Drag

Lecture 13

ME EN 412
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Outline

Factors that Affect Drag

Examples

Computation of Drag

$$V_\infty$$

$$p$$

$$\tau$$

$$V_\infty$$
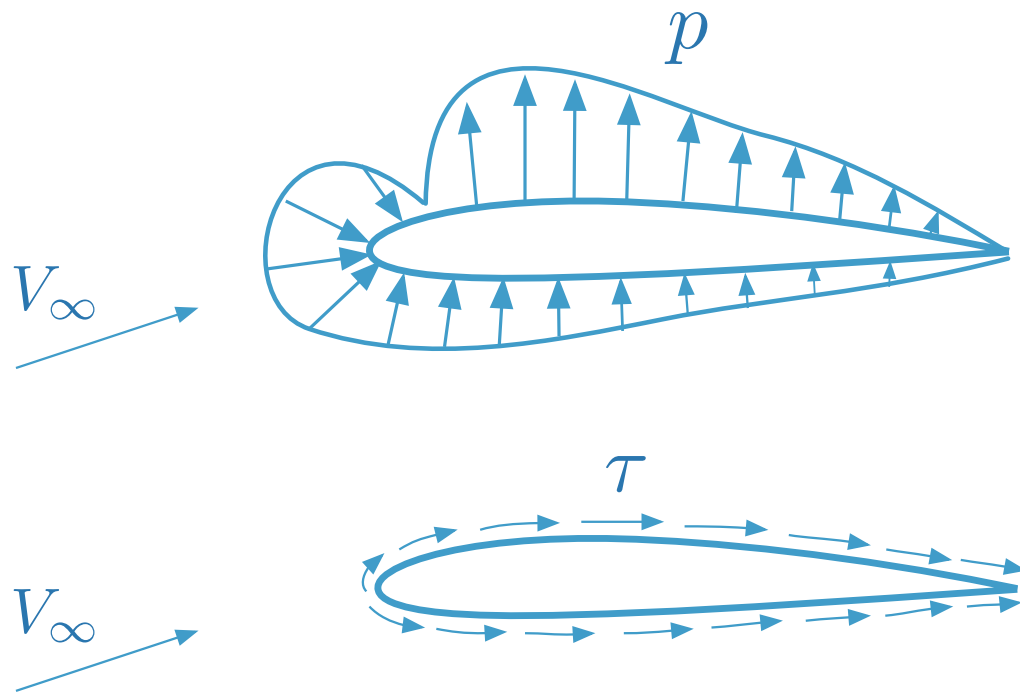
Factors that Affect Drag

Shape

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Reynolds Number

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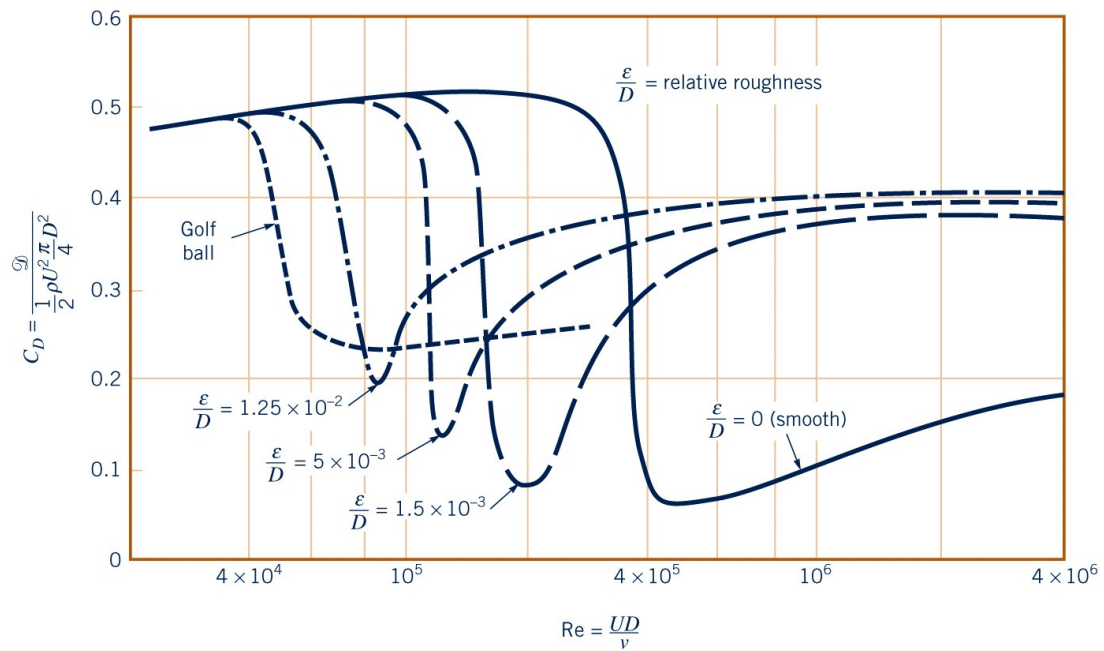
Surface Roughness

$C_D = \dfrac{\mathscr{D}}{\frac{1}{2}\rho U^2 \frac{\pi}{4} D^2}$

$\dfrac{\varepsilon}{D}$ = relative roughness

Golf ball

$\dfrac{\varepsilon}{D} = 1.25 \times 10^{-2}$

$\dfrac{\varepsilon}{D} = 5 \times 10^{-3}$

$\dfrac{\varepsilon}{D} = 1.5 \times 10^{-3}$

$\dfrac{\varepsilon}{D} = 0$ (smooth)

$\mathrm{Re} = \dfrac{UD}{\nu}$

$\mathscr{D}$, lb

Smooth golf ball

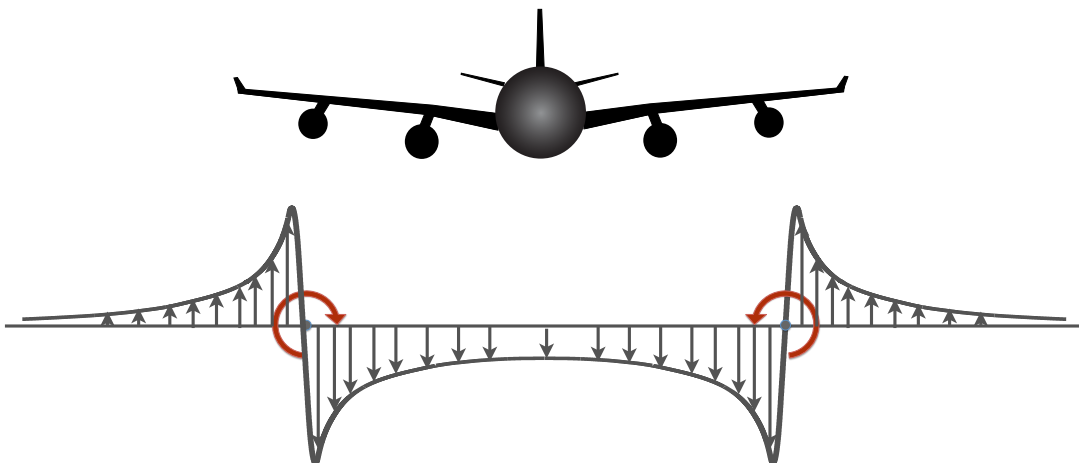Standard golf ball

U, ft/s
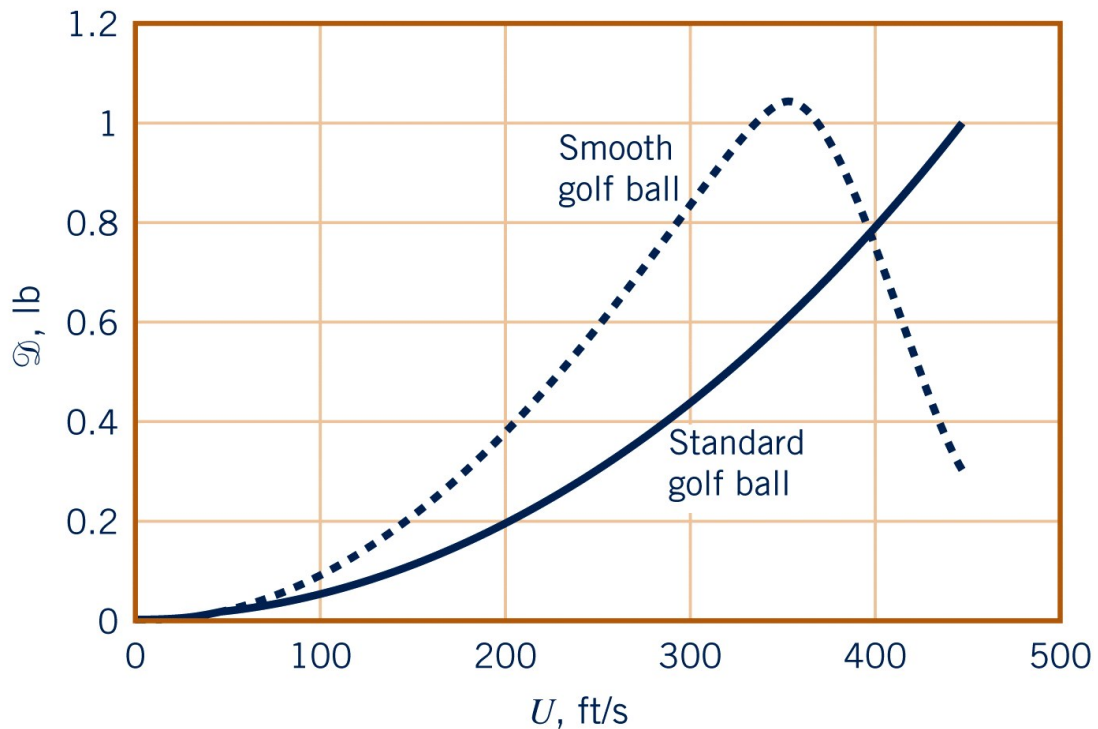
Compressibility

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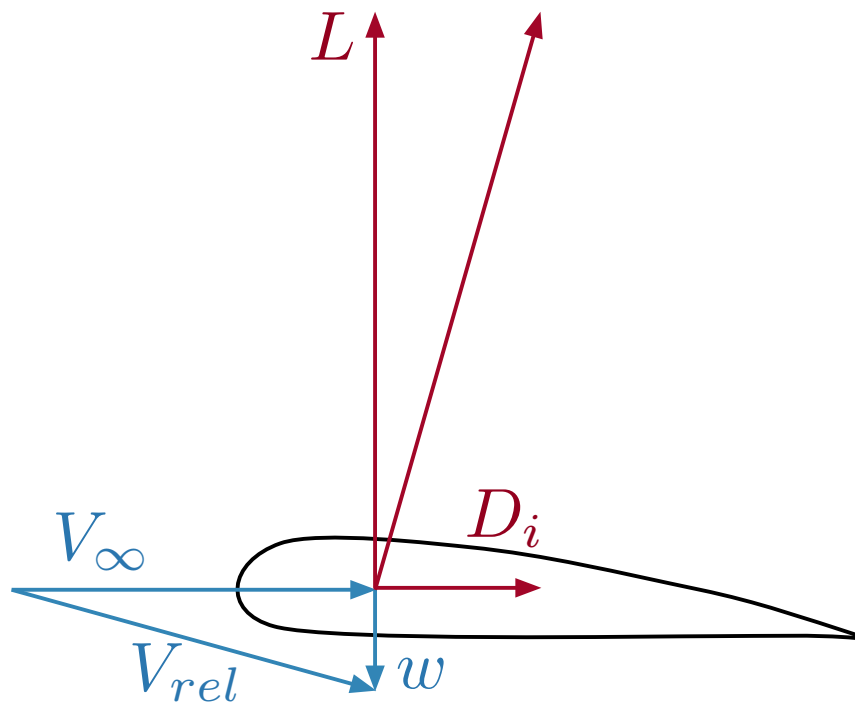
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Froude Number

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Lift

Induced Drag

$$C_D = f(shape, Re, \epsilon/L, Fr, Ma, C_L)$$

Total Drag

$$C_D = C_{Dp} + C_{Di} + C_{Dc}$$

Examples

What is your landing speed if you jump from an airplane at 5,000 ft?

What speed of wind will knock a golf ball off of a tee?