**Team Third**

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## I. Context and Purpose

This whole semester, I have been longing to capture the motion of flow in a time-lapse fashion. After a snow storm yielding nearly two feet of snow in Boulder, the weather warmed up and our surroundings transformed from thick blankets of snow, to life emerging from beneath a wet, icy, drippy environment. I saw this as the perfect opportunity to capture the changes our surroundings quickly undergo as climate fluxes in winter. The purpose of this image was to visualize even the minute detail in something that seems so *normal* to us: ice. However, within a single image, several fascinating minutiae emerge surrounding something typically seen as mundane.

## II. Description of Physical Phenomena

On a sunny afternoon on December 1st, I went out onto my back porch to examine the ice forming beneath the thick layer of snow leftover from the huge snowstorm the previous week. I immediately noticed the scallops, pockets, and dimples in the surface of the ice. To help visualize these better, I mixed blue food coloring with water, and after carefully removing the ice from the deck railing, I held the ice up to the clean blue backdrop of the sky and let the water run down the bumpy surface of ice.

Several interesting flow phenomena emerge from this image. First, the scallops in the ice, literally called ‘ice scallops’, are caused by the interface between ice and water. As the snow on top of the ice melts and creates liquid water, this ice scalloping occurs. As the water from above drips onto the ice, it is turbulent flow. This results in different melting rates of the ice underneath the water drops and thus the ablation of the ice. This scalloping affect can also occur at the interface between ice and flowing water and between ice and air.

Secondly, the second flow phenomena visualized here is the Raleigh-Plateau instability, as shown in the dripping of water, that causes the water drip to narrow, create a neck, and pinch off. Both the surface tension caused by the polar molecules of water combined with gravity, driving these bonds apart at a critical length, creates the Raleigh-Plateau instability. The surface tension of the water tends to drive the fluid to minimize the surface area as much as possible. Because of this, as the weight of the water pulls it downwards, the surface tension attempts to create the smallest surface area possible by necking and eventually splitting a droplet off from the rest of the volume of water.

## III. Visualization and Lighting

The lighting for this project was simple. I held the ice up, utilizing the natural light from the late afternoon. The sun was shielded by many buildings, but the ambient light was quite bright. It was easy to see the ice scallops by holding the transparent ice to a well-lit, neutral background. I let drops of blue-colored water fill the ice scallops and drip down the vertical surface of the ice as a means of highlighting the details in the ice and showing the Raleigh-Plateau instability.

## IV. Photographic Technique

Using my Canon Powershot S5 IS, I managed to capture three different images from three different drips to create one final image, showing the time-lapse between the different stages of drip. With my camera set with an F-stop of f/5, and exposure time of 1/400 second, a 6mm focal length, and an aperture of 2.875, I captured my final images. All three of my final images were 3264 by 2448 pixels.

For post processing, I simply cropped and resized every image so that the ice was the exact same size and could align perfectly. I then overlaid all three images and used a healing brush to take out the building in the back of the image. I only applied a slight increase in brightness and contrast because by overlaying the three images, a natural ombre and deep blue color were achieved. Shown below are my three original images and my final image.

## V. Final Thoughts and Future Improvements

I really enjoyed capturing this image because I had a vision for what I wanted, and I truly feel like I accomplished what I set out to do. I also learned a lot more than expected in the process about a few different flow phenomena that I didn't expect to discover. In the future, it would be really fascinating to redo this experiment with more steps in the drip to try to capture the sinusoidal perturbations in the drip due to Raleigh-Plateau.

## VI. References


[1] Bushnuk M, Holland D, Stanton T, Stern A, Gray C (2019) “Ice Scallops: A Laboratory Investigation of the Ice-Water Interface”, https://www.gfdl.noaa.gov/wp-content/uploads/2019/05/Bushuk_JFM2019.pdf

[2] John W. M. Bush (May 2004). "MIT Lecture Notes on Surface Tension, lecture 5," http://web.mit.edu/1.63/www/Lec-notes/Surfacetension/Lecture5.pdf