Objective :

To understand the aerodynamic concepts of how an airplane can overcome it's own weight and to understand how resistance to it's movement is generated and managed.
Student will read Phak Chapter 5

Motivation:

An airplane must overcome it's weight to fly and must be able to move through the air in order to do it. An understanding of these aerodynamic concepts/forces allow the pilot to understand how to anticipate and manage these forces.

Presentation: 45 Minutes

Airplane Components to Introduce:

1. Fuselage – Airplane minus the wings and stabilizers – contains the cabin, engine etc.
2. Airfoil – Generates force to overcome weight
3. Horizontal Stabilizer – Allows the airplane to be controlled to balance the effect of the airfoil

The Four Forces:

1. Weight
2. Lift
3. Thrust
4. Drag

Lift and Weight

1. For an airplane to fly it must overcome it's weight. Weight is always directed downward.
2. The force created to overcome weight is called lift
3. Newtons Third Law – Reaction
4. Bernoulli's Principle – Relationship of Pressure and Velocity
5. Airfoil components
6. Show restricted pipe and relate it to an airfoil
7. Relative wind – Parallel and opposite the flight path
8. Angle of attack of the airfoil – Larger AOA increases the path on the top of the airfoil = more velocity = increase in lift
9. Lift equation – Lift = 1/2 $\rho V^2 S C_L$ – Lift increases at the square of the velocity

10. Critical angle of attack – Air can no longer stay attached to the airfoil – Aerodynamic stall occurs – Lift decreases
11. Lift equation – variables controlled by the pilot are velocity and C_L (Angle of attack) The
12. slower the airplanes speed the more Angle of Attack is needed (C_L)
13. As speed or AOA increases lift increases and the Center of Lift (C_p) moves forward
14. Cp needs to always be behind the Center of gravity (CG)
15. Purpose of the horizontal stabilizer – Provides tail down force – keeps the wing from causing the airplane to rotate forward around it's CG.

Drag and Thrust

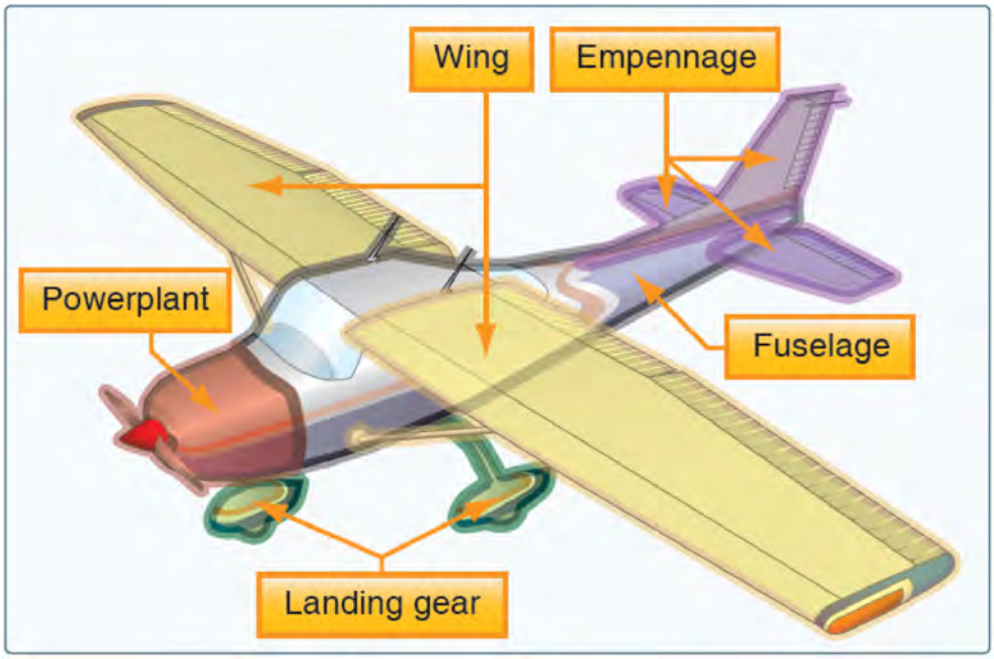
1. Thrust provides a means to create speed (Velocity)
2. Force that opposes motion that opposes thrust
3. Parasite drag caused by the airplane parts – The larger the surface area the more the drag
4. Parasite drag – Increases at the square of the speed – Show graph Drag vs Speed
5. Induced drag – As speed is slowed more AOA is needed – Lift vector is tilted rearward – component of lift acting rearward has to be overcome by thrust or speed slows
6. Induced drag – Wingtip vorticies increase with higher AOAs. At the wingtips the High pressure below can corkscrew up toward the low pressure area of the wing. It takes energy to create the vorticies and this energy is lost the airflow causing lift which means more drag
7. Induced drag – Show graph of Drag vs speed – Induced drag increases as speed is reduced (AOA is generating lift instead of Velocity)
8. Total drag is the combination of Parasite and induced drag (Show graph of Drag vs speed with total drag curve)
9. The lowest drag occurs at a particular speed
10. Drag must be overcome by thrust in order to both speed up (Parasite drag) or to go slower (Due to induced drag) to maintain level flight
11. Ground effect and how it relates to a decrease in drag

Wing Design and Planform

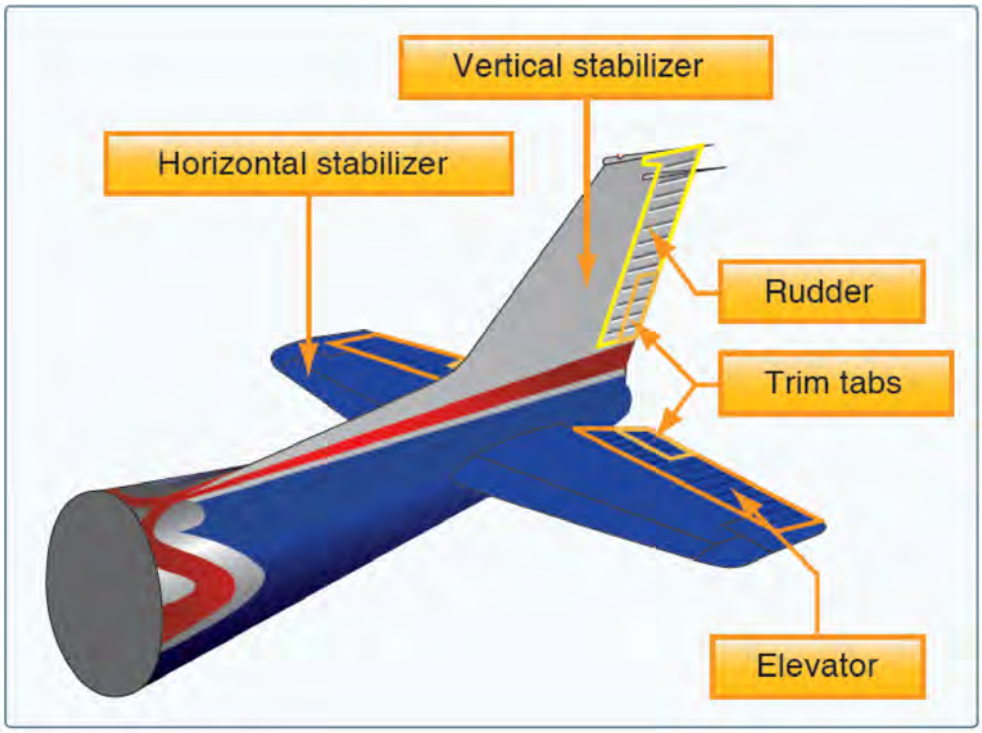
1. Aspect ratio as it relates to production of lift and drag
2. Design choices of various wing planforms for speed and handling

Additional Images

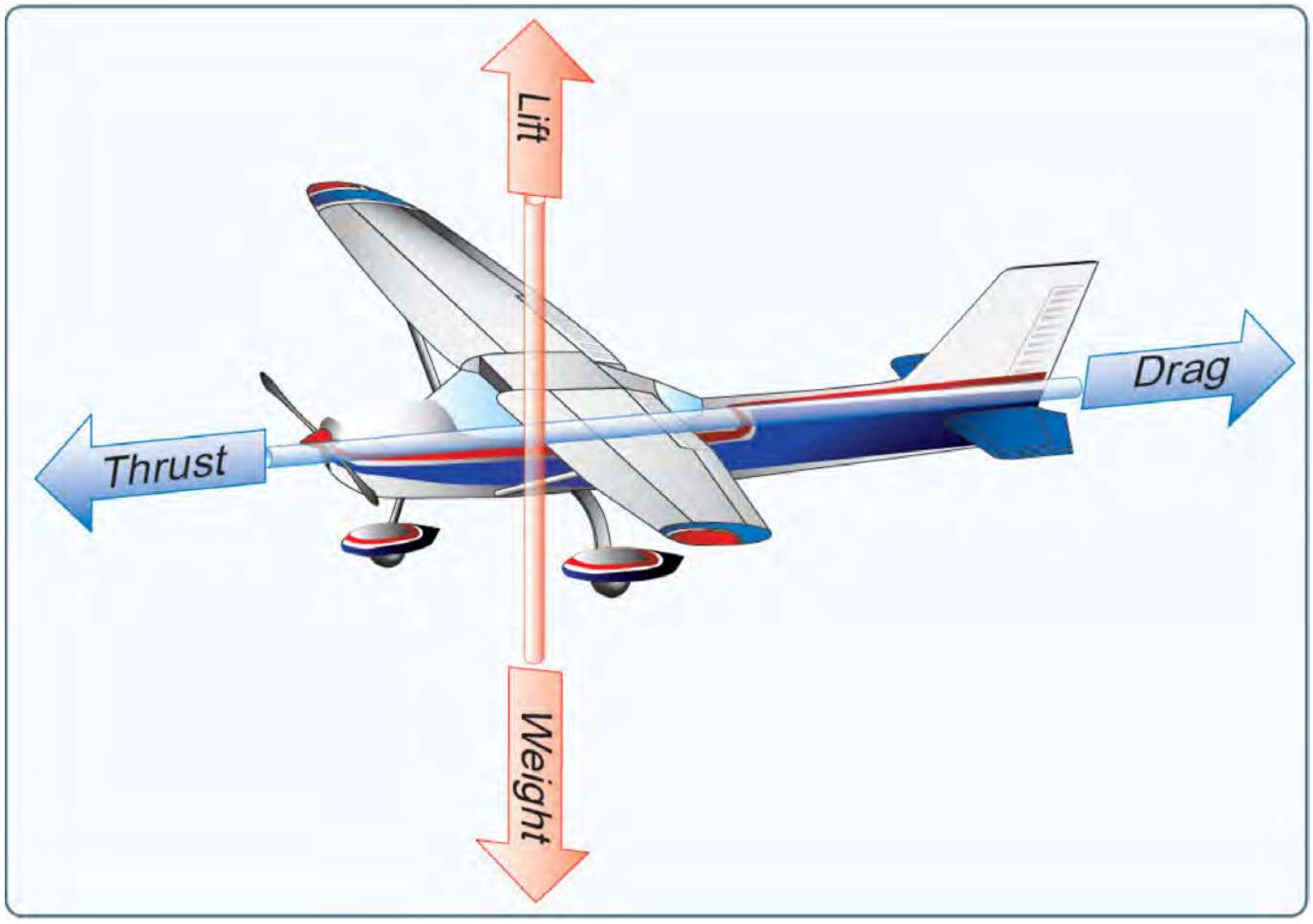
Components of an airplane



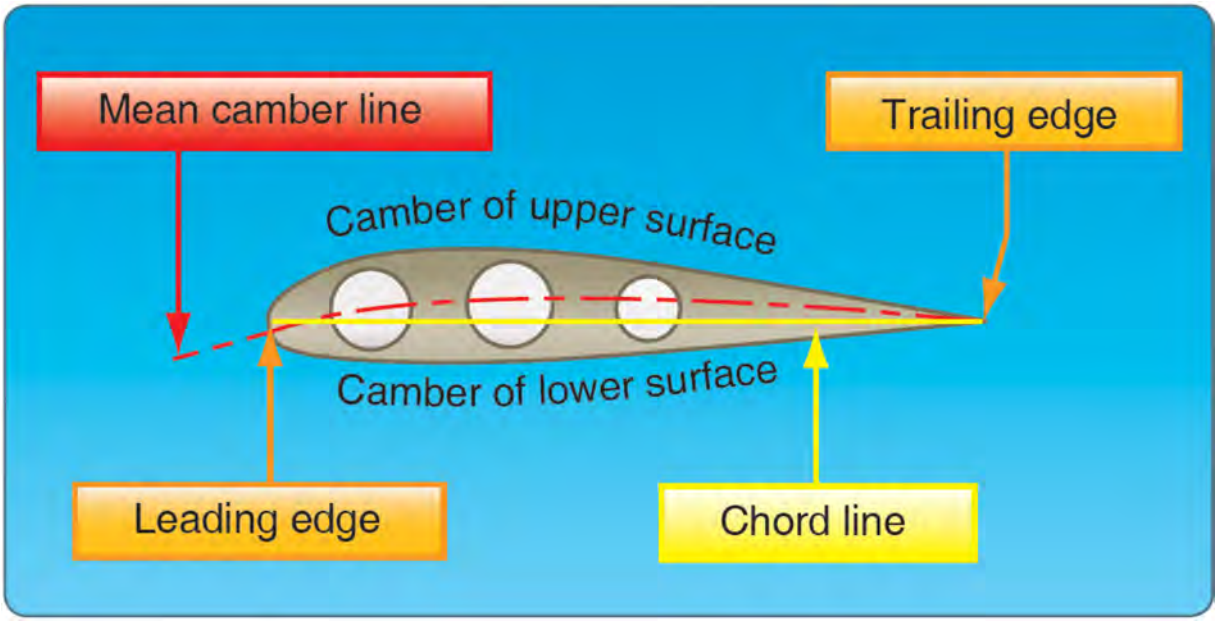
Horizontal Stabilizer



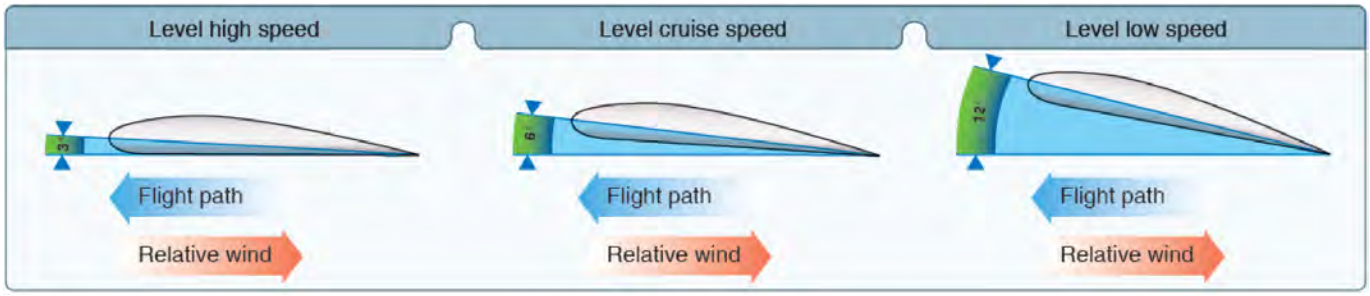
The Four Forces



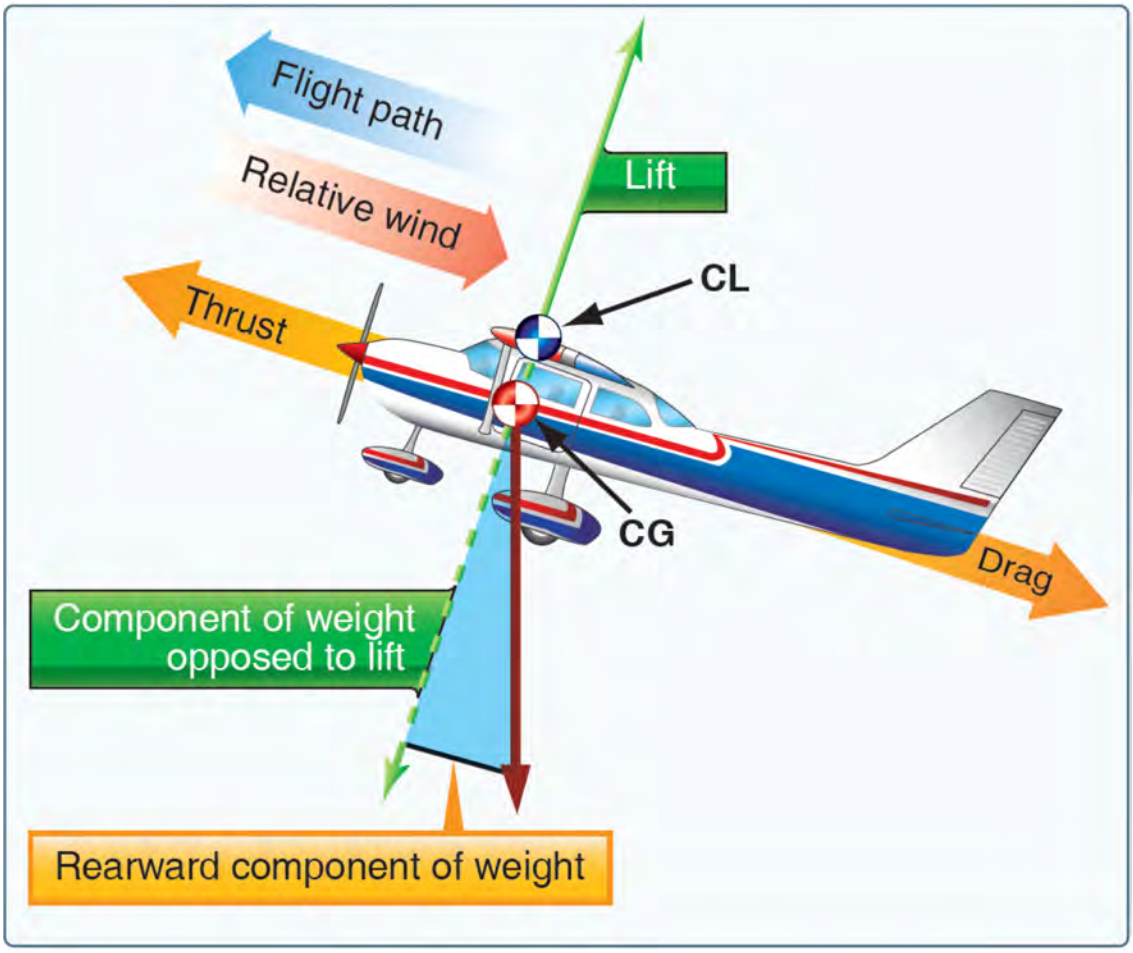
Parts of an airfoil



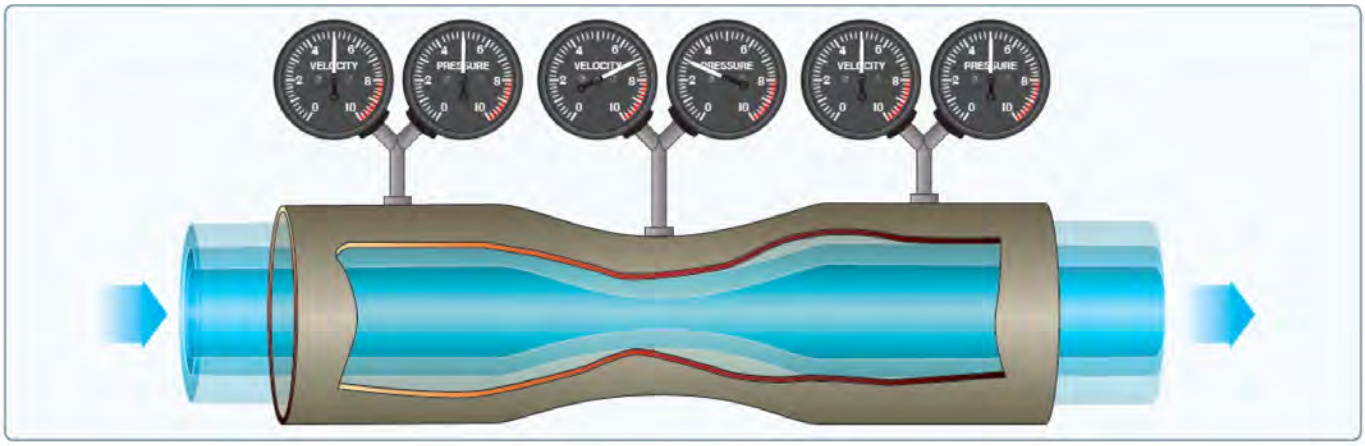
Relative wind as speed changes along the same flight path



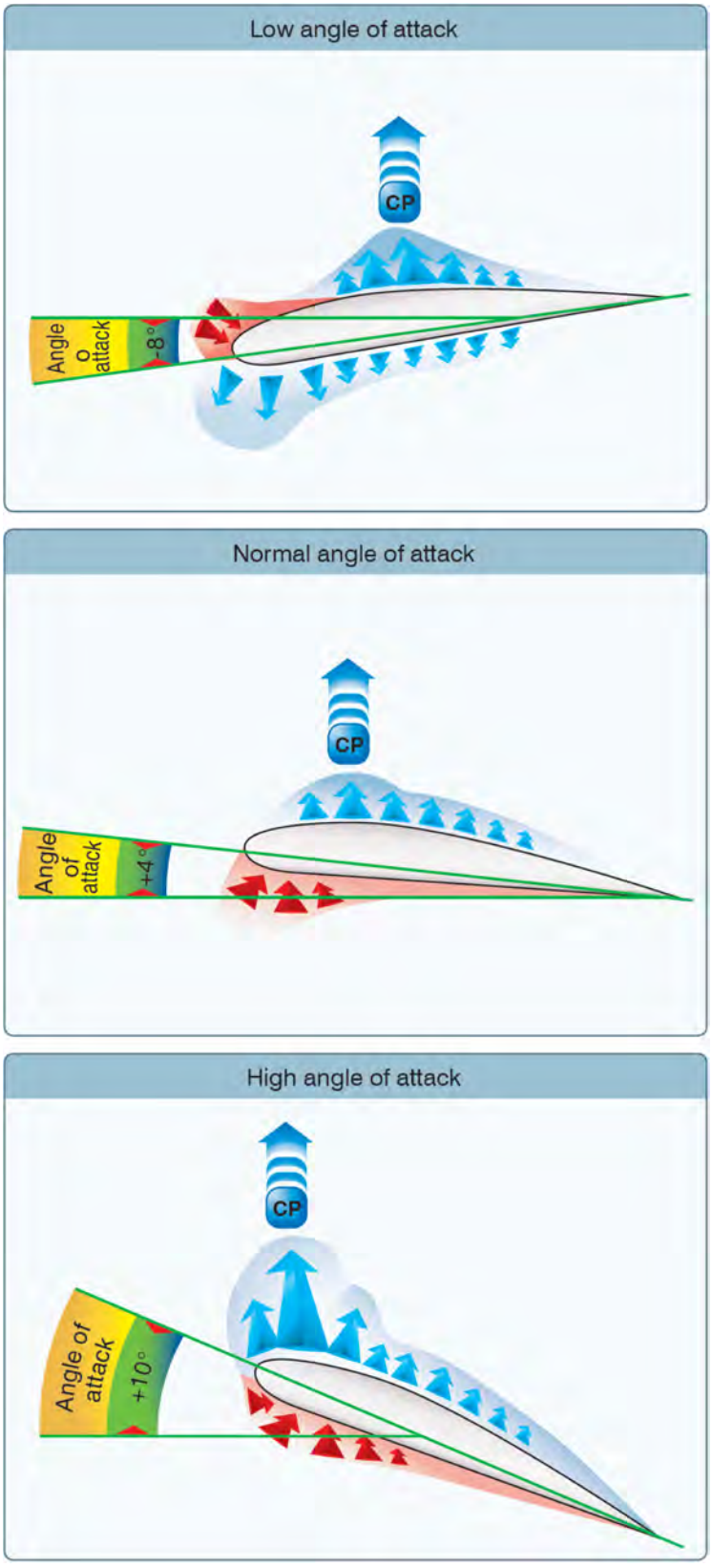
Relative wind in a climb



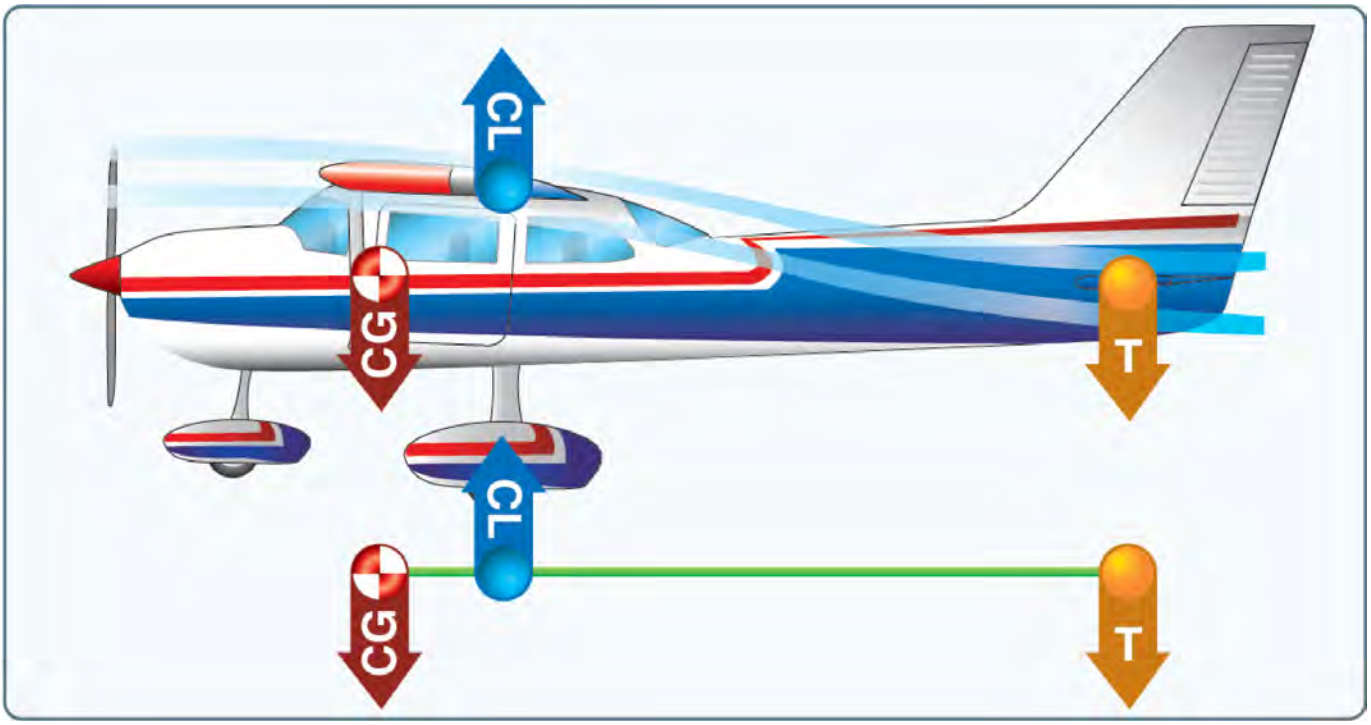
Relative wind in a climb



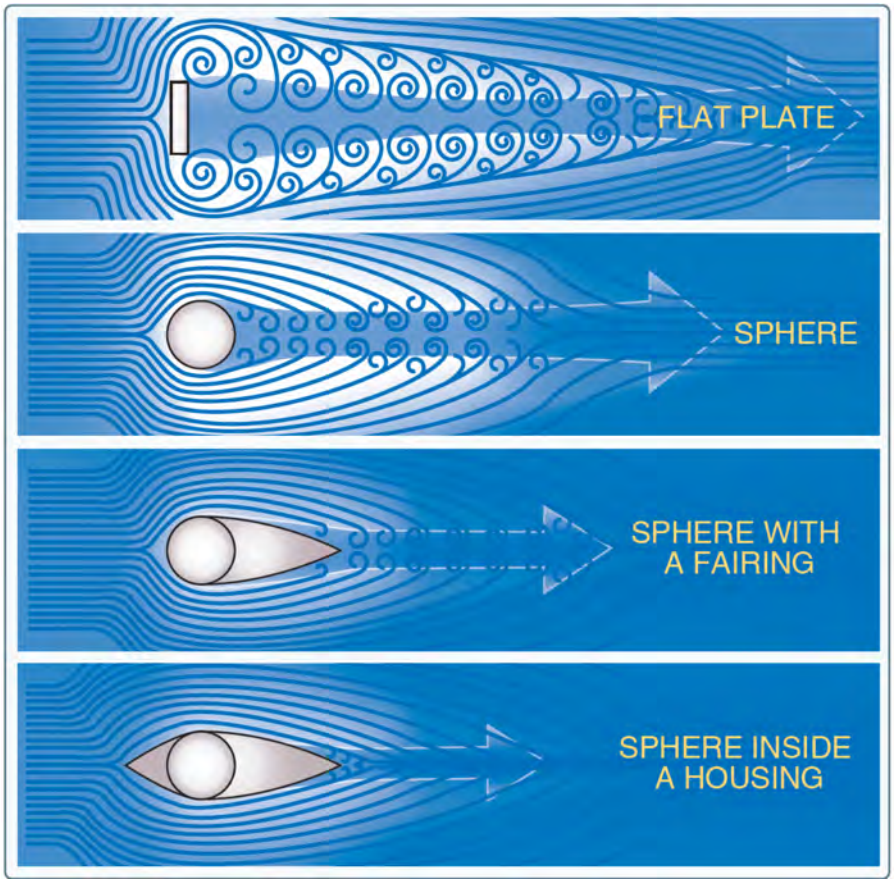
Center of pressure changes with angle of attack



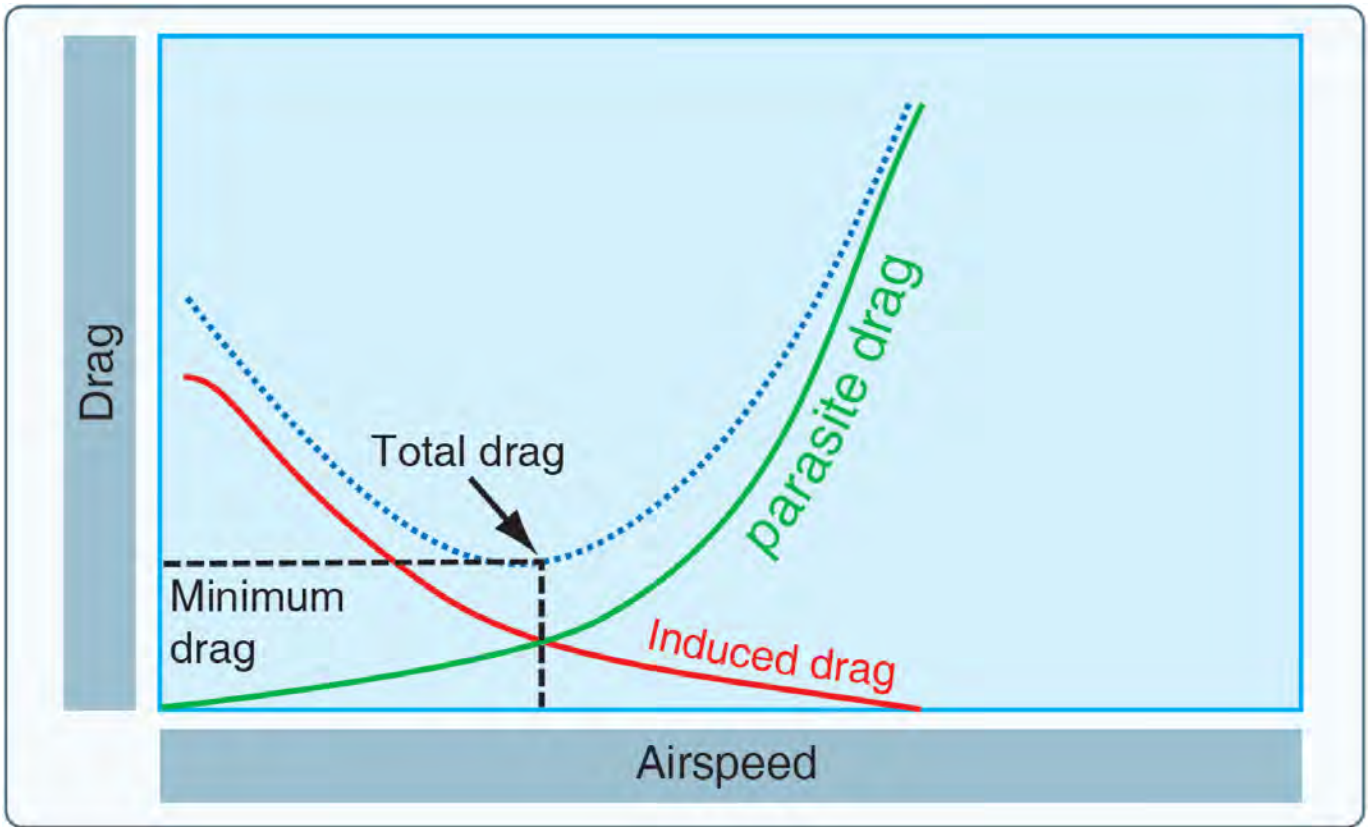
Tail-Down Force



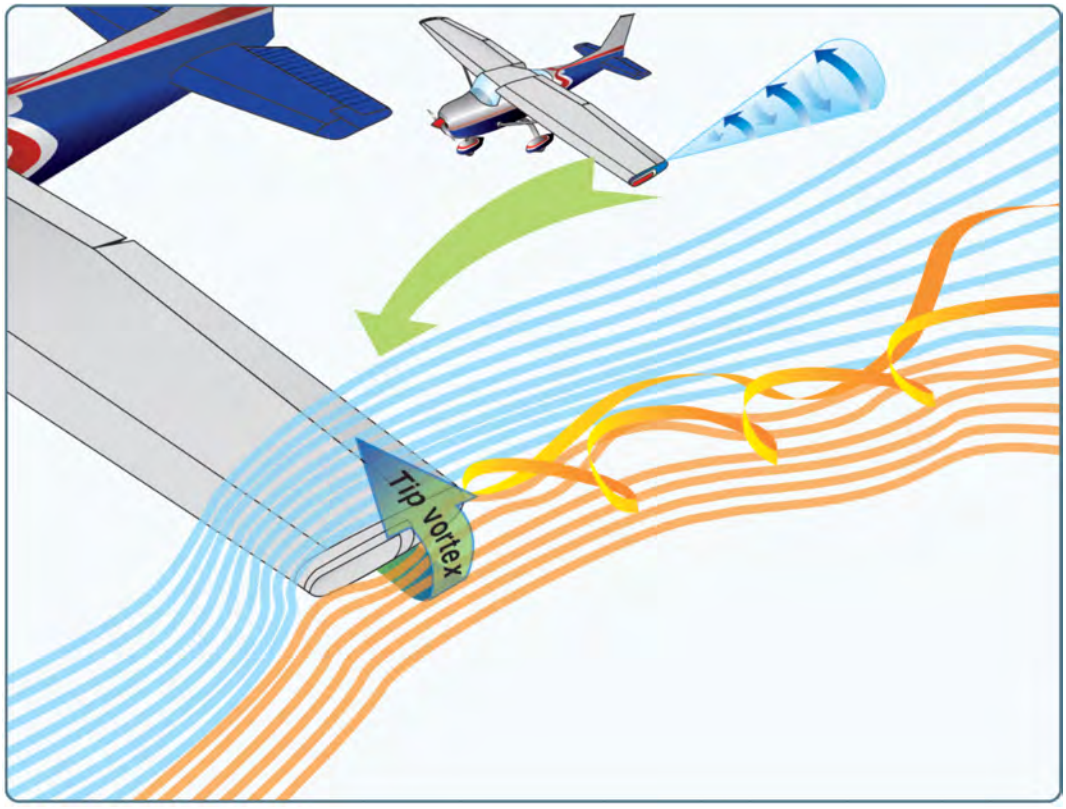
Parasite drag

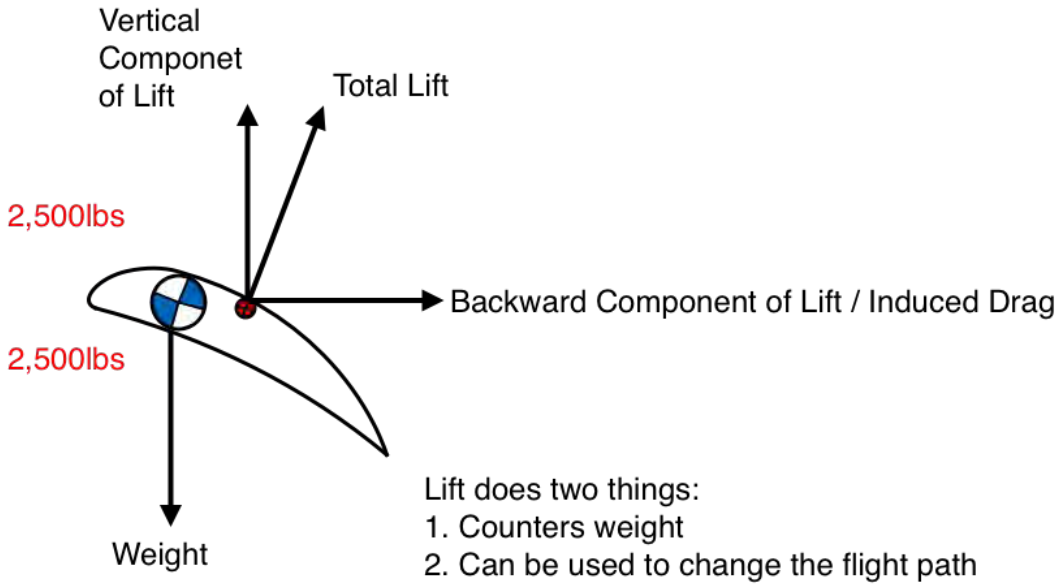


Drag Vs Speed



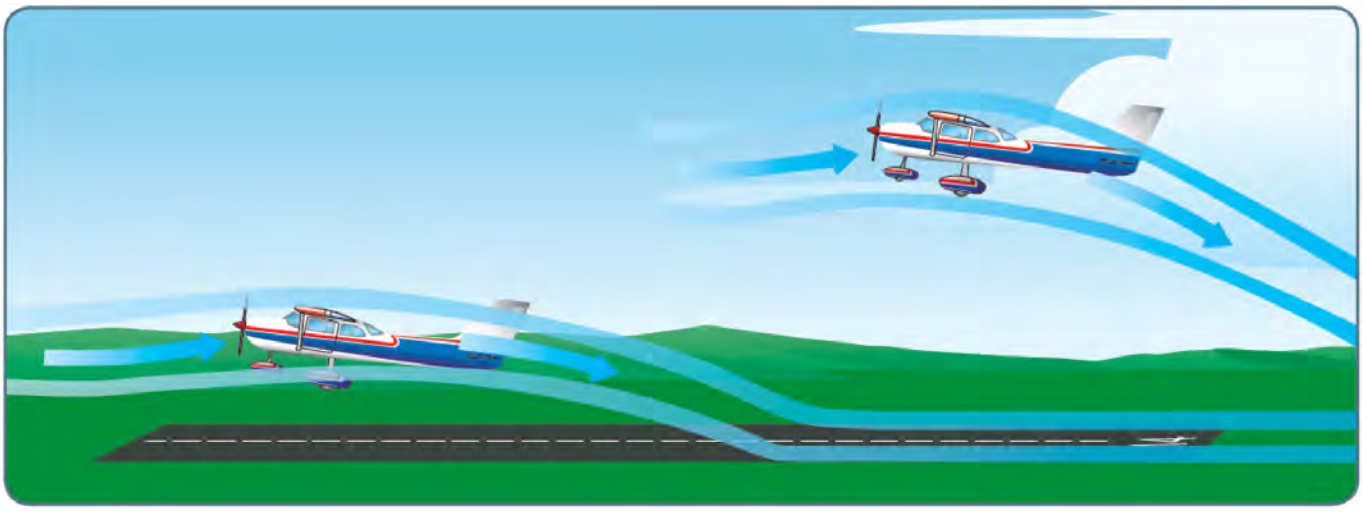
Wingtip Vortices





Thrust causes an airplane to climb, Lift causes flight path to be redirected.

Ground effect changes the airflow



Wing Planforms