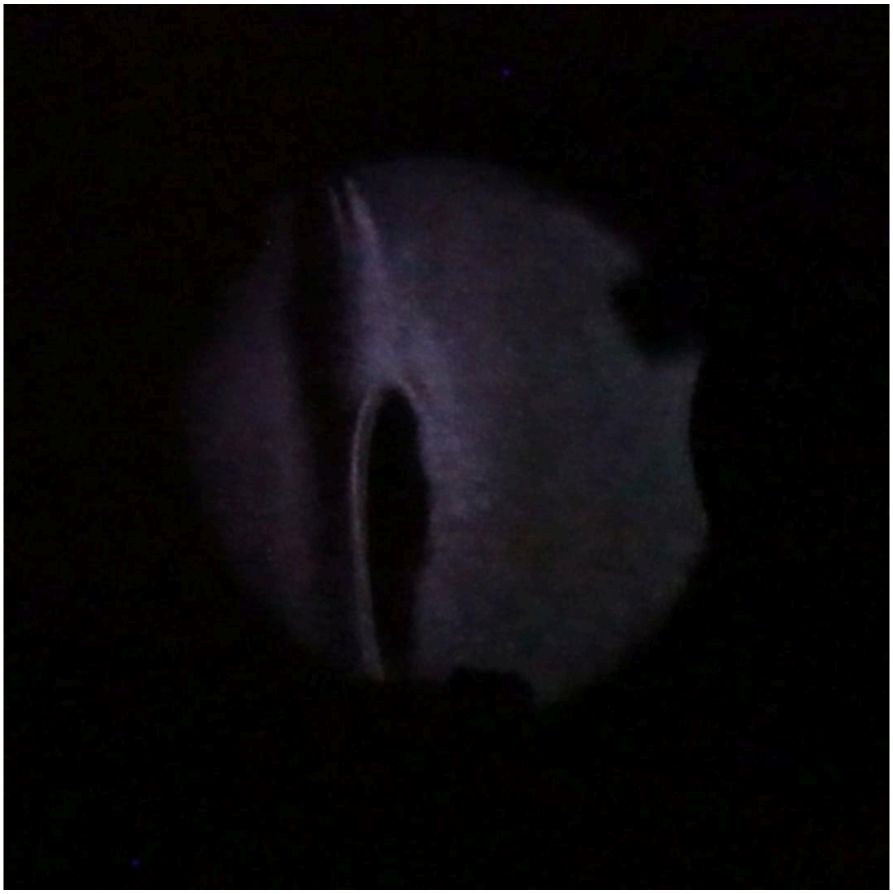

Schlieren Air Foil Flow

Team Second

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MCEN 4147

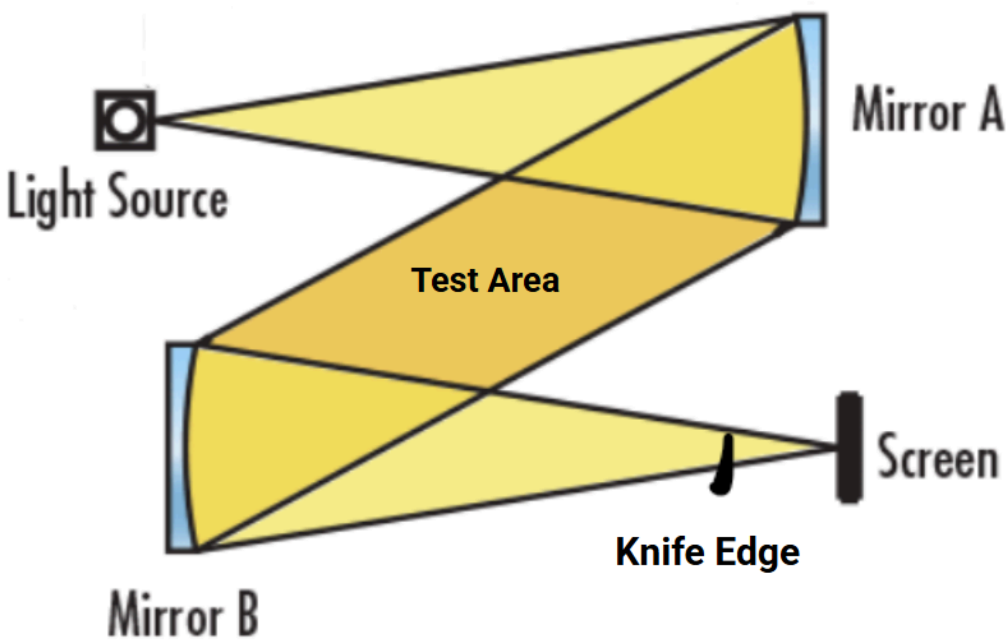
11/3/2025

For this project, we created a Schlieren visualization setup to capture the flow of air around an airfoil. By using a Schlieren setup we planned to capture how air foils create lift by developing high and low pressure zones on either side. This proved to be quite difficult in practice. The projected image would only appear on camera with a high exposure which decreased the amount of detail captured. With many trials we managed to capture the flow above.

$$Re = (0.7) * (0.050)/(1.5 * 10^{-5}) = 2.33 * 10^{3}$$

This Renolds number equation reveals that the flow is in the transitional phase, which is perfect for our experiment. Since it is so close from transitioning from laminar to turbulent flow, small differences in pressure and velocity caused by the air foil could change the flow from laminar to turbulent flow, which furthermore showed the function of an air foil.

This resulted in a flow that shows well defined laminar flow on the left and the fuzzy turbulent flow on the right, along with a clear boundary layer sitting along the airfoil's surface on the laminar side. The left side of the photo represents the top of the air foil, where pressure and velocity are lower which allows laminar flow to continue, while the right side contains higher pressure and velocity leading to more turbulent flow. This visualizes the pressure difference between each side of the air foil, demonstrating the core physics behind the lift generated on an air foil.



Shlieren imaging was chosen because it makes changes in the air’s density visible, which is ideal for capturing heated air rising over the airfoil. We used a Z-type Schlieren setup, which was focused on a 3d printed airfoil mounted around 4 inches above a lighter, with the airfoil centered across rising hot, low density air emitted from the lighter. A light source is allowed through a slit onto a series of two concave mirrors. The subject (the airfoil and lighter) sit in between the two mirrors, then after the second mirror at the focal point a knife edge is placed to exaggerate the effects of diffraction different densities cause in air. This final image was then shown on a black backdrop which the camera was focused on at a distance of 6 to 12 inches. By controlling the light path, lining up the knife edge, and moving the subject, the flow became visible as sharp gradients in the final image.

To capture the Schlieren effect clearly, we selected camera settings that mimicked what we have seen used in previous Schlieren setups, balancing sharpness and exposure.

Field of view: 6x6 in

Camera to projection distance: 6 in

Focal length: F5.6

Camera: Canon EOS Rebel T3i

ISO: 12800

Editing: Decreased sharpness, Increased contrast, Increased highlights

These choices allowed the Schlieren image to be visible on the camera and helped make the flow patterns more apparent and easy to interpret.

The final image successfully reveals the boundary layer and the difference between laminar and turbulent flow over the airfoil. Unfortunately the image is very dark and grainy, it lacks detail and sharpness. In the future if I tried this technique again, I would use a brighter light source and setup in a much darker environment. Overall, the experiment demonstrated the effectiveness of Schlieren visualization, and future improvements could reveal even more detailed fluid behavior.