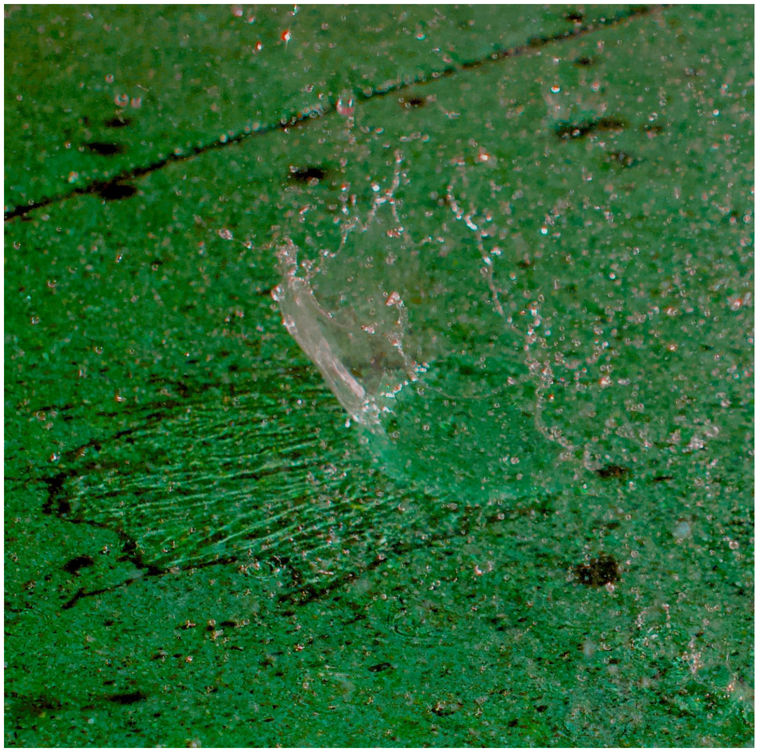
Team Third Report: Water Drop Impact



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MCEN 4151: Flow Visualization
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This photograph was taken for an assignment in the course *Flow Visualization* at the University of Colorado Boulder during the 2023 fall semester. The purpose of this assignment was to experiment with a particular fluid phenomenon and capture the image using manual photograph techniques to get an image that captures it well. The ultimate goal of this photoshoot was to display the “impact crater” created by a water drop hitting a solid surface. The author has had previous interest in how solid objects break upon impact. From this previous interest, it was decided to photograph how liquids change their shape after dynamic impact. After a day of snow, the author walked around the campus of the University of Colorado Boulder seeking motivation. Snow had been melting on the tile roof of the south side of the Duane Physics Building, causing a stream to pour onto the sidewalk (figure 1).

Figure 1: The location of the photoshoot

As mentioned in the previous paragraph, the flow apparatus for this assignment was the angled roof of the south side of the Duane Physics Building with curved tiles and metal channels at the end section of the roof that diverted the water to flow through in specific streams. After the water formed into the streams, there was an approximately 12 foot drop from the end of the roof tiles to the concrete below (figure 2).

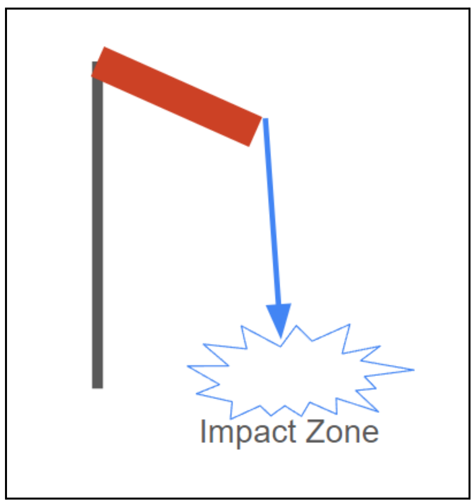

Figure 2: Diagram of Water Flow

The streams made contact with the pavement and water splashed upwards, with a fine mist being created after the impact of the water drops. The effect specifically seen in the image is produced by the crowning effect that takes place when a water drop impacts a surface. After this occurs, the natural next step is for the water to spread out into a thin film. The thin film is called a lamella. The lamella grows in the vertical direction and outwards until it reaches a maximum height. In some cases, the droplet can recover its spherical shape and bounce off of the solid surface. Splashing occurs when the weber number exceeds a critical value and the rim of the lamella breaks off from the surface (Rein). The weber number is the ratio between the fluid's inertial forces and its surface tension (Munson et al.). That being said, the impact is controlled by the liquid inertia and surface tension. Additionally, the viscosity plays an important part of the lamella, dictating the speed at which it moves.

To capture the photograph, the author was crouched down about 0.6 meters (approximately 2 feet) away from the drop impact. The camera was held by hand and the photos were taken in rapid-fire succession. The picture was taken at 1:22 pm on October 30th, 2023. There were not many clouds in the sky that day, so the sun was relatively bright. No additional lighting was used besides the sunlight. The picture was taken with a Canon EOS 40D. The following camera settings were used:

- 41 mm lens setting on a 30-50 mm adjustable lens.
- ISO: 800
- f/4
- Shutter speed: 1/8000s

These settings were chosen through trial and error based on how well the droplet impact was highlighted with respect to the picture's lighting, contrast, and saturation. The image was manipulated through the program *Darktable*. The image was also cropped through the program. The following adjustments were made:

Local Contrast

- Detail: 106%
- Highlights 87%
- Shadows: 72%
- Midtone range: 0.331

Color Balance RGB

- Hue shift: +85.87 (which provided the color change).
- Global vibrance: -10.55%
- Contrast: -17.89%

<u>Linear Chroma Grading</u>

- Global chroma: +24.77%
- Shadows: +32.11%
- Highlights: +37.61%

<u>Perceptual Saturation Grading</u>

- Global Saturation: +35.78%
- Shadows: +17.35%
- Mid-tones: +27.52%
- Highlights: -38.53%

<u>Perceptual Brilliance Grading</u>

- Shadows: +17.43%

Exposure

- Exposure: -0.206 EV
- Black level correctness: +0.0321

Rotate or Distort Image

- Rotation: -10.00°

The effects these adjustments made to the original image can be compared to figure 3.

Figure 3: Unedited Image

This image reveals a water droplet impacting a solid surface. The fluid physics are shown at a moderate amount, with a decent display of the lamella that develops after collision. A tripod would help to stabilize the camera while the picture was being taken, but other techniques regarding camera stability would be useful to know. It would also be interesting to know more about how the roughness of the sidewalk influenced the different parts in which the lamella developed. The intent of this project was fulfilled, however to improve in the next iteration, the water drops would be dispersed in a controlled environment and a plastic sheet would be used to guard the camera lens from the bounce back of water drops that was occurring, which made it more difficult to take the image. Also in the next iteration, the background would be neutral and the lighting source would be aimed toward the water lamella to further enhance the effect of the splash.

References

Munson B. R. Gerhart P. M. Gerhart A. L. Hochstein J. I. Young D. F. & Okiishi T. H. (2016). *Munson Young and Okiishi's Fundamentals of Fluid Mechanics* (Eighth). Wiley.

Rein, M. (1995). Wave Phenomena During Droplet Impact. In: Morioka, S., Van Wijngaarden, L. (eds) IUTAM Symposium on Waves in Liquid/Gas and Liquid/Vapour Two-Phase Systems. Fluid Mechanics and its Applications, vol 31. Springer, Dordrecht. https://doi-org.colorado.idm.oclc.org/10.1007/978-94-011-0057-1_14

Rozhkov A., Prunet-Foch B. and Vignes-Adler M. (2004). Dynamics of a liquid lamella resulting from the impact of a water drop on a small target. Proc. R. Soc. Lond. A. 460: 2681-2704. http://doi.org/10.1098/rspa.2004.1293