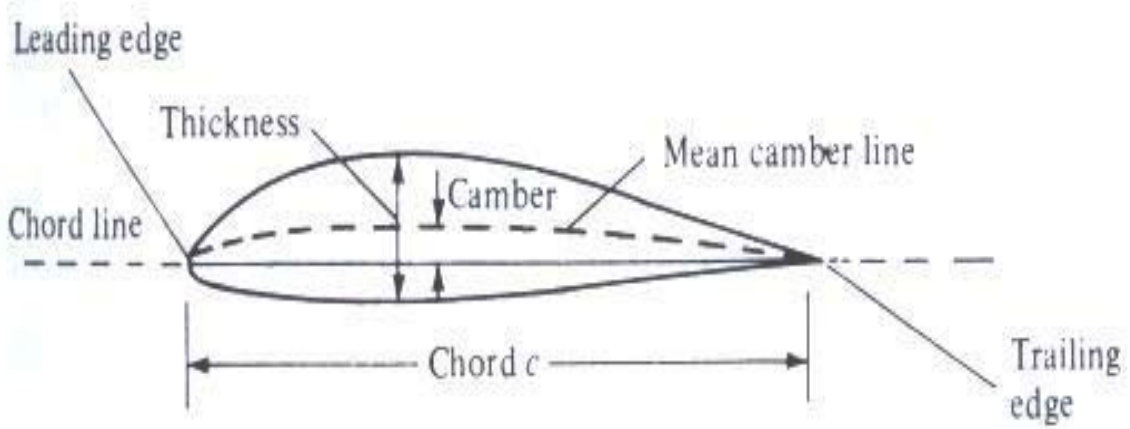
King Fahd University of Petroleum and Minerals

Aerospace Engineering Department

Experiment

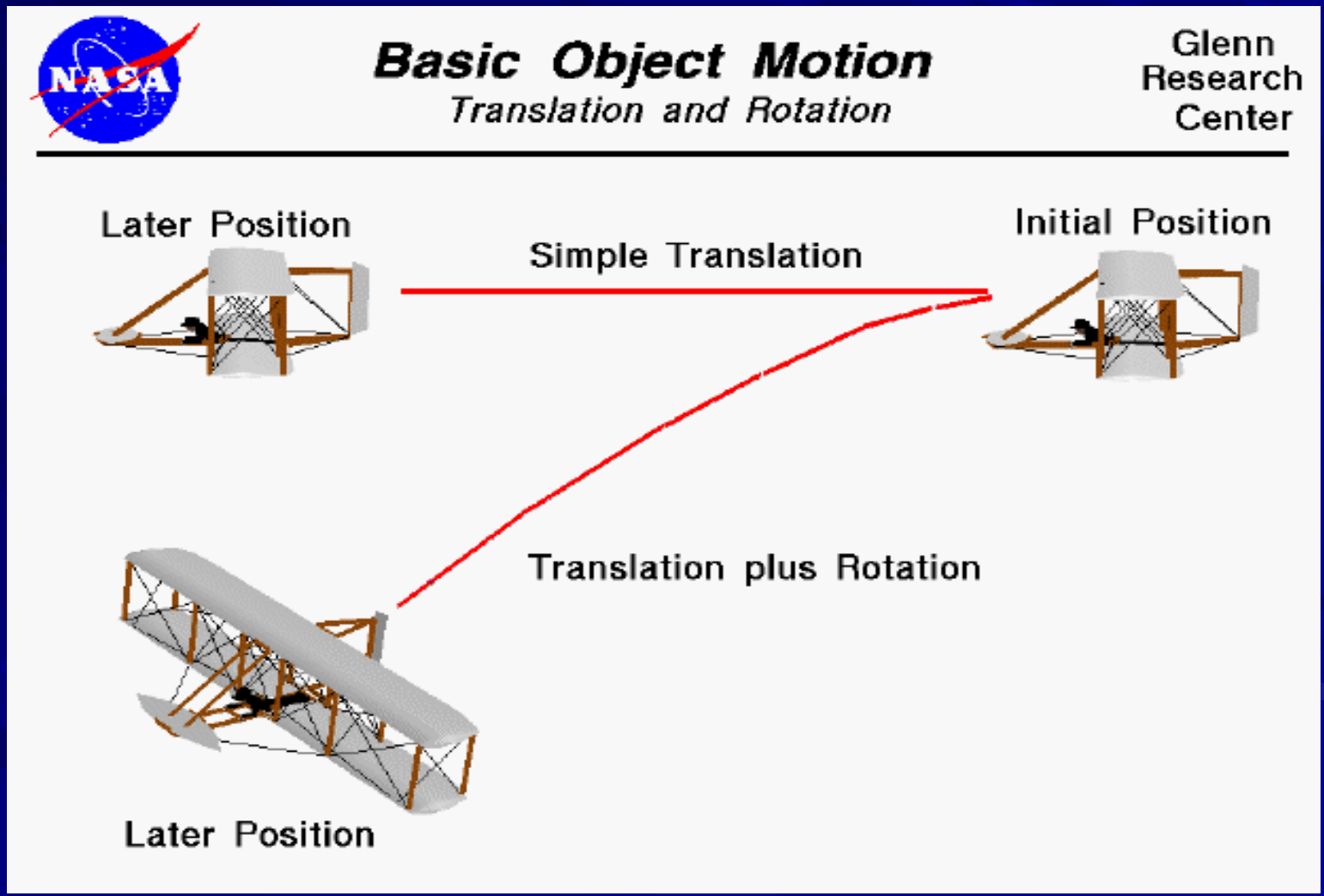
Measurement of Lift and Drag for and Airfoil Section

Basic Nomenclature



Airfoil nomenclature.

Flight of an Aircraft



Four Forces on an Airplane

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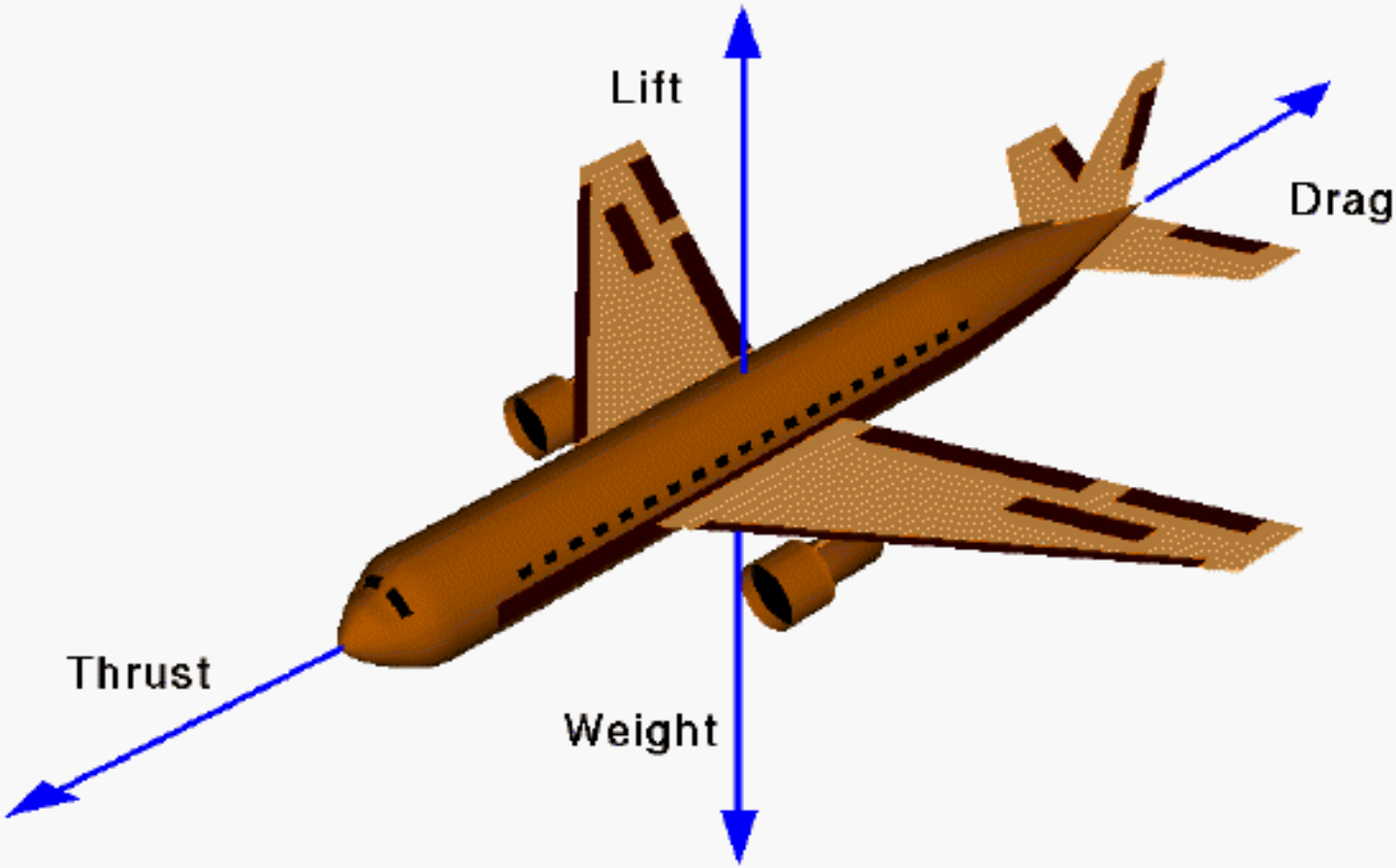

Three Forces on a Glider

Wright 1900 Aircraft

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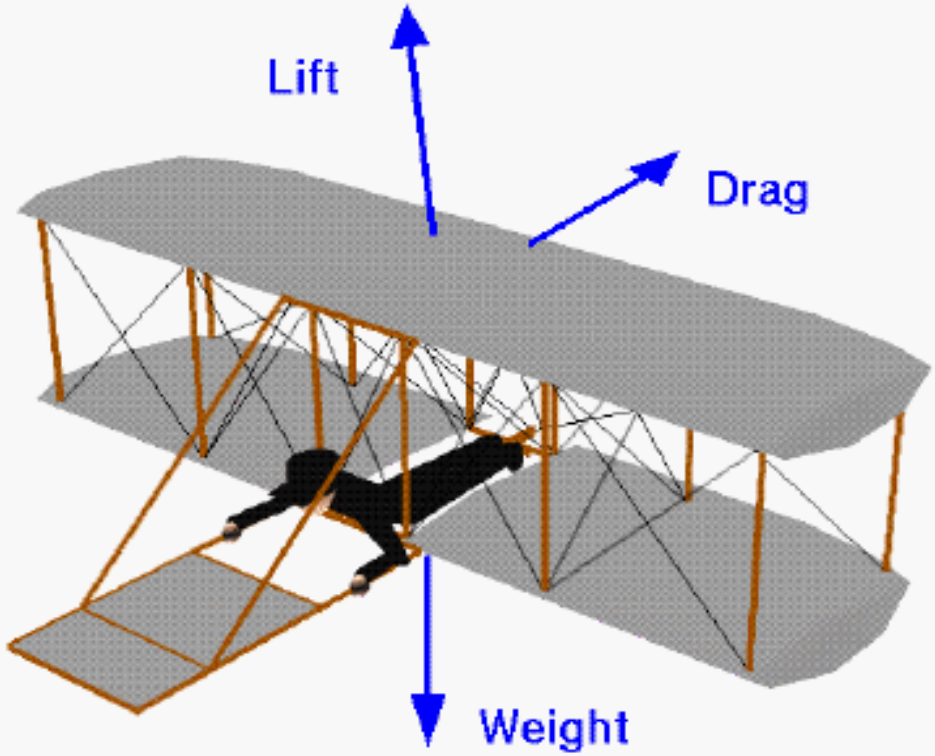
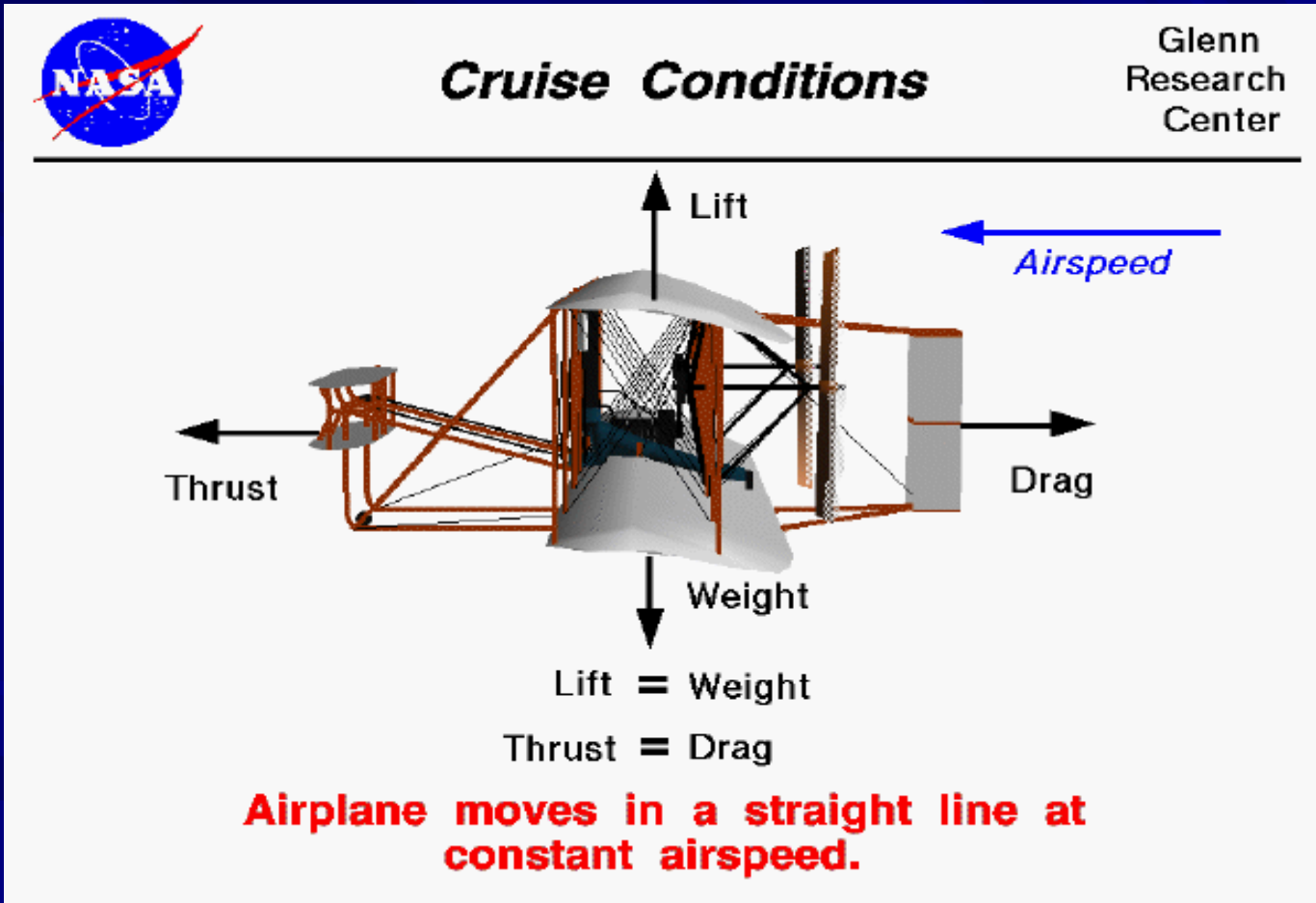


Some Considerations



Simplified Aircraft Motion

Unbalanced Forces

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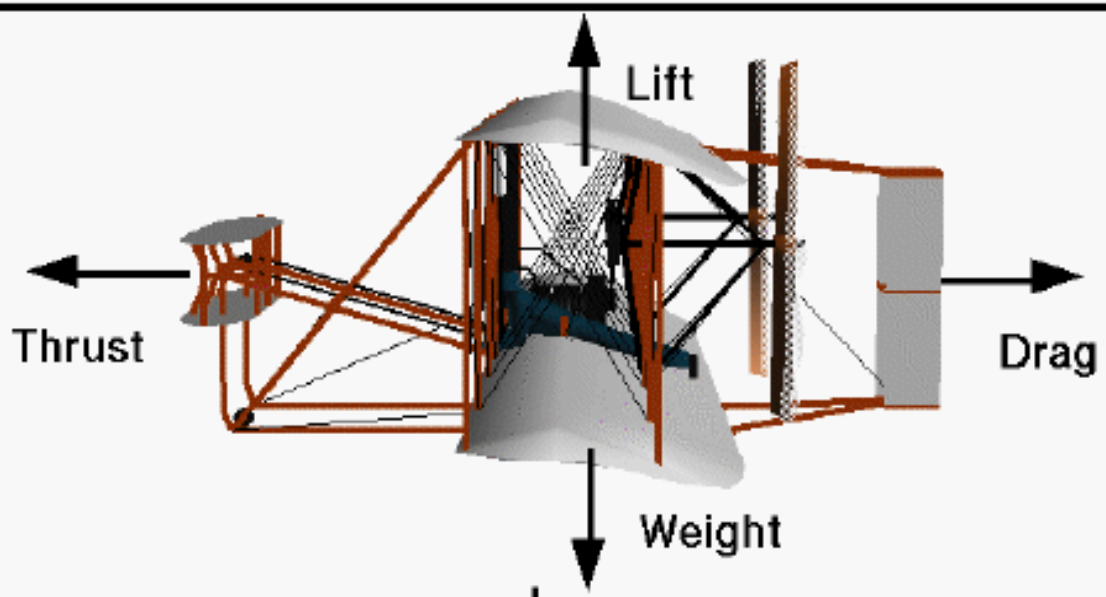

Flight Condition	Effect
Lift > Weight	Plane Rises
Weight > Lift	Plane Falls
Drag > Thrust	Plane Slows
Thrust > Drag	Plane Accelerates

Aerodynamic Forces

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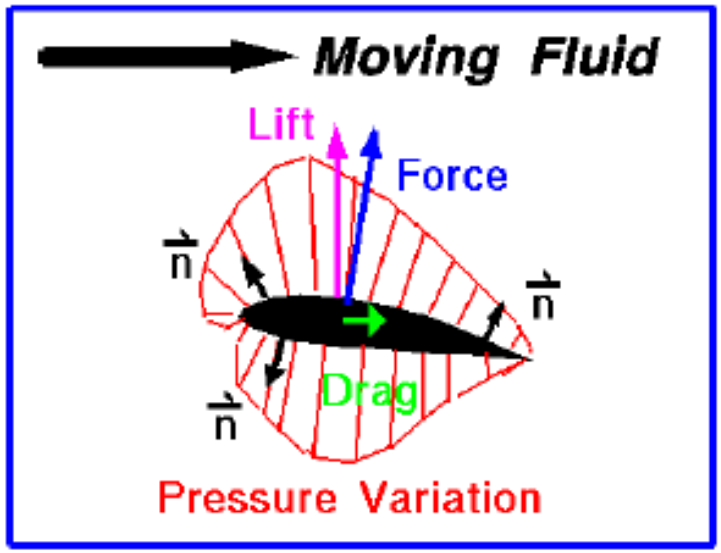


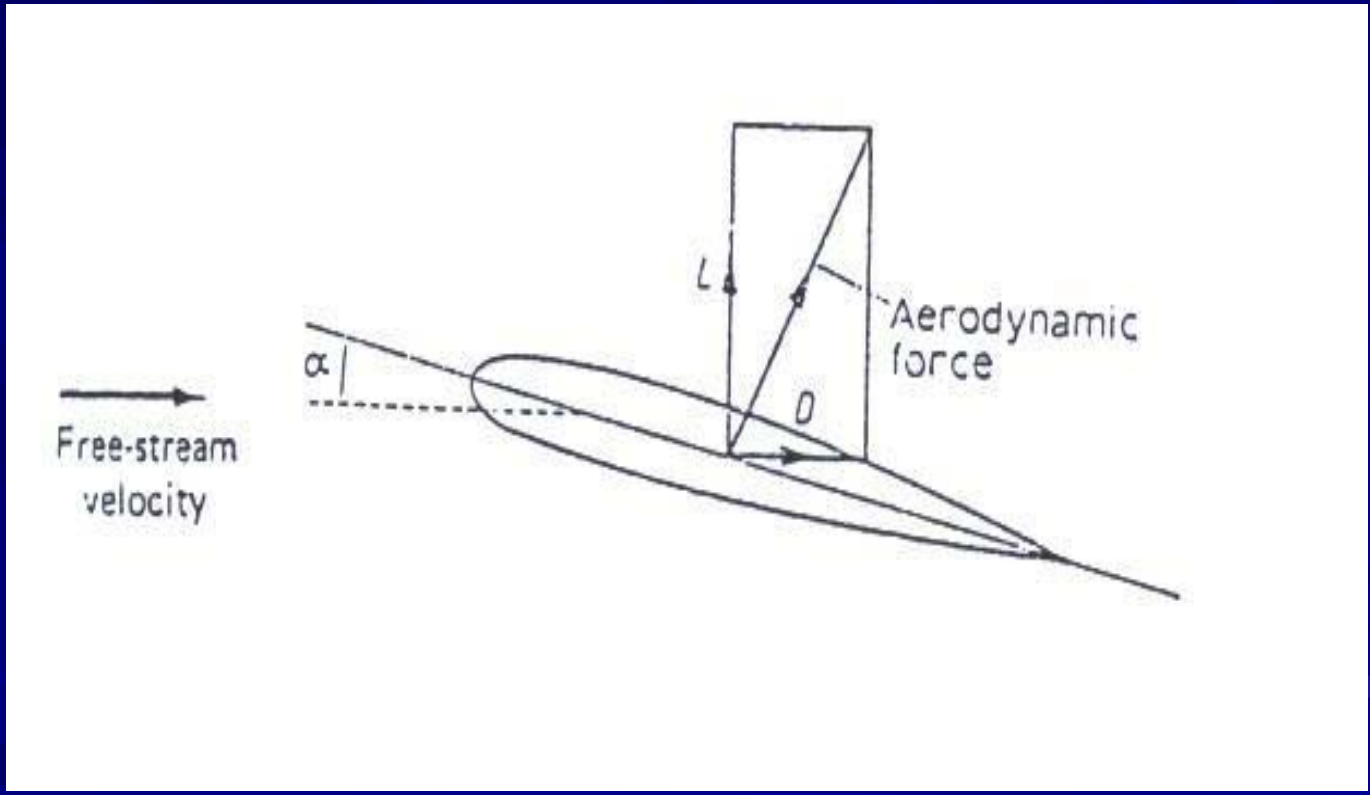
Pressure forces act normal (perpendicular) to surface.
Force on the body is the vector sum of the pressure x area around the entire solid body.

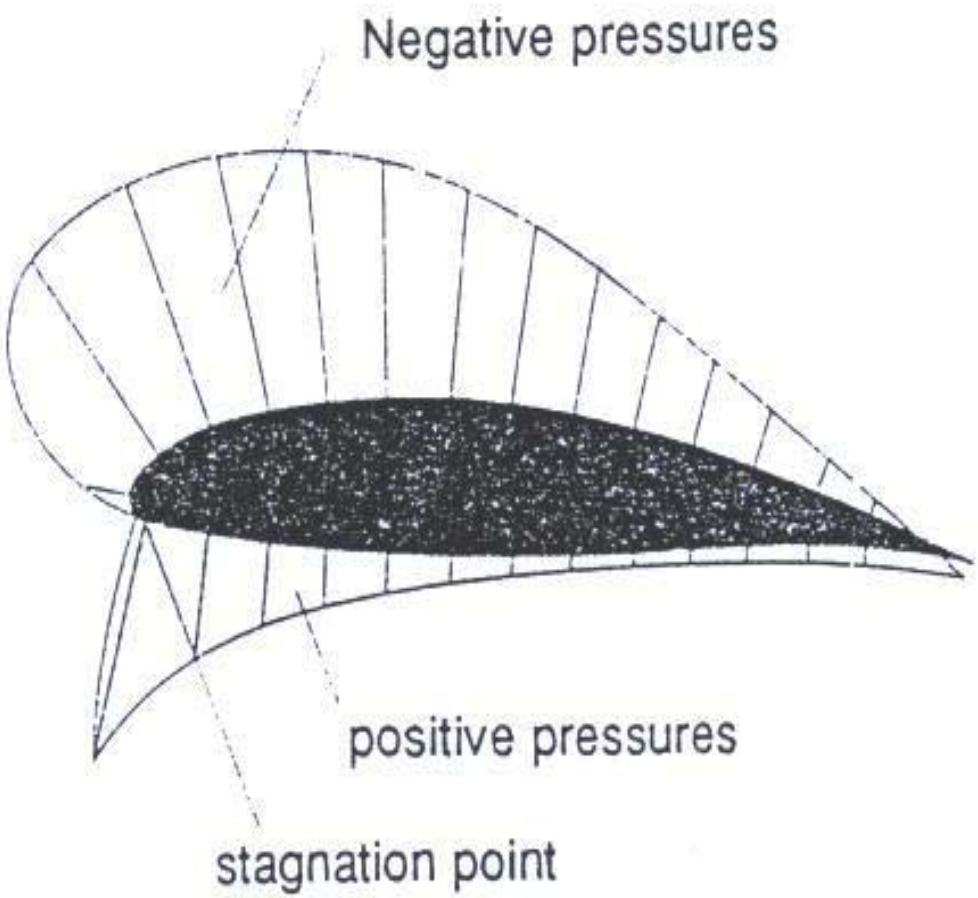
$$\vec{F} = \sum_{\text{surface}} p\,\vec{n}\,A = \oint p\,\vec{n}\,dA$$

Lift = F_{normal}

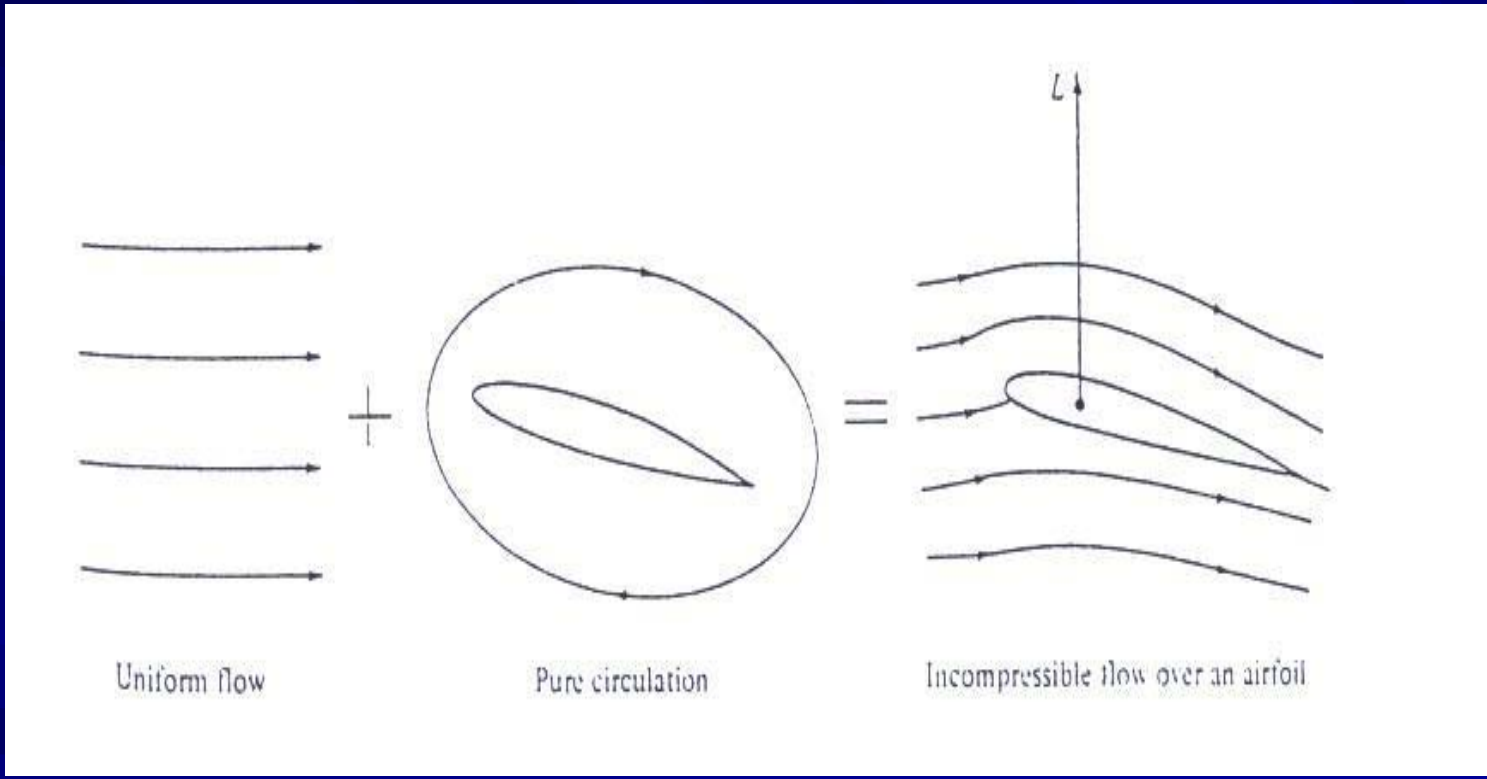
Drag = F_{stream}

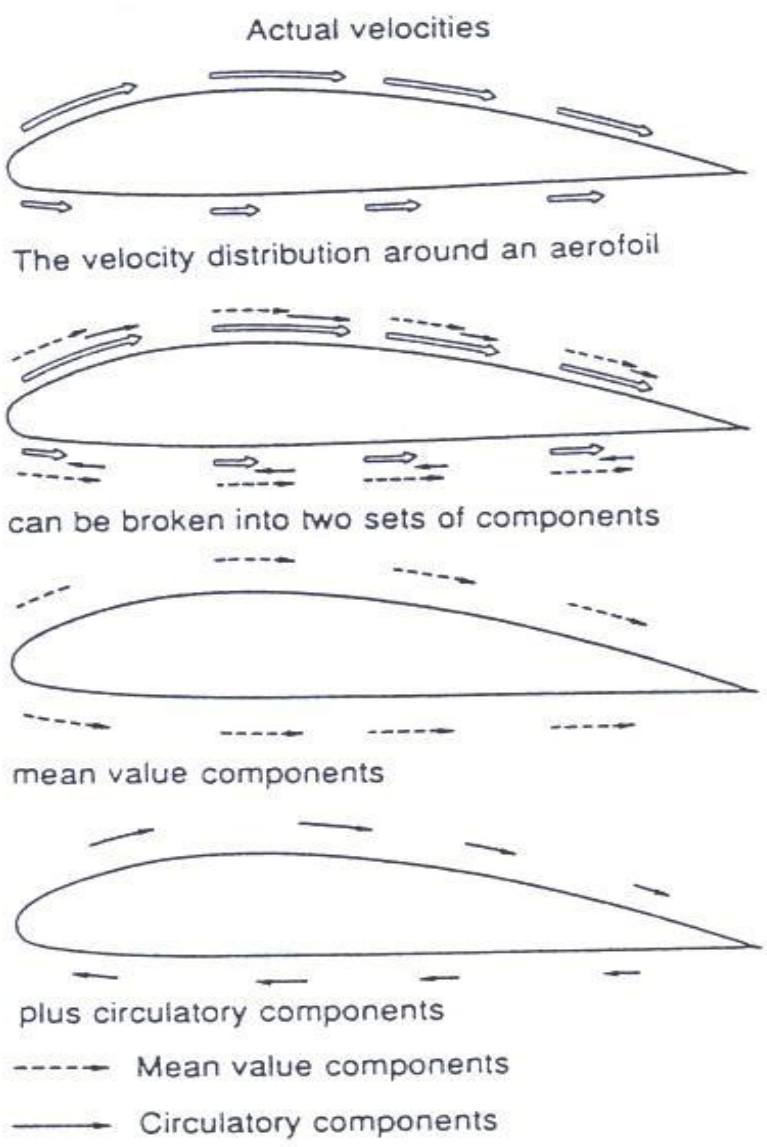
Lift and Lift Theories




Negative pressures
positive pressures
stagnation point

The Circulation Theory of Lift




Actual velocities
The velocity distribution around an aerofoil
can be broken into two sets of components
mean value components
plus circulatory components
Mean value components
Circulatory components

The Lift Equation

The Lift Equation

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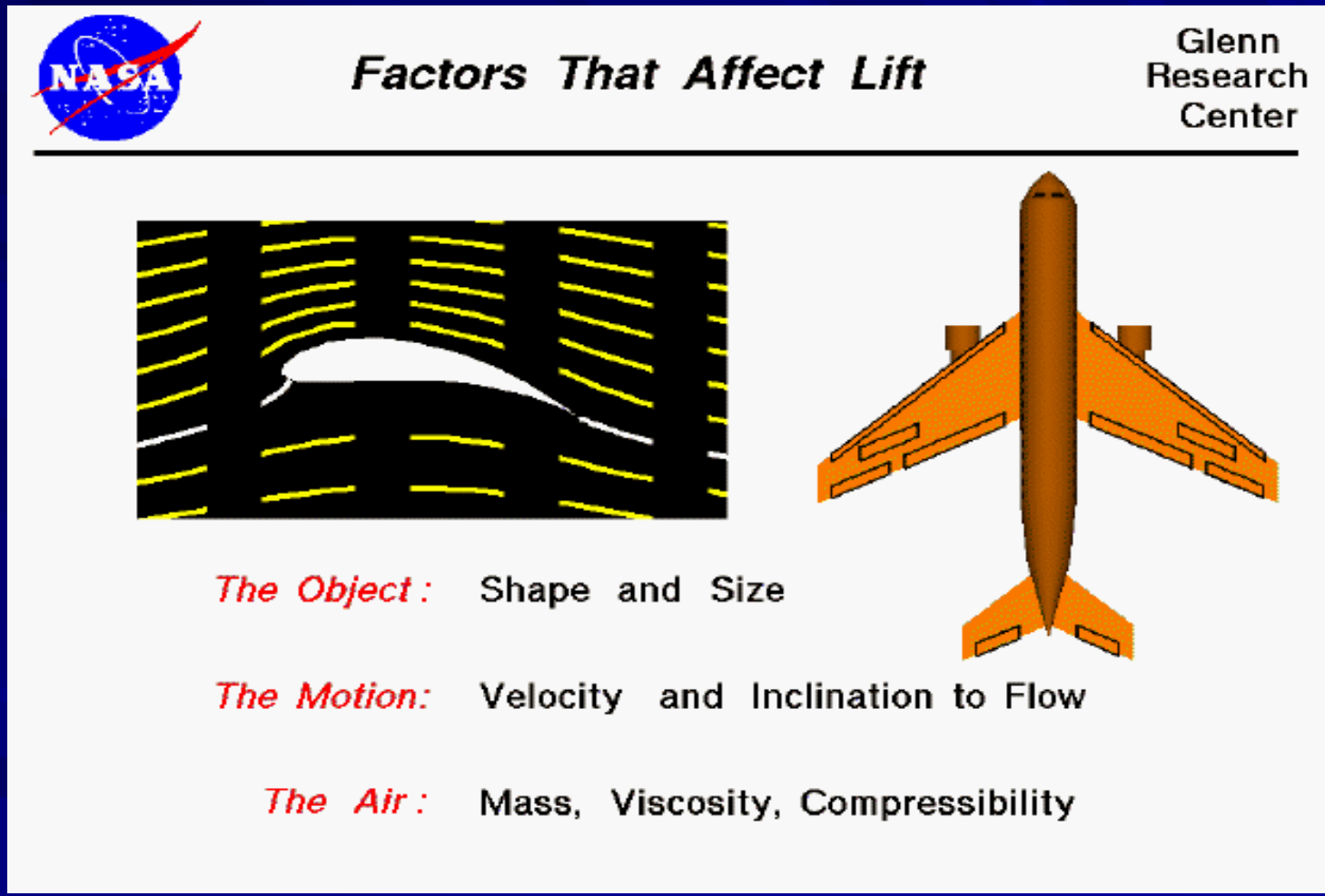
$$L = Cl \times r \times \frac{V^2}{2} \times A$$

Lift = coefficient x density x $\frac{\text{velocity squared}}{\text{two}}$ x wing area

Coefficient **Cl** contains all the complex dependencies and is usually determined experimentally.

Factors Effecting Lift



Shape Effects on Lift

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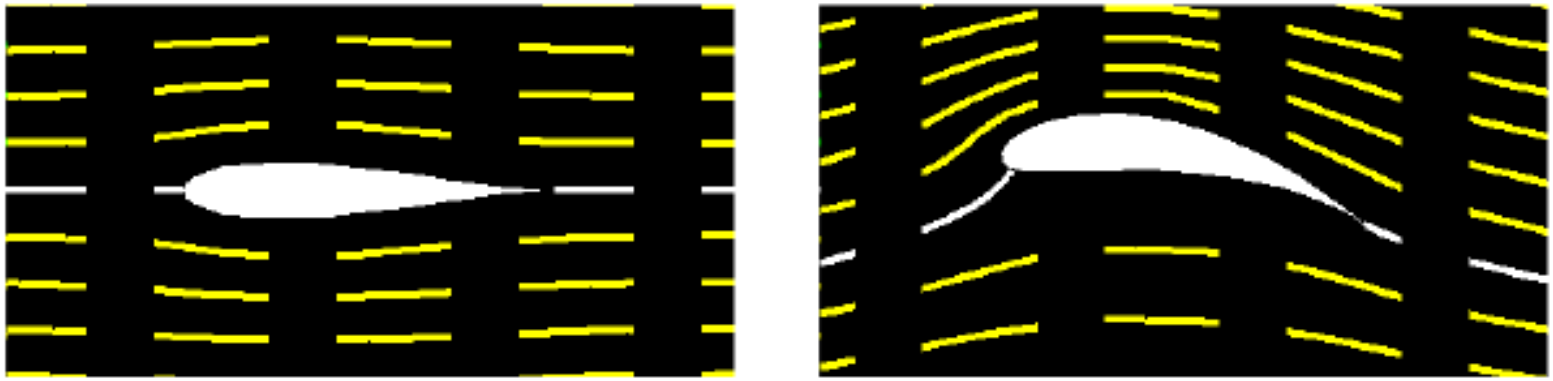

Flow turning at trailing edge is very important.

Higher Turning = Greater Lift

This effect is used for stability and control of the airplane.

Included in Lift Coefficient

Lift Coefficient

The Lift Coefficient

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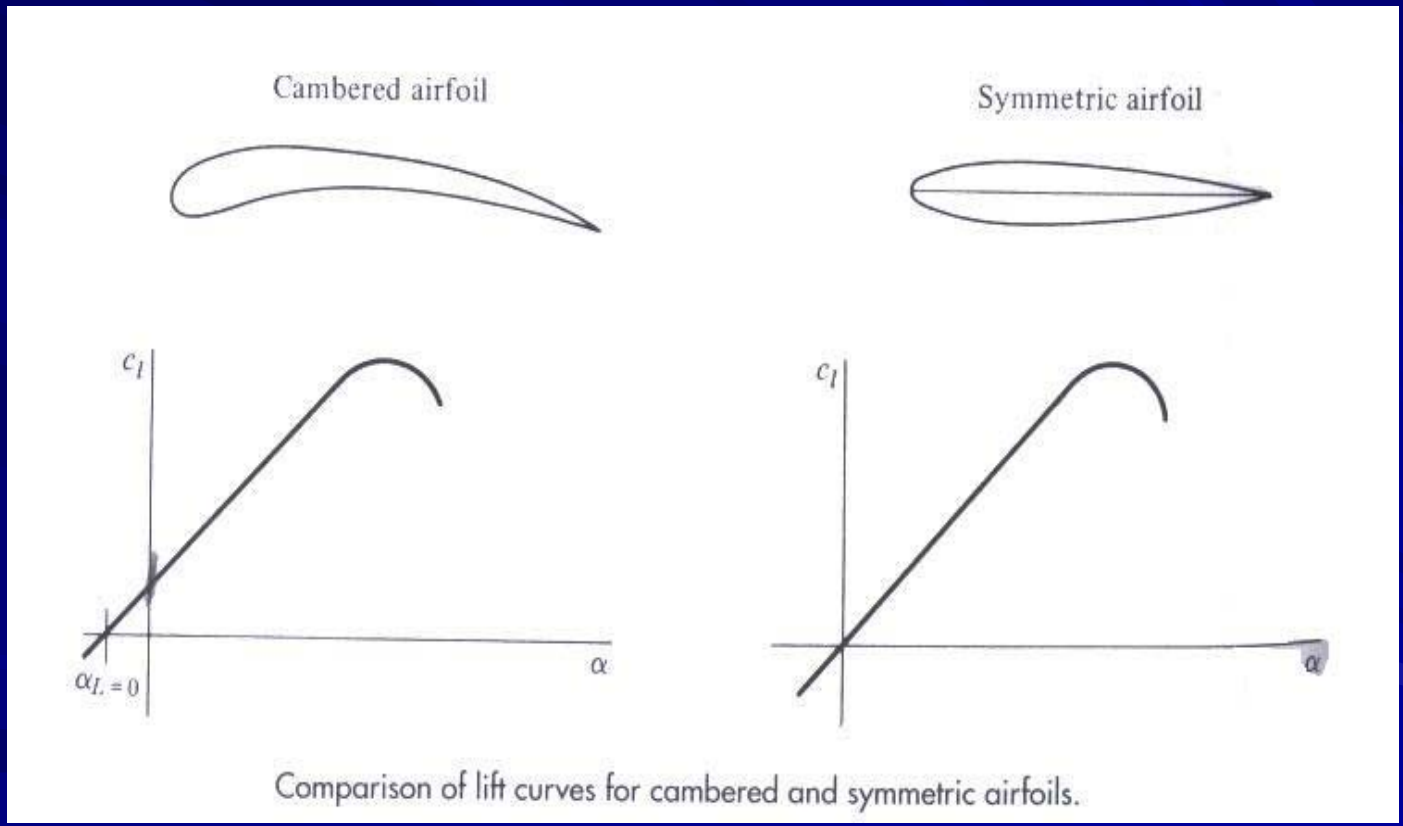
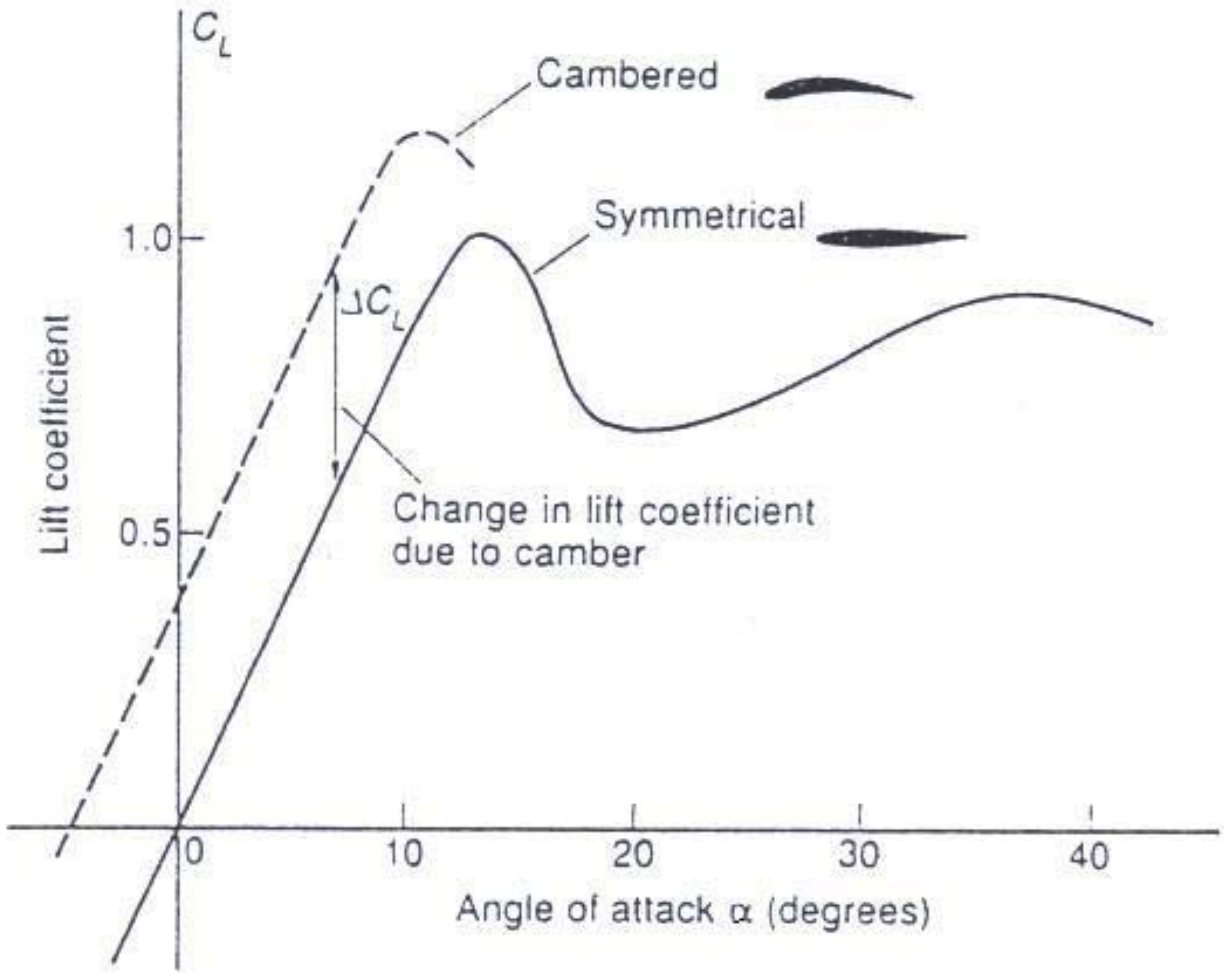
$$C_l = \frac{L}{r \times \frac{V^2}{2} \times A}$$

C_l contains all the complex dependencies and is usually determined experimentally.

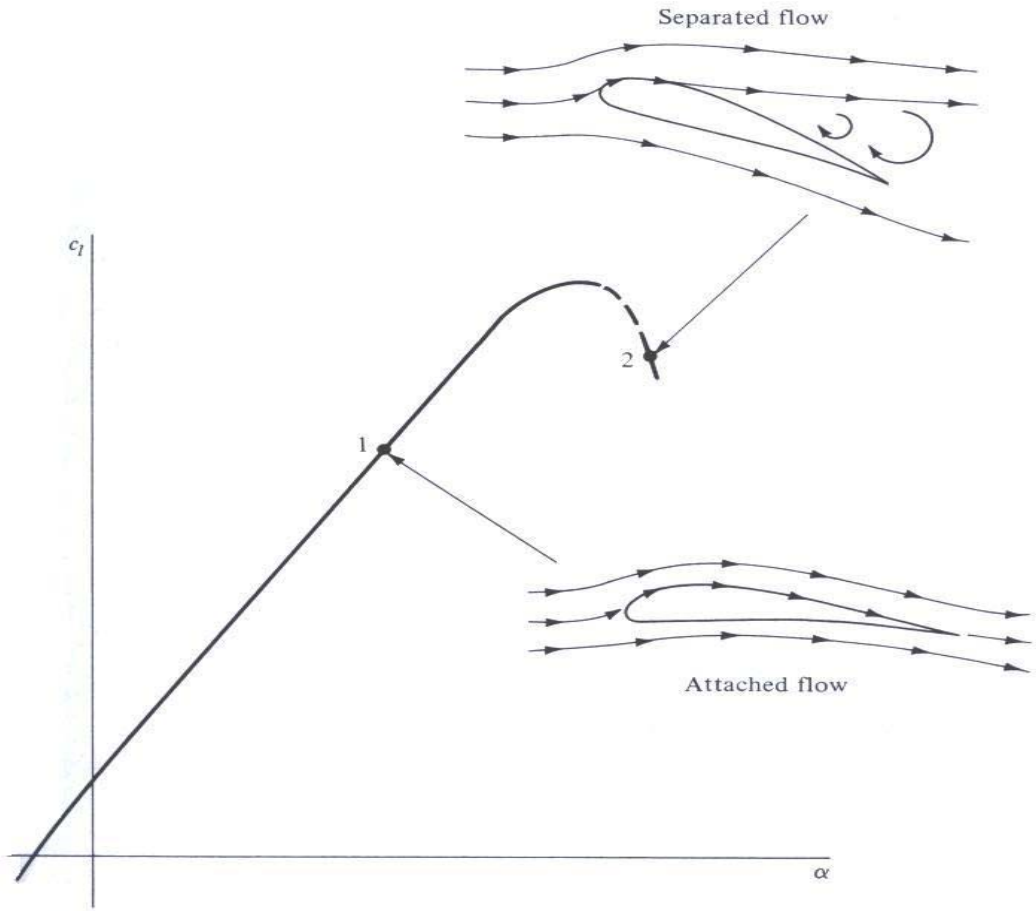
Shape Effect on Lift Coefficient



Comparison of lift curves for cambered and symmetric airfoils.


C_L
Cambered
Symmetrical
1.0
0.5
ΔC_L
Change in lift coefficient due to camber
Lift coefficient
0
10
20
30
40
Angle of attack α (degrees)

Stall



Flow mechanism associated with stalling.

Drag

Factors That Affect Drag

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The Object : Shape and Size

The Motion: Velocity and Inclination to Flow

The Air : Mass, Viscosity, Compressibility

Shape Effects on Drag

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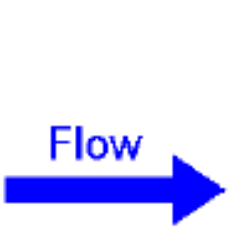
The shape of an object has a very great effect on the amount of drag.



Cd=1.28
Flat Plate

Cd=1.14
Prism

Cd= .295
Bullet

Cd=.07 to .5
Sphere

Cd= .045
Airfoil

$$Cd = \frac{D}{r\ A\ V^2/2}$$

A = frontal area

All objects have the same frontal area.

The Drag Equation

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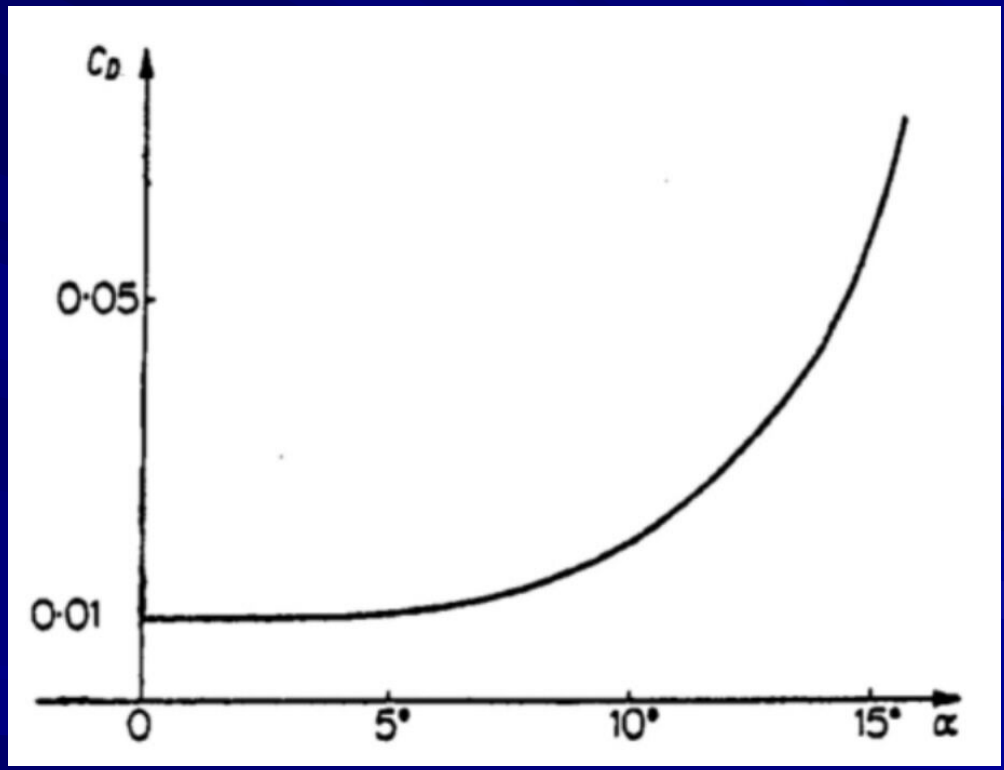
$$D = Cd \times r \times \frac{V^2}{2} \times A$$

Drag = coefficient x density x $\frac{\text{velocity squared}}{\text{two}}$ x reference area

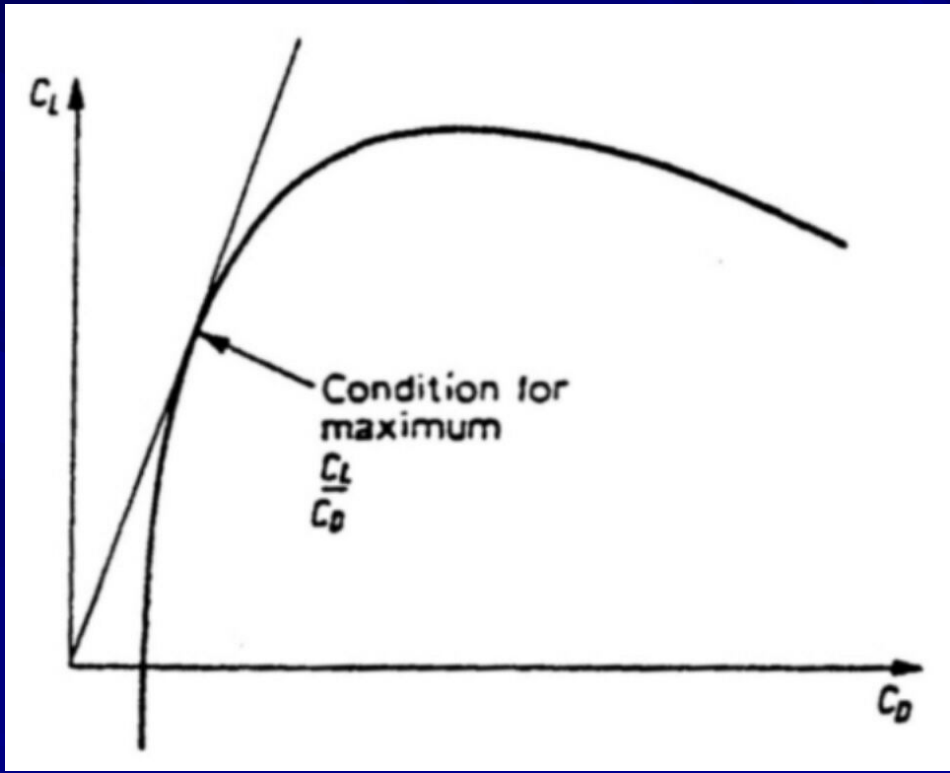
Coefficient **Cd** contains all the complex dependencies and is usually determined experimentally.

Choice of reference area **A** affects the value of **Cd**.

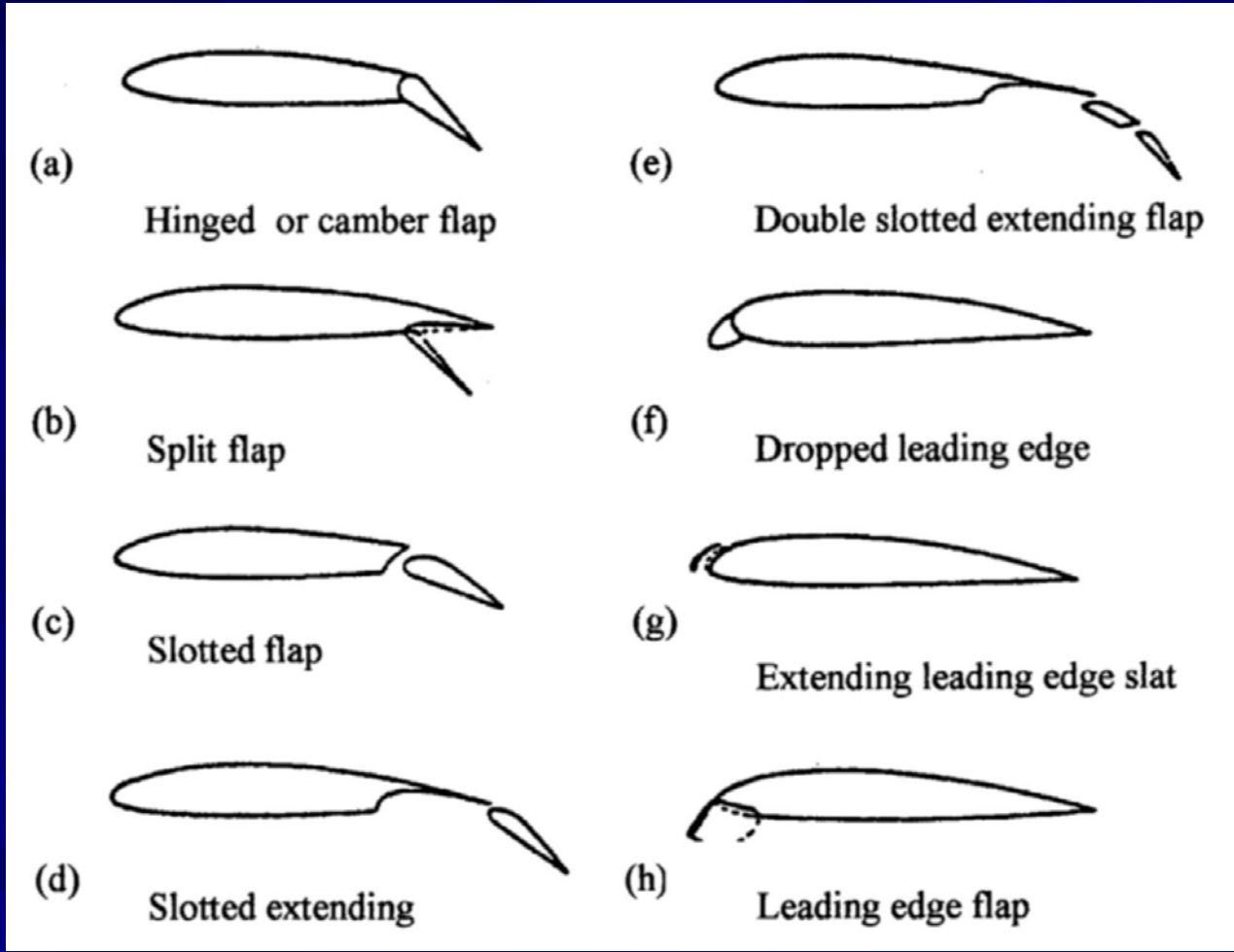
Variation of Drag Coefficient with Angle of Attack



Drag Polar



Flap and Slat



Thank You