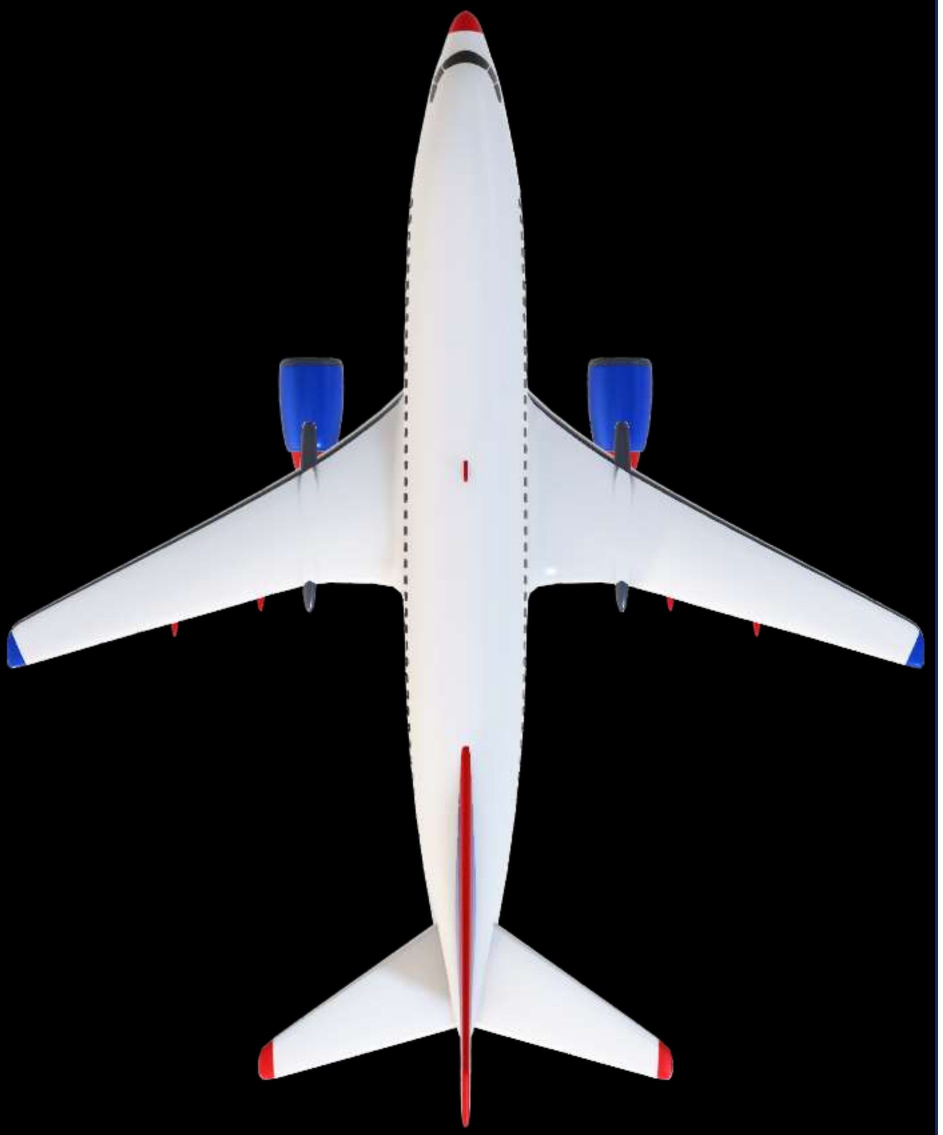
TEAM PHOENIX



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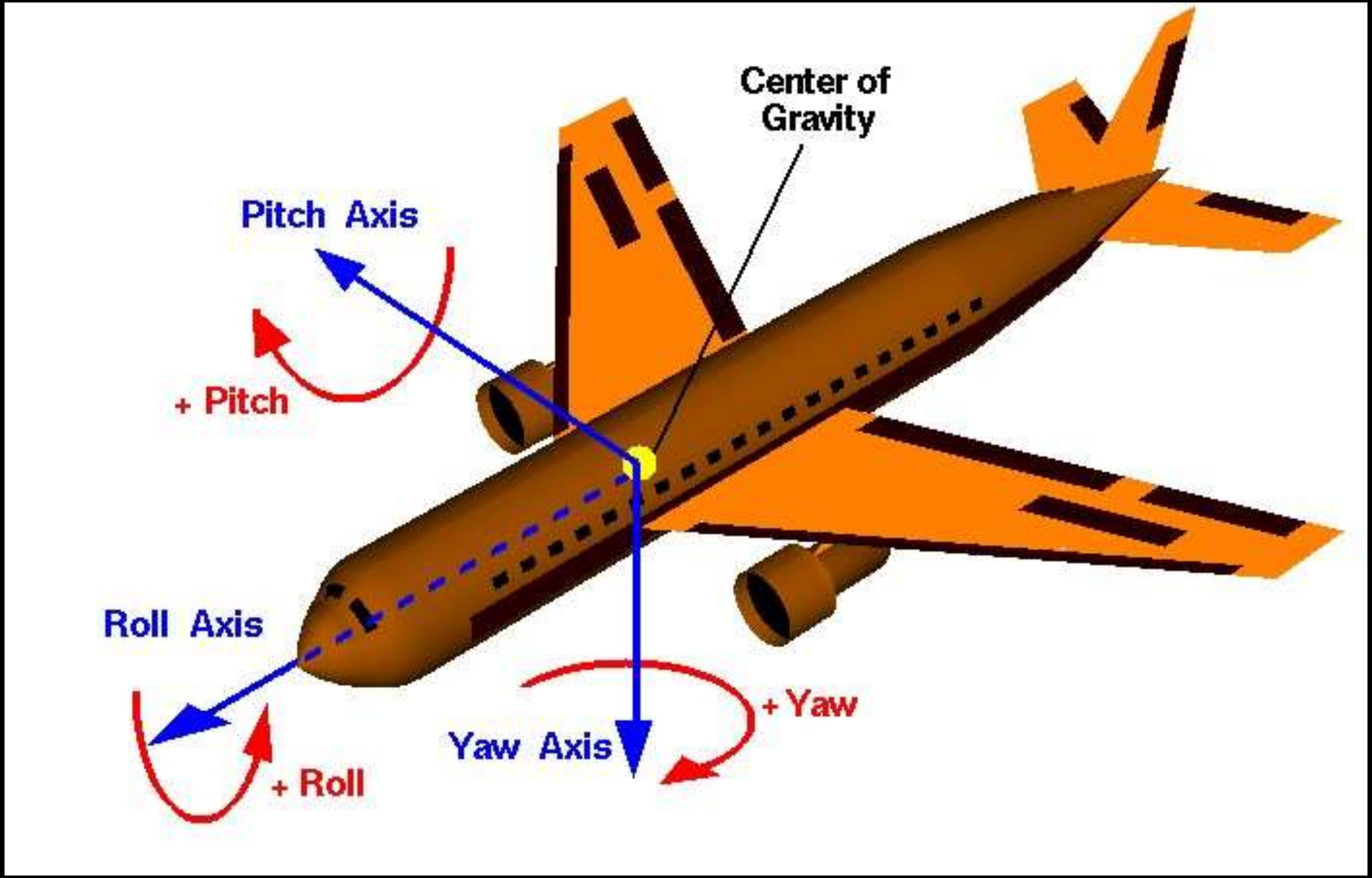
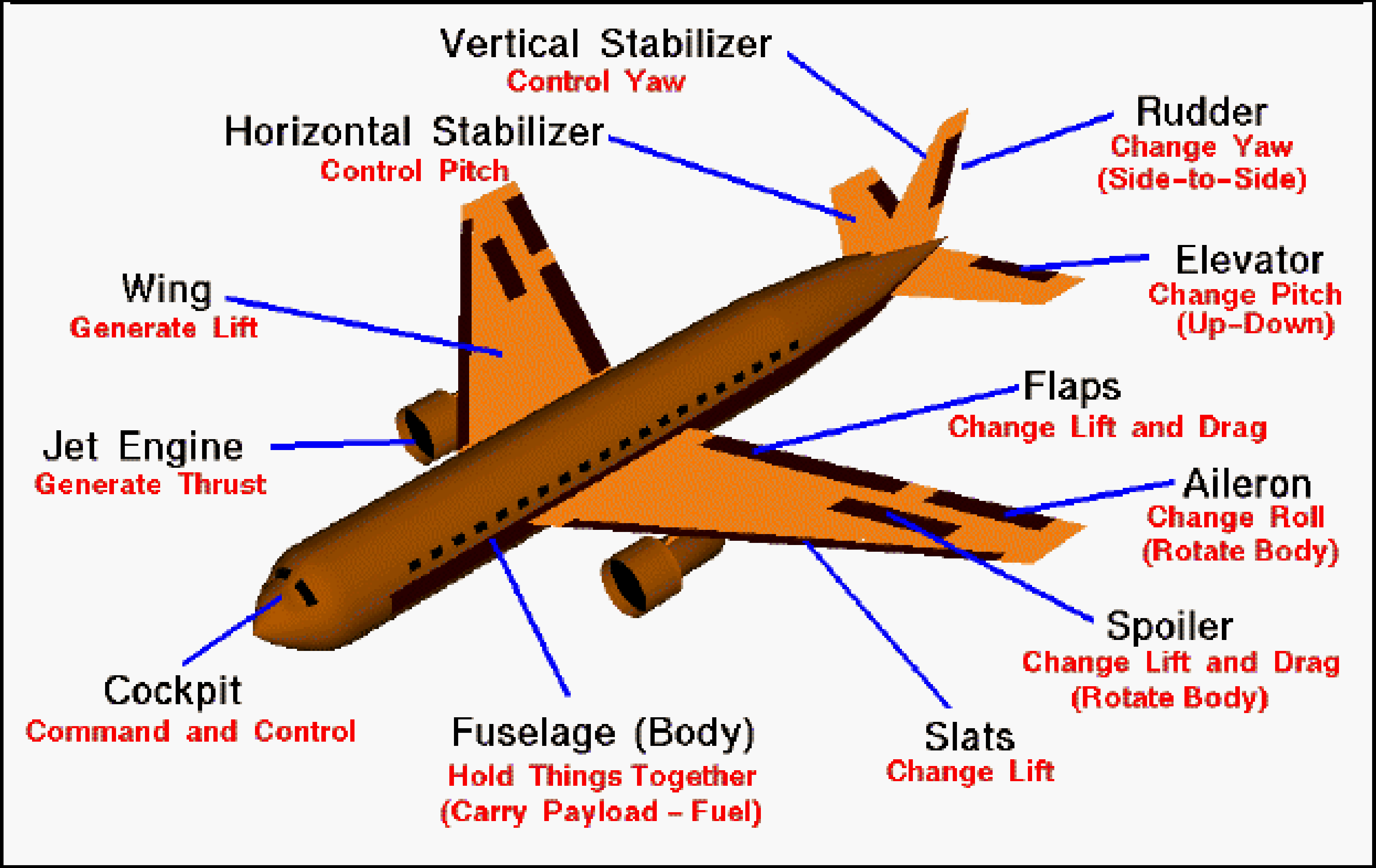
AXES OF AN AIRCRAFT

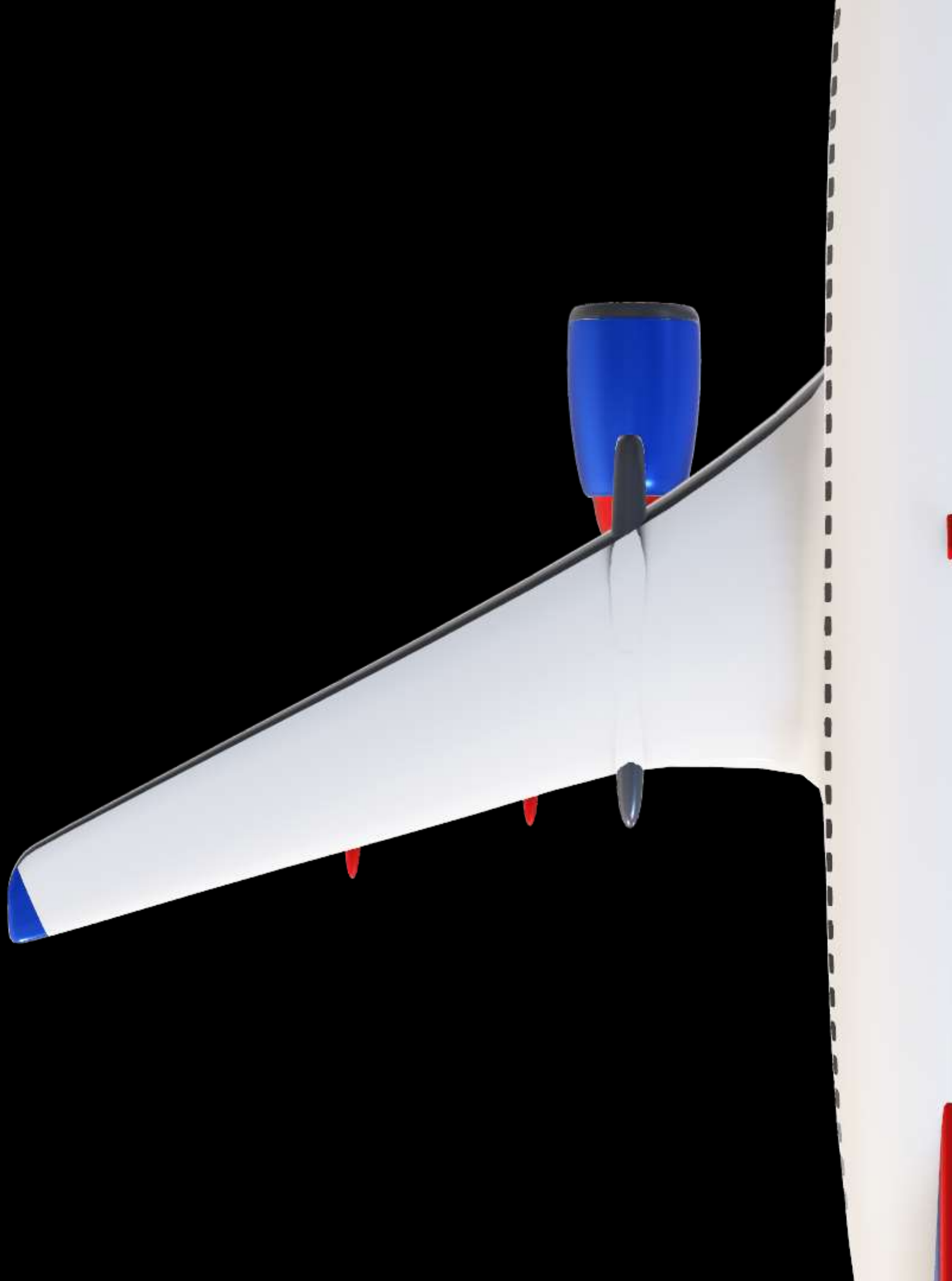


Parts of an airplane



wINGS

The **wings** of an airplane are its primary lifting surfaces, designed to generate the lift needed to overcome gravity and sustain flight. They work by manipulating airflow using their shape, known as the **airfoil**, to create a pressure difference between the top and bottom surfaces. Due to downwash lift is generated in aircraft.



Qna corner

1. What is the primary function of the wings on an airplane?

A) To control pitch
B) To generate lift
C) To stabilize yaw
D) To reduce drag

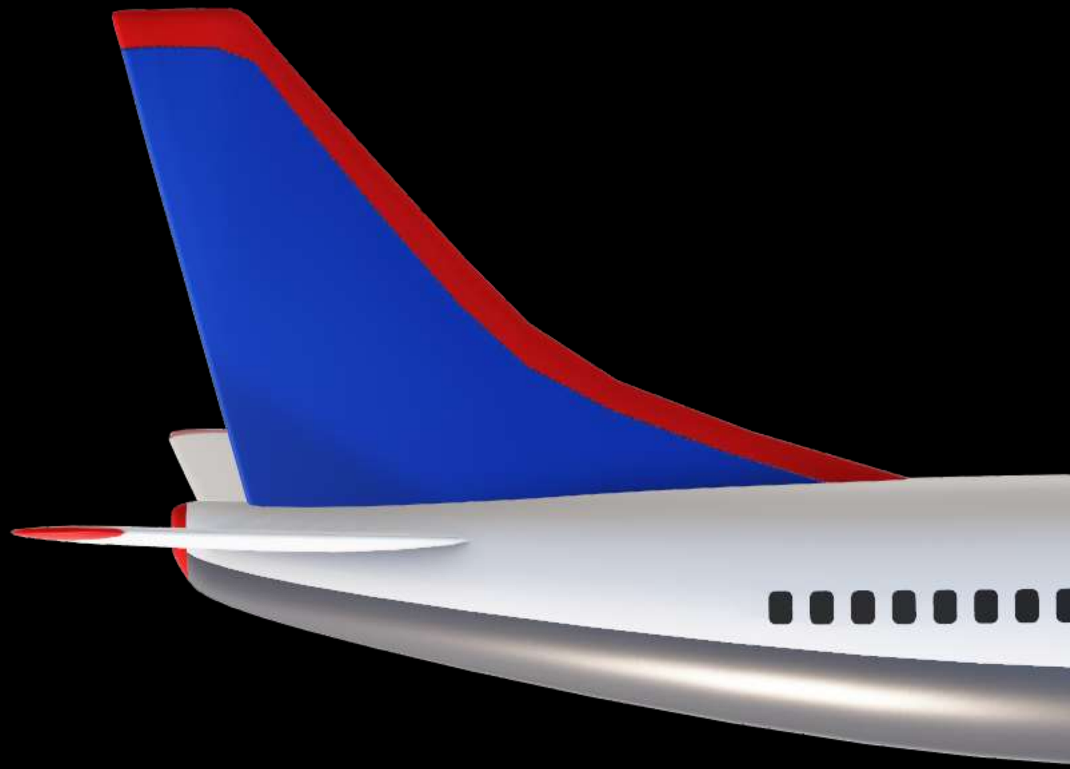
Qna corner

1. **What is the primary function of the wings on an airplane?**

A) To control pitch
B) To generate lift
C) To stabilize yaw
D) To reduce drag

Tail or empennage

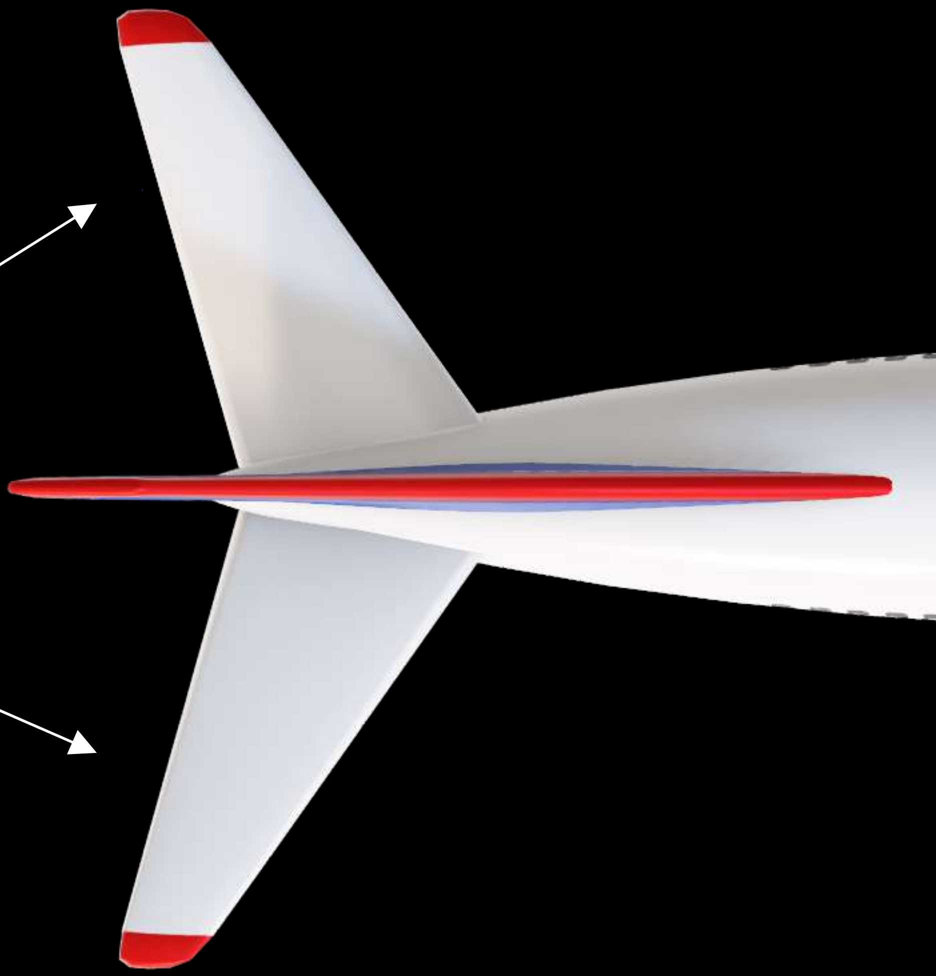
The **empennage**, also known as the tail assembly, is the aft structure of an aircraft that provides stability and control in flight. It ensures the aircraft remains balanced and can be steered effectively.



Parts of empennage

Horizontal Stabilizer:

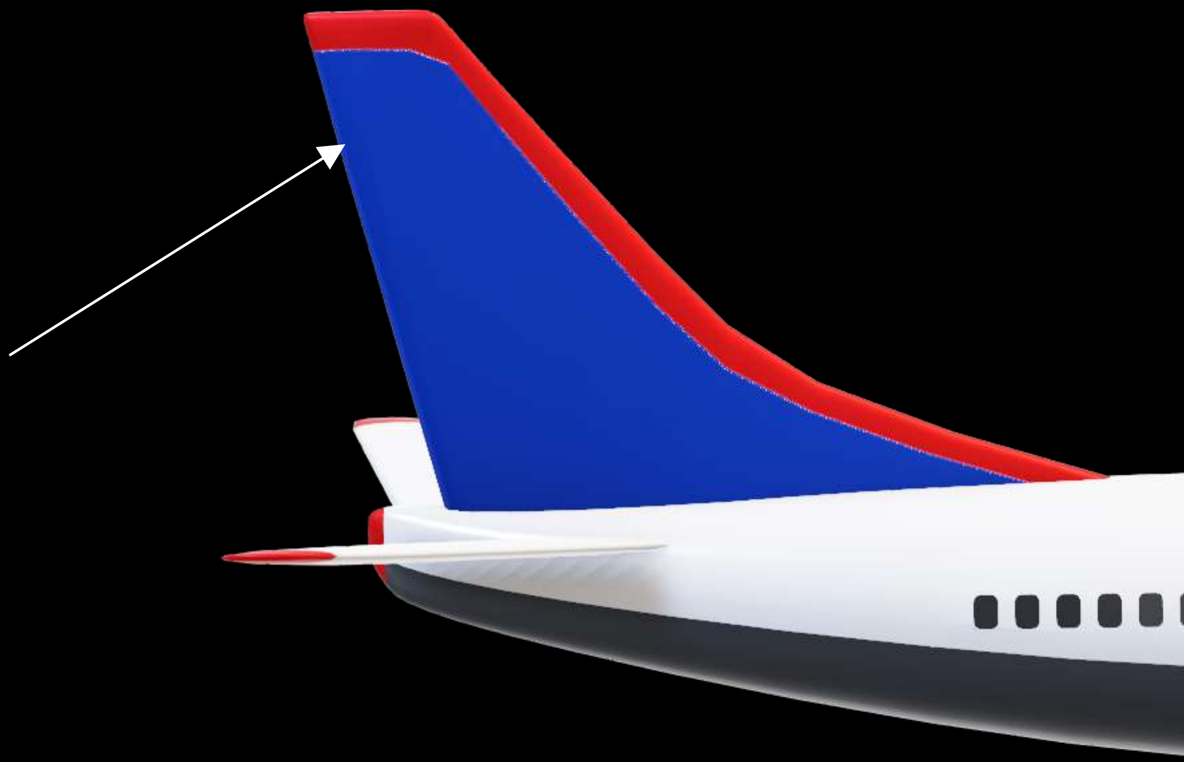
•Located at the rear, it provides pitch stability.
•Equipped with an **elevator** to control the pitch (nose up or down).



Parts of empennage

Vertical Stabilizer:

•The upright fin that provides yaw stability.
•Contains the **rudder**, which controls the yaw (side-to-side movement).



1

Ailerons:

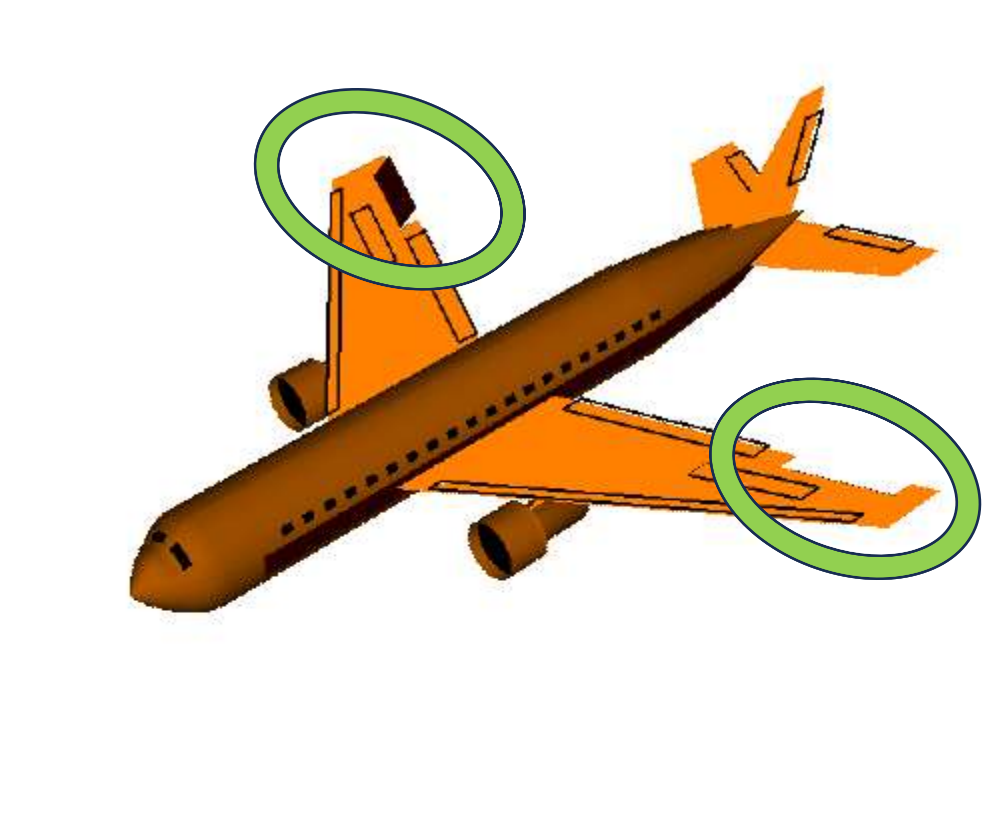
Hinged surfaces near the trailing edge of the wings. Control the aircraft's roll, helping it turn by raising one wing and lowering the other.

2

Flaps:

Located along the trailing edge of the wings, closer to the fuselage. Increase lift and drag for slower speeds during takeoff and landing.

3



vortices.

4

nose up or down.

5

Rudder:

Found on the vertical stabilizer in the tail. Control yaw, allowing the aircraft to move left or right around its vertical axis.

1

Ailerons:

Hinged surfaces near the trailing edge of the wings. Control the aircraft's roll, helping it turn by raising one wing and lowering the other.

2

Flaps:

Located along the trailing edge of the wings, closer to the fuselage. Increase lift and drag for slower speeds during takeoff and landing.

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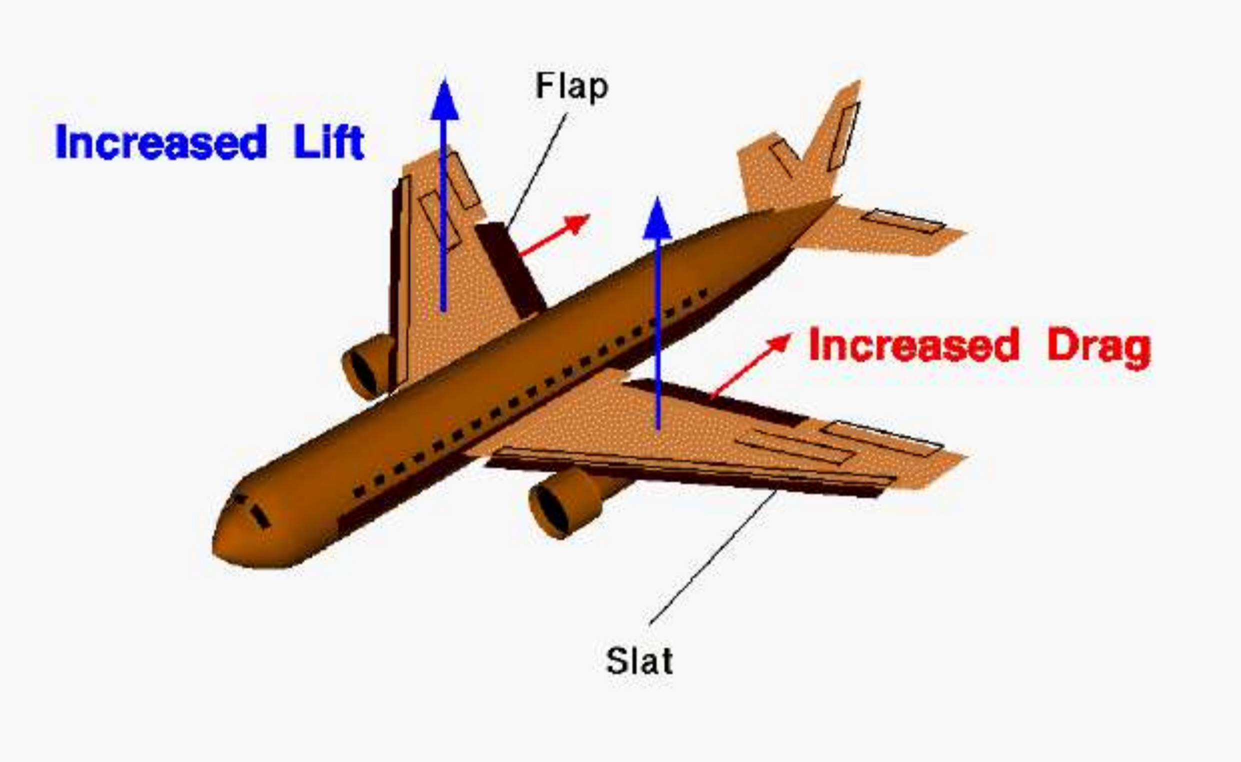
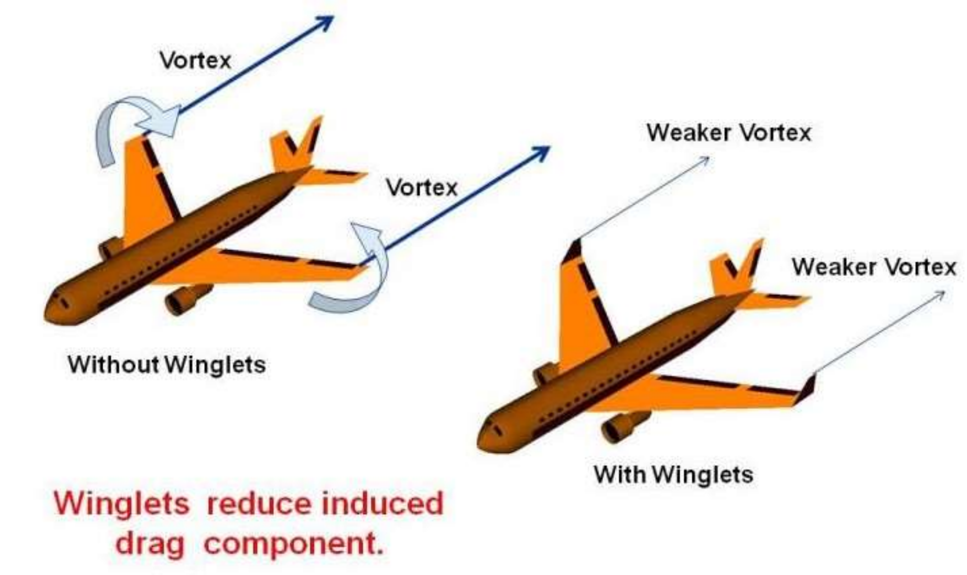


1

Ailerons:



lowering the other.

2

Flaps:

during takeoff and landing.

3

Winglets:

Vertical or angled extensions at the wing tips. Reduce drag and improve fuel efficiency by minimizing wingtip vortices.

4

Elevator:

Located on the horizontal stabilizer in the tail section. Control the pitch of the aircraft, adjusting its nose up or down.

5

Rudder:

Found on the vertical stabilizer in the tail. Control yaw, allowing the aircraft to move left or right around its vertical axis.

1

Ailerons:

one wing and
lowering the
other.

2

Flaps:

slower speeds
during takeoff
and landing.

3

Winglets:

Vertical or angled extensions at the wing tips. Reduce drag and improve fuel efficiency by minimizing wingtip vortices.

4

Elevator:

adjusting its
nose up or
down.

5

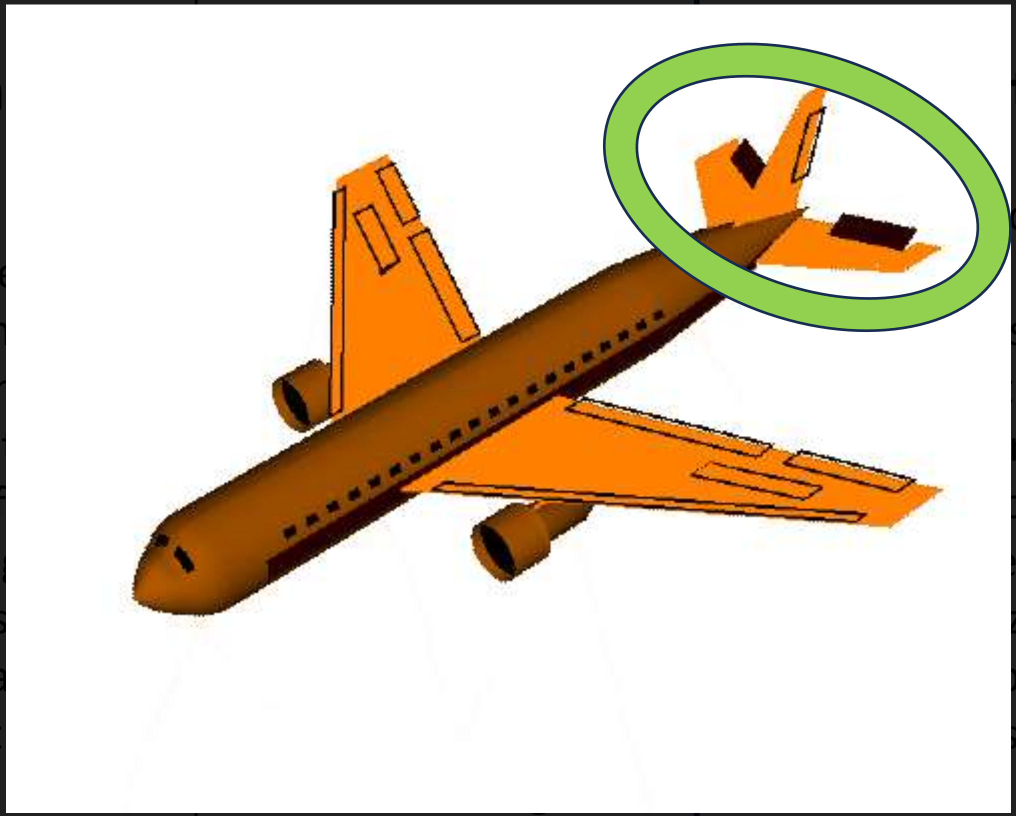
Rudder:

right around
its vertical
axis.

1

2

3



Aileron

Hinged surfaces ne the trailin edge of th wings. Con the aircraf roll, helpin turn by rais one wing a lowering t other.

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or s at ips. rag ove ency zing o s.

4

Elevator:

Located on the horizontal stabilizer in the tail section. Control the pitch of the aircraft, adjusting its nose up or down.

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Found on the vertical stabilizer in the tail. Control yaw, allowing the aircraft to move left or right around its vertical axis.

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2

Flap

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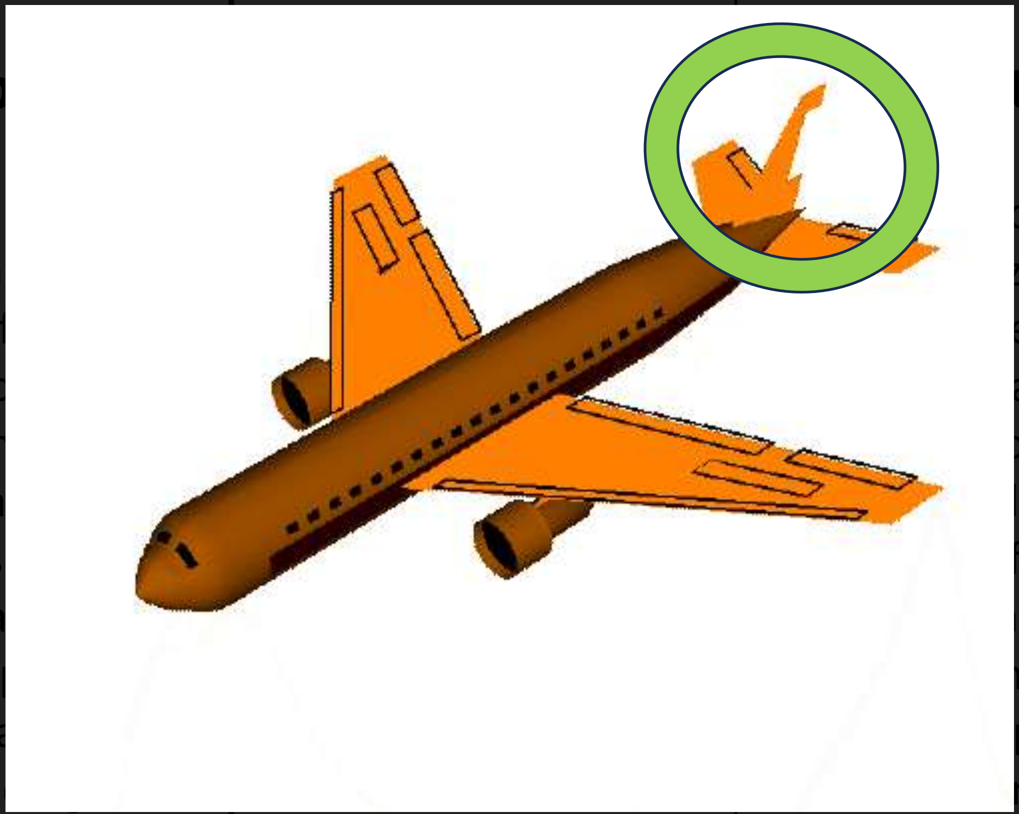

5

Rudder:

Found on the vertical stabilizer in the tail. Control yaw, allowing the aircraft to move left or right around its vertical axis.

Qna corner

2**. Which part of the empennage helps control the pitch of an airplane?**

A) Vertical stabilizer
B) Elevator
C) Rudder
D) Aileron

Qna corner

2**. Which part of the empennage helps control the pitch of an airplane?**

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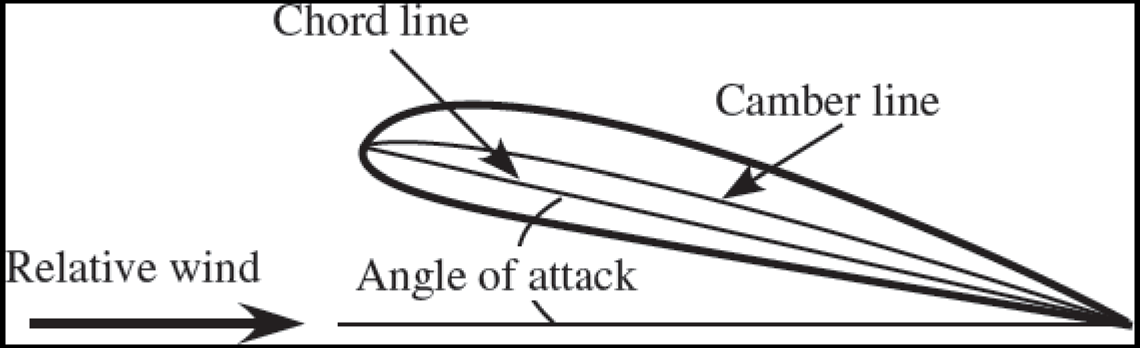
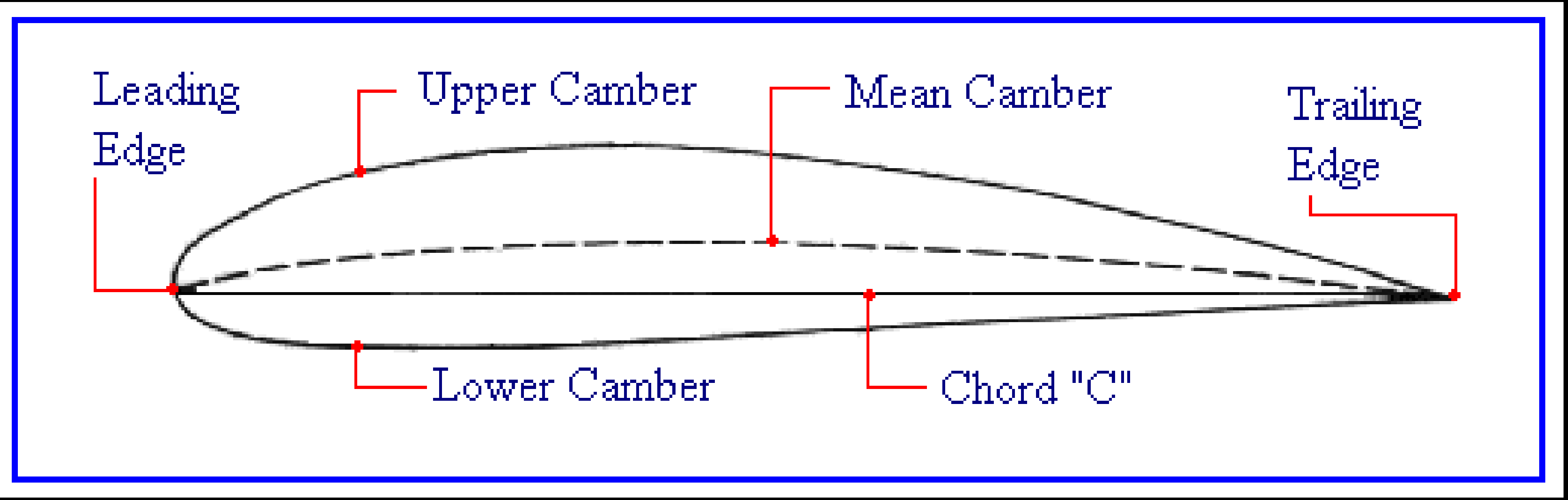
Airfoil

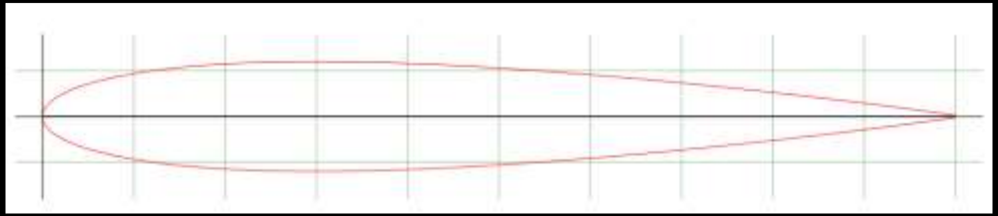


An **airfoil** is the cross-sectional shape of a wing or blade designed to generate lift as it moves through the air. It typically has a curved upper surface and a flatter lower surface, creating a pressure difference that lifts the aircraft.

Airfoil nomenclature



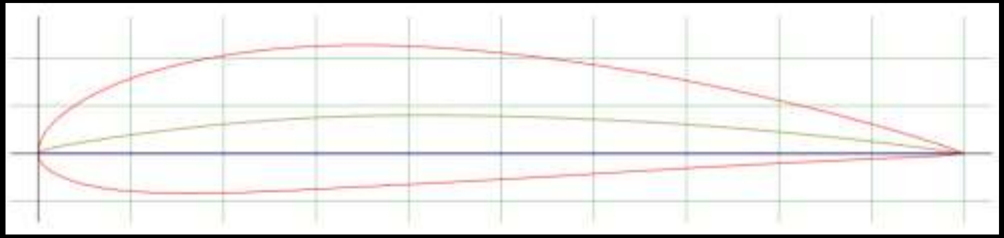
Types of airfoil



NACA 0012 Airfoil

Symmetrical Airfoil:

A **symmetrical airfoil** has identical upper and lower surfaces, with no camber. The mean camber line coincides with the chord line. It generates no lift at zero angle of attack.

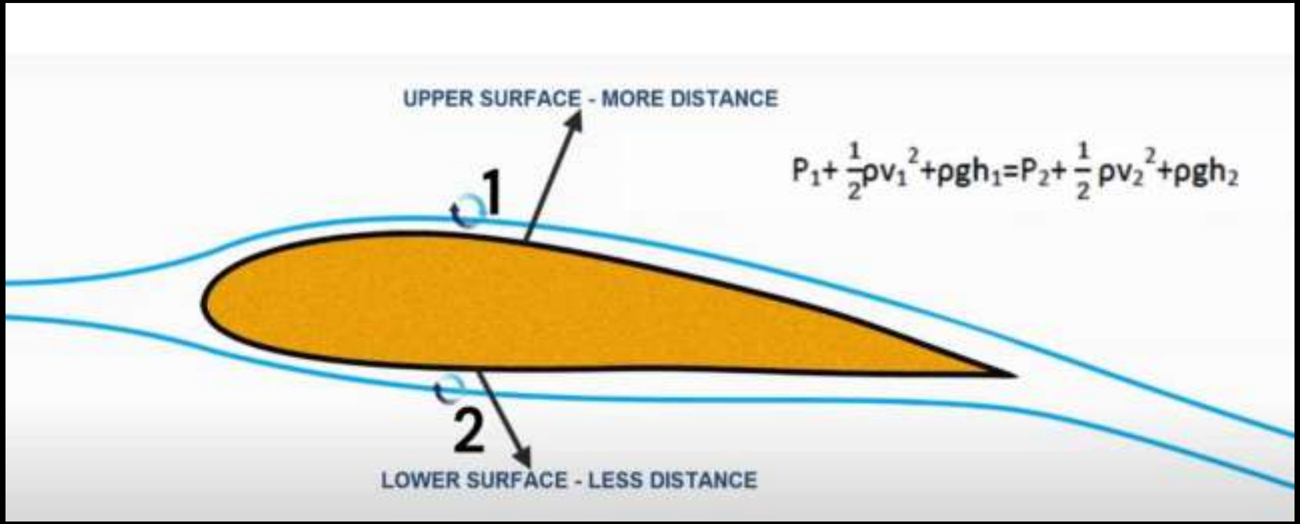


NACA 4415 Airfoil

Unsymmetrical Airfoil:

An **unsymmetrical airfoil** has a curved upper surface and flatter lower surface, creating camber. It produces lift even at zero angle of attack, making it ideal for most conventional aircraft where lift generation is a priority.

Equal Transit time theory



The **equal transit time theory** incorrectly suggests that air particles traveling over the longer, curved upper surface of an airfoil must meet particles traveling along the flatter lower surface at the trailing edge simultaneously. This idea was used to explain lift but is **not accurate**; lift is actually generated by the difference in pressure created by the airfoil's shape and the airflow's dynamics, as described by Bernoulli’s principle and Newton’s laws of motion.

Failure of equal transit time theory.

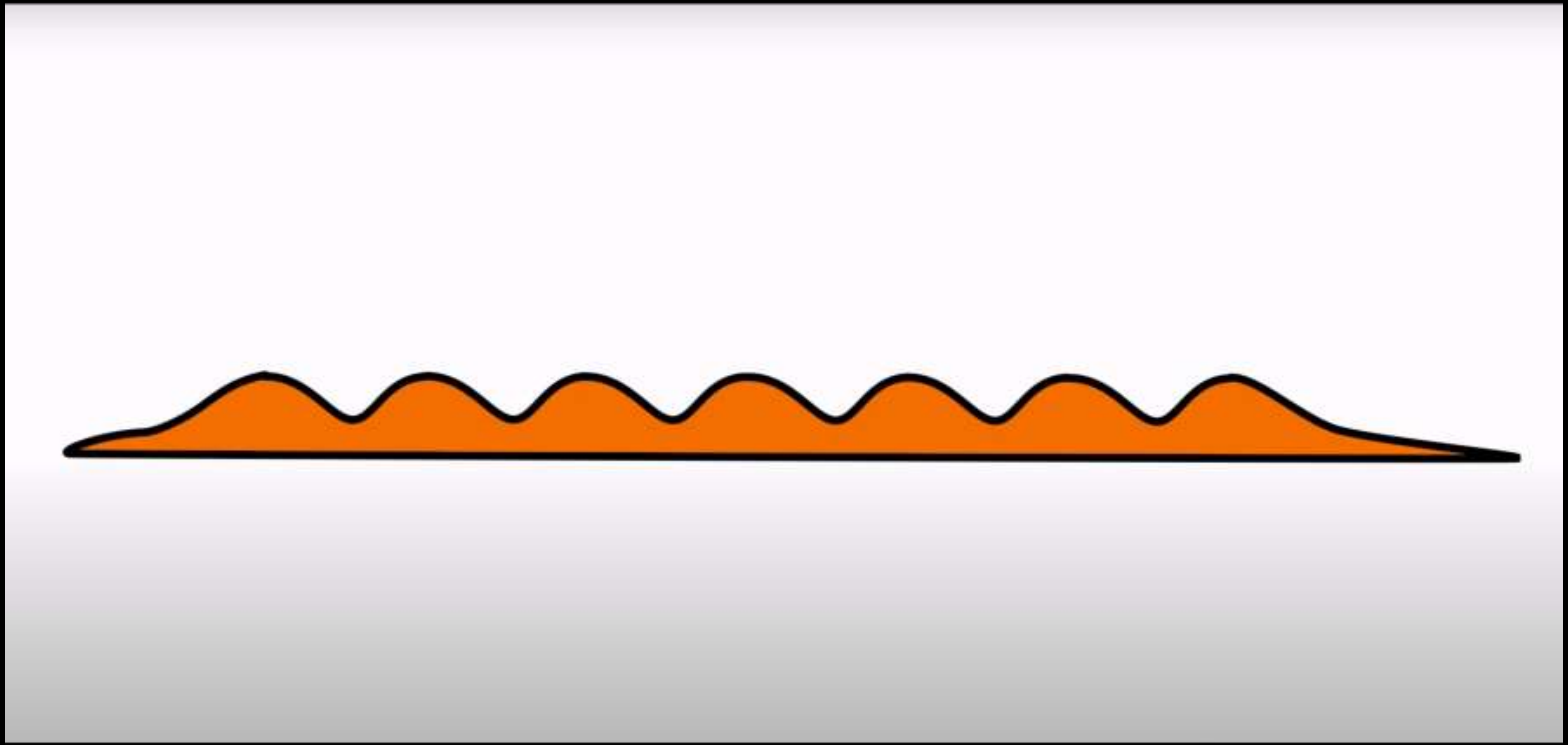
1. No Physical Basis for Equal Transit Time: There is no rule or law of physics
requiring air parcels to meet at the trailing edge of the wing simultaneously.

2. Ignores Actual Flow Patterns: Observations and experiments show that air traveling over the top of the wing moves much faster than predicted by the equal transit time theory, leading to a much greater lift than the theory suggests.

3. Does Not Account for Angle of Attack: Lift is also generated by the wing's angle of attack (the angle between the wing's chord line and the oncoming airflow). This critical factor is ignored in the equal transit time theory.

4. Fails to Explain Inverted Flight: Aircraft can fly upside-down, which cannot be explained by the equal transit time theory. Inverted flight relies on the angle of attack and airflow manipulation, not just wing shape.

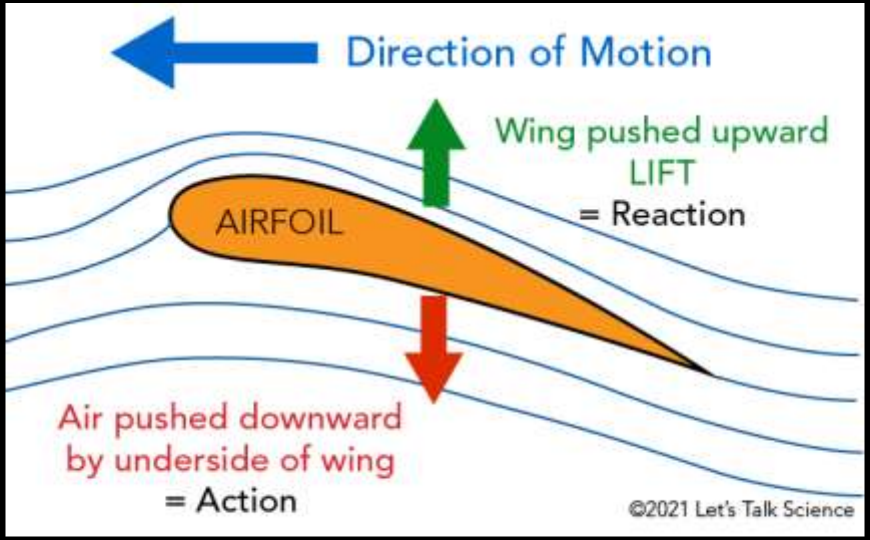
Failure of equal transit time theory.



Coanda effect

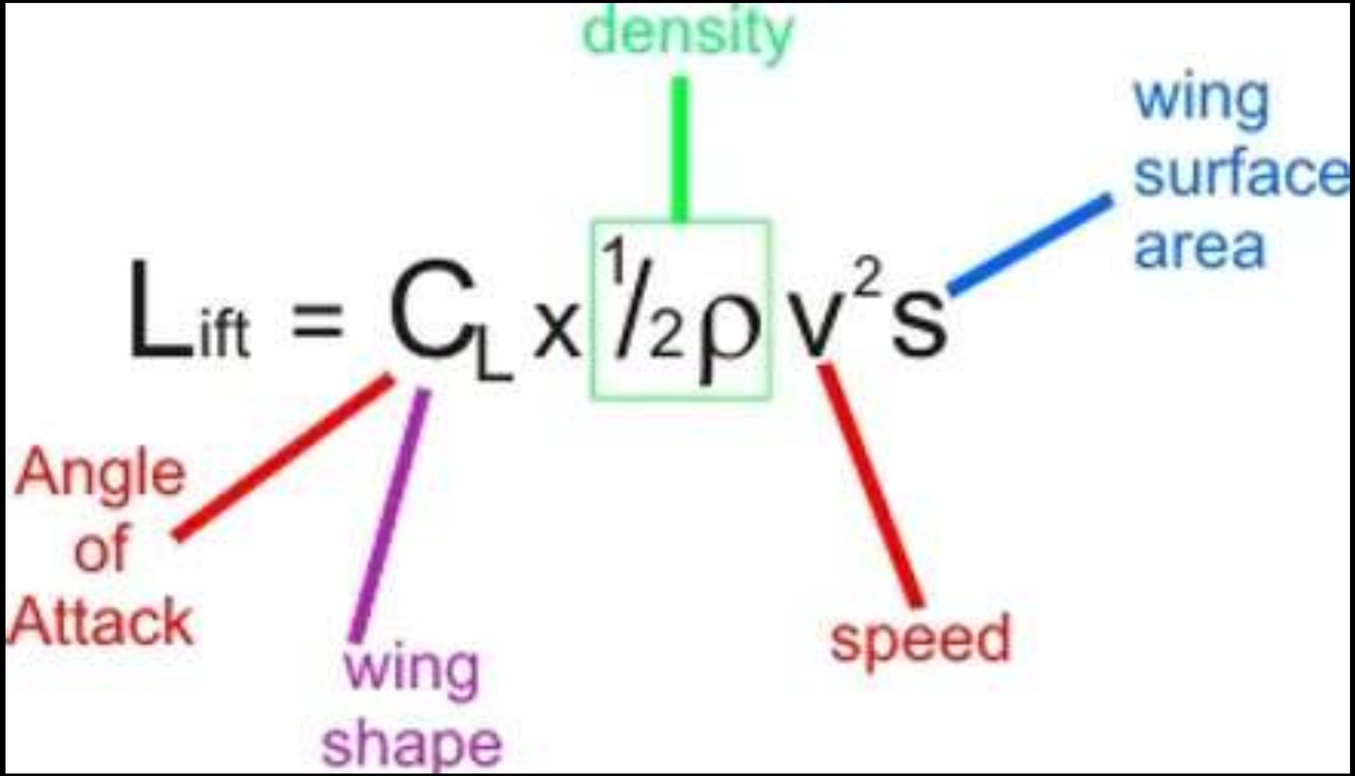
Due to viscosity of fluid, fluid layer closest to the solid boundary has less velocity as compared to upper layers. Due to this, the faster layers bend in the direction of slower layers, causing the fluid to follow the curve along the solid layer.

The correct approach :
Newton's 3rd law



Due to attached flow, air is pushed downwards by the wing at the trailing edge, which is called downwash. As a result of this, the air pushes the wing upwards due to which lift is created. The direction of motion is given by thrusters or engines.

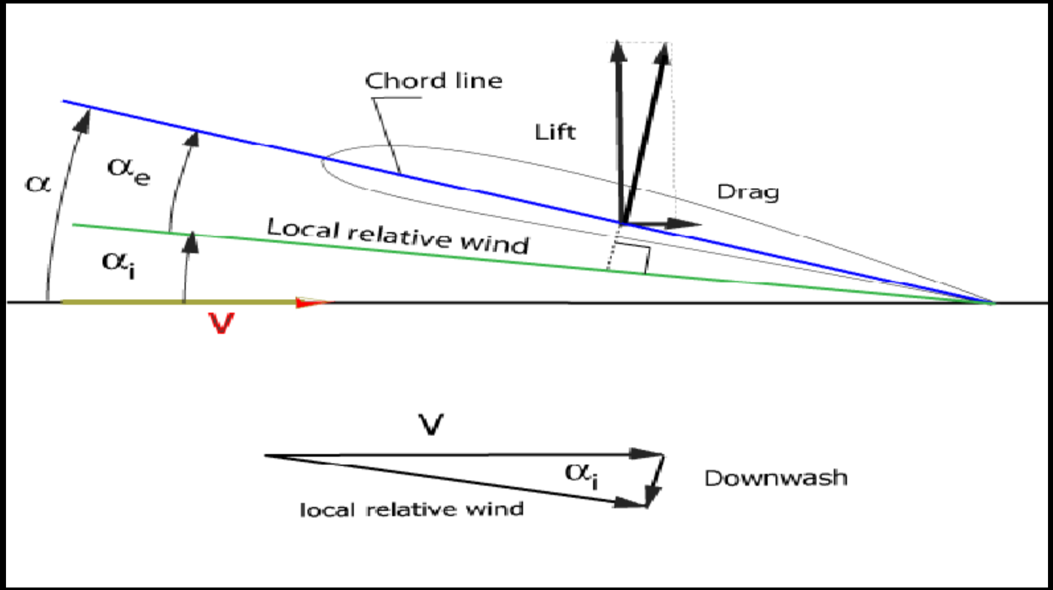
Lift calculation



Here Cl is called as the Lift Coefficient, which depends on various factors of the aircraft like wing shape and angle of attack.

Angle of attack

The **angle of attack (AoA)** is defined as the angle between the **chord line** of an airfoil (such as a wing) and the direction of the **airflow** (also called the freestream velocity). Its types are as follows :



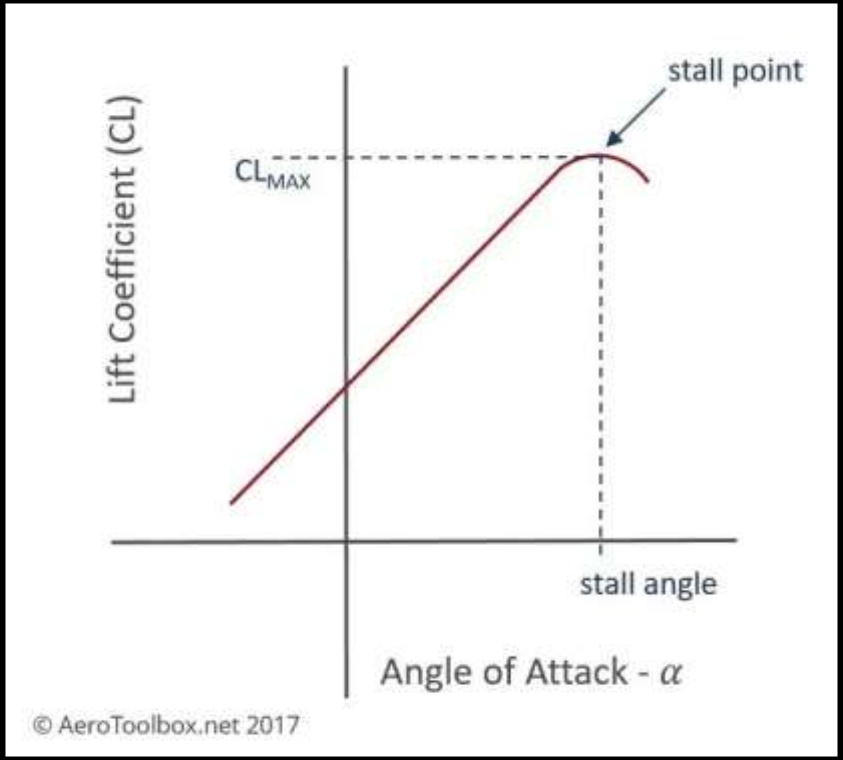
1. **Geometric Angle of Attack :** The angle between the **chord line** of the airfoil and the **relative airflow** (freestream velocity).

2. **Effective Angle of Attack :** The angle between the **chord line** of the airfoil and the direction of airflow **affected by downwash and induced flow** due to the wing generating lift.

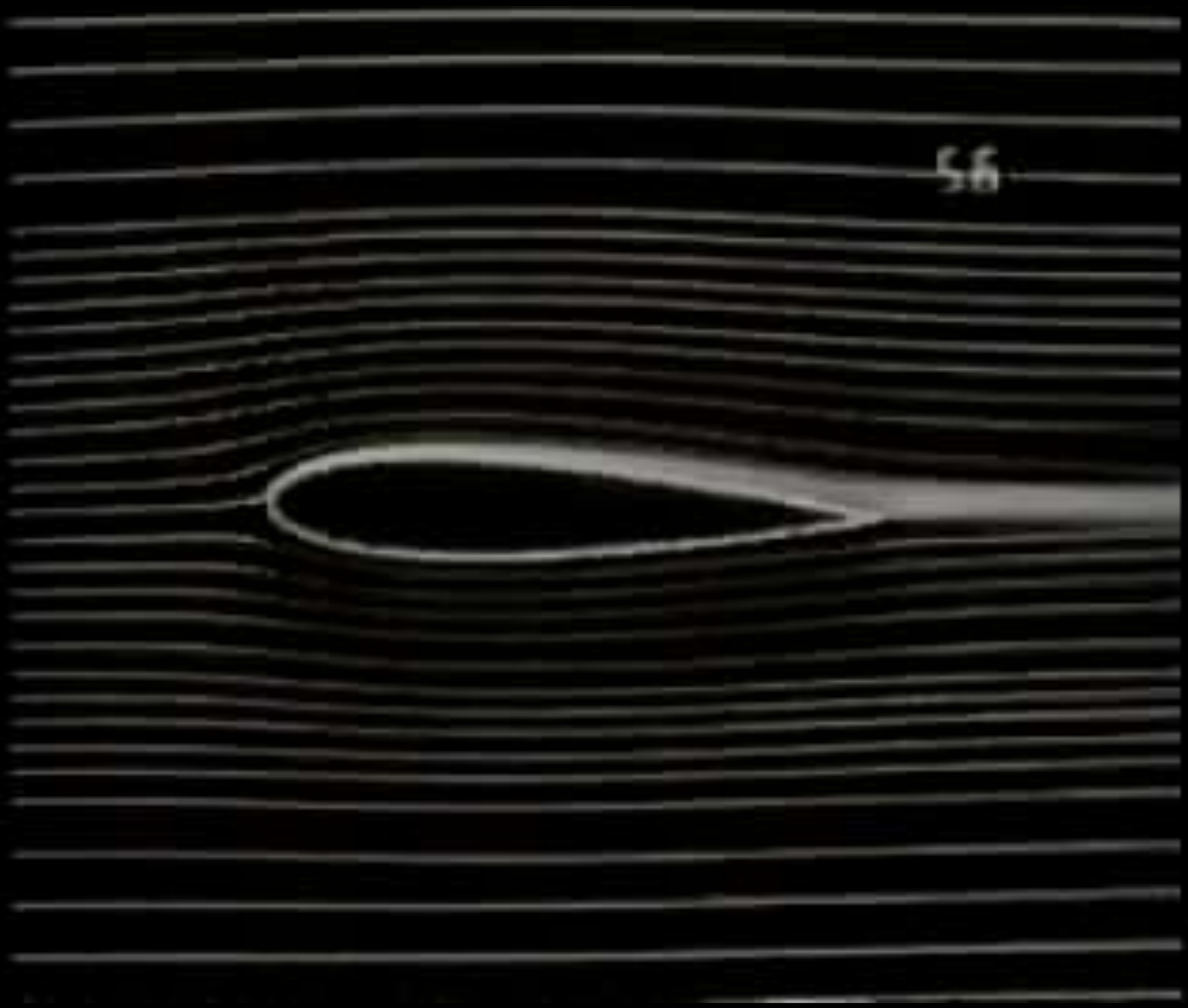
Relation between Angle of attack & lift coefficient

This is the graph between lift coefficient and angle of attack. Some graphs can also start from the origin unlike in this case where Cl is not zero at zero angle of attack. This specifies that the wing can experience lift at no angle of attack due to cambered shape which is causing downstream (action) and experiencing lift (reaction).

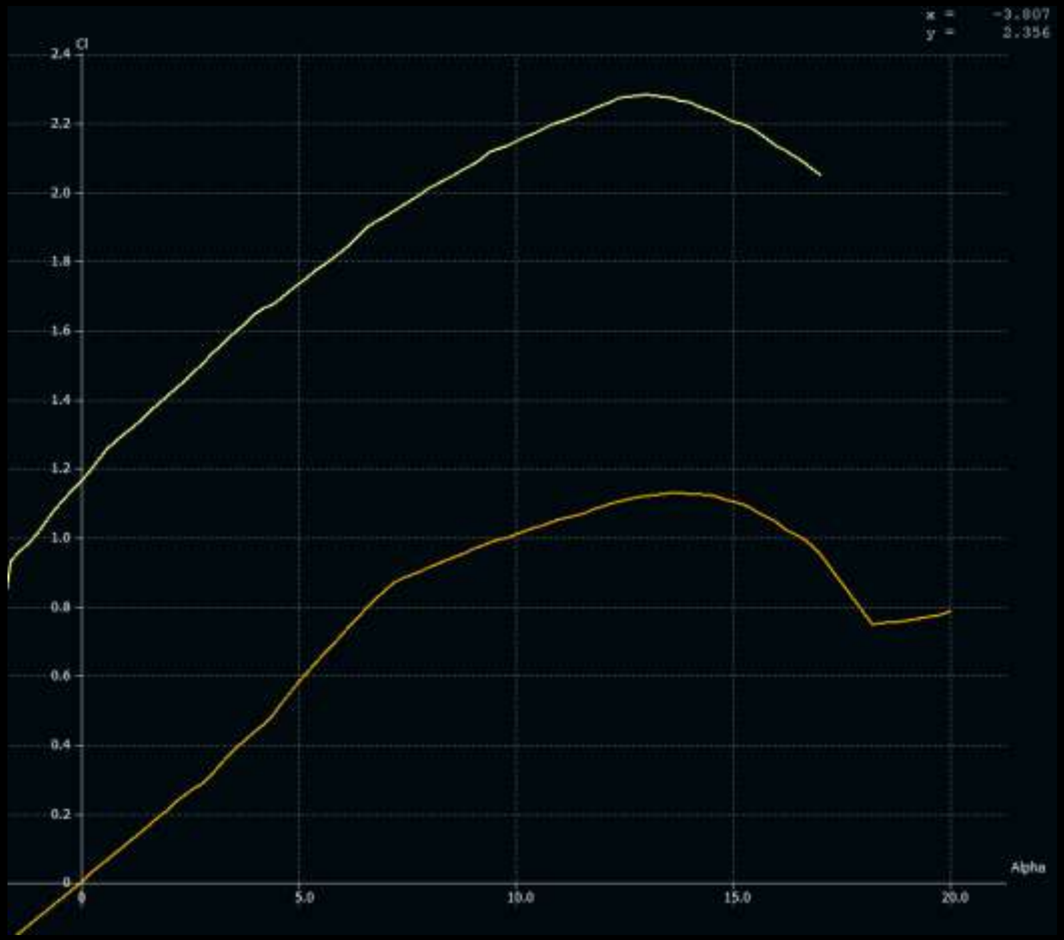
Graph increases linearly to the point where a very high angle of attack causes air to separate from the wing surface and decrease lift. This angle is called **critical angle or stall angle** and the plane starts descending at this point.



Boundary layer seperation



Relation between Angle of attack & lift coefficient



Qna corner

3. The ___________ is the angle between the chord line of an airfoil and the direction of airflow.

Qna corner

3. The ___________ is the angle between the chord line of an airfoil and the direction of airflow.

Answer: Angle of attack

Qna corner

4. In a graph showing the relationship between lift coefficient and angle of attack, the angle at which lift starts to decrease is called the ___________.

Qna corner

4. In a graph showing the relationship between lift coefficient and angle of attack, the angle at which lift starts to decrease is called the ___________.

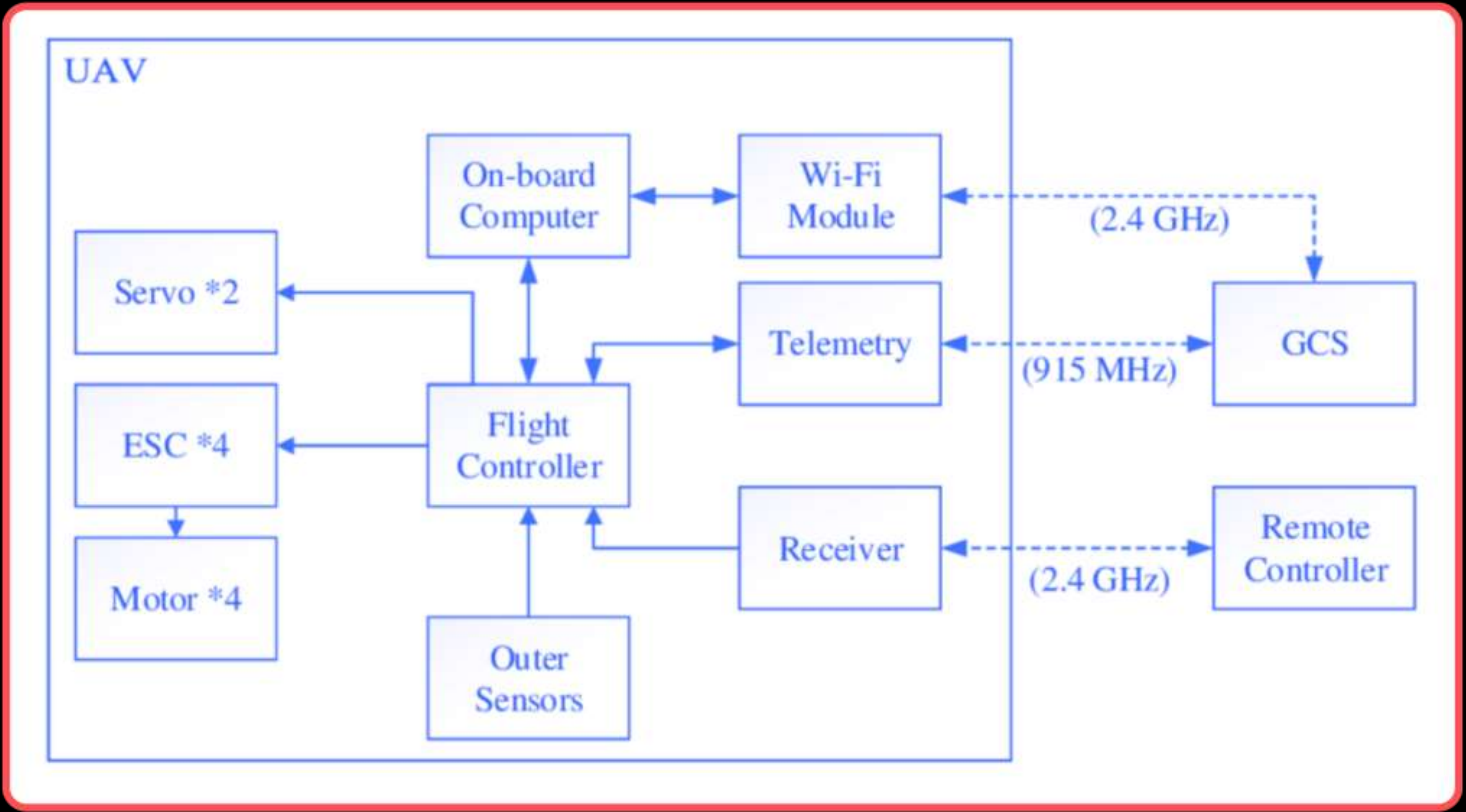
Answer: Stall angle or Critical angle

avionics

Fusion of electronics and aviation is basically known as avionics. It encompasses the electronic systems and equipment integral to aircraft, including communication, navigation, and control systems. It is an integral part of any flying machine, be it an RC plane or drone.

Electronics of an RC Plane and drone includes a radio transmitter and receiver for controlling the airplane, servos for controlling the aircraft's control surfaces (such as the rudder, elevator, and ailerons), an electronic speed controller (ESC) for controlling the motor, a motor, a battery.

Avionics flowchart

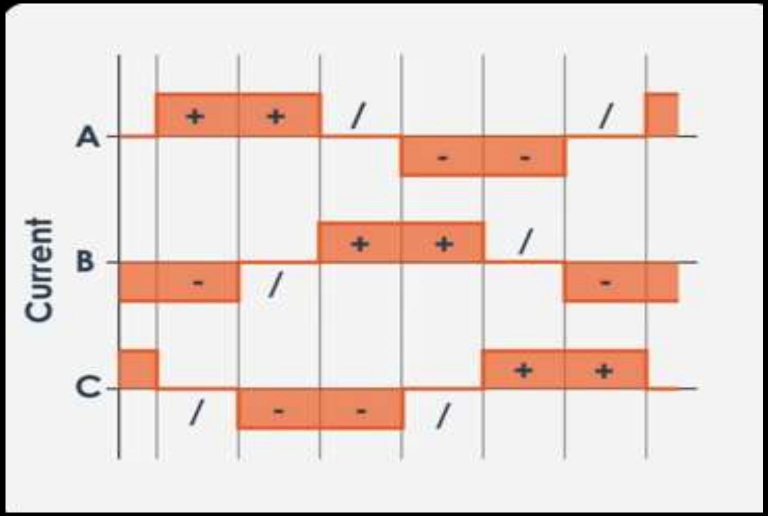


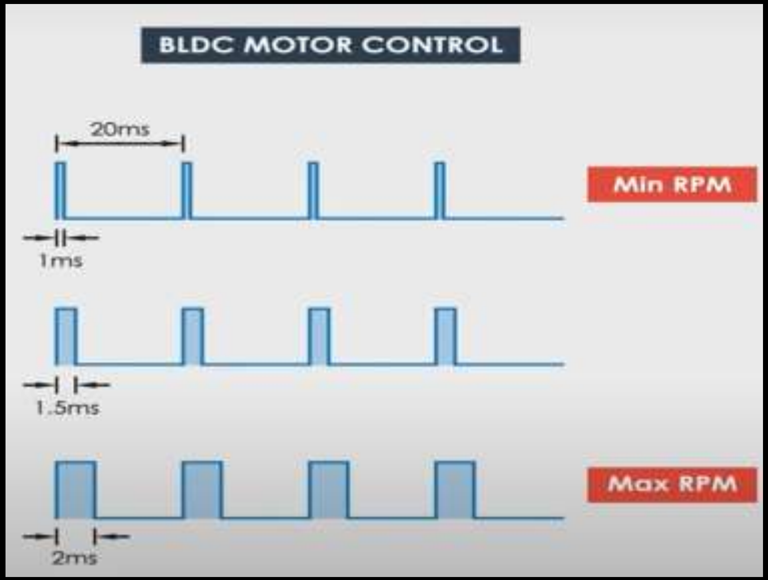
Bldc motors

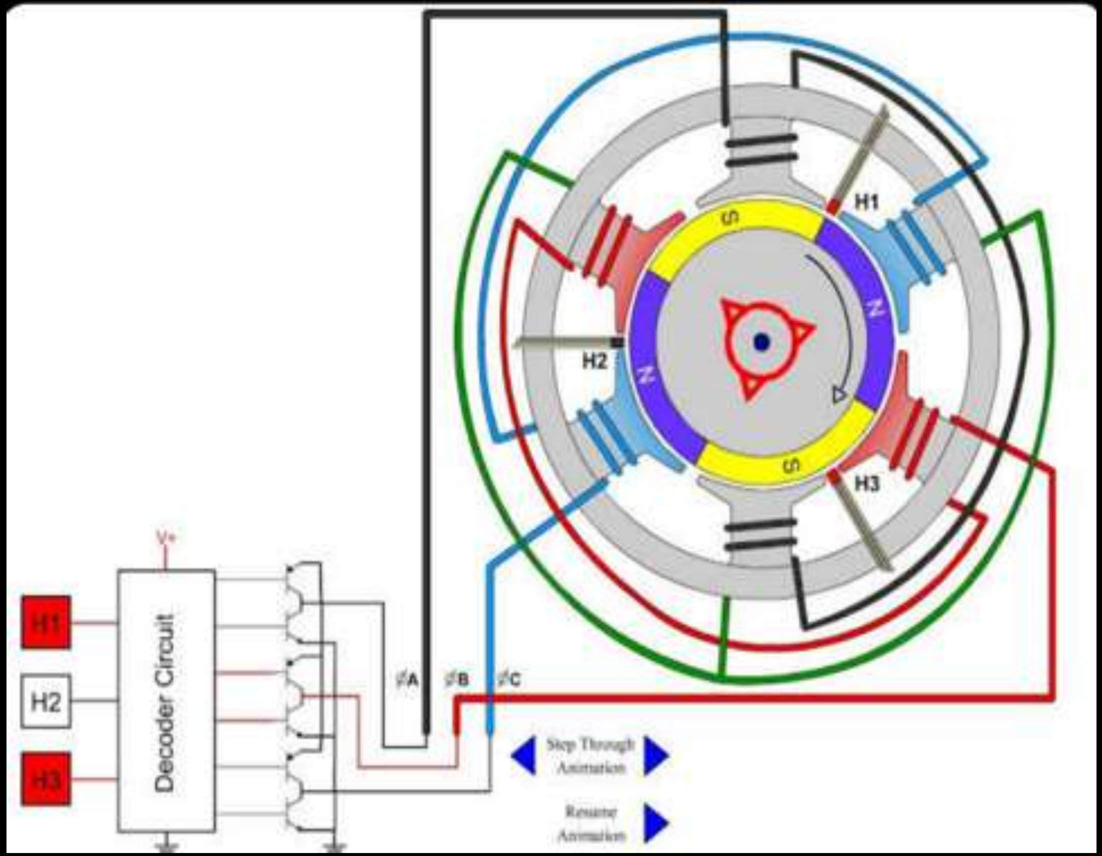
A brushless DC electric motor is a synchronous motor using a direct current (DC) electric power supply. It uses an electronic controller to switch DC currents to the motor windings producing magnetic fields which effectively rotate in space and which the permanent magnet rotor follows.

Motion is generated due to interaction between current and magnetic field. Also, brushless motors are more efficient and generate less heat than brush motors.

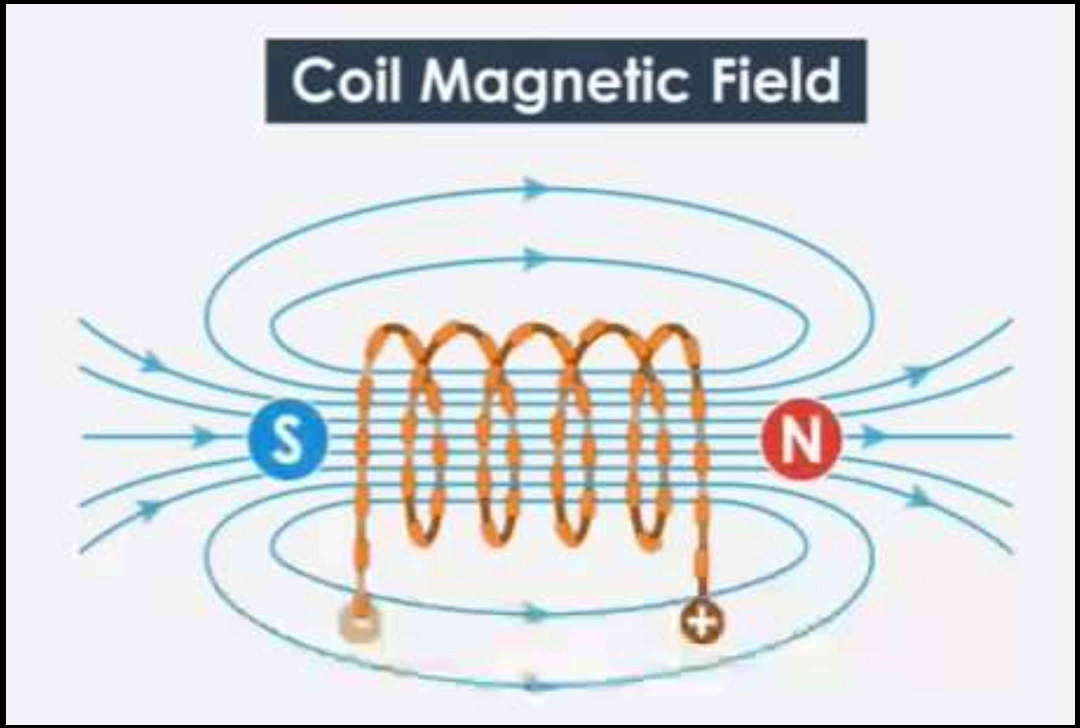
Bldc Motors Working Diagram

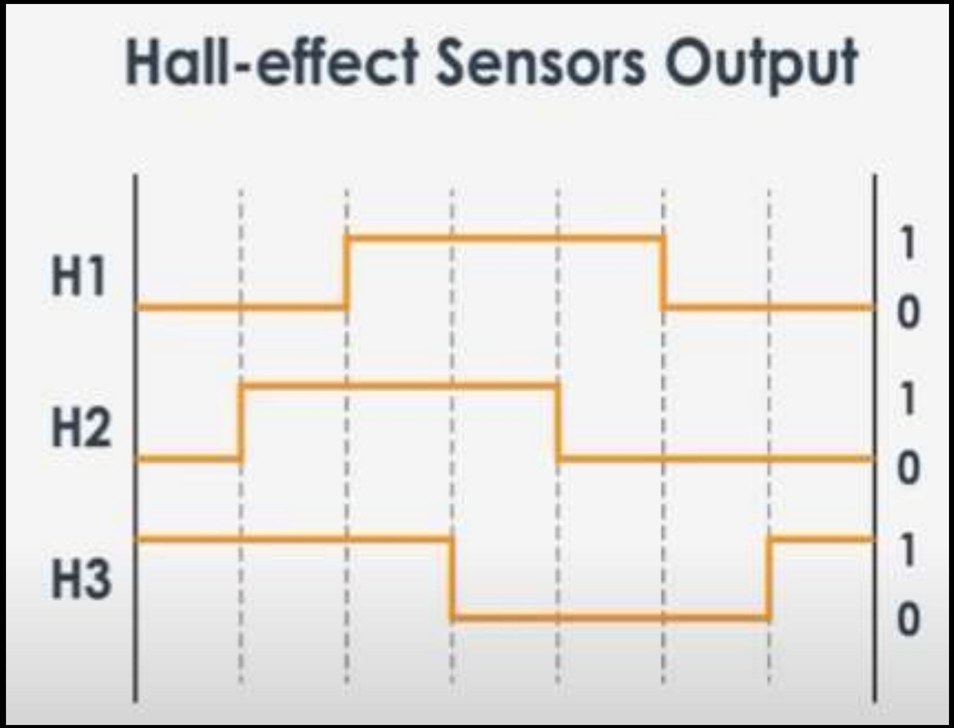




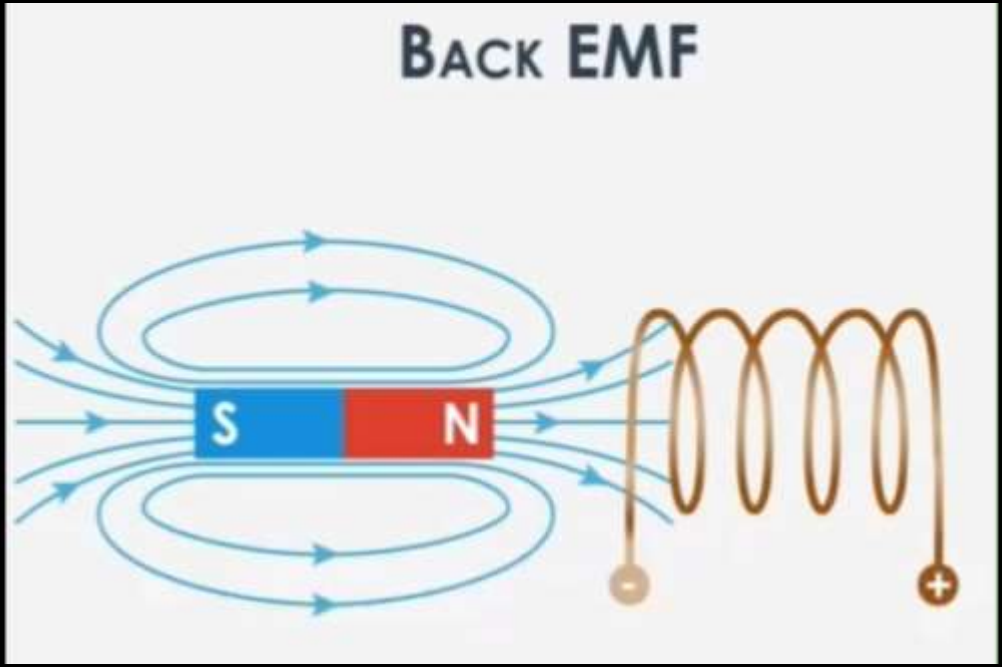


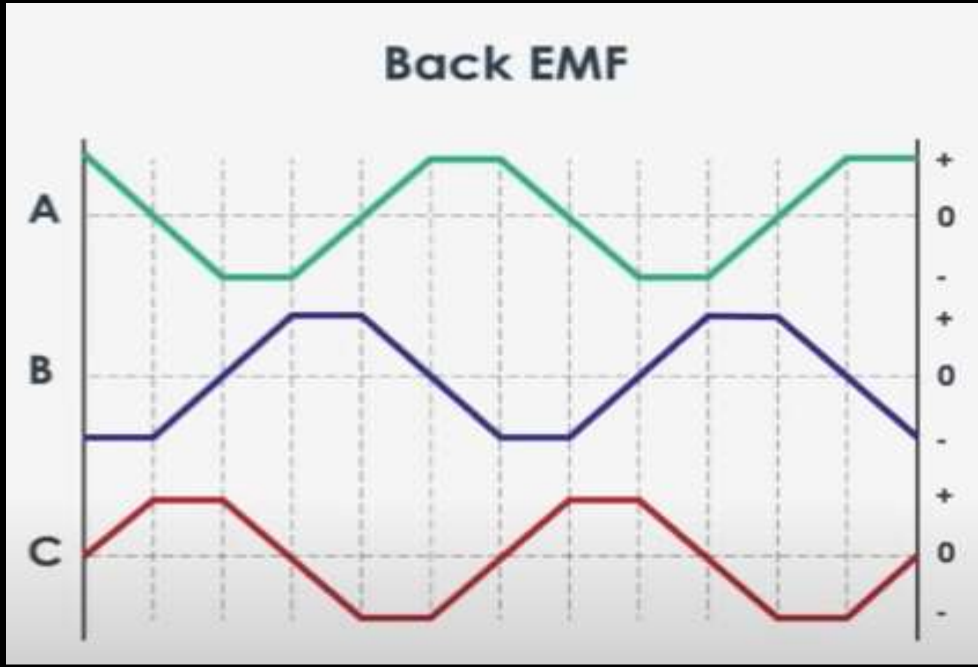
Bldc Motors Working





Bldc Motors Working





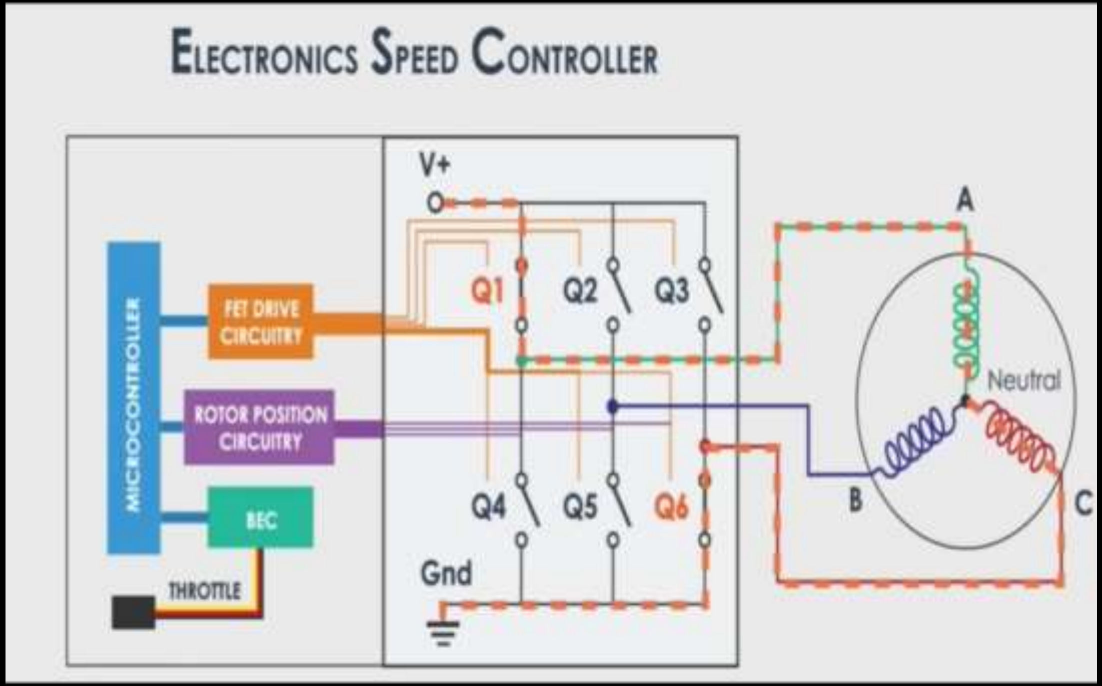
Electronic speed controllers

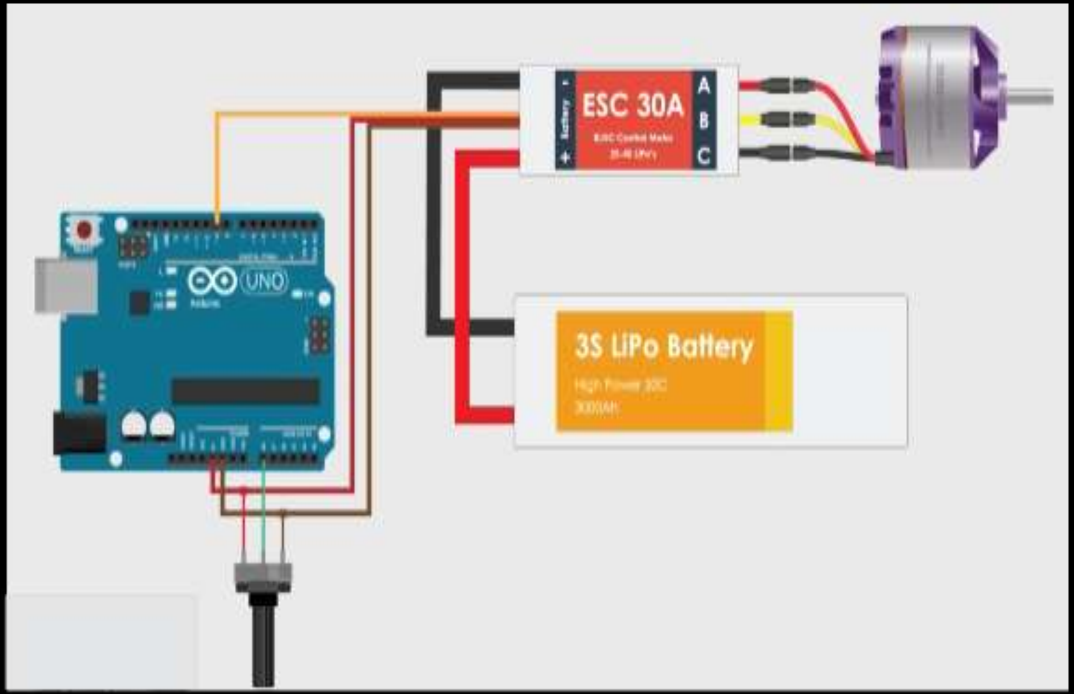
The Term ESC stands for Electronic Speed Controller and it works on PMW (Pulse Width Modulation) signals.

It Controls the speed and direction of motor by controlling the amount and direction of current supplied.

An electronic speed controller can be designed with three essential components like a voltage regulator/ BEC (Battery Eliminator Circuit), a Processer & the switching includes FETs.

Electronic Speed Controllers Working Diagram



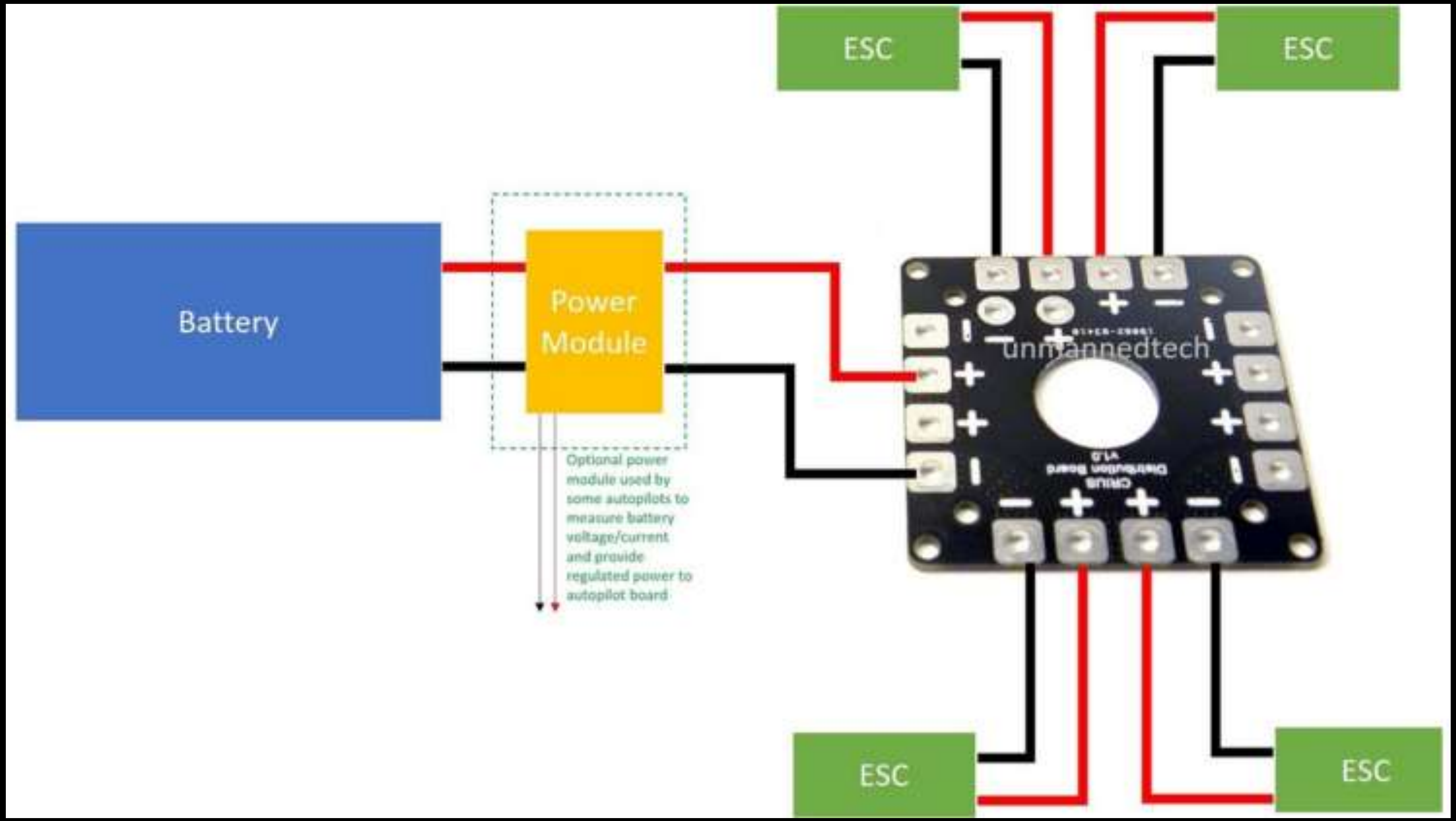


LIPO BATTERIES

A lithium-polymer battery (LiPo) is a rechargeable battery that, uses solid polymer for the electrolyte and lithium for one of the electrodes. They have high energy densities and are safer than Li-ion batteries. Commercially available LiPo are hybrids: gel polymer or liquid electrolyte in a pouch format, more accurately termed a lithium ion polymer battery.

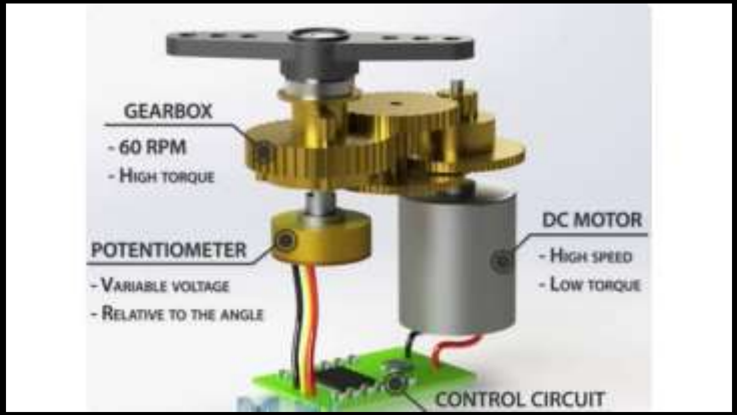
POWER DISTRIBUTION BOARD

It distributes power to all the electronic components.

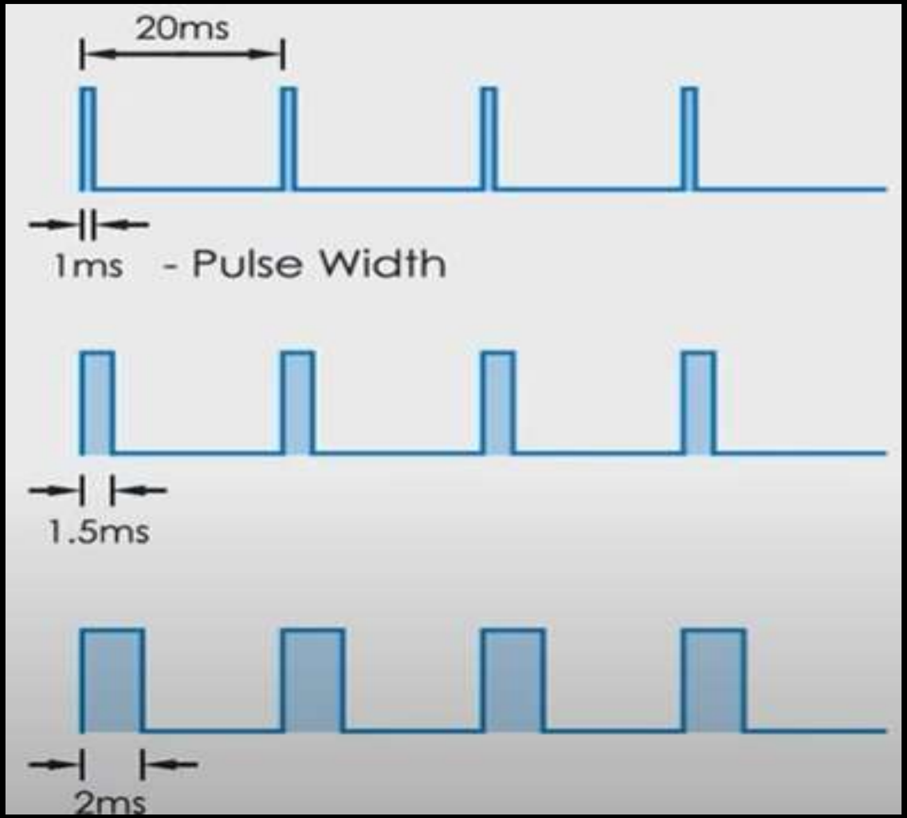


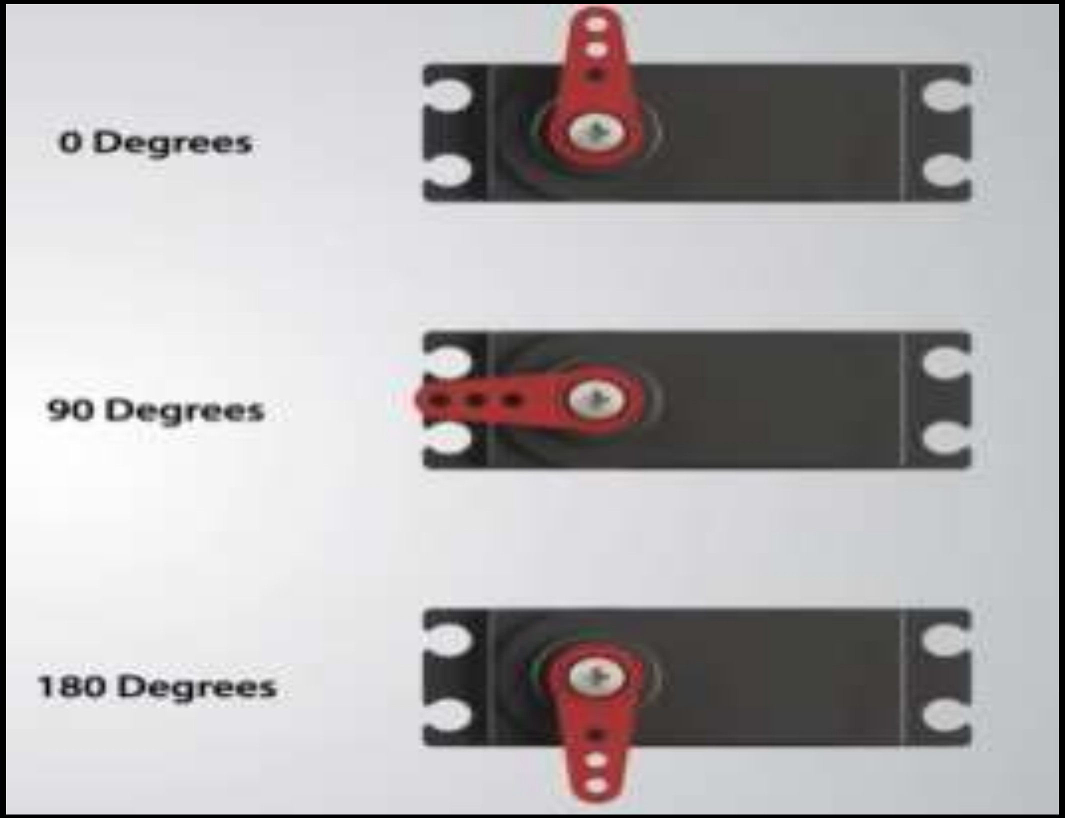
Servo motors

It is basically a combination of DC motor, control circuit and gears and it works on PWM (Pulse Width Modulation) signals. Normally this type of motor consists of a control circuit that provides feedback on the current position of the motor shaft, this feedback allows the servo motors to rotate with great precision. If you want to rotate an object at some specific angles or distance, then you use a servo motor.



Servo Motor Controls





gps

The Global Positioning System (GPS) is a satellite based navigation system that provides location and time information. A GPS receiver calculates its position by precisely timing the signals sent by GPS satellites. GPS is nowadays widely used and also has become an integral part of smart phones.

Flight controller

It controls the signals sent to the ESCs and It consists of several sensors like accelerometer, gyroscope which help to stabilise the drone and plane. It is used to stabilize the quadcopter during flight. Pixhawk 4 is an advanced autopilot designed and made in collaboration with Holybro and the PX4 team. To do so, it receives signals from sensors and sends them to the processor, which then sends the control signal to the ESCs, which in turn instructs the ESCs.

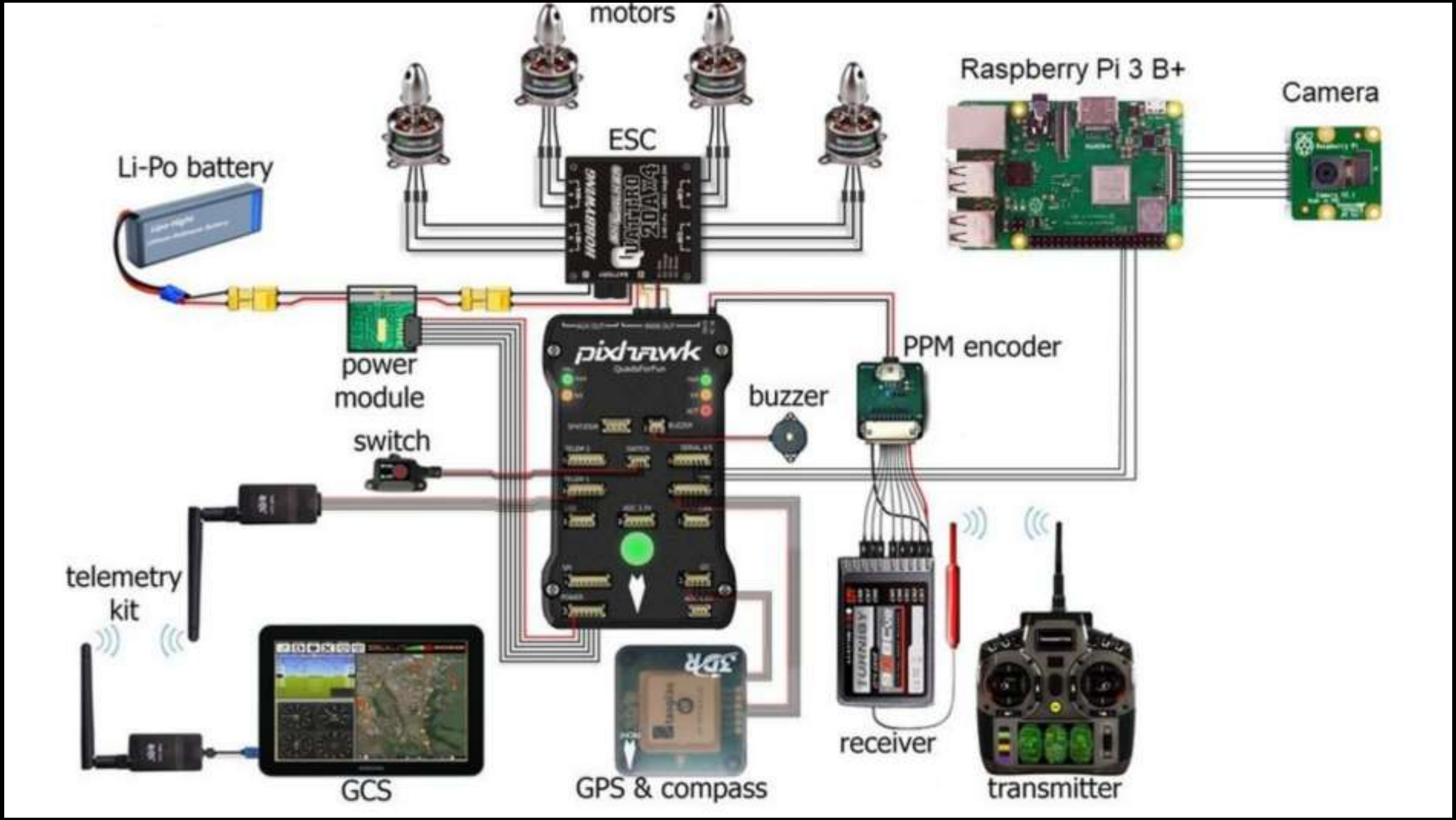
transmitter

This device used to transmit signal from one place to the other. The signal consists of information in the form of voice, video or data. It uses antenna to transmit the signal into the air.

Reciever

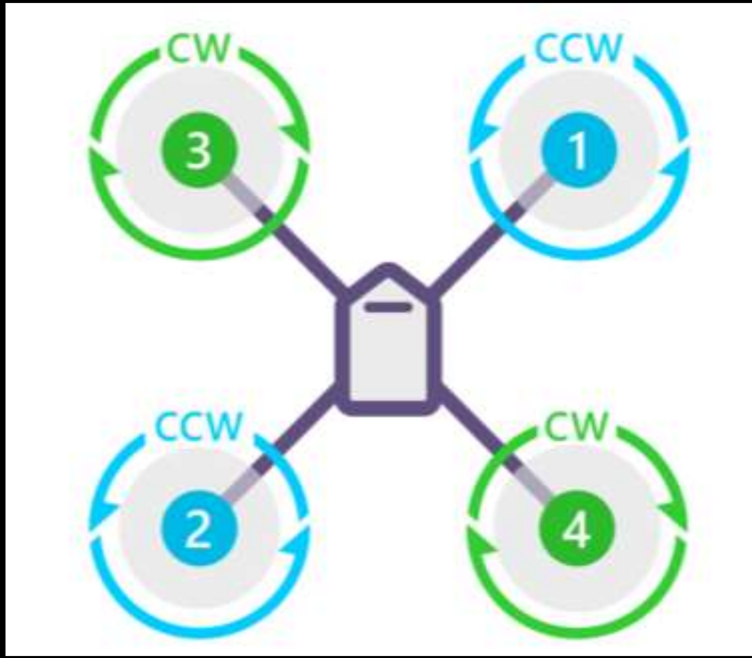
It decodes the transmitted information from the received signal. The receiver also uses antenna to receive the signal from the air similar to the transmitter.

Circuit diAGRAM



FLIGHT DYNAMICS

Pitch: Speed of motors 1 & 3 is reduced w.r.t. motors 2 & 4 for forward moment and the opposite is done for backwards moment.
Roll: Speed of motors 1 & 4 is reduced w.r.t motors 2 & 3 to roll towards right, and the opposite is done to roll towards left.
Yaw: Using the principle of Newton's Third law of motion, we can perform yaw motion. To do so, we reduce the speed of motors 3 & 4 w.r.t. motors 1 & 2 to induce a clockwise yaw and to the opposite for a counter-clockwise yaw.



QUADCOPTER

4 rotors located at the ends of a cross structure:

• Higher payload capacity.
• Maneuverability (e.g. traversing an environment with many obstacles or landing in small areas.

Controlled by varying the speeds of each rotor:

• Vertical Take Off and Landing (VTOL)
• hovering capability
• slow precise movements
• There are also definite advantages to having a four rotor based propulsion system

gallery

Thank you