

## Team Second: Water Caustics

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11/6/24

Flow Visualization: The Physics and Art of Fluid Flow

The goal of this project, similarly to Team First, was to demonstrate some type of fluid phenomena in a group. My group was the same as last time, which included Travis, Sam, and myself. We drew inspiration from the film Blade Runner 2049, in which there are multiple scenes that utilize water caustics as an interesting lighting technique. The image below is a shot from Blade Runner 2049, in which light is being shined through a pool of water above this hallway to achieve this interesting lighting effect [1].

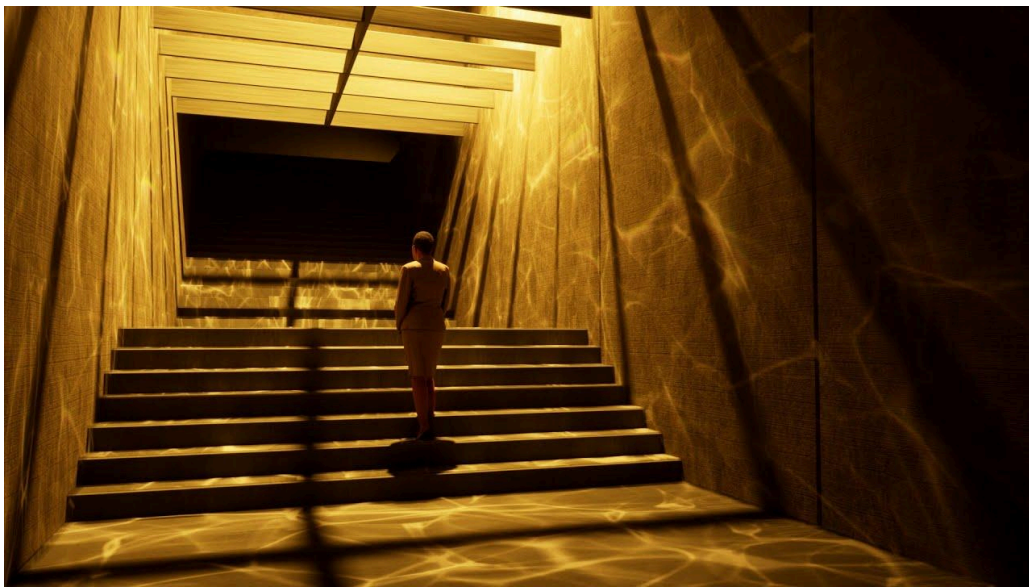


Fig. 1: Blade Runner 2049 Shot

The physics behind water caustics is actually rather simple and can be summarized through Snell's law which is shown below. The idea is that the light that is above the water is shining through turbulent water which will bend the light in various directions due to the waves that are created. At times the varying waves can bend the light in directions that are more dense than others and create brighter areas of light that can be seen in all water caustic examples. In the equation below you will notice that there are two  $n$ 's, which are the refractive indices of the media the light is going through. There are also two theta values which are the angle of refraction and the angle of incidence. One is for the incoming light and the other is for the transmitted light.

$$n_1 \sin(\Theta_1) = n_2 \sin(\Theta_2)$$

Eqn. 1: Snell's Law

To produce this phenomena our group tested different size containers and light sources in a dark room at the ITLL. We found that by using a larger tub of water combined with a softer and more direct light source we were able to create strong visual water caustics. I attempted to dye the water purple to try and add coloration to the water caustics much like the effect generated in image 1. This ended up not creating much of a difference in contrast to water with no food dye in it, the effect may work better if the container that it is shining through is a different color. The picture below shows how we were able to set up this experiment.



Fig. 2: Set up for water caustics

Although I can not put a video into this report, here is a screenshot from the water caustics slow mo video. I used a geode as a subject for the shot to try and make it look like the bottom of the ocean, but I think that the water caustics could be better captured without a subject and just the white background.



Fig. 3: Screen Cap from Slow-Mo water caustic video

To achieve this video I shot in slow motion on my iPhone 13, which does slow motion in 4k at 240 frames per second. The video was around a minute and a half due to the slow motion but this allowed me to capture a variety of interesting water caustic shots from the different turbulent conditions we created. The editing I performed on the video was very minimal and was only to add fade in/out features and a title card. I chose to also add some music to overlay the footage which has a very calming effect and matches the video perfectly. Going forward, if I were to reshoot this video on water caustics I think that I would probably try and capture just the white background to empathize the effect created by the light instead of having a subject.

Appendix:

[1] Blade Runner 2049. Directed by Denis Villeneuve, Warner Brothers / Sony Pictures, 2017