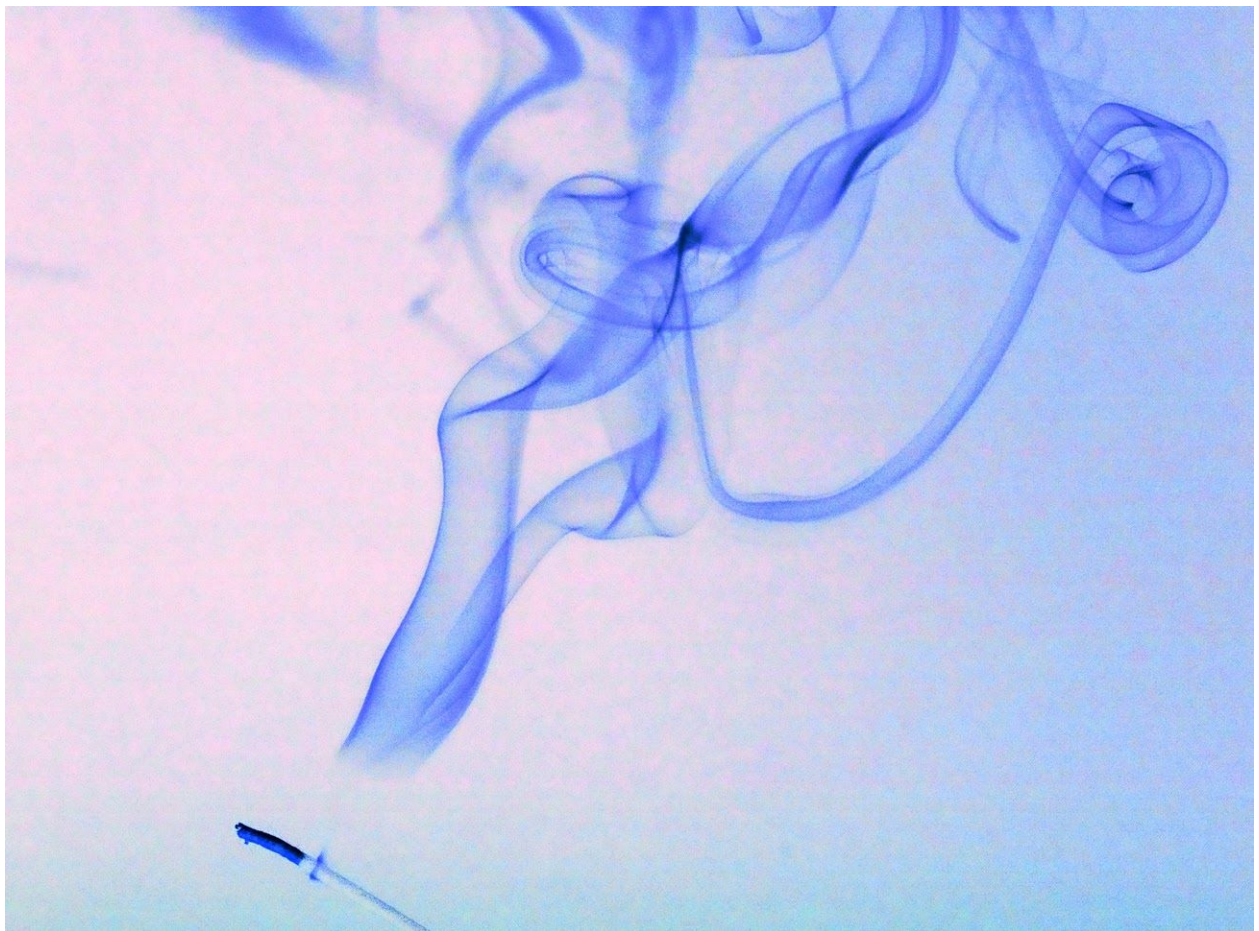


Max Kitay

ATLS 4151 - Flow Visualization

Image-Video #4

12/07/2020



This image was captured for the final assignment in ATLS 4151, Flow Visualization. The purpose of this assignment was utilize the knowledge we'd gained throughout the semester on flow visualization to capture an instance of fluid interaction to create a beautiful image as well as explain the physics occurring. My intent with the image was to capture the smoke flowing up through the air off the end of a burning incense stick.

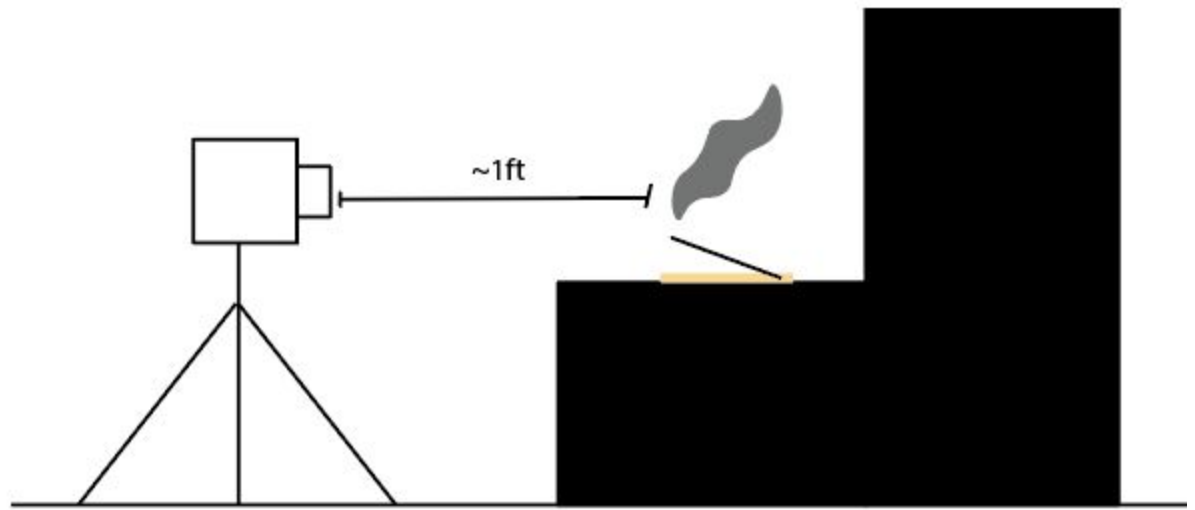
The main physics captured in this image involves the transition of the smoke plume from laminar to turbulent flow. Laminar flow occurs when fluids flow in parallel layers with no disruptions between layers.¹ Turbulent flow is characterized by chaotic property changes including variations in pressure and flow velocity. When the incense stick is ignited, burnt carbon particles, seen as smoke, begin to rise due to their lower density and higher temperature than the surrounding air.² The faster the smoke rises, the larger the temperature difference between the smoke and the air. As the smoke accelerates upward in a laminar fashion the velocity increases until a maximum velocity is reached and the flow turns turbulent. Within the turbulent section of the image a vortex can be seen on the right side where the fluid exhibits rotational motion around a centerpoint as smoke on the inside moves faster than the fluid on the outside.³

The visualization technique I used to capture this flow phenomena is the use of smoke. The smoke given off by the incense stick revealed patterns in the air not seen with the naked eye. The inversion of the colors in post production also helped to reveal the fluid flow more clearly. The lighting used in this setup was quite simple with just two 65 watt light bulbs pointed directly at the tip of the incense stick from the left side. The incense holder was placed about 1 foot from my camera tripod mounted straight ahead. The incense stick used was HEM brand's *Dragon Blood*.

¹ Laminar and turbulent flow. (2020). Retrieved December 03, 2020, from <https://www.vapourtec.com/flow-chemistry/laminar-turbulent/>

² Can, D. (2015). A buoyant incense smoke plume accelerates upward, triggering the Kelvin-Helmholtz instability. Retrieved December 03, 2020, from <https://www.flowvis.org/2015/09/07/a-buoyant-incense-smoke-plume-accelerates-upward-triggering-the-kelvin-helmholtz-instability/>

³ Nitsche, M. (2006). Vortex Dynamics. *Encyclopedia of Mathematical Physics*, 390-399. doi:10.1016/b0-12-512666-2/00254-6

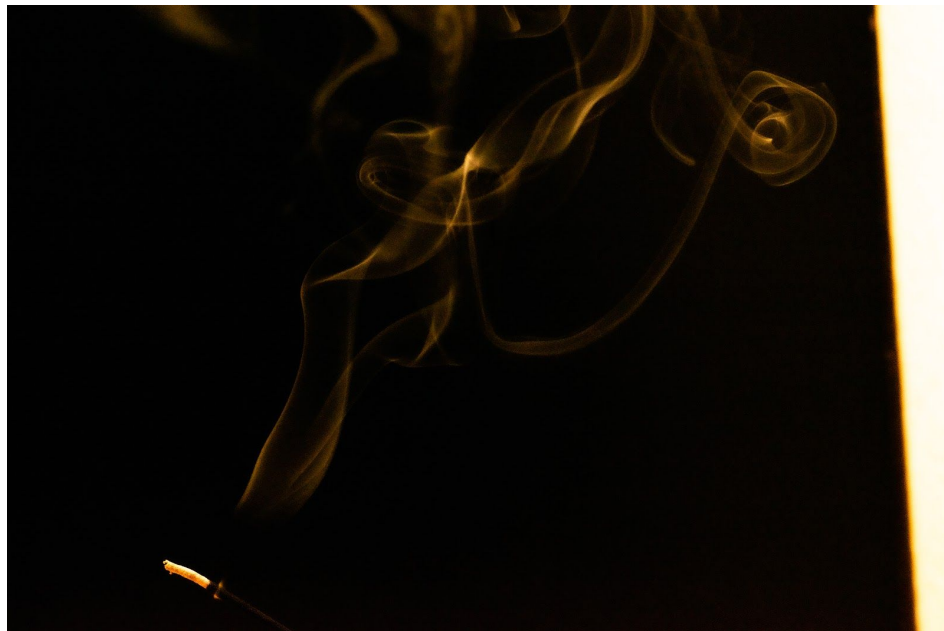


(Sketch of shot setup)

This shot was fairly difficult to capture as I wanted to minimize motion blur with relatively low lighting conditions and reduce noise as much as possible. Therefore I needed to keep my shutter speed fast but balance the ISO value to be able to pick up enough light. I settled on an ISO of 200, shutter speed of 1/250s, at an aperture of f/7.1. The shot was taken with a Nikon D3500 camera set on a tripod with an 18-55mm lens set at a focal length of 55mm. I wanted to frame the shot to capture the smoke just as it was leaving the incense stick as well as a few seconds following. The original image size was 6000 x 4000 pixels and the final cropped JPEG measured 1300 x 965 pixels. In post production I did quite a bit of editing within Adobe Lightroom Classic and Adobe Photoshop including greatly increasing the exposure and contrast, bringing up highlights and whites, as well as increasing overall clarity and texture. Within photoshop I inverted the colors to more clearly show the fluid flow.



(original image before editing)



(edited image before color inversion)

Overall, I am happy with the final outcome of this image however I believe a lot could be improved if I were to repeat this experiment. For one, I would use a bit more lighting to have a better idea of what I am shooting in the moment. As you can see in the pre-edited photo, the images I was capturing right out of the camera were essentially just black. Along with this I could also play around with slightly longer shutter speeds as I believe I can still stop the motion of the smoke with relatively low blur at a slightly slower shutter speed, allowing more light to enter the camera. I do

believe the fluid physics are demonstrated quite clearly in the inverted image and the flow is overall visually interesting to look at. This image reveals to me the complex movements of air happening around us all the time if we were only able to see it with our naked eyes. Fascinating!