Group Image 2

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This image was taken with the assistance of Peter Mitrano and the set up was designed with help from Christopher Svedman. The goal of this image was to attempt to visualize the formation of two separate vortices within close proximity of one another. Two holes were drilled in the bottom of a bucket, and then the bucket was filled with water and allowed to drain out the bottom. Then the fluid was then seeded with three differing colored food dyes to help visualize the flow of the water. Though the desired flow did not form the negative result proved to be just as informative about the physics involved in the system.

The construction of the apparatus was fairly straight forward and could be easily reproduced by people wanting to reproduce our results or elaborate on them in the future. A standard five gallon bucket made of white plastic was used to allow the colored dyes to stand out against the background with maximum contrast and to increase brightness of the image. Then the entire bucket was cut diagonally (as shown in the diagram below) using a handheld hack saw to allow in the maximum amount of sunlight and to remove any shadow created by the side of the bucket. Two holes were put in the bottom of the bucket with diameters of approximately two centimeters and separated from one another by approximately five centimeters. The bucket was then filled by use of a second bucket while the two holes at the bottom were plugged as to not allow any water to flow out. The water was then allowed to settle for approximately one minute to allow any flow due to the pouring of the water to dissipate. Then the plug blocking the two holes was removed and the water allowed to freely flow. Once a vortex was visually apparent the water was seeded with three food coloring dyes near the vortex. After only a few seconds the dye is sucked into the flow and pulled through the two openings in the bottom of the bucket. At this time multiple images were taken to try to capture the behavior of the fluid near the holes in the bucket.

Vortices form when a cylindrical volume of water begins to gain angular momentum over some sort of drain beneath the volume [1]. In this set up our goal was to create two separate vortices, one connecting to each respective hole in the bucket. Our experiment was not able to form this behavior with the holes drilled. Initially we suspected that it might be due to the secondary hole not being the exact same size as the initial hole. We gradually increased the size of this hole and consistently found the vortex still forming on the center hole of the bucket, even once the hole was larger than the initial hole. We are not certain if this is due to the bucket being symmetric about the center hole or some other phenomenon, but regardless is quite interesting and may warrant further investigation. When looking at the image it is clear to see that there is flow into the secondary hole, but a vortex is not forming, when looking at the lower hole there is blue dye that has settled in the bucket which is being pulled in while the red and yellow dye that is suspended higher in the water passes over the hole unaffected.

Overall I am pleased with how this image turned out, but am curious to perform further investigation into what factors control the formation of vortices in this set up. Further tests that have been suggested include closing the main hole to see if a vortex can form in the second hole, and then slowly increase the size of the main hole to see if and when the vortex goes back to the first hole. Another change that has been suggested has been to adjust the separation between the two holes and move them closer together until a threshold separation is found. Perhaps in this process it we will also be able to form two vortices simultaneously as originally desired.

**Camera Data:**

Exposure: 1/4000s

f-stop: 5.6

ISO: 100

Focal Length: 135mm

Image Stabilizer: On

Flash: Did not fire

Distance to Object: ~0.9m

Camera: Canon EOS Rebel Xsi

Lens: Canon 28-135mm f/3.5 – 5.6 IS

**Reference:**

[1] http://maxwell.ucdavis.edu/~cole/phy9b/notes/fluids_ch3.pdf

**Apparatus Diagaram:**