

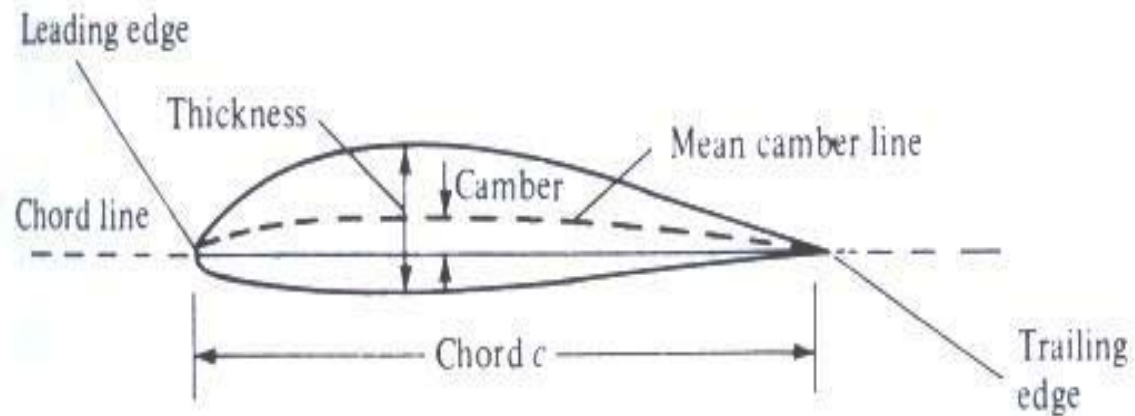
King Fahd University of Petroleum and Minerals

Aerospace Engineering Department

Experiment

Measurement of Lift and Drag for
and Airfoil Section

Basic Nomenclature



Airfoil nomenclature.

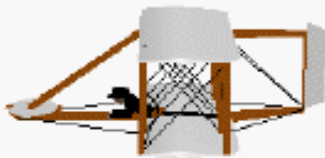
Flight of an Aircraft



Basic Object Motion *Translation and Rotation*

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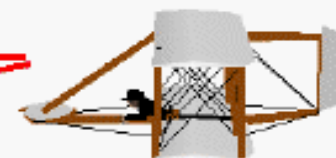
Later Position



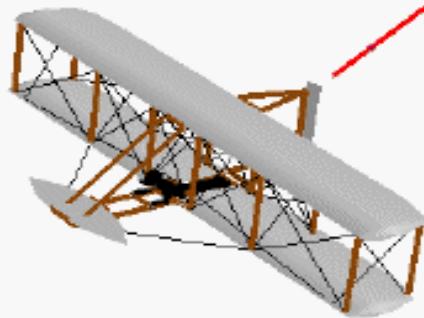
Simple Translation



Initial Position



Translation plus Rotation

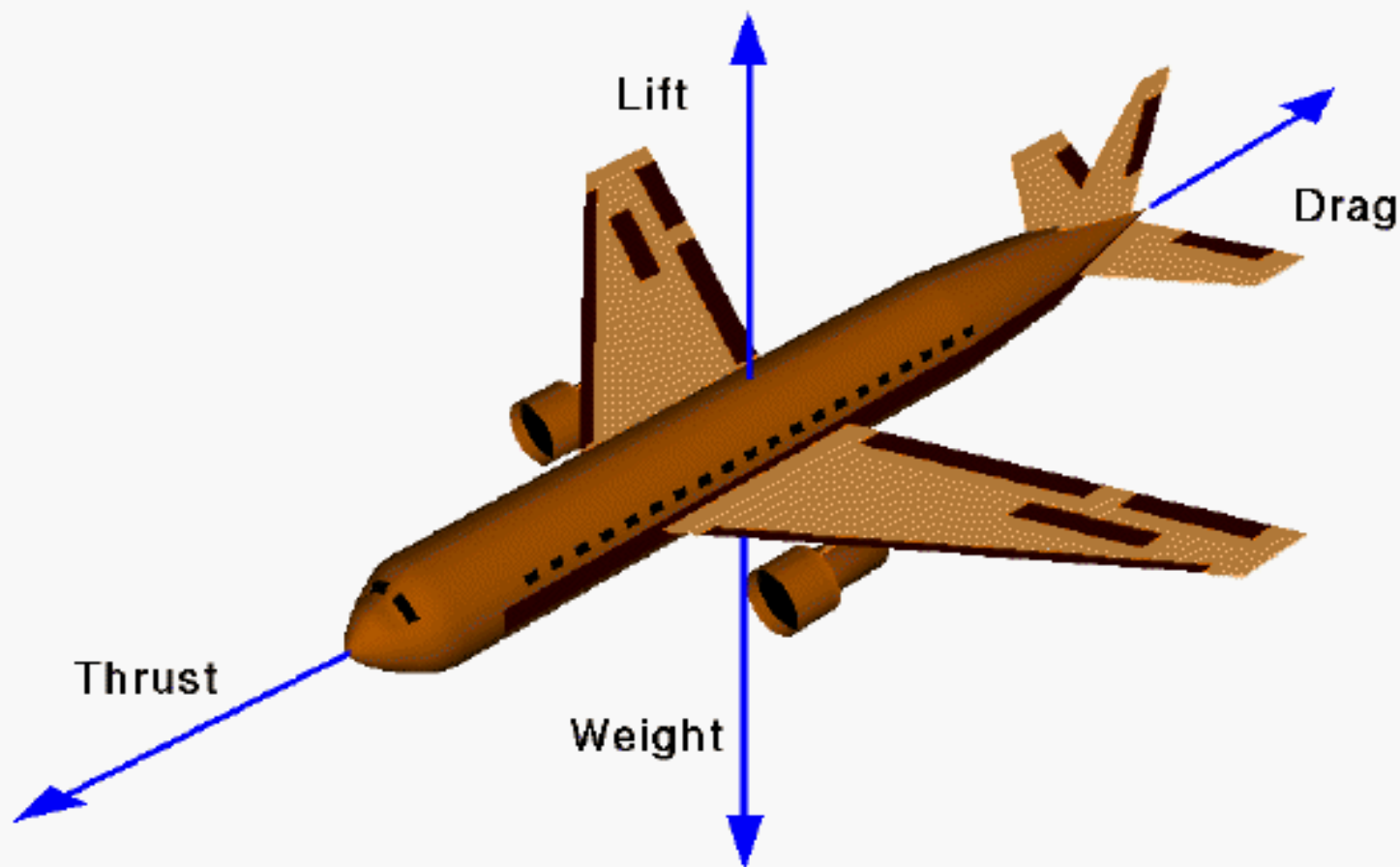


Later Position



Four Forces on an Airplane

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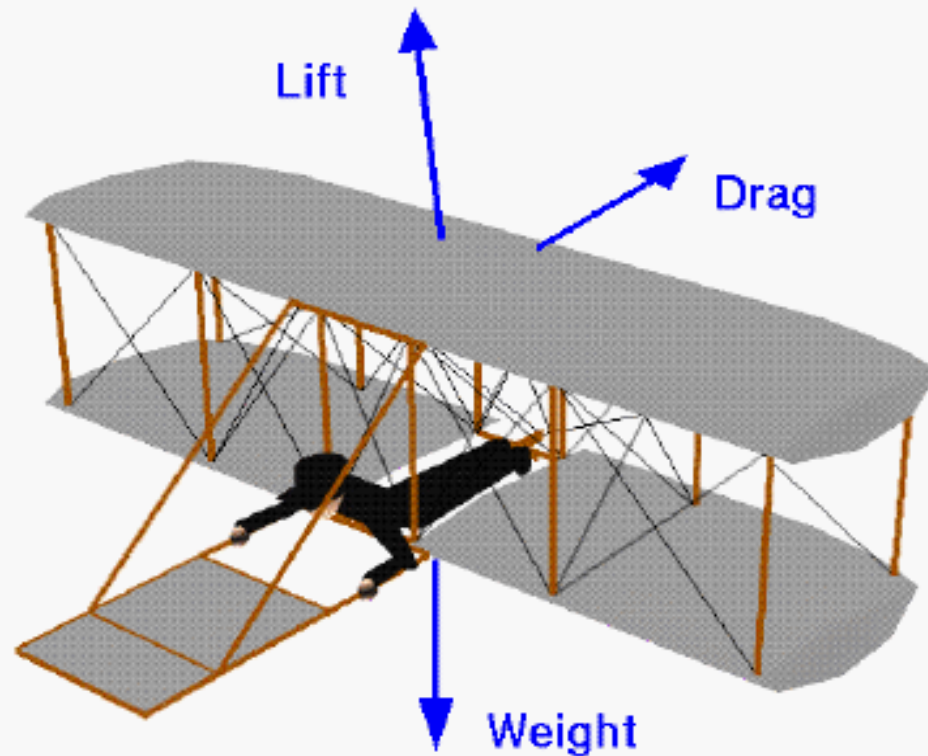




Three Forces on a Glider

Wright 1900 Aircraft

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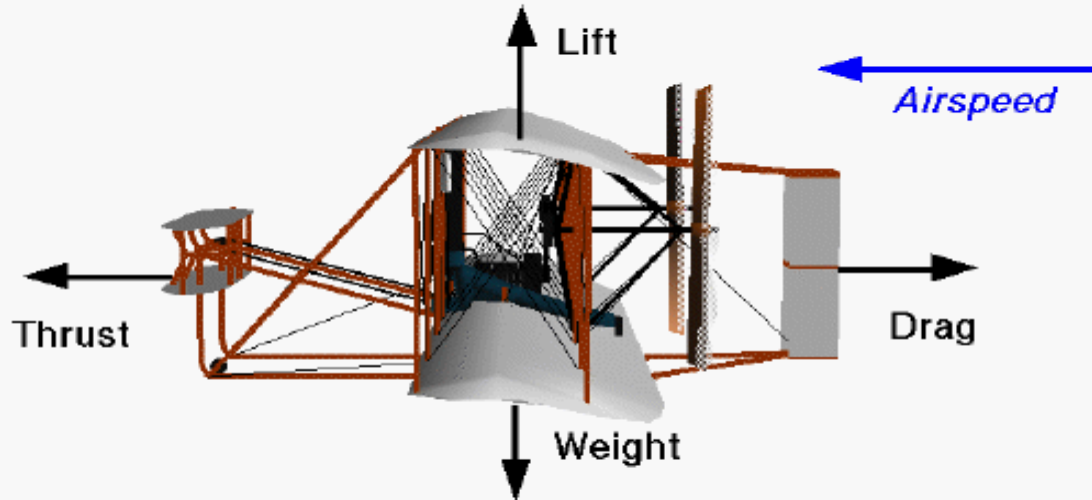


Some Considerations



Cruise Conditions

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$$\text{Lift} = \text{Weight}$$

$$\text{Thrust} = \text{Drag}$$

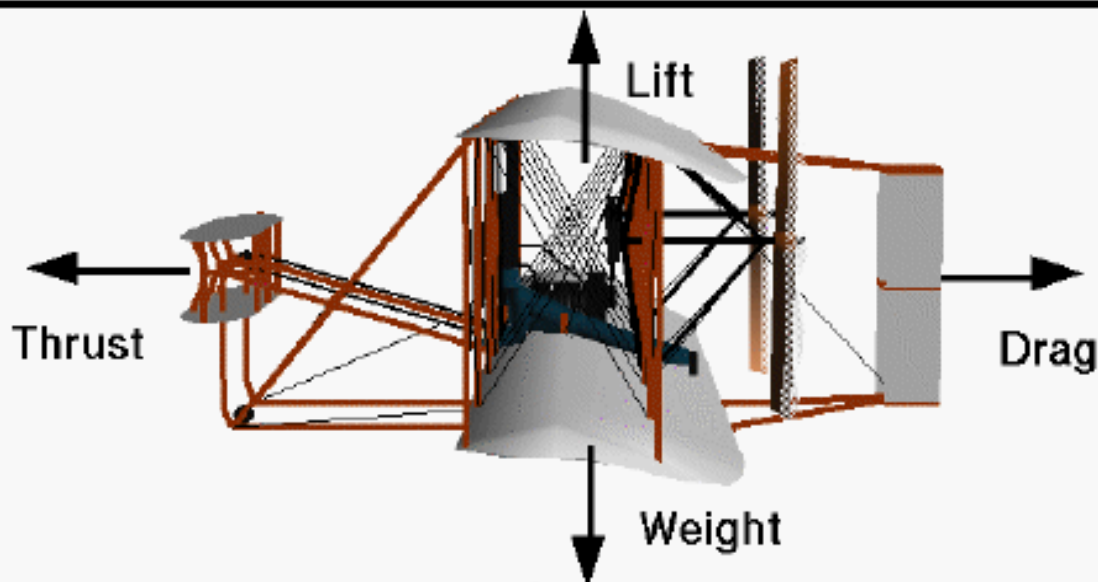
Airplane moves in a straight line at constant airspeed.



Simplified Aircraft Motion

Unbalanced Forces

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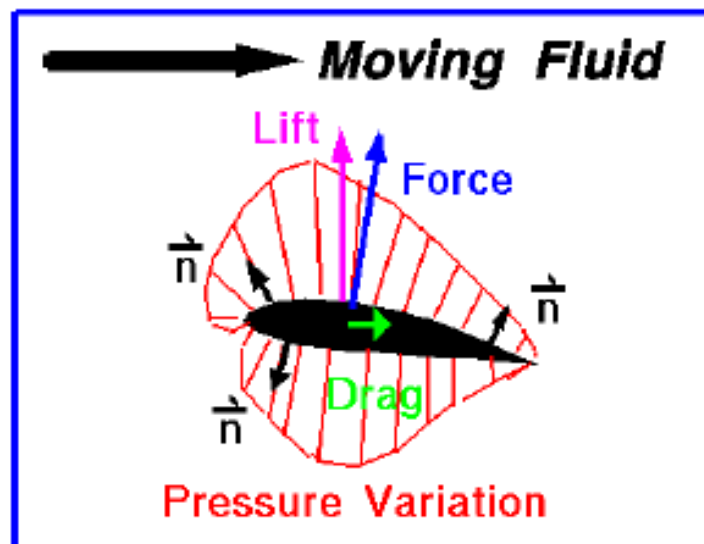


Flight Condition	Effect
Lift > Weight	Plane Rises
Weight > Lift	Plane Falls
Drag > Thrust	Plane Slows
Thrust > Drag	Plane Accelerates



Aerodynamic Forces

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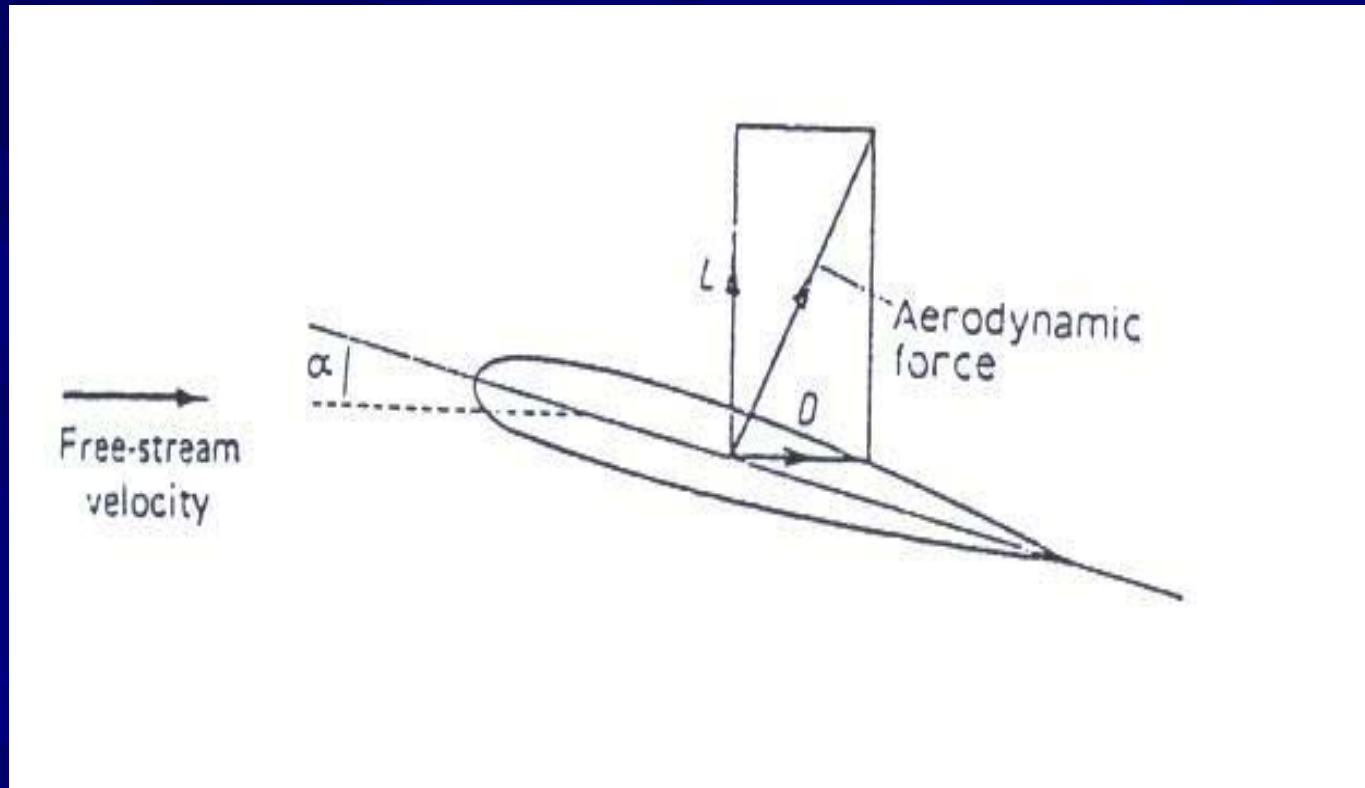
Pressure forces act normal (perpendicular) to surface.
Force on the body is the vector sum of the pressure x area
around the entire solid body.

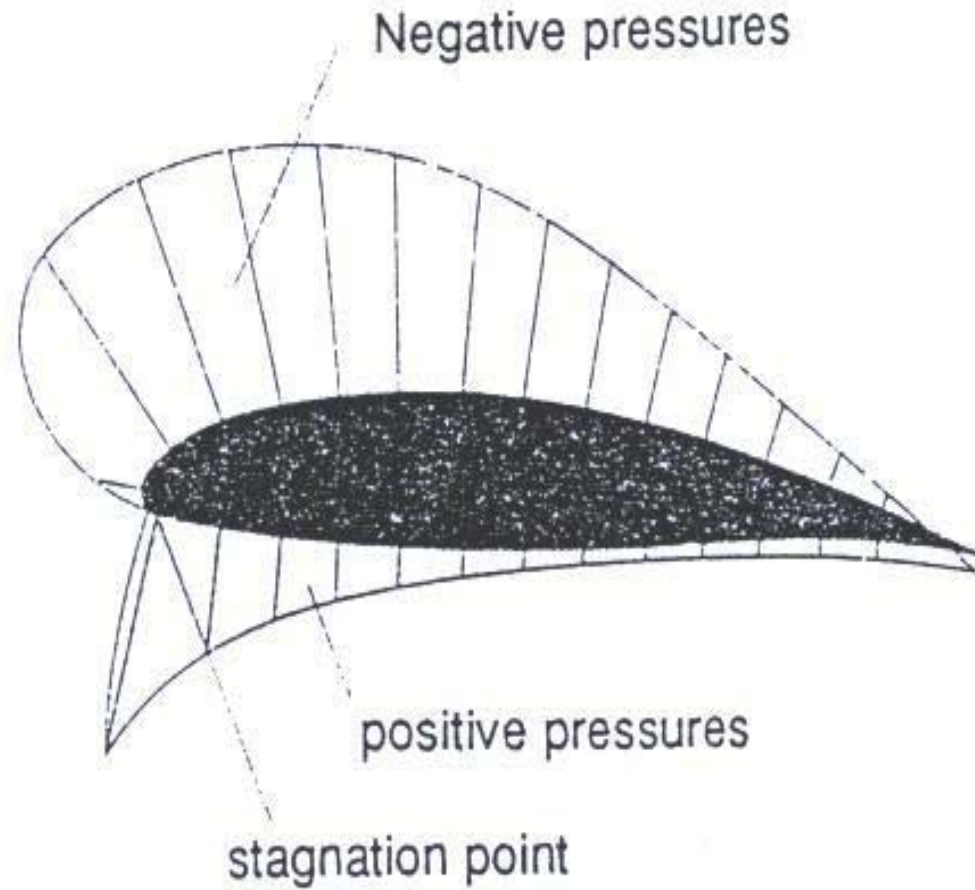
$$\vec{F} = \sum_{\text{surface}} p \vec{n} A = \oint p \vec{n} dA$$

$$\text{Lift} = F_{\text{normal}}$$

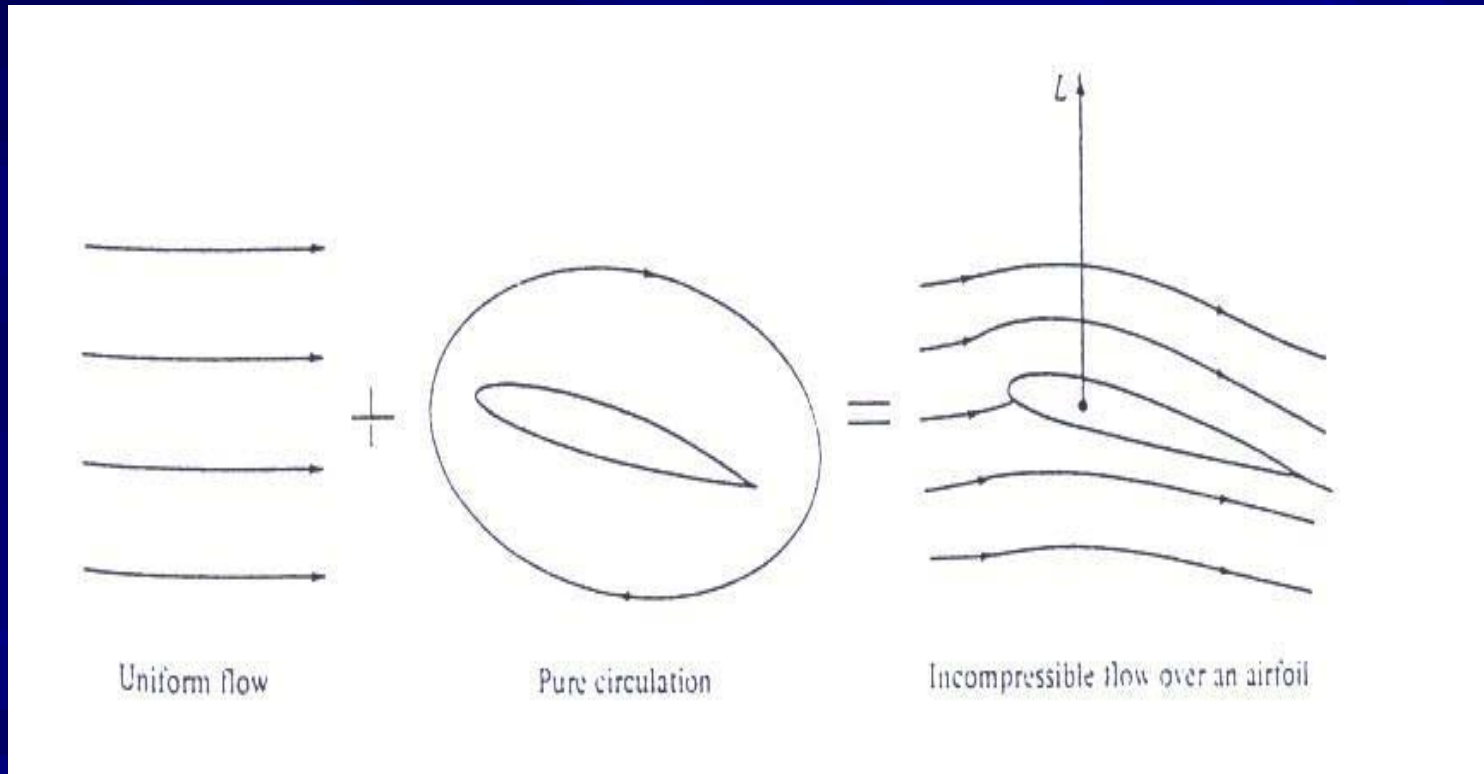
$$\text{Drag} = F_{\text{stream}}$$

Lift and Lift Theories

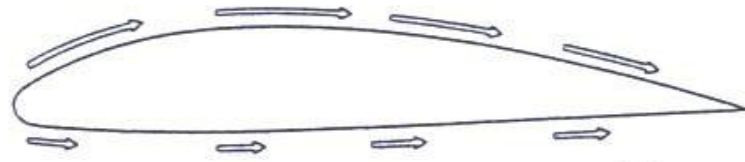




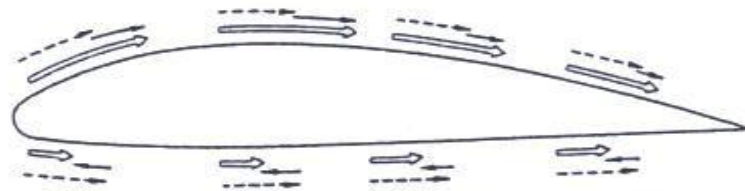
The Circulation Theory of Lift



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

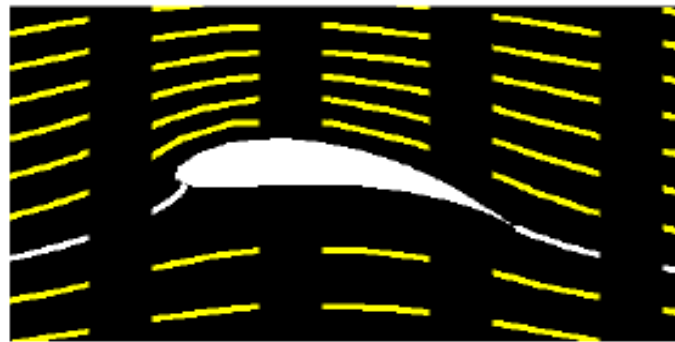
----- Circulatory components

The Lift Equation



The Lift Equation

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

Lift = coefficient x density x velocity squared x wing area
two

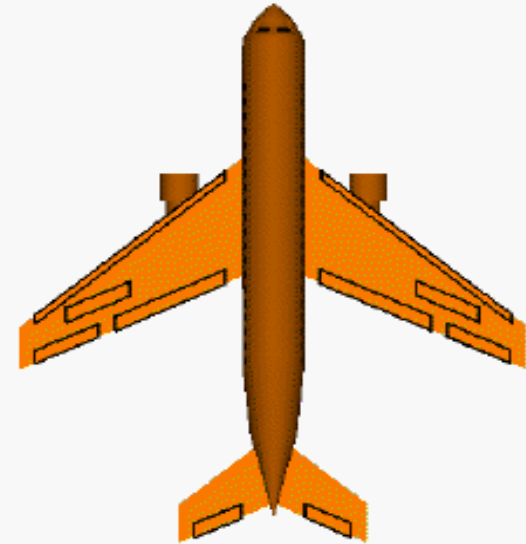
Coefficient **C_l** contains all the complex dependencies
and is usually determined experimentally.

Factors Effecting Lift



Factors That Affect Lift

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The Object : Shape and Size

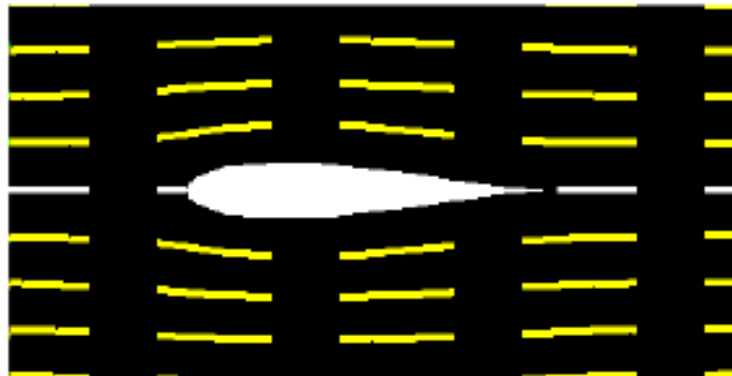
The Motion : Velocity and Inclination to Flow

The Air : Mass, Viscosity, Compressibility



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

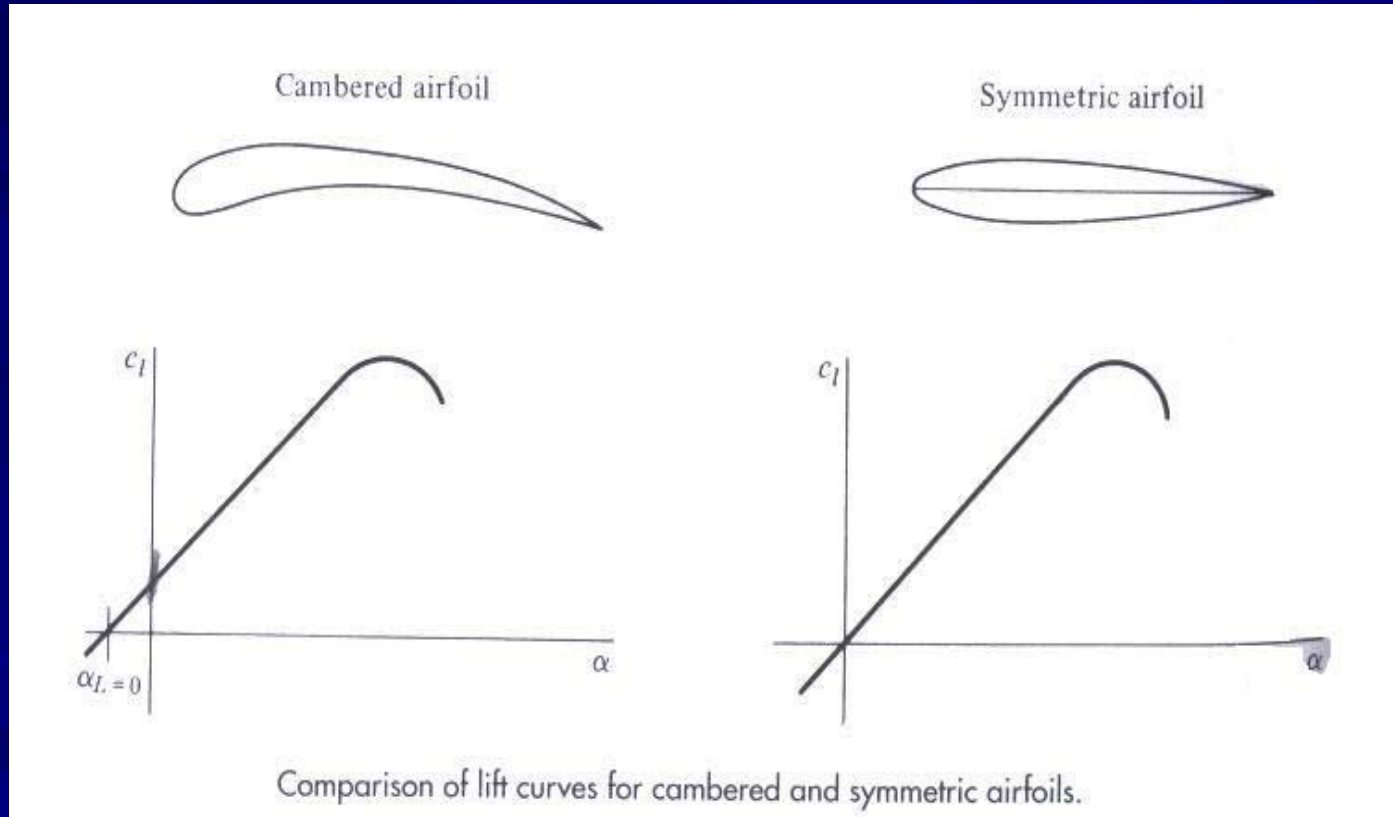
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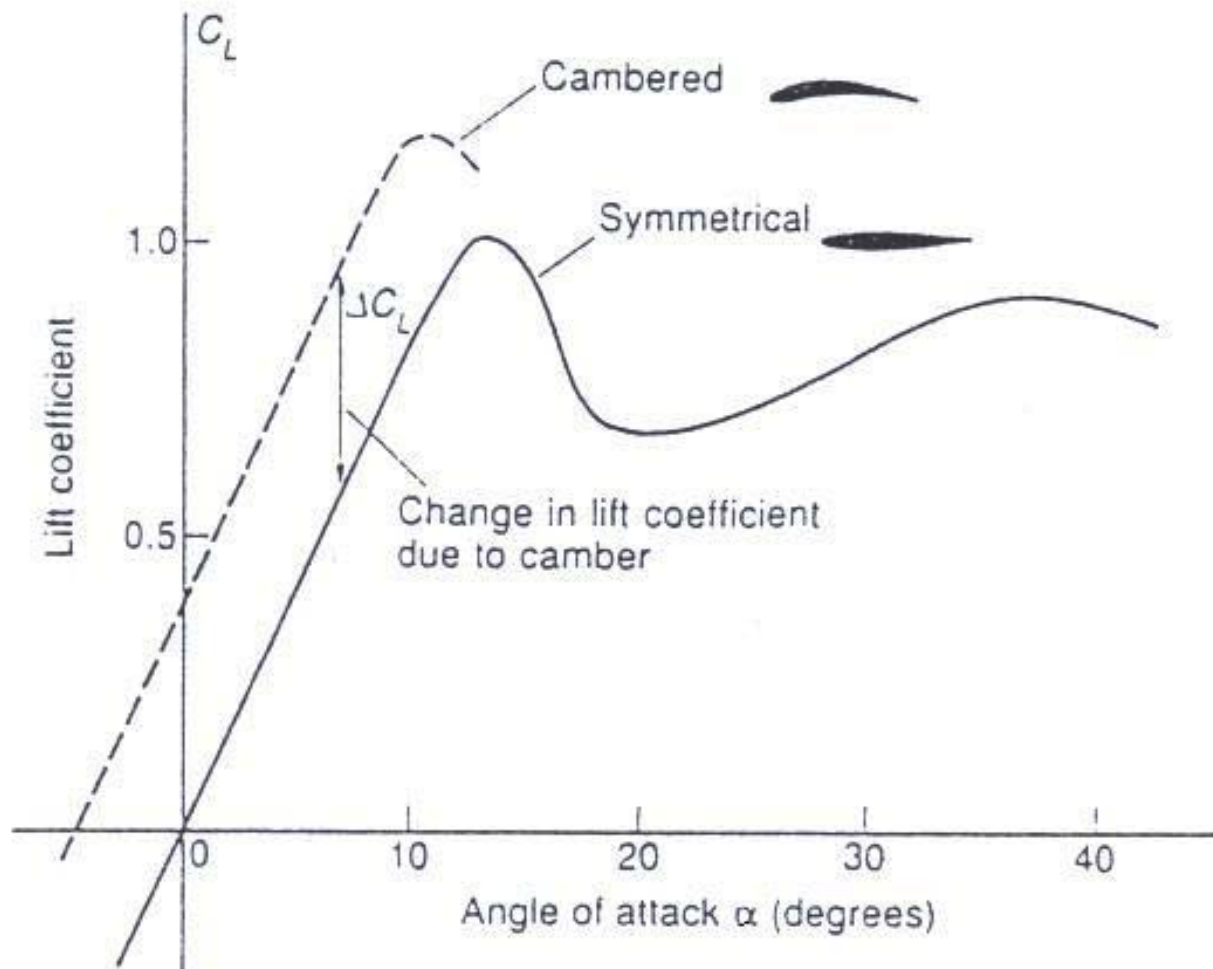


$$C_l = \frac{L}{r \times \frac{V^2}{2} \times A}$$

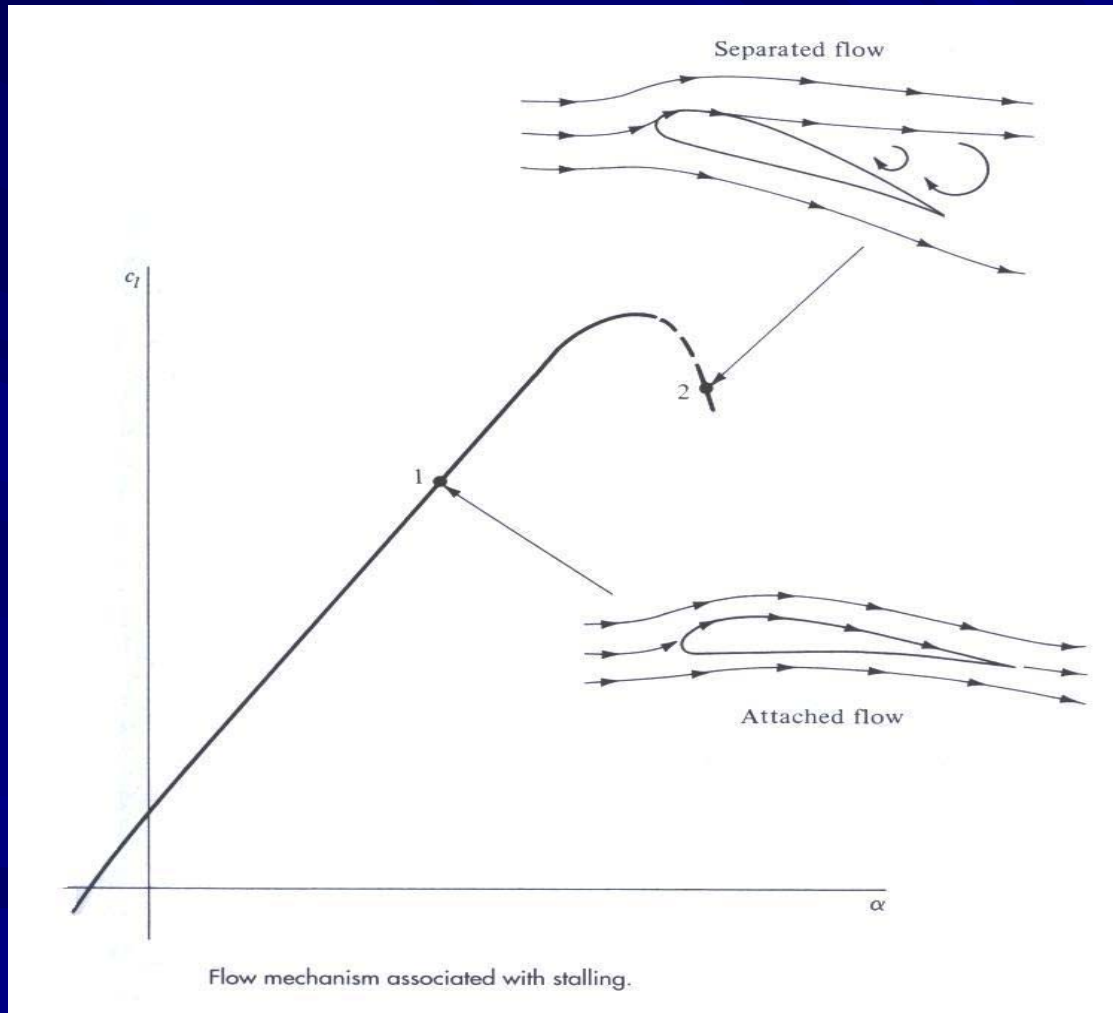
C_l contains all the complex dependencies and is usually determined experimentally.

Shape Effect on Lift Coefficient





Stall



Drag



Factors That Affect Drag

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The Object: Shape and Size

The Motion: Velocity and Inclination to Flow

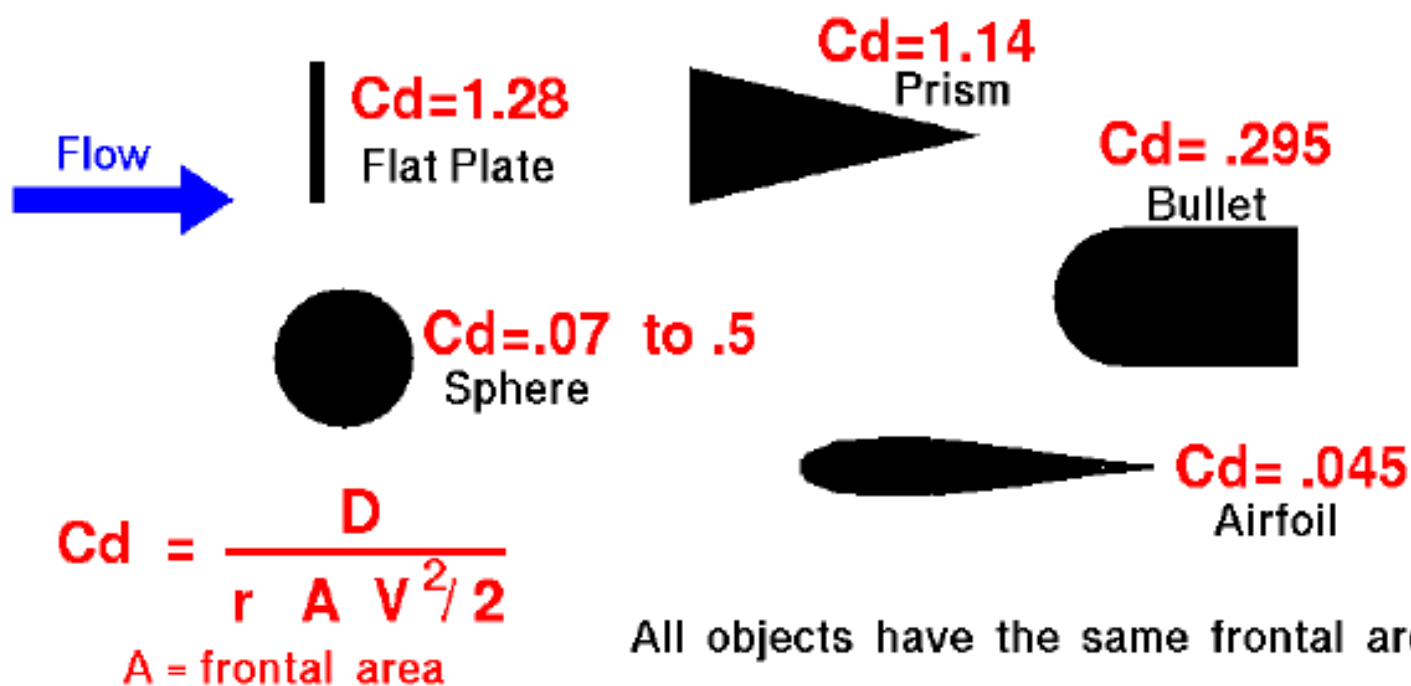
The Air: Mass, Viscosity, Compressibility



Shape Effects on Drag

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





The Drag Equation

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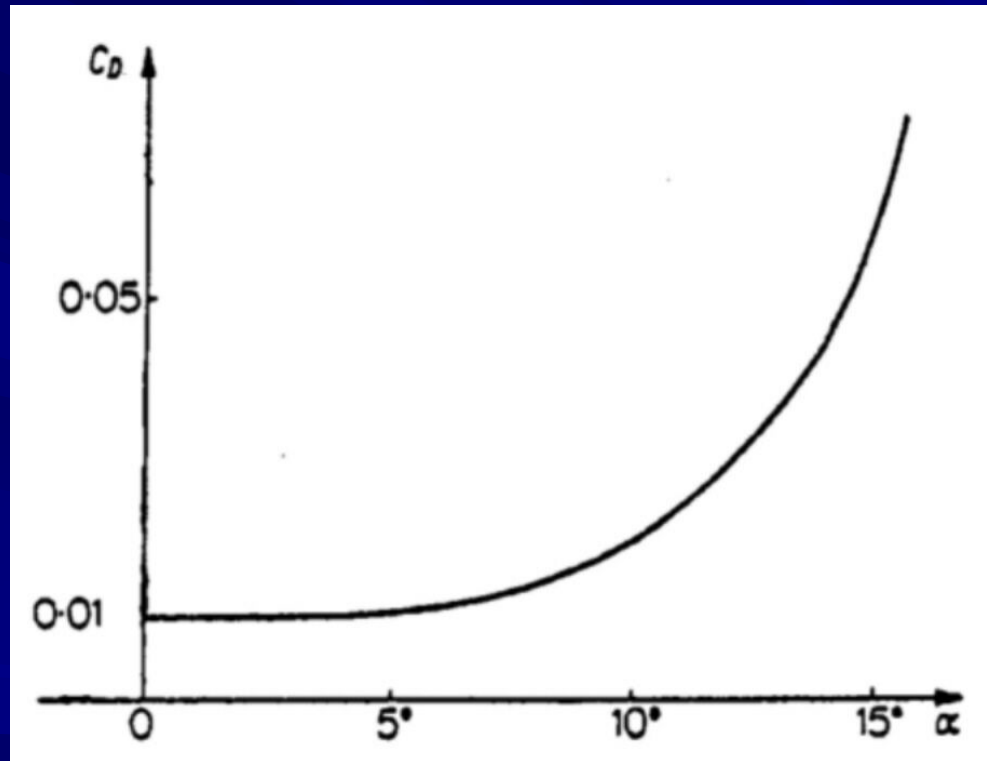
$$D = C_d \times r \times \frac{V^2}{2} \times A$$

Drag = coefficient x density x velocity squared x reference area
two

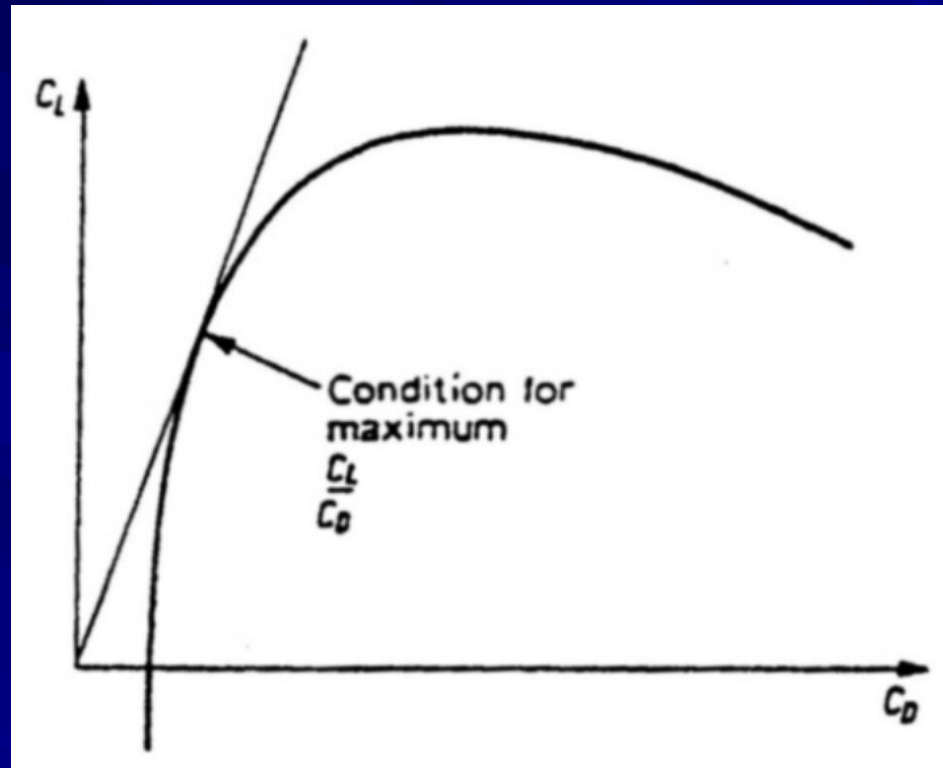
Coefficient **C_d** contains all the complex dependencies
and is usually determined experimentally.

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

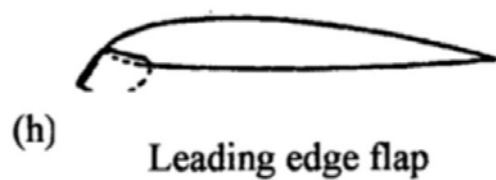
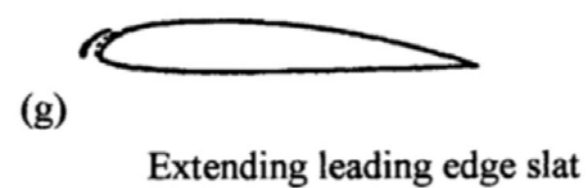
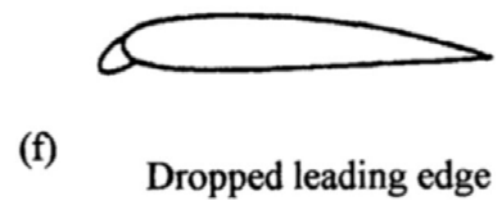
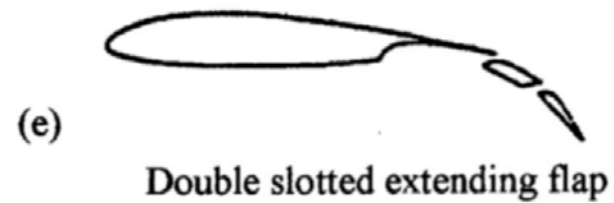
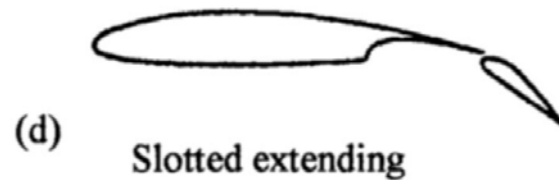
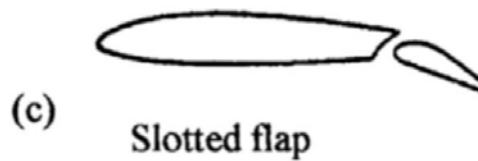
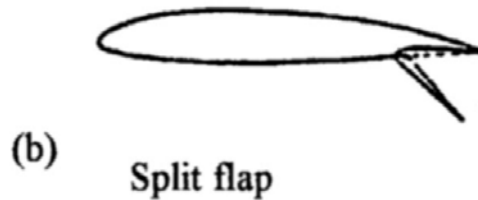
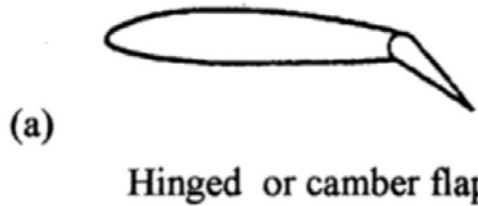
Variation of Drag Coefficient with Angle of Attack



Drag Polar



Flap and Slat



Thank You

