

PRINCIPLES OF FLIGHT 1



LECTURE ONE: THE ATMOSPHERE, LIFT

1. The Atmosphere
2. The Basics of Lift
3. Aircraft Design and Lift



THE ATMOSPHERE: BASICS



The ATMOSPHERE is a parcel of gases held to the earth by gravity

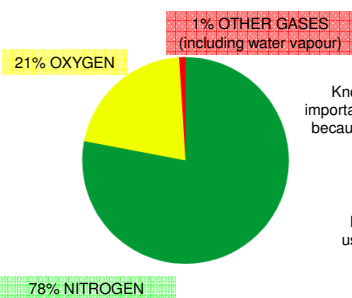
Due to the fact that the earth ROTATES, the atmosphere is flung outwards at the equator meaning that it extends further toward space at the EQUATOR than at the POLES

This is magnified by the fact that the air is hotter at the equator and rises



THE ATMOSPHERE: COMPOSITION

GROUND
SCHOOL



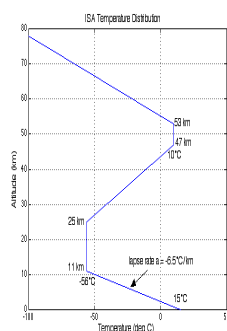
Knowledge of the atmosphere is important to pilots and aircraft designers because it is the medium we fly in and the air we breathe!

It is what the aircraft engine uses for combustion and what keeps us airborne



INTERNATIONAL STANDARD ATMOSPHERE (ISA)

GROUND
SCHOOL



ISA is a measuring stick against which we can compare the actual atmosphere to a convenient constant atmosphere

Some instruments, such as the **Air Speed Indicator** are calibrated to ISA conditions

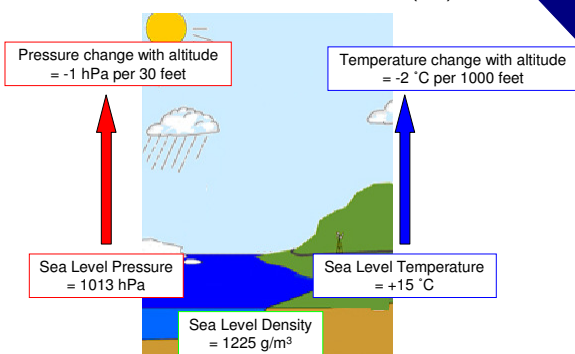
Aircraft take-off, landing and climb performance may be based on ISA conditions

If the temperature at a certain altitude is colder or hotter than it should be under ISA, this will affect how the aircraft or the instruments perform in relation to their published performance criteria



INTERNATIONAL STANDARD ATMOSPHERE (ISA)

GROUND
SCHOOL



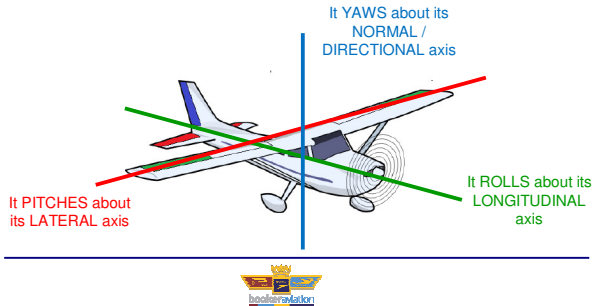
THE BASICS

GROUND
SCHOOL

Principles of Flight deals predominantly with AERODYNAMICS.

Before we start, we need to be sure of some definitions...

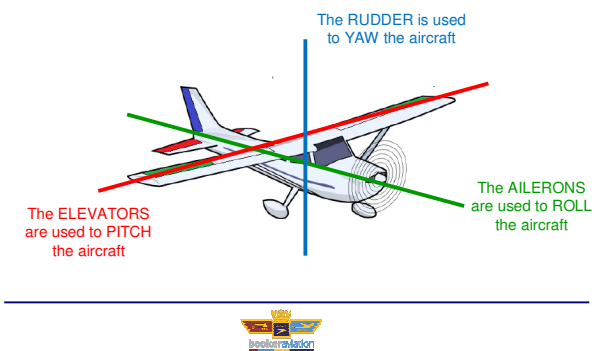
The Aircraft moves around three axes



THE BASICS

GROUND
SCHOOL

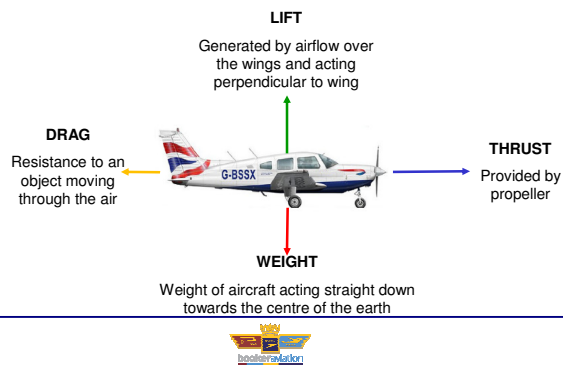
So how do we make the aircraft move about these axes?



THE BASICS

GROUND
SCHOOL

As pilots, we are trying to control these basic FORCES in flight:



THE BASICS

GROUND
SCHOOL

The way in which these forces are balanced (or not) defines the way in which the aircraft flies.

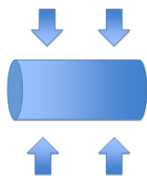


We are going to look at each in turn ... firstly in this lecture – Lift



FOUR FORCES: LIFT

GROUND
SCHOOL

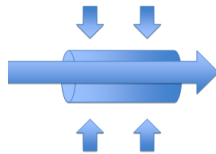


STATIC PRESSURE

Pressure exerted by the atmosphere
We feel this all the time

DYNAMIC PRESSURE

Caused by movement through the air
As the speed increases so does the dynamic pressure



FOUR FORCES: LIFT

GROUND
SCHOOL

Static Pressure + Dynamic Pressure = constant

Low velocity High Static Pressure High velocity Low Static Pressure Low velocity High Static Pressure



If static pressure falls, dynamic pressure must increase to maintain the constant

If you get two pieces of paper and blow between them they will get "sucked" together as the static pressure reduces with increased dynamic pressure

This is **Bernoulli's Principle**:

static pressure + dynamic pressure = total pressure



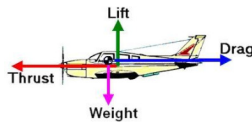
FOUR FORCES: LIFT

GROUND
SCHOOL



If the same diagram is split in half
the same effect will happen

Now let's change that diagram a little...



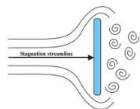
So if we now imagine a wing –
we have just created lift!



FOUR FORCES: LIFT

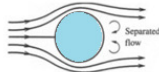
GROUND
SCHOOL

So why are wings shaped as they are?



FLAT PLATE

Great in one direction but always some, or
perhaps a lot of stagnant airflow which creates
drag



BALL

Too much separated flow at the rear of the object



AEROFOIL

Not perfect but close!



FOUR FORCES: LIFT

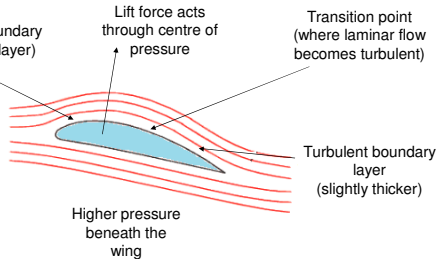
GROUND
SCHOOL

Laminar flow boundary
layer (very thin layer)

Lift force acts
through centre of
pressure

Transition point
(where laminar flow
becomes turbulent)

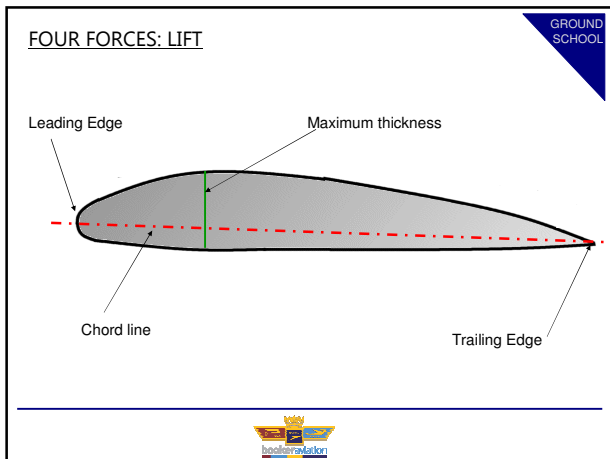
Relative
Airflow

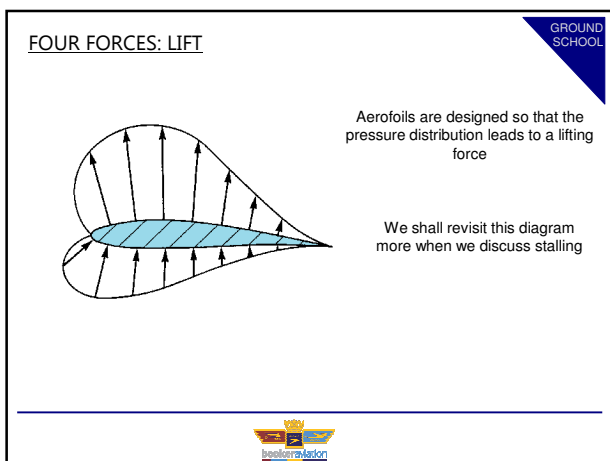


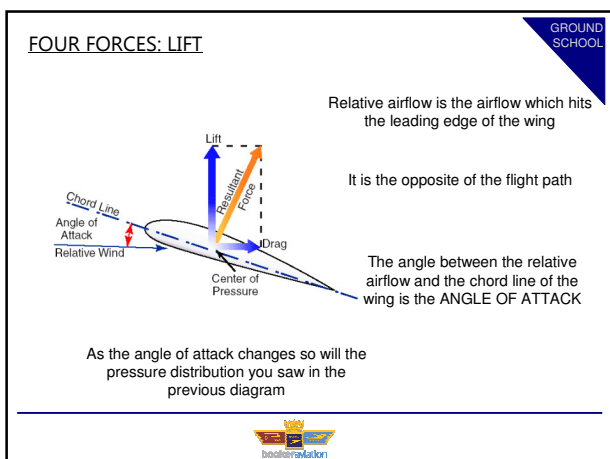
Higher pressure
beneath the
wing

What are the bits of the wing called? ...









FOUR FORCES: LIFT

GROUND
SCHOOL

We couldn't avoid formulas for ever ...

AIR DENSITY
(decreases with
increasing altitude)

WING SURFACE AREA
May be changed by
some flaps (more later)

$$\text{Lift} = C_L \frac{1}{2} \rho v^2 s$$

COEFFICIENT OF LIFT
Includes many things but
one important one is angle
of attack of the wing

VELOCITY
Combination of wind
speed and forward speed



FOUR FORCES: LIFT

GROUND
SCHOOL

The lift force is perpendicular to the relative airflow and depends upon:

Wing Shape

Angle of Attack

Air Density

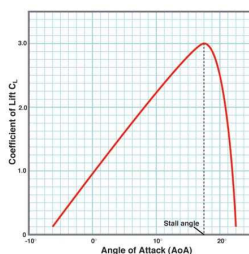
Velocity

Wing Surface Area



FOUR FORCES: LIFT

GROUND
SCHOOL



As the angle of attack increases, so does
the C_L (or amount of lift being produced
by the wing)

This rises to a maximum ($C_{L_{max}}$) as
the wing reaches the Stall Angle or
Critical Angle of Attack

Beyond the Critical Angle of Attack,
the wing will stall

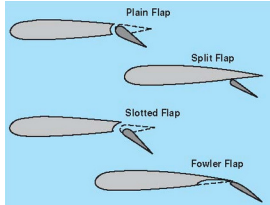
Most cambered aerofoils will begin producing lift at a
negative angle of attack (about -4°)



AIRCRAFT DESIGN AND LIFT

GROUND
SCHOOL

One way to change the amount of lift that a wing produces is by FLAPS



Standard "Plain" Flaps (as on the PA28) work by increasing the camber of the aerofoil

"Fowler" Flaps also increase the wing surface area

"Slotted Fowler" Flaps (as on the C152) also have a slot to ensure that the airflow "sticks" to the top surface of the wing despite the large camber

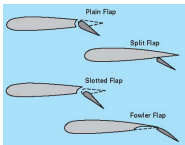


AIRCRAFT DESIGN AND LIFT

GROUND
SCHOOL

Let's think back to that lift formula....

$$\text{Lift} = C_L \frac{1}{2} \rho v^2 s$$



Plain flaps only affect the coefficient of lift

Fowler flaps also affect the surface area

There are, however, drag penalties with larger angles of flap selections

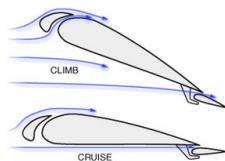


AIRCRAFT DESIGN AND LIFT

GROUND
SCHOOL

The other main addition to an aerofoil used to increase lift are SLATS

Again, they work by increasing the co-efficient of lift (C_L) and allowing the wing to produce lift at slower speeds and at greater angles of attack



They are mainly used in take off and on landing and are bypassed during faster speed flight and at lower angles of attack.

$$\text{Lift} = C_L \frac{1}{2} \rho v^2 s$$




GROUND SCHOOL

PRACTICE QUESTION!

Is air over the top surface of the wing at a greater or lower pressure than the surrounding air?

Lower pressure



GROUND SCHOOL

Lecture 1 complete
Any Questions?

