

Supplement to Lecture
March 3rd, 1998

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On Calculating the Drag Using Wake Survey

In the lecture, I showed that the correct calculation of the drag D is given by:

$$D = \int_{\text{rear surface}} \rho(U_{\infty}(y) - U_o)(\mathbf{V} \cdot \mathbf{n})dS, \quad (1)$$

where $U_{\infty}(y)$ is the measured wake x-velocity data, U_o is the upstream incoming flow velocity, $dS = dydz$ and

$$(\mathbf{V} \cdot \mathbf{n})_{\text{rear}} = U_{\infty}(y). \quad (2)$$

Hence, the “final” expression is:

$$\boxed{D = \int_{\text{rear surface}} \rho(U_{\infty}(y) - U_o)U_{\infty}(y)dS,} \quad (3)$$

This supplementary note is to show that this formula is **NOT** the same as the formula you would get if you simply ignore the top and bottom surfaces.

If you simply ignore the top and bottom surfaces, you would get

$$D = \int_{\text{front+rear}} \rho u(\mathbf{V} \cdot \mathbf{n})dS. \quad (4)$$

We now have:

$$(\mathbf{V} \cdot \mathbf{n})_{\text{front}} = -U_o(y), \quad (5)$$

$$u_{\text{front}} = U_o, \quad (6)$$

$$(\mathbf{V} \cdot \mathbf{n})_{\text{rear}} = U_{\infty}(y), \quad (7)$$

$$u_{\text{rear}} = U_{\infty}(y). \quad (8)$$

Hence, (4) becomes:

$$D = \int_{\text{rear surface}} \rho(U_{\infty}^2(y) - U_o^2)dS \quad (9)$$

which is **NOT** the same as (3).

Equation (9) is plain *wrong*. Equation (3) is correct. They are not the same.