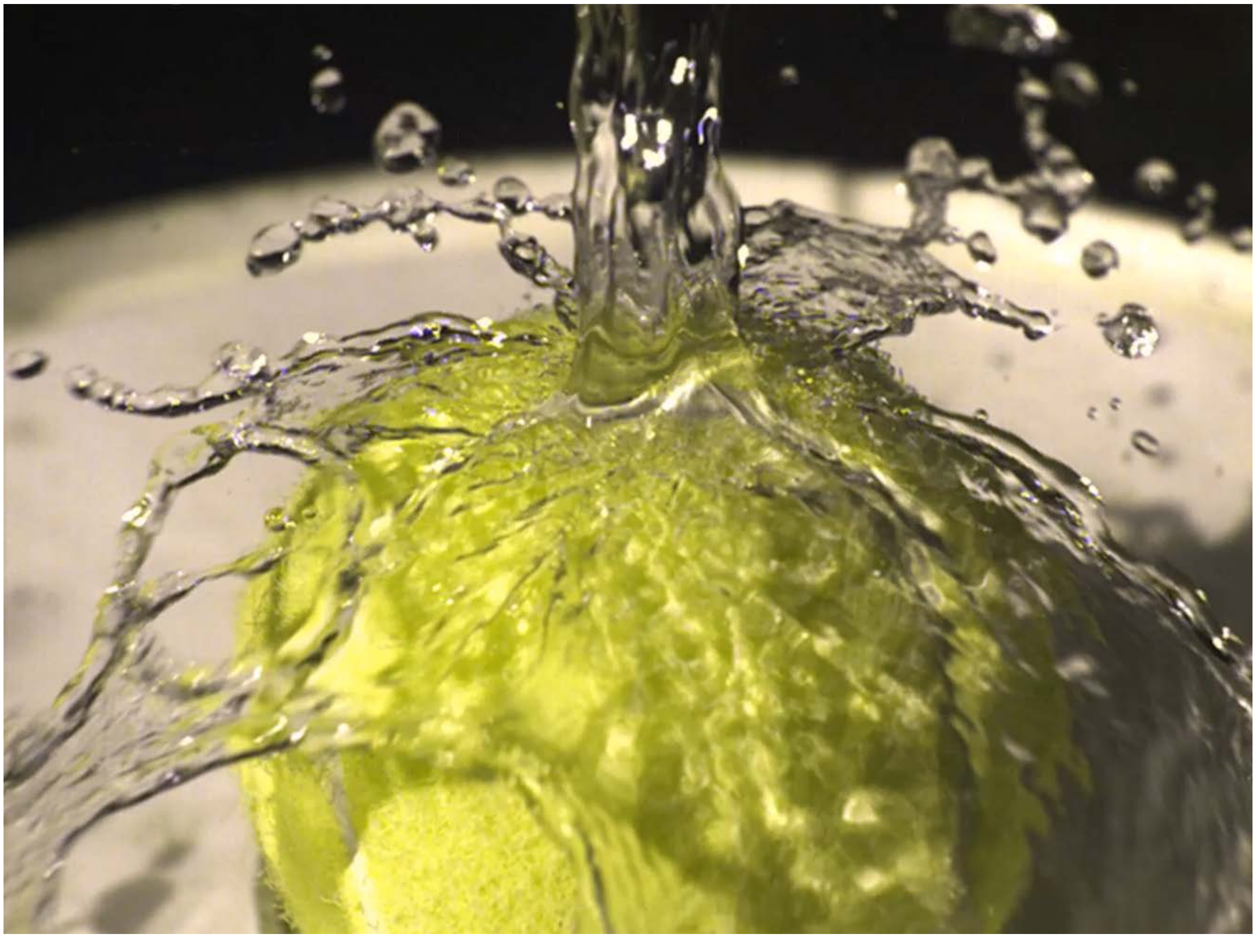

The Hydrophobic Tennis Ball

Team First

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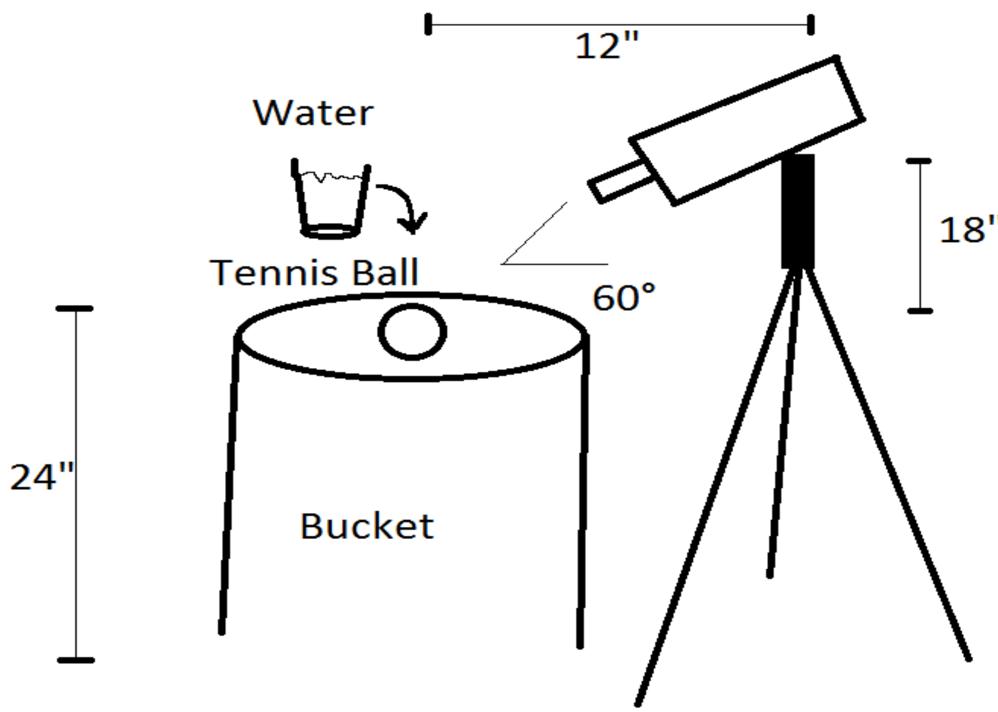
11/10/15

For the first team project, I wanted to try to use an imaging technique I was unfamiliar with and expand my video creation knowledge. To achieve this, our team chose to use the Olympus I-Speed high speed camera. This camera is capable of shooting at speeds greater than 30000 frames per second. For the flow phenomena, as a team we chose to work with the super hydrophobic coating, NeverWet. Hydrophobic coats are those that repel water and their effectiveness is gauged by a measurable parameter called the wetted contact angle. When the contact angle is above 150° the coating is considered super-hydrophobic [1].



The flow apparatus that I created to demonstrate the hydrophobic phenomena consisted of simple a bucket and a tennis ball that was coated with the two part Rustoleum NeverWet product. This consisted of spraying 3 coats of the base spray waiting about 5 minutes between coats. Waiting for 30 minutes for this to set. Than coating the tennis ball with 3 coatings of the top spray, again waiting about 5 minutes between coats. The tennis ball was then allowed to dry overnight. The following day, the tennis ball was set in a groove in the center of the bucket and an 8oz cup of water was dropped onto it. This whole process took place outside in direct sunlight at about noon with no clouds in the sky. The high-speed camera lens was positioned 12 inches away from the tennis ball, above 18 inches above it. The camera was pointed towards the tennis ball at about a 60° angle. The Reynolds number for the flow was calculated using the characteristic length equation.

$$Re = \frac{Vx}{\nu}$$

The characteristic length used was the falling distance after the water left the cup, x, in this case is measured to be .101m. The kinematic viscosity of water, ν, is .000001210 m2/s. Energy conservation is used to calculate the velocity of the flow at the point of impact.

$$\frac{1}{2}mv^2 = mgh$$

Mass cancels out and you are left with

$$v = \sqrt{2gh}$$

Where g= 9.8 m/s2 and h = .101 m. This gives us me a Reynolds Number of 83,000. This shows that the water is clearly turbulent at the point of impact [2].

The slow motion aspect of the video allows you to peer a little deeper in to the physics that are going on. During the pouring of the water, numerous linear ridges are evident in the surface of the flowing water. This shows the turbulence predicted by the high Re value we calculated. The hydrophobic properties of the water can been seen in the angle that the splash gets ejected off of the surface of the tennis ball. In the sheeting of the water, you are seeing the effects of cohesion, which is the tendency for water molecules to want to stick to other water molecules. This causes the really thin sheeting effects that you see in the video. The actual super-hydrophobic surface works by depositing nanometer sized particles onto the surface, the spacing between the particles is small enough that surface tension holds the water droplet together and repels the object. In nature this is visible in the lotus leaf and only recently have products exploiting this been available to consumers.

As described previously, the video was captured in direct sunlight at noon with no clouds. This game me a very bright light source to work with. The video was captured at 1000 frames per second at a resolution of 800 x 600. The I-Speed camera that was used had a selection of lens available and we chose to use the macro lens to capture what we were looking for. The lens had a fixed focal length of 25mm. The aperture was set at an f/ stop of 4.1 in order to give a usable picture, any lower and the image was completely over saturated. No video editing was done. Music was added from the free online music depository http://freemusicarchive.org/. The song used was "The Piano Tune" By Beat Doctor and is available for use under the Common Core Non-Commercial License.

I think the overall experience of working was the high speed camera was positive. I was able to capture details in water flow that are very challenging to see in real time. The camera itself was a challenge to work with, the technology is old dated and slow. It is limited to only 4 seconds of video and beyond 1000 frames per second, you can only gain a greater frame rate by sacrificing the video recording resolution. Care should be taken when working with the super hydrophobic coating as it's the possible health problems are not well understood.

[1] Cheng, Y. T., 2005, "Applied Physics Letters", http://www.lawrencehallofscience.org/sites/lawrencehallofscience.org/files/pdfs/college_resources/modules/Superhydrophobic/Superhydrophobic_Surfaces.pdf

[2] Munson, B., Okiishi, T., Huebsch, W., Rothmayer, A., 2013, "Fundamentals of Fluid Mechanics", Wiley, pp. 412, Chap. 8