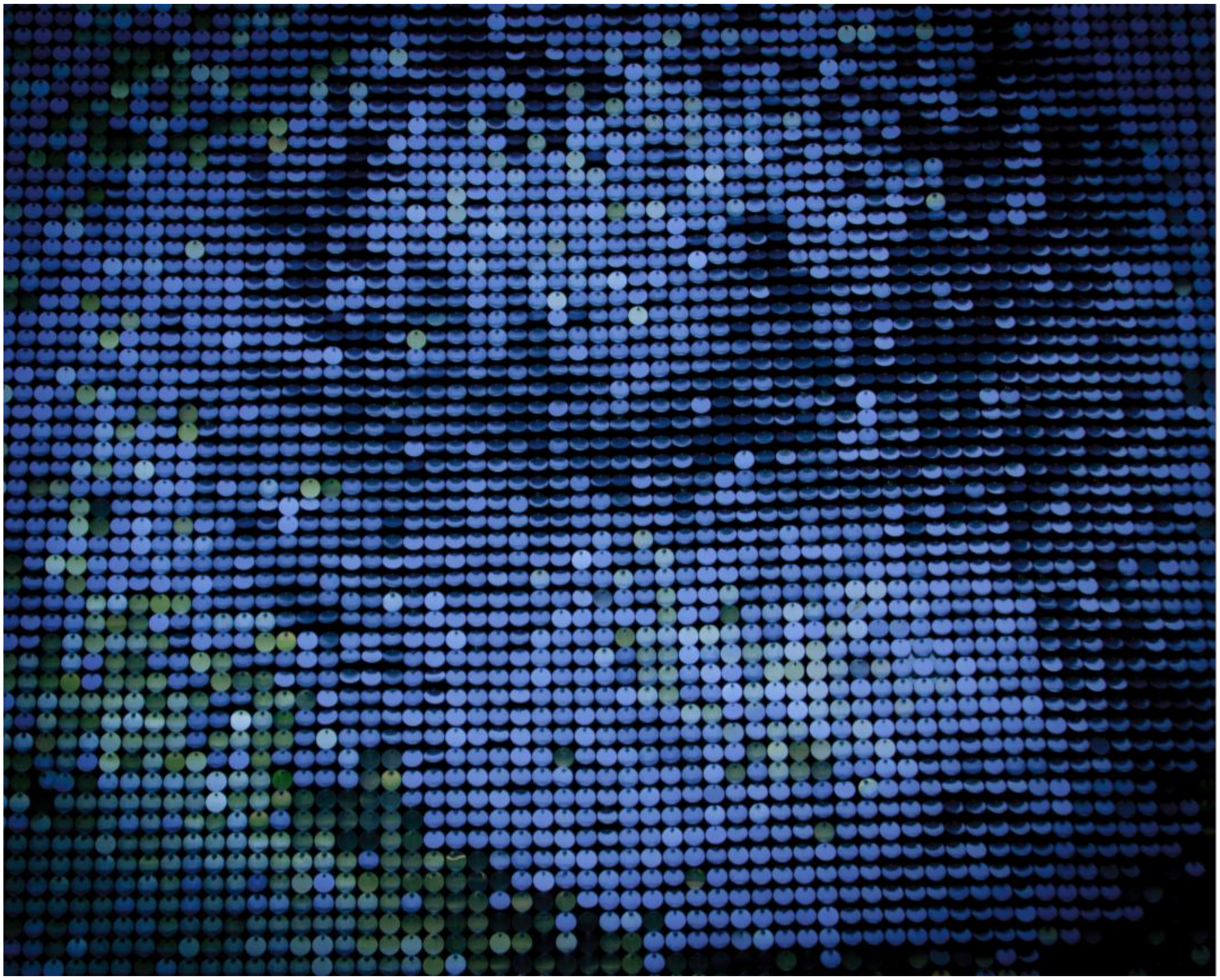
Team Project 3



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Flow Visualization

5/2/12

Purpose

The initial purpose of this photo was to try and capture the beauty of the "wind sculpture" outside of the ITLL. I have always enjoyed looking at that piece of artwork and I think it is a beautiful representation of wind flow. Basically the wind sculpture consists of a wall where there are hundreds of small circular disks attached by small posts to a membrane behind them. This then allows the small circular disks to flow in the wind and their silver color creates a beautiful illusion. Although, this picture was taken on a day when there was little to no wind, it did take longer to capture the picture. I also took several pictures at different angles, and from the side, but decided on a front view of the sculpture for my final picture.

Apparatus

The set up I had was very simple, since the sculpture was already created. However, Figure1 shows a side view of the different dimensions of the setup of how it took the picture.

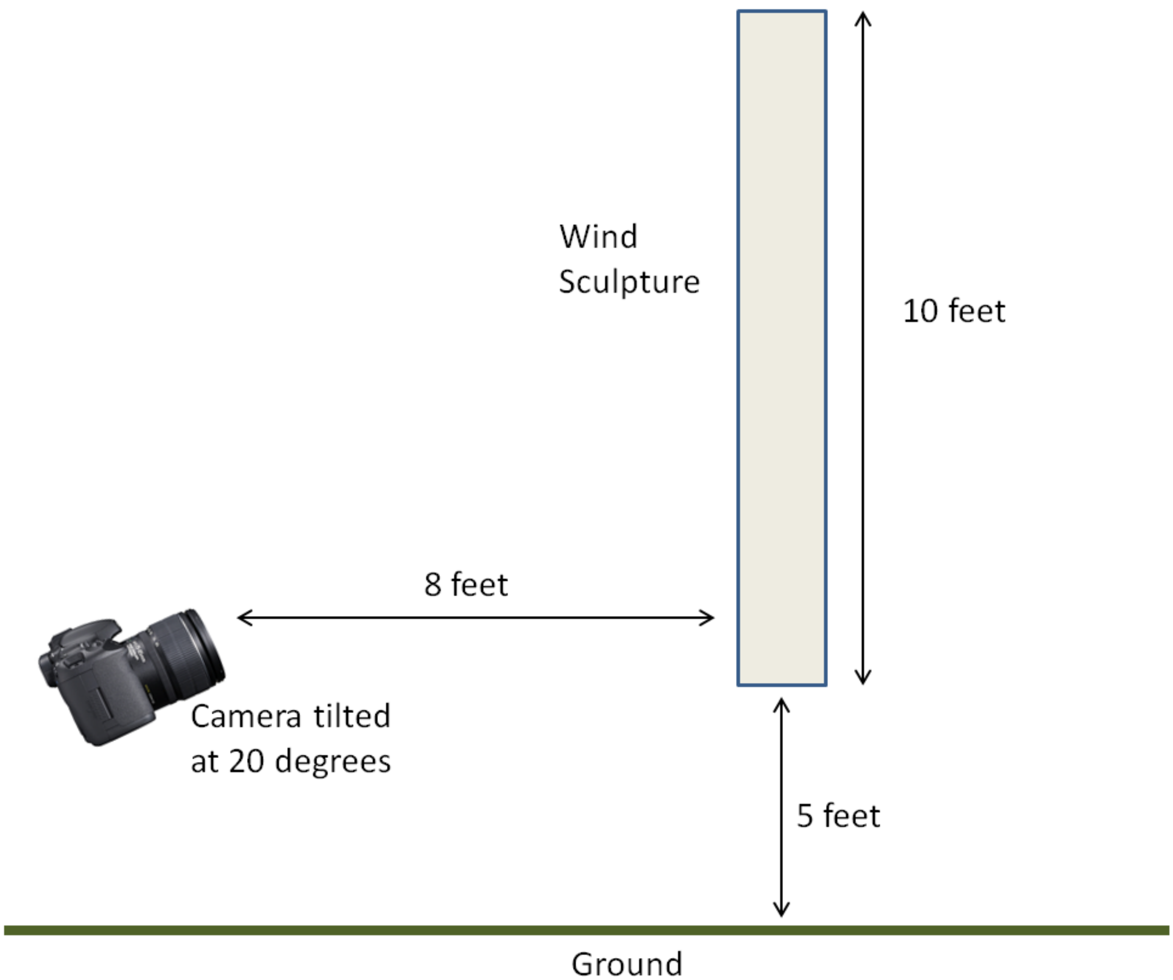

Figure 1: Side view of Apparatus

Physics behind the Image

During this day the wind was very mild and it was a challenge to capture a picture when the tiles were moving due to such a slow wind speed. According to weather.com on that day the average wind speeds were about 5 miles per hour. Knowing this information it makes it easier to determine the Reynolds number of the device. The Reynolds number is a dimensionless number that is the ratio of inertial forces to viscous forces [1]. The Reynolds number is then equal to the velocity multiplied by the characteristic length and all of it is divided by the kinematic viscosity. The characteristic length of the fluid is the distance from the edge of the sculpture to the disk which can vary from .0124 to .075 meters, the velocity is 2.24 m/s, the kinematic viscosity of air at 300K is $15.68\times10^{-6} m^2/s$ [2]. When these values are plugged into the definition of Reynolds number it is between 1,700 and 10,700. Since these numbers are relatively small when it is compared to the definition of turbulent flow, we can learn that the wind blowing that day through the disks was relatively laminar; however it is fairly close to turbulent and may have been at points during the day sue to varying wind speeds.

Besides the Reynolds number, the boundary layer thickness can have an effect on the fluid flow in this picture. Prandtl showed that the flow past a body can be divided into two regions: a very thin layer that is close to the body where the viscosity is important. The next is a layer that is further away and the viscosity can be neglected [3]. After this it was not difficult to convince people of the importance of viscosity in the drag equation [3].

Now that we are assuming the flow to be laminar we can now evaluate the boundary layer thickness. For the boundary layer thickness over a flat plate with laminar flow it is described as 4.91 multiplied by the distance downstream from the start of the boundary layer and all of it divided by the square root of the Reynolds number [4]. For this picture I am going to solve for the boundary layer thickness a six inches in and then at the end of the picture which is approximately three feet. At six inches in the boundary layer thickness is .0124 meters and at the very left of the picture it is .075 meters. This is also done assuming that the boundary layer begins at the very edge of the sculpture, which is on the right side of the picture and that no slip conditions can be applied. There are also several spots that look as if the flow is more turbulent or that it created vortices and this may have been due to the direction that the wind was blowing and the direction it hit the disks after it blew by the ITLL building.

Visualization Technique

The visualization technique used for this project was allowing small disks to flow in the wind. I didn't use any dye or anything special to create the image. It is merely small metal disks blowing in the wind. The field of view for this image is approximately two feet by two feet. The distance from the object to the lens was also approximately eight feet. The camera used was a Sony Alpha 230, that takes digital images, and the flash did not fire. The focal length of the picture was 55 mm, the f-stop was 6.3, shutter speed was 1/125 seconds, and the ISO was 100. The picture is 3,217 pixels wide and is 2,592 pixels in height. I also did some editing in Photoshop after capturing the picture to create a different effect. I did this since many of the engineering students have seen this sculpture, so I tried to give it a very different effect to make it seem a little more exciting. I changed the color a little more by adding blue tints to the picture as well as adding a little more contrast to the picture. After changing the picture, I add a vignette to the picture to add a little more of a dramatic effect to the picture. The original and final picture can be seen in Figures 2 and 3 respectively.

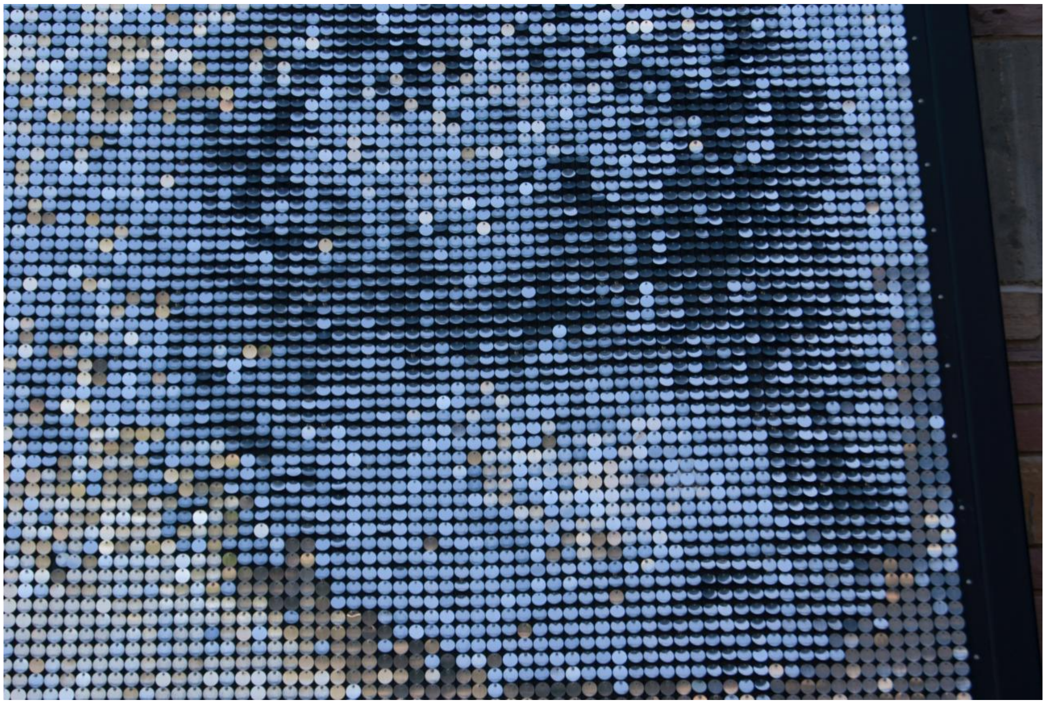

Figure 2: Original Picture

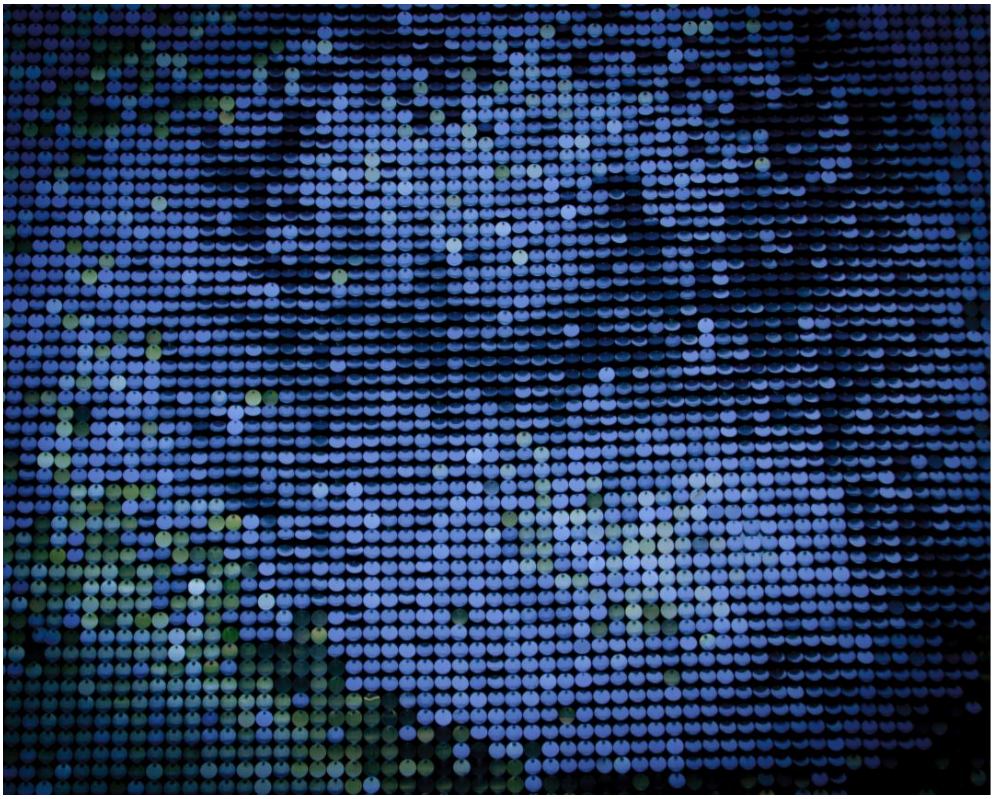

Figure 3: Final Picture

Conclusion

I really like how this image turned out and I was pleasantly surprised by it. I thought that it would appear almost boring and that it would look too plain. I like how there is so much depth in the picture and I like how it was taken at angle because I think it adds a little something to the picture. I think that the physics are shown pretty well in this picture although they may appear fairly plain they still look beautiful. I think that if I were going to take the picture again I would take it at an angle from the side and used slightly different editing techniques. However, I like how this photo turned out, because it looks interesting and it shows the physics of wind flow adequately.

References

[1] Streeter, V. L. (1962). *Fluid Mechanics* (3rd ed.). McGraw-Hill.

[2] "Air - Absolute and Kinematic Viscosity." *Air - Absolute and Kinematic Viscosity*. Web. 07 May 2012. <http://www.engineeringtoolbox.com/air-absolute-kinematic-viscosity-d_601.html>.

[3] Schlichting, Hermann. *Boundary-layer Theory*. New York: McGraw-Hill, 1979. Print.

[4] "Boundary-layer Thickness." *Wikipedia*. Wikimedia Foundation, 18 Apr. 2012. Web. 07 May 2012. <http://en.wikipedia.org/wiki/Boundary-layer_thickness>.