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Flow Visualization


"Get Wet Image"

2/9/14

The Image:

This is the first image that I have composed for this class. The requirements were very open ended; this image just had to capture any sort of fluid flow. I set up the scene and the lighting that I wanted and then experimented with dropping different fluids in a fish bowl filled with water. I was hoping to discover something that looked unique and interesting. What I finally decided to use was something I never would have expected in the beginning, ranch dressing.

Set Up:

To get started on this assignment I first set up a backdrop that would enhance the fluid. To do this I used a black jacket draped over a chair behind the fish bowl. The reason I used black was because I wanted the image to appear to be floating in space. This draws your attention to the fluid instead of the background.

The lighting I used was very black as well, with only a single ceiling light over the bowl and the rest of the lights in the room off. The single light above the bowl was causing light spots on the fish bowl in certain places when I took my first images. To fix this I taped a paper towel over the light to soften the tone and lower the brightness even more. This resulted in a very dark environment, which required a very high ISO to compensate.

Diagram:
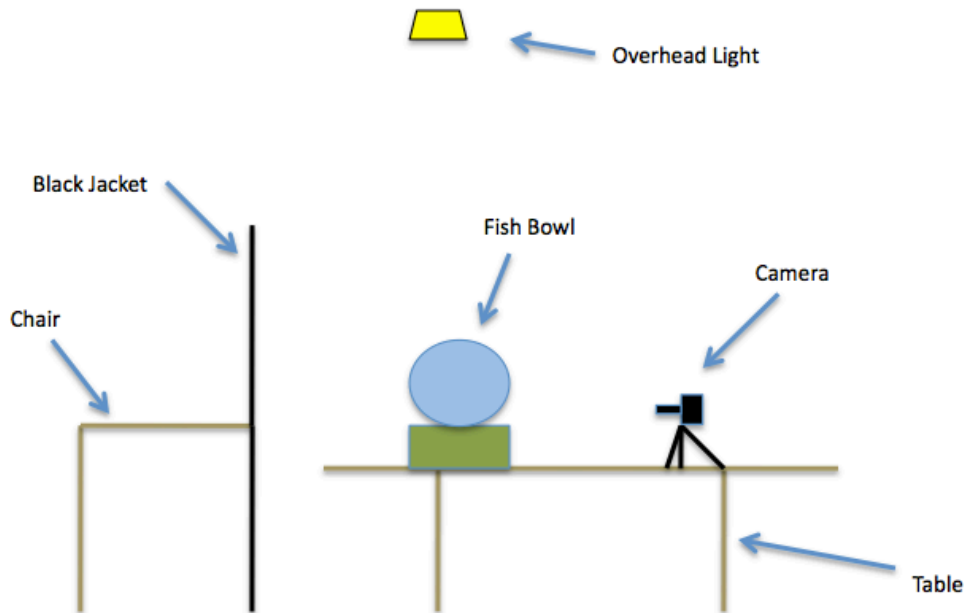
Camera:
        Make: Sony
        Model: A57
        Mode: TV
        F-Stop: 4.5
        ISO: 12800
        Shutter: 1/60
        Flash: None

The Experiment:

To capture the image of the ranch dressing several trials were taken. Each trial involved emptying the water, refocusing the camera by dipping a pencil into the center of the bowl, and finally dumping the ranch in. I switched up the amount of ranch and the speed that it was poured into the bowl to vary the results.

My original goal was to try and capture the moment when the ranch penetrated the surface of the water but I changed my approach. The stream of ranch penetrating the water resulted in underwhelming images. The final image came from the ranch touching the bottom of the bowl, collecting into a mass, and then rising back to the top. This occurred approximately 10 seconds after touching the surface of the water. The reason this occurs is because of the emulsion that occurs.

The mass of ranch in the final image is approximately 3 centimeters long and moving at approximately one foot per minute in the upward direction. Since my shutter speed is so fast no motion blur occurs in this image. The camera was placed two feet from the bowl at the same vertical height on a tripod.

Physics:

The first property the ranch possessed was momentum. Momentum is the product of mass and velocity. The ranch dressing was squeezed out of the bottle at a relatively high speed; it then accelerated even more as it fell approximately one foot downward towards the water. When contact with the surface was made the ranch possessed enough momentum to overcome the water's surface tension as well as the force of buoyancy and sink to the bottom. The momentum the ranch possessed went to zero as it contacted the base of the bowl. This resulted in the buoyancy force being the largest force and caused the ranch to rise back up to the surface.

The reason that the ranch clumped together and formed the shape present in the picture is because of the emulsion present[1]. This term refers to a mixture of two liquids that cannot be mixed effectively. This effect didn't occur instantaneously because of the violent mixing that occurred from the ranch being propelled into the water. This effect occurred after the ranch had time to settle.

The first thing that occurred was a cloudy appearance in the water; this was due to the surface tensions of the water breaking up the stream of ranch. I estimated the Reynolds number at impact to be 40. This indicates laminar flow would have occurred if not for the surface tension.

$$R_e = \frac{\rho V L}{\mu}$$

I used a density value of 1000 kg/m^3 , a velocity of 1 m/s, a length dimension of 3 cm, and finally .8 for the dynamic viscosity in the denominator[2].

Post Processing:

To make this image more pleasing to the eye I used Lightroom to reduce the exposure and the brightness. I also added a blue filter to the entire image, which made the flakey background more interesting. Finally I cropped out the edges that contained the bowl so that the image would appear to be floating in blackness. The original is shown below.

Conclusion:

When I started this project my goal was to capture an image of a fluid interacting with the surface of a bowl filled with water, what I ended up with didn't have to do with the surface at all. I am glad I kept my mind open during this process or my image might have been less interesting. The problem with this image is it is hard to explain and see what is occurring. This makes it intriguing to think about but hard to right a report on and explain to others. One more critique I have is that the image could have been more focused. If I were to redo this image I would attempt to use the manual focus feature on my camera.

References:

1) http://en.wikipedia.org/wiki/Emulsion
2) http://www.engineeringtoolbox.com/water-dynamic-kinematic-viscosity-d_596.html