Pint Glass Vortex

Eli Luke

Flow Visualization

Prof. Jean Hertzberg & Prof. Alex Sweetman

Project #6 (Final Project)

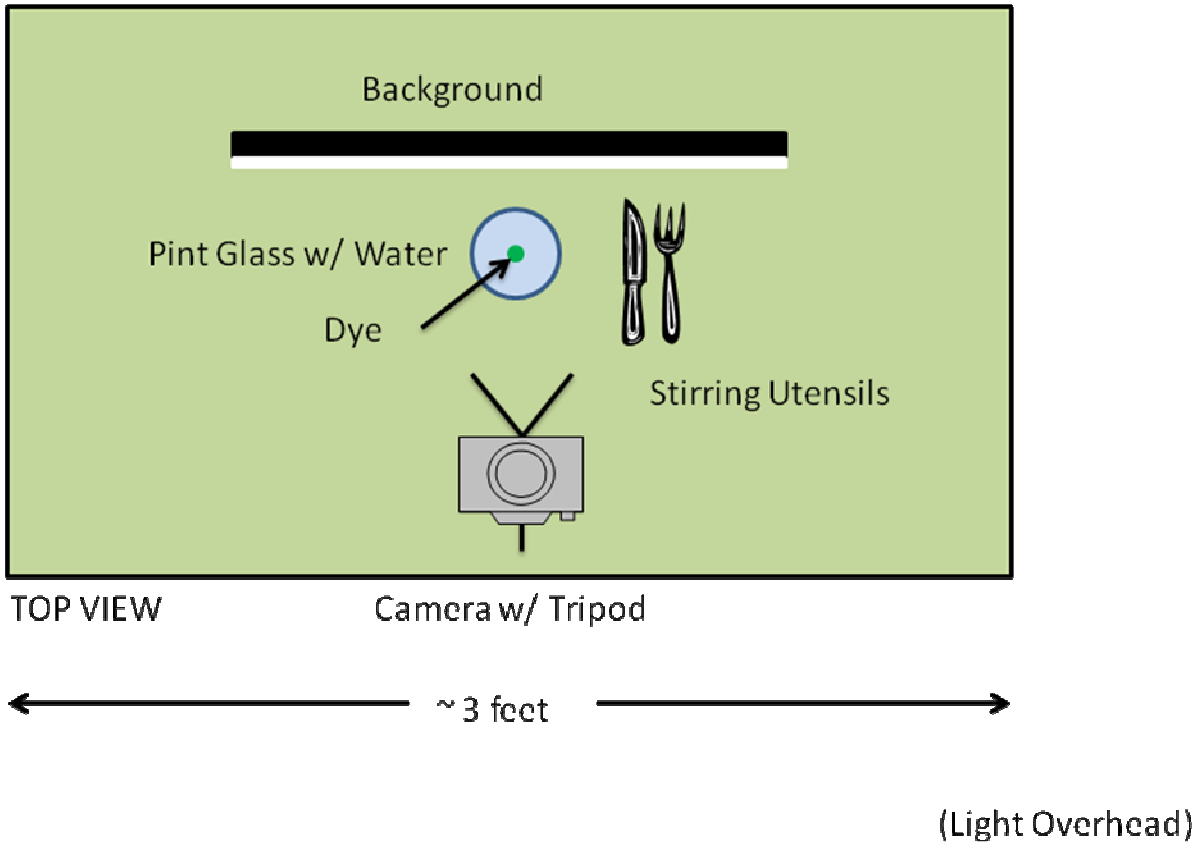
Due 12/13/07

Purpose:

This is the last project of the semester, and due to scheduling conflicts, our group was not able to meet. I decided to mess around with some food coloring and water. I ended up messing with vortex-type flow in a glass, while dropping food coloring in the middle of the flow. What resulted was pretty interesting. I was able to get some good photos, but more importantly, I captured some movies to show the full extent of what was going on.

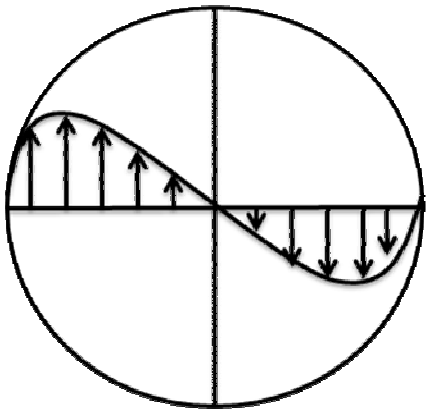
Experiment Setup:

The setup was pretty simple. It required a pint glass (clear), food coloring dye, water, and a stirring utensil. The glass was filled up with water, stirred in a circular fashion, and then dye was dropped in the center of the resulting flow. The full setup is shown below.

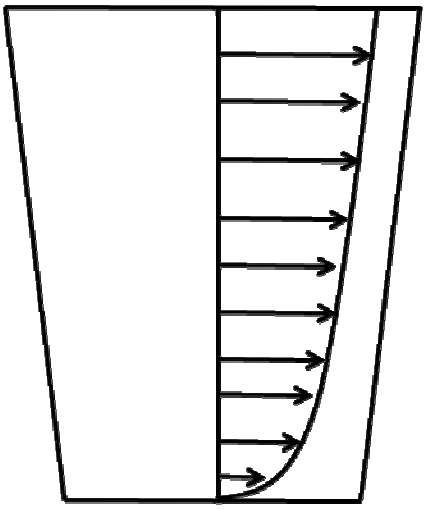


Physics:

The flow that was captured mimics an ideal vortex-flow in a cup when it is stirred at a constant stirring rate. If this stirring motion was constant, then an observer would see the following type of velocity profiles in the cup:



Top View
Angular Velocity (Radial Profile)



Side View
Angular Velocity (Vertical Profile)

These drawings show how the angular velocity changes with respect to cup radius, and also how it varies over the height of the cup. This of course is an idealized situation where the stirring would be constantly applied with the same force. Also, we can observe that there should be no flow in the vertical direction.

In our situation, there is flow in the vertical direction, just by direct observation. There are a couple things different in this case. One, the stirring isn't being constantly applied, so the angular velocity changes as a function of time as well. Also, the dye being dropped in has some vertical momentum downward, which would create flow in that direction. This would explain the behavior of the dye moving downward in the movie. The dye is also being stretched (or sheared), which mimics the water in the flow.

Although this particular flow is more complex than the scope of this paper, there were some important things noted. There can be flow in the vertical direction due to vertical momentum, but the flow is very much the same as an idealized steady vortex would be.

Photographic Technique:

The photo was taken when the flow had slowed down to the point where the temporal resolution wouldn't be a problem. The macro setting on the camera was selected for ideal resolution. House lighting from above (slightly at an angle) was used for the photo.

- Make/Model: Panasonic Lumix DMC-FX7 2560 X 1920 Pixels
- X res: 72 lines/inch Y res: 72 lines/inch
- Actual specs for photo: 10.1mm focal length, 3.8 F-Stop
- Field of View: ~ 4 inches
- Exposure Specs: 1/8 sec exposure, aperture value of 3.0, ISO speed rating of 200

The photo wasn't changed much. The image was cropped slightly, and some contrast/brightness touch-ups were done in Adobe Photoshop.

Pre-Photoshop (Original) Photograph

Final Photograph

The Image:

The image itself doesn't completely show what is going on in the flow, which is why a small movie was captured for this. By itself, the image is pretty interesting. It is aesthetically pleasing, but mysterious at the same time. The science was captured, but only for a moment in time, and when something varies with time, it calls for a movie or long exposure.

References:

[1] Kundu, Pijush K. (1990). Fluid Mechanics. San Diego: Academic Press, Inc.