Attention

Why does every type of plane have a different looking wing?

Objective

To get an understanding of why wings are shaped the way they are and how it affects flight.

Schedule

Ground instruction – 15 minutes

Reference Material

FAA PHAK
http://www.allstar.fiu.edu/AERO/
https://en.wikipedia.org/wiki/Lift_(force)
https://en.wikipedia.org/wiki/Aspect_ratio_(aeronautics)

Material

Leading Edge

The leading edge of an airfoil is the portion that meets the air first. The shape of the leading edge depends upon the function of the airfoil. If the airfoil is designed to operate at high speed, its leading edge will be very sharp, as on most current fighter aircraft. If the airfoil is designed to produce a greater amount of lift at a relatively low rate of speed, as in a Cessna 150 or a Cherokee 140, the leading edge will be thick and fat. Actually, the supersonic fighter aircraft and the light propeller-driven aircraft are virtually two ends of a spectrum. Most other aircraft lie between these two.

Trailing Edge

The trailing edge is the back of the airfoil, the portion at which the airflow over the upper surface joins the airflow over the lower surface. The design of this portion of the airfoil is just as important as the design of the leading edge. This is because the air flowing over the upper and lower surfaces of the airfoil must be directed to meet with as little turbulence as possible, regardless of the position of the airfoil in the air.

Chord

The chord of an airfoil is an imaginary straight line drawn through the airfoil from its leading edge to its trailing edge. We might think of this chord line as the starting point for drawing or designing an airfoil in cross section. It is from this baseline that we determine how much upper or lower camber there is and how wide the wing is at any point along the wingspan. The chord also provides a reference for certain other measurements as we shall see.

Camber

The camber of an airfoil is the characteristic curve of its upper or lower surface. The camber determines the airfoil's thickness. But, more important, the camber determines the amount of lift that a wing produces as air flows around it. A high-speed, low-lift airfoil has very little camber. A low-speed, high-lift airfoil, like that on the Cessna 150, has a very pronounced camber.

Upper camber refers to the curve of the upper surface of the airfoil, while lower camber refers to the curve of the lower surface of the airfoil. In the great majority of airfoils, upper and lower cambers differ from one another. Mean Camber Line is a line drawn halfway between the upper and lower surfaces. The chord line connects the ends of the mean camber line.

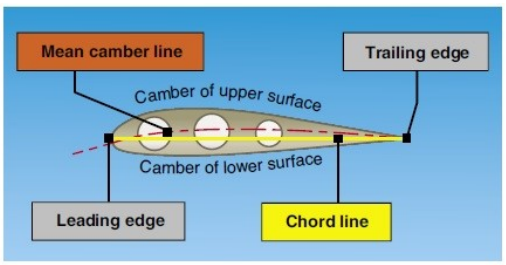

Figure 1

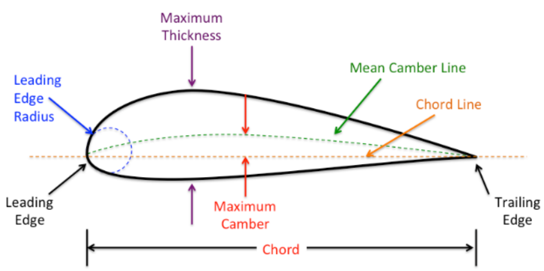

Figure 2

Bernoulli's Principle

Bernoulli's principle states that within a steady airflow of constant energy, when the air flows through a region of lower pressure it speeds up and vice versa.[26] Thus, there is a direct mathematical relationship between the pressure and the speed, so if one knows the speed at all points within the airflow one can calculate the pressure, and vice versa. For any airfoil generating lift, there must be a pressure imbalance, i.e. lower average air pressure on the top than on the bottom. Bernoulli's principle states that this pressure difference must be accompanied by a speed difference.

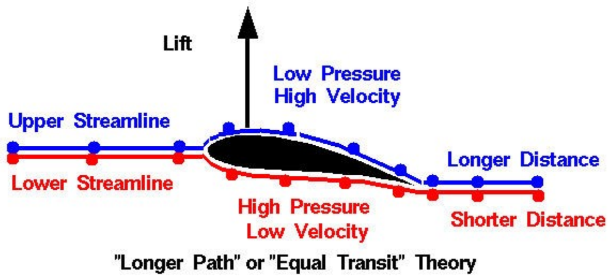

Figure 3

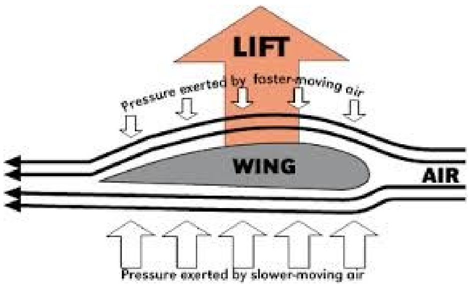

Figure 4

Angle of Attack (AOA)

The angle of attack is the angle between the chord line of an airfoil and the oncoming air. A symmetrical airfoil will generate zero lift at zero angle of attack. But as the angle of attack increases, the air is deflected through a larger angle and the vertical component of the airstream velocity increases, resulting in more lift. For small angles a symmetrical airfoil will generate a lift force roughly proportional to the angle of attack. As the angle of attack grows larger, the lift reaches a maximum at some angle; increasing the angle of attack beyond this critical angle of attack causes the upper-surface flow to separate from the wing; there is less deflection downward so the airfoil generates less lift. The airfoil is said to be stalled.

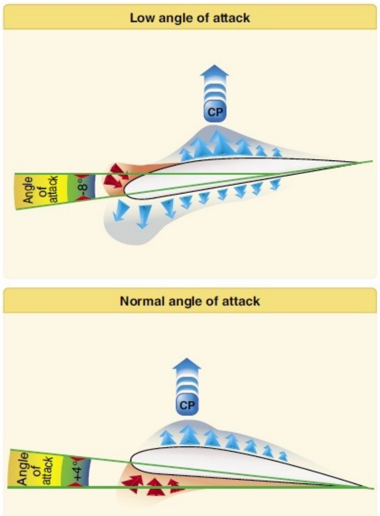

Figure 5

<u>Flaps</u>

Flaps change:
Chord line
Angle of attack
Camber/Mean camber
Lift and Drag

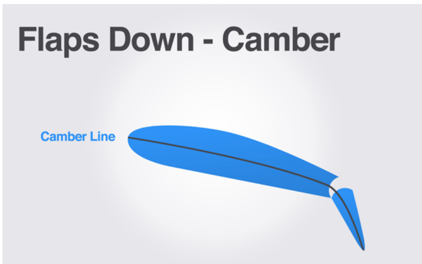

Figure 6

Fixed Slots:
Direct airflow up
Delay airflow separation at high AOA

Leading edge flaps/cuffs:
Maximize lift & camber
Lowers stall speeds

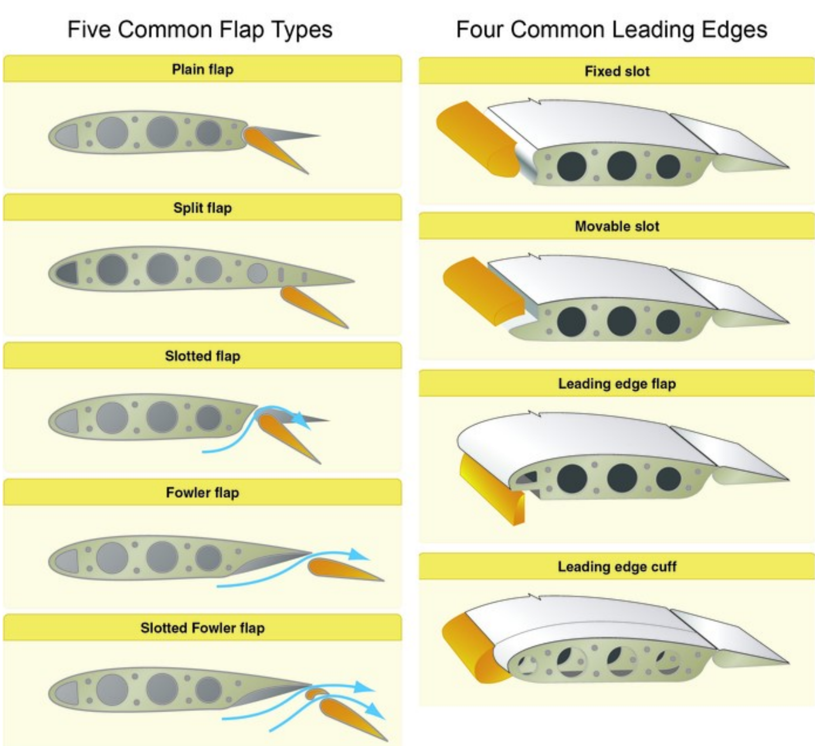

Figure 7

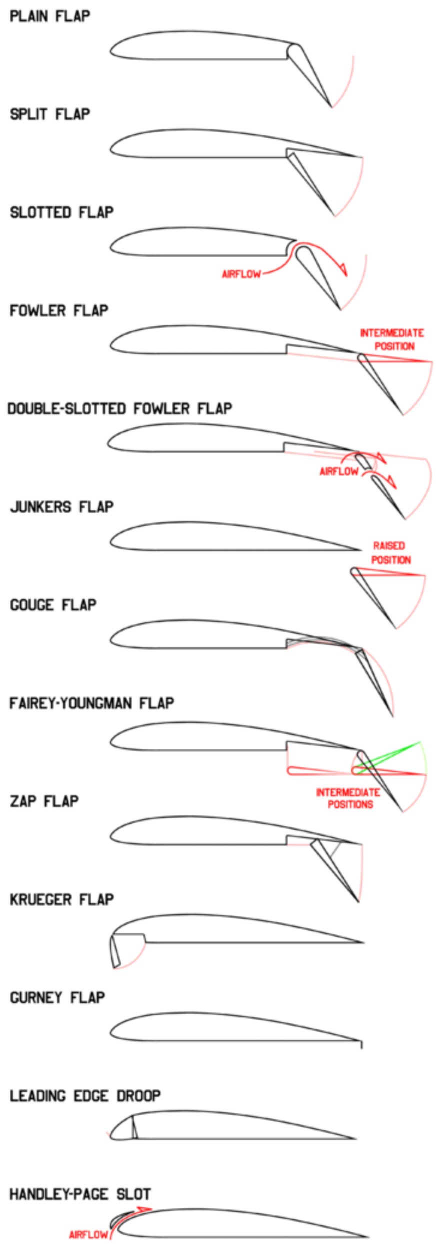

Figure 8

For more detailed info see:
https://en.wikipedia.org/wiki/Flap_(aeronautics)
http://www.boldmethod.com/learn-to-fly/aircraft-systems/how-the-4-types-of-aircraft-flaps-work/

Aspect Ratio

In aeronautics, the aspect ratio of a wing is the ratio of its span to its mean chord. It is equal to the square of the wingspan divided by the wing area. Thus, a long, narrow wing has a high aspect ratio, whereas a short, wide wing has a low aspect ratio.

Aspect ratio = wing span / mean chord

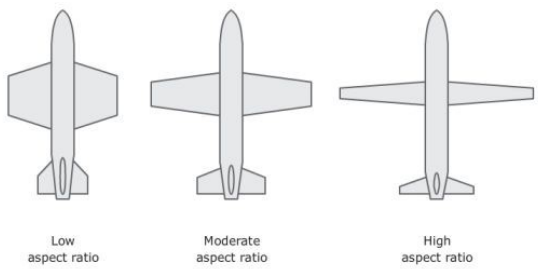

Figure 9

High aspect ratio –> lower stall speed

Characteristics of low vs high aspect ratios are…

Structural: A long wing has higher bending stress for a given load than a short one and therefore requires higher structural-design (architectural and/or material) specifications. Also, longer wings may have some torsion for a given load, and in some applications this torsion is undesirable (e.g. if the warped wing interferes with aileron effect).

Maneuverability: a low aspect-ratio wing will have a higher roll angular acceleration than one of high aspect ratio, because a high-aspect-ratio wing has a higher moment of inertia to overcome. In a steady roll, the longer wing gives a higher roll moment because of the longer moment arm of the aileron. Low aspect ratio wings are usually used on fighter aircraft, not only for the higher roll rates, but especially for longer chord and thinner airfoils involved in supersonic flight.

Parasitic drag: While high aspect wings create less induced drag, they have greater parasitic drag, (drag due to shape, frontal area, and surface friction). This is because, for an equal wing area, the average chord (length in the direction of wind travel over the wing) is smaller. Due to the effects of Reynolds number, the value of the section drag coefficient is an inverse logarithmic function of the characteristic length of the surface, which means that, even if two wings of the same area are flying at equal speeds and equal angles of attack, the section drag coefficient is slightly higher on the wing with the smaller chord. However, this variation is very small when compared to the variation in induced drag with changing wingspan.