University of Colorado - Boulder

MCEN 5151 - Flow Visualization

Image 1 Report

Leaf Droplet Surface Tension

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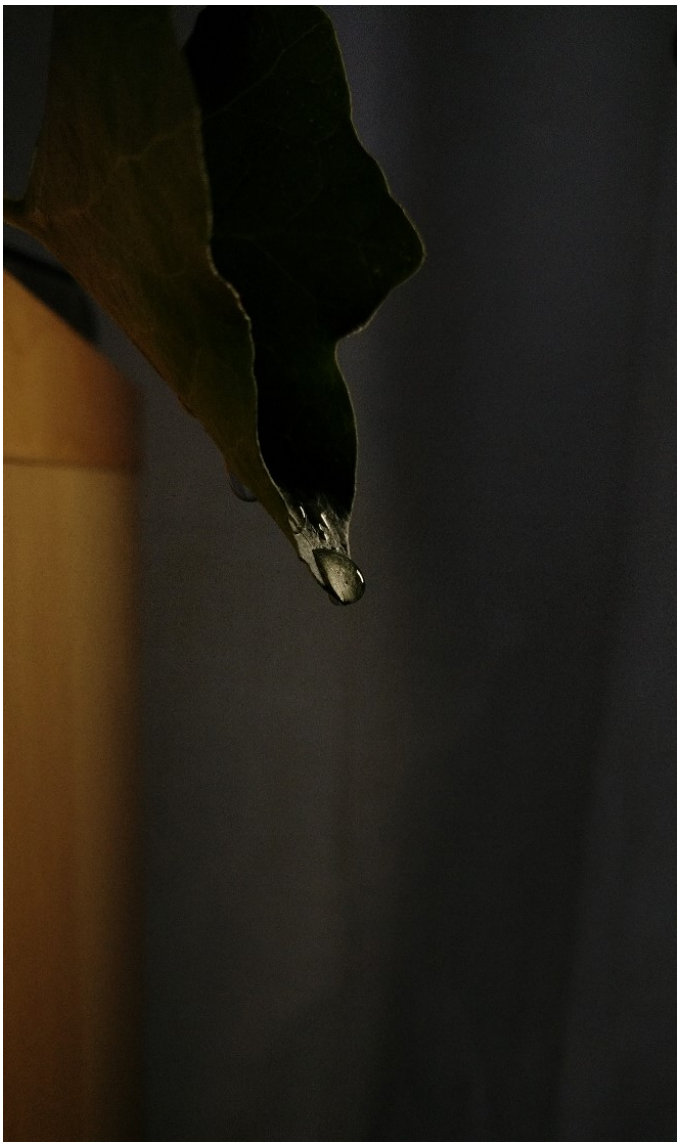

I. Introduction

The purpose of this picture is to explore photography as a means of capturing interesting fluid phenomena. In this case, the fluid phenomena is simply the surface tension holding a water droplet on the edge of a leaf. Its a fairly common photo, which was why I wanted to attempt it and see how difficult it would be to get a nice image. The following report showcases the experimental setup and procedure, discusses the flow phenomena, and outlines the photographic techniques used to obtain the final image.

II. Experimental Setup and Procedure

The setup for this photo was quite basic. I found a leaf with a naturally concave shape, dribbled some water onto it and placed it in the fashion shown in Fig. 1. The leaf stem was weighted down on top of the desk, which left the leaf hanging off the side. It is important to note that the water was not flowing as the picture was taken, rather, I dribbled water until I got droplets I was satisfied with, and then snapped the picture.

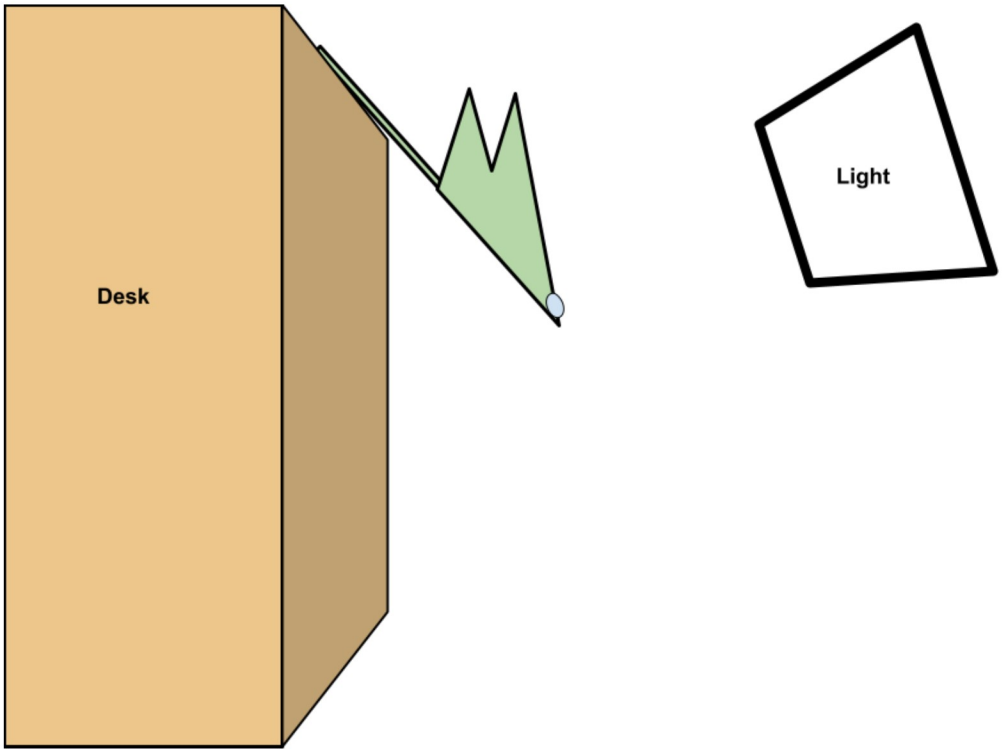

Fig. 1 Diagram of Setup

The most important part of this experimental setup was the placement and angle of the light. The light was placed roughly half a foot to the right of the leaf at an extremely steep angle with regards to the edges of the leaf. This made the back edge of the leaf cast a deep shadow on everything except the droplet in focus. The camera was placed flush against the side of the desk as a support, and level with the leaf (no tripod was used).

III. Flow Discussion

Surface tension is the flow phenomena in question. More specifically, the cohesion and adhesion of water between itself and the leaf. Cohesion is the attraction of the same molecules between themselves (water to water), and adhesion is the attraction between different molecules (water to leaf and water to air) [1].

A more detailed yet straightforward explanation was found from a recent article by M.V. Berry. In summary, the phenomena of surface tension can be split into two forces, the inward attraction on surface molecules and the tension parallel to the surface. In the bulk liquid (the center of the drop in this case), any given water molecule is attracted on all sides to other water molecules, which holds it in place. This is not the case at the surface, where the attraction is directed inwards. There is then a dynamic equilibrium between the attraction of molecules directed inwards and the repulsion of the surface molecule's immediate neighbors [2]. As for the tension parallel to the surface, Berry states,"The basic idea is that the component of fluid pressure directed parallel to the surface (we shall use the term 'pressure' loosely, to denote the normal component of the stress tensor) decreases and becomes negative - that is turns into tension - in the region near the liquid surface." [2].

IV. Photography Technique

Surprisingly, this image was simply taken with a smartphone camera, although manual adjustments were taken within the "pro mode" in order to change ISO, aperture, and get a sharper focus. The ISO was lowered in order to reduce as much noise as possible, and shutter speed was adjusted as necessary in order to accommodate for the darkness of the image. This resulted in the sharpest image possible considering the sensor that was used. The specific camera settings are listed below:

- Camera: 16 MP Sony IMX 298 sensor (OnePlus 3)

- Aperture: f/2
- Focal Length: 4.26mm
- ISO: 250
- Shutter Speed: 1/640s
- Original Size: 3480 x 4640p

Darktable was the program used for post-processing of the image, however, few edits were actually made. Aside from cropping, changes from the original include slight adjustments to the blackpoint, contrast, and highlights. The Appendix includes the original image for reference.

V. Conclusion

All things considered, I am extremely pleased with the results of this photo. I was not expecting to get such a crisp, high contrast, low noise image from just my 6 year old phone camera (which may be the reason why this type of photo is so commonly seen). It also showcases the desired phenomena (surface tension) exceptionally well. Unfortunately, because of the camera that was used, the quality of the image is not great, and if I were to recreate this image I would definitely use a better camera.

References

[1] "Adhesion and Cohesion of Water," 2021. URL https://www.usgs.gov/special-topic/water-science-school/science/adhesion-and-cohesion-water?qt-science_center_objects=0#qt-science_center_objects.

[2] Berry, M. V., "The molecular mechanism of surface tension," 2013. URL https://michaelberryphysics.files.wordpress.com/2013/07/berry018.pdf.

VI. Appendix

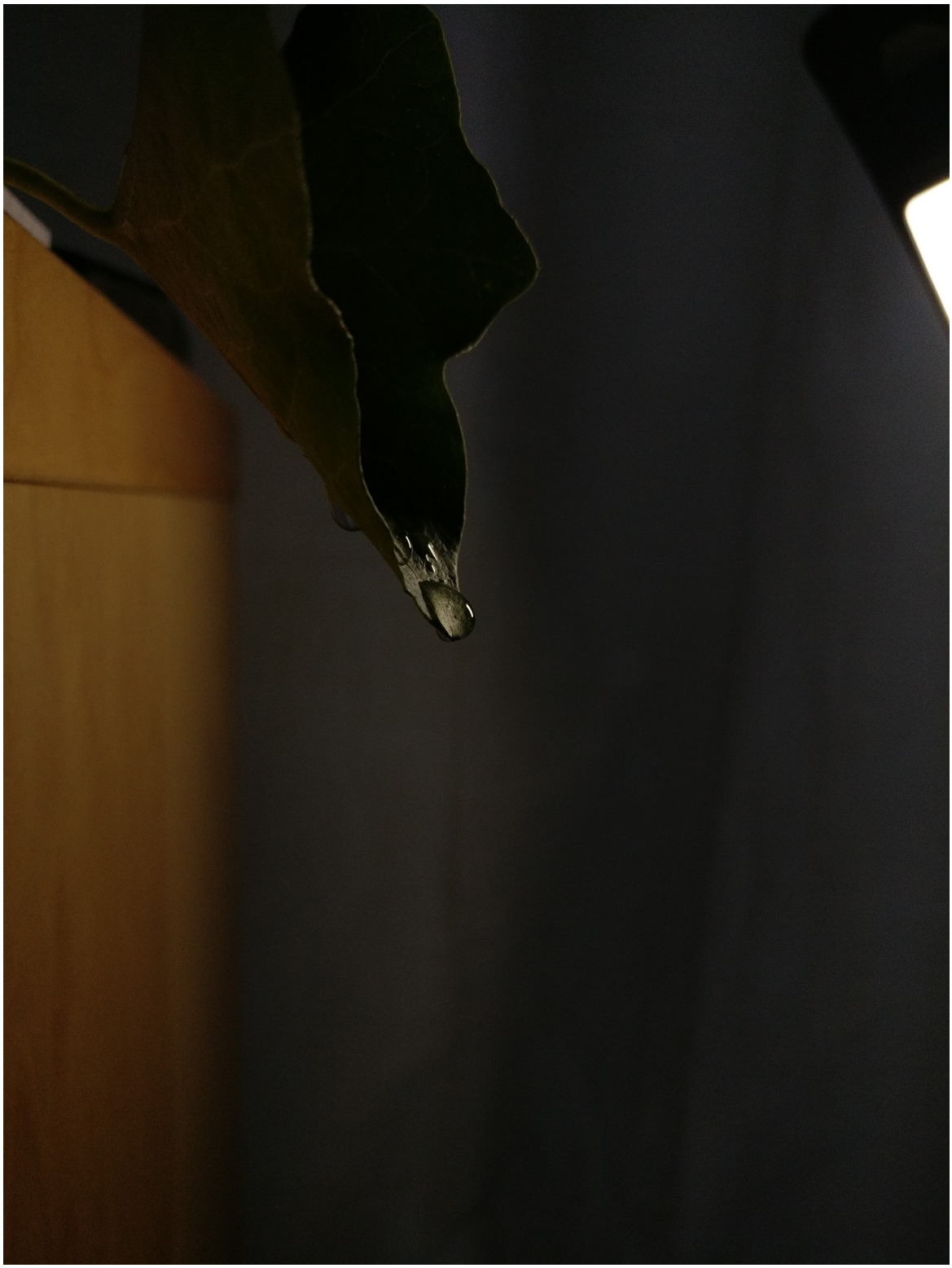

Fig. 2 Original Unedited Image