

Pilot Rating Theory of Flight

Derbysire Soaring Club

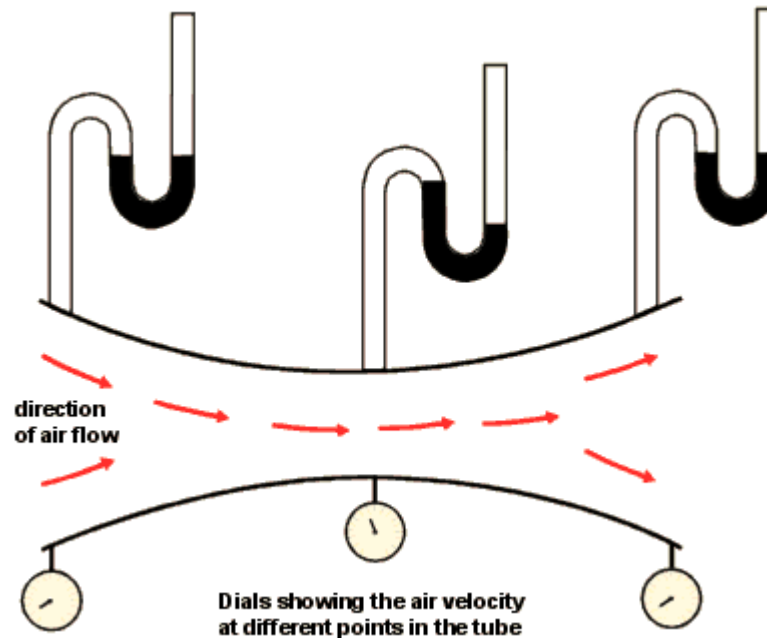
Syllabus

- Explain how a wing creates lift
- Define aeronautical terms
- Describe aerodynamics of stall
- Stability
- Glide angle and L/D
- Effect of Ballast
- Forces on a glider
- Different types of drag
- Understand polar
- Instruments

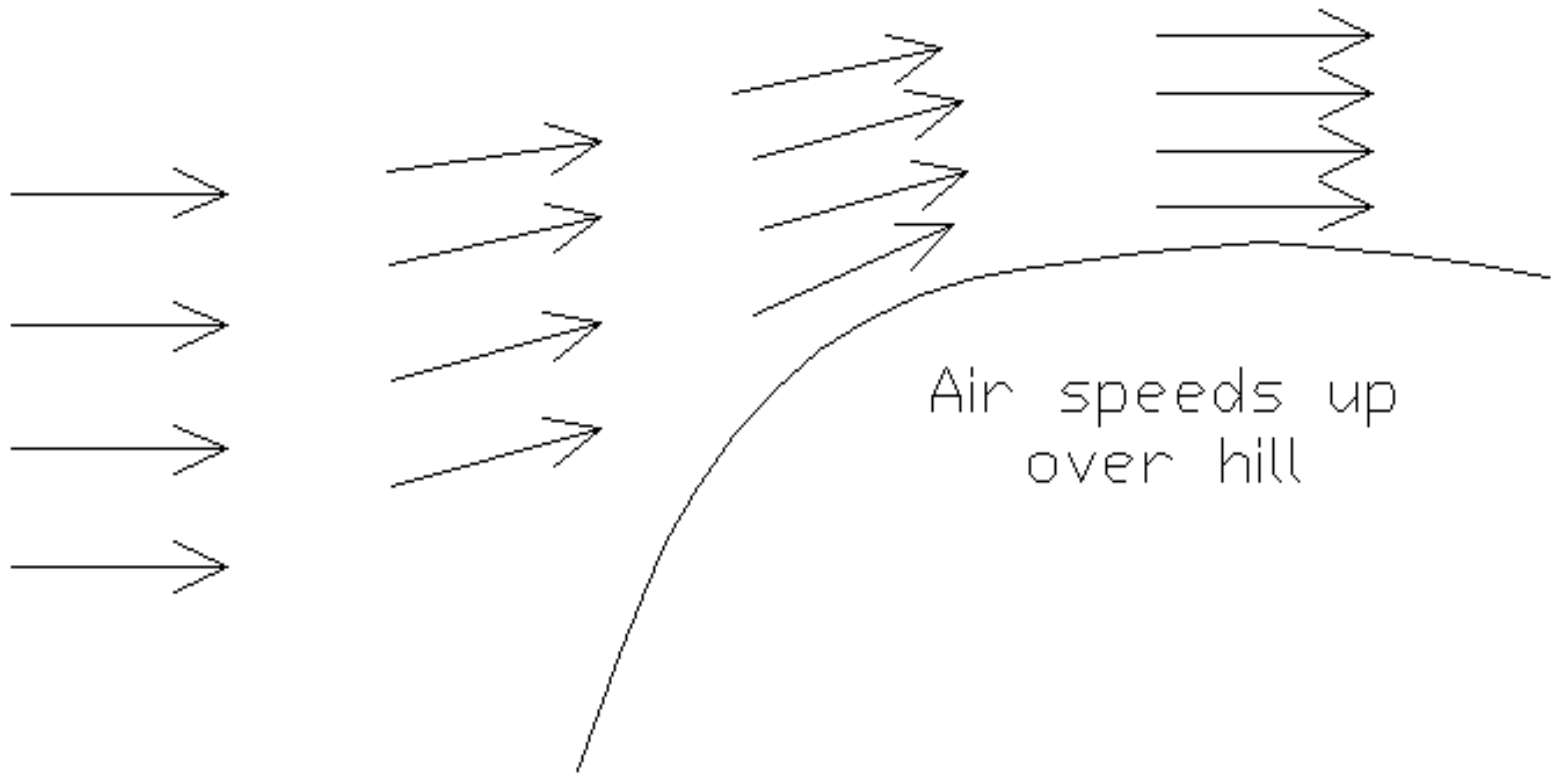
Bernoulli's Theorem

An increase in airflow causes a decrease
in pressure

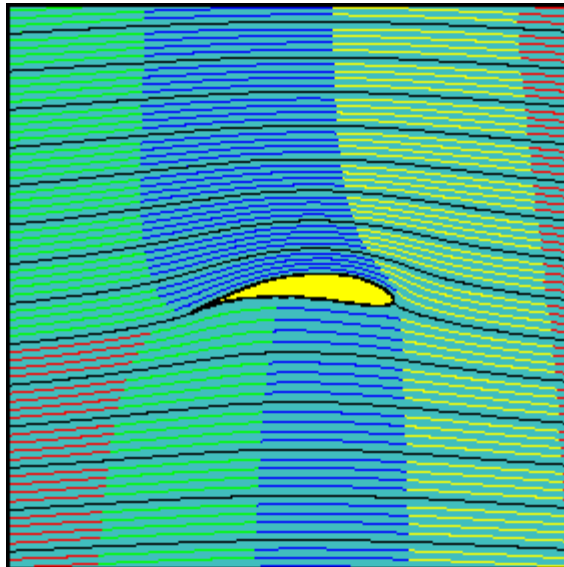
Venturi Tube (Bernoulli's Theorom)



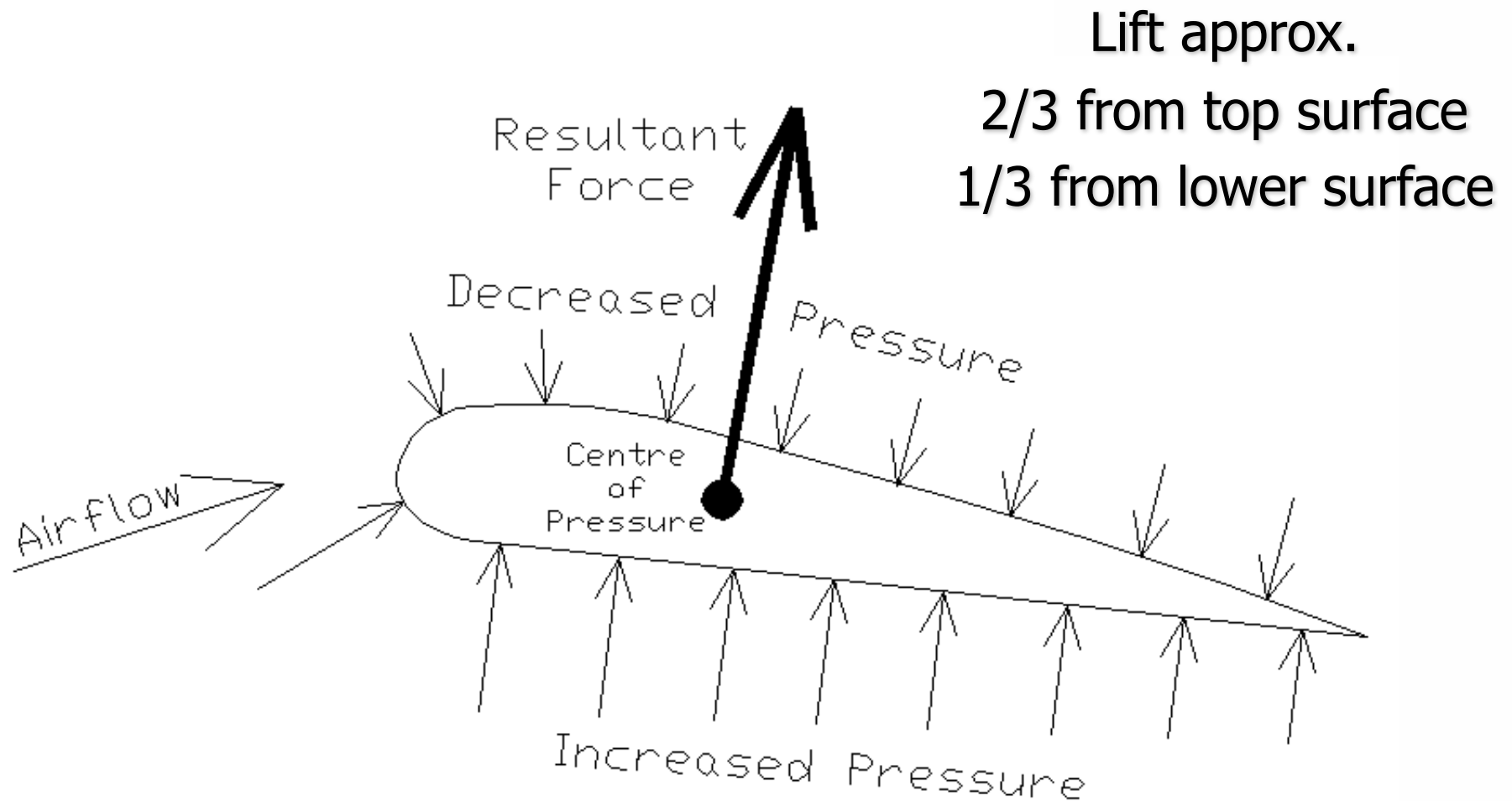
Venturi Effect



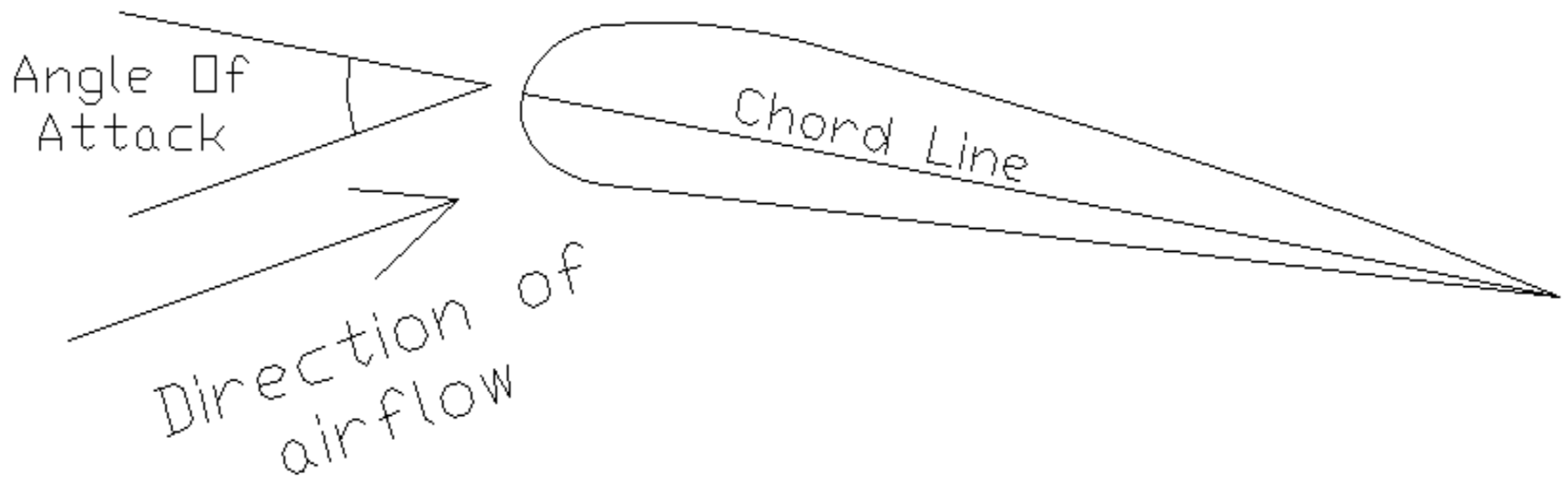
The Aerofoil



The Aerofoil

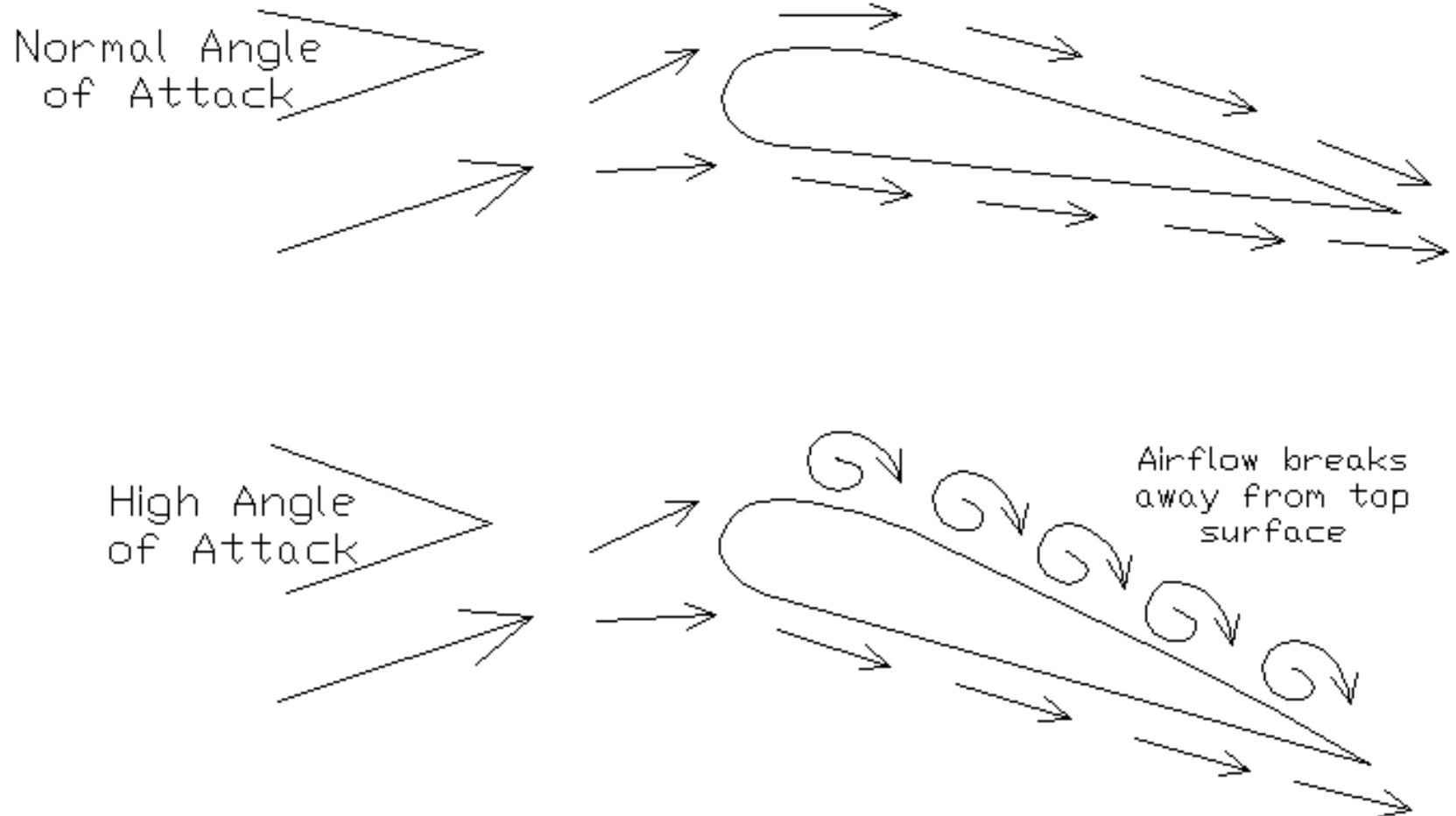


Chord Line - Angle of Attack



Chord line: imaginary straight line joining the trailing edge and the centre of curvature of the leading edge of the cross-section of an airfoil

Stall - High angle of attack



Stall

High angle of attack

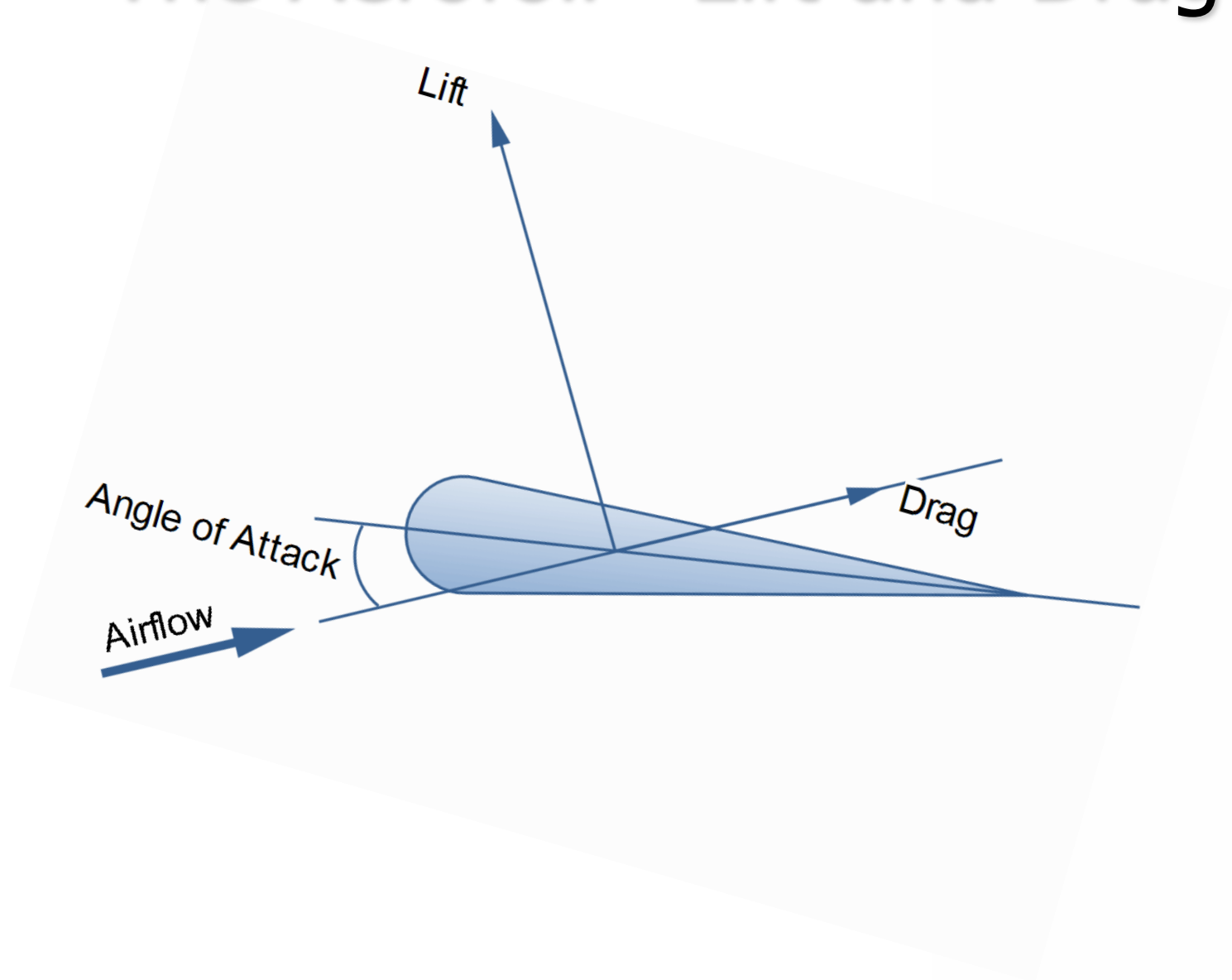
Turbulence on upper surface

High drag

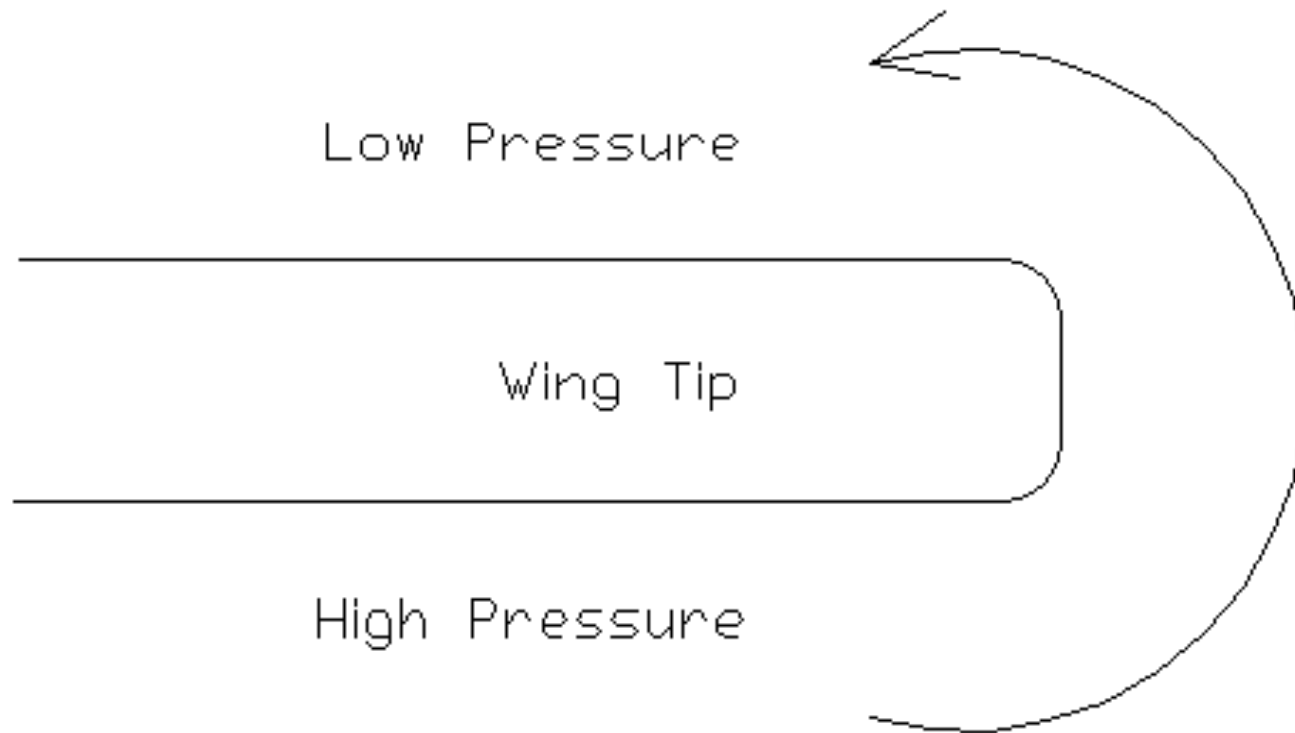
Loss of lift

Centre of pressure moves forward

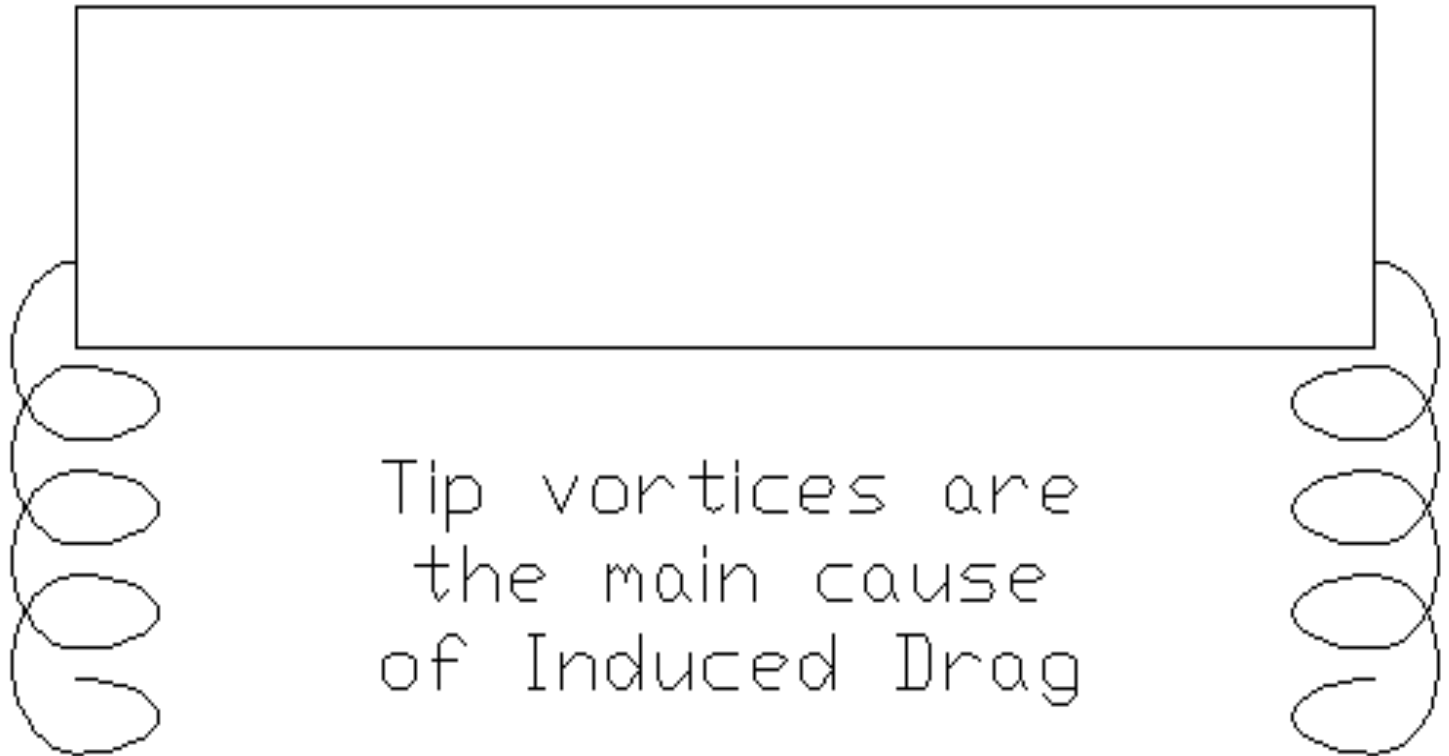
The Aerofoil - Lift and Drag



Tip Vortices



Tip Vortices - Induced Drag




Aspect Ratio

$$AR = \text{Wing span} / \text{Chord}$$



Low Aspect Ratio
high induced drag

A diagram of a low aspect ratio wing, represented by a short, thick horizontal rectangle. From the bottom corners of this rectangle, two vertical lines extend downwards, each ending in a series of three stacked, horizontal ovals. These ovals represent the wing's cross-sections, showing a high chord and low span.

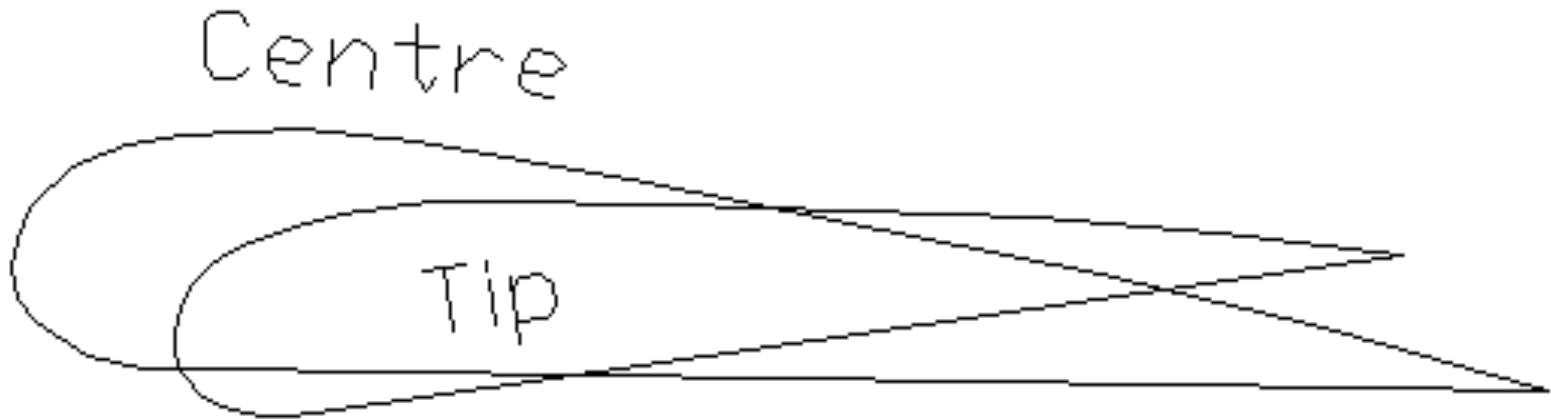


High Aspect ratio - Low induced drag

A diagram of a high aspect ratio wing, represented by a long, thin horizontal rectangle. From the bottom corners of this rectangle, two vertical lines extend downwards, each ending in a series of four stacked, horizontal ovals. These ovals represent the wing's cross-sections, showing a low chord and high span.

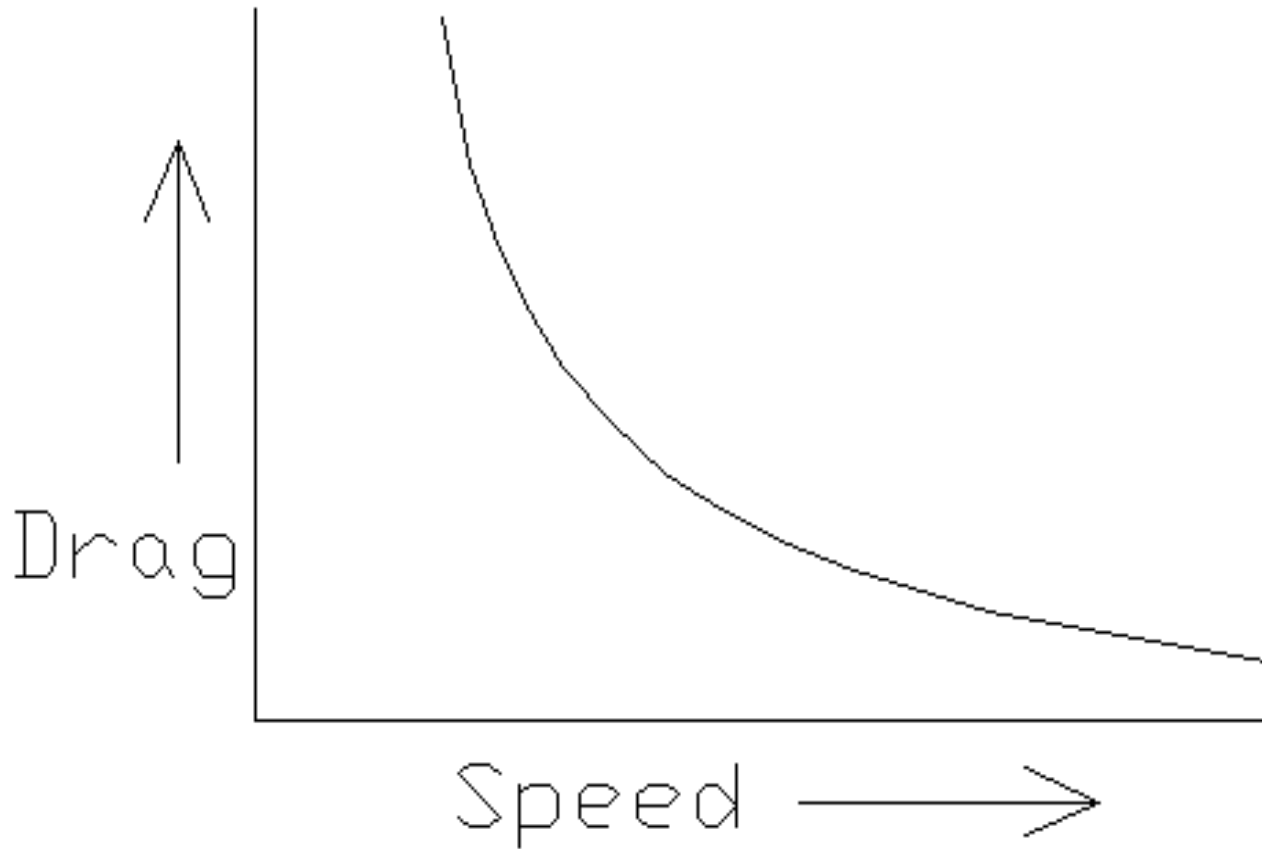
Washout

Reduces tip vortices and induced drag

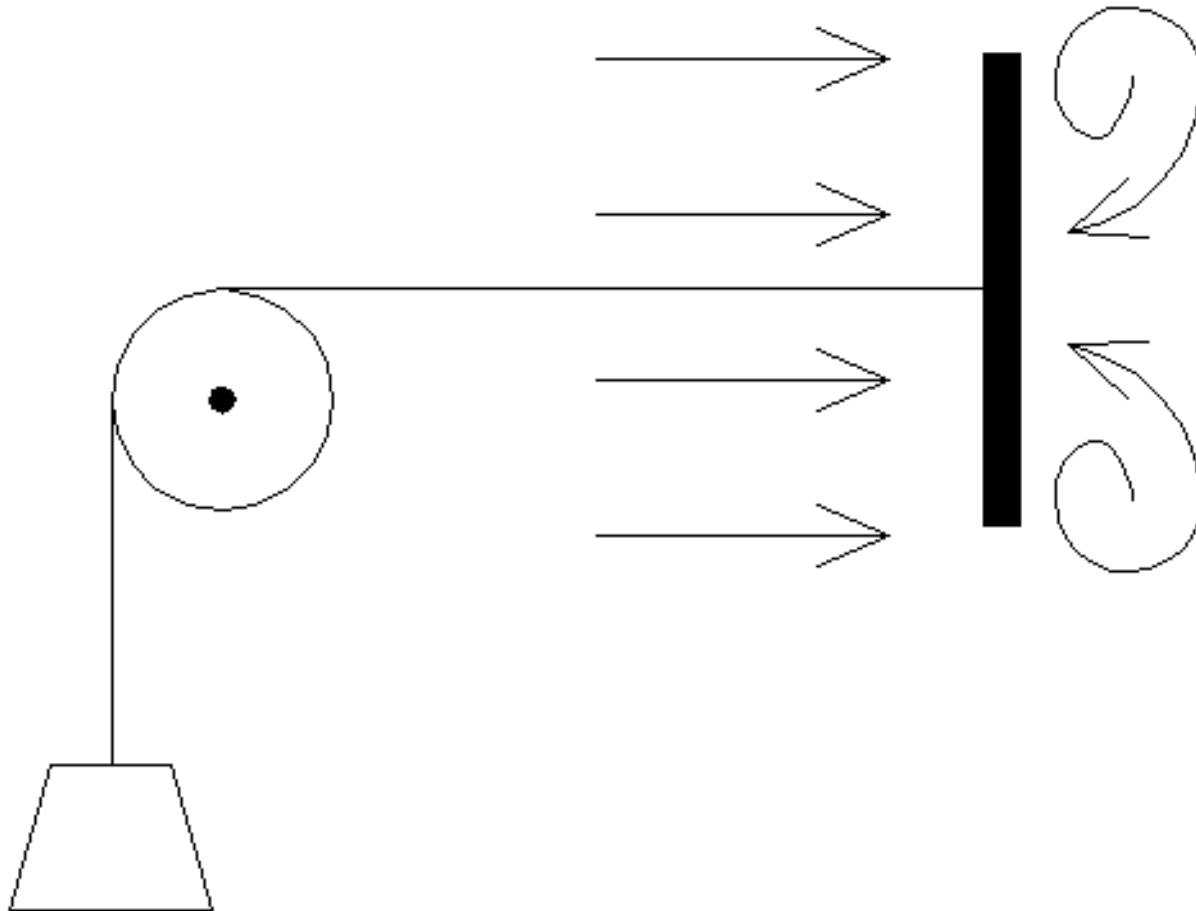


Angle of incidence
reduces towards
wingtip

Higher airspeed = Lower induced drag

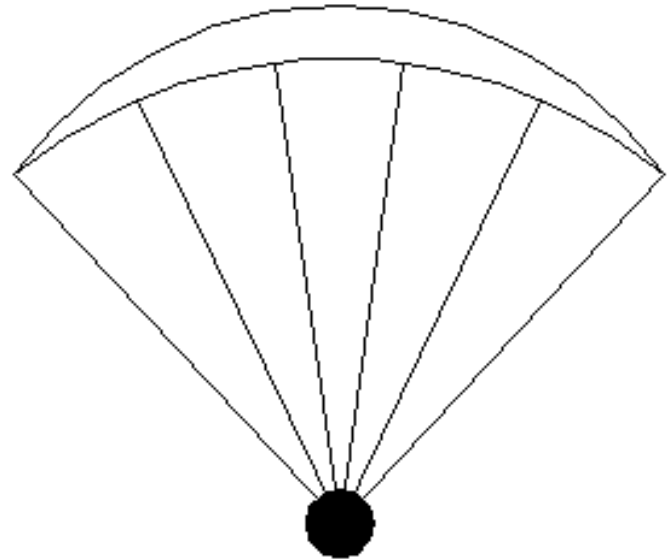


Parasitic Drag

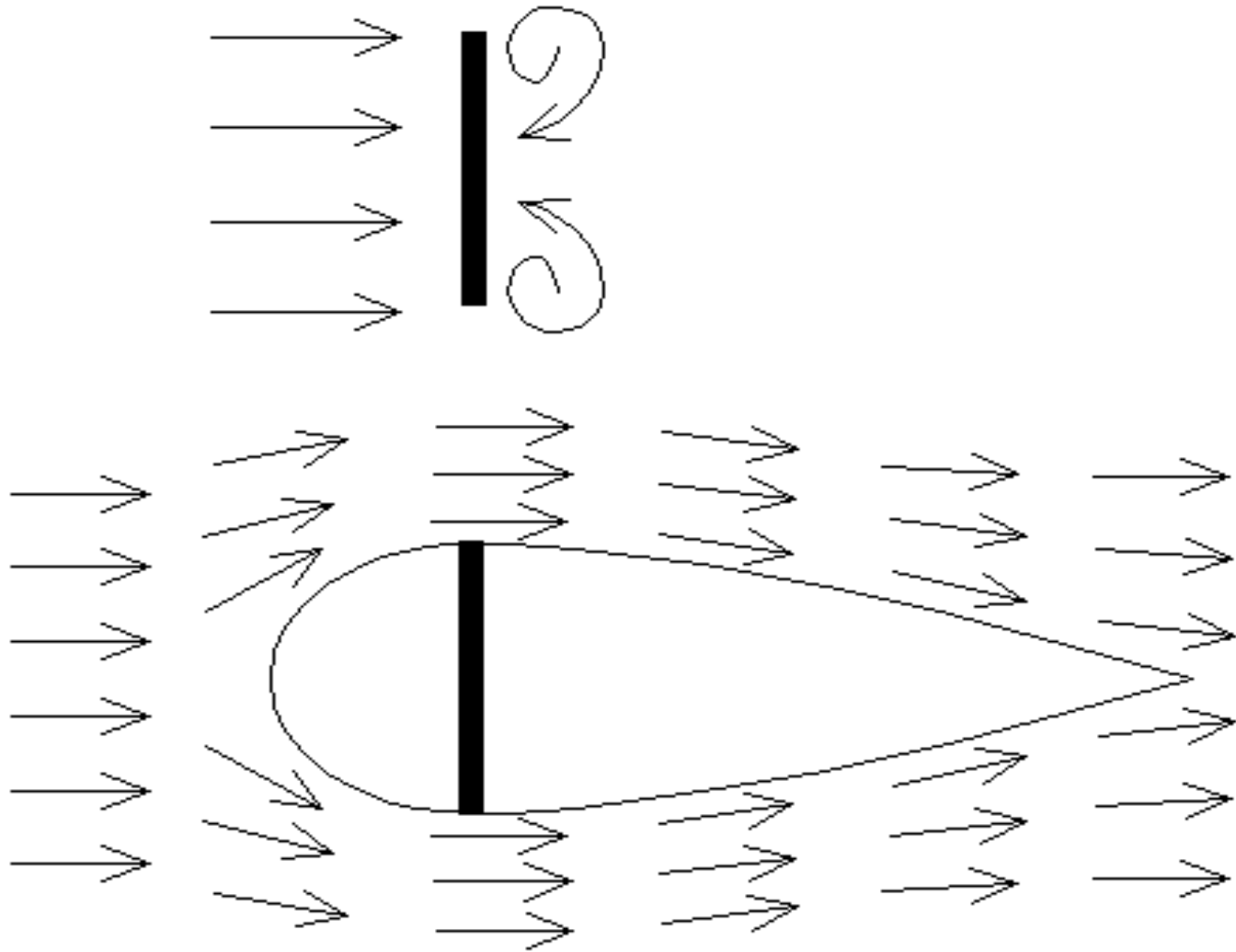


Parasitic Drag
= Form Drag + Skin Friction

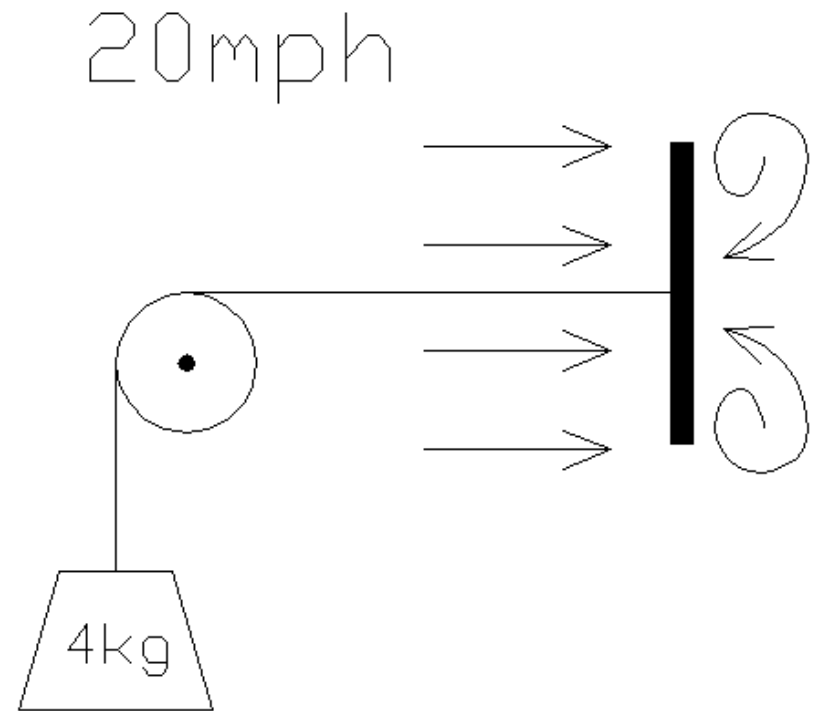
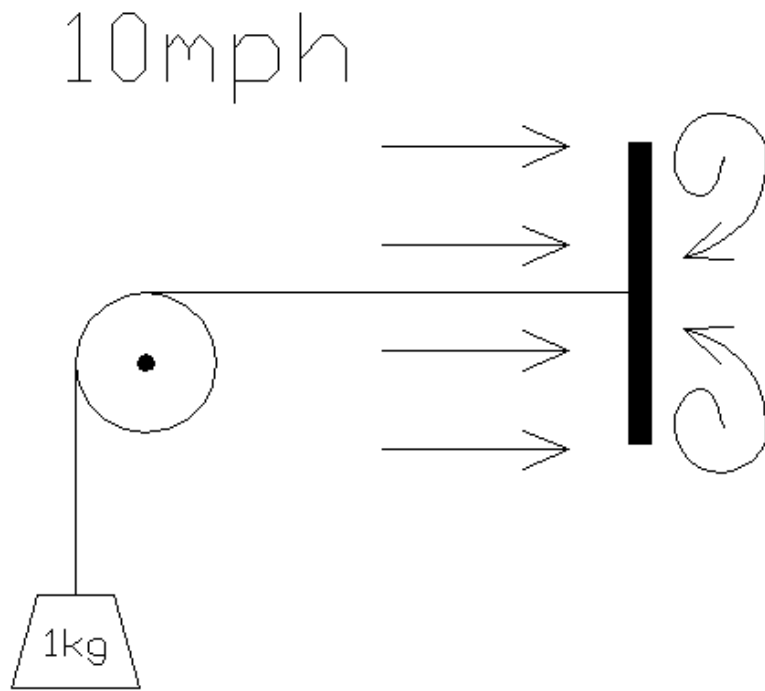
Form Drag is due to shape



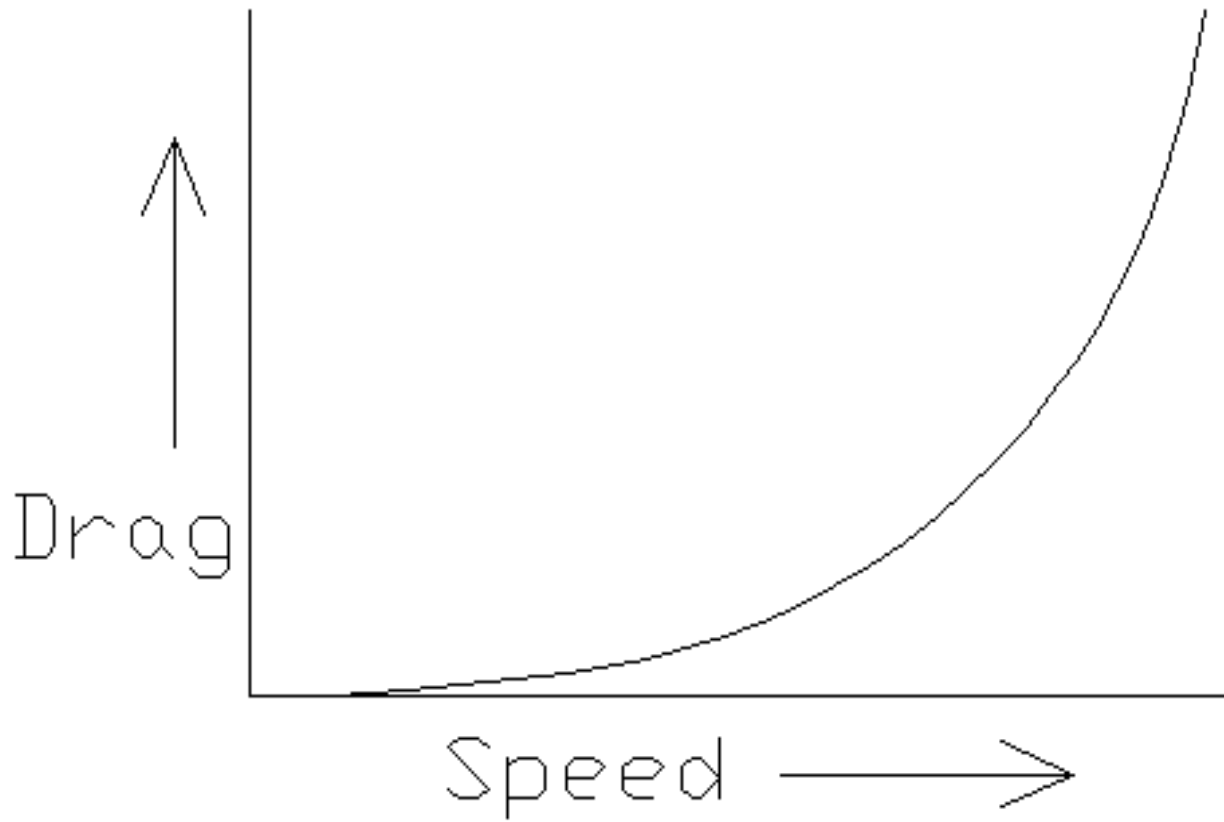
Parasitic Drag - Streamlining



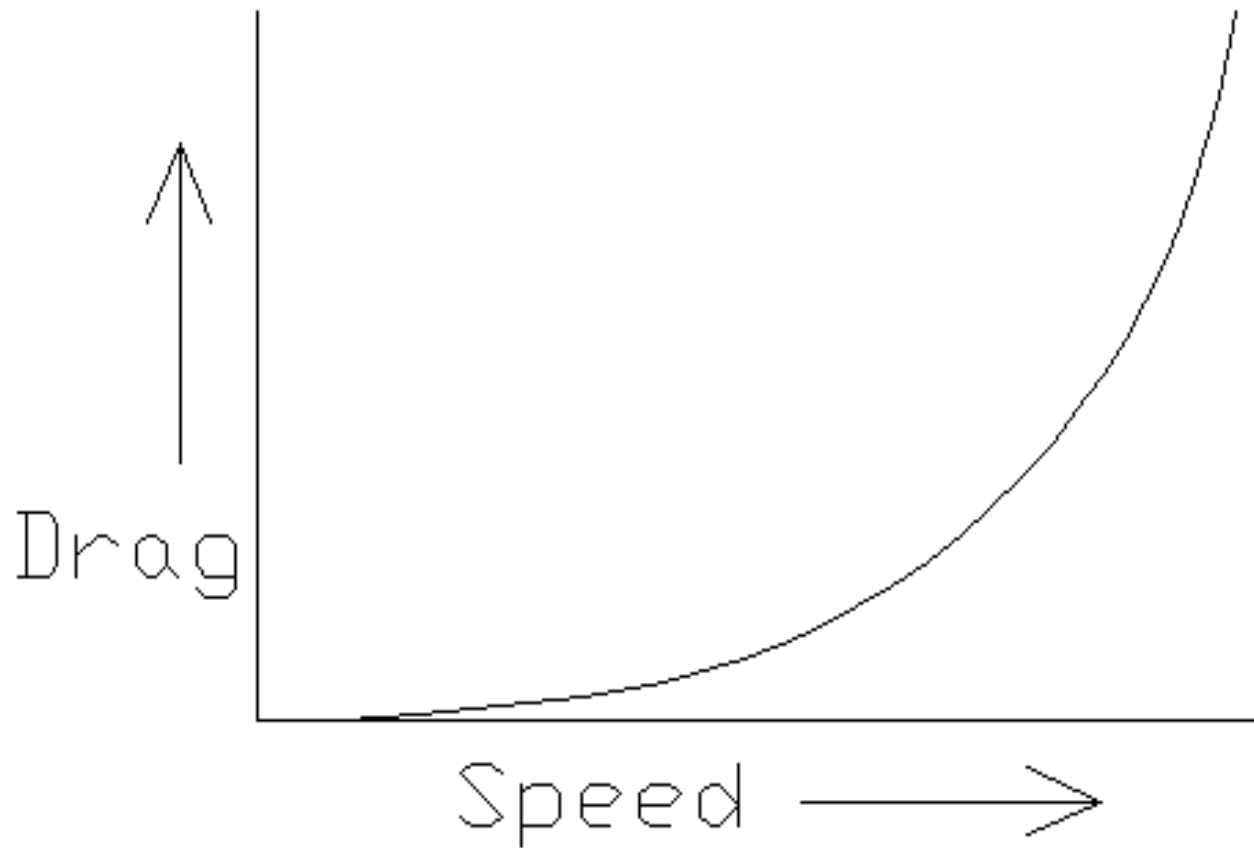
Parasitic Drag - Speed



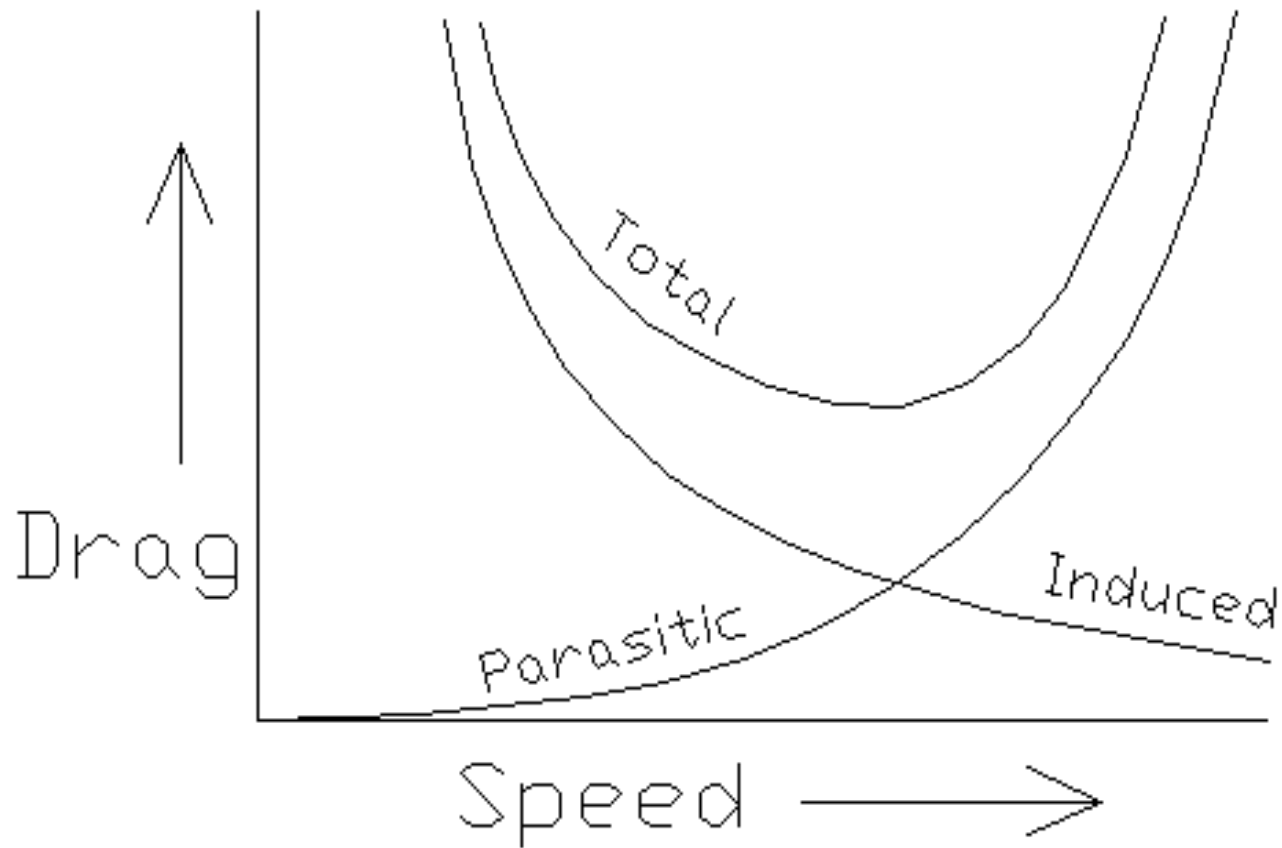
Parasitic Drag increases as the square of the speed
Double the speed makes four times the drag



Higher airspeed = Higher parasitic drag

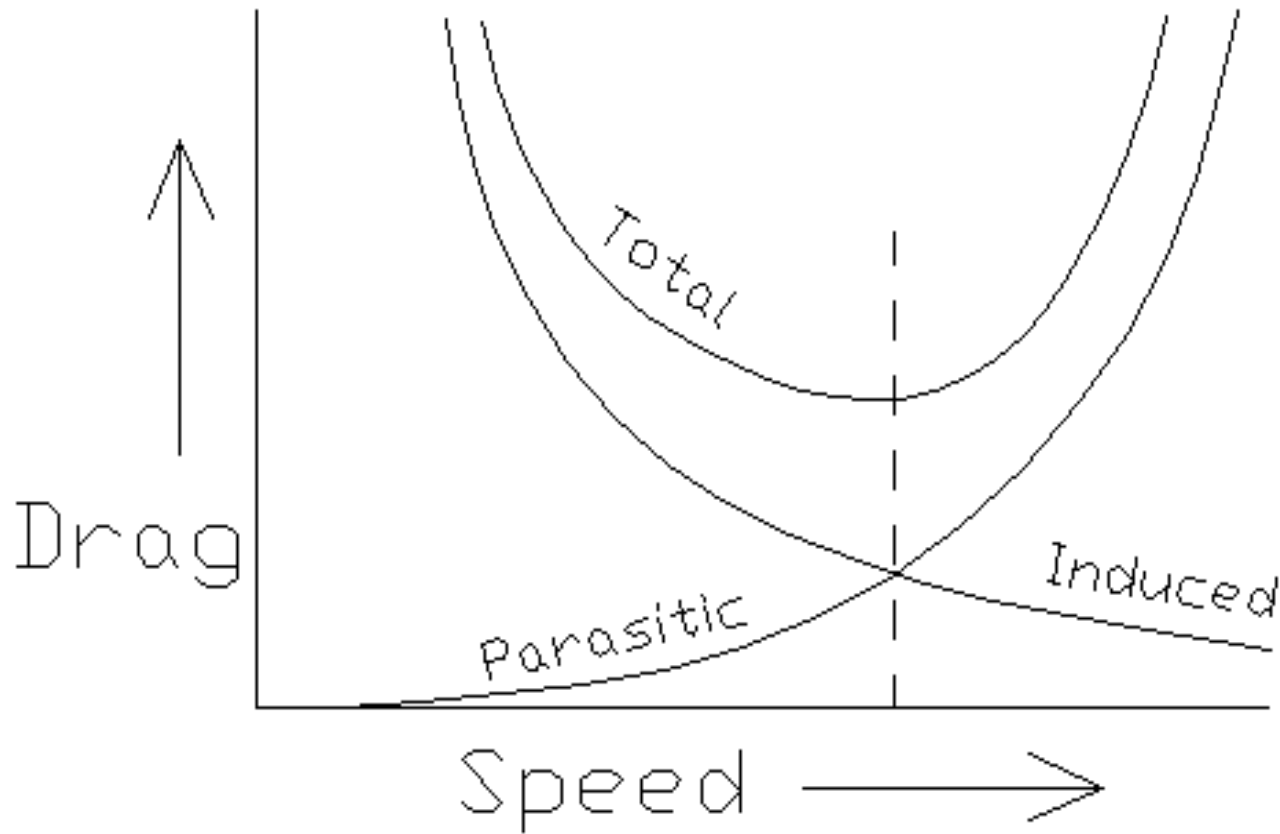


Total Drag = Parasitic + Induced



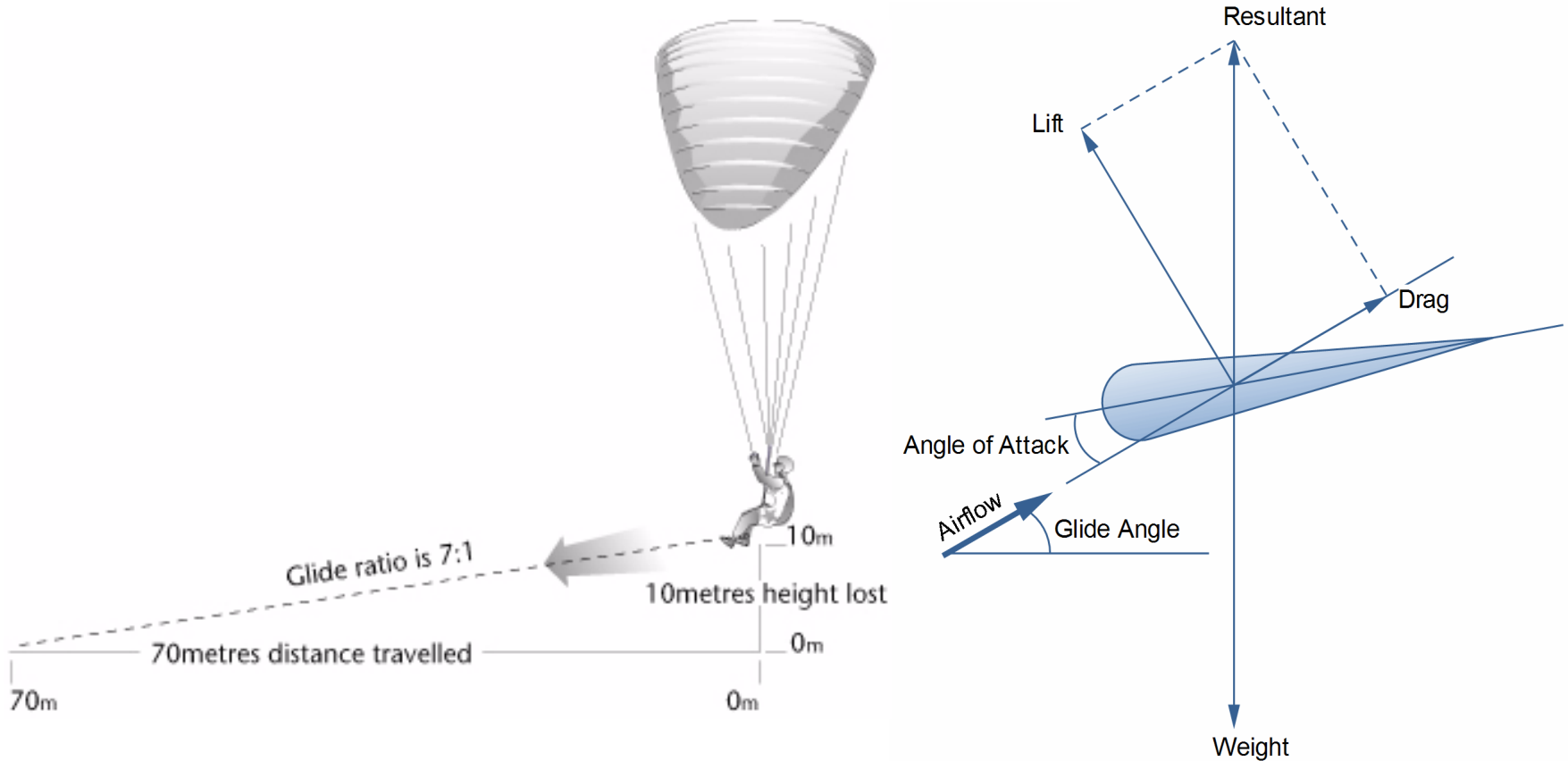
Best Glide - Minimum Total Drag

Parasitic Drag = Induced Drag



Balance of Forces

Glide Angle = Lift/Drag Ratio



Weight

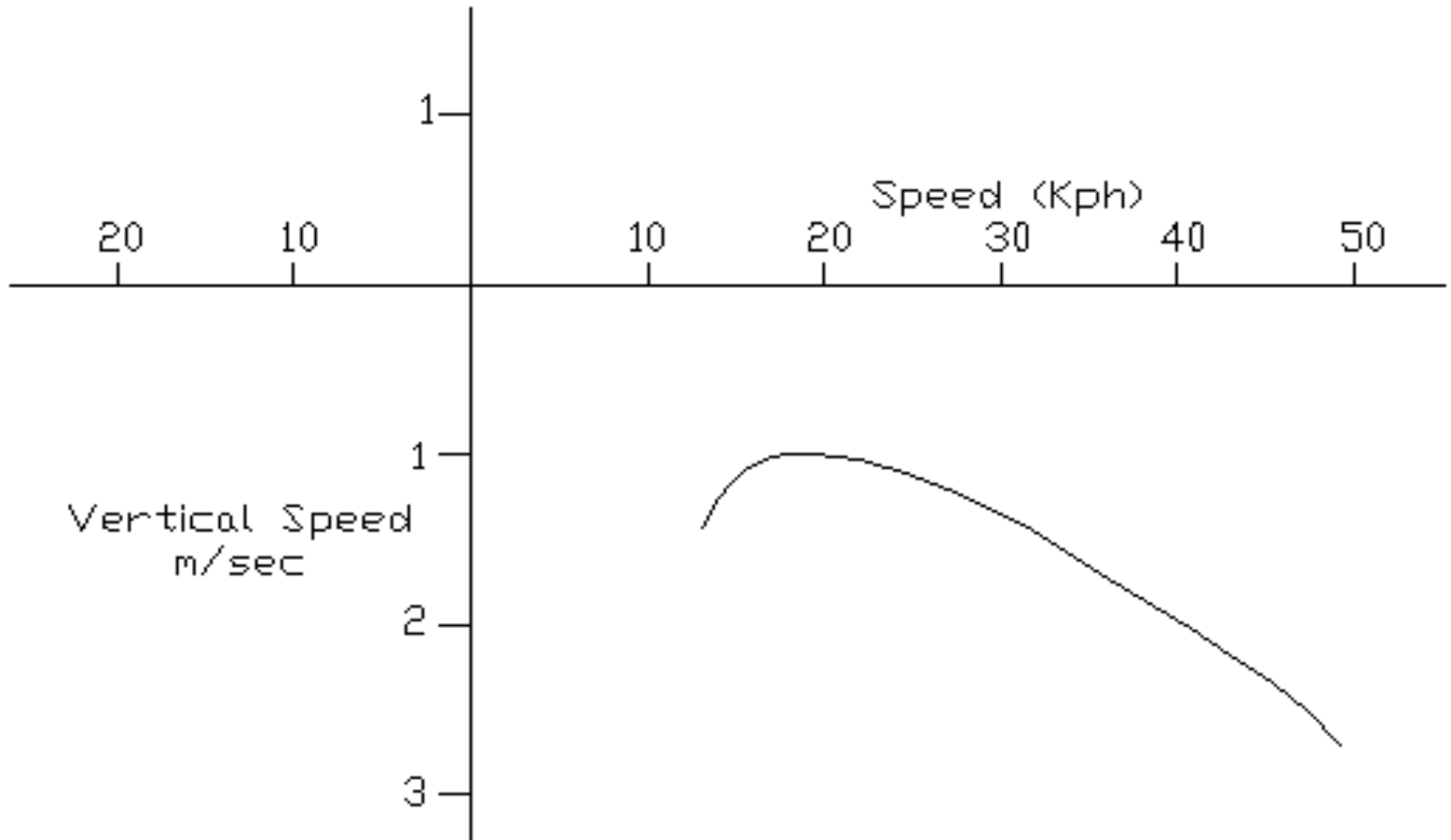
Increased Weight.

Glider flies faster at same glide angle

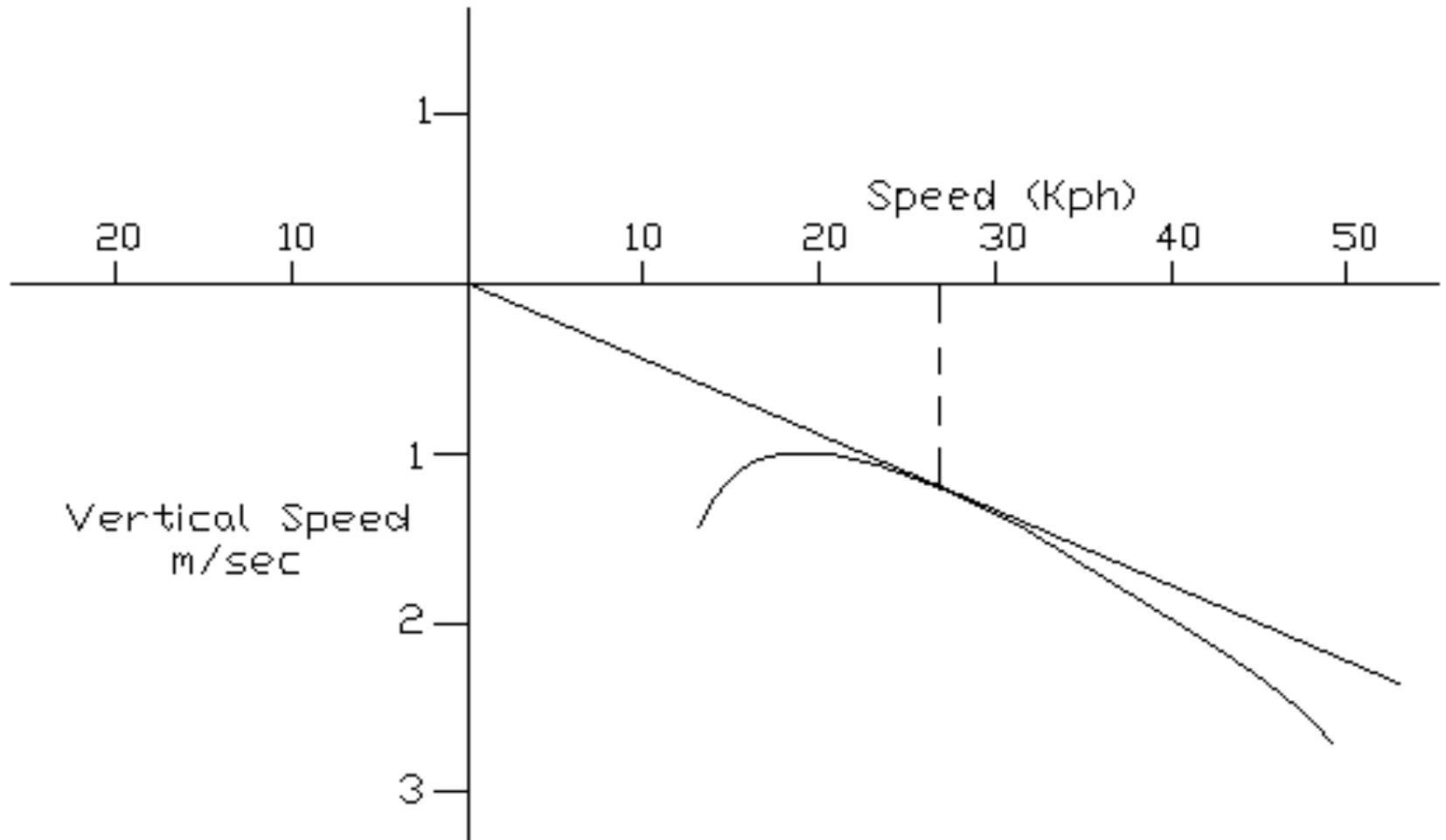
Best glide is the same

Sink Rate increases

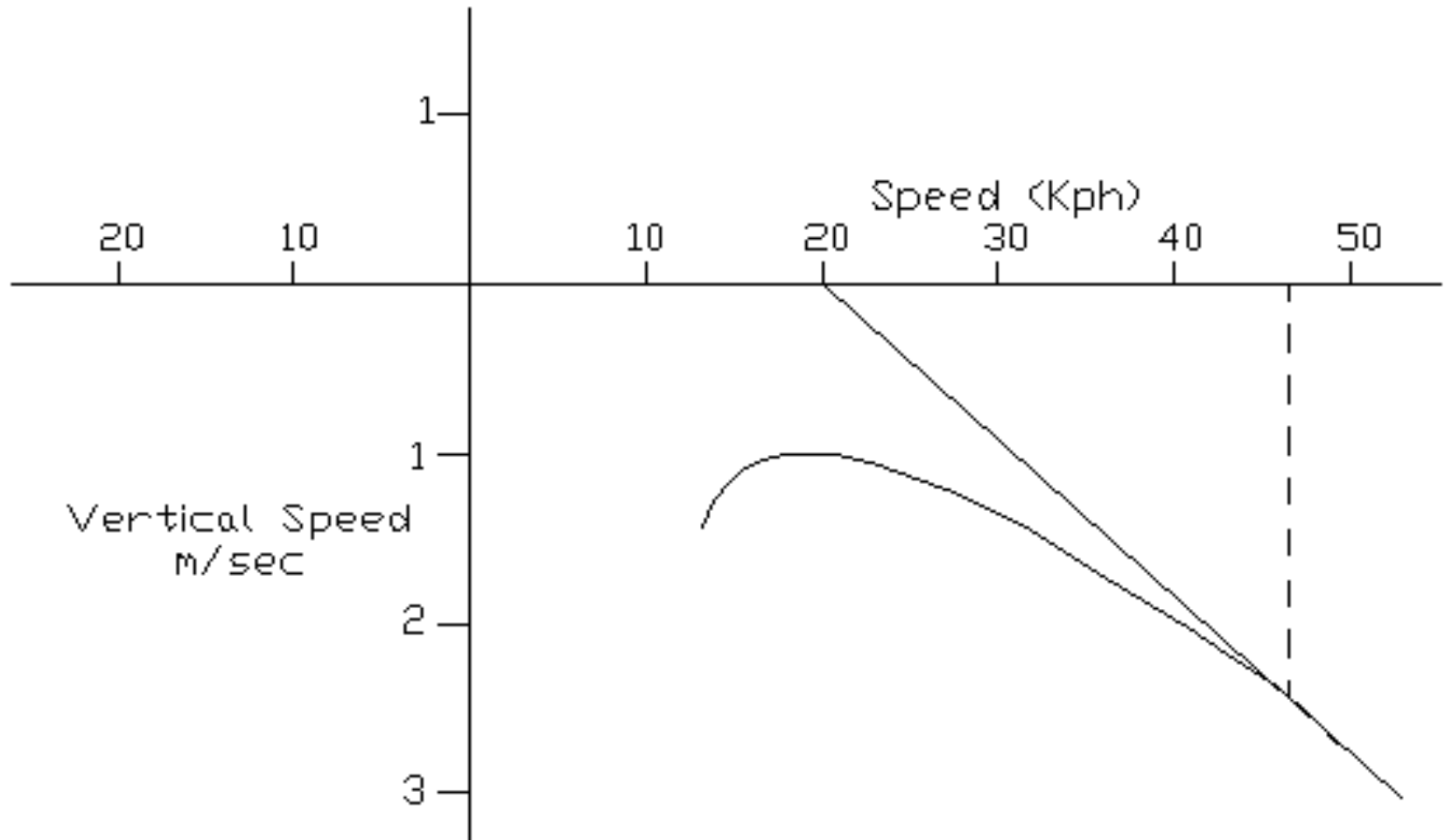
Polar Curve



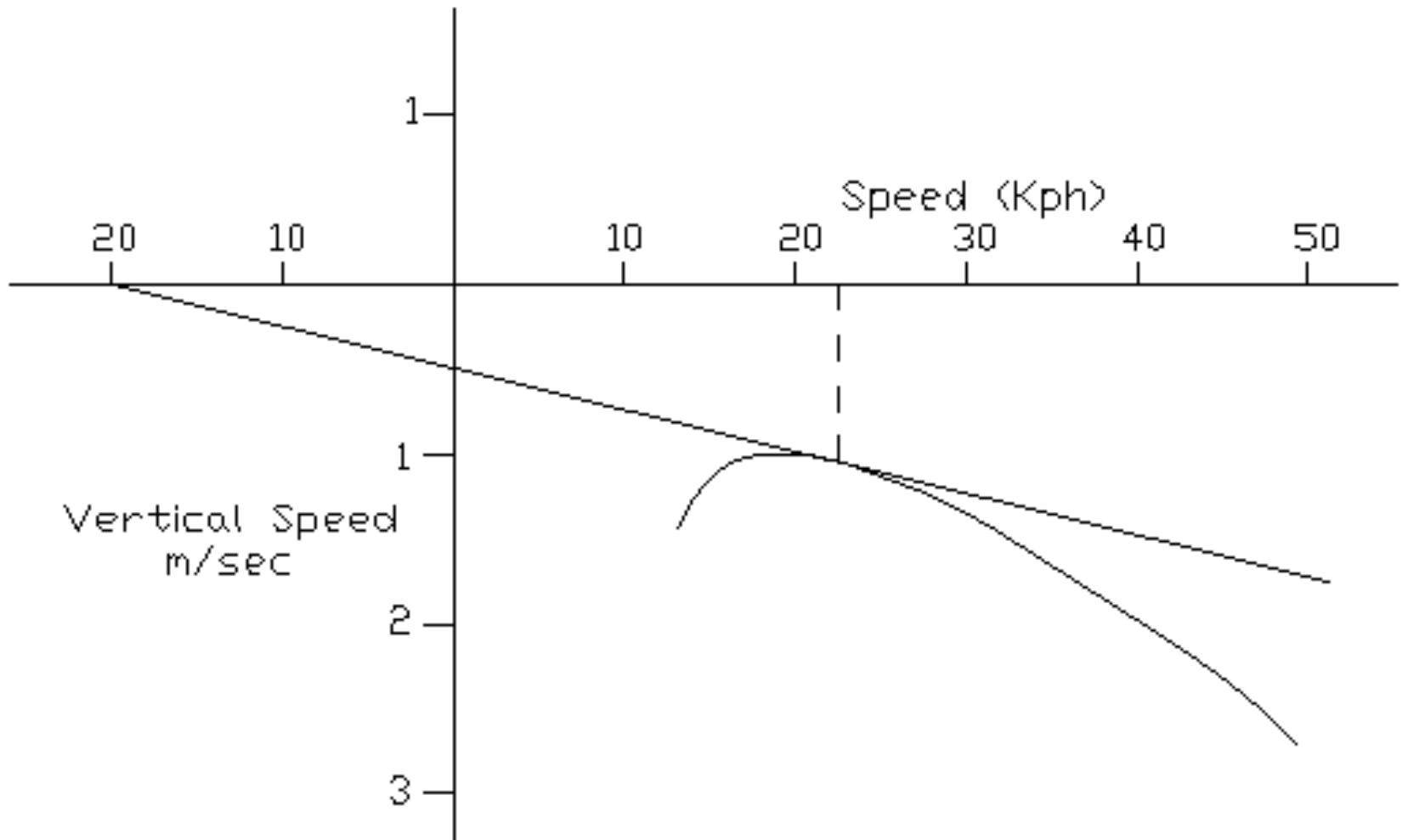
Polar - Best Glide in Still Air



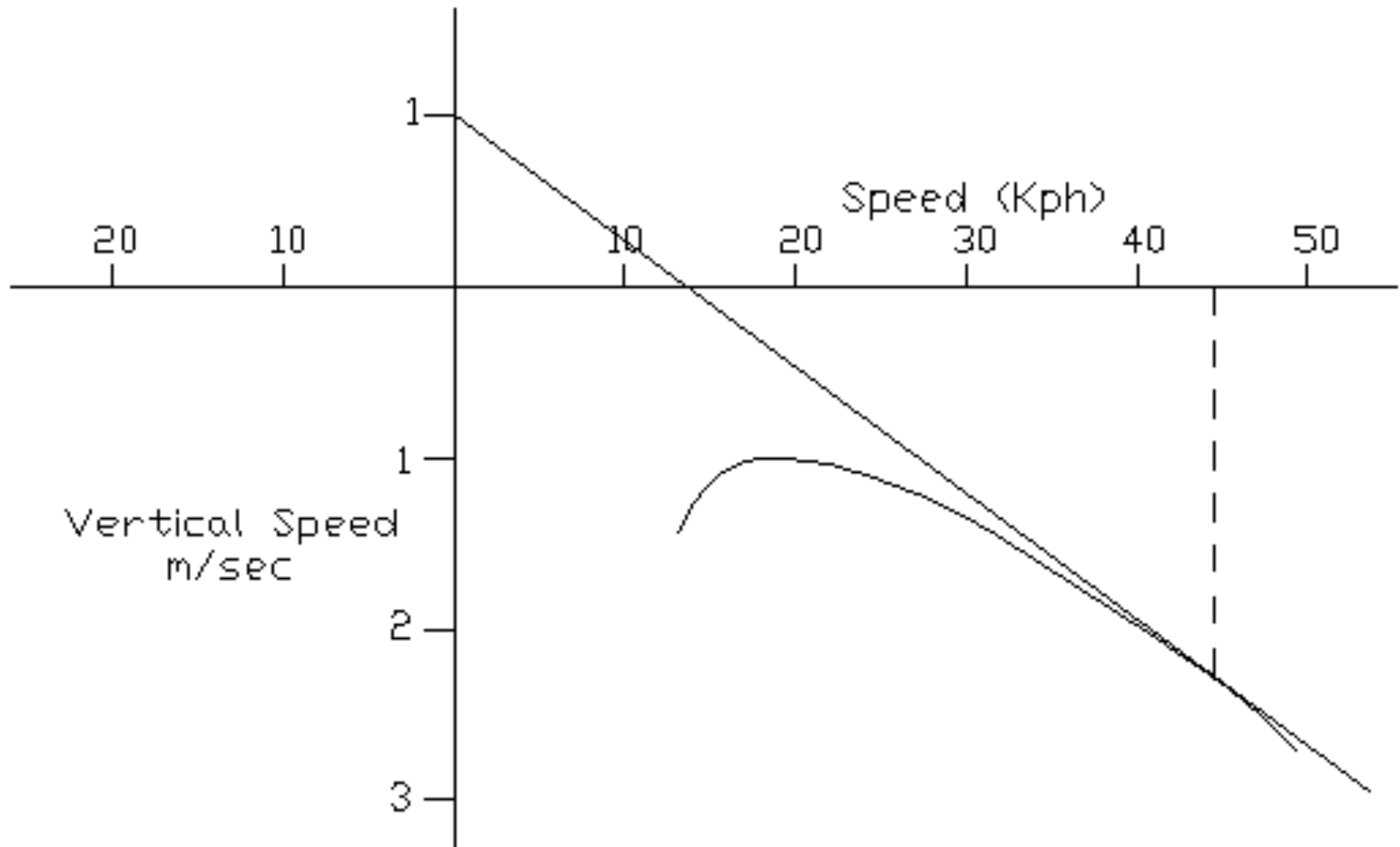
Polar - Best Glide in Headwind



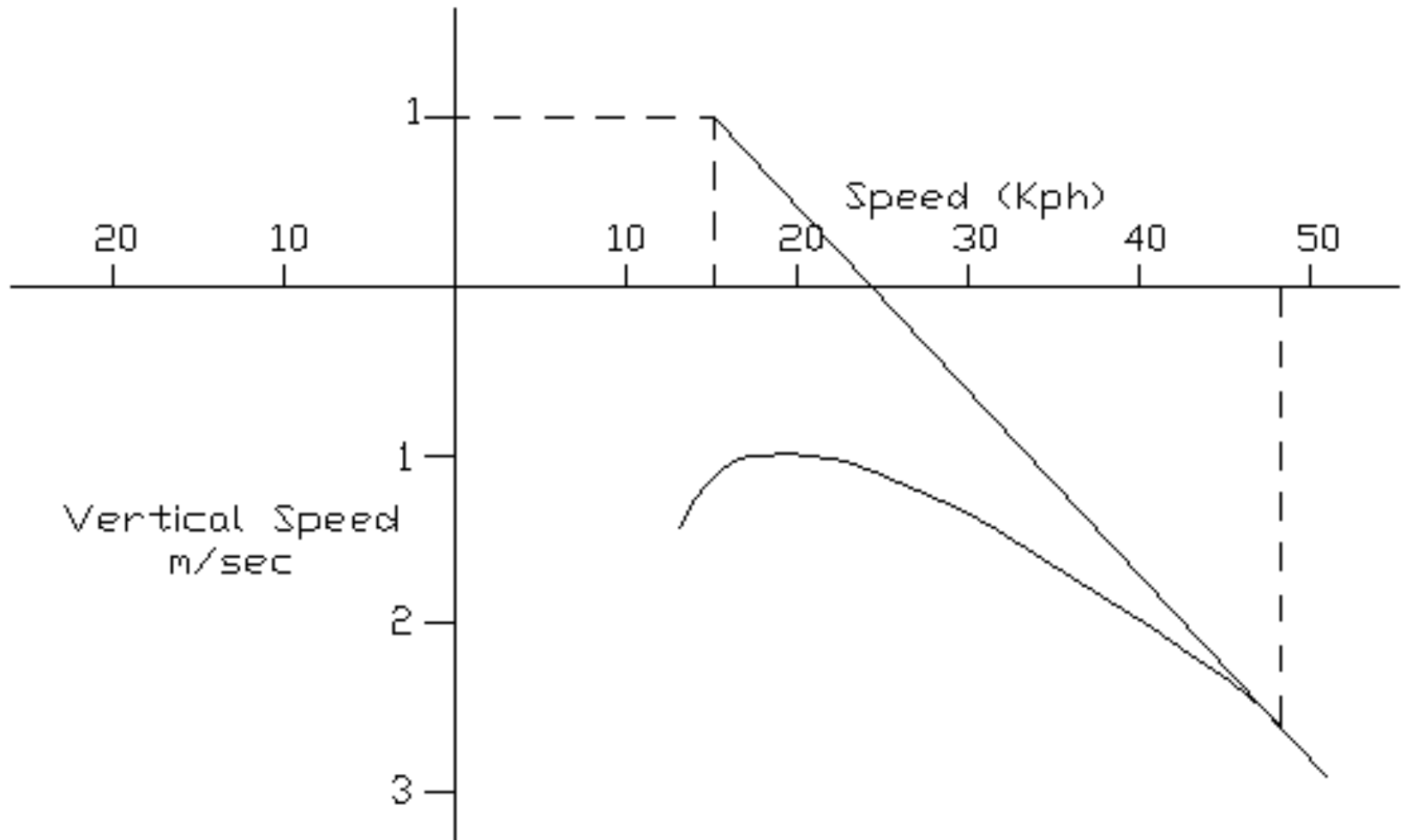
Polar - Best Glide in Tailwind



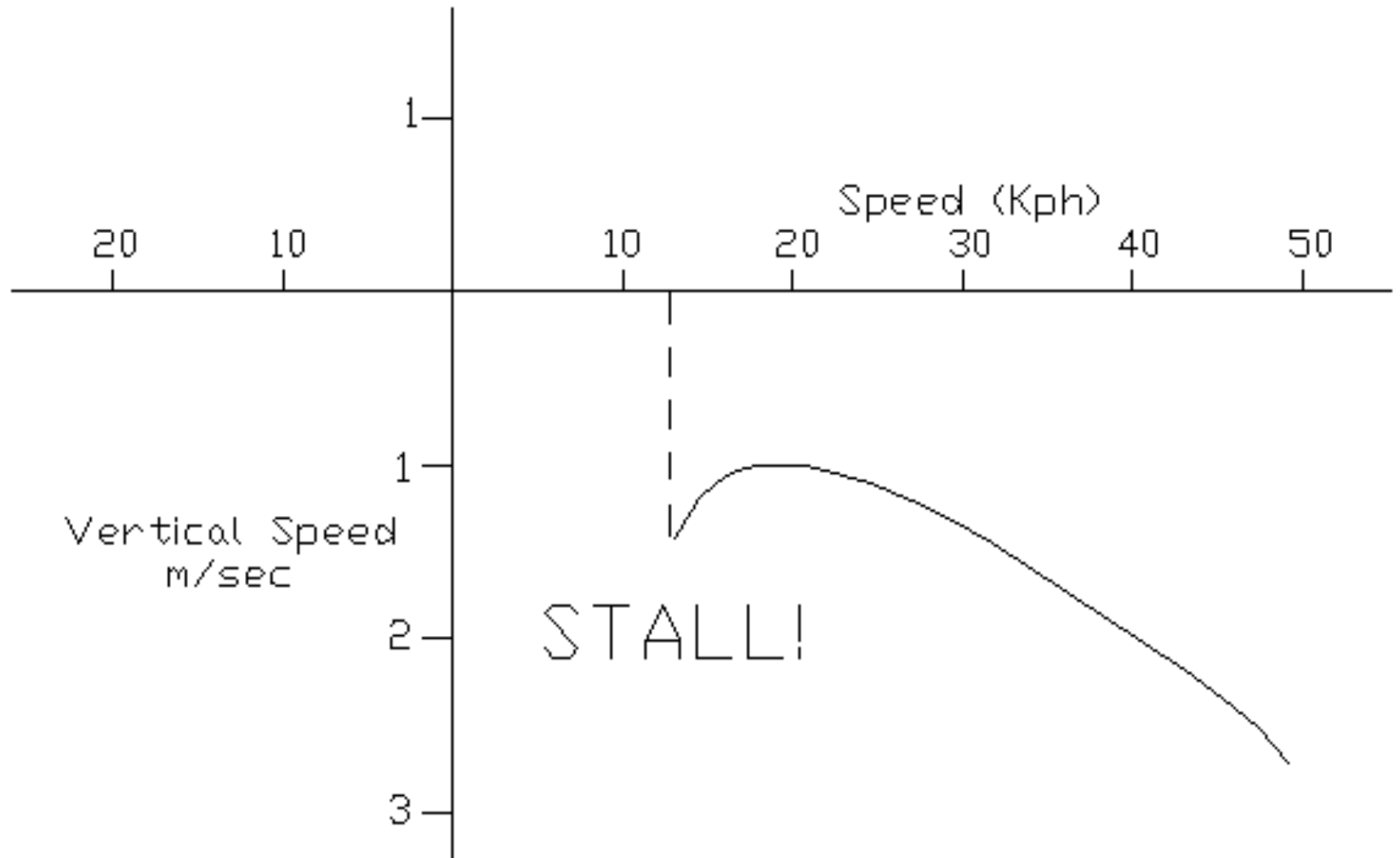
Polar - Best Glide in Sink



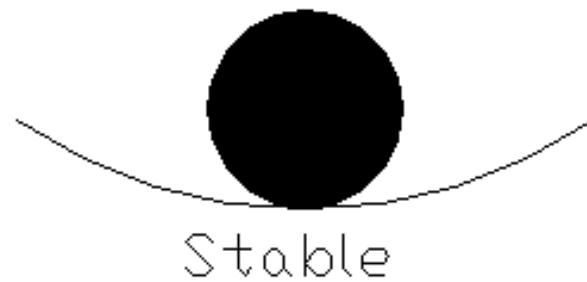
Polar - Best Glide in Sink/Headwind



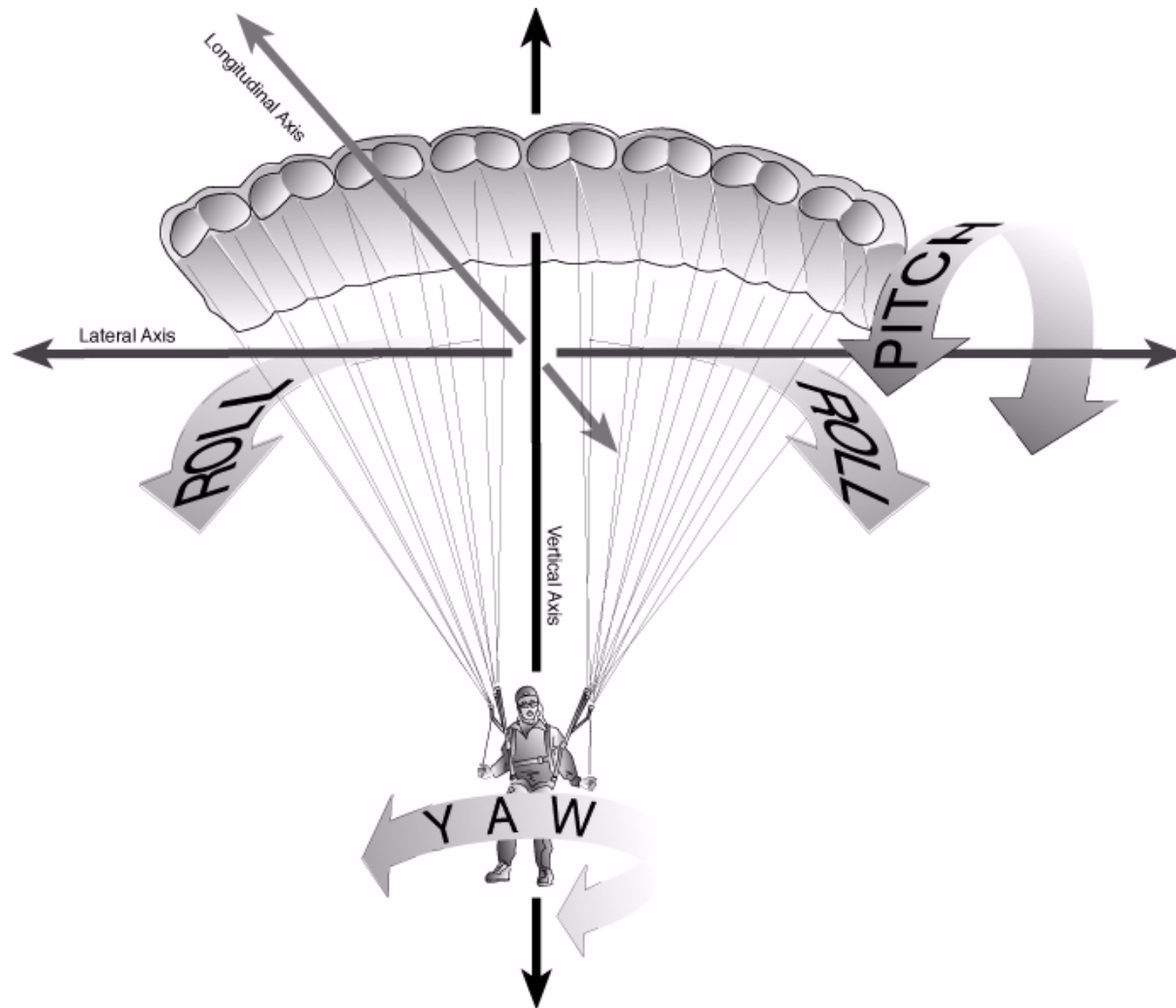
Polar - Stall!



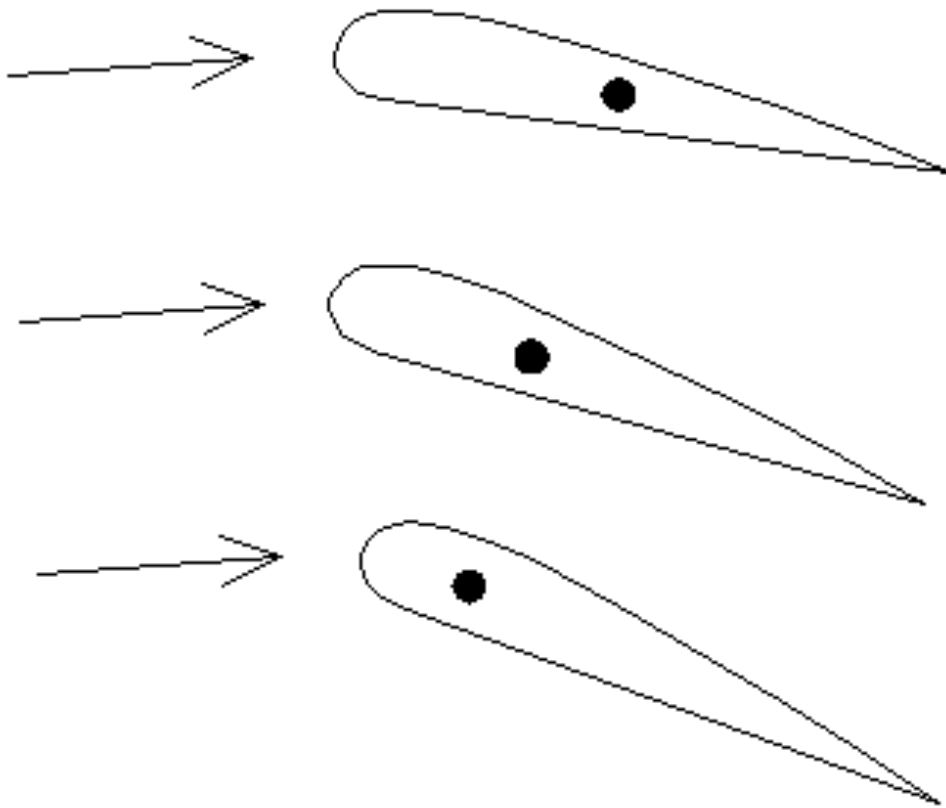
Stability



Stability



Centre of Pressure

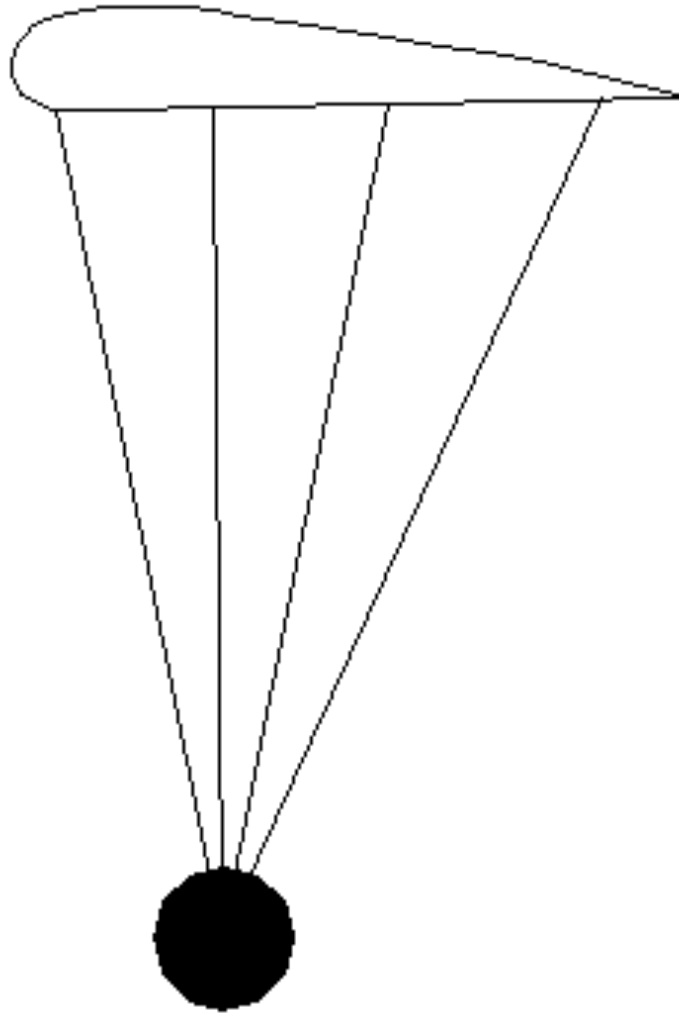


Centre of Pressure
moves forwards as
angle of attack
increases

Makes wing pitch
upwards

Wing alone is
unstable!

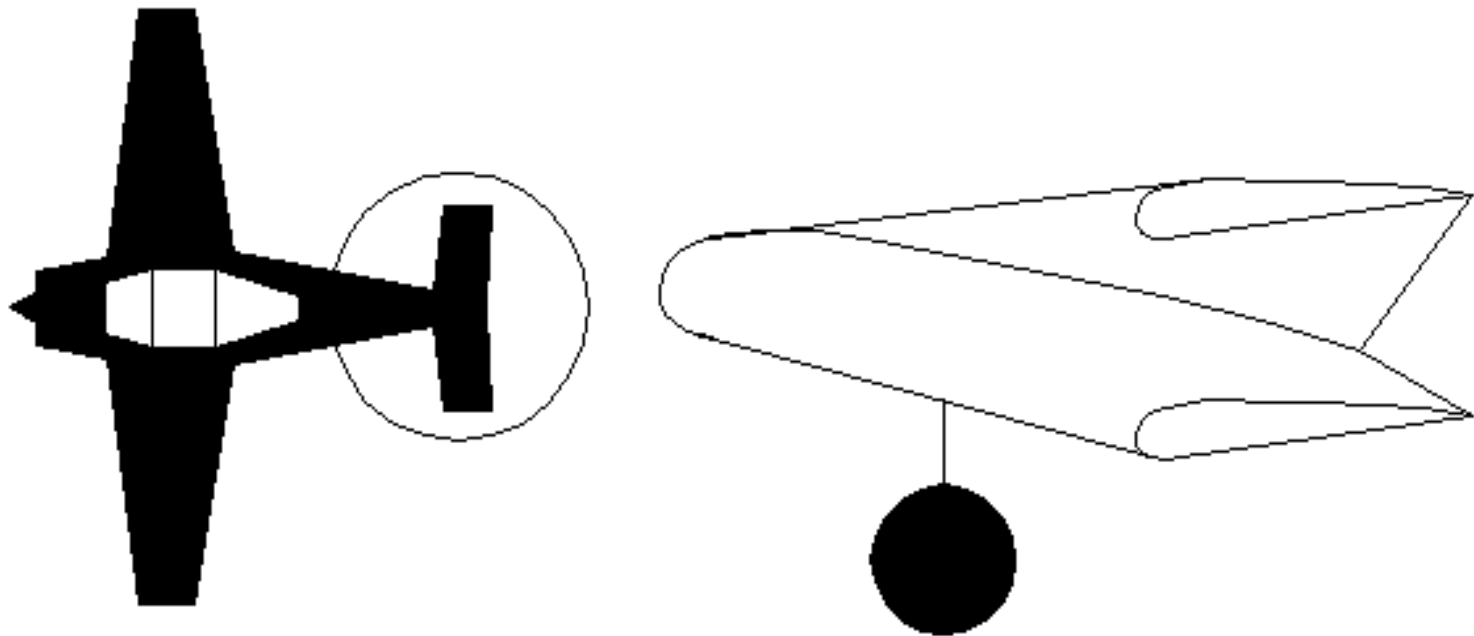
Pitch Stability - Pendulum



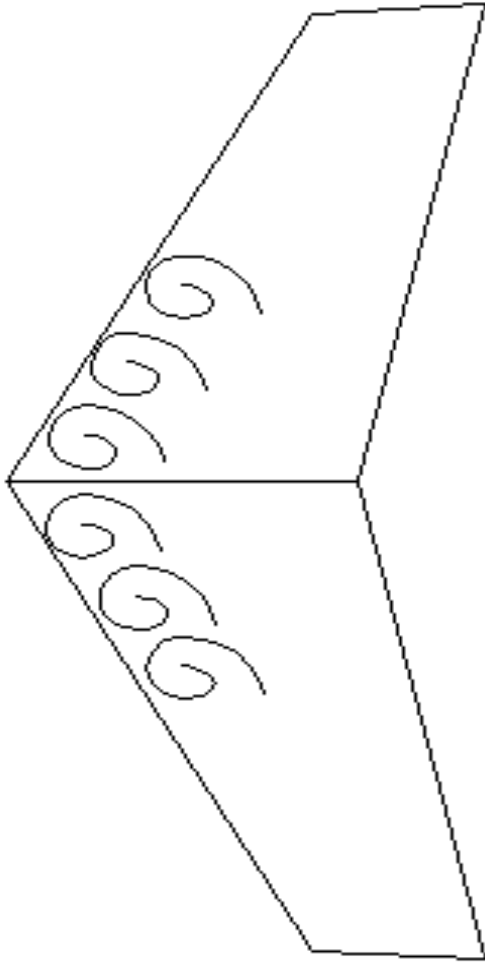
Pitch Stability - Hang Glider

Some pendulum stability

Sweep and washout create 'tailplane' surface



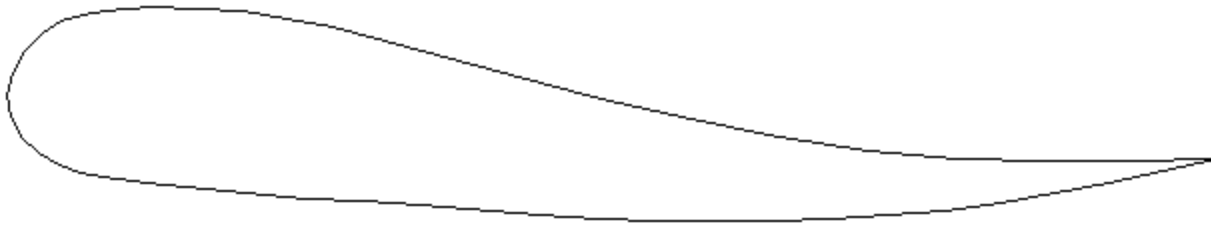
Pitch Stability - Hang Glider



Washout on swept wing makes center area tend to stall before tips.

Glider pitches down at stall.

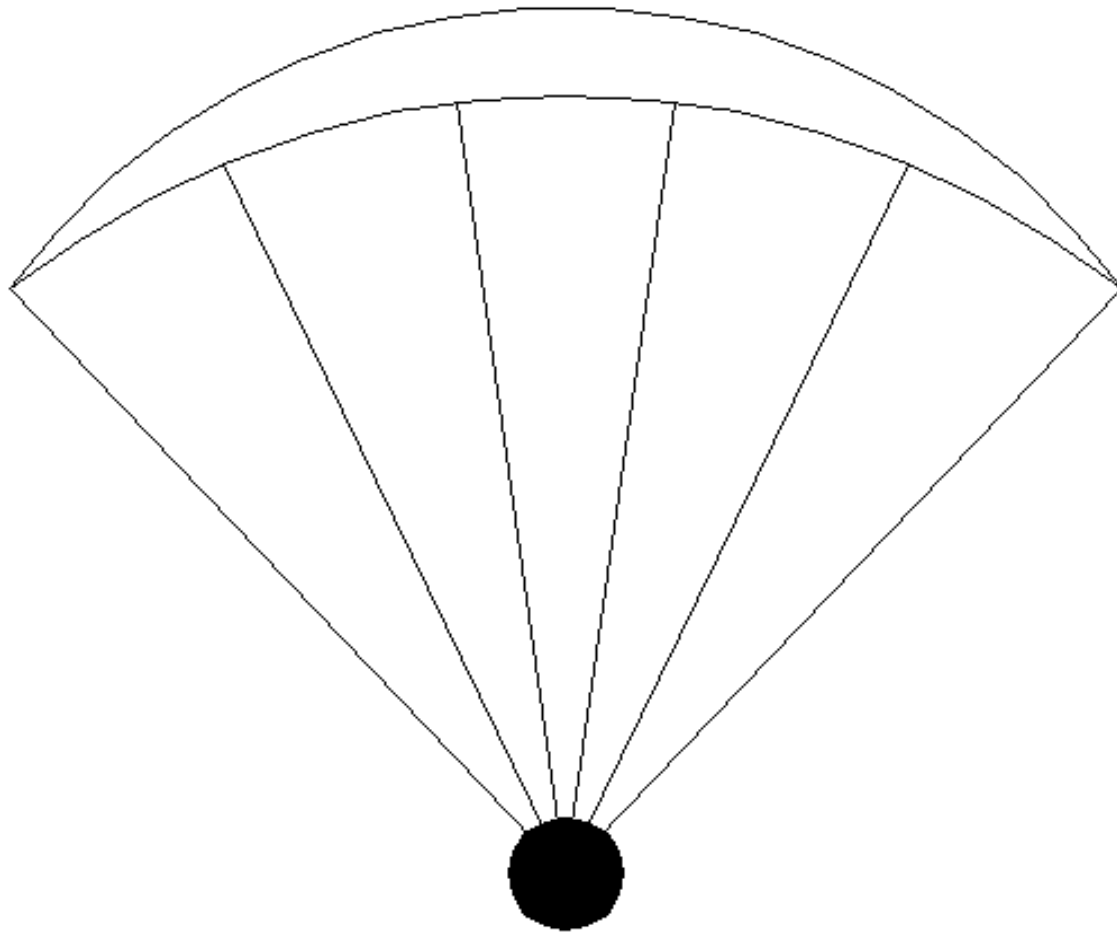
Reflex Aerofoil



Reflex aerofoil is less efficient but more stable than conventional aerofoil.

Hang-glider luff lines pull up trailing edge to form reflex at high speeds

Roll Stability - Pendulum



Roll Stability - Dihedral

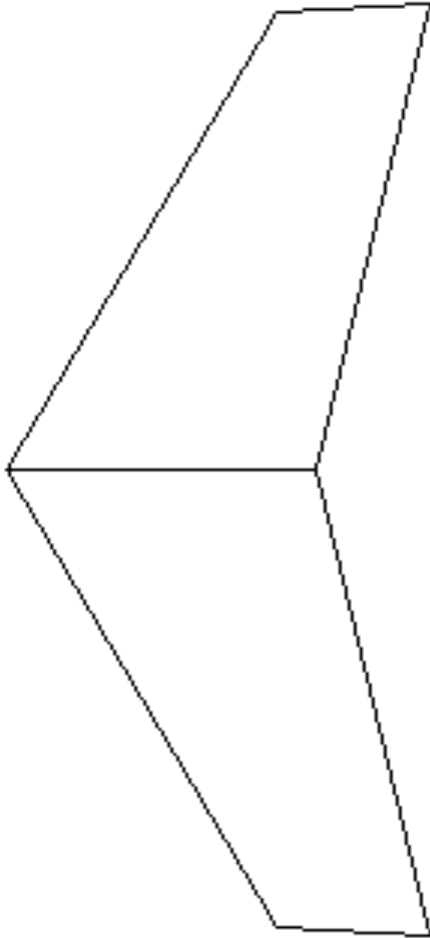
Common on rigid aircraft



Dihedral - Increases Roll Stability

Anhedral - Reduces Roll Stability

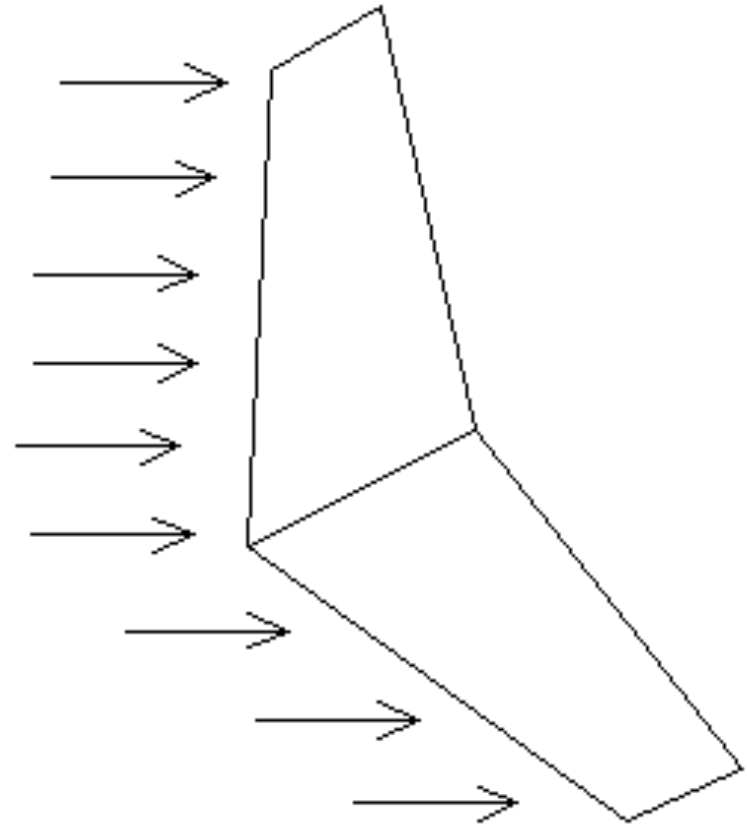
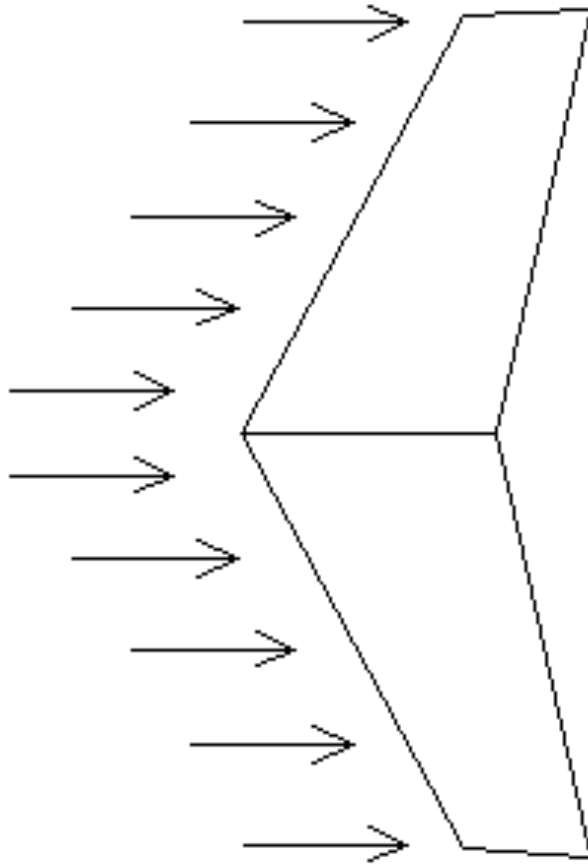
Roll Stability - Hang Glider



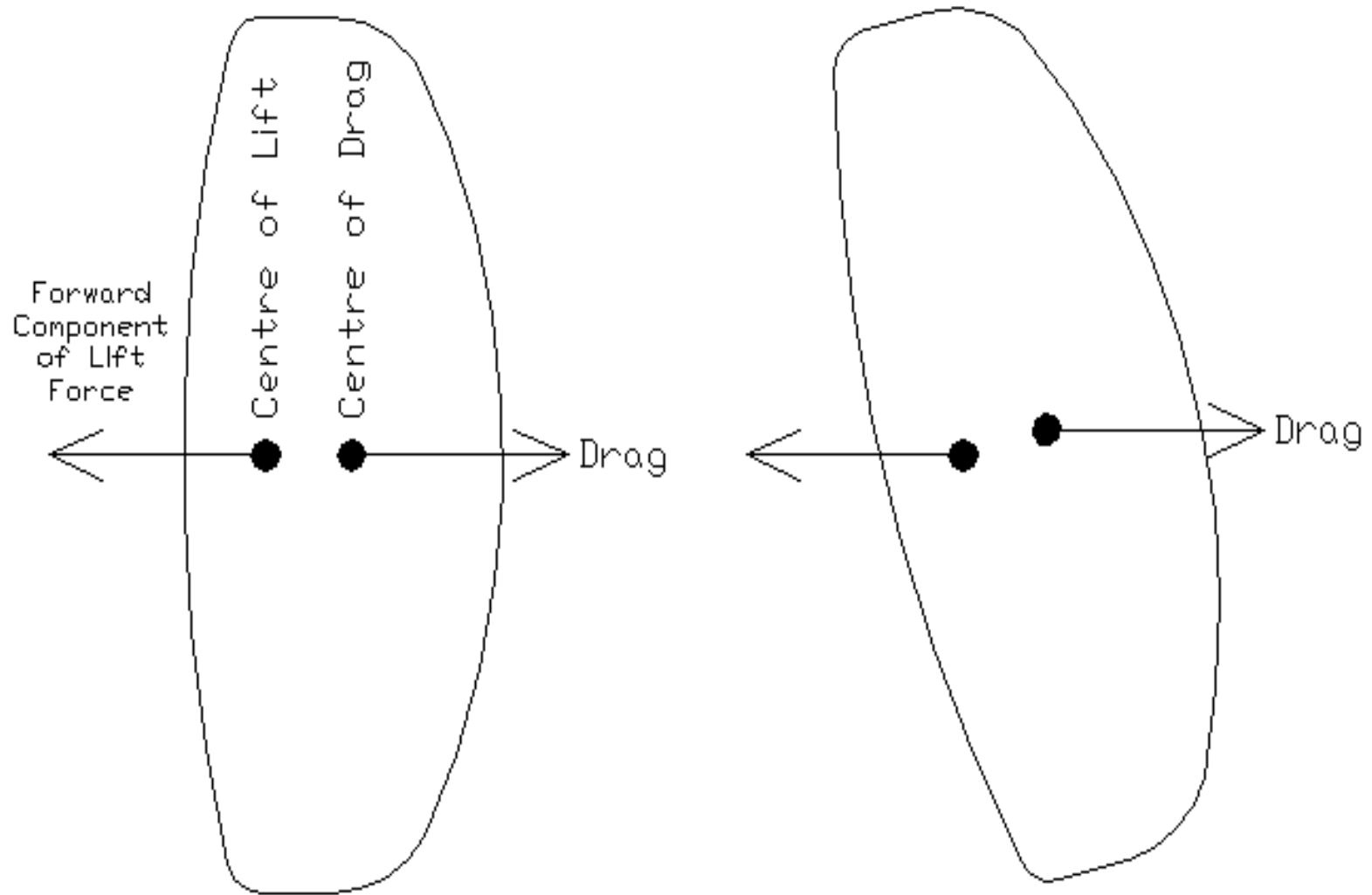
Swept wing is very
stable in roll

Some hang-gliders
have anhedral to
improve roll control

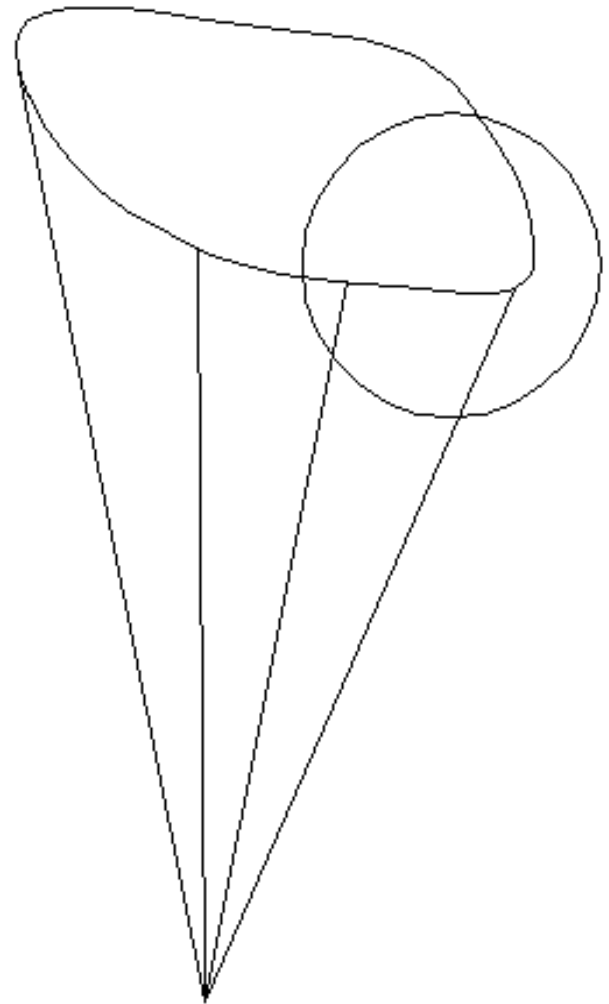
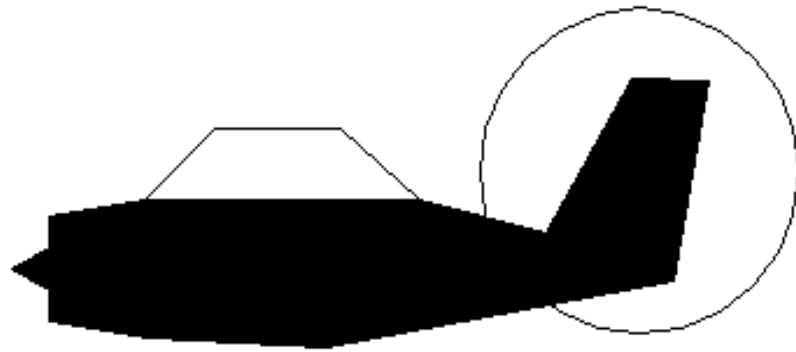
Yaw Stability - Sweep



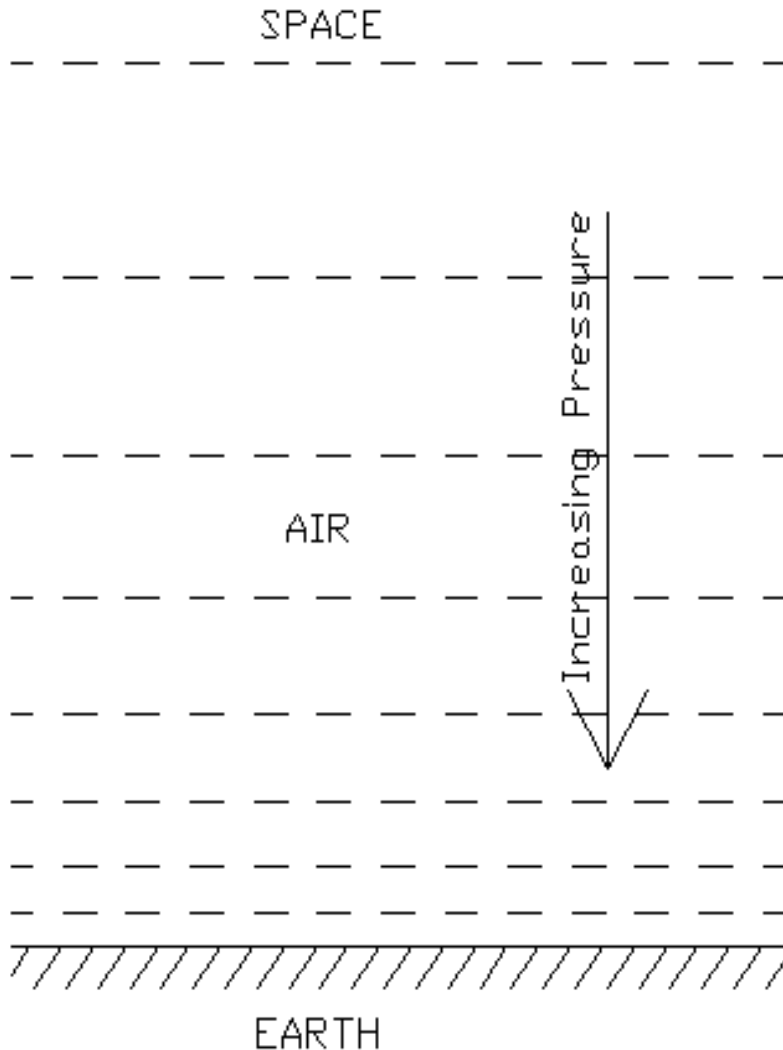
Yaw Stability - Paraglider



Yaw Stability - Fin Effect of Ears



The Atmosphere



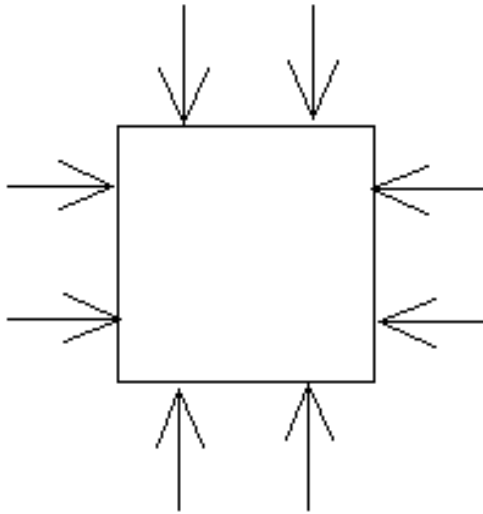
Gravity pulls the atmosphere towards the Earth

The weight of the air exerts a force on the surface of the Earth (barometric pressure)

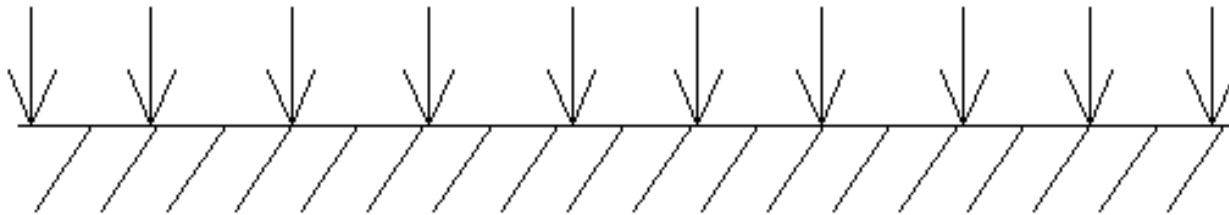
Pressure increases nearer the ground

$\sim 1\text{mb}/30\text{ft}$

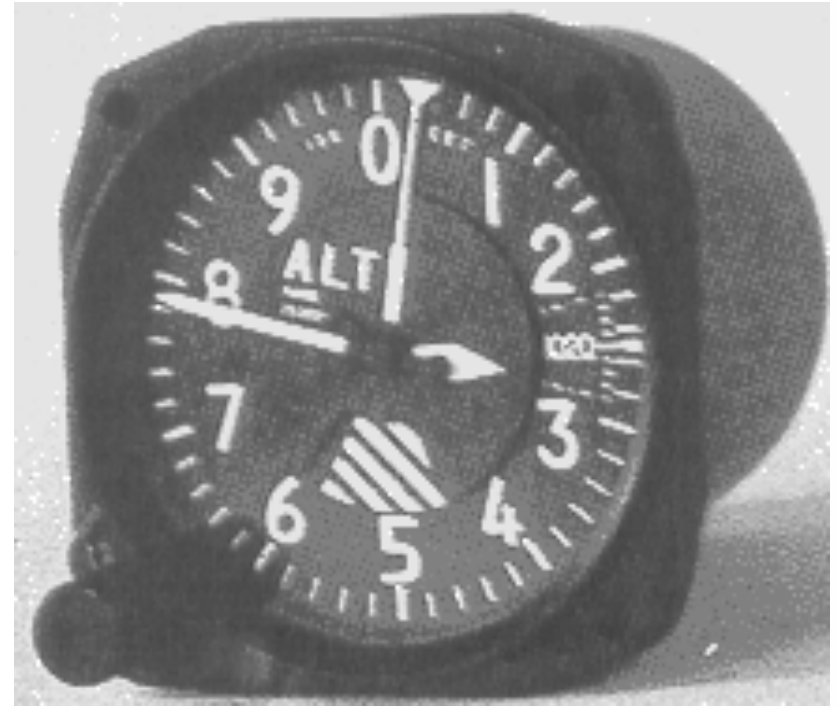
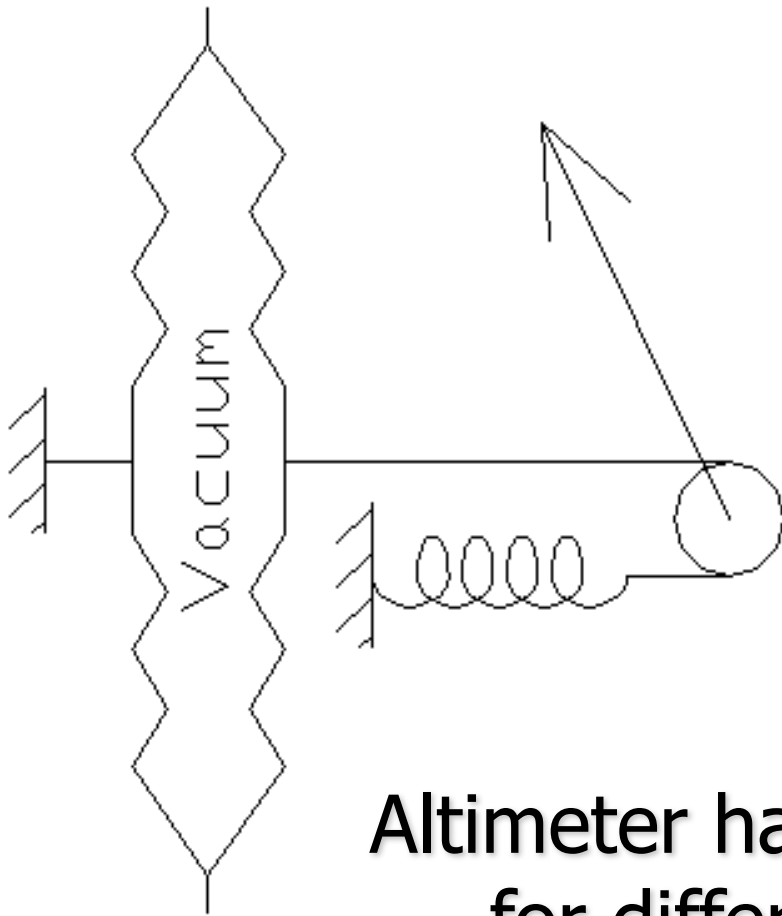
Air Pressure (Barometric Pressure)



Weight of air exerts
force on surface of
the earth and surfaces
of any bodies exposed
to it

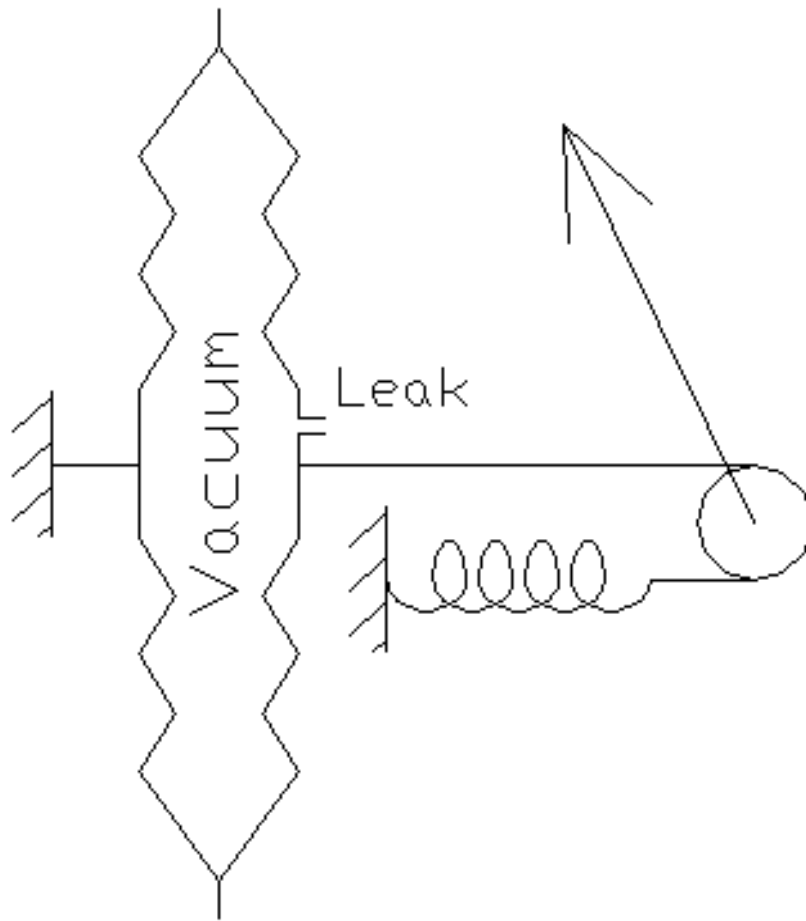


Altimeter



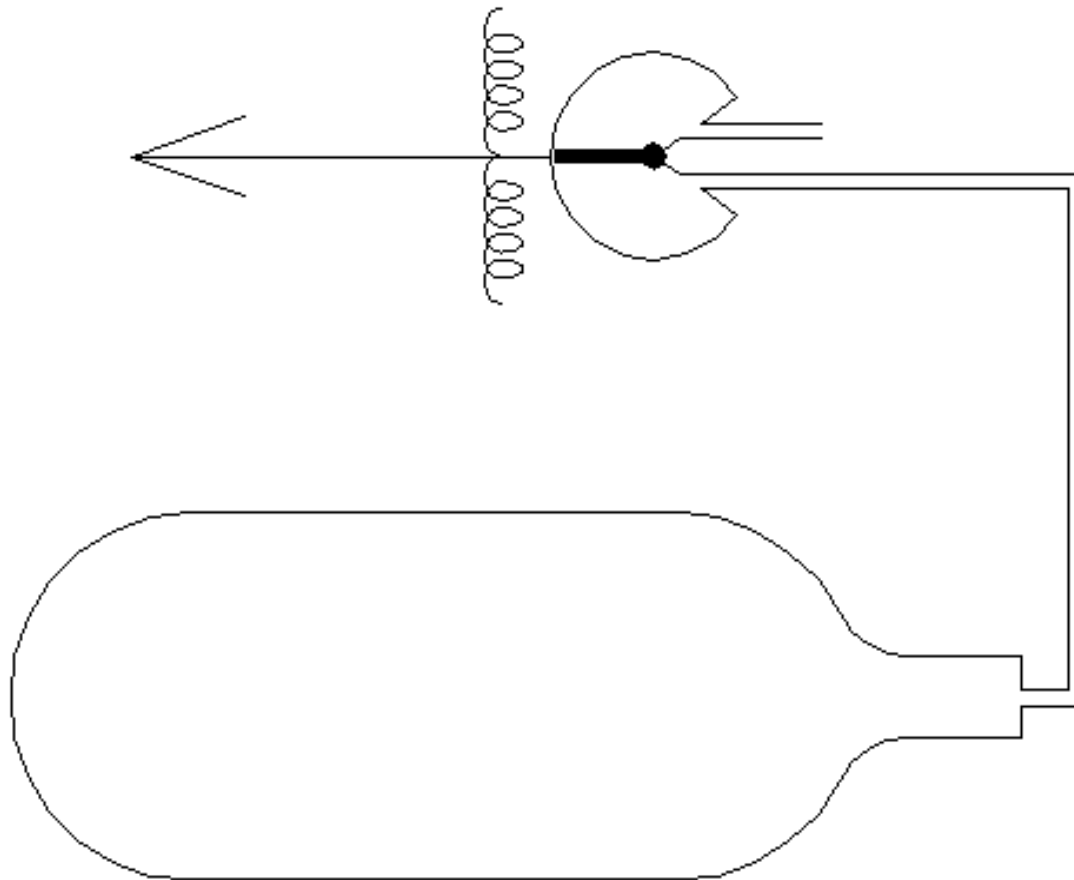
Altimeter has subscale device to adjust for different reference pressures

VSI (Vertical Speed Indicator)



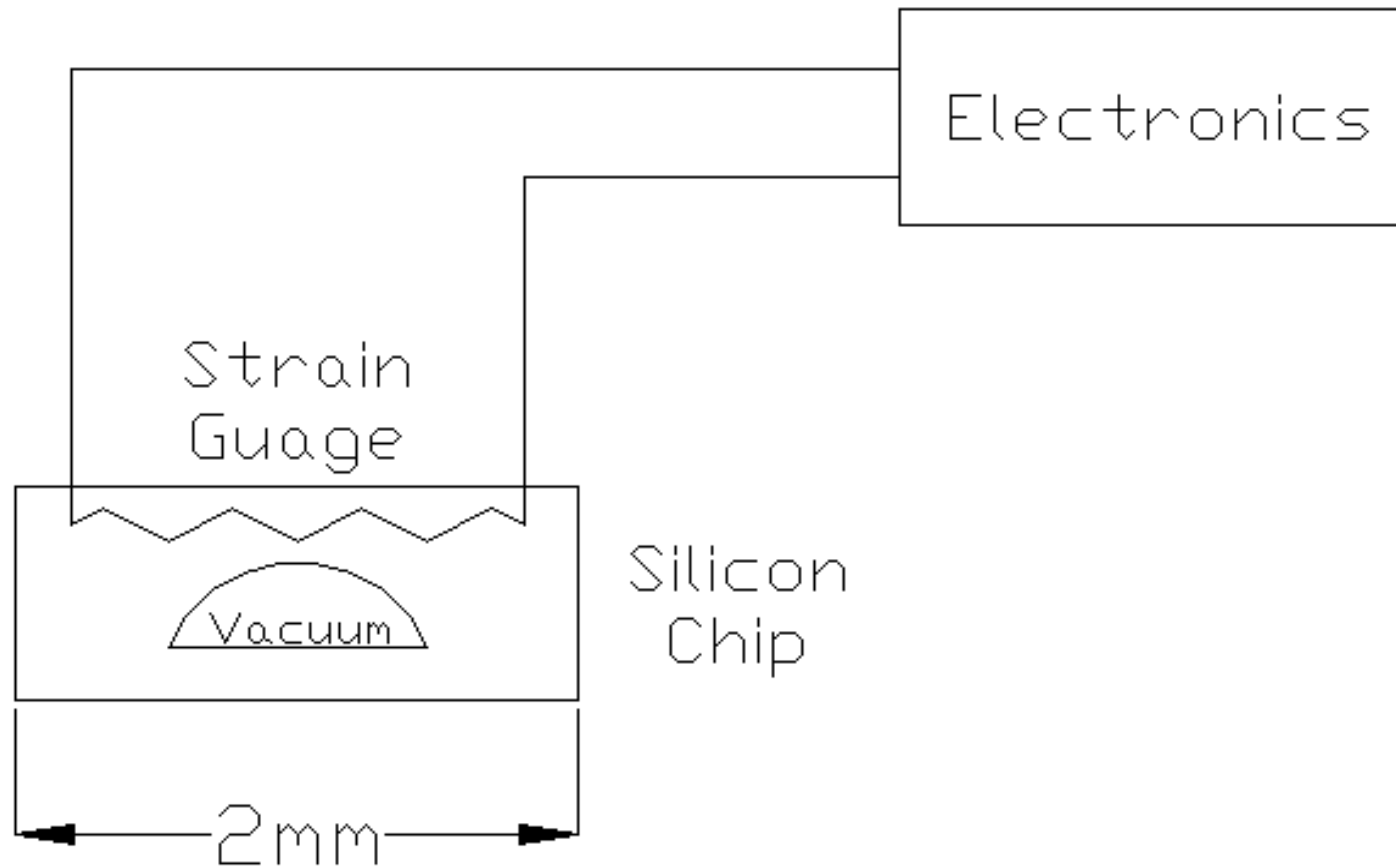
Poor
sensitivity
and lag

Flask Variometer

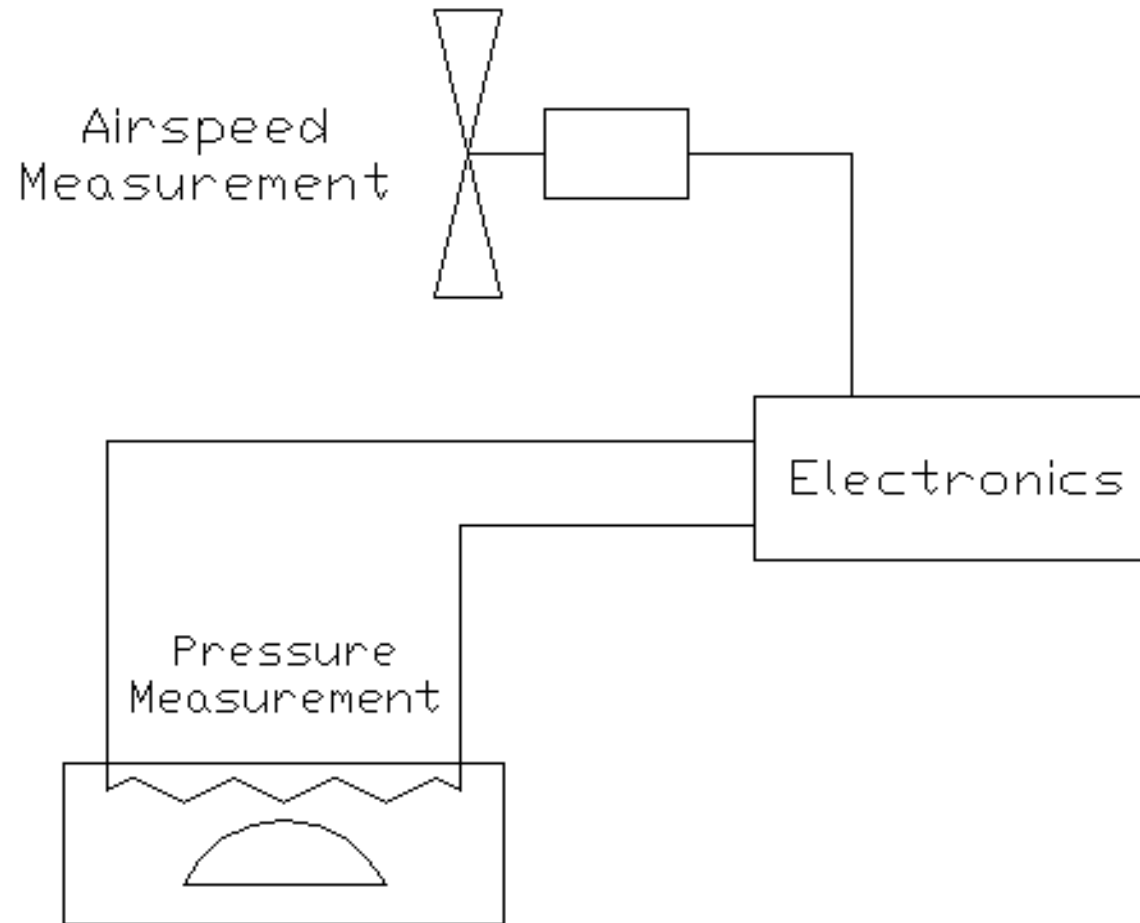


Sensitive
but bulky and
delicate

Electronic Altimeter/Variometer



Total Energy Vario



McCready Ring

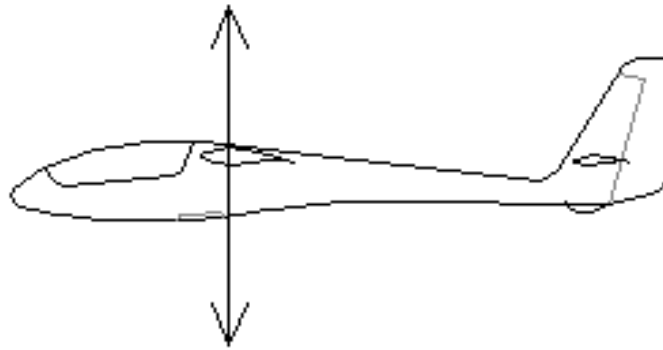
Shows speed to fly for best glide in lift or sink
Arrow may be set to average thermal climb rate for fastest cross country flying



Variometers

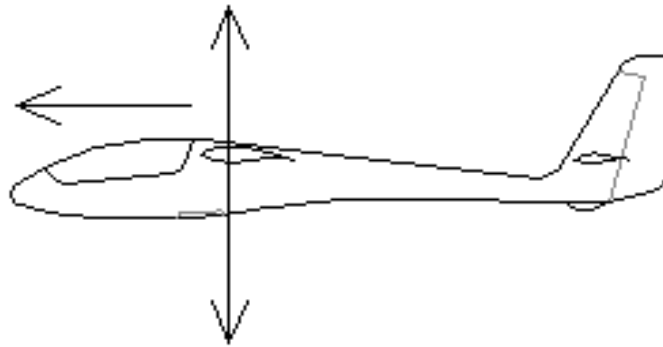
Basic Vario

Vertical
movement of
aircraft only



Total Energy

Vertical
movement and
airspeed of
aircraft



Airmass Vario

Vertical
movement of
air aircraft is
flying in



Terms

- Aspect ratio - ratio of the wingspan to the chord (high aspect ratio wings are long and thin). Also span squared divided by surface area
- Chord - Distance of airfoil trailing edge to leading edge
- Angle of attack - Measured angle from undisturbed airflow to chord line
- Dihedral - upward angling of wings from root to tip
- Anhedral - downward angling of wings from root to tip
- Centre of pressure - the point where the resultant of the lift and the drag is considered to be acting.
- Washout - A twist in the wings from wingtip to root. (Lower A of A at tips)
- L Glide angle (ratio) - expression of the efficiency of the glide. The less the angle or the greater the ratio, the better the glide.
- L Min sink - the slowest possible descent rate for a glider through the air (in fpm)
- Relative wind - the apparent wind as the glider is flying.