Advanced Physics Laboratory 2025 – Wind Tunnel Project

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Driver and Smoke Production

Figure 1: Obtaining Angle Data for White Fan.

Figure 2: Smoke Producing Machine

- While we originally wanted to use the white fan as shown in **Figure 1**, the wind speed was deemed too low to blow through the length of the wind tunnel.
- The black fan shown in **Figure 3** proved to be an adequate replacement, although still not very uniform as shown in **Figure 4**.
- Smoke production proved harder than first expected. We first used the smoke machine shown in **Figure 2**, however the smoke produced was too thick and *inconsistent*.
- Another design included burning incense in a mason jar, and then pumping smoke out of the jar. This design proved too weak, and we ultimately fell back on using the smoke machine we first landed on.
- *If* we were to use the smoke machine, the wind tunnel as a whole will be physically constrained to being outside, near a snorkel, near a fume hood, or other ventilation systems.

Figure 3: Black Fan.

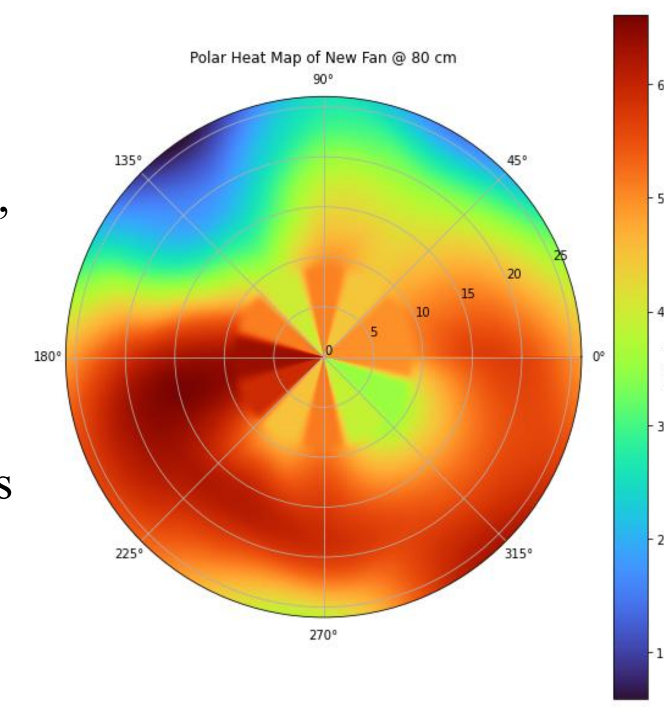


Figure 4: Polar Heat Map for Black Fan. Max Speed of 6.3 m/s.

Mechanical Design and Construction

Key Objectives:

- Develop robust, and repeatable construction methods with focus on flexibility and adaptability.

Materials:

- EPS foam board, contact cement, mod podge, black acrylic paint, hot glue, pins, and 3/8" bolts, nuts, and washers.

Construction:

- The housing chamber is created from four separate pieces of laminated bilayer EPS poster board secured by contact cement, with a 0.545x0.545 m cross section. The contraction chamber's dimensions are 0.545 x 0.545 m, narrowing to 0.25 x 0.25 m with a decline angle of 16.88°. The diffuser starts at 0.25 x 0.25 m and expands to 0.59 x 0.59 m with an incline of 19.55°. Flanges between chambers consist of four separate pieces of four layered EPS poster board, joined at mitered corners with hot glue.
- All pieces were painted with a 1:1 mixture of black acrylic paint and mod podge before assembly. Then, the panels for each chamber were assembled with a method detailed in our paper, pinned at a 90 degree angle, hot glued, and then trimmed to the correct size.
- After the chamber's body panels were glued together, the flanges were pinned to the ends of each chamber and hot glued, but the testing chamber flanges were only hot glued. The gap between the flange and the incline of the diffuser or contraction chamber were filled with hot glue to increase strength and prevent leakage.
- Finally, holes were drilled at 4 inches from each edge for the small flanges and 4 inches and 9 inches from each edge for the large flange using a 3/8" drill bit. 2.5 inch-long 3/8" hex head bolts were used to connect the flanges along with nuts and washers, a design that allows for the disassembly of the system into its separate parts.

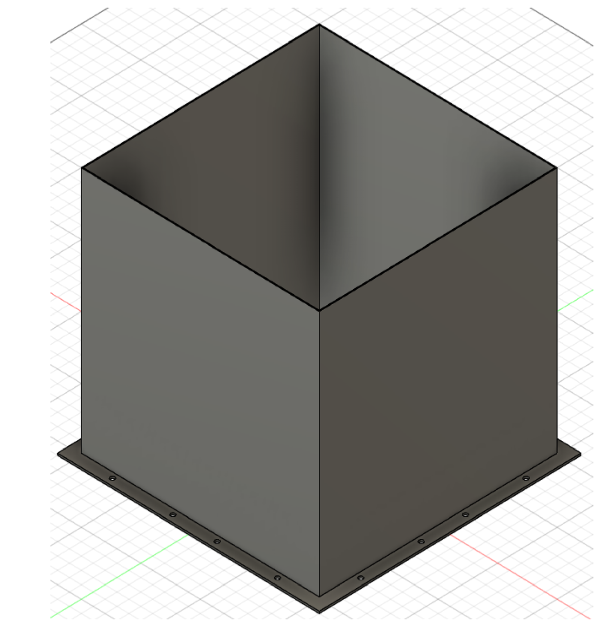


Figure 1: Housing Chamber

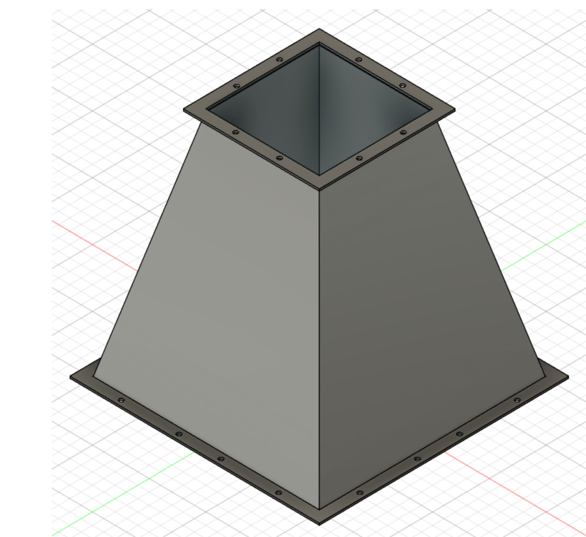


Figure 2: Contraction Chamber

Honey Comb

Achieving laminar flow requires the construction of a honey comb to prevent the formation of eddies or turbulence

Construction Process:

1. Modeled in Solid Works
2. Constructed wooden template to standardize layer dimensions
3. Used template to construct all 15 layers individually
4. Coated layers to alleviate imperfections
5. Attached all layers to create honey comb
6. Fit inside housing created by construction team

Key Design Factors:

- Ratio of honeycomb length to individual cell diameter should be between 6 and 8 (see Fig. 1)
- Surface porosity, or ratio of the cross-sectional area available for flow to the total cross sectional area (see Fig. 2)
- Both of these equations arise from manipulation of the Reynolds numbers laminar range.(Fig. 3)

$$6 \le \frac{L_{honey}}{D_{h\,honey}} \le 8$$

Figure 1

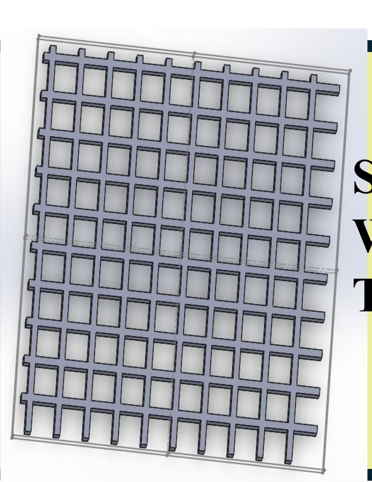
$$\frac{\Omega_{flow}}{\Omega_{tot}} \ge 0.8$$

Figure 2

$$R_n = \frac{QD_h}{vA}$$

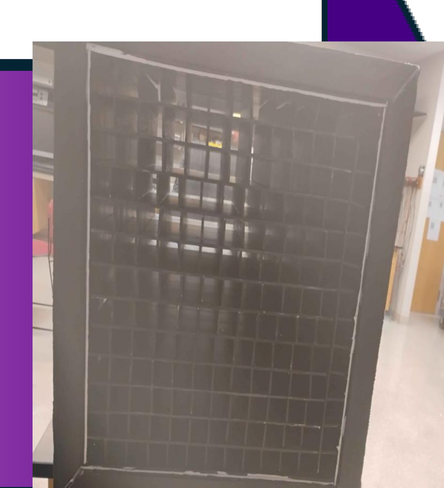
Figure 3

Step 1 Solid Works Model

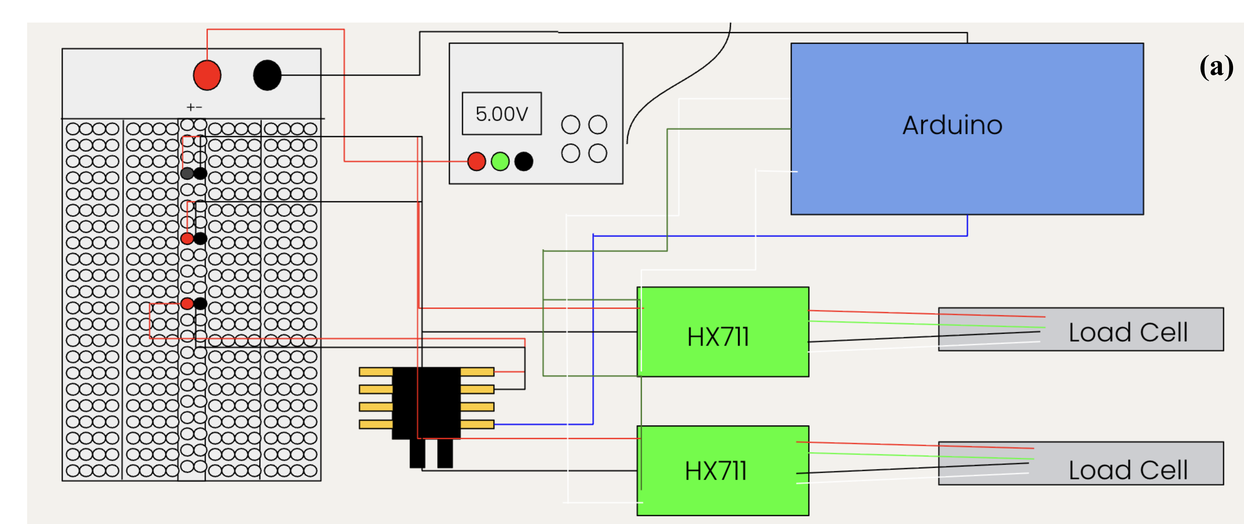


Step 2 Wooden Template

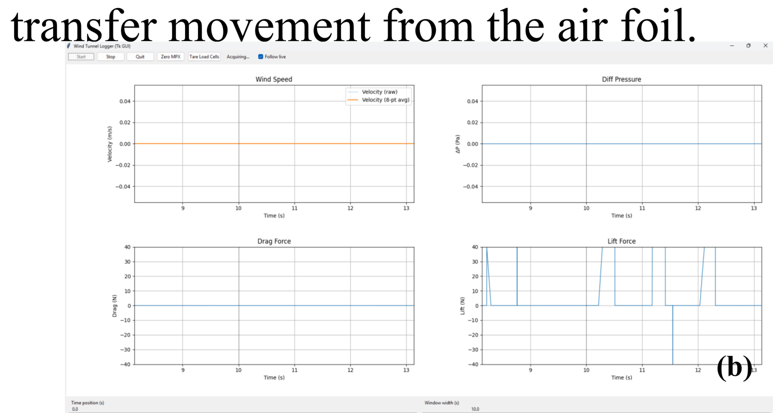
Step 3-5 Generalized Construction Process.



Testing Chamber



- Measured lift, drag, and wind speed with pressure sensor and force probes using the Arduino as an interpreter (a).
- Used python and Arduino code to graph data in real time (b).
- Attached pitot tubes to pressure sensor and arms to force probes to transfer movement from the air foil.



- Plexiglass chamber was built for combined maximum visibility and rigidity. J-B Weld epoxy and ducting tape were used to firmly attach the corners together (c).
- Stainless steel frame was made to house the chamber and the load bearing arms for the air foil (d).
- E387 air foil was 3d printed and inserted into the chamber for low wind speed testing.