Team First Report
Peter Booras
MCEN 5151-002
10/7/2024

For this project, I focused on capturing the interaction of water with a rock surface using a slow-motion video. This is the second assignment in the flow visualization course, where the objective is to observe fluid behaviors and document them through videography or photography. The purpose of this video was to highlight how water contours around an obstacle, forming complex wave patterns and showcasing surface tension effects. In one notable moment of the video, a small droplet is seen unexpectedly jumping up from the rock's surface—an example of water adhesion and cohesion forces interacting. Initial attempts faced challenges with lighting and water clarity, which affected visibility. I worked independently on this project, ensuring all camera setup, video capture, and editing were completed without external assistance.

The flow apparatus used in this video was a natural stream with a rock waterfall positioned center shot. The rock, approximately 12 inches in height and 8 inches in width, was secured between two other larger rocks, allowing water to flow over it. The depth of the lower part of the stream at the recording location was about 6 inches, and the channel width measured roughly 12 inches. As water moved over the rock's surface, it formed a thin layer that followed the contours of the rock, generating visible ripples and eddies downstream. Additionally, in the video you can witness an almost perfect spherical water drop take shape because of the momentum of the water from above falling into the water bason at the base of the small fall. To explain the behavior of the small droplet seen jumping from the rock, the Young-Laplace equation was applied, which describes the pressure difference across the surface of a droplet due to surface tension. This equation, $\Delta P = \frac{2\gamma}{r}$, where γ is the surface tension of the water and r is the droplet's radius, helps predict droplet formation and stability.[1] The surface tension forces overcame gravity and cohesion, causing the droplet to momentarily form a near-spherical shape before detaching. This phenomenon is consistent with findings on droplet detachment forces and surface interactions as detailed in a study on the Young-Laplace equation and droplet behavior.[2] To further analyze the droplet behavior, the properties of surface tension and adhesion at the rock's surface were examined. When the flow velocity increased slightly, it created localized pressure differentials along the rock's surface, promoting droplet formation and subsequent ejection from the surface. This phenomenon, where droplets detach and reform, can be related to the balance of forces as described by the Young-Laplace equation and adhesion principles. Such interactions have practical implications in understanding how surface texture and flow conditions affect droplet detachment, as explored by Daniel and Koh (2023) in their research on droplet detachment forces and adhesion.

---

[1] Pendant Drop Tensiometry: A Machine Learning Approach. (n.d.). *arXiv.org*. Retrieved from https://ar5iv.labs.arxiv.org/abs/2006.10111.
[2] Daniel, D., & Koh, X. Q. (2023). Droplet detachment force and its relation to Young–Dupre adhesion. *Soft Matter, 19*(43), 8434-8439. https://doi.org/10.1039/D3SM01178J.

For this video, I utilized the iPhone 14 Pro's built-in camera, positioned on a small tripod almost in line with the waterfall to capture the water's movement at a consistent angle. No additional visualization techniques, such as dyes or additives, were used, as the intent was to preserve the natural appearance of the water flow. The recording took place at 5:40 PM with the sun setting soon after, providing natural diffused lighting conditions. The environmental conditions during filming included minimal wind and a relatively clear sky. No flash or artificial lighting was necessary, as the ambient light was sufficient for capturing detailed water behavior. The slow-motion feature on the iPhone was set to 240 frames per second, allowing for a high-definition view of droplet formation and flow patterns. This setup can easily be replicated by using a similar camera and tripod configuration during early evening hours for optimal lighting.

For this video, I used the iPhone 14 Pro's digital camera to capture detailed footage of the water's interaction with the rock. The field of view for the shot was approximately 8 inches tall by 12 inches wide, providing a clear focus on the rock and surrounding water. The center of the rock was positioned about 4 to 5 inches from the camera lens to ensure the droplet formations were captured in high detail. The iPhone 14 Pro utilizes a triple-lens system with a 48 MP main camera, featuring a wide-angle lens with a focal length equivalent of 24 mm, f/1.78 aperture, and a 1/1.28" sensor size. The video was recorded at 240 frames per second using the iPhone's slow-motion feature to accentuate the dynamics of water flow and droplet behavior. This choice allowed for smooth playback and an enhanced view of the droplet's formation and detachment. The original and edited video dimensions were 1920 x 1080 pixels. In post-processing, I used MiniTool MovieMaker to refine and enhance the video for a more polished final product. The original video was cropped by approximately 40%, mainly removing the left side of the frame that consisted of excess rock, allowing for a tighter focus on the interaction between the water and the rock. Additionally, I shortened the video from 32 seconds to 23 seconds, highlighting the most interesting part where a water droplet jumps up from the lower portion of the shot. This edit allowed me to maintain viewer engagement and emphasize the unique droplet behavior. I also increased the contrast, saturation, and brightness, bringing out the rich colors of the water and rock surfaces, which were naturally illuminated by the golden hour light. These adjustments helped to accentuate the vibrant hues and ensure that the droplet movement stood out clearly against the surrounding environment. I added a unique title page at the beginning of the video with the title *The Edge of Surface - Tension*, and to enhance the auditory experience, I included the music "Photo Album," a stock track provided by MiniTool MovieMaker. These choices created a more cohesive and professional final presentation.

The video effectively reveals the intricate dynamics of water as it flows over and interacts with a solid surface, demonstrating phenomena such as adhesion, surface tension, and cohesive forces. I particularly like how the slow-motion playback allows for the detailed observation of the water's movement, especially the moment where a droplet detaches and jumps up from the rock's surface. This capture accentuates the forces at play, such as surface tension overcoming gravitational forces, which might not be visible at regular speed. One aspect I dislike is the overall composition of the frame. While the cropping focused the viewer's attention on the key interaction, I feel that the resulting view left some imbalance, making the scene less visually appealing.

Additionally, a small amount of motion blur was present due to the automatic exposure settings on the iPhone, which slightly detracted from the clarity of the droplet. The fluid physics are shown quite well, particularly in the way the water sheets and then forms droplets around the rock's surface. The video successfully captures the interplay between cohesive and adhesive forces, demonstrating how water can be both drawn along surfaces and, under the right conditions, detach as a droplet. This visualization prompts questions about how the surface roughness of the rock affects droplet formation and whether varying the flow rate would lead to different behaviors. Overall, I believe I fulfilled my intent to showcase the interaction of water with a solid object and to capture a unique fluid behavior. However, I would like to improve the sharpness and depth of focus in future captures, possibly with the DSLR that broke while trying to film a different phenomenon. To develop this idea further, I could experiment with different rock textures and shapes to see how they influence droplet behavior or introduce dyes to highlight flow paths and separation points.