# Fall 2023 Get Wet

MCEN 4151

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The image you see before you display a “chunk” of dry ice on the pavement behind the Aerospace building on east campus. Purchased at Safeway for $1.25 a pound, it was truly a deal. The dry ice itself has minimal visible vapors. This was most likely a result of the properties of dry ice. Dry ice is frozen carbon dioxide and given carbon dioxide is a gas at the nominal outside temp of 68ºF it moved quickly from frozen to gaseous state. There was little time for the carbon dioxide to condense and for visible vapor to form. To remedy this Kenny and Kush poured water on the dry ice which condensed quickly. The water is the vapors that you see in the picture, evident by the wet concrete you can see around the dry ice.

Exploring the beauty of fluids is not the only purpose of this photo. The fundamental fluid science at play can be witnessed as art and science. In this image you can see the condensation of water around the dry ice because of the decrease in the localized dew point. Just as fog forming in the morning due to the heating of the air and its interaction with cold ground. We observe the same phenomena with the dry ice lowering the dew point of the localized area and producing fog from the water in the air. The water vapor shows a Rayleigh-Taylor instability as its density causes instability with the less dense dry air. The best nondimensional characteristic to describe this flow can be found in the Gashof number.

$$Gr_L = \frac{g\beta(T_s - T_\infty)L^3}{v^2}$$

$$Gr_L = \frac{9.81 * \frac{1}{20}((-7\ \ .5℃ - 2\ \ ℃)0.1^3}{(1.48 * 10^{-5})^2} = 2.205 * 10^8$$

The Grashof number was between $10^8$ and $10^9$ showing a transitional flow[1], tending toward a laminar flow. This is consistent with what we see in the photo, with a lack of vortices and defining factors of turbulent flow. The temperatures used correspond to the freezing point of CO2 $-78.5℃$ and the outside air temp of $\sim 20℃$ . The characteristic length of 10cm was about the size of the piece of dry ice. The kinematic viscosity used was that of air at $15℃$.

The camera setup was entirely manual. The lighting effect seen within the image was a result of trying to diffuse the flash of the camera with my hand. The process of taking photos was conducted in the evening as the sun had started to set. Quickly it became clear that the lack of light was a problem. Many of the other photos came out blurry or under exposed. An over exposure of light would have made the vapors hardly visible. The settings sues are described in the table below:

| Setting / Specification | |
|---|---|
| Camera | Canon EOS REBEL T3 |
| Lens | 28-200mm Lens |
| Focal length | 28.0mm |
| Aperture | 4.0 |
| Exposure | 1/60 |
| ISO | 800 |

Table 1. Camera Settings

Photoshop was used to sharpen the image. The original image can be seen bellow:

Looking back, I prefer the unedited image. At the time the lighting seemed too intense and the image too blurry. However, I seem to have added a weird hue to the boundary between the light and the shadow that the image would have been better off without. Having worked with my group I could certainly improve the lighting of the image.

References:

[1] C.J. Sanders, J.P. Holman, Franz Grashof and the Grashof number, International Journal of Heat and Mass Transfer, Volume 15, Issue 3,1972, Pages 562-563, ISSN 0017-9310, https://doi.org/10.1016/0017-9310(72)90220-7.

(https://www.sciencedirect.com/science/article/pii/0017931072902207)