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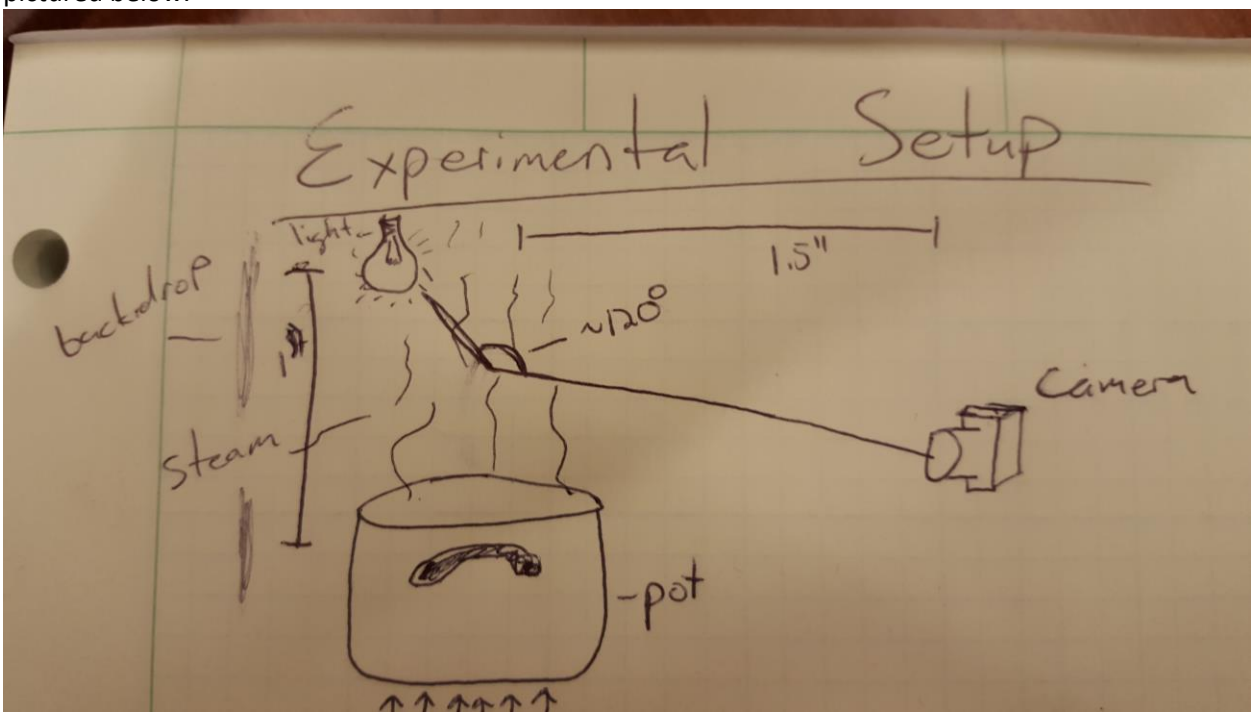
"Get Wet" Project
Flow Visualization
Fall 2015

Steam Rising from a Boiling Pot of Water

As the introductory project for this course, the "Get Wet" picture was left open to any fluid flow phenomenon that we wanted to photograph. My intention with my image was to capture the physics of an unstable microsystem in the air. In essence I wanted to capture how hot air rises in a room temperature environment. I tried photographing rising smoke from a cigarette as well as the hot air rising from the flame of a blowtorch. However, my favorite image came when I was able to capture the steam rising above a boiling pot of water. The oven light reflected off the smoke at an angle of about 120^{o} which really showed the physics of the rising smoke. In order to bring out some of the detail in the image I used the post-processing software GIMP to colorize the image to increase the contast in the density of the steam.

When the picture was taken the ambient temperature in the room was 69^{o}F as measured on the thermostat in the room. In Boulder, Colorado the boiling temperature of water is approximately 202^{o}F due to the elevation of the city [1]. As the water in the pot reaches boiling temperature it will not rise above that temperature because all of the added heat will be absorbed into the latent heat of vaporization and used to evaporate the water in the pot [2]. As the liquid turns into a vapor the volume expands by a factor of about 1600 [3]. The vapor released from the surface of the water in the pot is much hotter(202^{o}F) than the ambient temperature(69^{o}F) and tries to rise very quickly through the air. The water vapor is dense enough as it rises to scatter light that passes through it and so you see steam. The turbulence of the unstable air (hot vapor under ambient air) causes the steam to dance around and move very quickly. The goal of this image was to capture that phenomenon with a camera. The best way to view light scattered by steam is at a 120^{o} angle of reflection. The experimental setup of the image is pictured below.



This image was created by placed a large pot approximately 10 inches across on the burner of a stove. The pot was filled to about ¼ of its volume with water and brought to a boil on the highest setting of the stove. Ambient temperature was 69°F, and an averagely dry September day in Colorado. Yellow gridded paper was hung behind the steam as a backdrop. No flash was used in the image, the only light source was the oven light above the stove. This light reflected off of the rising steam and was captured by the camera approximately 1.5 ft from the pot in a horizontal direction. It should be noted that in future attempts of this type of photography I would recommend using a darker backdrop to try to achieve higher contrast in the steam.

The image was created with a Nikon Coolpix P520 digital camera. Shutter speed was controlled to be 1/250 of a second. The goal here was to capture the image with as little motion blur as possible but still capture enough light for the image. Aperture was set to f/3.7 and the ISO at 1600. The distance from the subject of the photo (the steam) and the lens was approximately 2.2ft, and the focal length was 10mm. The field of view of the image was about 3ft by 2ft, much larger than the eventual cropped image. Main subject was approximately ¾ of a foot across. The wider field of view was used to capture the whole situation and then I zoomed in on the really valuable physics. Post processing was performed in GIMP. Besides cropping the image, black/white contrast levels were adjusted linearly to darken the background and intensify the steam. After that manipulation was performed I adjusted the RGB color channels individually in a non-linear fashion. In the brightest pixels (the densest steam) I brought out the blues and hid the greens and reds. In the darkest pixels (the background) I brought out the reds. In the middle range I brought out the green. I believe that this post processing did a good job of showing the physics of the steam, even if there is some noise that resulted from the color altering.

The image does a good job of capturing a rising pocket of hot steam as it travels upwards. I like how in that small section of the image, the physics come through really clearly where the steam dances in front of the oven light. If I was to attempt this image again I would try to think of ways to really isolate that information and maybe change the brightness/size of the bulb above the stove so as to make the light more intense. The post-processing really makes it an aesthetically interesting image, but also sacrifice some of the smaller details in the image for a greater sense of overall understanding. I believe that my initial intent was fulfilled, and I am excited to try to capture more of these gaseous systems with my improved knowledge of how to go about doing it.

References

[1] "Boiling Points of Water at Various Elevations." Accessed October 2, 2015. http://www.engineeringtoolbox.com/boiling-points-water-altitude-d_1344.html.

[2] "SteamNotes - SteamNotes.pdf." Accessed October 2, 2015. http://geosci.uchicago.edu/~moyer/GEOS24705/Notes/SteamNotes.pdf.

[3] "Water to Steam." Accessed October 2, 2015. https://www.physicsforums.com/threads/water-to-steam.209842/.