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Flow Visualization
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Team Project 1 Report

This video was done for the first group project and is a high-speed visualization of two water balloons impacting the ground and exploding. The intent was to capture a high quality, slow-motion account of the properties that liquid water exhibit when undergoing an impact within a latex water balloon. It was a very challenging thing to do when first starting out, but after my group and I practiced for quite some time, we were able to attain some amazing footage.

For this video, no special flow apparatus was used. Two latex balloons were both filled with liquid water until they had diameters of 3.5 inches. This translates to a volume of 22 inches cubed. Each balloon was tossed at a velocity of approximately 3 feet per second, from a horizontal distance of 3 feet away and a vertical distance of 3 feet away from their point of impact, in the direction perpendicular to the lens of the camera. It was attempted to release both balloons at the same time, but due to human error this was impossible to replicate.

Within the video, there are many different forces causing many different things to occur. First, there are the forces that the balloon exhibits on the water it holds as it breaks from impacting the cement. When the latex breaks, it peels away in shear, creating a rippled effect in the water's surface tension [1]. Next, there are the forces of the volume of water impacting the ground. These are body forces of gravity and mass multiplied by acceleration acting here. When the water impacts the solid flat surface, it creates a crowning effect, splattering droplets of water everywhere [2], including back up vertically. Lastly, the forces of water droplets impacting other water droplets must be considered. These forces are both of the body and surface type. They cause the water droplets to collide, blend, change shape, and diffract direction in an almost intrinsic and beautiful harmony. The sunlight that is shining on these events as they occur cause beautiful shows of refraction and reflection, especially when shot using a high speed camera.

All the above forces and attributes can be expected when dealing with a turbulent flow such as this one. This was determined by calculating the Reynolds number of the flow. For each balloon: the size D = 3.5 in, the speed U = 3 ft/s, the density rho = 62 lb/ft^3 [3], and the viscosity mu = 2.344 x 10^-5 lb s/ft^2 [4]. This translates to a Reynolds number equal to 2 million. Anything over a few thousand represents a turbulent flow, so we know for sure that the flow was turbulent, and the effects of inertia were far greater than those of viscosity. Unfortunately, because the resolution is still unknown, no calculations for motion blur could be done.

No special visualization techniques were used for the filming of this video. The water balloons used were basic latex water balloons purchased from any grocery store. They were filled with regular faucet water out of a standard sink. The video was shot at approximately 3:30 pm on March 2, 2010. The location was outside of the Durning Mechanical Engineering Lab on the red cement stones. The weather was incredibly clear, roughly 60 degrees Fahrenheit, with no clouds and plenty of direct sunlight. At this time, the sun was beginning to set in the West and the camera was pointed downward 45 degrees at the red cement, directly inline with the sun. No additional lighting was used to capture this video.

The size of the field of view using a height dimension from the top to the bottom of the frame is 10 inches. The patch of red cement that the water balloons exploded on was at a distance of 4 feet from the lens of the camera. The lens focal length and other specifications are unknown. My group and I could not figure out this information using the unfamiliar high speed technology. Nor could we figure out the resolution or most of the exposure effects. All we know is that the shutter speed was shooting at 300 frames per second. The camera we were using was an Olympus i-Speed, high-speed, digital camera with CDU capable of shooting at 30,000 frames per second. Though we would have liked to increase our shutter speed, we learned that there simply was not enough light outside to capture quality footage. The video clip that I submitted was altered in one way. Professor Hertzberg helped me use Adobe Premiere to adjust the white level of the video to 121, making it brighter and easier to see the flow phenomena.

The video reveals an amazing slow-motion, yet still very focused flow phenomena. I absolutely loved working with the high speed camera and intend to use it with further projects. What I do not like, however, is not being able to attain all the information I need about the resolution, lens and exposure specs. I believe that the fluid physics are shown well and that my intent was fulfilled. To develop this idea further I would like to use a controlled environment with much more lighting, so I can shoot at an even higher speed.

[1] http://www.environmentalgraffiti.com/featured/exploding-water-balloons-crystallized-time/13557

[2] http://en.wikipedia.org/wiki/Drop_(liquid)

[3]http://www.physlink.com/Education/AskExperts/ae157.cfm?CFID=26689891&CFTOKEN=448a962085120d10-6328006A-15C5-EE01-B9FA1DDDA7E21D41

[4] http://www.engineeringtoolbox.com/water-dynamic-kinematic-viscosity-d_596.html