WORTH-ington (the) Jet?

Flow Visualization MCEN - 4228

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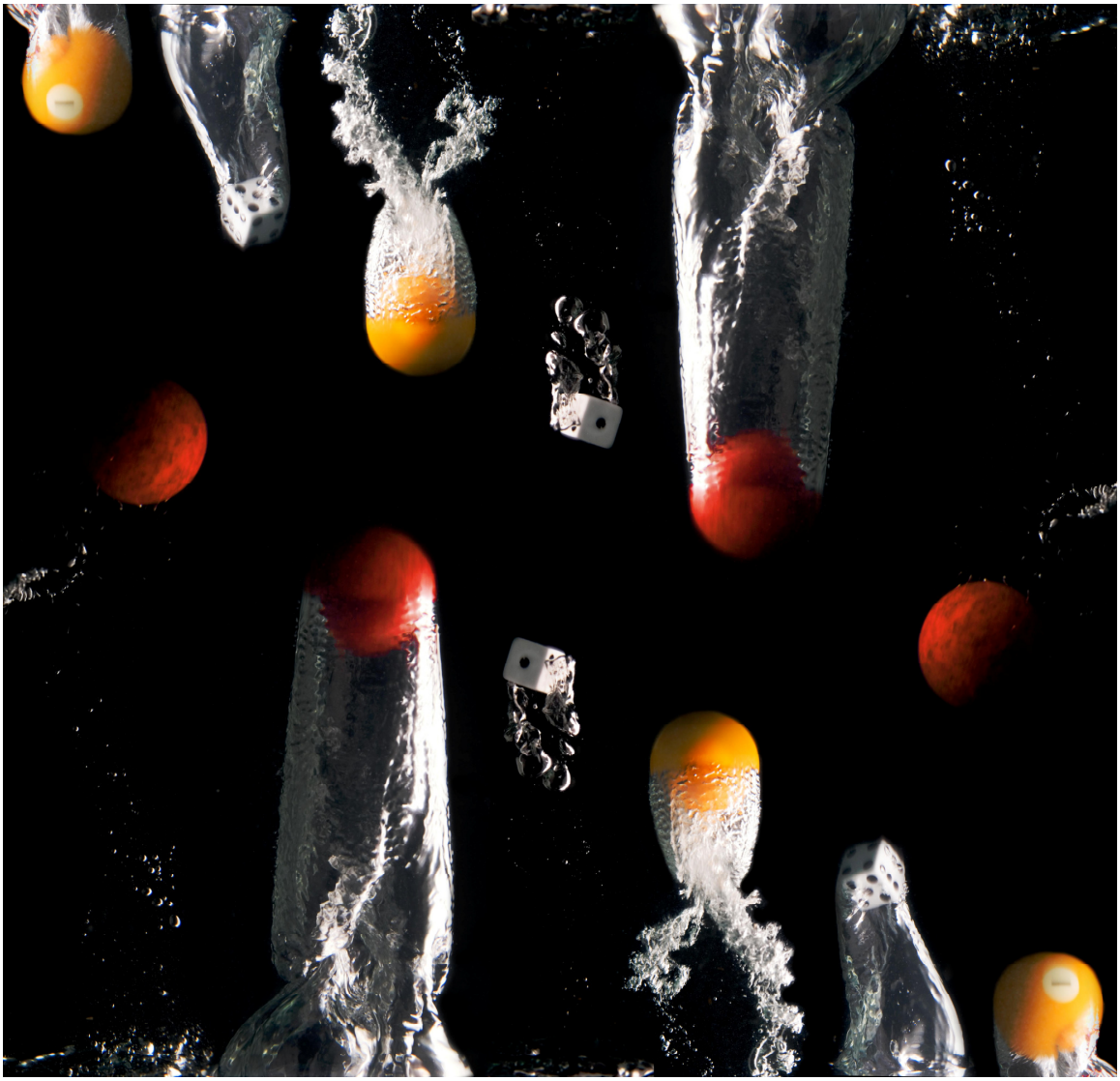

The purpose of this image was to explore the visualization of the Worthington Jet using objects of different size, shape, and volume. We chose both spherical and cubic objects to drop into a tank and create the effect. We also wanted to analyze the visuals below the surface of the water also. This would allow us to learn much more about the effect and hopefully see some really interesting and inspiring fluid dynamics. Since this apparatus is relatively inexpensive, with the exception of a very high quality White Lightning radio controlled strobe, we anticipated being able to capture numerous quality images. After analyzing the both the above and below the surface shots I determine, separate from the rest of my group, that the below the surface shots were much more intriguing and I focused on developing those shots exclusively. The final image is a collage of the most inspiring images, placed together in a reverse height line. Although the presentation of the image was not part of the initial experiment, it adds much more information than I could have created by placing them in individual shots side by side. So although my presentation of the project differs from the initial intent, I believe there is still much that can be learned from the image.

The apparatus that was required for the image was a large 20 gallon fish tank, two cameras on individual tripods, and the White Lightening Strobe. We also placed a cushioning towel at the base of the tank to alleviate any harsh impacts that might cause damage to the tank. The following images show the apparatus that was used to take the images:

Figure - Worthington Apparatus.1

Figure - Worthington Apparatus.2

The apparatus was placed into a room which was very dark. Any windows and doors were also covered with sheets to remove any exterior light. The objects that were dropped into the tank were an orange foosball, a regular die, and a billiard ball. We placed a make-shift alignment apparatus at the top of the tank to help ensure that we were placing the objects in the same position relative to the camera each time. The activation of the strobe was done manually which required a syncing of the objects descent with the strobe. This was all done by an audible countdown and manual trigger to activate the strobe at the appropriate time.

Although the individual images are stitched together the frame of reference for each object is equal, so the size of the die is the same relative to the billiard ball. Since the size of each object is different the characteristic dimensions differ for each. An approximation of the Reynolds number varies between 1.82E5 for the billiard ball and 3.64E4 for the die. Unfortunately these approximations are valid for the entry of the objects into the water, it shows that for the larger image a turbulent boundary is created, but for the smaller objects a laminar boundary is created. This can be seen in the images since the billiard ball and foosball both are carrying large air pockets into the water characteristic of a turbulent boundary layer, while the die has shed most of the air pocket as it has slowed significantly and is now flowing in a laminar manner through the water.

The key lighting feature that we used to capture the image was the White Lightening Strobe, no other lighting was introduced.

The following information is provided to describe the photographic specifications:

- Size of the field of view- 8 inches by 4 inches
- Distance from object to lens- 1.5 feet

- Lens Focal Length – 50mm
- Type of Camera – Canon EOS 40D
- Exposure specs:
    - Aperture – f/8.0
    - Shutter Speed – 0 (Manual)
    - ISO - 100

In order to create the image it was post processed in Adobe Photoshop. First, each image was defogged with an un-sharpen mask. The curves were adjusted then the levels were adjusted before boosting the saturation to bring out the colors. The contrast was also slightly boosted. As stated before the layers were merged, and the image was copied, flipped, and rotated to show it coming from both the top of the image and bottom.

The image is quite impressive when placed together in the collage. Every time I look at it I gain more information; seeing the foosball maintain a high velocity while the turbulent air pocket follows it. Yet, in the far image it has decreased speed significantly enough that the air pocket is gone and a fully laminar flow exists. I also especially enjoy seeing the twisting that is occurring after impact. Whether there was twisting that existed from the objects being dropped, or the surface structure of the water is shearing the object in a rotational manner, the effect is visually impressive. Although the original intent was not realized the final product is still worth the effort. I am completely satisfied with the output and can safely say it is my favorite image of all I was able to capture this semester.