Integral Boundary Layer Equation

Lecture 9

ME EN 412
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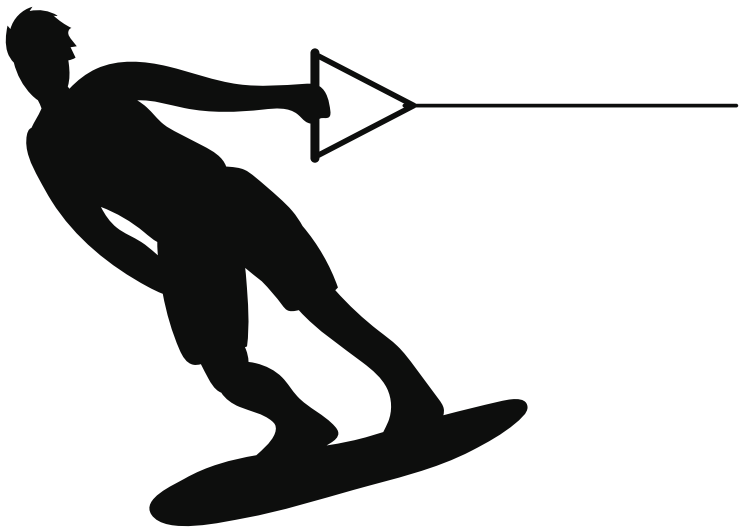
Outline

Examples

Example 1: Estimate friction drag on wakeboard

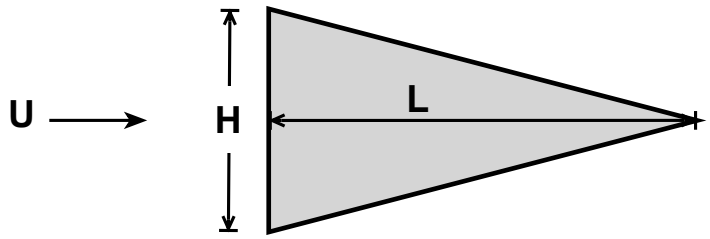


Example 2

Show that the skin friction drag of the triangular flat plate is given by:

$$D = 0.885\, U^{3/2} H \sqrt{\rho \mu L}$$

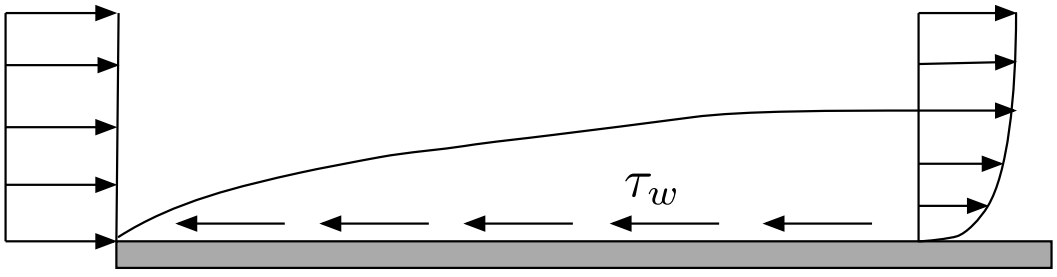
Assume laminar flow.



Compute the drag coefficient assuming a Reynolds number based on length of the plate of $Re_L = 5e5$. The reference area for the drag coefficient should be the triangular planform area. Return your answer in "counts" of drag. One count is 1/10,000 or in other words $C_D = 0.00123$ would be 12.3 counts of drag.

Integral Boundary Layer Equation

How can we estimate drag due to shear more generally?



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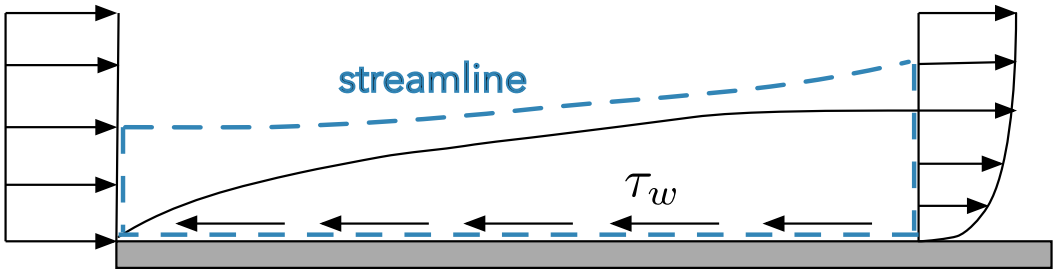

Von Karman Momentum Integral Equation

$$\frac{d\theta}{dx} + \frac{\theta}{U_e}(H+2)\frac{dU_e}{dx} = \frac{1}{2}c_f$$

where $H = \delta^*/\theta$

If there is no pressure gradient:

$$\frac{d\theta}{dx} = \frac{1}{2}c_f$$

XFOIL Demo