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Flow Vis- Get Wet Report
2/16/2012

Get Wet Image 3652 x 2256 pixels: 1/400 s F7.9 ISO 800

For the Get Wet image I really wanted to just take a clear photo. I took many pictures of different flow phenomenon that are available around the house, but tried to keep the set up simple. This photo was taken after blue dye had been stirred in to water in a wine glass. This was not the original concept that I wanted to photo but looked interesting as I did it so I shot some pictures. The resulting image depicts a vortex that is deforming back to a still, flat water surface. Different backgrounds were tried, white paper and wax paper, to try and diffuse the light behind the photo. In the end the photo was taken in a window with only a snowy, sunny background.

The flow was created in a wine glass. It was filled up almost to the top, a depth of 4.5 inches, where the width of the glass was 3 inches. I used a chopstick to swirl the water and spun at approximately 120 rpm in the clockwise direction until a vortex had formed as much as it would. At this point I withdrew the chopstick and took a photo as the bottom of the vortex receded.

In a vortex the rotational velocity is the greatest at the center and gets smaller as the distance from the center increases[1]. The rotation causes particles in the water to be affected by centripetal acceleration and move to the sides of the wine glass. Air occupies the space that the water vacates and, as can be seen in the photo, is sometimes stirred in to the water to create bubbles. Once the spinning has stopped the water is slowed down by gravity until it reaches a smooth, flat surface again. This photo was taken after the spinning had stopped allowing us to see instabilities in the vortex during deformation. These instabilities are created from water bonding effects while rotation is still happening, although slowing down, in the fluid.

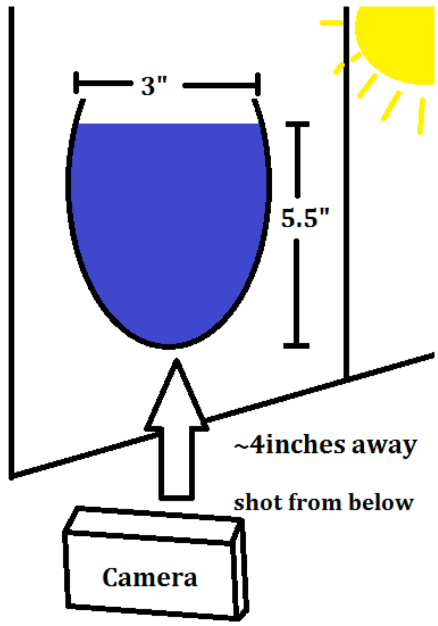

Photo Setup

Some assumptions about the flow, and some known constants, allow for an in depth look at what is going on here. The Reynolds number determines whether or not flow is laminar (smooth) or turbulent (rough). In order to determine this we need a few different values. The velocity of the flow can be determined by approximating the stirring of the chopstick. I would estimate that I was able to make 3 rotations in one second, one rotation is about 9 inches, making the velocity about 27 inches per second (2.25 ft/s). The diameter of the wine glass is 3 inches (0.25 ft) and the kinematic viscosity for water can be looked up. The resulting Reynolds number is:

$$Re = \frac{u*D}{v} = \frac{2.25\,\frac{ft}{s} * 0.25\,ft}{1.052E{-}5\,\frac{ft^2}{s}} = 53{,}469 \qquad [2]$$

This number is very large, signifying that the flow was turbulent. A high Reynolds number was expected since flow in a vortex is often turbulent[1].

The visualization technique used in this photo is a blue food coloring and light refraction of the surfaces in the water. One drop of food coloring was put in to an almost full wine glass and stirred in until the water was fully diluted with dye. The glass of wine was placed in a north facing window at roughly 10:00 AM on a morning that it had snowed a lot. The sun was very bright due to the snow making for a great light source for the photo. The water in the glass was stirred as fast as possible using a wooden chopstick. About 2 seconds after stopping the water stirring the photo was taken.

In order to really get good detail of what was going on I decided to take the photo close to the glass, about 4 inches away. Being this close to the object I was taking a picture of lead it to take up most of the frame. This is exactly what I was trying to do as the area adjacent to the glass was very bland but distracting from the main focus I wanted. The camera used to take this photo is a Casio digital “point and shoot” that has a lens focal length of 4.24-53.0 mm. In order to get the correct exposure a shutter speed of 1/400 seconds was used in pair with an aperture of 7.9 and an ISO of 800. Photoshop was used for the image editing after the original was captured. First the original was cropped to put further focus on the flow phenomenon. After the image was framed properly I used curves to really make the colors I wanted come out more, while getting others to not be as noticeable. The last thing I did to alter the image was to use the clone stamp tool in order to remove some of the bubbles that I felt withdrew focus from the flow.

The image reveals what happens to a fluid when it is rotated very quickly. The perception of depth in the vortex is my favorite part. The different light refractions create a texture that really makes the picture come alive. Some of the bubbles get in the way of cool features which is disappointing, but other bubbles accent the flow very well. I would have liked to get rid of a few, but keep others. Since the vortex is not fully formed the physics of the flow is not depicted as well as it could be. Since it is deforming more physics come in to effect, the center seems to have split to create more than one high point. This would lead me to believe that the center is no longer the highest point of rotational velocity but instead that point has split off to two or more points that have the highest velocity. I am happy with the outcome of the photo. My main focus was to take a really clear photo that looked interesting and I believe I fulfilled that goal. I would have liked to have a better camera, but mine did a very good job considering it is not the best camera for these types of photos. In the future I would like to control the experiment a lot better. My intent was to use a different photo and this one was just more practice with my camera. After seeing how the photo turned out, and it fulfilling all of my expectations, I decided to use it even without a sufficient data set. Next time I would use a cylindrical container and a tool with a known rotational velocity to create a fully formed vortex. This would allow me to do more analysis on the flow that had developed. It would be interesting to see how different rotational velocities and container sizes affected the depth and angles created by the vortex.

Reference:

[1] "Vortex." *Wikipedia*. Wikimedia Foundation, 30 Apr. 2012. Web. 01 May 2012. <http://en.wikipedia.org/wiki/Vortex>.

[2] "Water - Dynamic and Kinematic Viscosity." *Engineering ToolBox*. Web. 01 May 2012. <http://www.engineeringtoolbox.com/water-dynamic-kinematic-viscosity-d_596.html>.

Original unedited photo