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IV1
MCEN5454
9/26/2022

1st Paragraph:
For IV 1, I chose to document the change in surface tension with a fluid much more viscous than water. Specifically, I chose a type of soy glaze with an assumed viscosity similar to honey. Initially, I was hoping to achieve a matrix of drip patterns with the apparatus for this project. Unfortunately, the fluid was too viscous and instead of dropping evenly off of the metal rack, they caught the apparatus and formed large droplets. In addition to documenting this flow phenomena, I also wanted to make an aesthetic statement with my project. I was hoping to produce a photograph that could show surface tension, with a stark, geometric composition. Also, I knew from the conception of this idea that I was going to edit the image from color to black and white in post-production, so it made sense to use the soy glaze as opposed to honey to achieve higher contrast. I worked on this project independently, but received help lifting and lowering the apparatus from my friend Easton Gloyd.

2nd Paragraph:
The apparatus for this experiment was rudimentary. A diagram, with corresponding components is available for reference below (see Figure 2). An undertray held a reservoir of the excess viscous fluid on the tabletop where I conducted the experiment. A wire rack was then submerged into the undertray, until completely saturated. In order to lift the rack out evenly, so I could get a clean shot of the underside of the matrix, I tied four strings to the corners of the wire rack. As the saturated rack was pulled out of the excess fluid, it dumped a large volume of the working fluid, and ultimately large droplets formed at the intersections of the wires on the rack. The anatomy of this process is shown in Figure 1 and Figure 2.

In order to get voluminous droplets on the wire matrix, I allowed the rack to shed excess fluid into the undertray. This took about 5 seconds per photograph. Therefore, technically the fluid, and the phenomenon I was documenting, was reliant on a lack of movement. Because the fluid phenomenon does not involve flow, I will first introduce some physical properties of honey, a comparable fluid, in Table 1 in air (Tyowua et al. 2021) (Mambang et al. 2019).

Property	Value	Unit
Diameter of droplet	3 ± 1	mm
Apparent Contact Angle	92 ± 5	deg
Hydrostatic pressure of honey*	20 ± 5	Pa

*This value is calculated based on a given kinematic viscosity of honey: 4000 mPa * s. The internal pressure can be calculated based on the assumption that the droplets sat stagnant for 5 seconds, and we therefore assign an uncertainty of 5 Pa (1 second).

After introducing these physical properties, we can calculate the actual surface tension using a simplified version of LaPlace's Law (Surface Tension). For this equation, we assume the tension due to air on the droplet is negligible.

$$F_{tension} = \frac{P_{fluid} * r_{drop}}{4} = 10\,\frac{mN}{m}$$

Lastly, because there is no fluid flow, there is no Reynold's number.

3rd Paragraph:

The method used for this project was mostly static. I was documenting surface tension, which is well-suited for visualization without any movement. There was no dilution of the working fluid, nor injection speed. In fact, the fluid was so viscous that the initial desired effect, a series of localized droplets, was not achieved.

I aimed to achieve an even lighting background so I could use a quick shutter speed, but also wanted to include a bright pointed light source to reflect off the individual dark droplets. In order to achieve this effect, I employed a 25 W bright white LED bulb as the pointed source. It was oriented above the field of view. Then, in order to evenly distribute light in the shot, I angled a matte white poster board to reflect light onto the field of view. This entire configuration can be seen in Figure 1.

4th Paragraph

I used a Canon 7D, Mark 1 for this visualization experiment. This camera is a digital single-lens reflex (DSLR) camera. This means that photos are captured through an aperture and sensor. The light emitted to the sensor is controlled by the camera's shutter speed, as well as the lens aperture. In addition to my camera, the photographic setup had the following parameters: an EF 18-135 mm zoom lens, with an f/3.5-5.6 aperture range. Specifically for my submission, my camera was zoomed at 42 mm, with an f/5.6 aperture, a 1/60" shutter speed, and an ISO of 2500. I shot in the high-fidelity RAW photo format, with a final resolution of 3888 x 2592 pixels. I then cropped the photo to 3888 x 1359 pixels in order to better frame the fluid, and omit the apparatus' strings from the shot. In post-production I processed the image in black and white in Photoshop. Lastly, I increased the highlights, in order to emphasize the bright glint in the very dark fluid. The field of view around was 18" x 24", and the fluid was photographed approximately 4 inches from the end of the lens.

5th Paragraph:

This experiment clearly shows the ability for highly viscous fluids to create a matrix of different droplet sizes due to high surface tension. A higher viscosity and surface tension means the fluid is highly workable, and for an application like this, easier to manipulate. From an aesthetic standpoint, I also feel this experiment was a success. The composition of the shot shows a good sample matrix of different droplet sizes. Additionally, the crop and black and white edit in post-processing framed the shot such that the droplets really become the focal point of the photograph. If iterating this experiment, I would push the droplet sizes even further, and attempt to compare them visually in a line instead of a matrix. Employing a series of increasingly large honey dippers, for instance, would show larger and larger surface tension effects. Overall, I feel this undertaking was both visually and experimentally successful.

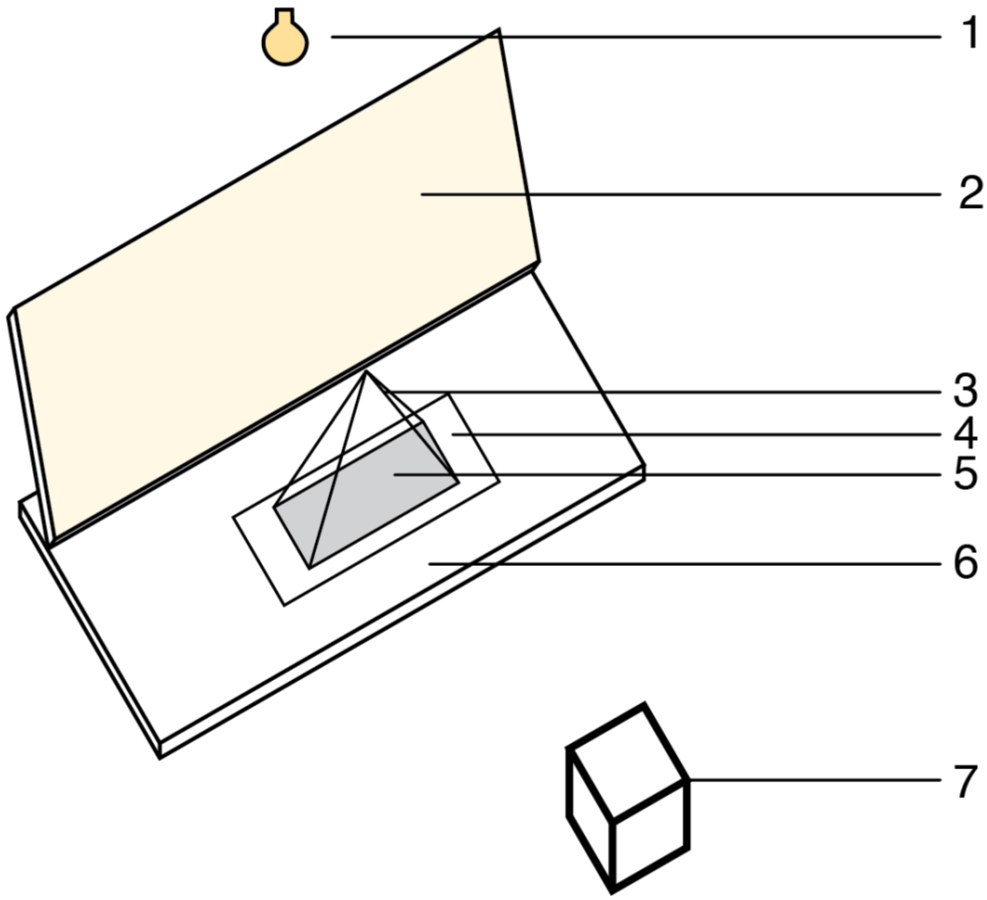

Figure 1: Apparatus in field of view

1	25 W LED point light source
2	Matte white poster board to diffuse light
3	Strings attached to the wire rack
4	Undertray to hold excess fluid
5	Wire rack, lifted in and out of undertray
6	Table upon which the experiment occurred
7	Camera

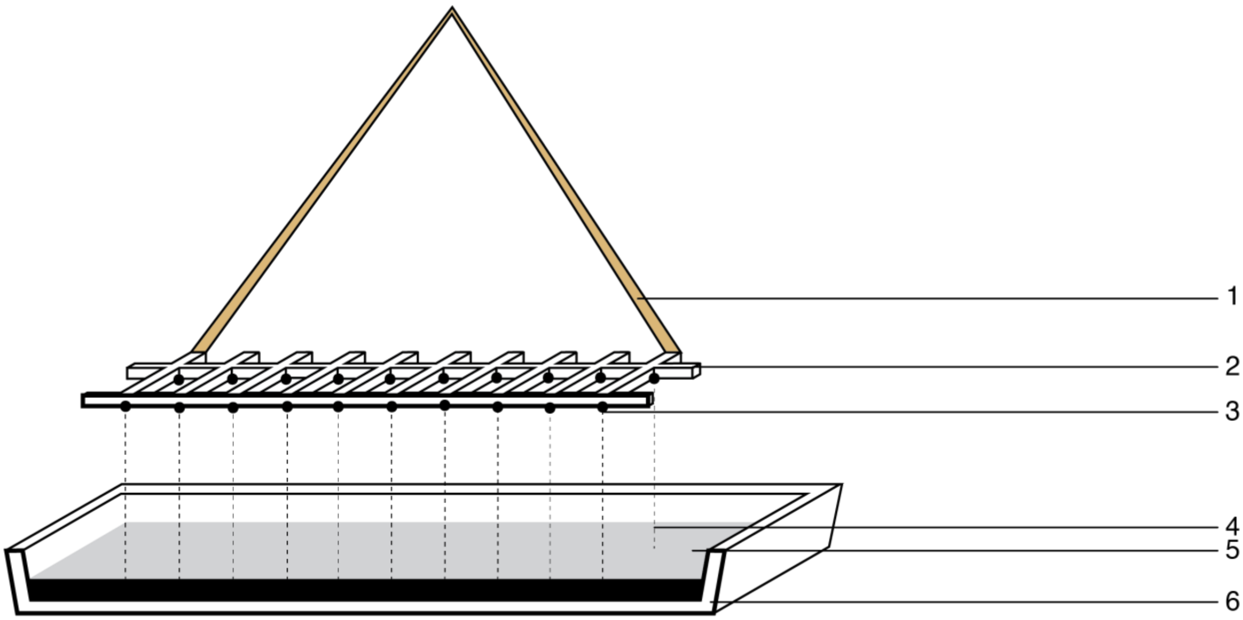

Figure 2: Cross section of droplet apparatus

1	Strings attached to the wire rack
2	Wire rack, lifted in and out of undertray
3	Individual droplets attached to the rack matrix
4	Lift profile: perpendicular to the undertray
5	Fluid reservoir in undertray
6	Undertray to hold excess fluid

References:

Tyowua, A. T., Abel, O. O., Adejo, S. O., Mbaawuaga, M. E. (2022). Functional properties of emulsified honey–vegetable oil mixtures. ACS Food Science Technology, 2(3), 581–591. https://doi.org/10.1021/acsfoodscitech.1c00475

Bambang, N., Ikhsan, M., Tensiska, Sukri, N., & Mahani. (2019). Rheological properties of honey and its application on honey flow simulation through vertical tube. IOP Conference Series: Earth and Environmental Science, 334(1), 012041. https://doi.org/10.1088/1755-1315/334/1/012041

Surface tension and bubbles. Surface Tension. (n.d.). Retrieved September 26, 2022, from http://hyperphysics.phy-astr.gsu.edu/hbase/surten2.html