# Double Slit Interference Visualization

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## Nomenclature

| | | | |
|---|---|---|---|
| $\lambda$ | = | fluid density | $[kg\ m^{-3}]$ |
| $n$ | = | integer number | [ ] |
| $\theta_n$ | = | angle number n | $[rad]$ |
| d | = | distance from wave source to projection screen | $[m]$ |
| $c_p$ | = | phase velocity | $[m\ s^{-1}]$ |
| $c_g$ | = | group velocity | $[m\ s^{-1}]$ |
| $g$ | = | acceleration due to gravity | $[m\ s^{-2}]$ |
| $h$ | = | wave height | $[m]$ |
| $H$ | = | water depth | $[m]$ |

## I. Introduction

THIS experiment was an attempt to visualize the double slit wave interference that provided a source of inspiration for Young's famous double slit interference experiment. In this experiment, parallel gravity waves were generated in a shallow (1.5cm) tank of water. These waves passed through a double slit apparatus to produce the same sort of interference pattern that helped Young to demonstrate the wave nature of light.

The experiment was designed as part of the Flow Visualization class at the University of Colorado at Boulder. In this class, undergraduate and graduate students from multiple disciplines produce experiments to capture images that demonstrate both aesthetic beauty and interesting physical phenomena.

## II. Flow Apparatus

To create this image, a glass tank with a base footprint of roughly 25x50cm was filled with water to a depth of 1.5cm. A wood block was manually vibrated on the left side of the tank in order to produce the parallel waves that would pass through the double slit barrier in the center of the tank.

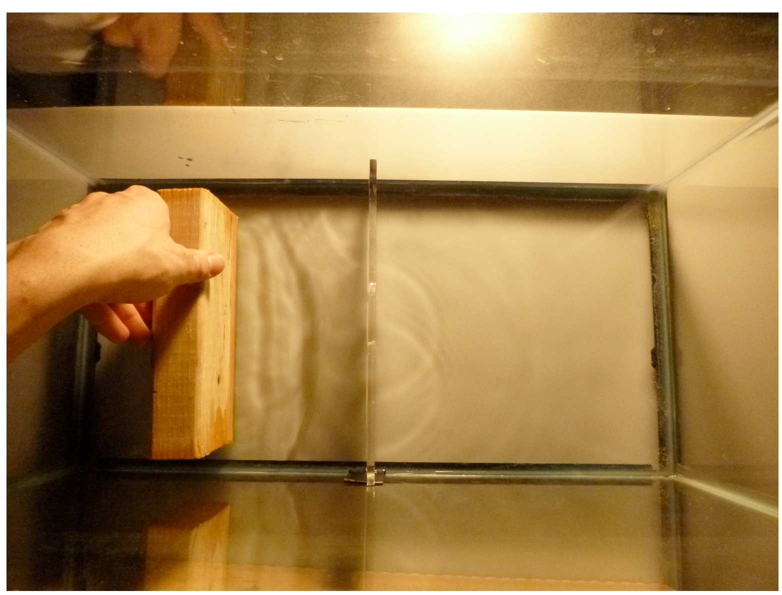

**Figure 1: Visualization setup image**

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The wood block was not the ideal tool for wave generation, because it was not as wide as the tank, so it could not produce perfectly parallel waves. A floating piece of styrene foam cut to match the width of the tank is suggested for future experiments. The waves passed through a 0.25in piece of acrylic that contained two .25in slits separated by 2in. After the waves passed through the barrier, they propagated radially from each slit and formed an interference pattern where they met. Unfortunately, the finite width of the tank meant that the waves also started to form reflections when they encountered the boundary of the tank. Therefore, a larger tank is suggested to allow waves to propagate further before reflective interference occurs.

## III. Visualization Technique

It was possible to visualize the waves indirectly by shining a light at an angle of no more than 10° above the surface of the water. This way, the waves produced shadows on a white background placed beneath the tank of water. The light source used was a set of work lights available in the Media Shack of the Integrated Teaching and Learning Laboratory. For future experiments, a parallel light source like sunlight would be suggested to create sharper shadows.

## IV. Flow Analysis

When Thomas Young performed his double slit interference experiment, he shined light of a single wavelength on a screen with two small holes and he noticed that "when the two newly formed beams are received on a surface placed so as to intercept them, their light is divided by dark stripes." [3] A similar pattern can be found by looking at the wave height in this experiment in sections parallel to the double slit barrier. One can see bright and dark sections that indicate areas where peaks or troughs of the waves have met with each other to increase their amplitude. The reason that the two patterns appear similar is because the photons that Young saw are actually acting like waves, and they don't truly occupy a given point at a given time unless an observation is made.[2] Young's observations were critical to establishing the wave-like characteristics of light and particles in modern physics.

Looking at the image taken for this experiment, we can explain the angular spacing of the peaks in a plane parallel to the barrier can be described using the equation:

$$d\theta_n = n\lambda$$

Unfortunately, in this image it was only possible to capture a single wave, so the only peak location is that of $\theta_0 = 0°$.

Because the waves observed can be categorized as gravity waves in shallow water, we can estimate the group and phase speed of the waves using the following equation [1]:

$$c_p = c_g = \sqrt{g(h+H)}$$

By filling in known and measured values, we can estimate a speed of 0.15m/s for an individual wave in the tank of water. This agrees well with the velocity of the waves observed in a video taken of the experiment. In the video, the waves propagate from the slit to the end of the tank (13cm) in 1.1s for a speed of 0.12 m/s. This speed difference may be explained by the water depth being slightly shallower at the right end of the tank due to a non-level table.

## V. Photographic Technique

**Figure 2: Image alteration comparison**

The image was captured using a Panasonic DS20 point-and-shoot digital camera and was processed using Adobe Photoshop photo editing software.

The camera that captured the image used a shutter speed of 1/400s, an ISO sensitivity of 800, a focal length of 4.5mm, and an aperture of f/3.9, which was the maximum aperture that the camera could achieve. The low shutter speed and high ISO value were used in an attempt to reduce motion blur of the image. Based on the recorded wave speed, the wave traveled a distance of 0.3mm in the time of the image capture, so the image was temporally resolved. However, this high ISO seems to have produced some noise based on the grainy quality of the final image. The camera was about 0.5m from the subject when the image was recorded, and a closer image would have improved the number of available pixels after cropping, as seen in Figure 3.

The image was first cropped from its original size of 3648x2736 to a final size of 1146x1003 pixels. The RGB brightness of the image was adjusted on only the left side of the image to balance the brightness of the two sides. Then, the RGB brightness of the whole image was adjusted using a transfer curve to increase the proportion of very bright and very dark pixels. A comparison between the original and final images can be seen in Figure 3.

The waves in the image are about 40 pixels wide, so the image was able to maintain spatial resolution for the wave shadows created in this experiment. However, if the light source was improved, it would be possible to visualize finer detail in the wave, and the image would have to increase in resolution to account for new details.

## VI. Conclusion

The image in this report successfully demonstrated an example of the double slit interference pattern. One can see alternating peaks and troughs due to the superposition of the waves as they interact after passing through the slits. However, the image could be improved with better lighting, and a larger tank to allow for more wave formation. It is suggested that the experiment be reproduced using sunlight to visualize wave shadows, or using a camera angle closer to the surface to visualize reflections from the waves.


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## References


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