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DEPARTMENT OF AEROSPACE AND MECHANICAL ENGINEERING

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Advanced Aerodynamics

Homework 4

1. We have shown in class that the superposition of a uniform flow U in the x direction and a source located at the origin of strength Q gives the flow around a two-dimensional body with a rounded head and extending downstream with a constant width h.

   (a) Calculate the source strength Q in terms of h and the velocity U. Plot the shape of the body and a few streamlines around the body for $U = 20m/s$ and $h = .5m$. Determine the location of the body head and its intersection with the y axis.

   (b) Calculate and plot the pressure coefficient along the body

   $$C_p = \frac{(p - p_\infty)}{(1/2\rho U^2)}.$$

   (c) Calculate the drag applied by the fluid on the body.

2. Consider the flow resulting from the superposition of a uniform stream V_∞ and a source-sink pair placed at a distance b to the left and right of the origin, respectively as shown in figure 1. The strength of the source and sink are Q and $-Q$, respectively. The stream function for the combined flow is given by

   $$\psi = V_\infty r sin\theta + \frac{Q}{2\pi}(\theta_1 - \theta_2). \tag{1}$$

   (a) Express the stream function in terms of the $x - y$ coordinates.

   (b) Show that the stagnation points are located at

   $$OA = OB = \sqrt{b^2 + \frac{Qb}{\pi V_\infty}}. \tag{2}$$

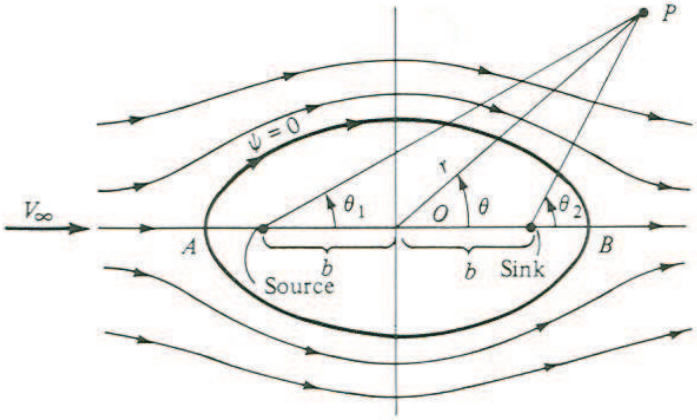

Figure 1: Flow over a Rankine oval: superposition of a uniform flow and a source-sink pair.

(c) Plot the stagnation streamline and show that (1) represents the flow about an oval. This is known as the Rankine oval flow. Plot a few streamlines around the oval for

$$b = 1, \quad \frac{Qb}{\pi V_\infty} = 0.1, 1, 10.$$

$$b = 0.1 \quad \frac{Qb}{\pi V_\infty} = 0.1, 1, 10.$$

3. Consider a source of strength m at a distance a from an infinite thin wall as shown in Figure 2.

   Use the method of images to write the expression for the velocity potential and calculate the pressure induced by the source along the wall. Show whether the source push or pull source.

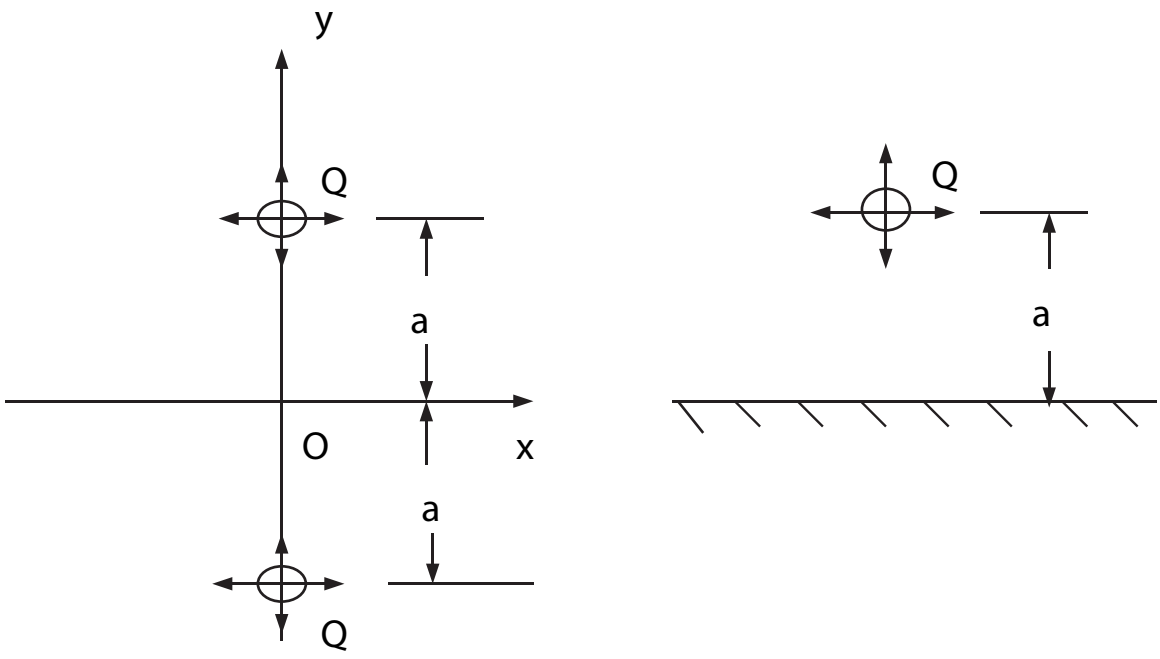

Figure 2: A Source in Presence of a Wall