Group Project #2
https://vimeo.com/144418760

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Purpose and Intent

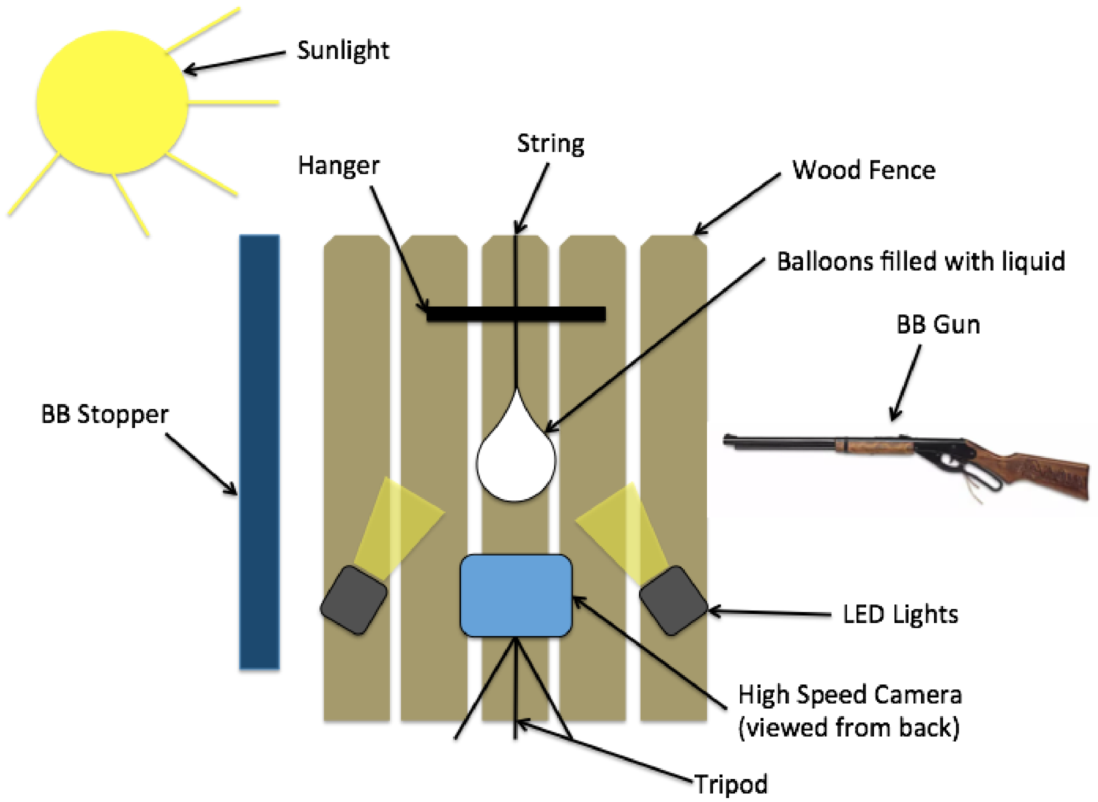
The purpose behind this visualization was for the second group assignment for the Flow Visualization course taught at the University of Colorado, Boulder. This course, taught by Professor Hertzberg, serves to bring together the phenomena of physics with the aesthetics and visualization of art. This image and setup came from the collaborative ideas of myself (Christopher O'Brien), William Olson, Ian Macfarlane, and Gamal Elbialy and we decided to utilize a high-speed camera to capture water balloons bursting. I personally wanted to capture a video that clearly shows the entrance and exit of a BB through a single balloon.

Safety

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.

Flow Apparatus

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 BB. In 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, which 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. Seen below is a diagram to help visualize exactly how our image was set up.



Visualization Technique

Although the lighting was important, it was also important to find a way to further add color to the liquid. 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.

Photographic Technique

For this project, I used an Olympus I-Speed camera to take the video. I had the camera setup on a tripod approximately 5 feet away form the balloon creating a field of view that was about 3 feet wide and 2 feet tall. With the camera set to 1,000 frames per second, extra light was needed. Using two professional quality LED lights, I was able to brighten up the video enough. For the shutter speed, this camera has a default setting of 1 μs, and that is what was used. At the shutter speed of 1,000 fps, the camera has a resolution of 1,280x1024. The ISO for this camera ranges between 1,600 and 12,800. Unfortunately I forgot to write down what ISO setting I was using and cannot access this information from the video file. Once the video had been taken, the only editing that was done was trimming the clip to a more desirable length and slowing it down. Filmed at 1,000 fps and played back at 30 fps gives the final video which can be viewed at : https://vimeo.com/144418760

Sources:

[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