ES 212 | Fluid Mechanics

Homework 8

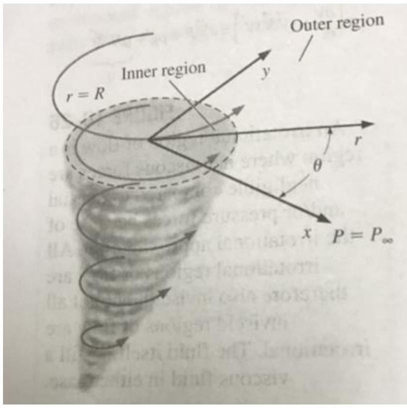
(Due: April 12, 2017 before class begins)

Problem 1

A person drops three aluminum balls of diameters 2 mm, 4 mm, and 10 mm into a tank filled with glycerine at 22° C (μ=1 kg m/s), and measured the terminal velocities to be 3.2 mm/s, 12.8 mm/s, and 60.4 mm/s, respectively. The measurements are to be compared with theory using Stokes law for drag force acting on a spherical object of diameter D expressed as $F_D = 3\pi\mu DV$ for Re $\ll$ 1. Compare experimental velocities values with those predicted theoretically.

Problem 2

A horizontal slice through a tornado is modeled by two distinct regions. The inner or core region (0 < r < R) is modeled by solid body rotation - a rotational but inviscid region of flow. The outer region (r > R) is modeled as an irrotational region of flow. The flow is two-dimensional in the rθ-plane, and the components of the velocity field $\vec{V}$= (u_r, u_θ) are given by



$$u_r = 0 \qquad u_\theta = \begin{cases} \omega r; & 0 < r < R \\ \frac{\omega R^2}{r}; & r > R \end{cases}$$

where ω is the magnitude of the angular velocity in the inner region. The ambient pressure (far away from the tornado) is equal to P_∞. Calculate the pressure field in a horizontal slice of the tornado for 0 < r < ∞. What is the pressure at r = 0? Plot the pressure and velocity fields.

Problem 3

Plot the streamlines and equi-potential lines using Matlab for the following cases. Please include your Matlab code and plots in your submission.

a) Uniform flow in x-direction
b) Line source and sink at origin
c) Line vortex at origin
d) Doublet at origin
e) Superposition of uniform flow in x-direction and doublet at origin (non-lifting flow around a circular cylinder).

Hint: Generate arrays for x and y coordinates and use contour plot in Matlab

Problem 4

Consider a superposition of a doublet, a uniform flow in x-direction, and a vortex at origin. Assume a two dimensional , incompressible, and irrotational flow. The superimposed flow represents a lifting flow over a circular cylinder

1. Obtain the stream function and velocity potential for this flow pattern, using a clockwise vortex.
2. Find the velocity field and locate the stagnation points on the cylinder surface
3. Obtain the surface pressure distribution and integrate the pressure distribution to obtain the drag and lift forces on the circular cylinder. How does the result compare with the case of a non-lifting flow around a circular cylinder?
4. Plot the streamlines and compare with those obtained for the case of a non-lifting flow around a circular cylinder. Include a brief discussion of the results and comparison.
5. Plot the velocity and pressure fields and compare with those obtained for the case of non-lifting flow around a circular cylinder. Include a brief discussion of the results and comparison.
6. Describe atleast one potential relevance/application of this problem in the field of sports.

Please include your Matlab code and plots in your submission.