

# Capítulo 4. AERODINÂMICA



## *The Drag Equation*

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Center



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

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

Coefficient **C<sub>d</sub>** contains all the complex dependencies  
and is usually determined experimentally.

Choice of reference area **A** affects the value of **C<sub>d</sub>**.



## *Factors That Affect Drag*

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*The Object:* Shape and Size

*The Motion:* Velocity and Inclination to Flow

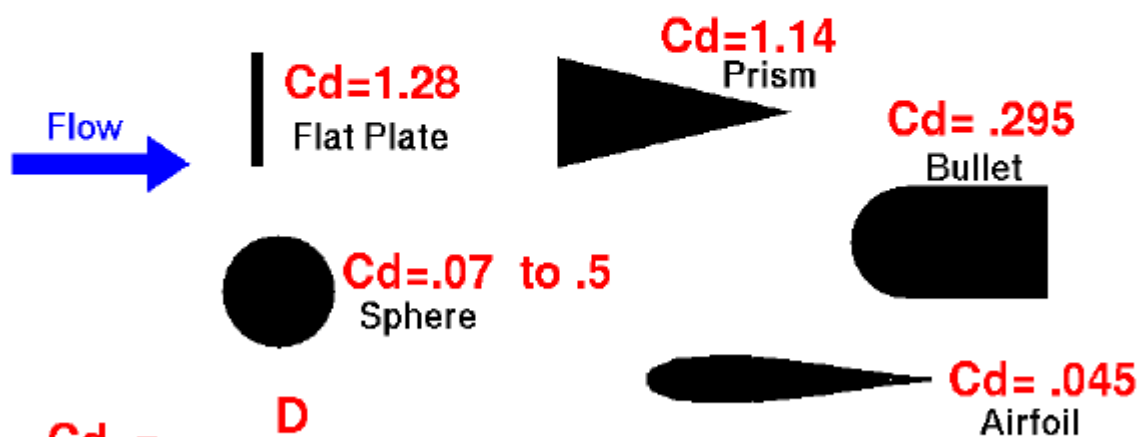
*The Air:* Mass, Viscosity, Compressibility



## Shape Effects on Drag

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



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

A = frontal area

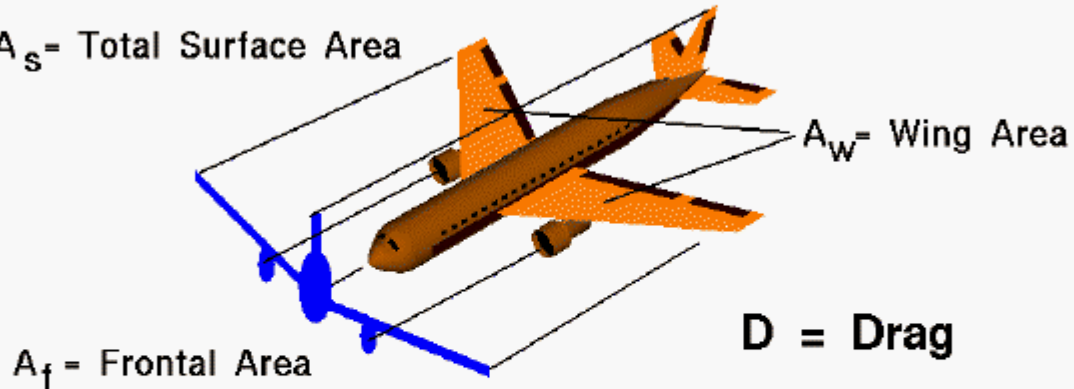
All objects have the same frontal area.



## Size Effects on Drag

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$A_s$  = Total Surface Area



$A_w$  = Wing Area

$A_f$  = Frontal Area

$D = \text{Drag}$

$$A_s \sim A_f \sim A_w$$

Drag is directly related to reference area

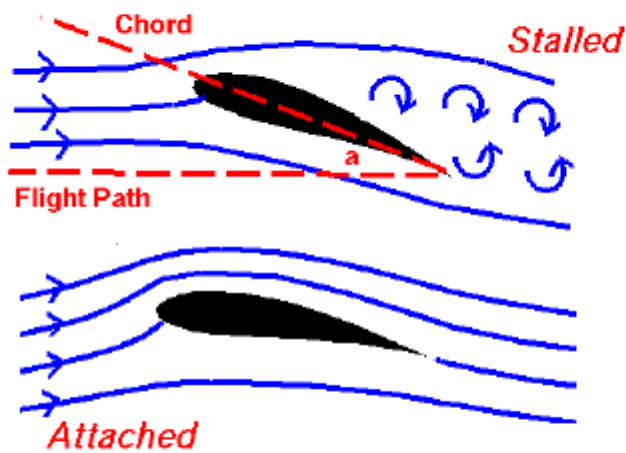
$$D = \text{Constant} \times A_{\text{ref}}$$

Double the Area --> Double the Drag



## Inclination Effects on Drag

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For small angles, drag is nearly constant.

As angle increases, drag increases.

**Greater Angle = Greater Drag**

After stall, relationship is quite complex.

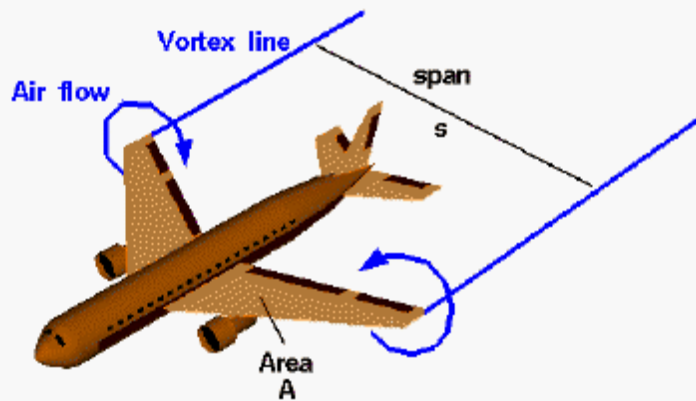
**Included in Drag Coefficient**



# Induced Drag Coefficient

Drag due to Lift

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Aspect Ratio = AR

$$AR = \frac{s^2}{A}$$

$$Cd_i = \frac{Cl^2}{\pi AR e}$$

efficiency factor = e

for an ellipse e = 1.0

in general e < 1.0

Pressure difference across wing surface causes spillage around the wing tips.

Downwash causes a local induced angle of attack with additional induced drag on a finite wing.