Houghton Physics Research Symposium

DESIGN, CONSTRUCTION, AND TESTING OF THE RETURN PORTION OF A CLOSED-RETURN WIND TUNNEL

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Motivation

- Experimental results can offer the most accurate results
  - Wind tunnels can help air travel safety
  - Can improve manufacturing of sport balls
- At Houghton:
  - Current and future aerodynamics and fluid mechanics courses
  - Also allows for us to perform research

Outline

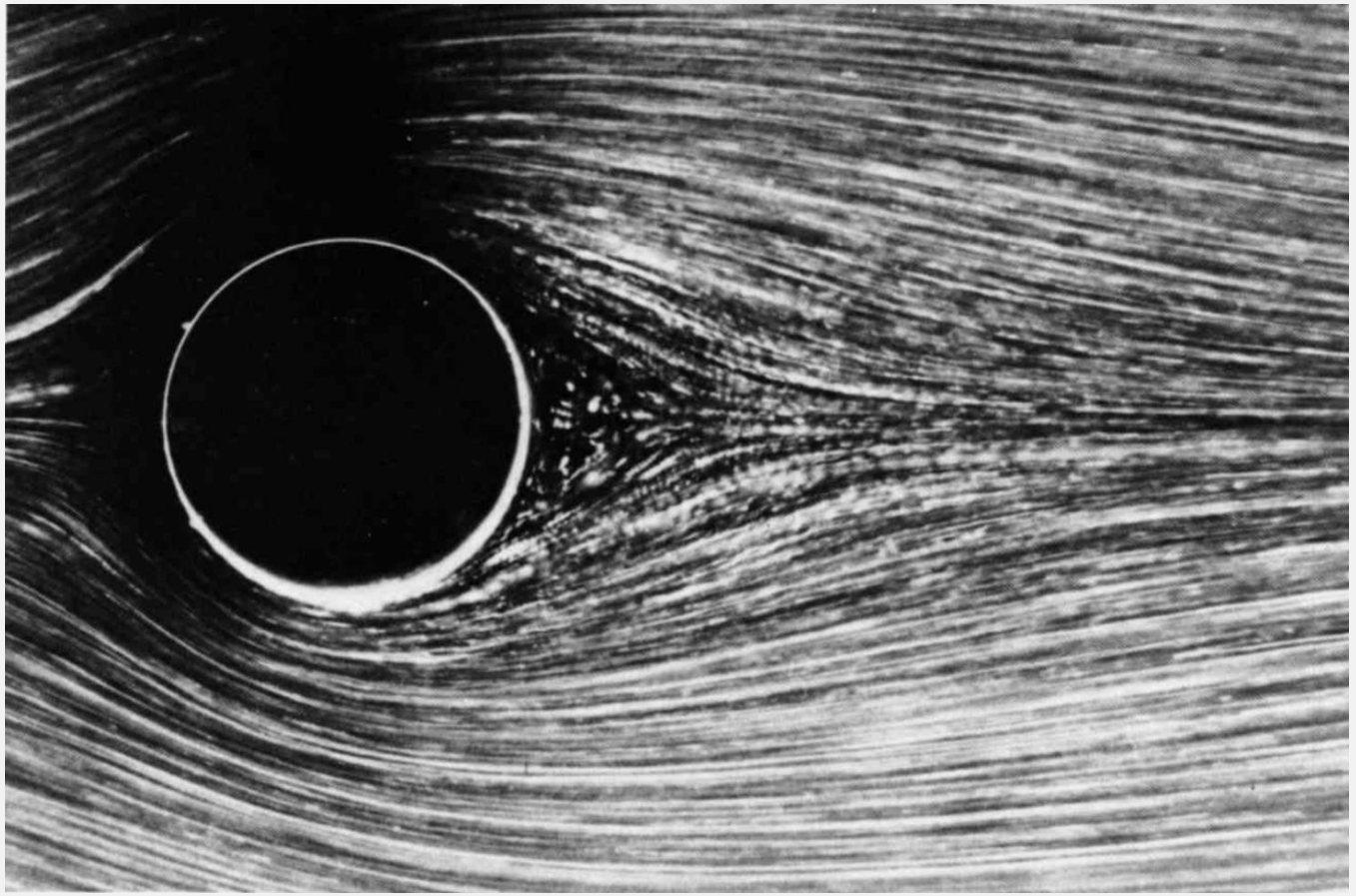
I. Introduction to Wind Tunnels

II. Relevant Theory & Flow Phenomena

III. Experimental Apparatus

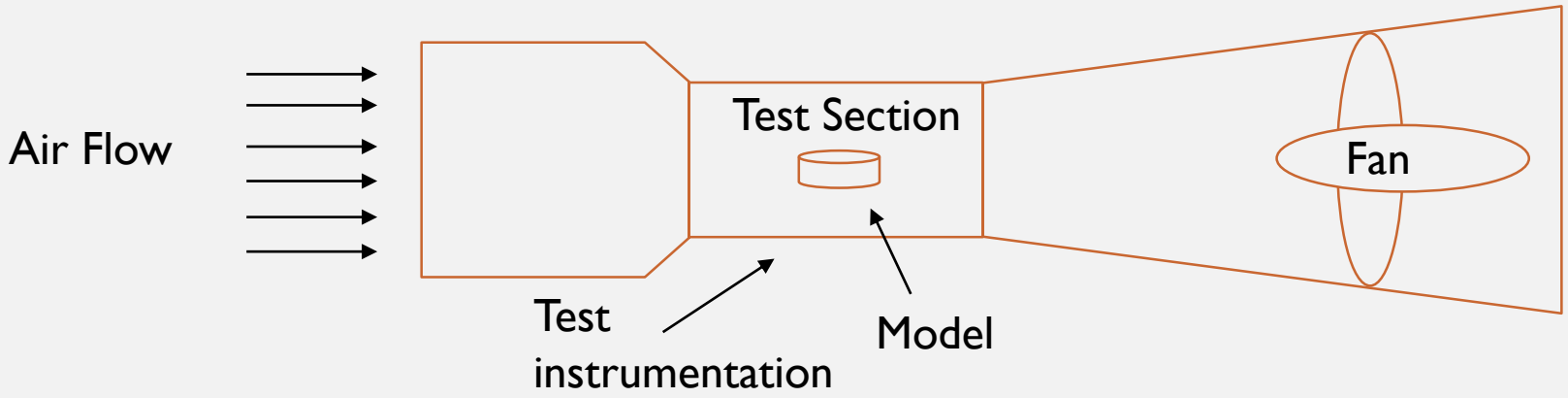
IV. Diffuser Experiment & Results

V. Conclusions & Future Work

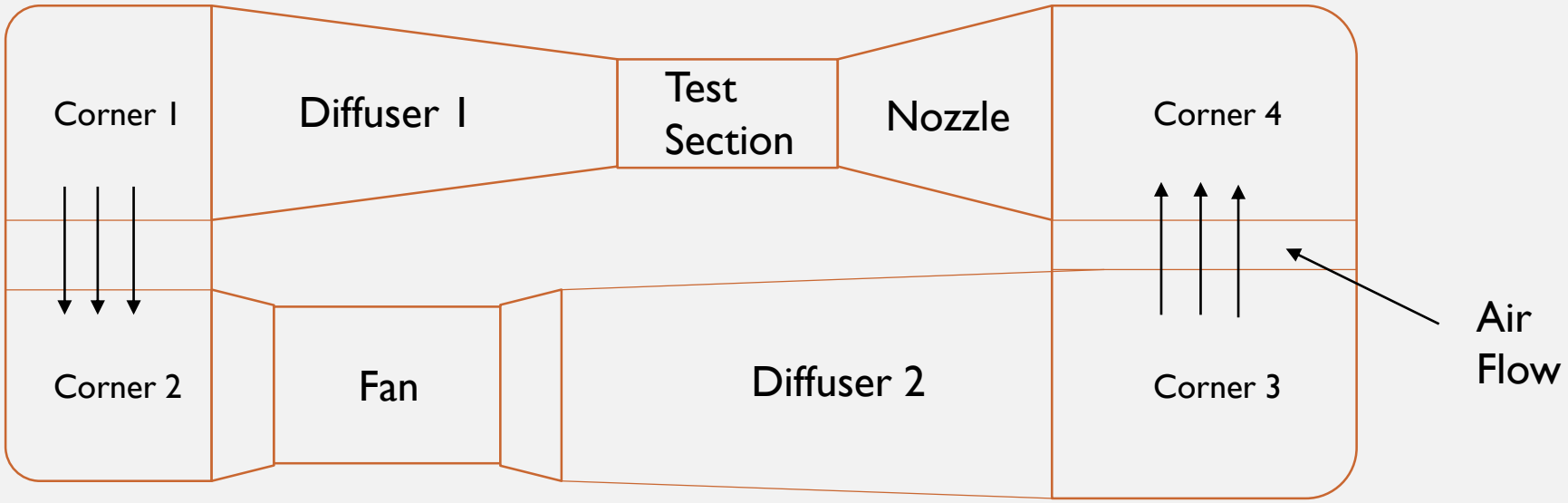


Introduction to Wind Tunnels

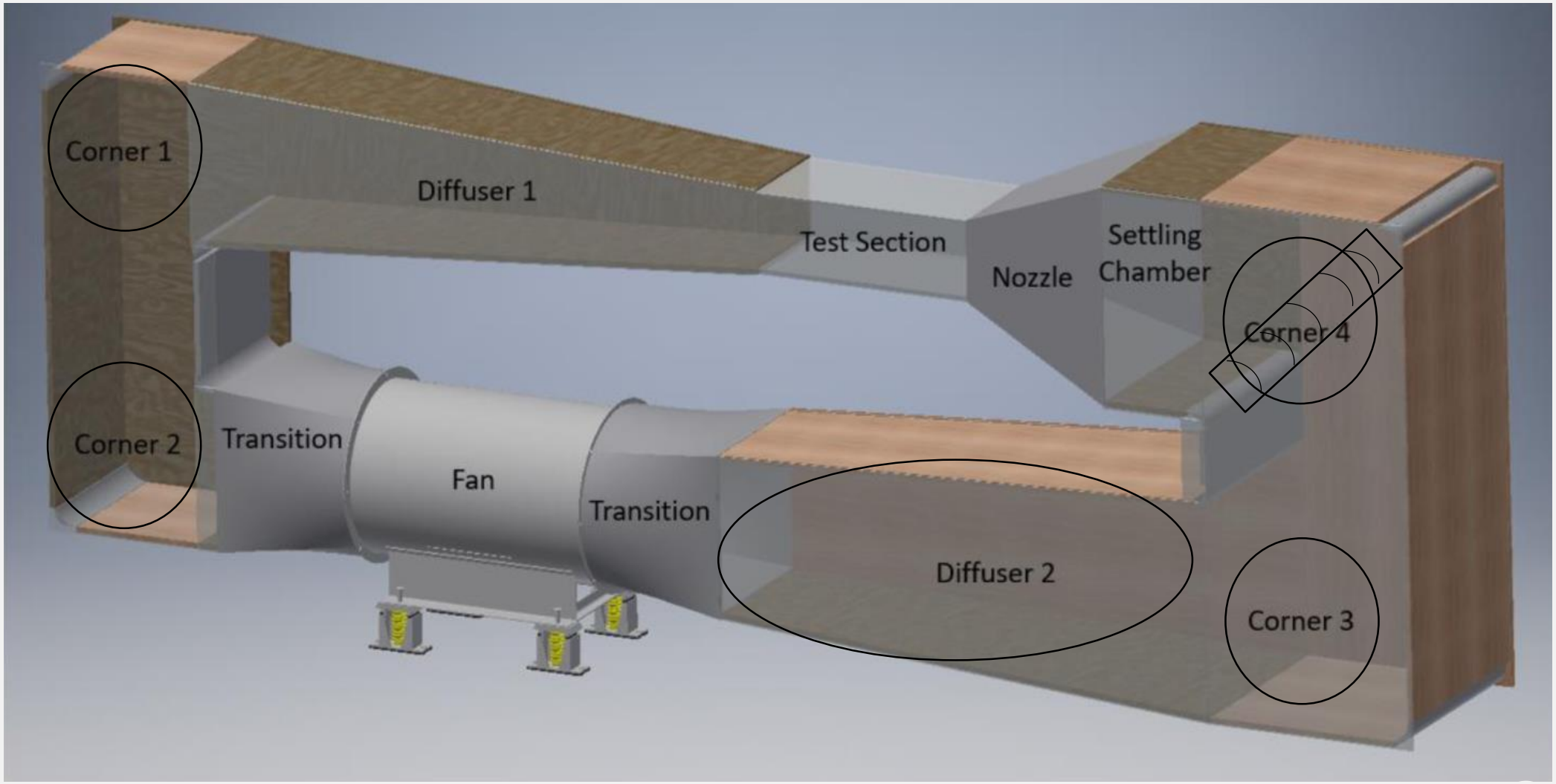
Open-Return Wind Tunnel:



Closed-Return Wind Tunnel:



Houghton College Low-Speed Closed-Return Wind Tunnel



Theory

Navier-Stokes equations

Assumptions:

- Incompressible fluid
- Irrotational flow
- No body forces
- No friction
- Uniform velocity
- Gradual change in area

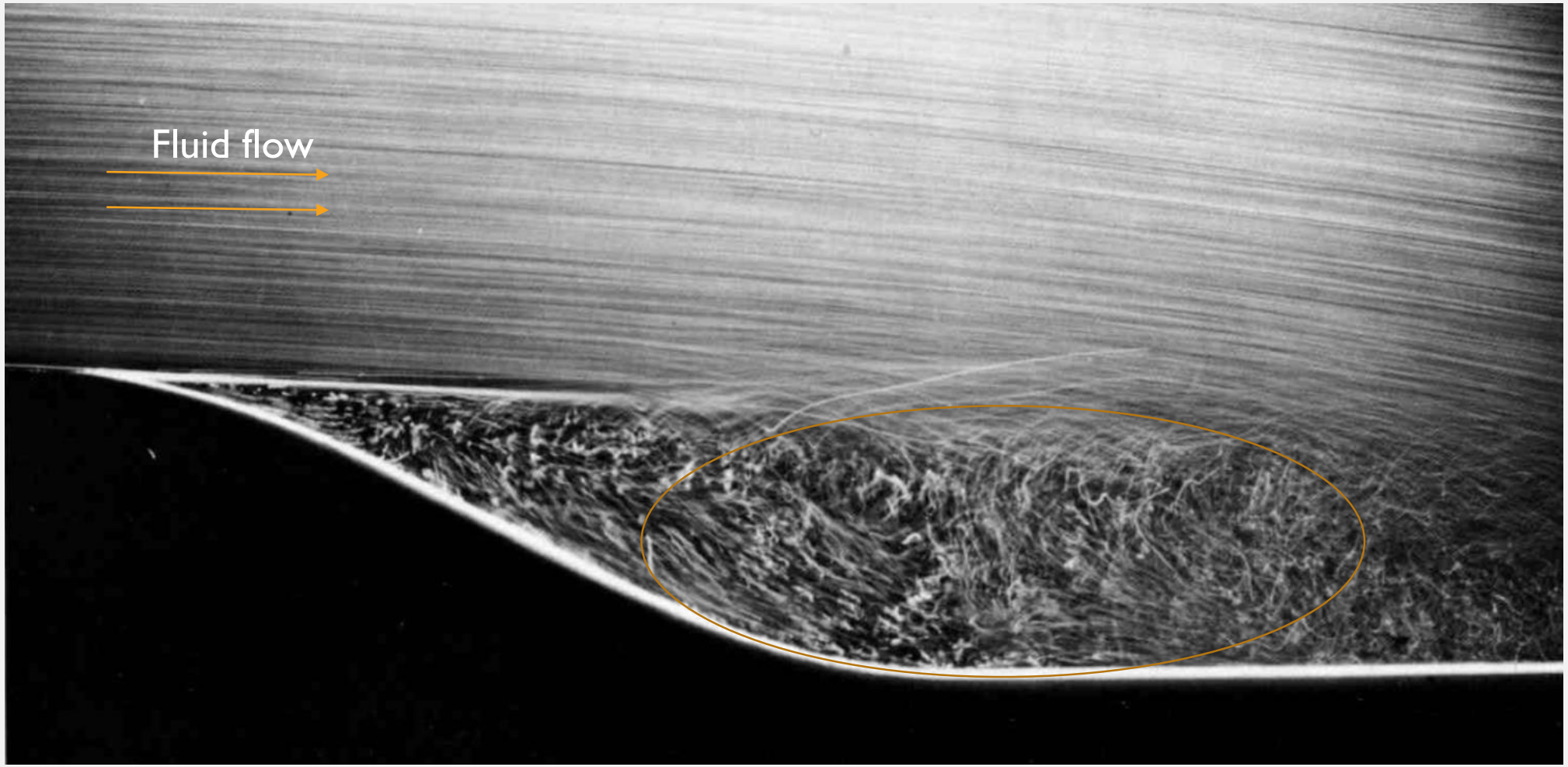
Continuity Equation: $A_1V_1 = A_2V_2$

- Represent conservation of mass

Bernoulli's Equation: $P_1 + \rho\frac{V_1^2}{2} = P_t = \text{constant}$

- Represents conservation of energy

Flow Phenomena



Air bubbles in water

Prior Work on Corner Vanes

For smaller corners:

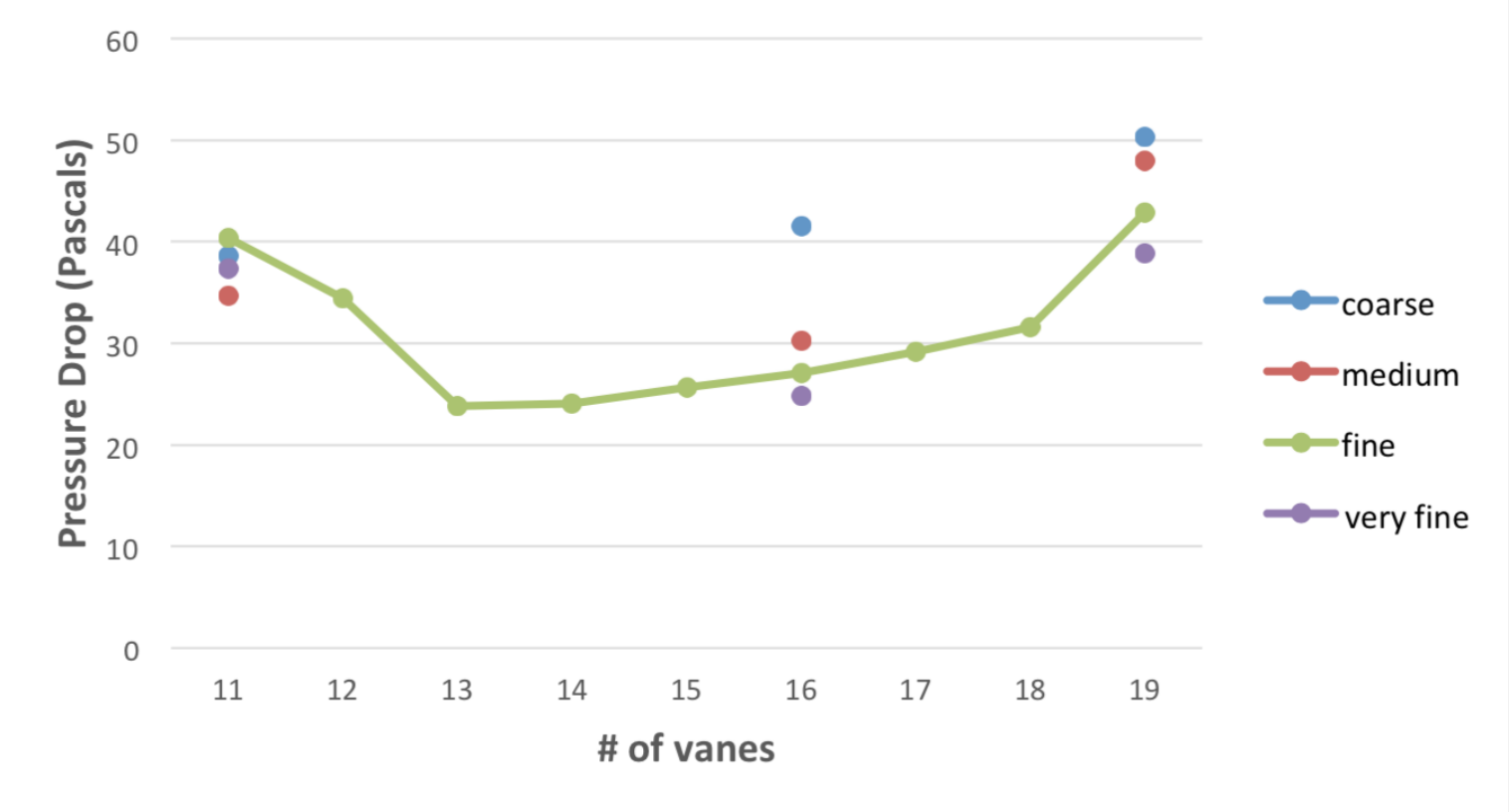
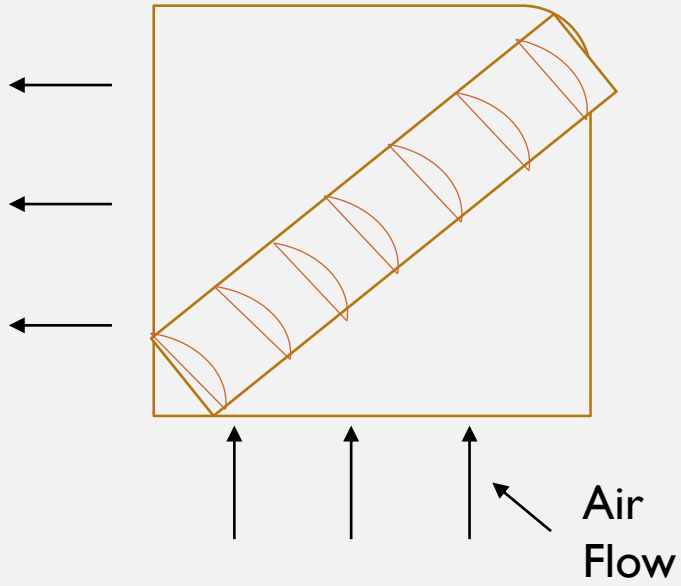


Figure taken from Eager (2018)

- Corner vanes were purchased from Aerodyne
- Using CFD simulations, numbers of vanes were decided
  - 13 vanes for smaller corners
  - 19 vanes for bigger corners
- Minimized losses and maximized flow uniformity

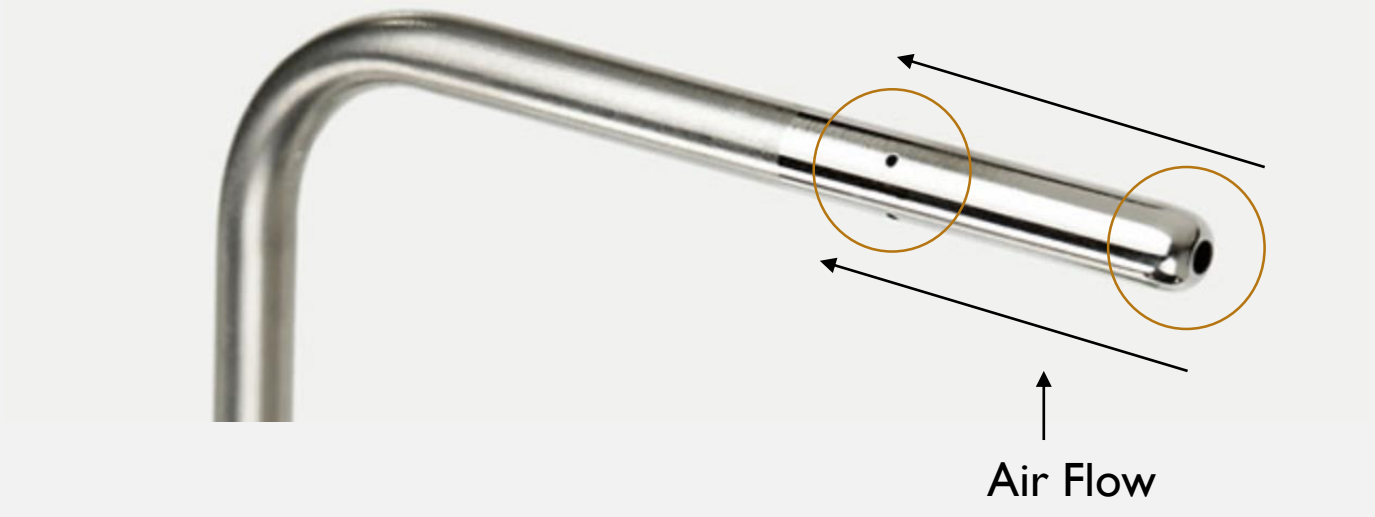
Corner Vane Construction

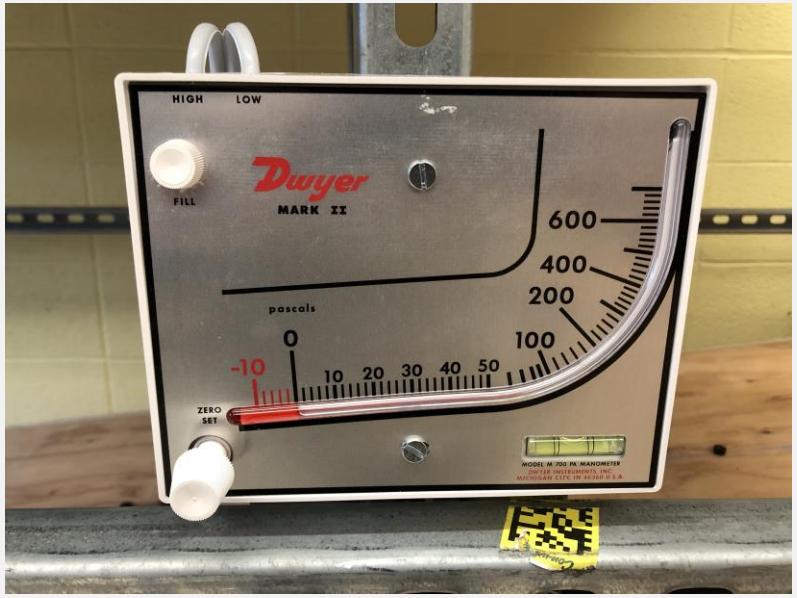


- Needed to cut the vane to 19.5 inch sections
- Vane deformed easily
- Used dense foam
  - Fill vanes
  - To support vane structure

Apparatus

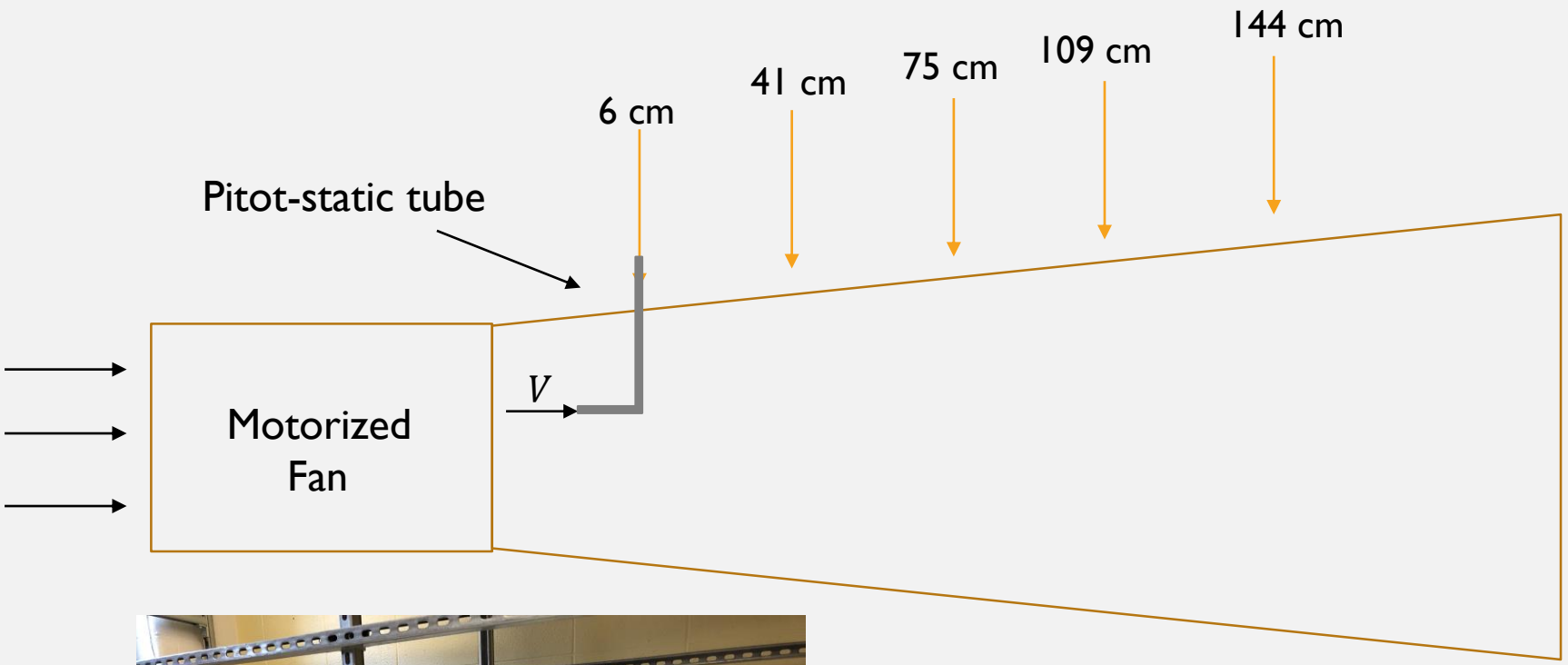
Instrumentation: Pitot-Static Tube





- The pitot-static tube measures the difference between the static and total pressure
- Center hole is exposed to total pressure and smaller holes are exposed to the moving fluid
- Manometer displays the difference between the two

Experiment

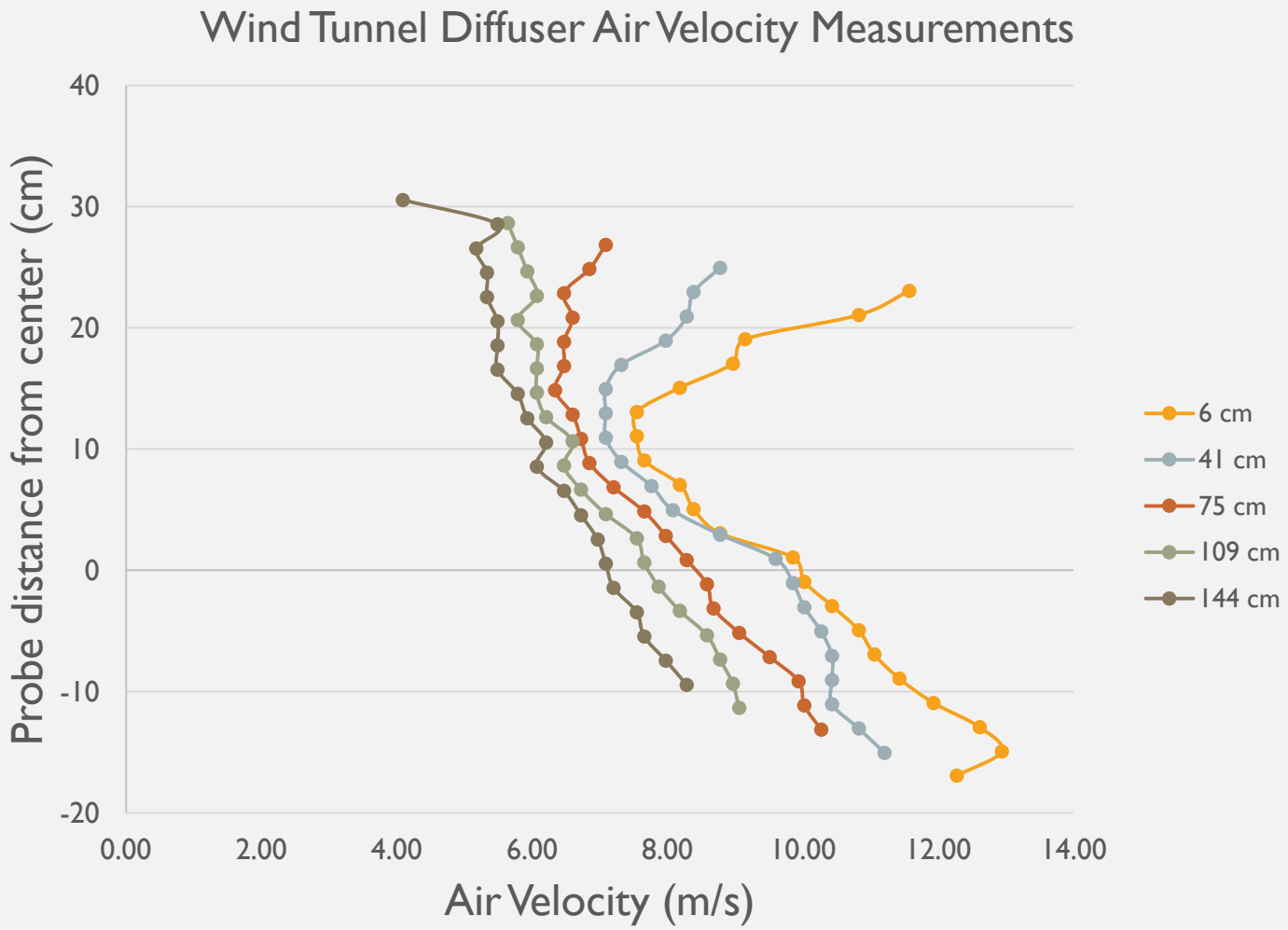


- Drilled 5 holes
- Speed set to 30 Hz (~1750 rpm)
- Measured the difference in pressure

From Bernoulli's Equation:

$$V = \sqrt{\frac{2(P_t - P_s)}{\rho}}$$

Experimental Results



Conclusions & Future work

- Conclusions
  - Cut the vanes filled with the foam filler
  - No large separation in diffuser
  - Results follow Q1D continuity equation

- Future work
  - Continued building of the corners
  - Which test instrumentation to implement
  - General construction of the rest of the wind tunnel

Acknowledgments

- Dr. Kurt Aikens
- Jonathan Durbin
- Daniel Eager
- Jonathan Jaramillo

Thank you!

References

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