Splash Slosh: Get Wet Fall 2018

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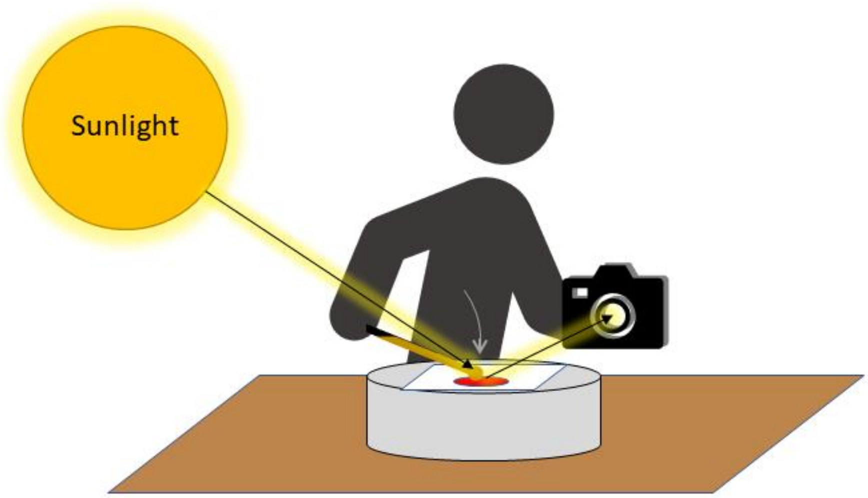
The idea behind my image was to capture the effect of an impacted drum head on standing water. I wanted to capture the splashing effect that occurs when a hard surface (drum head) is the driving force behind the fluid motion as opposed to the fluid's initial velocity causing its splash. I initially placed a small container (5 inches tall with a 5-inch diameter) on top of the drum and took photos of dyed water in the container as I hit the drum with a stick in a separate location. However, after many attempts, I found my best setup to be placing the liquid directly on a piece of paper covering the drum head and striking the drum head in the exact area of water placed on the sheet as shown below.



I held the camera with one hand while holding the stick with the other. The stick was bounced with a loose but forceful grip, using the middle finger as a fulcrum and the pinky and ring finger as actuators. The image was taken instants after the standing water was struck. This setup provided a combination of fluid splash from the impact of the stick on the fluid as well as slosh from the rebound of the drum head [2]. In the image, droplets fly upward and reach their peak at about eye level which is approximately two feet above the drum head. Since the drops are about a tenth of the size of the 1 cm wide drum stick tip, they have a volume of $\frac{4}{3}\pi r^3 = \frac{4}{3}\pi(0.0005\ m)^3 = 5.24 * 10^{-10} m^3$, where $r = 0.5\ mm = 5.0 * 10^{-4} m$. To reach this height of 2 feet = 0.610 m at a volume of $5.24 * 10^{-10} m^3$, a droplet of water with known density $1.00 * 10^3 \frac{kg}{m^3}$ (assuming T = 68 deg F, and atmospheric pressure) would have a mass of

$\left(1.00 * 10^3 \frac{kg}{m^3}\right) * (5.24 * 10^{-10} m^3) = 5.24 * 10^{-7}\ kg$. Gravity is given by $g = 9.81 \frac{m}{s^2}$ and acts in the negative y-direction (toward the ground). Using the equations of motion for a mass subject to gravity, we can calculate the initial velocity of the droplet as follows:

$$\Delta E_{total} = 0 = mgh + \frac{1}{2} mu^2 \ \rightarrow\ u = \sqrt{-2gh} = \sqrt{-2g(0.601\ m)} = 3.43 \frac{m}{s}$$

Using this drop velocity near the pictured instant, we can solve for the Reynolds number of the flow knowing the drop diameter is 0.001 m and the kinematic viscosity of water is $1.004 * 10^{-6} \frac{m^2}{s}$ [4].

$$Re = \frac{uD}{v} = \frac{\left(3.43 \frac{m}{s}\right)(0.001\ m)}{1.004 * 10^{-6} \frac{m^2}{s}} = 3.42 * 10^3$$

Since turbulent flow occurs for $Re > 3{,}000$, This aspect of the flow is turbulent and unstable [4]. This discovery makes sense as the fluid particles appear to be in a chaotic state in the photo. The field of view in this photo is approximately five inches wide and 3.75 inches tall. The shutter speed of 1/1000 s was sufficient to capture the motion of fluid moving up to 3.43 m/s without causing motion blur. The wavy shapes of fluid jets emerging from the splash can be explained by the Plateau-Rayleigh instability whereby liquid streams branch out and form regions with the same volume but lesser surface area as they are propelled upwards [3]. This instability is caused due to small perturbations in the standing fluid that become revealed through the motion of the fluid [3]. Another appealing effect of the photo is the ribbed surface of slosh in the fluid remaining on the drum head which is due to the vibration of the drum membrane [1]. The slosh gives a nice visual effect once edited with the increased contrast levels.

The fluid used was dyed red water with four drops of dye per five cubic inches of water. About two cubic inches of dyed water were placed on the drum head before it was struck. The drum was a Pearl metal snare with Remo drum heads (membranes) and the stick was a Vic Firth 5a. The temperature was approximately 70 degrees Fahrenheit and it was a cloudless day. The lighting was provided by direct sunlight onto the backdrop of a white sheet of paper.

I used a Canon T6i DSLR to achieve this shot. The field of view was about five inches wide by 3.75 inches tall. The lens was held at about seven inches from the splash and the focal length of the lens was $f = 55mm$ which is the maximum zoom for the kit lens used. I used an aperture of f/5.6 which gave a narrow depth of field and made the center of the image pop. The fast shutter speed of 1/1000 sec gave a crisp image with low motion blur. An ISO of 100 was utilized to allow for proper exposure with ample lighting due to the direct sunlight. Digital Photo Professional 4 was critical for cropping and editing the image by applying the tone curves to come to the final version.

Image Before Editing

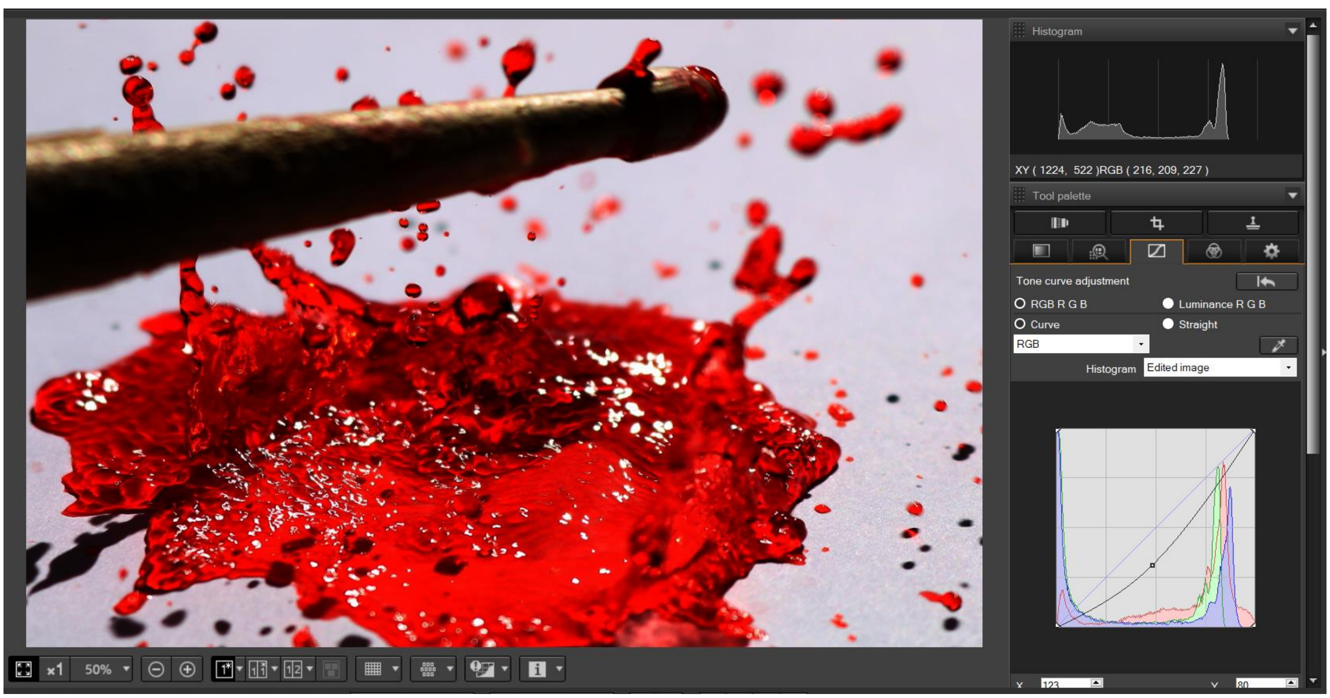


Image After Editing Process

This image is a powerful representation of a combined splash and slosh phenomenon. I like the action and motion in the image shown by the narrow depth of field and the bright red coloring. I wonder if I could achieve a more symmetrical splash with the same setup but by hitting the liquid pool more in the center with more precision. I would like to try and achieve more symmetry in the shot and to have a tripod to properly hold the camera while I strike the drum head. I may be able to achieve a mushroom-like effect if I hit the water in a centered location and I would like to get the stick out of the shot if possible.

References

[1] Abramson, H.N. "The Dynamic Behavior of Liquids in Moving Containers." NASA SP-106, 1966.

[2] Moiseyev, N.N. & V.V. Rumyantsev. "Dynamic Stability of Bodies Containing Fluid." Springer-Verlag, 1968.

[3] Papageorgiou, D. T. (1995). "On the breakup of viscous liquid threads". Physics of Fluids. 7 (7): 1529–1544. Bibcode:1995PhFl....7.1529P. doi:10.1063/1.868540.

[4] "Reynolds Number". www.grc.nasa.gov.