Get Wet

First Image

Flow Visualization: Spring 2010

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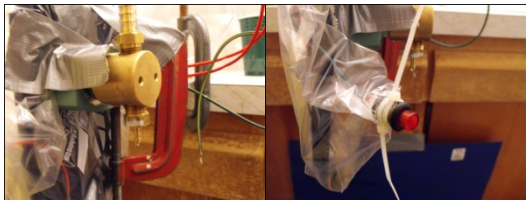
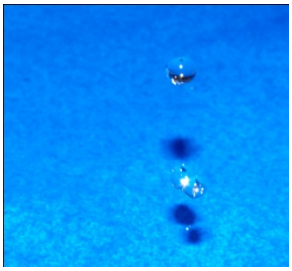
2/8/2010

This image was the first image assignment in Flow Visualization, Spring 2010. The assignment was named Get Wet. The context of the image was free reign on any fluid phenomenon, which could be observed naturally or constructed through intent. In this image, the purpose was to utilize high speed photography techniques to capture a Worthington jet collision. A Worthington jet is the column of water that rises in the place of where a droplet had fallen in a pool. The collision occurred when a second droplet struck the top of the jet on its way down. While going through the process many images of Worthington jets alone were potential candidates (such as the one shown below), however the final image chosen had the collision.

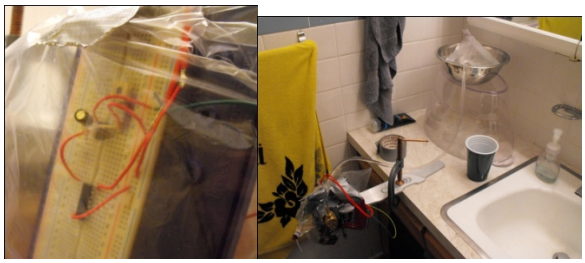
In order to successfully capture the image, every process involved in taking the picture had to be repeatable. Initial trials were crude and simple which involved wetting a rag and squeezing it to create droplets. As this was neither repeatable nor accurate it was not a suitable apparatus. In order to control the droplet delivery, I used a solenoid valve connected to a water reservoir and a pushbutton.



The pushbutton would close a circuit for the solenoid valve to open and allow water to flow through. The solenoid valve had an intravenous drip bag type of reservoir connected to it. By raising the bag, there was no problem in providing constant pressure and flow. By varying the bag's height above the valve, I could control how much water pressure was being applied to the drip. For this image, it was necessary to have a low pressure in order to create small droplets. On the other end of the solenoid valve was a 3mm nozzle. A small nozzle was chosen in order to keep the size of the droplets constant. Droplets are formed as gravity overcomes the water's surface tension.

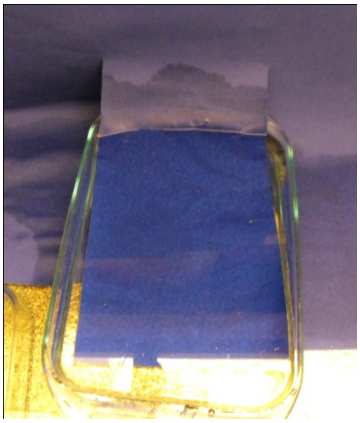


At the nozzle, water is pulled down by gravity and forms a neck. When the neck “snaps”, the water tension pulls the water into a spherical shape. This shape is distorted as it falls through air, but since the drop distance was relatively short, the drop distortion was negligible. While this setup yielded more constant results, they were not as repeatable as I would have liked. In order to solve this I added an astable 555 timer circuit to open and close the valve.



The circuit, when enabled by the pushbutton, would pulse at a specific time cycle in order to better control the droplet delivery. I added a potentiometer to change the amount of time between pulses, and therefore drops. While the time and duty cycle varied along the process the final values for the pulse were approximately 5% duty at $1/10^{th}$ second between pulses.

The best way to visualize this phenomenon is through boundary visualization. I had a choice of applying color to the fluid, reflecting light off the surface, or change the light passing through the fluid. I was restricted to coloring the fluid or changing the light passing through since the only flash I had access to was my camera’s flip open flash, and could not control the angle of the flash in order to effectively reflect light off the surface. I chose to change the background, thereby changing the light through the water. This was simply done by sliding a blue poster board into the bottom of the pool which I was using. This added a texture to the photo which made the refraction of the ripples more defined.



In order to actually capture the image, I implemented some simple high speed photography techniques. I setup in a dark room (my bathroom: dark and didn't matter if anything got wet) and set my camera flash to ON. Since I didn't have a remote for my camera, I set the camera to timer (10 sec) and timed the water droplets to hit when the camera timed out. The dark room removed any ambient light and the flash froze the motion of the collision. The camera was set to Macro and placed ~2¾" from the collision. In the original image, the field of view (FoV) was 5" by 8". The final photo was cropped have a FoV of 3" by 6". To give a better idea of the size, the jet was approximately 1.8" tall. As far as the camera settings; ISO 100, 8mm focal length, f/4.5, and shutter speed of $1/60^{th}$ sec. The dimensions of the original were 3648x2736 pixels and the cropped had 2920X2424 pixels. This photo was taken by a FUJIFILM FinePix S1000fd.

I was very excited about how the image turned out. It was clear and precise about what I was trying to capture. The phenomenon is one that cannot really be appreciated by the naked eye, so it was very cool to be able to capture it frozen in time. My only concern about the photo is that the depth of field is too shallow which caused the impact to not be as clear as the rest of the photo. The rest of the photo turned out exactly as I had hoped. To improve this picture, I would like to try some of the other flow visualization techniques I talked about earlier. I would also like to incorporate higher grade equipment such as slaved flashguns, photogates, and remote controlled cameras.