Worthington Jet Crown
The Physics and Art of Fluid Flow

Introduction

This project, “Team 1,” is designed to get students to form teams in order to create a better set up and more complicated fluid dynamics. The fluid flow captured in this project is a Worthington jet crown. Fluorescein dye is used to create a crown on top of water. This image was captured with the assistance of Jeremiah Chen, Mark Noel, and Daniel Bateman using a Canon EOS 70D.

The Physics

The substance used in this project is fluorescein dye, which was obtained from highlighters. Fluorescein reflects the black light, giving it a unique glowing effect. The fluorescein is held in a syringe about 8 to 12 inches from the surface of the water. Using steady hands, drops of fluorescein are then carefully aimed to land on top of each other. The first effect is a Worthington Jet crown, which is formed when droplets fall with enough velocity onto the surface of a liquid (Inglis-Arkell 2015). The droplet will form a crater in the surface as the droplet dives deeper into the liquid. The liquid on the surface is then displaced to form a crown. This crown is the fluid flow depicted in the image. The after effect is the actual Worthington Jet, which rises from the center of the crown. This fluid flow can only happen with turbulent flow, which the Reynolds number is calculated to be 82221 shown below in equation 1.

Reynolds Number For Turbulence

Velocity, $v = \sqrt{vi^2 + 2ad} = 6.5\ m/s$
Estimated Diameter, $D\ = 0.5\ in\ = 0.0127\ m$
Kinematic Viscosity of Water at 20 degrees Celcius, $v = 1.004x10^{-6}\ m^2/s$

$$Re\ =\ \frac{UD}{v} = \frac{6.5*0.0127}{1.004E-6} = 82221\quad >\ \ 2000\ \ Turbulent\ Flow \tag{1}$$

The Art

The medium of the artwork is fluorescein in water with black acrylic for the background. For this image, two light sources are being used. There is no sunlight in the room, as both light sources are from black lights. Using the black light is the only way to properly light and define the fluorescein dye in the dark. Both the fluid flow of the crown and the after effects of the fluorescein dispersing throughout the cup can be seen.

The camera, a Canon EOS 70D, was taken using a tripod directly in front of the cup pointing at about 20 degrees downwards. The focal length is 50mm and the focus was directly in the center of the cup. An ISO of 3200, aperture F1.8, and shutter speed of 250 was used to ensure that the crown will be focused and the image will be clear in the current lightings. Photoshop was used to

bring out the contrast of the image, remove distracting backgrounds, and adjust the hue for a more aesthetically pleasing image.

Conclusion

The final image definitely has revealed both the physics and the art. However, some improvements can be made. The contrast of the picture can be increased to further accentuate the crown. The image can be cropped such that the main focus will be the crown; however, the flow of the fluorescein into the water will be lost.

The project was originally supposed to be done in a fish tank performing von Karman flow. However, the setup too hours and did not produce any results. The final product was achieved using a water cup. The project can be improved if the von Karman flow was successfully produced in the fish tank. The fluorescein die was hard to wash off and stained the hands for many hours. Overall, this was a learning experience that allowed me to learn to use black lights with fluorescein dye. Upon completion of this project, I have learned the physics behind how a Worthington Jet works.

References

Inglis-Arkell, E. (2015, June 11). A Rare Look Inside The Formation Of A “Worthington Jet” Of Water
http://io9.gizmodo.com/a-rare-look-inside-the-formation-of-a-worthington-jet-1710712711