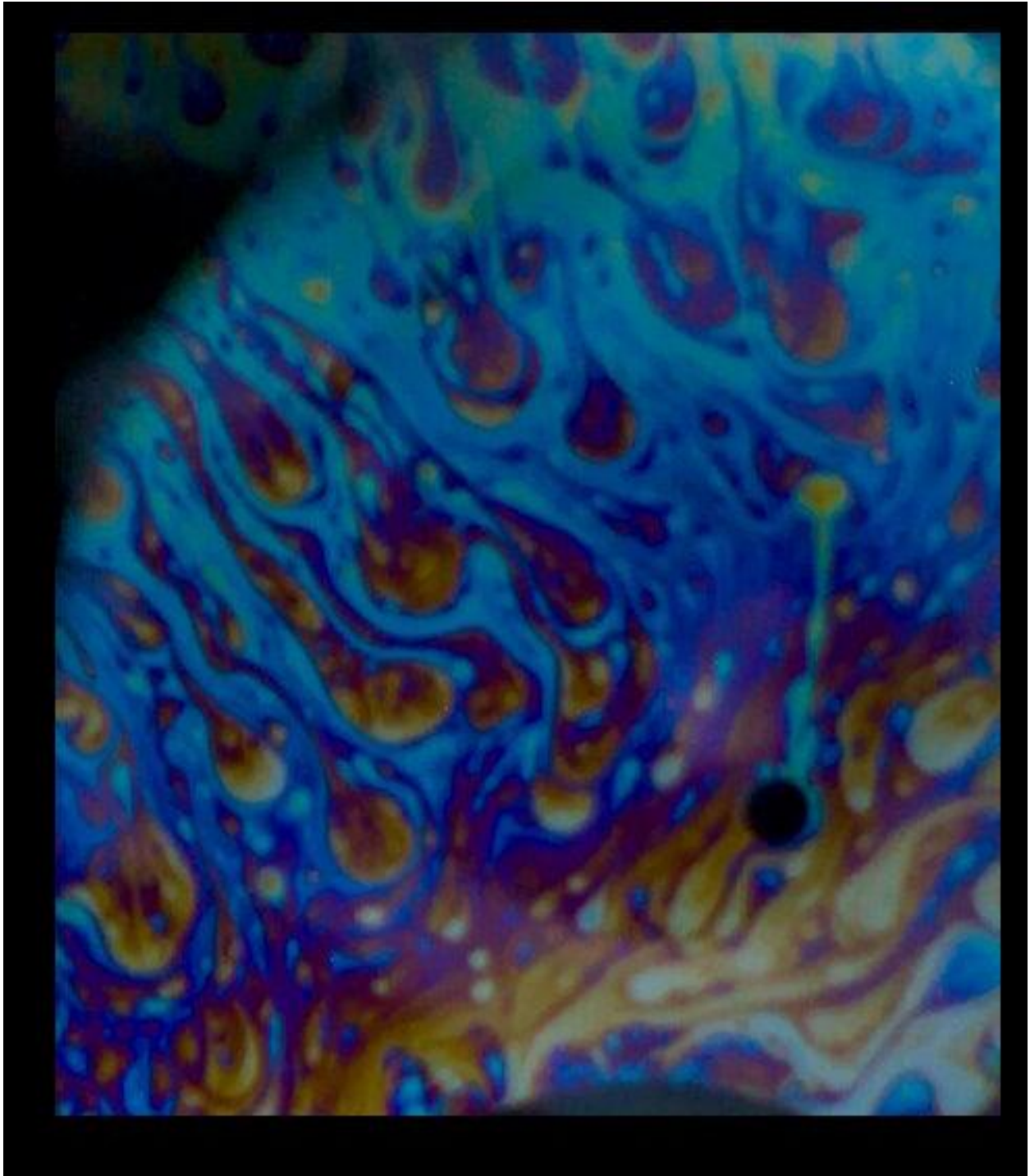


Thin-Film Interference on Film Canister

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10/5/26

MCEN 5151: Flow Visualization, Team First Report



Introduction

The goal of this experiment was to visualize thin-film interference by capturing a soap-and-glycerin film suspended across the opening of a black 35 mm film canister. I was particularly interested in observing the colorful thin film contrast against the canister's dark interior. My teammates Alessandro and Mathew helped with this experiment, and together we tried many approaches and iterations to capture the flow. We did not get the colorful thin film we were hoping for. However, at home, I used a mixture that included glycerin and direct sunlight from a window, and I successfully got the colorful thin film I was originally looking for.

Flow & physics

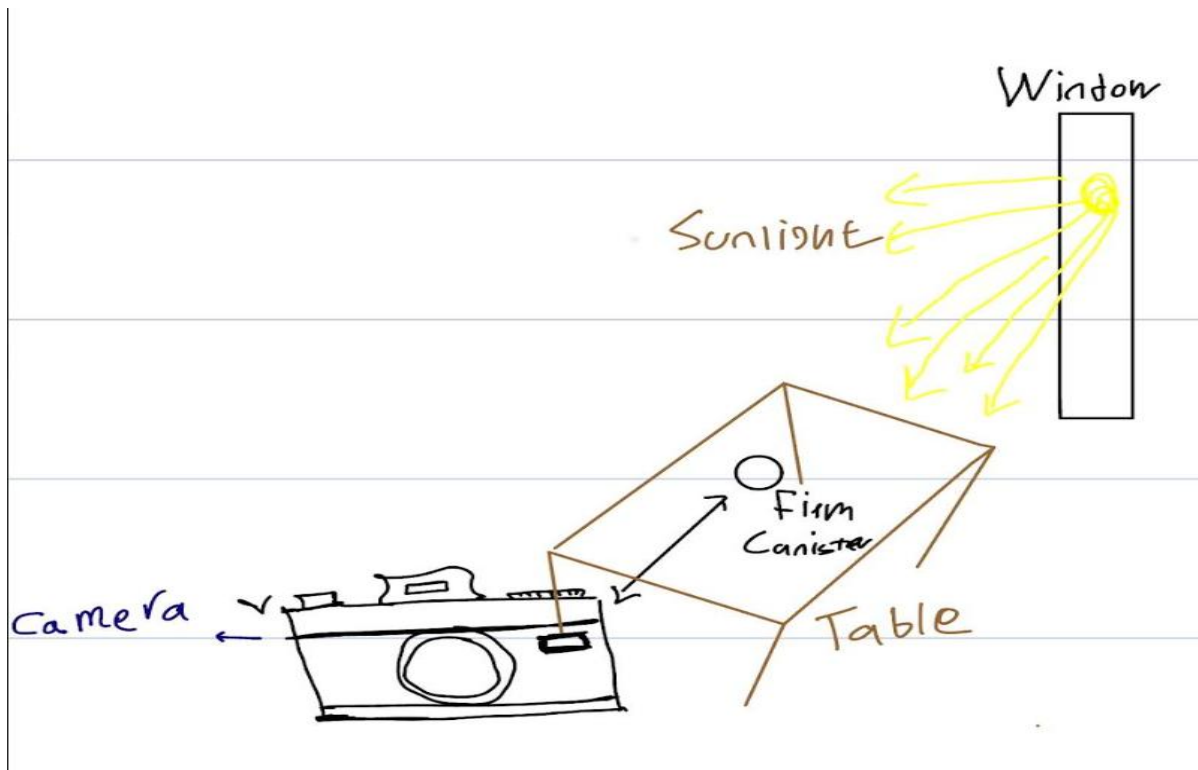


Figure 1: Schematic of the experimental setup

In this experiment, Gravity pulls liquid downward, causing fast internal motion and uneven thickness. Because the film is only micrometer thick, these variations create bright interference colors (Lenavetier et al., 2024). Adding glycerin (glycerol) increases the fluid's dilatational viscosity, which strongly affects film flow and slows downward drainage (Rutgers et al., 2001).

Sunlight reflecting off the front and back of the film mixes to create colors through constructive interference:

$$2nd \cos(\theta_i) = \left(m + \frac{1}{2}\right) \lambda$$

Where n is the refractive index, d is the varying film thickness, θ is the angle of refraction, m is an integer, and λ is the light wavelength.

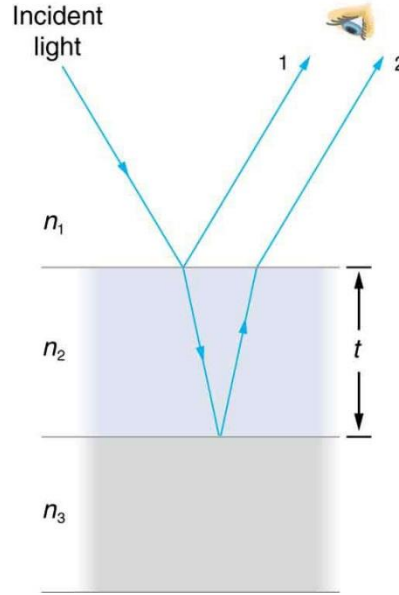


Figure 2: Schematic of thin-film interference, showing incident light reflecting from the upper and lower boundaries of a fluid film with thickness d to create constructive interference paths (OpenStaxCollege & Beceiro-Novo, 2023).

Next, to classify the flow, the Reynold number (Re) is given by:

$$Re = \frac{UD}{\nu} = \frac{(1.16 \times 10^{-3} \text{ m/s})(0.035 \text{ m})}{2 \times 10^{-6} \text{ m}^2/\text{s}} = 20.42$$

Where:

- $U = \frac{d}{t} = \frac{0.035 \text{ m}}{30 \text{ s}} = 1.16 \times 10^{-3}$, is the estimated gravity-driven fluid speed.
- $D = 0.0032 \text{ m}$ is the canister diameter
- $\nu = 2.0 \times 10^{-6} \text{ m}^2/\text{s}$ is the estimated kinematic viscosity.

A Reynolds number of 20.41 indicates smooth, laminar flow dominated by viscous forces.

To ensure image sharpness, we calculate the distance d the fluid moves during the $1/30 \text{ s}$ exposure (t):

$$d = Ut = \left(1.16 \times 10^{-3} \frac{\text{m}}{\text{s}}\right) \left(\frac{1}{30} \text{ s}\right) = 3.86 \times 10^{-5} = 38.6 \mu\text{m}$$

The camera's 21.15 cm field of view across 6000 pixels means each pixel covers $35.25 \mu\text{m}$. Since the fluid moved only $38.6 \mu\text{m}$, motion blur is limited to roughly 1.1 pixels, which ensures that the $1/30 \text{ s}$ shutter speed froze the flow effectively.

Visualization Technique:

The visualization technique relied on thin-film interference within a custom soap mixture. The fluid was

created by diluting two spoonfuls of Dawn dish soap and spoonfuls of commercial glycerin into tap water. The setup was indoors on a table. It used only sunlight through an adjacent window, and the sunlight hit the film at approximately a 45 to 60-degree angle. This lighting and background arrangement was chosen because the black interior of the film canister acted as a dark cavity behind the transparent soap film, which provided maximum contrast so the vibrant colors of the reflected light could be clearly captured.

Photographic techniques:

The image was captured using a Nikon D5200 equipped with a 50 mm f/1.8 lens. The photographic settings and specifications were chosen to balance the natural indoor lighting while freezing the slow-moving fluid:

Field of view: approximately 21.5 cm

Distance from object to lens: approximately 45 cm

Original and final resolution: 6000 x 4000 pixels

Aperture: f/2.4

Shutter speed: 1/30 seconds

ISO:900

Image processing: The raw .NEF file was edited in darktable. The primary edit was a tight crop to remove the distracting table background and the edges of the canister. Because raw files naturally appear flat, I used the Contrast and Color Balance (RGB) modules to make the color bright and natural again.

Reflection:

Overall, the photograph successfully captures the fluid mechanics of thin-film interference driven by gravitational drainage. What I like most about the image is the rich color saturation and strong contrast achieved against the dark film canister, while what I dislike is the same as in the Get Wet assignment: the image quality. I still don't know why my Nikon D5200 doesn't produce high-quality images that show the smallest details clearly, even after trying different camera settings. Finally, I achieved my intent of capturing a stable, visual representation of thin-film fluid dynamics. For future assignments, I may discuss this with my team and Dr. Sunberg about why my camera doesn't produce a high-quality, fully detailed image.

References:

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