Homework problem 3(3.5p.), Fluid Mechanics SG2214
Due Oct 24, 2013

Be careful to explain and motivate each non-trivial step of the solution to these problems.

1. (2 p.)
Complete the lab report according to the instructions in the lab PM.

2. (1.5 p.)
A cylinder of radius a is facing a free stream with velocity U_∞ at large Reynolds numbers. The measured pressure coefficient distribution, c_p, on the cylinder surface is shown in figure 3.1 for three different Reynolds numbers, **R** (or *Re*), along with the pressure coefficient distribution given by irrotational flow theory (frictionless flow) for 2D flow around a cylinder.

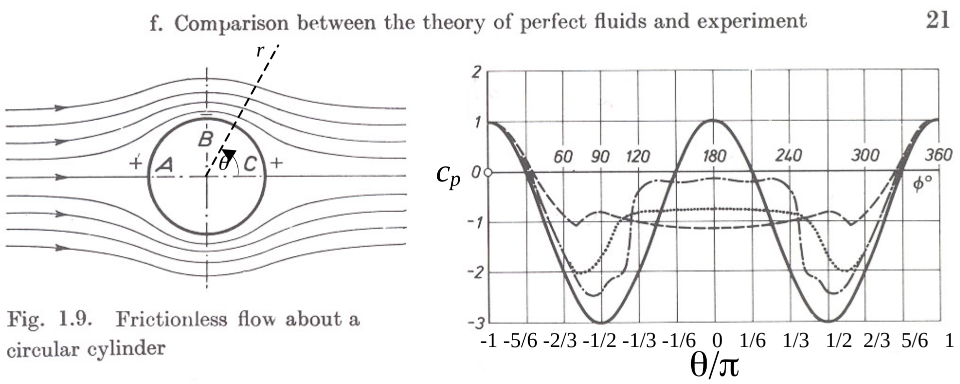

Fig. 1.9. Frictionless flow about a circular cylinder

Fig. 1.10. Pressure distribution on a circular cylinder in the subcritical and supercritical range of Reynolds numbers after the measurements of O. Flachsbart [4] and A. Roshko [13].

——— frictionless flow
– – – R = 1·9 × 10⁵ } Flachsbart (1932)
— · — R = 6·7 × 10⁵
. . . . . R = 8·4 × 10⁶ Roshko (1961)

From: Schlichting, Boundary layer theory, McGraw-Hill

Figure 3.1

As a rough approximation for the two smallest values of *Re*, the pressure can be taken from 2D irrotational flow theory on part of the surface and taken as a constant on the remaining part. This approximation is illustrated in figure 3.2, where for *Re=190000* the pressure is constant for $|\theta| \le 3\pi/4$ and for *Re=670000* the pressure is constant for $|\theta| \le \pi/6$.

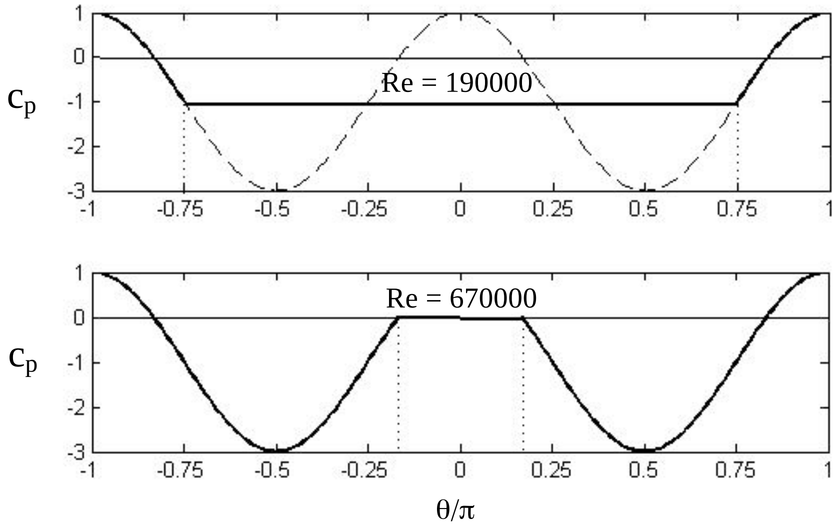

Figure 3.2 $c_p = \left(p(\theta) - p_\infty\right) \Big/ \frac{1}{2}\rho U_\infty^2$

a) Derive the pressure coefficient $c_p(\theta)$ for irrotational flow around the cylinder without circulation. Then calculate the contribution from the pressure distribution to the drag coefficient,

$$C_D = \frac{D_x'}{\frac{1}{2}\rho U_\infty^2 2a},$$

for the two approximations given in figure 3.2. Compare these two calculated values of C_D with the corresponding experimental results taken from figure 10.22 of Kundu & Cohen.

b) Make a brief explanation why the flow does not agree with irrotational flow theory on the whole surface of the cylinder at large Reynolds number. Make sketches of the flow that qualitatively illustrate the differences for the two *Re* discussed above. Try to explain the reason for this difference.

(The fact that the flow behind a circular cylinder may be oscillatory in nature is not considered here. You may regard the present model as an average over time.)