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Flow around a Circular Cylinder

Figure 1: Plot of Velocity Profile

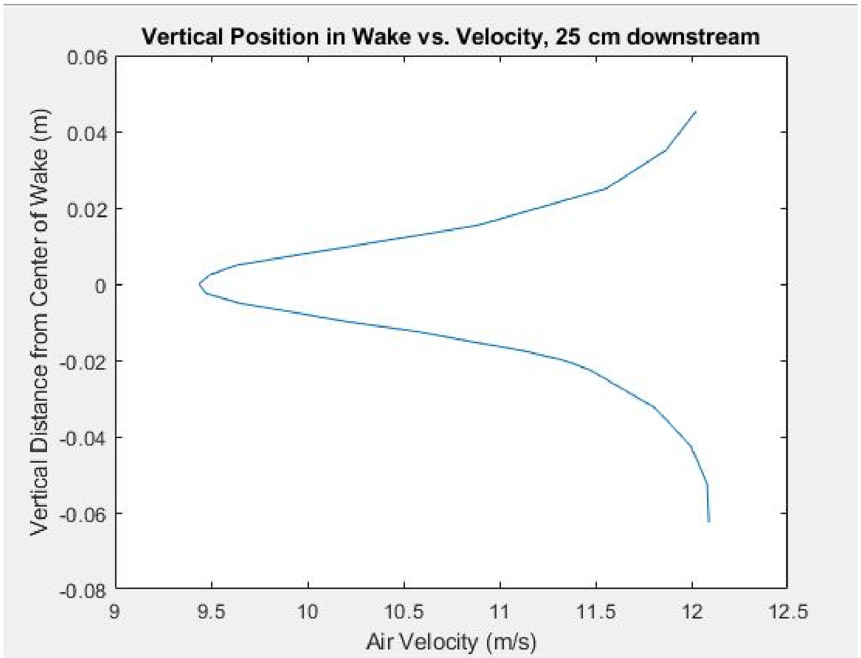
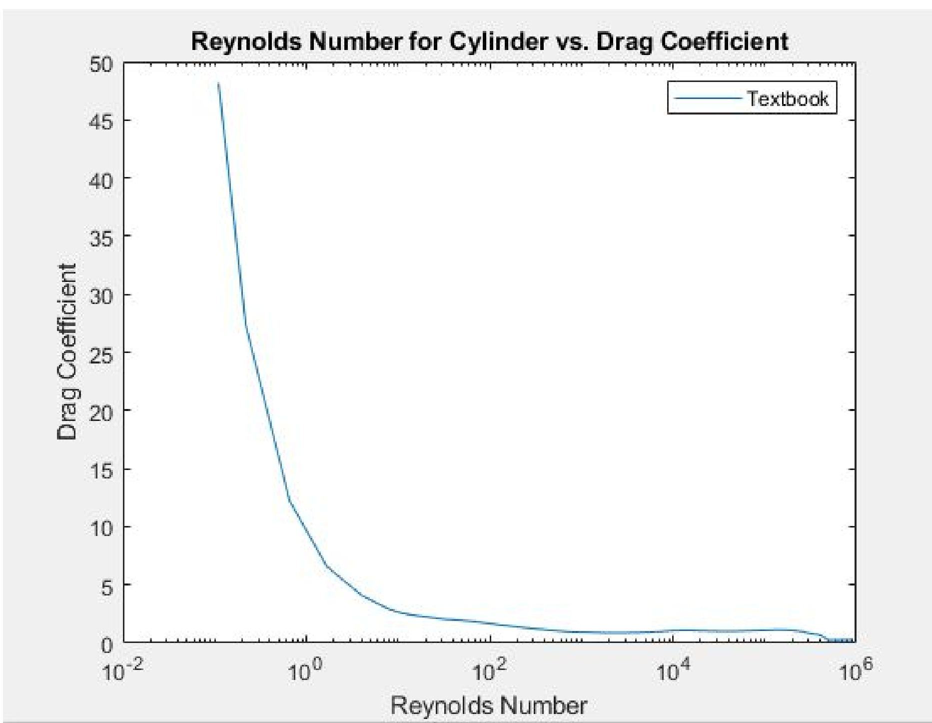


Figure 2: Plot of Reynolds Number vs. Drag Coeffcient



Short Answer Questions:

1.State the percent difference in the drag coefficient C_D obtained from your data compared with the "accepted value" at the same Reynolds number. Write this as a complete sentence that includes the value of your Reynolds number.

The calculated Re was 14186, and the calculated C_D was ___. The accepted value of C_D at that Re is about 1.01, so the percent difference is __%.

I was unable to calculate C_D. I think the problem is the free stream velocity is less than most of the measured wake values, so C_D comes out negative. ??

2. Speculate on how the experiment or data analysis methods could be modified to improve accuracy. Write 3–4 sentences, including any references as necessary to support your response.

Friction drag along side walls was ignored - a larger wind tunnel would decrease that effect. A more accurate integration could have been used, such as Simpson's rule. Finally, it's likely that the velocity profile was not very uniform upon entering the wind tunnel, so that could be checked.

3. Estimate contribution from skin friction drag along side walls.

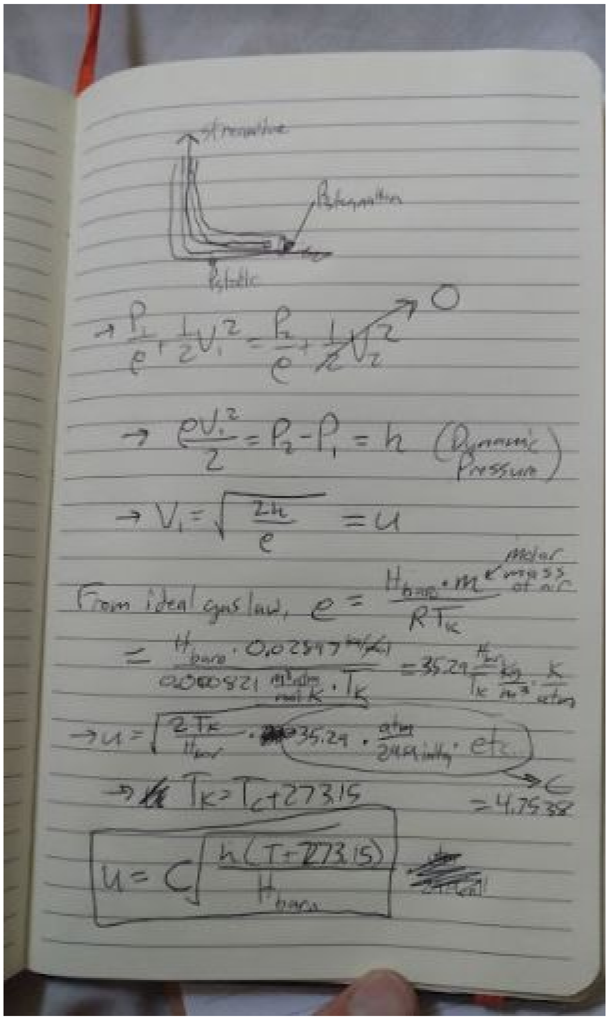
I will estimate L = 15 cm = 0.015 m from the exit of the wind tunnel contraction section.

$Re_L = \rho U_\infty L/\mu \simeq (1.1981\ kg/m^3)(11.34\ m/s)(0.015\ m)/(0.000001828\ Pa*s) = 111500 < 5*10^5$
$\rightarrow C_D = 1.33/sqrt(Re_L) = 1.33/sqrt(111500) = \mathbf{0.00398}$

W = H = 12 in = 0.305 m
Length = about 1 m
$F_D = C_D \rho U_\infty^2 A = C_D \rho U_\infty^{2}*(2(H + W)*Length)$
$F_D = 0.305*(1.1981\ kg/m^3)(11.34\ m/s)^2(2)(2*0.305\ m)(1\ m) = 57.3\ N$ = very approximate

This assumes that the calculated drag coefficient at the cylinder is a good average of the drag coefficient along the entire wind tunnel.

Derivation of Equation 3:



Streamline

Pstagnation

Pstatic

$$\rightarrow \frac{P_1}{\rho} + \frac{1}{2}V_1^2 = \frac{P_2}{\rho} + \cancel{\frac{1}{2}V_2^2} \rightarrow 0$$

$$\rightarrow \frac{\rho V_1^2}{2} = P_2 - P_1 = h \quad \left(\begin{matrix}\text{Dynamic} \\ \text{Pressure}\end{matrix}\right)$$

$$\rightarrow V_1 = \sqrt{\frac{2h}{\rho}} = u$$

From ideal gas law, $\rho = \frac{H_{baro} \cdot m}{R T_K}$ ← Molar mass of air

$$= \frac{H_{baro} \cdot 0.02897 \, \text{kg/mol}}{0.0821 \, \frac{m^3 \cdot atm}{mol \cdot K} \cdot T_K} = 35.29 \frac{H_{bar}}{T_K} \frac{kg}{m^3} \cdot \frac{K}{atm}$$

$$\rightarrow u = \sqrt{\frac{2 T_K}{H_{bar}} \cdot 35.29 \cdot \frac{atm}{29.92 \, inHg} \cdot etc.} \rightarrow C = 4.7538$$

$$\rightarrow T_K = T_C + 273.15$$

$$\boxed{u = C\sqrt{\frac{h(T + 273.15)}{H_{baro}}}}$$