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Air turbulence Over an Airfoil Producing Downforce

For this project, we were tasked to create an interesting and visually stunning representation of a fluid flow phenomenon. In this project, Chris Leong and I set out to show the turbulence and drag caused by downforce. We wanted to observe how the air coming off an airfoil would look visualized in something other than CAD.

For this project, we created a makeshift wind tunnel, with cardboard and 3-d printed parts. We made a tunnel put of carboard and put 3-d printed air straighteners on the ends. We poured boiling water over dry ice to make sublimated CO2 gas. We put a fan at the end of the tunnel to pull air through the tunnel. The airfoil was held in place with a cotton swab and a pipe cleaner in the back of the apparatus. The fan creates a low-pressure area at the right side of the tunnel causing the air to accelerate due to this pressure difference and the air moves, pulling the CO2 with it. The CO2 then flows over the air foil, which creates turbulence. The Renolds number of this equation was about 3286.75 making this flow transitional. The inlet of the tunnel was about 120mm, and I estimated the speed of the air due to inconsistencies due to changes in the distance of the fan when we were experimenting. In this shot I believe that the flow is transitional, however when we pressed the fan up to the end of the tunnel, the flow was

turbulent. According to Science Direct, the phenomenon we see (downforce) is created by low pressure on the bottom of the airfoil and high pressure on the top. This is achieved by leading-edge creating vortices that accelerate the air on the bottom. According to NASA most of this effect is generated by the acceleration of a gas in a particular direction, in this case gas is being moved upward, causing the foil to feel a downward force.

$$Re = \frac{0.12m \cdot .4\frac{m}{s} \cdot 1.225\frac{kg}{m^3}}{1.789 \cdot 10^{-5}\, pa \cdot s} = 3286$$

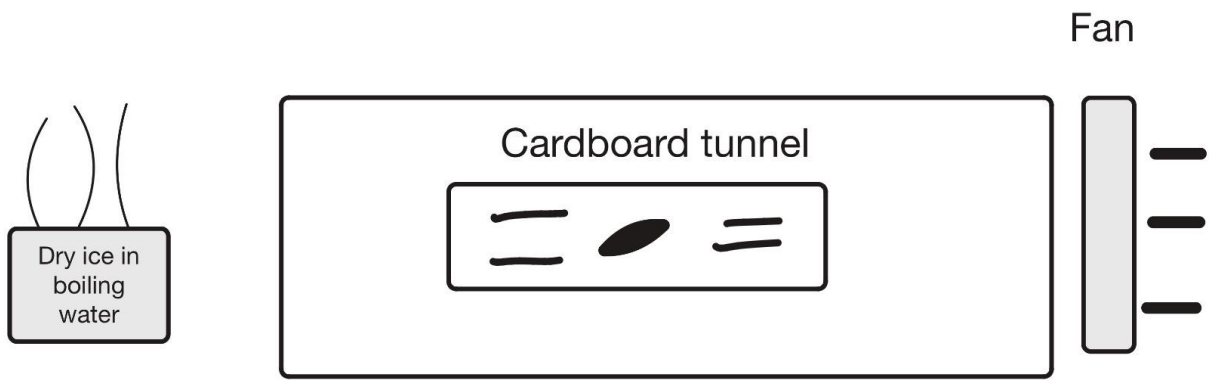


Figure 1: Diagram of setup



We used sublimated CO2 gas made from putting dry ice in boiling water. We obtained dry ice from Safeway in Superior. We shot in a dark garage, to reduce the glare created by the very reflective acrylic that we used for the viewing window. To light the shot, we cut a hole in the top of the tunnel and shone a headlamp through. This was good because it was less harsh than a flashlight and didn't cause unwanted reflections.

The camera was around 6 inches away from the foil. This was shot on a Sony A7II , the lens was a Tamron 17 – 28 with and f stop of f 2.8, a focal length of 28mm, a shutter speed of 1/250, and an iso of 640. We were able to light our phenomenon well which made shooting it easier and we were able to

resolve the photo much better. The final image was 6,022 × 3,266 pixels. The image was cropped down, and the global brilliance of the photo was increased to make the gas more obvious.

This image reveals the chaotic, yet very beautiful flow of air over aerodynamic devices such as this one. I believe our intentions were met, and we are able to show a very beautiful flow. The turbulence of the flow was captured in a meaningful way. The fluid physics are revealed in a meaningful way and it is very telling. If we did this again, I would shift the focus of the camera further back so that the fog is the focus and not the foil itself, and I would change the material of the tunnel so that it looked prettier.

Works Cited

Downforce - An Overview | Sciencedirect Topics, www.sciencedirect.com/topics/engineering/downforce. Accessed 5 Nov. 2026.

"What Is Lift?" *NASA*, NASA, 21 July 2022, www1.grc.nasa.gov/beginners-guide-to-aeronautics/what-is-lift/.

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