Team First Report
MCEN 4151

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With the help of Team epsilon
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This is the first team project, we were trying to understand the flow of smoke in ambient air and the interaction between smoke and a laser projector. Smoke's motion is usually turbulent; therefore, we were trying to see this turbulence and understand the reason that causes it. Initially, the team thought about using smoking vape as a source of smoke. However, the vaporizer we used produced a heavy smoke making it more difficult to study and analyze. Also, the team was trying to generate a flow that looks both beautiful and scientific, our vaporizer did not generate the flow that we were wishing to see. Hence, the team decided to use candle smoke since it is lighter and creates better shapes. The team helped me to produce my video, I used Philip Nystrom's Camera, and Zach Marshall was holding and blowing out the candle under the projector.

The motion of the smoke is laminar initially and then it starts to move back and forth which makes it turbulent at this stage. Figure 1 shows the flow of candle smoke after blowing it out, region A shows the laminar flow, while B shows the turbulent flow. This shows us that there is something changing between region A and B. If we review the Reynold's number equation we can see that if the speed increased, then Reynold's number increases as well, which explains the phenomenon shown in figure 1.

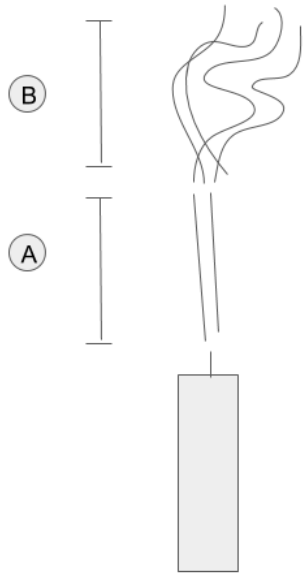

Figure 1: Two different regions of candle's smoke.

Equation 1 is the Reynold's number equation, which tells you whether a flow is turbulent or laminar. The characteristic length of the candle's smoke was approximately 0.381 meters, while the smoke speed was approximately 0.2032 meters per second. Also, smoke density is approximately 2200 kg/(m^3) since it consisted of ^{12}C. Finally, taking the dynamic viscosity of smoke to be $1.2 * 10^{-5}$ kg/(m*s), assuming it is the same as air. Hence, plugging these values in equation 1 we will get a number larger than 2000 which indicated it is a turbulent flow.

$$Re = \frac{\rho v l}{\mu}$$ Equation 1

Since our project tries to see the effect of a projector's laser on the smoke, we tried to blow out the candle under a projector. Since the density of the smoke is lower than the density of air, then the smoke will raise up until the projector's laser hits the smoke and creates a colorful flow of smoke. The experiment was made in one of the classrooms at the University of Colorado Boulder, and the team used the projector that was available there. Therefore, the temperature was ambient temperature, and all the lights were turned off. The only source of light used in that experiment was the light of the projector.

The camera that was used to take this video was Canon 6D with a fixed 50mm lens. The field of view is about 1 meter while the distance from object to lens is 1.5 meters. The video is 720x1280 pixels at 60hz. The video was made using Lightworks video editor, and the speed of the video was reduced to ½ the original speed.

The image reveals the flow of smoke and how air affects its motion. As seen in the video, the smoke is taking complex shapes due to the effect of air. Therefore, we can conclude that smoke can easily get affected by the speed of air since it is less dense than air. What I like the most about the video is the color of smoke and how it is diverging the light. I believe that the image clearly shows the effect of air speed on Reynold's number since the smoke started to flow in a laminar motion, then it became turbulent after interacting with air. I would like to improve the video by making it to fade to black instead of cutting it off mid image, as well as making it a little bit longer. To develop this idea further, I would try using o-ring smoke generator and try to shoot them in front of the projector.