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Get wet Report
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MCEN 4151-001

This image results of the first project and is of smoke vapor becoming turbulent in air. This produces vortices and streaks in the smoke cloud. The intent of the image is to visualize smoke curling about itself. I originally used a soft light, a phone flashlight, to illuminate the underneath section of a smoke cloud; however, my images weren't as bright as I'd like them to be. I switched to trying to visualize different densities of fluid pipped into water with a flood light underneath the container. This setup gave me an idea to use glycerin-aerosol extruded from an e-cigarette device to visualize the flow of smoke going over a light source.

A smoke cloud was produced via vaping device and was "shot" over a water container that was illuminated underneath via flood light. As the smoke cloud arrived over the lip of the container, it started to become turbulent as it hit the lip. Turbulence is a motion of fluid that results from chaotic differences in flow velocity and pressure. With the pressure and flow speed adjusting from the interruption of the lipped container, this caused the cloud of smoke to curl undergo instability. The appropriate Reynolds numbers given some unit analysis are:

$$Re_1 = \frac{\rho V D}{\mu} = \frac{\left(1261\frac{kg}{m^3}\right)\left(0.25\frac{m}{s}\right)(0.0762\ m)}{(5.5\ Pa-s)} = 4.367$$

$$Re_2 = \frac{\rho V D}{\mu} = \frac{\left(1261\frac{kg}{m^3}\right)\left(0.25\frac{m}{s}\right)(0.254\ m)}{(5.5\ Pa-s)} = 14.55$$

Assuming:

- The cloud diameter leading up to the container is 3 inches.
- The cloud diameter once it hits the container is 10 inches.
- Estimating the flow speed to be ¼ m/s.

Re_1 represents the Reynolds number as the cloud is released from the start and is laminar in flow. Re_2 represents the Reynolds number as the cloud is hitting the lip of the container, it expands and becomes turbulent. Visualizing Re_2 to be 3 times larger than Re_1 explains the occurring flow patterns. My 6'4 roommate expelled the cloud at an angle of 2° down from the horizon using his own breath with roughly a 2-inch diameter mouth. With an assumption of ¼ m/s speed of flow, the Reynolds number is:

$$Re_3 = \frac{\rho V D}{\mu} = \frac{(1261\frac{kg}{m^3})(0.25\frac{m}{s})(0.0508\ m)}{(5.5\ Pa-s)} = 2.91$$

Below is an approximate diagram for the experiment setup:

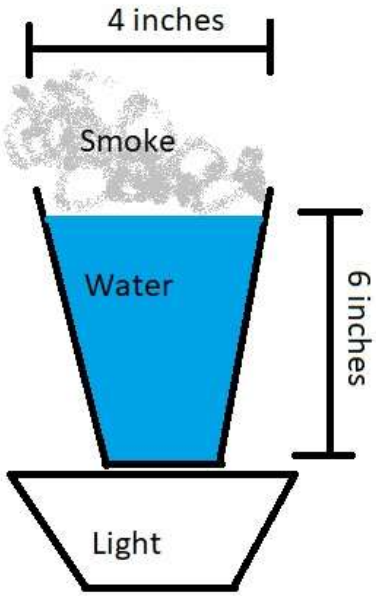

Figure 1: Physical experiment setup

The visualization technique used is was glycerin-aerosol dispensed through an e-cigarette device. The device was my roommate's e-cigarette and the juice used was sourced at Red Star Vapor. The experiment was setup in my kitchen with an overhead light as well as a flood light underneath the container. No flash was used to light any part of the setup.

The field of view of the image is 4 ½ x 4 in. with a 3 – 4 in. distance from smoke cloud to lens. The focal length is roughly estimated to be 5 inches so I could focus on the center of the circular rim of the container. I used a 18-55 mm lens on a digital Canon EOS-50D. My exposure specifications are 1/80 second shutter speed, 640 ISO, and f/29 aperture. For editing the image, I used Microsoft Paint to crop the image and resize it to the proper pixel width.

The image reveals a smoke vortex on the left side of the image with turbulent flow following it on the right side of the image. I enjoy the great lighting of the image; however, the attention of the eye is brought to the container rim. This rim is at an angle and could have been simply cropped out or the image could have simply been rotated. The fluid physics are shown well and the image clearly shows the curvature and vorticity of smoke as it encounters physical obstacles. My only question is: are there any better methods for creating a "crisper" photo in terms of changing my camera settings? I did fulfil my intent on capturing smoke as it travels over or through a light source. I'd like to improve on the picture taking and editing process. To develop this idea further, the experiment could be captured with a camera on a tripod to ensure there is no motion blur. I'd also like to get a large container to remove the boundary effects on the smoke cloud and set up physical barriers to closely inspect the movement of the smoke as it goes through or passes over various sized barriers. A different smoke color could also be interesting to contrast with if my background was a different color as well.