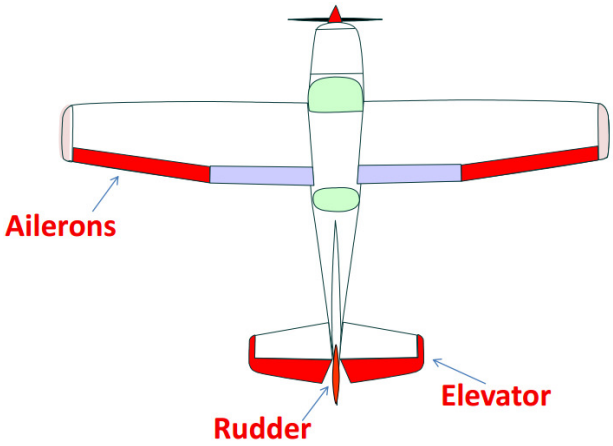
Theory Brief 1: Effects of Controls

Aim:

"To understand the effect of each control, how they work together and recognise the importance of 'stick and rudder' co-ordination."

Objectives:

1. Understand the fundamental aerodynamic effects of an aerofoil;
    a. How lift is produced
    b. The ways we can change the amount of lift
    c. The relationship between the production of lift and the subsequent by-product of drag
2. Understand the three axis of flight and Identify the controls both inside and outside the cockpit in;
    a. Longitudinal
    b. Lateral
    c. Vertical
3. Understand the Primary, Secondary and Further effects of each control input;
    a. Pitch
    b. Roll
    c. Yaw
    d. Power
    e. Trim
4. The student can understand the use of aileron and rudder inputs together in co-ordinated manner and to the correct quantity
5. Airmanship
    a. Definition
    b. Handover Takeover



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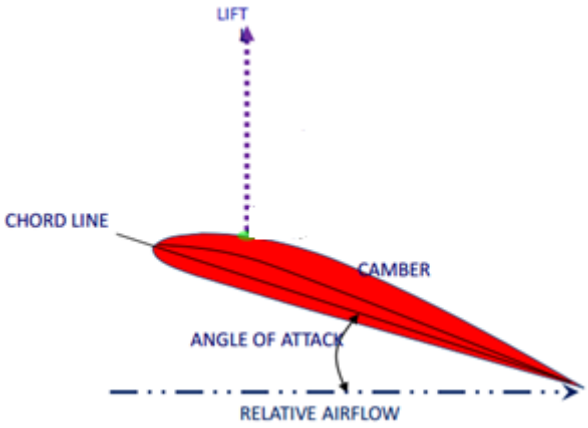
Aerodynamic Principles

The Aerofoil

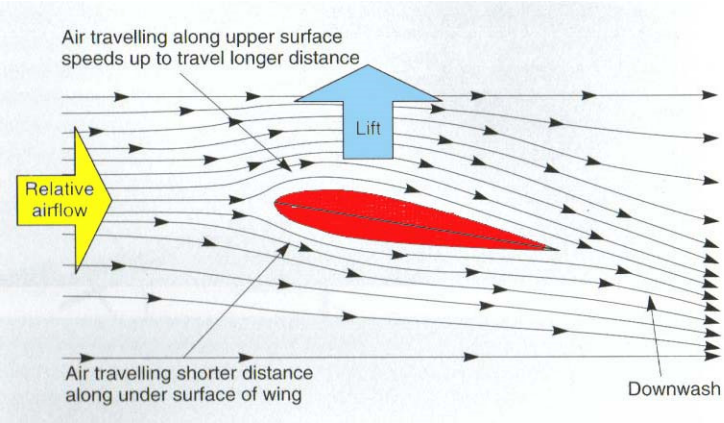
- Chord line: The imaginary line running from the leading edge directly to the straining edge (Reference line)
- Relative Airflow: Also known as 'Relative wind'
- Angle of Attack: The angle difference between the relative airflow and the chord line.
- Camber: the 'roundness' of the aerofoil
- Centre of Pressure: the centre of which the lifting force acts upon.

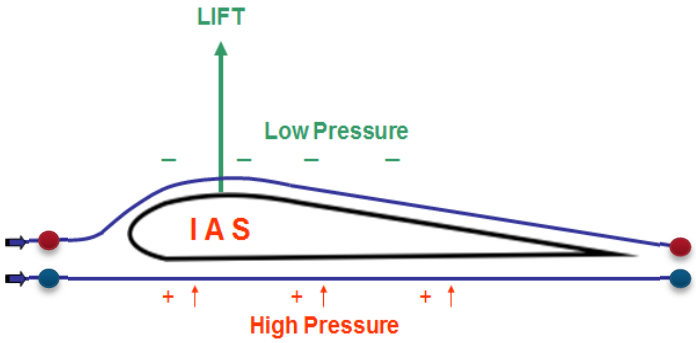


Production of Lift

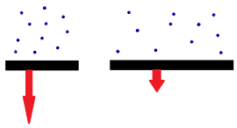
Bernoulli's Theorem

- Physicist discovered: "the amount of energy [over an aerofoil] remains constant"
- As a bi-product it was found if two molecules at the leading edge are separated (one travelling over, the other under), they will meet again at the trailing edge in the same amount of time.





- This meant, the particles flowing over the aerofoil are 'stretched' over the greater distance more than the particles flowing along the under surface of the wing.
- This results in a change in pressure
- As we know, pressure is defined as the amount of molecules acting on a given area. In figure to the right, the same amount of molecules 'pushing' downwards on a larger area give less pressure.



- So, there is less pressure on the upper surface (greater separation of particles) of the wing in comparison to the underside.
- Change in P x Area = Lift

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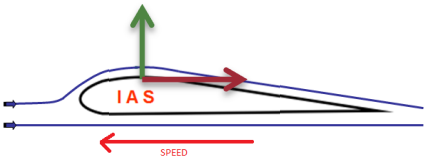
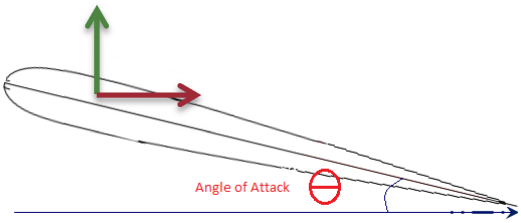
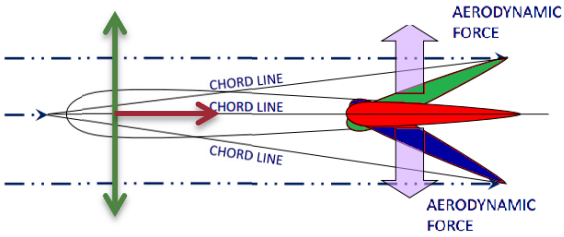
3 ways to change the amount of lift







Increase in Airspeed

Increases the amount of Lift

An increase in Angle of Attack increases the amount of lift

The change of shape of a surface can either increase or decrease the amount of lift produced.

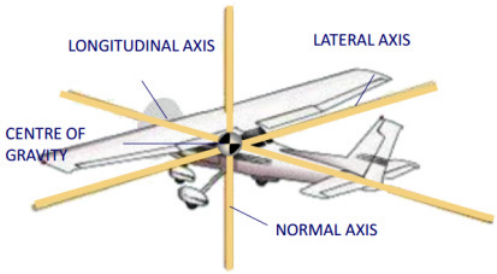
A downwards deflection changed the chord line to a greater angle of attack and hence increases lift.

Drag:

With any generation of lift also means creation of drag.

Therefore,

increase the amount of lift = increase the amount of drag



The Aircraft Control surfaces and Axis

Axis	Control	Control Input	1st Effect	2nd Effect	Further Effect
LATERAL PITCH	CONTROL STICK	Forwards	Nose Up	NIL	Indicated Air Speed
LONGITUDINAL ROLL	CONTROL STICK				Spiral Dive = Death Exceeding VNE
VERTICAL YAW	RUDDER				Spiral Dive = Death Exceeding VNE
	THROTTLE	PUSH IN = MORE PULL OUT = LESS			CLIMB DECEND
LATERAL PITCH	TRIM LEVER			NIL	Indicated Air Speed

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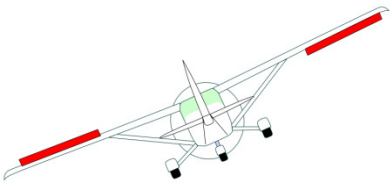
Secondary Effect of Controls

The effects of the controls, as described above, are referred to as the **primary** effects. However, when some of the controls move they also produce other effects, which are called **secondary** effects.

ELEVATORS

The elevators produce no secondary effects comparable with the other surfaces but may change the speed and altitude of the aircraft.

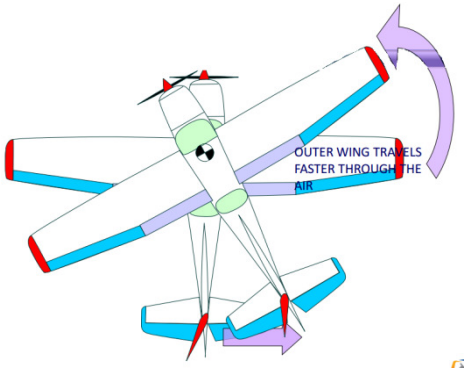
AILERONS



Controls moved to the left:

- Left aileron will move up and the right aileron down.
- Left aileron will effectively reduce the angle of attack in that region of the wing on which it is located, thereby **reducing the lift and drag**.
- Right aileron goes down; the angle of attack in that area of the wing is effectively increased, **increasing the lift and drag**.
- Due to the combination of reduced drag on the descending wing and increased drag on the rising wing, the aircraft will yaw in a direction opposite to that of the intended turn.
- This secondary effect of the ailerons is known as **adverse aileron yaw** or aileron drag. It has the effect of yawing the nose "out of the turn" and thus causing it to slip. This yaw can be countered by use of the rudder.

RUDDER



Aircraft yawed left:

- For a short time, the right wing speeds up and the left wing slows down to the relative airflow.
- As a result, more lift is generated by the right wing than by the left and the aircraft rolls to the left. Thus the secondary effect of the rudder is roll.

TRIM

- An aircraft is said to be "trimmed", when there is no necessity for the pilot to apply any elevator control pressure to maintain the flight attitude.
- This is usually achieved by the use of trim tabs, but in the case of the Jabiru, **elevator trim** is by way of an adjustable tensioned bungie cord which applies enough load to the elevator, relieving load to the control column.

THROTTLE

- Applying throttle creates power from the engine to increase the thrust from the propeller, thus causing the aircraft to move forward; until drag increases to halt the acceleration (drag is equal to thrust).
- Increasing thrust increases slipstream rearwards, which creates improved responsiveness of the rudder and elevator. Decreasing thrust reduces slipstream rearwards, which reduces effectiveness of the rudder and elevator.
- Increasing thrust has the effect of raising the nose and yawing the Jabiru to the left (right hand spinning propeller). Decreasing thrust has the effect lowering the nose and yawing the Jabiru to the right (right hand spinning propeller).
- Depending on the aircraft, this can be different for other aircraft types.

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Airmanship

Definition:

Airmanship can be defined as the "art of handling an aircraft".

To put it simply, it's to be courteous on the ground and in the air to yourself, your crew and others, whilst having a complete understanding of cause and effect when operating the aircraft.

It requires the combination of:

1. Personal discipline
2. Skill
3. Proficiency

Once this is in place, one needs to have good knowledge of

1. Self
2. Team
3. Risk
4. Environment
5. Aircraft
6. Mission

This will lead to better Situational Awareness, thus enabling you to exercise good judgement which, in turn, promotes good airmanship.

Handover /Takeover

To prevent any confusion in the cockpit as to who is flying the aircraft, the 'handover takeover' technique is used.

Instructor: "you have control"	Instructor maintains control of throttle, control stick and rudder until student also holds the throttle, control stick and rudder. Only then –
Student: "I have control"	Only now can the instructor release the controls and the student is flying.

Note that:

This technique applies when two (2) pilots are in the cabin

In the event of an emergency, the "Pilot in Command" will take control and will state 'I have control'.

In the event of an emergency with a student pilot, the instructor is the "Pilot in Command".

Air exercise:

This flight is an opportunity for the student to fly the aircraft and gain an awareness of the controls and their effects, as well as gaining some "feel" for the aircraft and flight in general.