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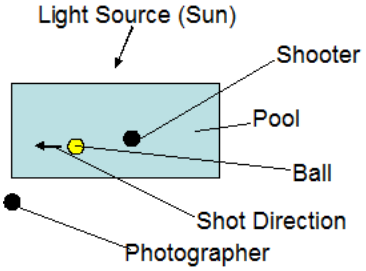
MCEN 4151 Flow Visualization
Professor Jean Hertzberg
May 3, 2012

Team 3

This was the third team image that was set up for this class. This shoot was set up in the pool area at the rec center to try and capture various fluid phenomena associated with a standard day at the pool. We photographed cannonballs off the diving boards, water trails off thrown water polo shots, and the surface tension of the water over swimmers "breaking out." In the end we decided that a skip shot with a water polo ball was the coolest to look at and try to explain. The image was set up so that the shooter was lined up with the sun light coming through the windows in the pool area to better illuminate the water's behavior. We tried to set up the shot so that the bouncing ball was the center and focus of the image, but we wanted to leave the shooter in the image to give the ball some context as to where the shot came from, and how this image was set up. After a few small camera position adjustments (to get out of the way of stray splashes and balls that caught a weird bounce) we were able to get a few good shots of this phenomena.

After doing a lot of research, I was able to find some of the physics at work here. The main factors that affect the trajectory of the ball include its speed, its spins, the angle of incidence, the surface area of the ball. There are also pressure forces at work here. As the object hits the water, it experiences a multitude of forces. There is momentum transfer as the ball hits the water, it loses a bit of its forward momentum; but when this happens the ball also produces waves on the surface of the water which will cause the object to move back up those interference waves and back into the air. There are also the pressure forces acting in the form of buoyancy. The ball is less dense than the water it is hitting and it moves a greater volume of water than the submerged part of the ball causing an upward force as the water "pushes" back into place and sends the ball back into the air at roughly the same angle as that of incidence. While shooting this ball, it is traveling at roughly 30 mph and had and angle of incidence of roughly 40 degrees. (the angle of incidence is so high because of the way in which the shot was set up; it was set up to bounce very high instead of resemble an actual shot to better capture the fluid behavior of the ricocheting ball)



Looking at the photo, you can also see a secondary fluid flow caused by the ball hitting the water and my arm hitting the water. Where both the ball and my arm displaced water, it caused a pressure driven flow resembling a free jet. The water near my arm can be seen as traveling as a thin laminar sheet that then breaks into turbulent particles flowing away from the initial displacement, where as the ball caused a more uniform turbulent flow with the water it displaced.

In order to best capture the fluid behavior in this image, the light source position was critical. I wanted to be able to see the little trails and sheets of water that were being created during each shot, so I told my photographer(Zach Strande) where I wanted everything positioned in the photo so we could best accomplish this. The position of the sunlight coming in from the back illuminated the water and really helped define their behavior and boundaries. With this light in the back, we are really able to see how the water behaves under these stresses.

This photo was shot with the following specifications;

CAMERA	Canon EOS Rebel T2i
SHUTTER SPEED	1/400 sec
F-STOP	f/9
APERATURE VALUE	f/4.6
ISO	640
FOCAL LENGTH	36.0mm
LENS	EF-S18-55mm f/3.5-5.6 IS
PIXEL DIMENSIONS	5184 by 3456

I really like how this image reveals multiple types of fluid flow during one event. It shows buoyancy properties as well as free jet behavior. I really like how the backlighting from the sum helps illuminate the flow and really make the image pop. The set up of the image was everything I wanted it to be, and I really cannot complain about how the image turned out. The only other avenue I would like to pursue is the possibility of setting up a high speed camera closer to the ricochet point to really see what the liquid is doing throughout the whole process. Overall, this was one of the most fun shoots and a really fun way to end the semester.

Sources:

"When Airplanes Crash in Water." . U Tutor, 2002. Web. 8 May 2012. <http://www.physicspost.com/physicsforums/topic.asp-ARCHIVE=&TOPIC_ID=5750.htm>.

A S Soliman, S R Reid, W Johnson, . "International Journal of Mechanical Sciences." *The effect of spherical projectile speed in ricochet off water and sand*. MENDELEY, n.d. Web. <http://www.mendeley.com/research/effect-spherical-projectile-speed-ricochet-water-sand/>.