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MCEN 4151
Image/Video 2 Report
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11 Oct 2021

Crashing Wave

I. INTRODUCTION

The goal of this project was to capture the natural fluid flow of an ocean wave crashing against an exposed rock. Additionally, instead of focusing on a singular image this time, a video was taken in order to capture an entire fluid flow process from start to finish. Inspiration for this project was a spur of the moment idea when I was at the beach in New Jersey last month.

II. PROCEDURES

The apparatus was very simple for this project, with me acting as the stationary camera operator while sitting in a beach chair. The camera was approximately 50ft from the impact point of the wave onto the exposed rocks. The apparatus can be seen below in **Figure 1**.

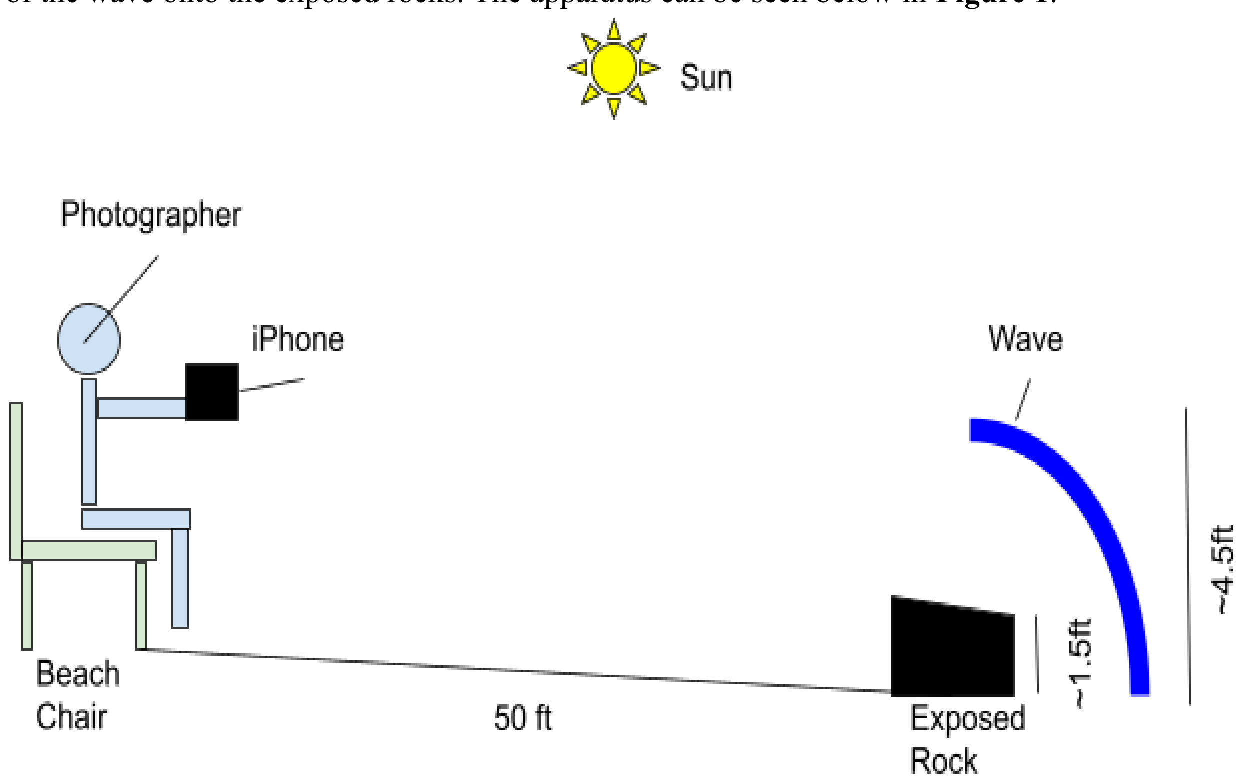

Figure 1. Diagram of apparatus for video. All values have been approximated

Waves began crashing onto the jetty--which is a structure extended into a sea, lake, or river to influence the current or tide--and the impact zone was in the perfect spot to cause the seawater to be dispersed into the air. The setup process was minimal for this project specifically because this was both spur of the moment and also would only be capturable for a small interval of time. Additionally, there was no camera equipment besides the iPhone 11 Pro Max that was accessible at that time, so a slow motion video was chosen as the best method to capture the crashing waves. The final video that was submitted was actually wave 20 of the 30 that were filmed. A continuous slow motion video was taken, with the video being stopped and restarted multiple times. Submission worthiness was benchmarked by overall size and spread of the water spray after impacting the rock.

III. RESULTS AND ANALYSIS

From a fluid mechanics perspective, this is a great example of the natural occurrence of fluid flow. Ocean waves are a product of wind and the gravitational pull of the moon and sun. If you are at the beach it is almost always windy because sea breeze is a product of the different heating rates of land and the ocean [1]. When wind blows across a body of water for extended periods of time the result is the creation of waves, and the longer and harder the wind blows the larger the waves will be. Additionally, tides are a product of the gravitational pull of the sun and the moon [2]. At a given time, different areas of the ocean will be impacted more than others depending on the positioning of the Earth in relation to the moon and sun. This is why high and low tides act on a roughly 12 hour cycle, lining up with the 24 hours it takes for the Earth to spin once on its axis. As a result, the beach will grow or shrink in size as the tides change. The tide was shifting towards high tide when the video was captured. This is relevant because the impact point of the waves was coming closer to the shore and was approaching the exposed jetty. This means that there was a small window of time where the impact point of the waves would be directly on the exposed rock that was causing the large water spray.

Along with gravitational and wind effects that cause waves, the phenomenon of a wave crashing on a rock is a great example of the conversion of potential energy into kinetic energy. The equations for potential energy and kinetic energy can be seen below:

$$PE = mgh \tag{1}$$

$$KE = \frac{1}{2}mv^2 \tag{2}$$

Where *m, g, h,* and *v* are mass, acceleration due to gravity, height, and velocity respectively. When the wave reaches its apex height it has maximum potential energy and then as it is crashing downwards onto the exposed rock and shoots out in multiple directions we see it get transformed into kinetic energy. Due to the angled surface on the rock, the water was projected upwards after impact and gained ~3x the height as the initial wave. While the equations above are useful for conceptual understanding, there are too many assumptions to be made in order to accurately estimate the potential energy of the wave prior to it crashing onto the rock. The impact force on the rock was maximized only at a certain instance while the tide was changing. Based on the final video, I am confident that the capture was one of the highest and widest sprays of water before the tide moved in farther and the waves stopped crashing on that particular rock.

The camera setup for this project was an iPhone 11 Pro Max, which was manufactured in 2019. Since I was on vacation, I did not have access to a more high-end camera and had to work with what I had with me at the time. However, the iPhone SlowMo does a great job of capturing quality video. The video was filmed in landscape mode and had dimensions of 1920x1080 and the capture rate was 60 frames per second. The regular wide cameras on the iPhone 11 Pro feature a focal length of 26mm. Unlike a normal digital camera, the iPhone does not have a lot of variability when it comes to capturing photos and videos, and there are a lot of tricks done on the software side to help it be at least somewhat comparable to high-end cameras.

For the final submission, no post-processing was done on the original video. The lighting was provided strictly by the sun and there were only scattered clouds at the time of filming. There were no visible shadows that needed to be accounted for either, which resulted in the decision to add no other effects on the end product. The blue backdrop (barring a few clouds) in the sky and darker blue ocean complimented the white foam of the waves and provided a nice contrast. Additionally, the line of the darker ocean vs the light blue sky was an added bonus to the video. While there are instances where post-processing will greatly benefit an original capture, in this case the conditions were very ideal and left untouched. The only instance of video degradation can be seen starting at the 17 second mark near the top right corner where the water droplets are passing in front of a cloud as they fall. The bit rate of the video has a noticeable drop and it almost looks as if the background is glitching as the droplets fall to the ground. No tripod was used to stabilize the camera and I relied on keeping my hands steady along with the video stabilization technology in the iPhone to ensure that the movie was not too shaky. Overall, I do not feel the iPhone camera took away from the overall effectiveness of the project and performed rather well for this particular capture.

IV. CONCLUSION

Overall, I feel the final video was very visually pleasing and interesting. The fluid physics paired with the rarity of the waves hitting directly onto that particular rock was an opportunity that could not be passed up. While the process is not necessarily impossible to repeat, these are situations that come and go and I was lucky enough to be able to capture it on film. Additionally, since CU Boulder is located in a landlocked state, a FlowViz project featuring the ocean seemed like a unique idea. If I were to do this project again I would certainly improve my setup. I would try and potentially get different angles of the crashing wave and try to move closer as well. It would also be beneficial to have higher quality filming equipment, which could help reduce the bit rate problem mentioned above. Another alteration would be to focus on taking still images of the water spraying outward as it impacts the rock. In a situation where I only had my iPhone again, I believe having a day with no cloud coverage in the background would have helped limit any noticeable frame rate issues with the iPhone that were exposed by a singular cloud. However, the overall lack of cloud coverage in the background was close to perfect. Finally, my last improvement would be to stabilize the iPhone/camera with a tripod to ensure that no unnecessary shakiness is introduced to the video. I believe the final product was worthy enough and that the setup at the time was adequate. Overall, I really enjoyed this image/video assignment and was glad to feature the beach in some capacity within my video as well.

REFERENCES

[1] WeatherBug Meteorologists, “Land and Sea Breezes: What Causes Them?” WeatherBug. [Online]. Available: https://www.weatherbug.com/news/Land-and-Sea-Breezes-What-Causes-Them. [Accessed: 7-Oct-21]

[2] National Oceanic Service, “What are tides?” National Oceanic and Atmospheric Administration (NOAA). [Online]. Available: https://oceanservice.noaa.gov/facts/tides.html. [Accessed: 7-Oct-21]