

Image Report 3  
Flow Visualization | CINE 4200  
Trevor Peterson | 12/3/21



### **Introduction:**

This is the third image for the class, and the image captures smoke coming from an incense stick in a dark room with lighting. The intent of the image was to capture both the aesthetic beauty of the smoke as well as the effect that turbulence in the surrounding environment has on the flow. Shown below is an image to summarize the set up in which the photo was captured.

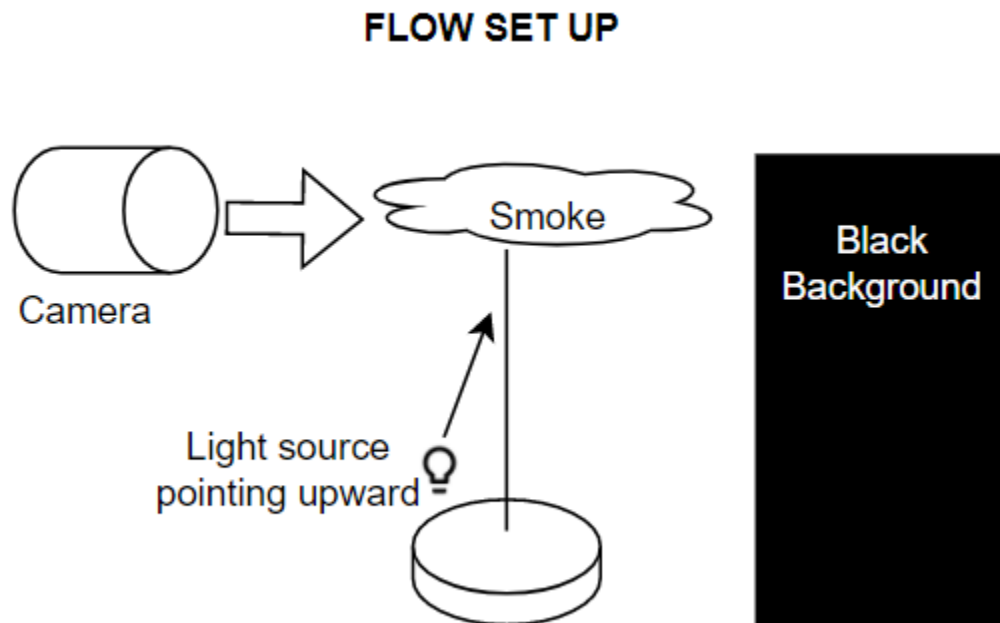


Figure 1. The set up for taking the image, with the incense stick continuously creating a stream of smoke for imaging.

### **Analysis:**

The flow was captured as shown in the image above, where the flow itself was continuously created from the incense stick burning. The flow itself is around 4 to 8 inches in length and rises steadily from the stick unless there is a disturbance in the surrounding air to invoke non-laminar flow phenomena.

After waiting for the smoke to rise steadily from the tip of the stick, then a small perturbation was created in the air roughly 3 inches from the stream with a ruler being pulled directly upward. This created a disturbance in the smoke stream which was subsequently captured with the camera. The original image below has been cropped for aesthetics in the final image above, but the totality of the stream provides more context to the fluid phenomena present.



Figure 2. Full unedited image of incense stick and smoke stream.

This image shows in detail how minute differences in air pressure can drive the path of the smoke flow. When the ruler is pulled upward next to the smoke stream, it pulls air away from its path behind, creating a pressure gradient with the lower pressure behind the ruler as it moves. It can be seen here that some of the smoke in the stream is curling backwards on itself due to these pressure gradients in the surrounding area driving the smoke into the lower pressure pockets in the ruler's old path.

The eddies created at the top of the smoke path are almost similar to the Kelvin-Helmholtz instability sometimes observed in clouds, where multiple eddies are formed in sequence with one another.



Figure 3. Clouds displaying Kelvin-Helmholtz instability by Paul Chartier<sup>1</sup>

**Technique:**

The incense stick used was a Satya Sandalwood incense stick, with a wooden cabinet painted black for the background. The stick was set to smoking with a handheld lighter with proper safety precautions. For lighting, the camera's flash was used, and the smoke was also bottom lit via an iPhone XR flashlight pointed directly upward. The camera was held steadily around 10 inches from the stream itself at approximately the height of the end of the incense stick.

For this project, a Canon Rebel SL2 was borrowed and used to capture the image. The camera was on manual focus for the image, as it had difficulty picking up the correct focal distance with the smoke and lighting conditions. The ISO was set relatively high at 3200 due to the flash being on, and f/5 was utilized to increase the depth of field as the smoke stream is not in a 2D plane relative to the lens of the camera. With a 1/60 shutter speed, there is little blur from the motion of the smoke as the image was captured, allowing for a crisper photo. The photo was originally 4096x2730 pixels before editing.

The photo had limited post processing, although adjusting the base curves of the image was explored. It was ultimately decided that the image should be cropped to highlight the crisper

parts of the flow, and that the saturation be turned slightly up to bring out a slightly more washed out blue color from the iPhone flashlight for aesthetics.

**Opinion:**

The goal of this image was to capture effectively a flow that was dynamic and challenged by knowledge of using DSLR cameras. This image did a great job of accomplishing these goals by forcing an in depth exploration of focal length adjustment, ISO, and f stop optimization to capture an image that was representative of the set up created.

In the future I'd love to explore utilizing color in the image somehow, either with some kind of colored powder coating the incense stick or different colored lighting/lasers to continue building on the image already created.

**Sources:**

1. "Kelvin-Helmholtz Clouds Look like Waves in the Sky: Earth." *EarthSky*, 25 May 2021, <https://earthsky.org/earth/kelvin-helmholtz-clouds/>.
2. Kundu, P. K., Cohen, I. M. "Fluid Dynamics", 4th Edition, Academic Press, 2008