

MAE 103 Assignment 7: Due TUESDAY, May 21, 2002

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(Please turn in at the end of the class session at 10 am)

- Recall from class that we derived an expression for the drag force D , resulting from a laminar boundary layer acting on a flat plate over the length x (the depth of the plate is b):

$$D(x) = \rho b \int_0^{\delta(x)} u(U_o - u) dy$$

Here U_o is the x-component of the velocity in the freestream, outside of the boundary layer, and $u = u(x, y)$ is the x-component of velocity within the boundary layer.

Show that, if the velocity profile within the boundary layer may be approximated as

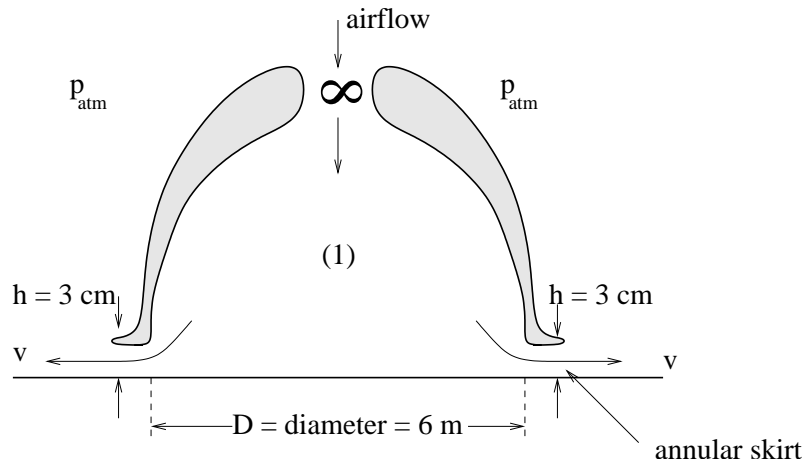
$$u(y) = U_o \left(\frac{2y}{\delta(x)} - \left(\frac{y}{\delta(x)} \right)^2 \right)$$

then the drag on the plate of length x is

$$D(x) = \frac{2}{15} \rho b U_o^2 \delta(x)$$

HINT: instead of integrating over y , transform from y to $\eta \equiv \frac{y}{\delta(x)}$ and integrate over η .

- The air cushion vehicle in the figure below brings in air through a fan (which does work on the air) and discharges it at high velocity through an annular skirt with small ground clearance, h .



If the vehicle weighs 50 kN and atmospheric pressure p_{atm} is 101 kPa, atmospheric temperature T_{atm} is 20° C, estimate:

- the volumetric flow rate of air, Q , in m^3/sec , through the skirt, and
- the power delivered by the fan, given in kilowatts (kW) or kJ/sec.

HINT: the air in region 1 is nearly stagnant and supports the weight of the vehicle. Consider air to be **incompressible** to be able to use Bernoulli's equation for one part of the problem.

3. Problem 6.11 in Munson, et al.'s text.
4. Problem 6.77 in Munson, et al.'s text.
5. Problem 6.83 in Munson, et al.'s text.
6. Problem 5.93 in Munson, et al.'s text.
7. Problem 5.108 in Munson, et al.'s text.