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Team First Report
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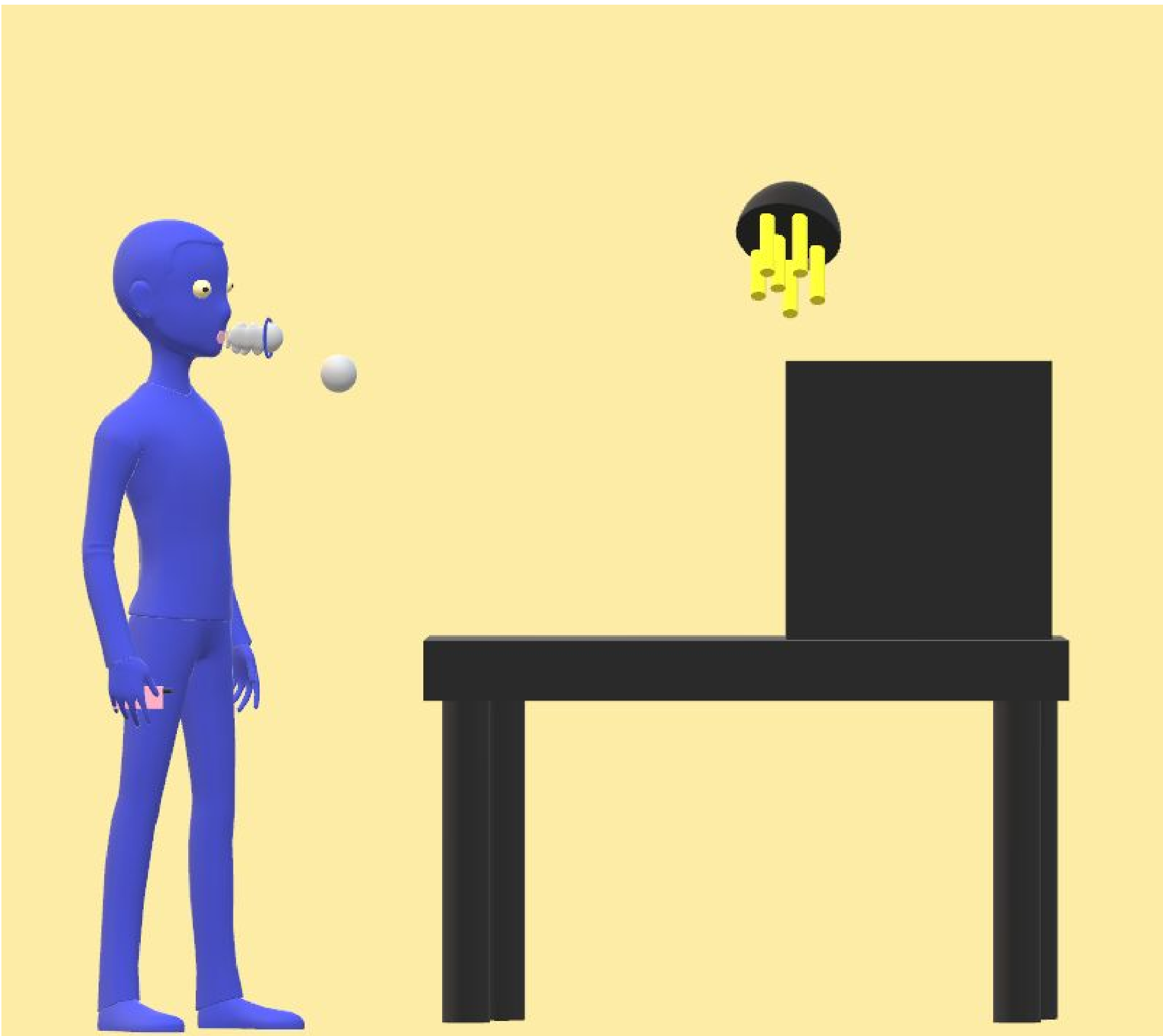
The image being analyzed in this report was taken for the first team photography assignment of the flow visualization course. The image was taken with the intent of showing the interesting fluid mechanics that occur when a bubble pops. These mechanics involved surface tension, pressure gradients and density differences resulting in expansion of the fluids inside of a bubble. The image, taken by my teammates, was that of vapor inside of a soap bubble, which I had blown, that has just been popped.

The flow apparatus can be seen below and includes a person inhaling vapor (primarily containing vegetable glycerin and propylene glycol), and blowing said vapor into a film of bubble solution, creating a bubble filled with vapor. This bubble would then float down onto the backdrop surface (which was illuminated by a single lamp) due to a difference in density between the vapor-filled bubble and the air surrounding it, and pop on or near the surface, hopefully at the point of focus for the camera. As it was difficult to predict the trajectory and popping location of the bubble once it had been blown, it was difficult to focus properly on the bubble to produce a sharp image. Once the bubble popped, however, as seen in the photo, all of the vapor inside went in all directions so as to expand into the surrounding atmosphere. This flow is difficult to analyze with respect to dimensionless parameters such as Reynolds number, however, using some assumptions, an appropriate guess as to whether the flow is turbulent or laminar can be made.



The Reynolds number can be calculated using the parameters seen in the equation here for the value of a reynolds number in a cylindrical pipe: $Re = \frac{\rho v D}{\mu}$. Now, given that the bubble is a sphere, one can assume that each small clump, or even particle, of smoke (which can be assumed at 25 C and 1 atmosphere to have the properties of air) that was ejected from the bubble would be going in a different direction and therefore could assume its own reynolds number as if it were traveling through a tube made out of the air surrounding it. That being said, the value of

D would be so small that the reynolds number would end up being in the laminar regime (<2300) even though the dynamic viscosity of air is 0.018cP.

It is important to consider the bubble itself as well. The bubble was held together by the surface tension between soap and water molecules that make up the bubble itself. A bubble is made up of a layer of water sandwiched between two layers of soap, which have their hydrophobic heads pointing away from the water in the center and the hydrophilic tails pointing towards the water between them (Leigh 1). The bubble will have a slightly higher pressure than atmospheric inside of it when it is blown and will thus expel the fluid inside outwards when it is popped, as seen in the photo taken.

The visualization technique used involved using a vaporizer with a 1.2 ohm coil to vaporize a mix of propylene glycol, vegetable glycerine and flavoring, that was then blown into a bubble. The bubble solution was a generic solution purchased at a nearby store. The backdrop used was simply a dark tablecloth draped over a large table that has a smaller side table on the back of it so as to create a surface and backdrop for the photo. The lighting used was from a lamp off to the top left of the photo. This light can be seen shining onto the bubble and backdrop in the unedited photo.

The field of view in this photo was not significantly large, as it was about 4ft wide and 3 ft high, however, given that the scale of the experiment was a 5-10cm bubble in most of our trials, it was still a bit too large. The distance from the lens to the bubble itself was approximately 2 feet, but this value changed significantly as the bubbles tended to drift. The lens focal length was 16 mm with an F-stop of f/2.8. This photo was taken using a Fujifilm X-T1 digital camera, resulting in an image that had a size of 1920x1280 pixels. On this camera, the ISO was set to 5000, with an exposure time of 1/125 seconds, in order to be able to capture the explosion of the bubble and the expulsion of the fluid inside. This photo was then processed in photoshop to crop it, remove some imperfections in the background, and increase contrast and colors so as to better see how the flow is acting.

This image reveals the delicate balance of bubbles and how the fluid inside acts when they are popped. Unfortunately, the picture was not as dramatic as expected, and therefore does not really provide a spectacular to look at photo. That being said, the intent of capturing the flow that occurs once the bubble is popped was accomplished. In the future, it might be a good idea to use slow motion video capture instead to see exactly what happens throughout the whole process of a bubble popping so as to better understand how the fluid inside moves and also create a more interesting image.

Leigh, Katie. "How Bubbles Are Made". Accessed October13, 2019.
https://sciencing.com/how-bubbles-made-4912993.html.