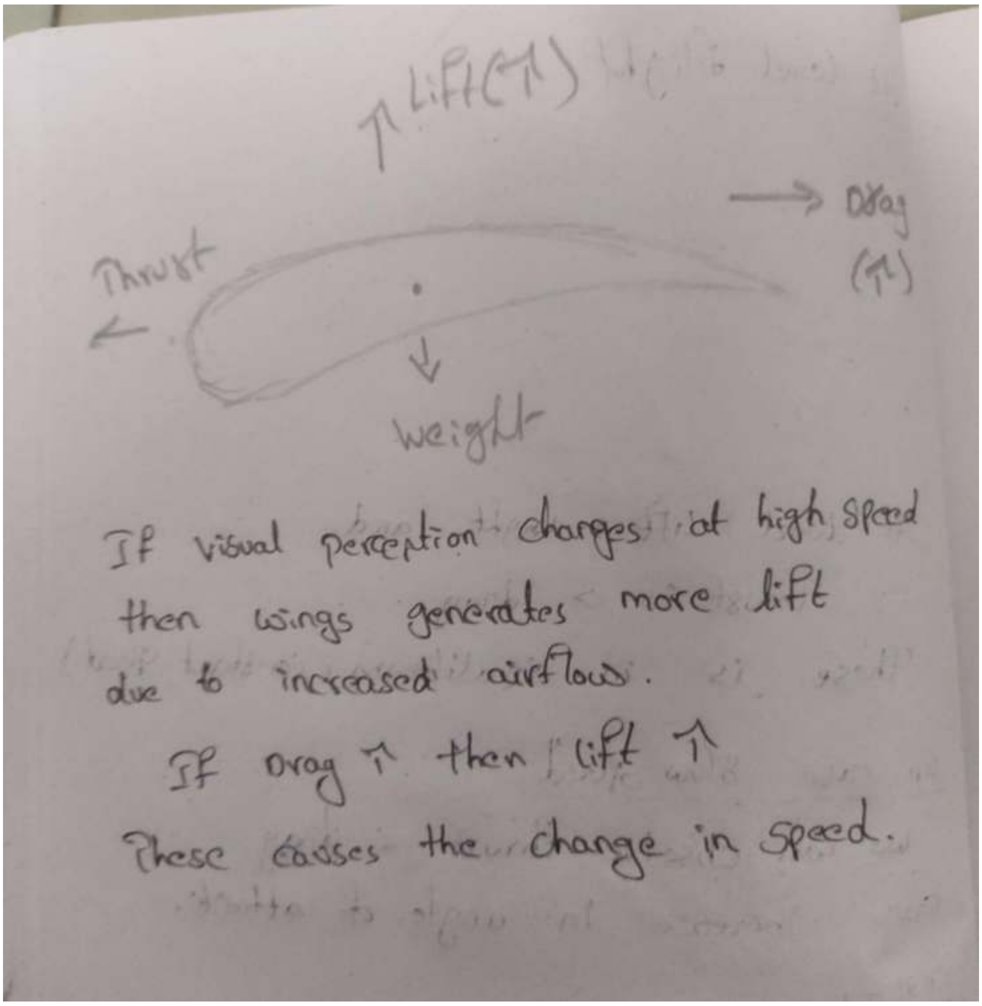
At High Speeds:

- Increased Lift and Drag: The visual perception changes at high speeds   with the wings generating more lift due to increased airflow. However   the higher speed also leads to an increase in drag   as shown by the opposing arrow in the diagram.
- Thrust Requirements: The horizontal arrow representing thrust highlights the need for a significant forward force to overcome the heightened drag and maintain or increase speed. Pilots



must manage engine thrust to achieve the desired velocity.
- *Conclusion:*

- In both scenarios the visual perception of the aircraft involves a careful consideration of aerodynamic forces. Whether at slow or high speeds pilots use their training and controls to maintain a delicate balance ensuring the aircraft's stability and controlled movement through the air.



C. High Lift Devices (Flaps) Impact:

Use diagrams to illustrate changes in the angle of attack with the deployment of flaps.

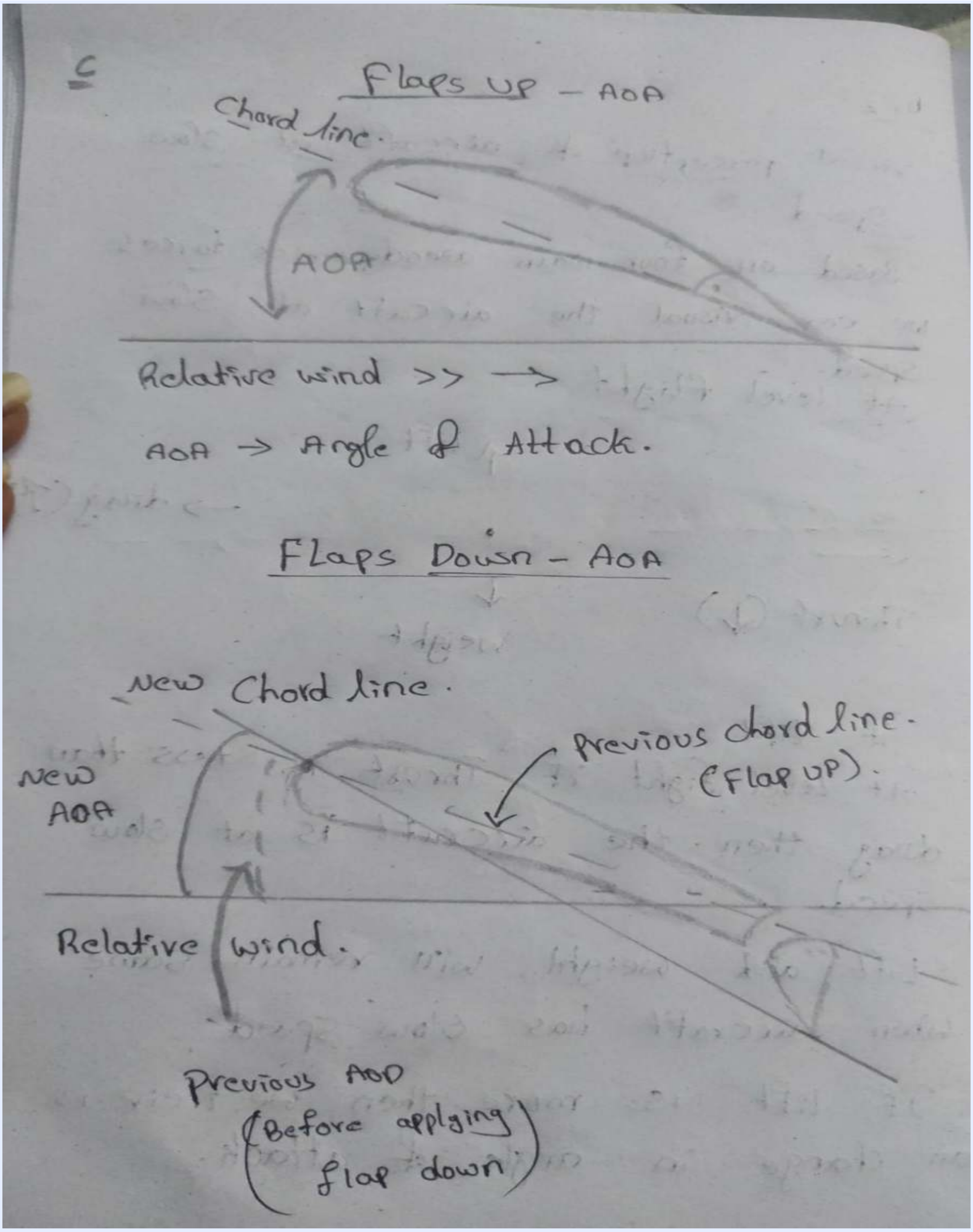
When the flaps are up   the chord line (the straight line from the leading edge to the trailing edge of the wing) is in its original position   and the AOA is measured relative to this line and the oncoming air (relative wind).

When the flaps are deployed (flaps down)   the trailing edge of the wing moves downwards and backwards. This movement effectively changes the position of the trailing edge   which in turn alters the chord line. The new chord line is longer than the original one   and it changes the AOA.

The new AOA (after applying flaps down) is larger than the previous AOA (before applying flaps down). This increased AOA allows the wing to generate more lift   which is particularly useful during takeoff and landing.

NOTE:-

it’s important to note that increasing the AOA also increases drag which is why flaps are retracted (flaps up) during normal flight to improve the aircraft’s aerodynamic efficiency.



d) Enhanced Lift with Fowler Flaps:

1. Making the wing surface larger :The deployment of Fowler flaps increases the overall surface area of the wing which results in more lift being generated.

2.Extending the wing backward and downward :- The movement of Fowler flaps when they are deployed. They move downwards and slide backwards changing the wing's properties.

3.Creating a longer wing chord :- The deployment of Fowler flaps changes the position of the wing's trailing edge which in turn alters the chord line. The new chord line is longer than the original one.

4.Changing the wing's shape or camber :- The downward movement of the Fowler flaps increases the wing's camber or curvature. A more curved wing generates greater lift.

5.Increasing the angle at which the wing meets the air :- This is another way of saying that the deployment of Fowler flaps increases the wing's angle of attack leading to increased lift.

6.Allowing the plane to fly at lower speeds without stalling : The increased lift generated by the deployment of Fowler flaps allows the aircraft to generate the necessary lift at lower speeds which is particularly useful during takeoff and landing.

Note:-

While changes increase lift they also increase drag which is why flaps are retracted during normal flight to improve the aircraft's aerodynamic efficiency.

Diagram for the Fowler flaps

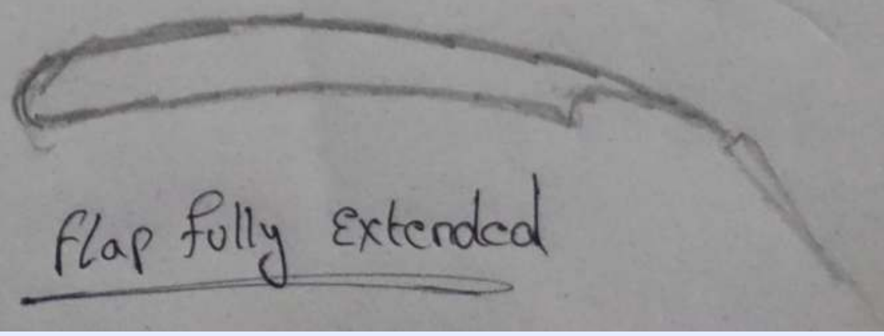
Fowler Flap

A split flap that slides backwards, before hinging downward, thereby increasing first chord. then camber. The flap may from form part of the upper surface of the wing, like plain flap, or it may not, like a split flap, but it must slide rearward before lowering.

A gap between the flap and the wing forces air from below the flap helping the airflow remain attached to the flap increasing lift.

Flap retracted.

Intermediate Position.



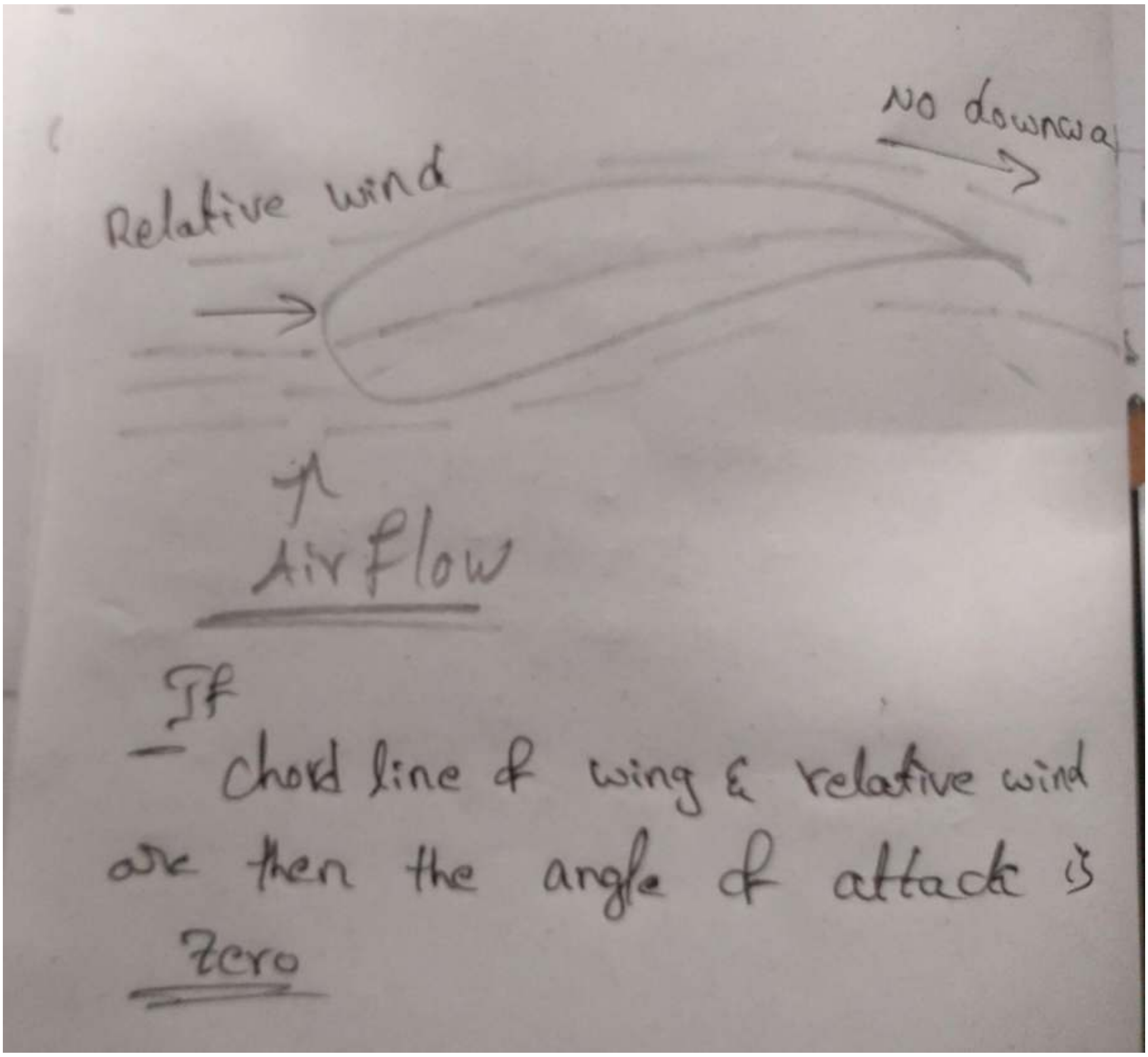
Flap fully Extended

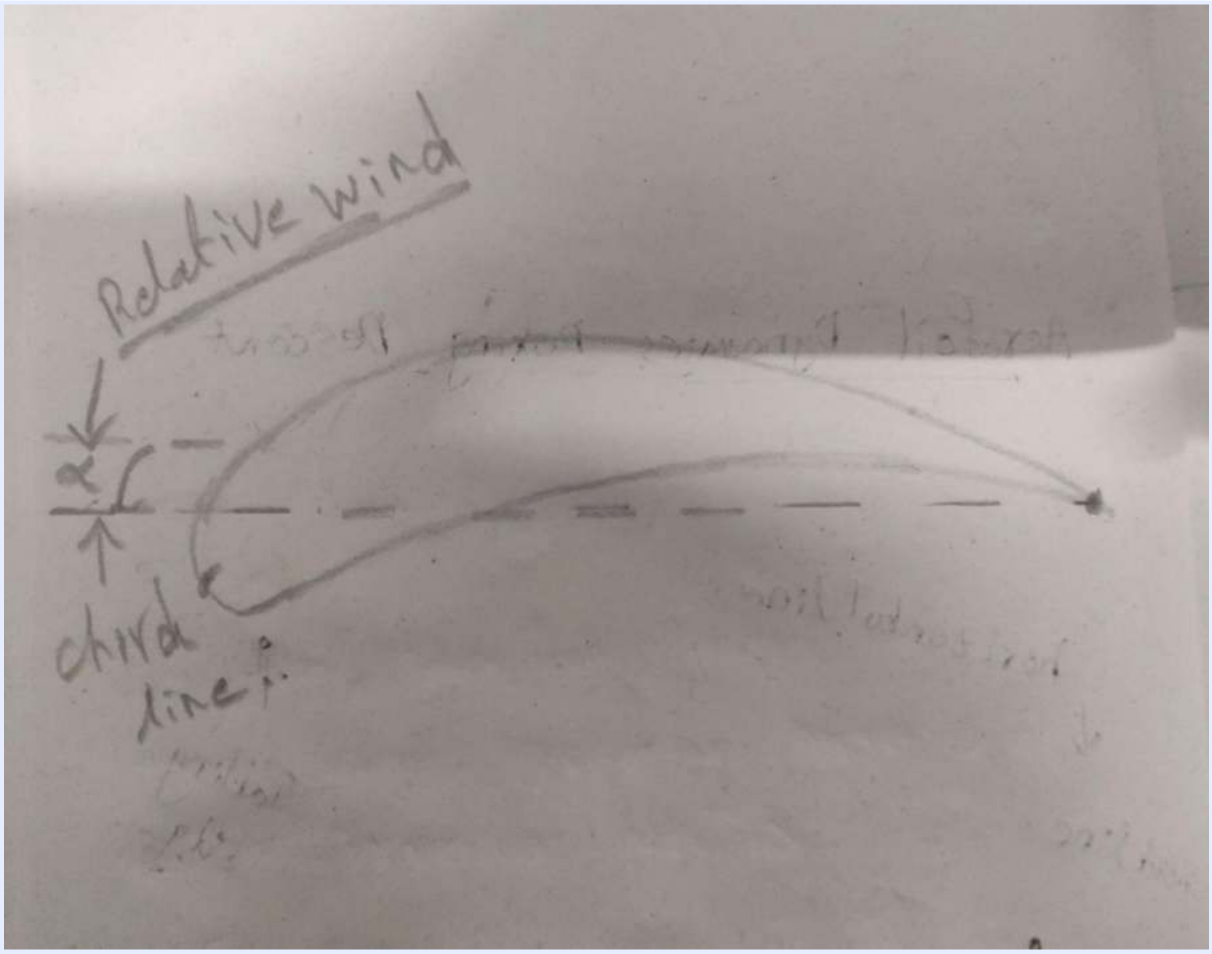
Question 3: Aerodynamic Characteristics of Aerofoil

a) Airflow Changes and Center of Pressure:

A zero angle of attack occurs when the chord line of a wing is parallel to the relative wind

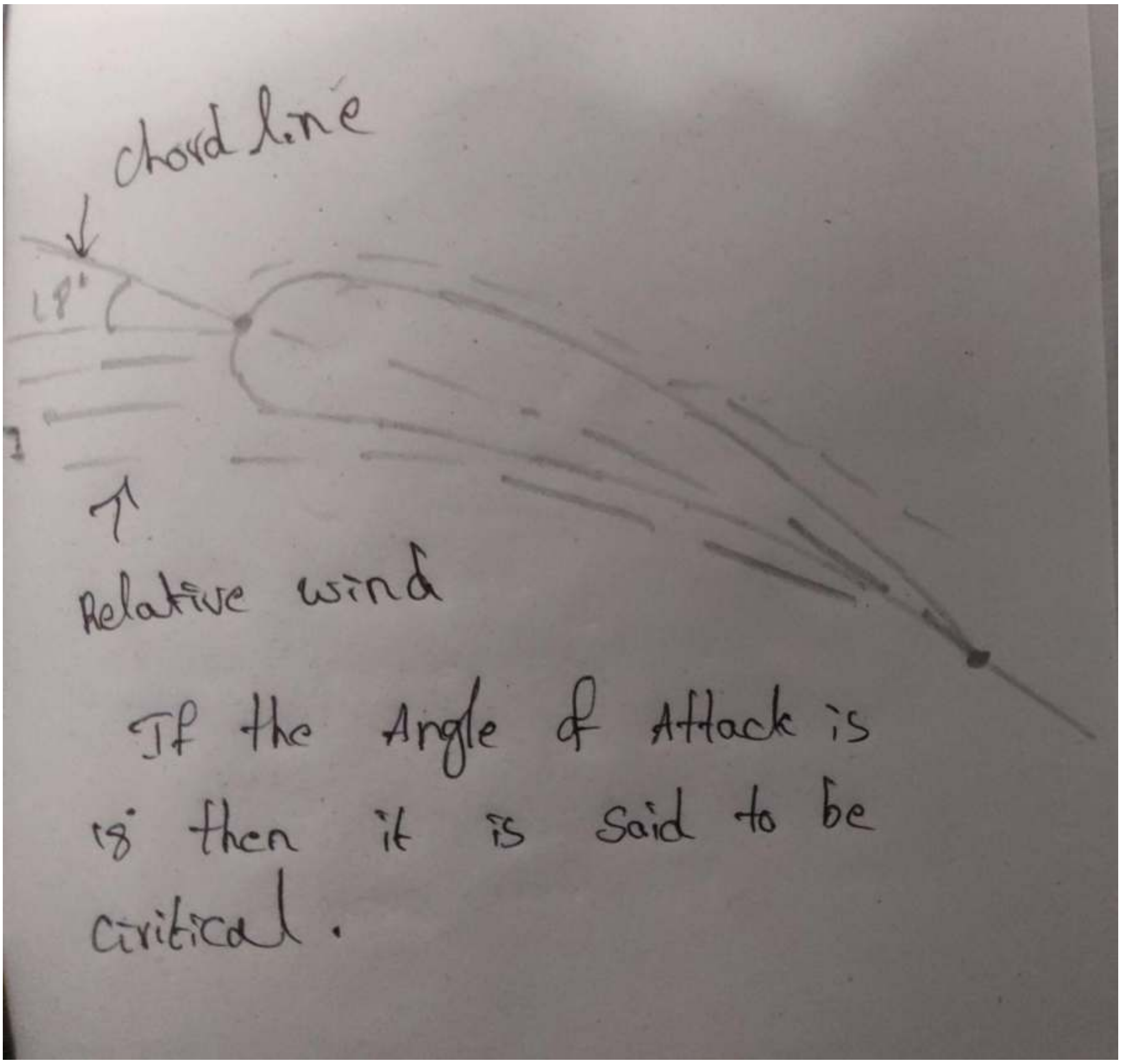
ZERO ANGLE OF ATTACK





ANGLE OF ATTACK BETWEEN 0 AND CRITICAL ANGLE OF ATTACK

Here alpha is angle of attack with an angle between zero and critical angle



CRITICAL ANGLE OF ATTACK

The critical angle of attack is the angle of attack which produces the maximum lift coefficient.

2. Identify the likely position of the center of pressure on each diagram.

Center of pressure(CP)

The center of pressure is the point where the total sum of a pressure field acts on a body.

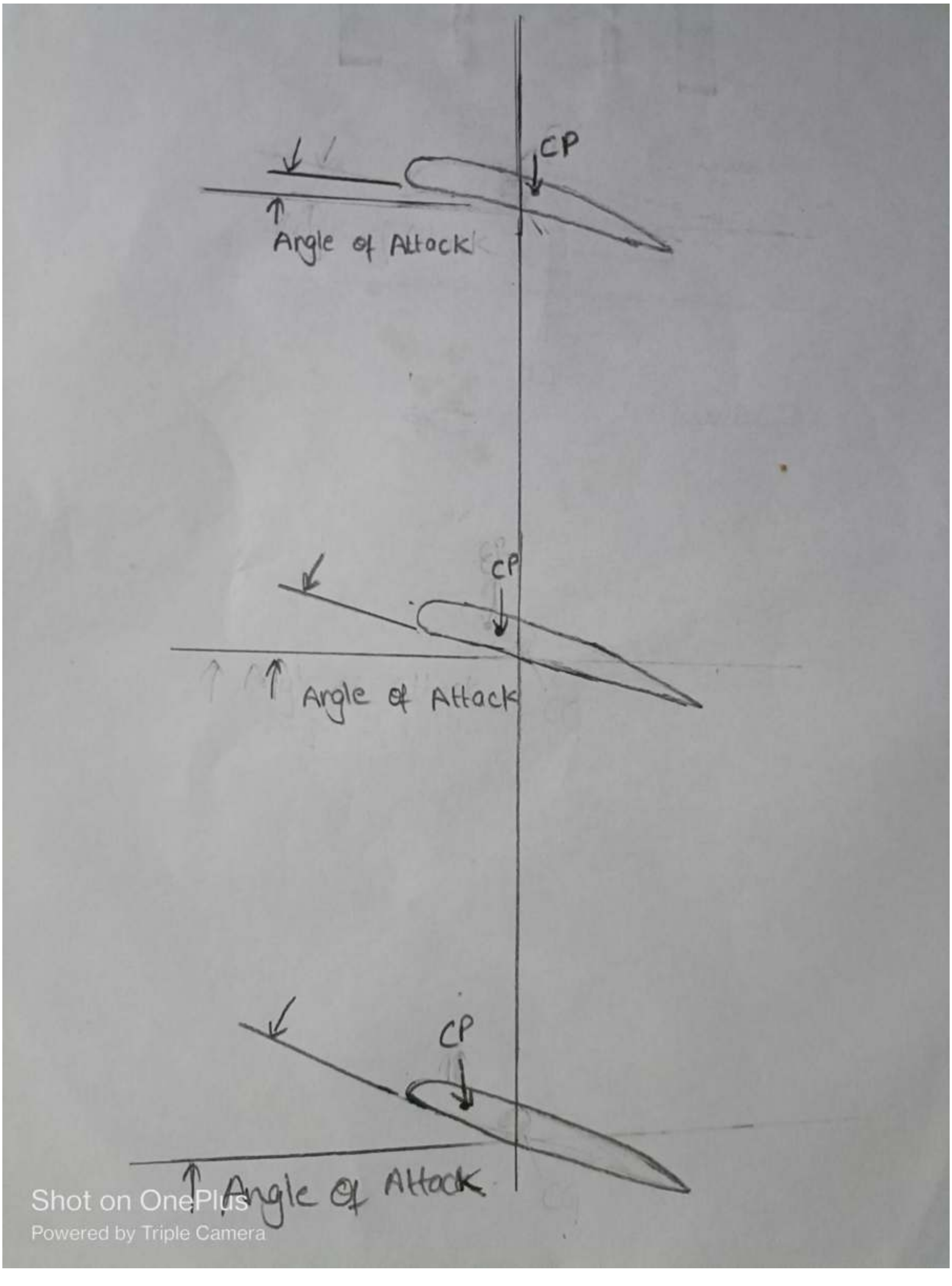
Center of Gravity(CG):

where the weight of an object is balanced

Maintaining the proper center of gravity is vital for stability and control during flight. Pilots must ensure that the aircraft's load is distributed correctly to maintain a safe and balanced flying condition

As the center of gravity (the point where the weight of the body acts) is fixed, this movement of center of pressure affects the stability of the aircraft.

AS the angle of attack increases the centre of pressure moves forward in the above image and the centre of gravity is constant in the image shown above


CP
Angle of Attack
CP
Angle of Attack
CP
Angle of Attack
Shot on OnePlus
Powered by Triple Camera

- For a conventionally cambered airfoil, the center of pressure lies a little behind the quarter-chord point at maximum lift coefficient (large angle of attack), but as lift coefficient reduces (angle of attack reduces) the center of pressure moves toward the rear.

b) Washout and Stall Control

Explain the concept of washout on a wing and its role in controlling the aircraft near the
Stall.

Answer:-

Washout on a wing is like a smart design trick to keep an aeroplane safe. Imagine the wing is a bit twisted – the tips are slightly lower than the centre. This twist is called washout.

Role in Controlling Near the Stall:

- Balancing Act: Washout helps balance the lift across the wing. The twist makes the tips produce less lift than the center.

- Gentle Warning: As the plane gets close to a stall (that's like a sleepy moment for the wing) the twisted design makes the inner part of the wing keep flying while the outer part starts to doze off. It's like a gentle warning to the pilot.

- Smooth Stall: When the stall happens it starts from the wings' centre and moves outward. Washout helps make this process more gradual and controlled.

- Safer Handling: This design keeps the plane more stable and easier for pilots to handle especially when it's flying slow or doing maneuvers. It's like having a friend reminding the wing to take it easy when things get a bit tricky.

C. Winglets for fuel Efficiency:

Briefly describe how winglets enhance fuel efficiency in modern jet aircraft.

Answer :- Winglets are like smart wing tips that help modern jet aircraft save fuel.

- Reducing Drag: Winglets point upwards at the end of the wings. This design cuts down on a force called "drag," which is like air resistance that tries to slow down the plane.

- Minimising Airflow Swirl: As the plane moves through the sky, the air around the wingtips tends to swirl. Winglets help control this swirling, making the air flow more smoothly.

- Saving Fuel: Smoother airflow and less drag mean the engines have to work less to push the plane forward. So, winglets help the plane use less fuel, making it more efficient.