GREENWOOD MILITARY AVIATION MUSEUM

Flight Education Reference Manual

THE FORCES OF FLIGHT

GMAM FltEd Program
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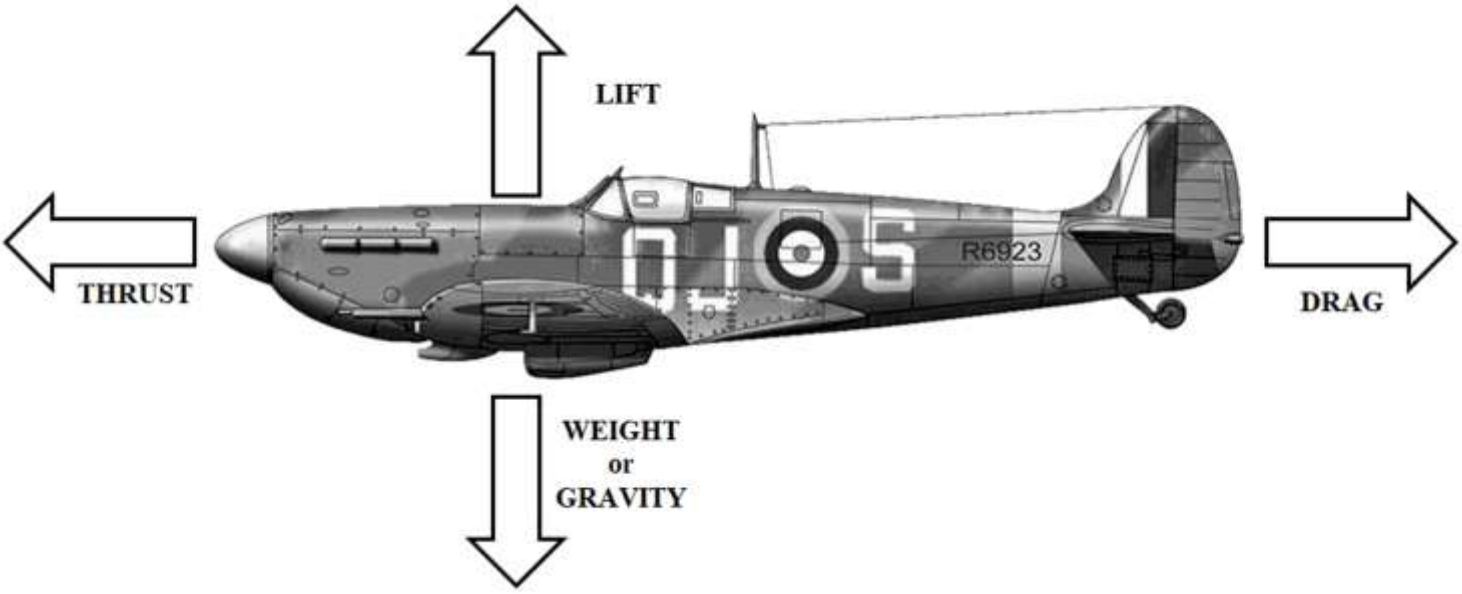
THE FORCES of FLIGHT
(Basic Aerodynamics)



While in flight, there are four (4) forces acting upon an aircraft:

THRUST: The force that causes forward motion of the airplane

LIFT: The force that causes an airplane to rise into the air

DRAG: The force that tries to hold an airplane back.

WEIGHT or GRAVITY: The force that tries to make an airplane return to lift.

When an airplane is simply cruising along, all of the forces are equal. The airplane will maintain a steady speed and altitude.

When ***"THRUST"*** becomes the strongest force, the airplane will accelerate or go faster.
When ***"LIFT"*** becomes the strongest force, the airplane will ascend or go higher into the air.
When ***"DRAG"*** becomes the strongest force, the airplane will slow down.
When ***"Weight or Gravity"*** becomes the strongest force, the airplane will descend or come down.

The "Forces of Flight" can be manipulated by the pilot to achieve controlled flight and make the airplane go where he wants it to go. The airplane's controls and flight surfaces are used to achieve this controlled flight.

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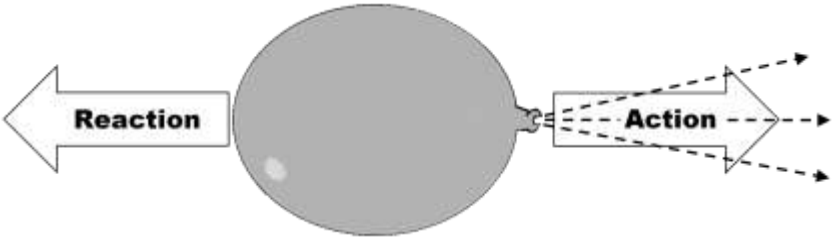
THRUST:

Sir Isaac Newton's 3rd Law of Motion: ***"For every action, there is an equal and opposite reaction".***

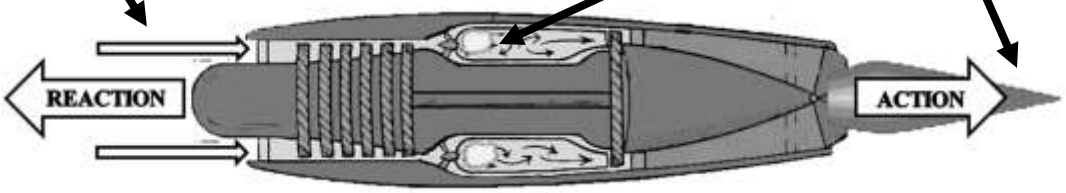


When the air escapes from an inflated balloon *(Action)*, the balloon will shoot forward *(Reaction)*. The forward motion of the balloon is *"THRUST"*.

1. Air drawn into the front of the engine

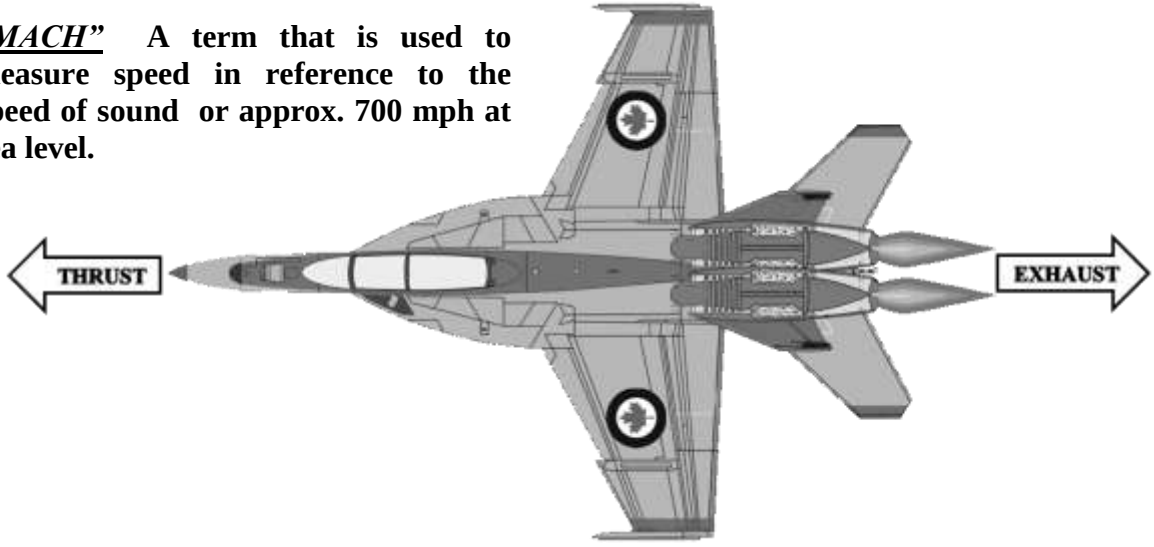
2. Air / fuel mixture compressed and ignited

3. Hot gasses shoot out the rear of the engine



A jet engine produces "thrust" sort of like the balloon does. Air is sucked into the font of the engine, compressed, mixed with fuel, and ignited. The hot gasses created then shoot out the rear of the engine with great force *(Action)*, causing the whole engine to move forward *(Reaction)*. Again, this forward motion is known as *"THRUST"*.

"MACH" **A term that is used to measure speed in reference to the speed of sound or approx. 700 mph at sea level.**



The Canadian CF-18 jet fighter has two powerful jet engines. As the hot gasses shoot out the back, the engines move forward taking the jet with them. The *"THRUST"* produced by these engines can move the CF-18 forward at a speed of *"Mach 1.5"* or nearly 1150 miles per hour.

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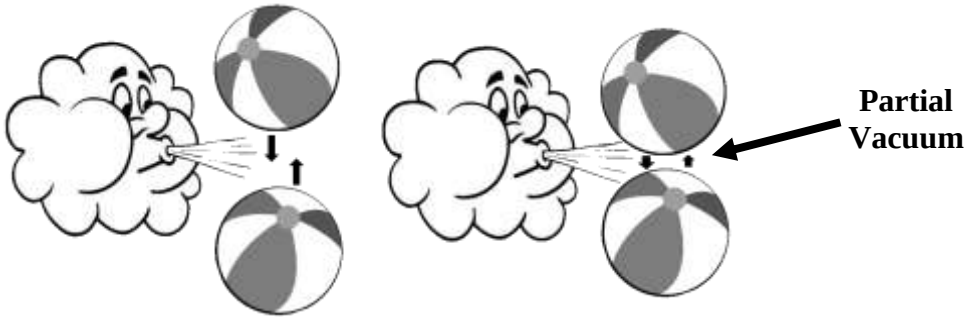
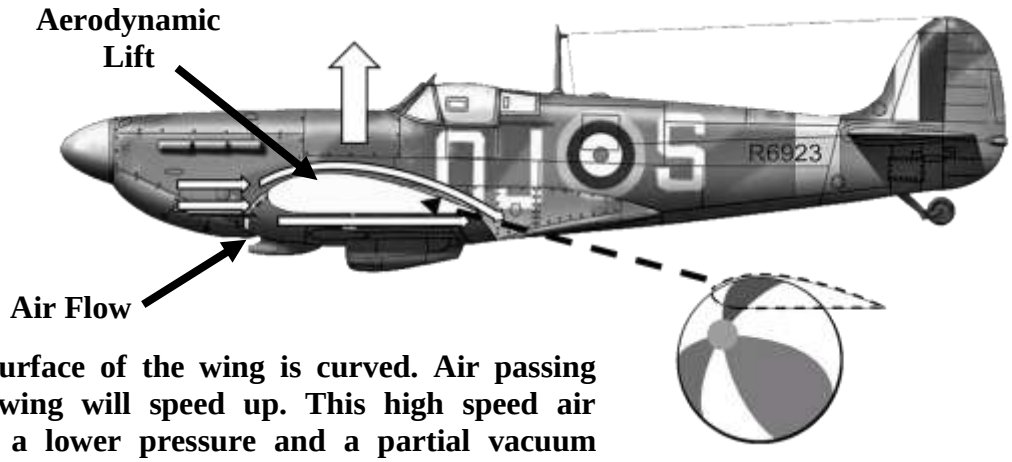
LIFT:

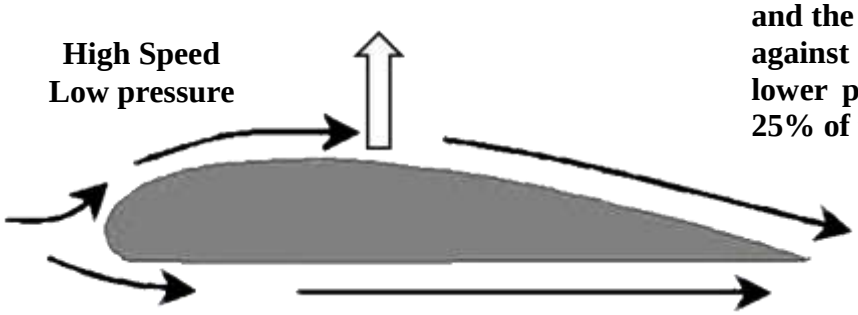
Bernoulli Principle: ***When air passes over a "curved" surface the velocity of the air will increase resulting in a lower pressure creating a partial vacuum.***



The velocity of the air passing over the curved surface of the beach-balls will increase. This will cause a lower pressure and result in a partial vacuum. Instead of the balls being blown away from each other, they will be sucked toward each other.



The top surface of the wing is curved. Air passing over the wing will speed up. This high speed air results in a lower pressure and a partial vacuum being created. This aerodynamic lift is approx. 75% of the total lift produced by the wing.



The airflow on the bottom of the wing is travelling slower and the pressure is higher. This high pressure air will push against the bottom of the wing as it tries to flow into the lower pressure area on top of the wing. This is approx. 25% of the total lift produced by the wing.

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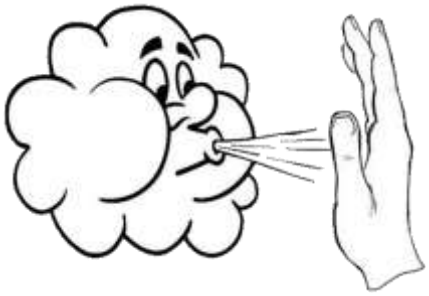
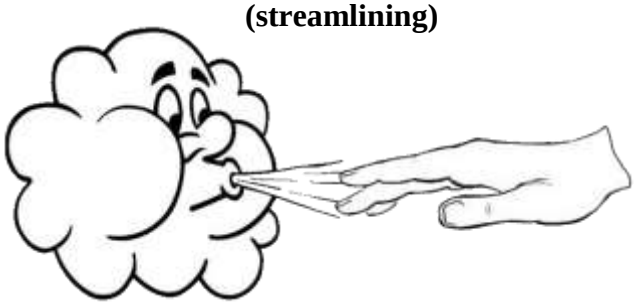
DRAG:

High Drag – High Resistance

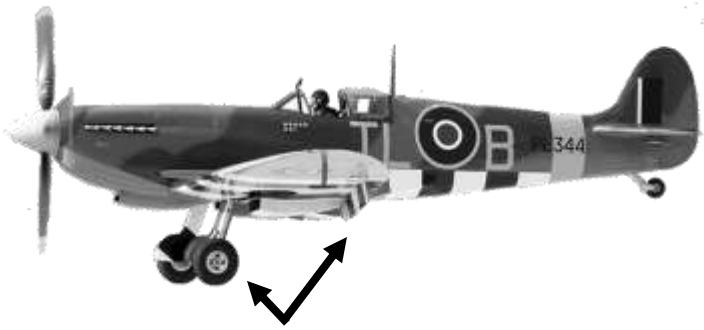


When you hold your hand perpendicular to a moving airstream – *(in a breeze or out the window of a moving vehicle)* – the force of the air trying to push your hand back is drag.

Low Drag – Low Resistance (streamlining)

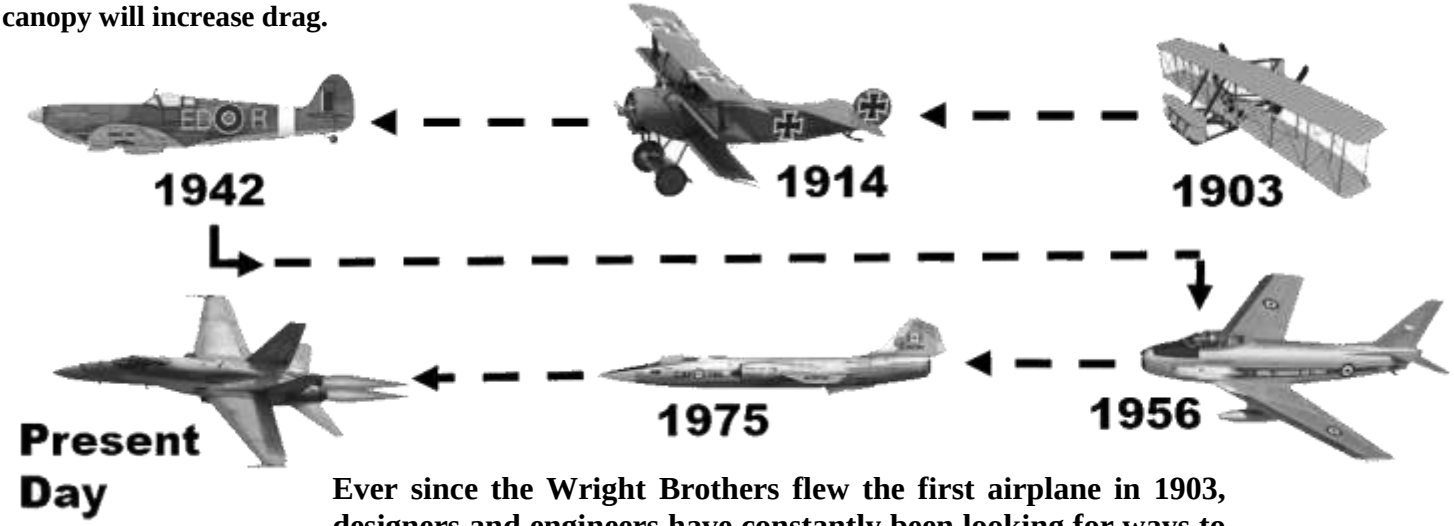


When you position your hand more parallel to the airstream, you can feel that the drag is very much reduced. This is known as streamlining.



On an airplane, any objects protruding into the airstream will cause drag. The landing gear and flaps in the "down" position along with the open canopy will increase drag.

With the landing gear up, flaps up, and canopy closed, drag will be very much reduced and the airplane is more streamlined.



Ever since the Wright Brothers flew the first airplane in 1903, designers and engineers have constantly been looking for ways to increase "Thrust" and decrease "Drag".

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GRAVITY (Weight)

What is Gravity: ***The acceleration of a freely falling object under the influence of "GRAVITY" is expressed as a rate of velocity increase per unit of time that amounts to a value of 9.81 meters (32.2 feet) per second.***

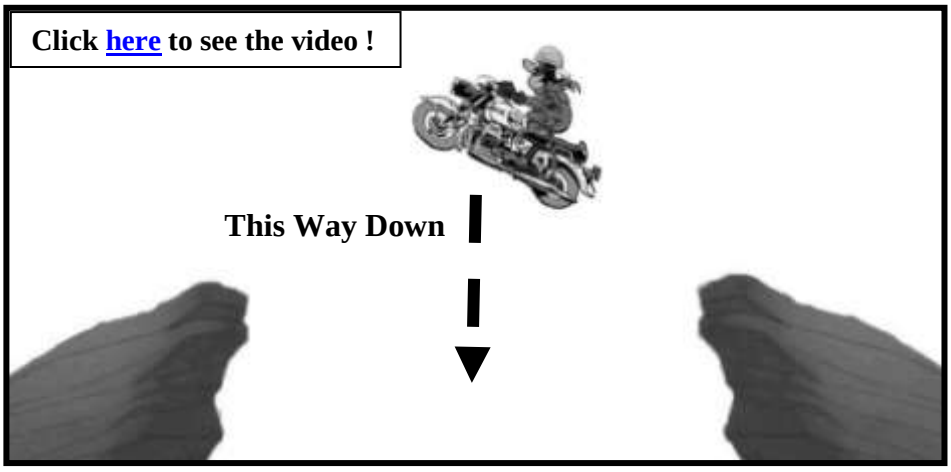
"Huh ???"

The natural force that causes any un-supported object to fall rapidly toward solid ground is known as *"GRAVITY".*

"OR" More Simply

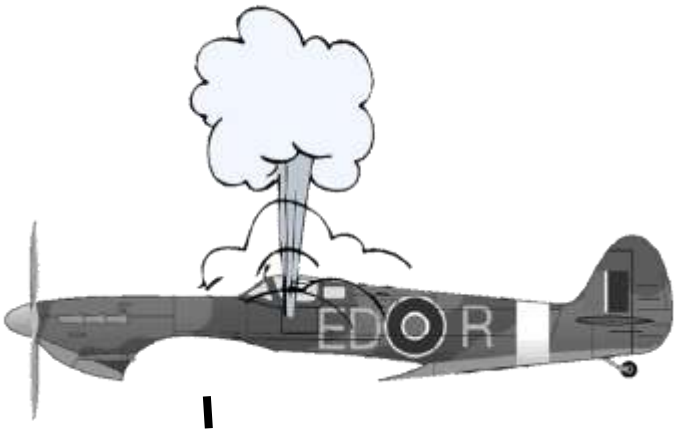
When the motorcycle tries to jump the cliffs …. Gravity will do its' thing.

Usually - "NOT GOOD"



The wing(s) provide an airplane with the support needed to overcome gravity. Without its' wings, an airplane would meet the same fate as the poor motorcyclist missing his cliff jump.

Gravity can be useful also – if an airplane's engine suddenly stopped, *"GRAVITY"* can be used as a source for *"THRUST".* As the airplane glides back toward earth, the thrust provided by gravity allows air to continue flowing over the wings to create *"LIFT"* while *"DRAG"* works with gravity to bring the airplane back to earth



No Wing
No Support
No Control
This Way Down