Team Third

MCEN 4151

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The image described in this report is the last deliverable in the University of Colorado's Flow Visualization class and was intended to be a team project, however, due to time constraints I was forced to do this one alone. My intention was to capture the amazing flow presented by the beautiful sculpture in the Engineering Center courtyard. In this sculpture, water pressure alone is levitating a huge stone sphere it such a way that the sphere may rotate freely and the water does not jet out in an enormous fountain as one might expect. This is called a Kugel fountain.

The apparatus for this demonstration is simple. A polished granite sphere is placed into a socket of matching radius. Water pressure is then applied to the underside of the sphere through a small orifice in the socket. The water pressure then displaces the granite sphere and is allowed to escape past the socket/sphere interface and become recycled back into the fountain. This geometry can be seen in figure 1.

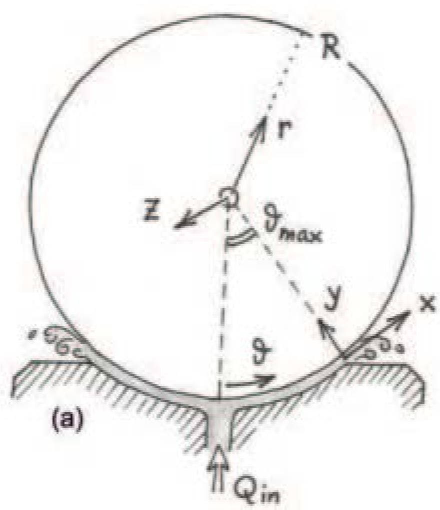

Figure 1: A graphical representation of how a Kugel fountain is oriented.[1]

The driving factor behind the Kugel fountain levitation is simple lubrication. The pressure in the water build up an extremely thin layer of fluid that squeezes itself between the surface of the socket and the sphere. This pressure is very small, but when integrated over the area of the submerged sphere tunes out to be the same as the enormous weight of the granite sphere. If F_g is the weight of the sphere and F_{up} is the force exerted on the sphere by the water pressure, then

$$F_g = F_{up} = \iint_{A_{sub}} [P(\theta) - P_{atm}] \cos\theta dA,$$

Equation 1

[1] Snoeijer, J., K. Weele. "Physics of the granite sphere fountain." *Department of Mathematics, University of Patras, Greece* (2014). Print.

where A_{sub} represents the total submerged area of the sphere.[2] This means that for a granite sphere of roughly $1\ m$ ($\cong 1440\ kg$), as the Engineering Center courtyard fountain is, it only takes about $0.1\ atm$ of pressure beyond that of current atmospheric pressure to levitate. With such a surprisingly low pressure required, it become clearly obvious why the fountain works the way it does and does not shoot streaming jets of water out in every direction.

The setting for this photo was a beautiful spring day with the sun brilliantly shining… the quintessential end of Spring Semester day. The light was perfect for capturing the glistening water coming of the Kugel fountain producing a wonderfully contrasted and dazzling final image for Flow Visualization.

This photo was taken with a Motorola Droid Razr HD 8 MP camera. The focal length was $4.4\ mm$, the F-stop and aperture values were $f/2.4$, and the shutter speed was $1/Infinity\ sec$. I chose the particular angle and field of view because I liked the aesthetic it was providing at the moment. Finally, I used Photoshop to post process the image. I increased contrast, decreased exposure, cropped, and adjusted gamma correction to achieve a satisfactory final image. The original of this image can be seen in figure 2.

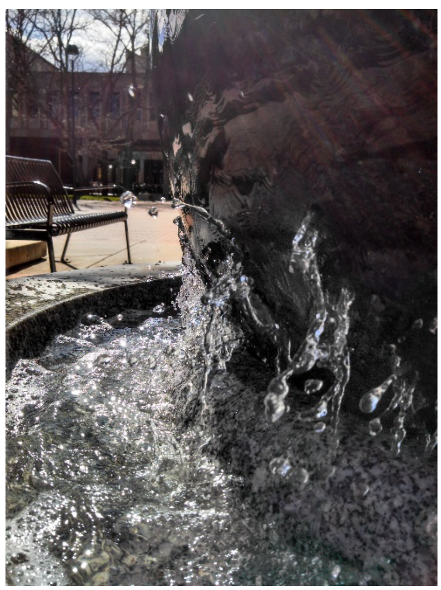

Figure 3 – Original image as captured before Photoshop.

This image is particularly near and dear to me as this Kugel fountain was the first I had ever seen when I started my Engineering degree here at CU in 2005. One of my fondest memories was sitting by this fountain in between classes freshman year, reading Ishmael and contemplating all the possibilities of what will come over the next 4 plus years. Now, I am graduating, contemplating the possibilities of what will come now, and will always remember those moments spent by the Kugel fountain.

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[2] Snoeijer, J., K. Weele. "Physics of the granite sphere fountain." *Department of Mathematics, University of Patras, Greece* (2014). Print.