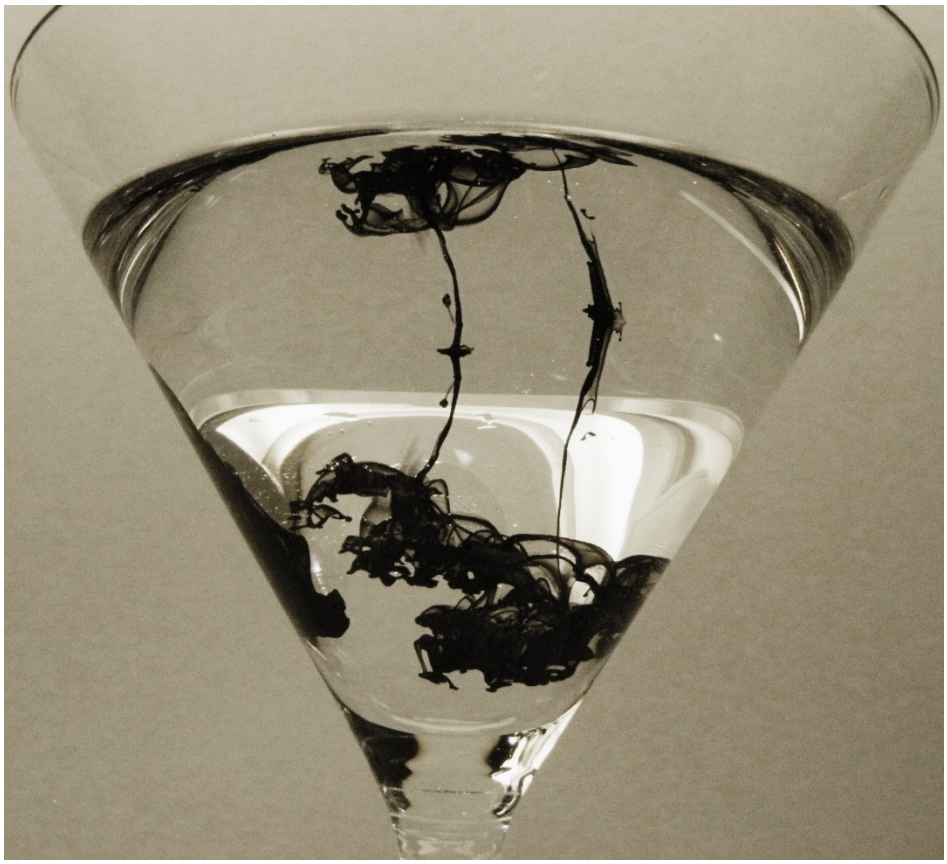
India Ink Dropped into Martini Glass



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INTRODUCTION AND PURPOSE

This photograph and paper was created for the Team First Photo assignment in the Flow Visualization course at CU Boulder. The instructions for this assignment were to simply capture an image of any flow that displays physical phenomenon. I decided to interpret physical phenomenon related dropping liquids of different color/density into other liquids in order to display unique characteristics and instabilities. In order to display this effect, I used droplets of india ink into a martini glass of tap water.

FLOW GENERATION

The apparatus used to capture this image consisted of several components: a tall martini glass filled with tap water, hand soap, india ink (with ink dropper), and a large sheet of white foam core. Figure 1 (seen below) displays the arrangement of the components to capture the image. After the water was poured into the glass (instantaneously, to avoid bubbles), a tiny bit of hand soap was dabbed into the surface of the water. Next, india ink was dropped into tap water/soap mixture, while photographs were simultaneously taken. The camera angle was adjusted slightly in order to get the reflection of the india ink dropping at the surface of the water. A description of why this procedure was used can be seen in the fluid physics section below.

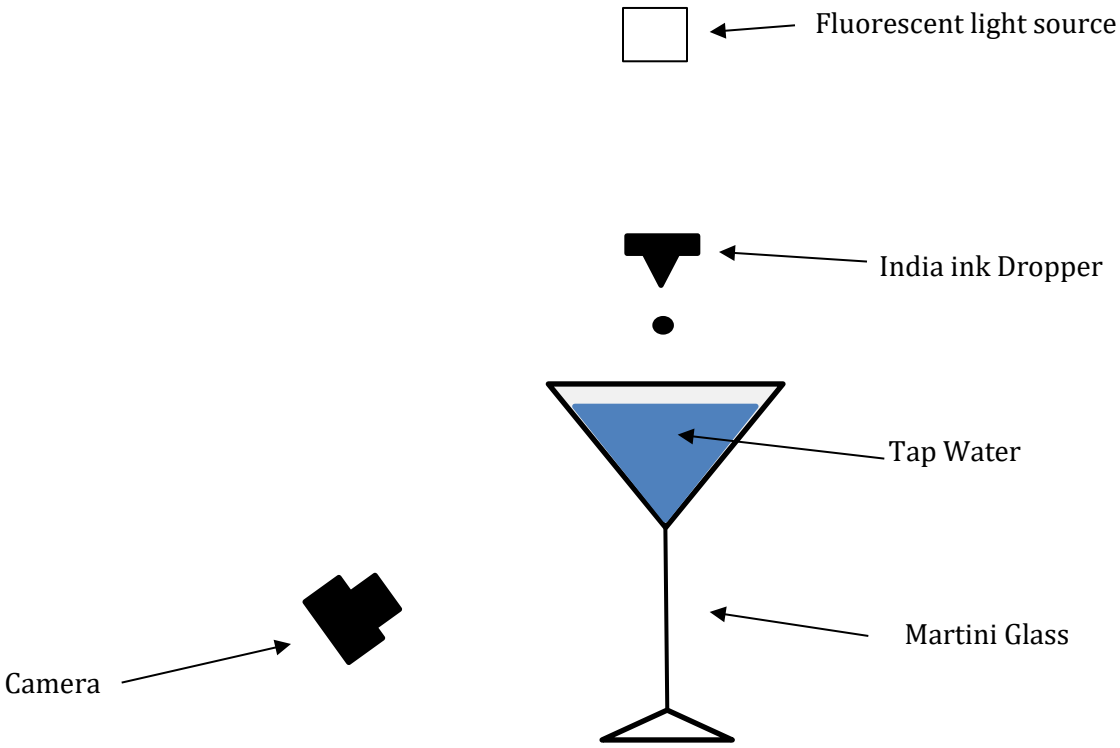

Figure 1: Flow Setup Diagram

FLUID PHYSICS

The india ink that was used to drop into the liquid has a higher density than water, thus the dye sinks when added to the water due to gravity. Calculating a Froud number gives a ratio of the india ink's resistance to the water as it falls downwards.

$$Fr = \frac{U_d}{\sqrt{gR}} = \frac{.06}{\sqrt{9.8 * .6}} = 0.24$$

In the equation above, Ud is the velocity of the dye, g is the gravitational force, and R is the radius of the droplet. Using basic assumptions, the dye was dropped at approximately.06 m/s into the water, and the diameter was about 1 cm, so, .6 cm was used. As gravity is pulling the ink down, the water in the cup is resisting the fall, creating this unique and beautiful instability.

The reflection seen in the image is created when the light hitting the water-air boundary must be at an angle that reflects light instead of refracting it, called the critical angle. To calculate this, Snell's las is used (seen below).

$$n_i \sin(\theta_C) = n_t \sin(90)$$

Where, ni is the index of refraction of water (1.333), nt is the index of refraction of air (1.00), and theta c is the critical angle. Using this equation, the critical angle is determined to be about 49 degrees. Ensuring that the critical angle is greater than this 49 degrees, indicates that the reflection of the ink drop would be captured.

PHOTOGRAPHIC TECHNIQUE

The camera used to capture this shot was a Nikon CoolPix P80 held at approximately a 60 degree angle, as can be seen in Figure 1. As can be seen in the data in Figure 3, a fairly large aperture was used f/3.5, giving the image a greater depth of field. This allowed for the depth of the instabilityes to be seen. The light source from the flashlight created an intensely bright spot, so I was able to use a fast shutter speed of 1/70th of a second, in order to prevent motion blur in the image.

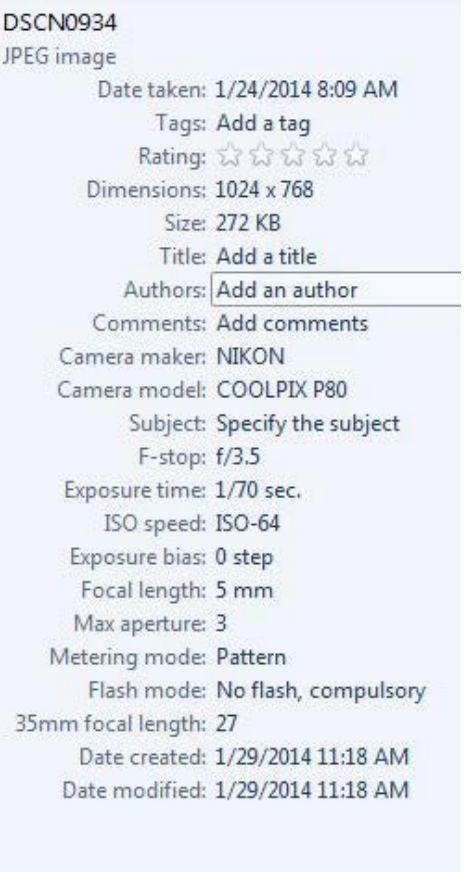

Figure 2: Photo data

IMAGE POST PROCESSING

In the final stages of this image creation, I did minimal edits using Adobe Photoshop. Using the Curves function, I essentially made the blacks blacker in the image, I wanted to remove the excessive background, so the image was also cropped slightly. I also de-colorized the image, thinking that it added to the simplicity and drama of the shot.

Figure 2: Left: Original image, Right: Final image

REFERENCES

1. http://www.astro.virginia.edu/VITA/ATHENA/rt.html