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MCEN 4151/ARTF5200

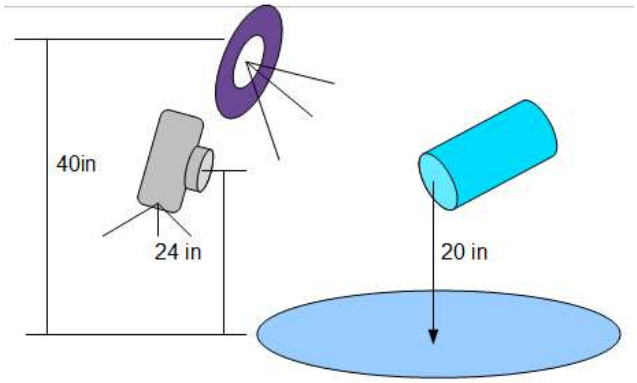
The image is a picture of laundry detergent being poured into a pan filled with water. It is the first individual image of the Flow Visualization course. The theme for the assignment was “get wet.” The image is intended to show an interesting fluid flow. The original intent of the image was to visual surface vortices or swirls on the surface of the water. The original idea did not work for several reasons. First, due to the use of a black light, the image needed a long shutter time to take successfully without significant noise, which meant that in a vortex there was significant blur in the image. There were also problems with the use of the detergent. It proved to be extremely difficult to stir the mixture without creating bubbles. When combined with the long shutter time the result was white streaks in the image combined with hazy images that were minimally visible at other points. The image instead was taken to show the diffusion effects of the detergent flow after it has been poured into the water. The image was taken with three different clouds of detergent visible, and each had been poured at a different time. The final cloud was captured at the moment of impact between the detergent flow and the water.

The flow that is seen in the image is created due to the effects of gravity and diffusion. By using laundry detergent, a substance that can mix with water, it is possible to see the diffusion into the surroundings. There are three flows visible in the image, each one originated roughly two seconds apart. The flow in the lower right is the image of the detergent striking the surface of the water, the flow in the upper is the second oldest image, and has been diffusing through the water for approximately two seconds. The fluid flow visible in the middle of the image is the oldest diffuse flow, and was initiated slightly less than four seconds prior to when the image was captured. Each flow that can be seen is roughly three to four inches in length. The flow diffused quickly after impact, due to the conversion of the potential energy into kinetic energy. The flow slowed after the initial impact, but continued to

diffuse at a steady rate, even well after the image had been taken. It eventually diffused into a relatively even mixture across the entirety of the pan. A calculation of the Reynold's number, assuming plate flow and using the properties of water with a slightly higher viscosity to account for the addition of the detergent in the mixture being poured shows that the flow along the edges of the diffusion flow is laminar as expected.

$$Re = \frac{\rho V D}{v} = \frac{(\frac{1kg}{L})(\frac{1in}{s})(2in)}{.00099(Pa\ s)} \approx 1300$$

The flow was created by pouring a detergent-water mixture out of a glass soda bottle. A diagram of the setup can be seen above. The mixture in the bottle was approximately 50% water and



50% detergent. The mix was used because it was discovered that using pure detergent did not provide a good visualization of the diffusion flow, as it would either form bubbles or sink to the base of the pan very quickly unless agitated. It was also discovered that a mixture should up brighter under the light. The process for creating the flow was simple. The bottle was filled with the mixture, which was then poured into the pan of water from a height of approximately twenty inches. The light source used to create the image was a single 60 watt black light in a desk lamp. No flash or other source of external light was used, and the image was taken in a room that was made as dark as possible in an attempt to maximize the contrast in the image.

The image was taken using a Canon SD1300 point and shoot camera. It was put in programmable mode, and the long shutter setting was used. The shutter speed was set to one second, and the camera was set to shoot six shots in continuous mode. The captured image was 4000x3000 pixels, and the camera records the image in JPEG format. The size of the field of view is approximately six inches across. The camera ISO setting was at 200. The f-stop was ¼. The camera was zoomed in slightly despite the image being shot close up, which allowed a focal length of nine millimeters. The aperture is not manually controllable on the camera; however it was recorded as being four in the image exif data. The distance from the lens of the camera to flow was around twenty four inches. The camera was placed farther back from the flow to prevent any fluid from splashing on it and then the desired image size was achieved by using the optical zoom.

The image shows the diffusion of two fluids of similar viscosity that are capable of mixing over a short period of time. The focus of the image is sharp, and the contrast and colors turned out as desired. The flow in the image is simpler than was desired, however the desired flow could not be adequately achieved, and the results of the flow used are clearly visible. By catching the stream as it contacted the water surface the image was given a sense of scale as well as time. It was suggested in several comments that the focus of the image should be the point of impact. Multiple attempts were made to capture the impact on film, however, in each attempt there was either too much blur, or poor focus, and timing the shot at the point proved difficult. In addition, because the detergent was poured by hand, the impact point moved slightly over the duration of the image capture and the desired effects were not clearly visible. In future images of this type it would be desirable to attempt to either capture the impact using different methods, or to revisit the idea of creating a vortex.