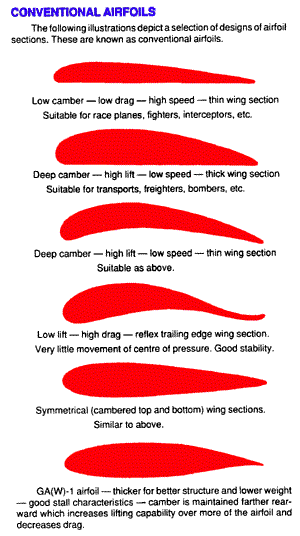
**Lesson 6**

**Lift and Drag**

Read FTGU 91-98

1. Bernoulli’s Principle- how lift is created
   1. The total energy in a system remains constant
   2. In order for an increase in kinetic energy of a fluid (such as air) to occur, a corresponding decrease in potential energy must occur
      1. i.e. for the air to increase in speed, it must decrease in pressure
   3. Airfoils are shaped in a way that causes the air passing over top of the wing to move a greater distance than the air passing under it, making use of Bernoulli’s Principle
      1. The increased distance over the top of the airfoil causes the air passing over top to move faster, creating an area of relatively low pressure above the wing
      2. The air passing over the bottom is now in an area of relatively high pressure
      3. The pressure differential creates a force we know as lift
2. Airfoil terms
   1. Relative airflow
      1. The direction of the airflow with respect to the wing.
      2. It is created by the movement of the airplane as well as the movement of air.
      3. Relative airflow is usually opposite to the flight path.
      4. Relative airflow itself is not related to lift
   2. Angle of Attack
      1. The angle at which the airfoil meets the relative airflow
   3. Centre of Pressure
      1. The average of the pressure on the airfoil
         1. The sum of the distributed pressures on the airfoil acting through a single straight line
      2. Moves forward on an airfoil as the angle of attack is increased
3. Angle of attack versus lift
   1. As the angle of attack increases
      1. Lift increases
      2. Drag also increases
4. Angle of Incidence
   1. The angle between the mean aerodynamic chord of the wing and the longitudinal axis of the aircraft
   2. The angle of incidence impacts forward visibility, take-off and landing characteristics, and drag in level flight
5. Types of airfoils



1. Types of Drag
   1. Parasite Drag
      1. Drag of all parts of the airplane which do not contribute to lift
      2. Can be minimized, but is difficult to eliminate
      3. Two different types:
         1. Form drag
            1. Caused by the shape of the aircraft

Landing gear, antennas, struts, wing tip fuel tanks

* + - 1. Skin Friction
         1. Friction produced by the air flowing over the body clinging to its surface
         2. Ice or dirt build up contributes significantly
         3. Aircraft are painted and rivets are often counter-sunk
  1. Induced Drag
     1. Caused by those parts of the airplane which actively produce lift
     2. Cannot be eliminated
        1. May be reduced with a high aspect ratio

1. Wingtip Vortices
   1. Due to pressure changes as air flows around the wing, air flows inward over the top (low pressure) and outward over the bottom (high pressure)
   2. At the wing tip, a vortex is created
      1. This produces a large portion of induced drag
   3. This can be particularly intense behind large aircraft
      1. Small aircraft must wait for a set period of time before landing or taking off behind large aircraft to avoid “wake turbulence” caused by the vortices
2. Streamlining
   1. Streamlining is shaping the aircraft to minimize drag.
   2. Allows for less fuel consumption in powered aircraft
   3. Allows for better glide characteristics in gliders