CE 360 Virtual Lab
Vortex Shedding from a Circular Cylinder
Spring 2016
Due April 8th, 2016

Assignment:
Using the supplied excel sheet you will complete the lab journal section, compute the calculations and create the graphs outlined in the Problem section below. Submit your excel spreadsheet and dimensional analysis work, along with a brief write-up - 1 page or less - of your findings and the meaning of the pi groups found.

Background:
Determining the shedding frequency at the model scale is useful in understanding the dynamics at play for actual systems. Vortices can create lift-induced drag on an aircraft and create vibrations against skyscrapers that can possibly cause the failure of the structure. Vortices also cause vibrations as water flows past blunt obstructions. This creates flow separation and a boundary layer to form with strong flow oscillations in the wake area behind the body. The unsteady separation of flow is known as a Karman vortex street.

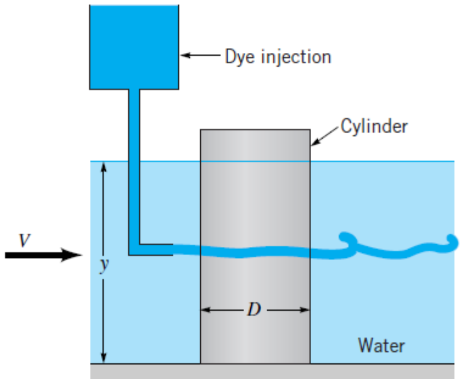
The following gives a brief overview of the model setup used to create a Karman vortex street.

Model Objectives:
Under certain conditions, the flow of fluid past a circular cylinder will produce a Karman vortex street behind the cylinder. As shown in the figure below, this vortex street consists of a set of vortices (swirls) that are shed alternately from opposite sides of the cylinder and then swept downstream with the fluid. The purpose of this experiment is to determine the shedding frequency, ω cycles (vortices) per second, of these vortices as a function of the pi groups formed using dimensionless analysis.

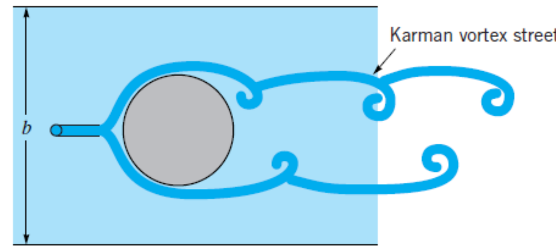
Equipment that would be used to set up the model:
Water channel with an adjustable flowrate; flow meter; set of four different diameter cylinders; dye injection system; stopwatch.

Theoretical Experimental Procedure:
Insert a cylinder of diameter D into the holder on the bottom of the water channel. Adjust the control valve and the downstream gate on the channel to produce the desired flowrate, Q, and velocity, V. Make sure that the flow-straightening screens (not shown in the figure) are in place to reduce unwanted turbulence in the flowing water. Measure the width, b, of the channel and the depth, y, of the water in the channel so that the water velocity in the channel $V = Q/(b*y)$, can be determined. Carefully adjust the control valve on the dye injection system to inject a thin stream of dye slightly upstream of the cylinder. By viewing down onto the top of the water channel, observe the vortex shedding and measure the time, t, that it takes for N vortices to be shed from the cylinder. For a given flowrate, repeat the experiment for different diameter cylinders. Repeat the experiment using different flowrates and depths of the water in the channel. Measure the water temperature so that the viscosity can be looked up in Table 1.4.

Side View



Top View



Pilot vs model:
Length of the model is scaled by 5 for the pilot. Use the fluid properties of water for the model and fluid properties of sea water for the pilot.

Hints:
Hint 1: We want to study system behavior by looking at dimensionless numbers involving V and ω. Because V is included, Q, b and y should no longer be included in the dimensionless numbers. Similarly, because ω is included, N and t should not be included.
Hint 2: the dimensionless numbers you will find should match some of the well known dimensionless numbers we introduced in the course
Hint 3: watch out for the difference between dynamic and kinematic viscosity and their units.

Problem:

1. Use Buckingham Pi Theorem and the details provided above to determine the dimensionless pi groups you will use for the model experiment.
2. Using the virtual lab excel sheet to simulate the experimental procedure, alter the diameter, D, using the following values to be tested in the model system: [0.02 0.0314 0.0421 0.0518] (ft). Calculate a minimum of 4 trials for each diameter varying Q and/or y and record the results to the lab journal section.
3. For each trial:
   a. Calculate the vortex shedding frequency, $\omega = N/t$
   b. Calculate the pi groups
   c. On a single graph, plot the vortex shedding frequency, ω as ordinates and water velocity, V, as abscissas. Plot each of the four cylinders as their own series.
   d. On another graph, plot one dimensionless number, pi1, versus the other, pi2, as a scatter plot.
4. Based on the D values given above what are the diameter values associated with the pilot system?
5. Given a real velocity range of 1-6.5 ft/s in the pilot system, what should be the range of velocities to be tested in the model system?

6. For a model velocity of 0.14 ft/s and D of 0.045 ft, calculate your dimensionless number, read off the figure you created in 2(c) and estimate the model ω. What will be the corresponding ω of the pilot system?