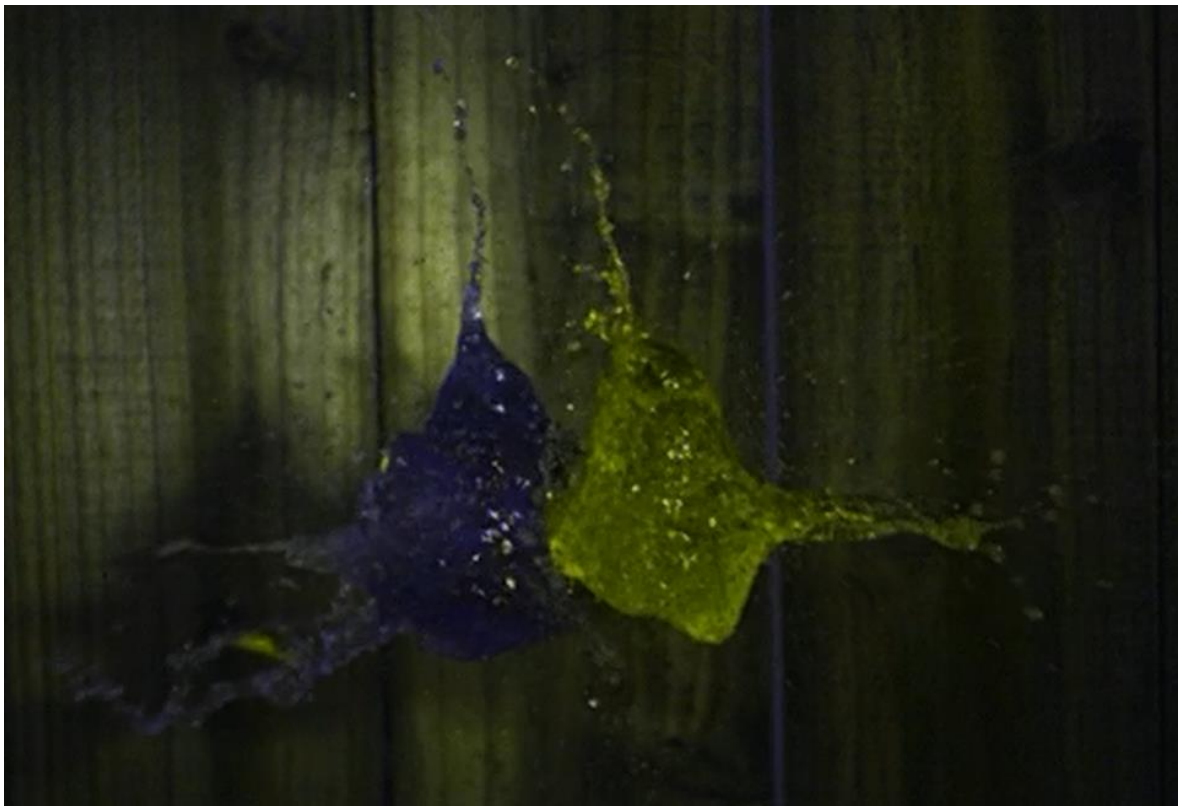
Team Project 2
Flow Visualization



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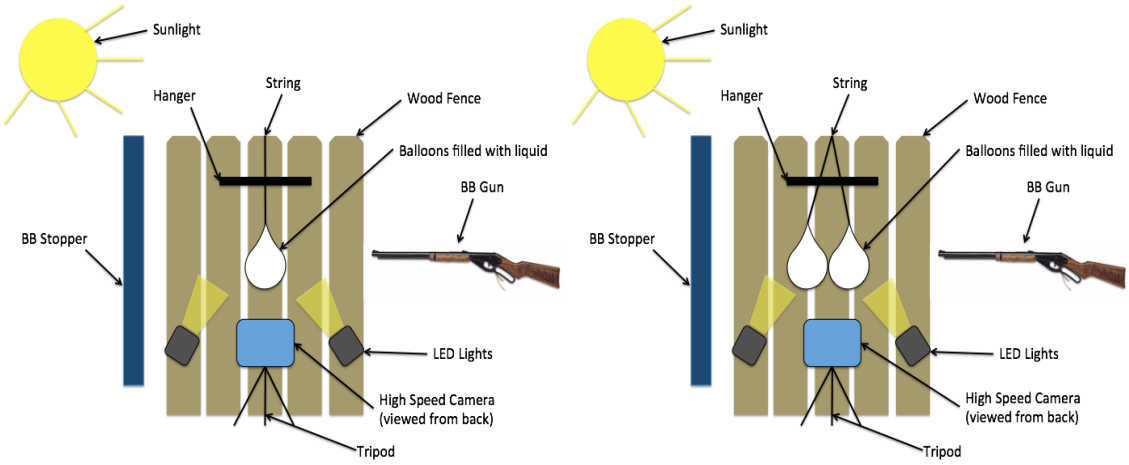
Introduction

This project is for the "Team Project 2" assignment in the Flow Visualization Class with Professor Jean Hertzberg at the University of Colorado Boulder. Amazing fluid flow phenomenon occurs around us every day; however, most go unnoticed. This experiment is focused on the behavior of contained fluids that and their behavior under a quick change in environment. In this experiment, 2 water balloons will be popped using a BB gun. The BB gun will rupture the balloons and the waters behavior will be observed. To help visualize the water better, a different food dye will be used for each of the balloons. This flow was captured in collaboration with Chris O'Brien, Ian Macfarlane, and William Olson.

Experimental Setup

The decision of capturing breaking of balloons required an integrate setup. The basics included suspending the desired latex balloons by a string or wire and then puncturing the balloons with a high speed small ball bearing from a bb gun. **I**n order to capture our desired subject we needed a set up that would allow us to capture the action with a high speed camera. Due to the use of the camera, the Olympus I-Speed, it was necessary to perform our experiment in a very well-lit area. In order to acquire enough light we conducted the experiment in direct sunlight with the addition of two hand held portable led lights. We placed the Olympus I-Speed approximately 5 ft. from the subject with the background being a wooden fence that as stated before was in direct sunlight. The balloons were held at approximately 1 ft. from the fence by a hanger and left until they were completely motionless. With the balloon(s) in place we proceeded to carry out the plan and shoot them with a bb gun. The shot was taken at

perpendicular angle from 10 to 15 ft. away. According to the specs the BB left the Daisy Red Ryder BB gun and was travelling at a rate of 350 feet per second as it entered the balloon. We began recording 20 seconds before the shot was taken and ended when all the liquid left the image frame.



Photographic Technique

The intention was to capture the flow using a high speed camera to be able to slow down the experiment and better visualize the fluid behavior right after impact. The camera of choice was an Olympus I-speed camera. The camera was placed as described in the experimental setup. The camera was set to 800 frames per second, this means a very fast shutter speed is used. To accommodate for the high shutter speed, it was important to ensure an ample supply of lighting for the experiment; therefore, the experiment was done in broad day light; in addition, bright LED lights were pointed at the balloons to make the setting even brighter. The video was then uploaded onto windows movie maker and the brightness was adjusted to make it even brighter because despite all the lighting, the images were still fairly dark.

Visualization Technique

Although the lighting was important, it was also important to find a way to further add color to the liquid, especially because of the use of 2 balloons. The use of food coloring inside the balloons made it easier to capture the flow following the rupture of the pressurized balloon. With food coloring, there was minimal transparency in the liquid allowing us to capture all the reactions of the liquids following the shot from the metal BB and all the physics were observed. When the BB initially punctures the balloon, the latex fibers of the balloon that were originally in tension contract in all directions away from the hole. At first, the water maintains the shape of the balloon after the pop, but as gravity pulls the water downwards the air resistance separates the water due to friction [1]; additionally, as the latex contracts and pulls away from the water, it creates a void, which causes the water to splash out to try and fill their air space created.

When the balloon originally pops the retracting latex applies a force called skin friction to the liquid. Skin friction is a type of parasitic drag caused by viscous drag within the boundary layer. The boundary layer from skin friction usually starts out as laminar, but turns turbulent eventually. [2] Although it is very difficult to see enough detail in the video taken of the balloons popping, if the boundary layers were examined it would be expected to see an originally laminar flow that turns turbulent.

I was hoping to see a mixing of the two fluids. I chose a yellow and blue dye so that if they mixed, a green color would be the product of the two fluids. However, the fluids did not mix in this experiment.

Safety Procedures

When working with a BB gun such as the Daisy Red Ryder it is important to take safety precautions to ensure nobody gets hit with a BB. To do this, before cocking the gun, we first always made sure everyone maintained a safe distance from the balloon. We also created a setup that allowed the balloon to be suspended without the use of a team member holding it. The balloon was held by a string that was attached to the top of a fence with a clothes hanger placed between the fence and string to separate the balloon from the wall. To eliminate any chance of ricochet from the BB a thick comforter was placed as a backdrop for the BB.

Summary

The video was satisfying to my experiment goals. However, I am curious if the behavior of the fluids would be different if the balloons weren't so close to each other. How would other fluids like oils behave under the same conditions? If the field of view was larger, would that give sufficient time for the two colors to mix and result in a combination of the two? (Green in this case). These are all considerations I would like to take given the time to repeat this experiment.

References

[1] http://science360.gov/obj/video/ef933250-6e76-4b2e-b653-99ce6394ca63/physics-popping-water-balloon

[2] https://en.wikipedia.org/wiki/Parasitic_drag#Skin_friction