Principles of Flight

Chapter 1 Lift and Weight

- **Sir Isaac Newton**- 'for **every action, there is an equal and opposite reaction**'. E.g. a car weighing 1 tonne parked on the road would press down on the road with a force of 1 tonne - so from Newton's law; to support the car, the road must press up with a force of 1 tonne.

Wind Tunnel Tests

Changes in speed

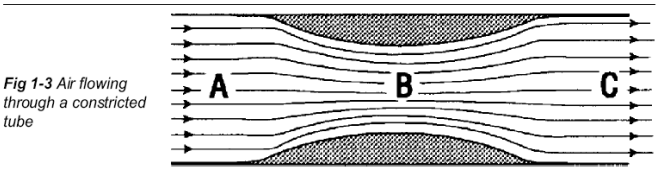


Fig 1-3 Air flowing through a constricted tube

- The amount of air leaving the tunnel must be the same as the amount of air entering it. Therefore, the **air must speed up to pass through the narrowest point**. A to B - Airspeed increases with a Maximum at B.
- These speed changes have an effect on the **pressure of the air**; when air is moving in a streamlined flow (i.e. smooth and not turbulent) when the **airspeed increases**, the **air pressure decreases** and vice versa.

Lift

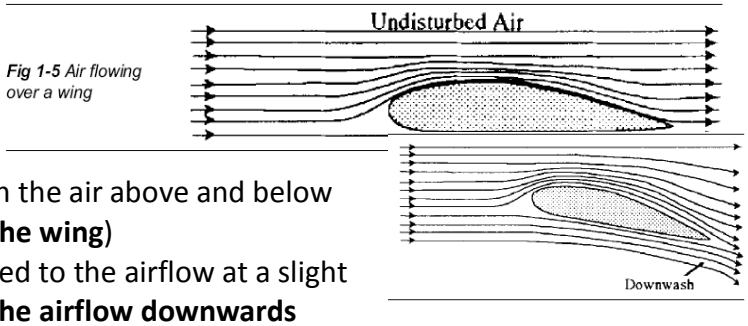
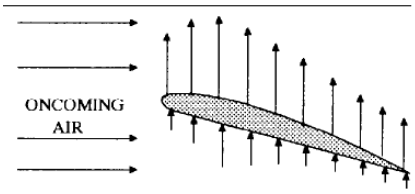


Fig 1-5 Air flowing over a wing

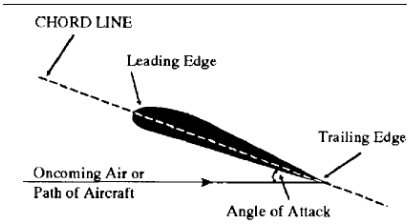
- The air flows over the wing at an increased speed - and therefore at a reduced pressure - compared with the surrounding atmosphere.
- The resulting pressure difference between the air above and below the wing lifts it up. **(high pressure below the wing**)
- In most flight conditions, the wing is inclined to the airflow at a slight positive angle so that it **deflects some of the airflow downwards** producing 'd**ownwash**' contributing to lift.

Distribution of lift



- Lift is not distributed evenly around the wing.
- The top surface normally generates more lift than the bottom surface
- **All lift forces act at 90° to the direction of the airflow** - which is the same as the flight path of the aircraft.

How Lift Varies



a. **Airspeed**: Double the airspeed gives four times the lift; treble the airspeed gives nine times the lift, and so on.

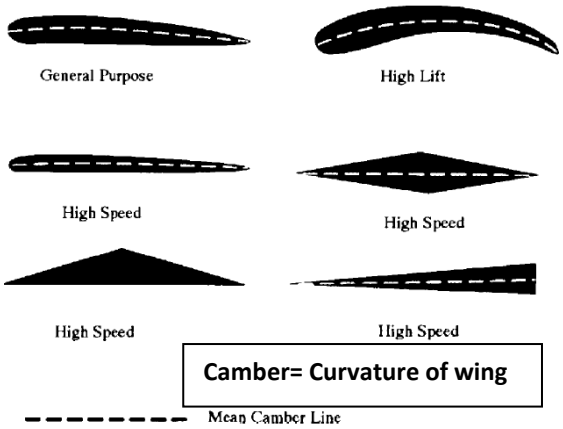
b. **Angle of Attack**: This is the angle between the chord line of the wing and the oncoming air. The amount of lift will increase until the angle reaches about 15°, If the angle of attack is increased beyond this point, the lift rapidly decreases and the wing is stalled.

c. **Air Density**: If the air becomes 'thinner' or less dense (and this can happen with increases of height, temperature or humidity), the amount of lift is reduced.

d. **Wing Shape and Area**.

Fig 1-11 Hinged flap increases camber

Fig 1-12 Fowler flap increases camber and wing area



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Chapter 2 –Thrust and Drag

Thrust

- To generate lift airflow is needed. This is produced by 'thrusting' the aircraft forwards through the air – which is done by the **engine.**
- The engine **throws air backwards**, either by having a propeller which 'screws' the air backwards or by expelling air from the rear, in the case of a jet engine. In both cases, throwing the air backwards thrusts the aircraft forward (**Equal and opposite reaction**)

Drag

- **The faster you go, the more air resistance you encounter - 'Drag'.**
- Every part of the aircraft over which the air flows produces drag which **resists forward motion.**
- It can be reduced by **streamlining** which makes the airflow as smooth as possible.

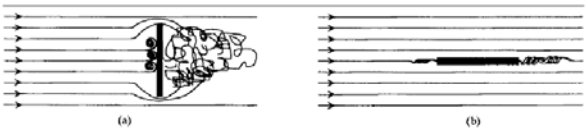

Fig 2-1 Flat plate: a) at 90° to the airflow b) parallel to the airflow

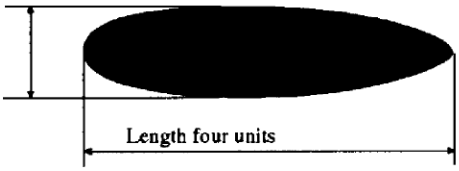

Fig 2-5 Fineness ratio

Variation of Drag with Airspeed

- The amount of drag varies with the square of the airspeed - that is, at **twice the airspeed there is 4 times as much drag.**

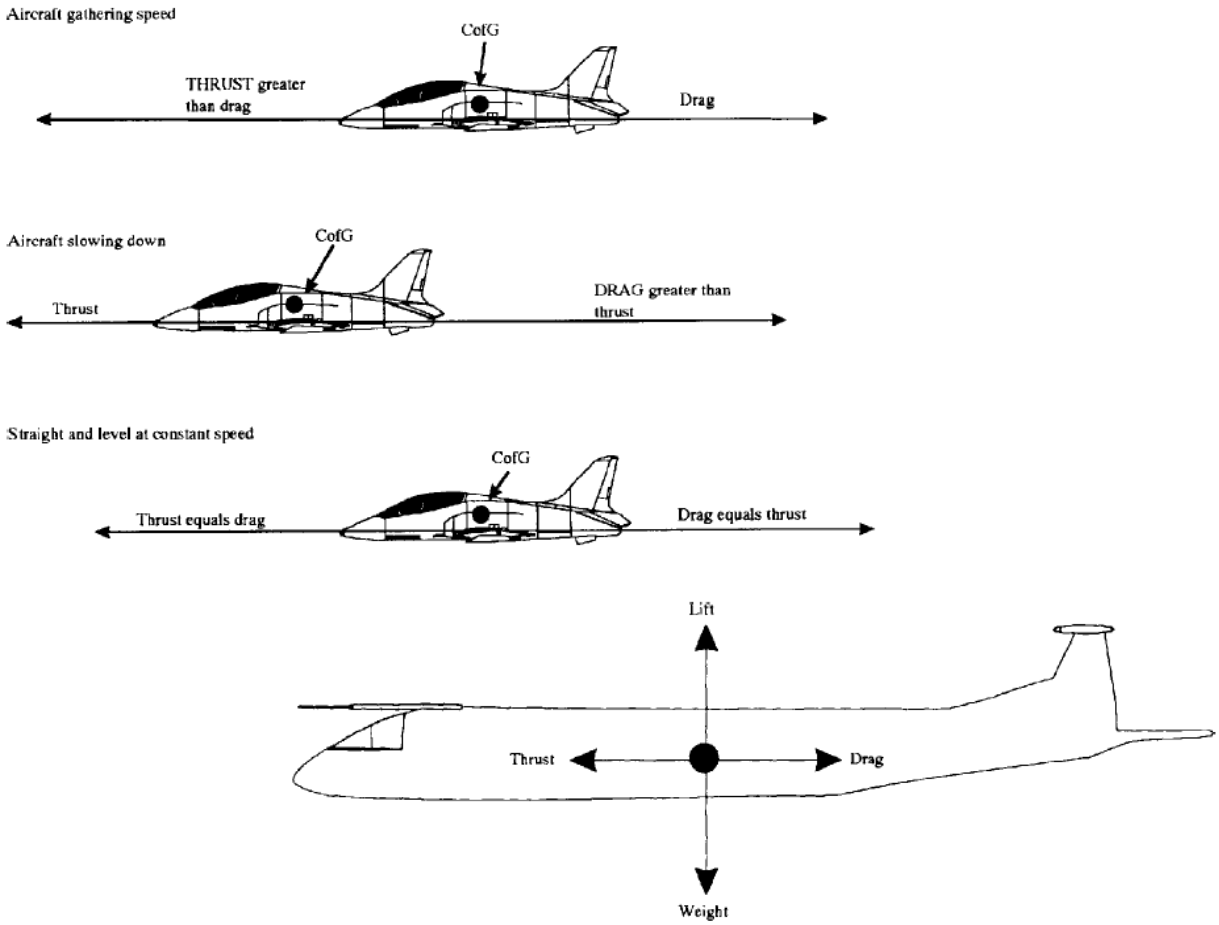

***Fig 2-7** Aircraft forces in balance*

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