Image Report 2
Flow Visualization | CINE 4200
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Introduction:

This image was taken of a non-conventional subject to explore the idea that plant matter, in this particular case wood, can be viewed as a highly viscous fluid. The phenomena visualized is similar to air streams around an airfoil. The velocity of the flow is inversely proportional to the density of the grains of the wood.

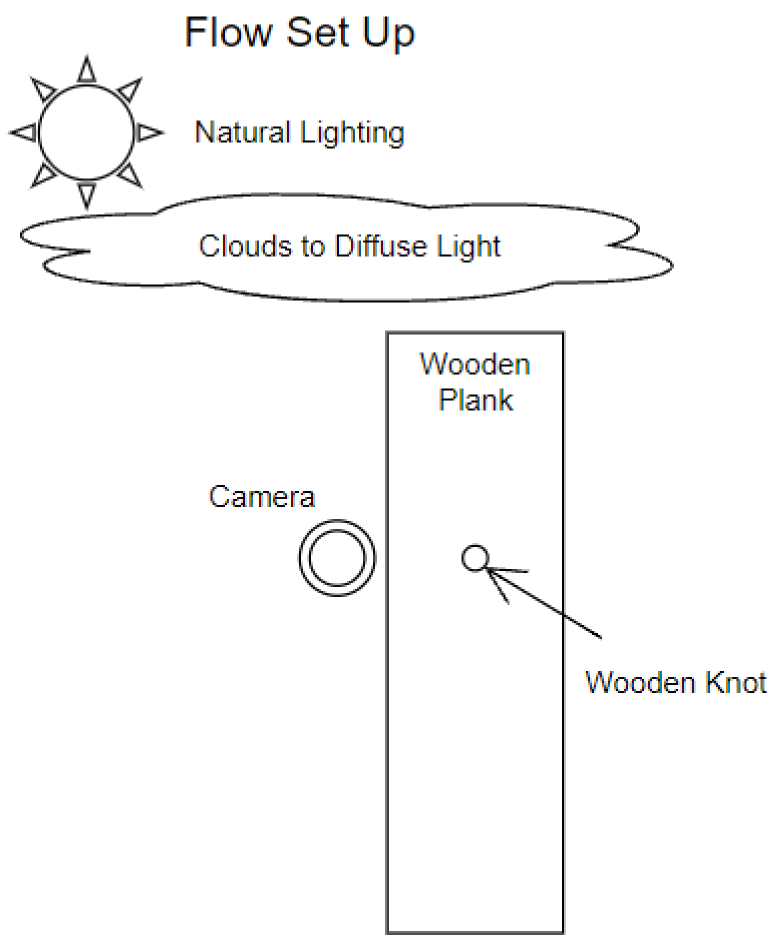

Figure 1. The set up for taking the image, with the flow already having been created and stationary on the plank.

Analysis:

The flow was captured as shown in the image above, where the flow itself was complete and stationary, being that the tree had been cut down and was no longer growing. The fence plank itself can be seen as a still image of the flow of the trunk mass around the tree knot. In trees, the plant matter grows at a rate proportional to the amount of available water that year. In years with more growth, the rings of the tree will be larger with less growth during the years of drought. As shown in the image below, it can be observed that the rings (darker portions of the tree wood) are at varying lengths from each other. This is due to the fact that the growth of the tree matter can also be slowed if it hits a hard barrier, like a knot in the trunk wood.

Figure 2. The image of wood growth with the knot in the middle.

This image below shows in greater detail the specific phenomena that is occurring here, which is a good visual of the Kutta-Joukowski theorem. This theorem describes the lift between an airfoil, or even circular cylinders (such as the tree knot) and a fluid at a relatively constant flow velocity.

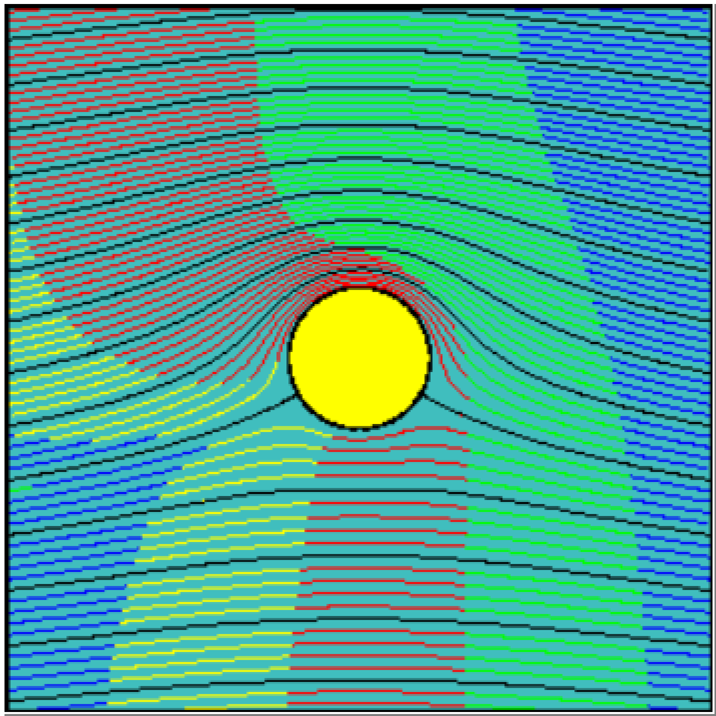

Figure 3. Flow lines around a circular cylinder.[1]

Due to Bernoulli's equation, the pressure at the top of the cylinder is higher than that of the pressure below the cylinder, creating lift force. This is why the grains of the wood on the bottom of the knot are much wider and more spread out than the grains above the knot.

$$P_1 + \frac{1}{2}\rho {v_1}^2 = P_2 + \frac{1}{2}\rho {v_2}^2$$

Equation 1. Bernoulli's equation, which allows us to see that the pressure above the cylinder is higher than that of the pressure below the cylinder, due to the relative densities and velocities of the plant matter.[2]

<u>Technique:</u>

The image was taken using natural lighting, where the sun was covered by a large amount of clouds to defuse the light and provide even lighting. This allowed for the image to have limited to no shadows and highlights the grain over the texture of the wooden plank.

The camera utilized for this photo was an iPhone camera, where the shutter speed of the camera was not important as the flow was stationary during the picture. The ISO was set to 400 to not overexpose the image but also capture enough of the detail of the grain. In editing the image, the contrast was slightly increased to bring out the difference between the light and dark grains, while the shadows were brought down to ensure that the details of the wood were clearly visible. The saturation of the photo was also slightly dropped, so that the color of the wood would not be distracting from the flow phenomena being captured. Finally, the knot in the wood was centered during the photo for framing purposes, with the camera parallel in plane with the plank of wood.

<u>Opinion:</u>

The goal of this image was to provide a new perspective on what fluid flow is, by imagining that the plant matter in a tree trunk is a highly viscous fluid that flows around objects such as tree knots and branches as it flows upward interestingly against gravity. This image shows how the trunk matter's growth rate is altered by the presence of a knot and resembles the phenomena one would see with a circular cylinder interrupting fluid flow.

I'm curious about the physical properties that could be estimated for trunk matter, I was unable to find a viscosity for tree trunks, due to it being better represented as a solid. I'd be curious to see a similar plank of wood from a different tree species to observe differences between the two.

<u>Sources:</u>

1. Sanghyeokjeffpark. "Kutta - Joukowski Theorem." *LOFF*, 4 June 2020, https://lifeofaflyingfreak.com/kutta-joukowski-theorem/.
2. Roderick, Michael L., and Sandra L. Berry. "Linking Wood Density with Tree Growth and Environment: A Theoretical Analysis Based on the Motion of Water." *New Phytologist Foundation*, John Wiley & Sons, Ltd, 4 Jan. 2002, https://nph.onlinelibrary.wiley.com/doi/10.1046/j.1469-8137.2001.00054.x.