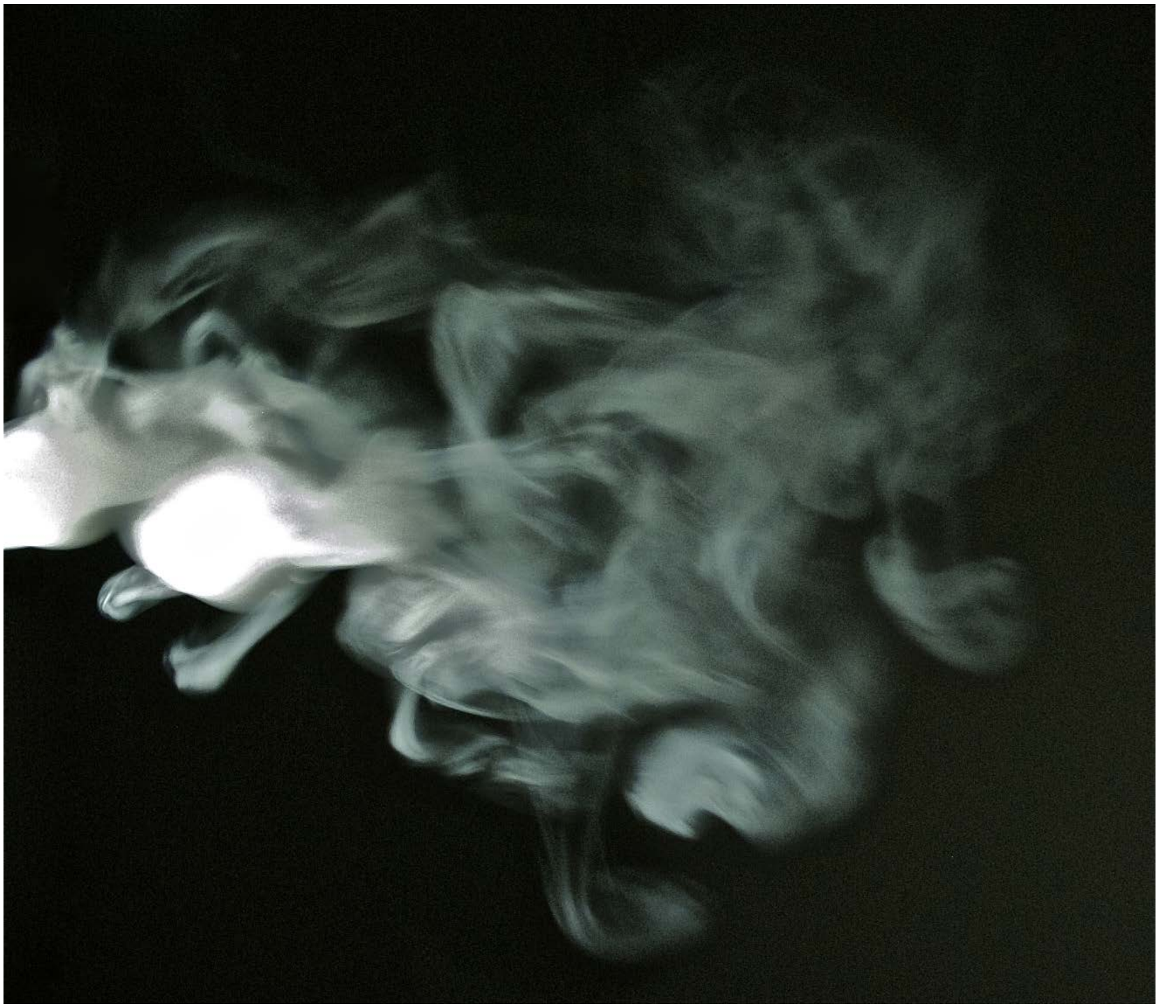

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MCEN 4151
May 1, 2014

Background

For the 3rd group image, the flow investigated is smoke. Smoke is a natural phenomenon that is very easy to create. The smoke in this photo was created from exhaling the smoke from an electronic cigarette. The smoke plume will be analyzed for type of flow, and any instabilities that could be caused by the buoyancy forces.

Flow Apparatus

A volunteer in a dark room inhaled from an electronic cigarette and then proceeded to exhale the smoke at a constant velocity. A light source from the bottom illuminated the smoke. The flow observed looked like a turbulent flow. A schematic of the setup can be seen below.

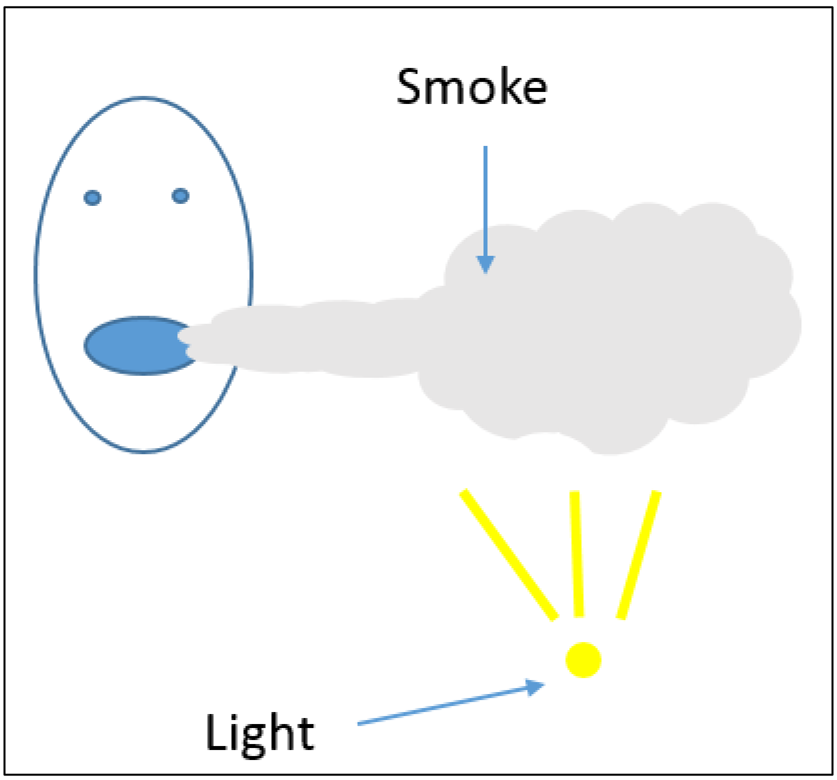

Figure 1. Shows the Experimental Setup

The smoke from an electronic cigarette is caused by an atomizer that vaporizes the electronic cigarette fluid. There is no combustion to produce the smoke. Therefore, the smoke is purely vapors. After the smoke is inhaled, the volunteer was then able to exhale smoke at body temperature. As the majority of the smoke consists of air, the average temperature of the smoke and room temperature can be used to compute the dynamic viscosity to calculate the non-dimensional Reynolds number. Body temperature is 98.6

°F and the room temperature is 68 °F, creating an average temperature of 83.3 °F. At 83.3 °F, the dynamic viscosity is 2.075 x 10^{-5} kg/m*s. The density of air in Colorado is 0.960 kg/m^3. The velocity of the smoke is exhaled at 0.5 m/s. The length of the plume is 0.75 m. The flow can be characterized by its Reynolds number:

$$Re = \frac{\rho V L}{\mu} = \frac{(0.960\frac{kg}{m^3})\left(0.5\frac{m}{s}\right)(0.75m)}{2.075 \times 10^{-5}\frac{kg}{m*s}} = 17{,}349$$

Where:

V = velocity
ρ = density
L = length
μ = viscosity

The Reynolds number 17,349 is much greater than 5000, indicating that the flow is fully turbulent. This confirms the initial prediction that the flow was turbulent.

The lighting used was used from the flashlight app of an iPhone 5. This was done to illuminate the smoke in white. The camera used was a Nikon D60 camera. To accommodate the low lighting an ISO of 1600 was used along with an aperture of f/3.5. To minimize the motion blur a shutter speed of 1/10 seconds. A Nikon D60 camera was used in conjunction with a Nikon DX 18-55 mm lens. The photographic specifications are listed in the table below.

Camera Type	Nikon D60
Focal Length	18 mm
Aperture	f/3.5
Exposure Time	1/10 seconds
ISO	1600
Distance of Object from Lens	8 inches
Image Size	2164 × 1878
Original Image Size	3872 × 2592

Post editing was done with iPhoto. The image was cropped to eliminate the volunteer to focus on the fluid physics of the smoke. The sharpness was increased to give the smoke better definition. The highlights were increased to make the smoke brighter. This helped give the smoke the body and depth needed to demonstrate all of the physics.

The 3rd team image reveals the turbulent behavior in a plume of smoke. I like how the image shows the chaotic characteristic seen in turbulent flows. Increasing the shadows helped create and brighten up the smoke while keeping the background black. I was hoping to see vortices from the Kelvin-Helmholtz instability but the flow might have turned turbulent before the smoke exited the volunteer's mouth. I wish I was able to capture the photo with better focus but I had a difficult time balancing shutter speed and ISO. Every time I tried to increase shutter speed, the plume was too dark to decipher the fluid physics. I would have liked to improve the lighting technique used. Using the flashlight app was not the best idea but I did not want to illuminate the whole room from a larger light source.

References:

"7 Things You Need to Know about Electronic Cigarettes | Al Jazeera America." *7 Things You Need to Know about Electronic Cigarettes | Al Jazeera America*. Web. 01 May 2014.

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