MAE 253 – Experimental Aerodynamics I
Lab 2 – Wind Tunnel Turbulence Study

Shreyas Narsipur
NCSU
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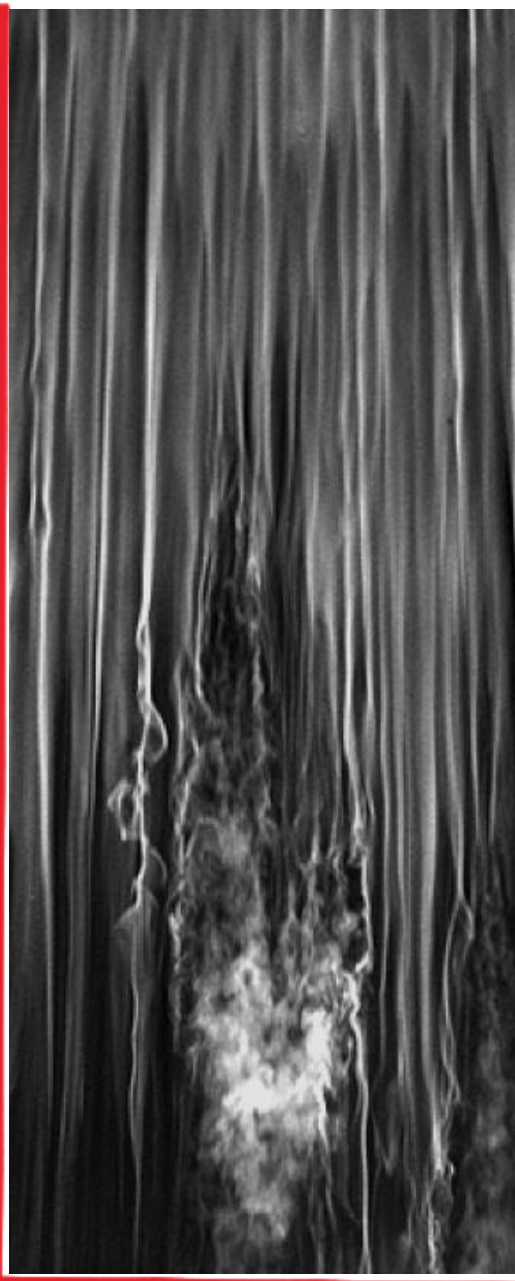
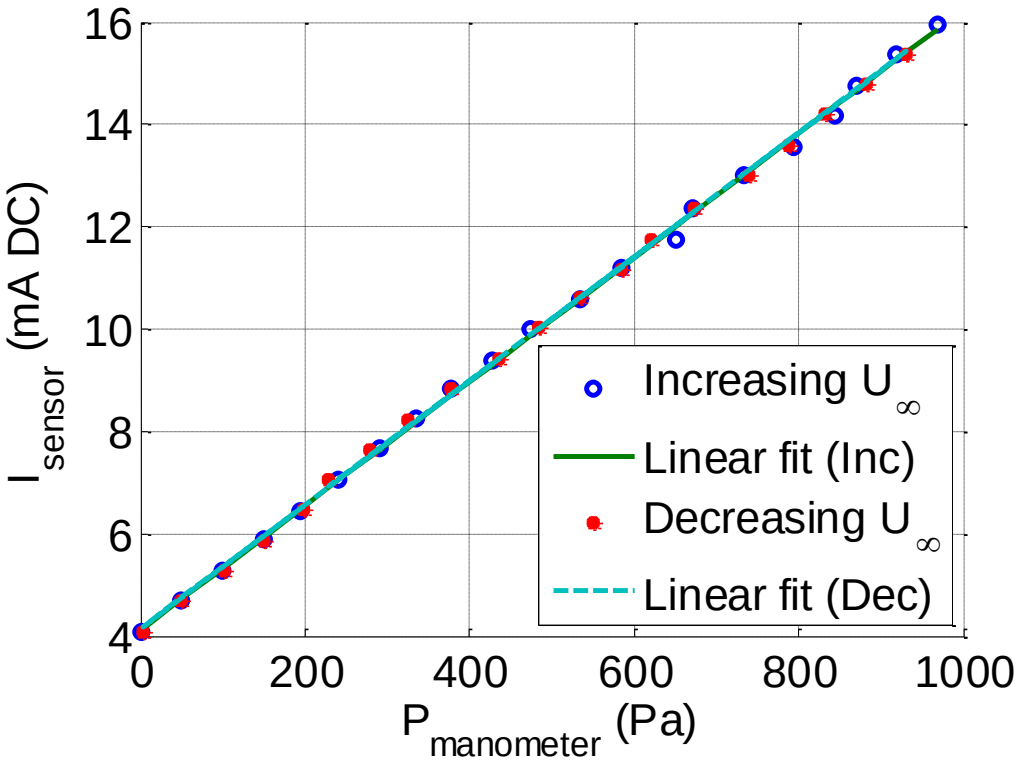


Outline

- Lab 1 - Solutions
- Lab 2 - Objective
- Lab 2 – Theory
- Lab 2 - Expectations

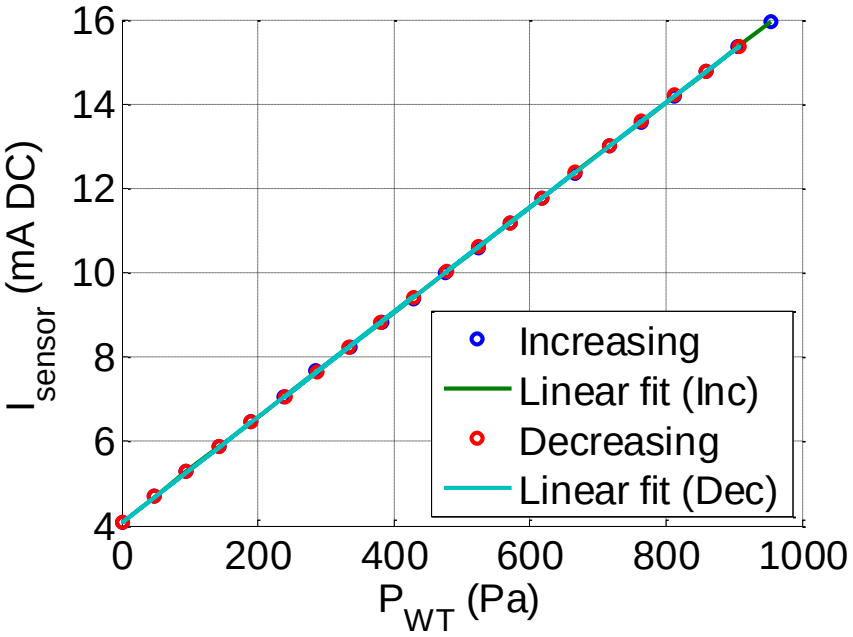
Lab 1 - Solutions

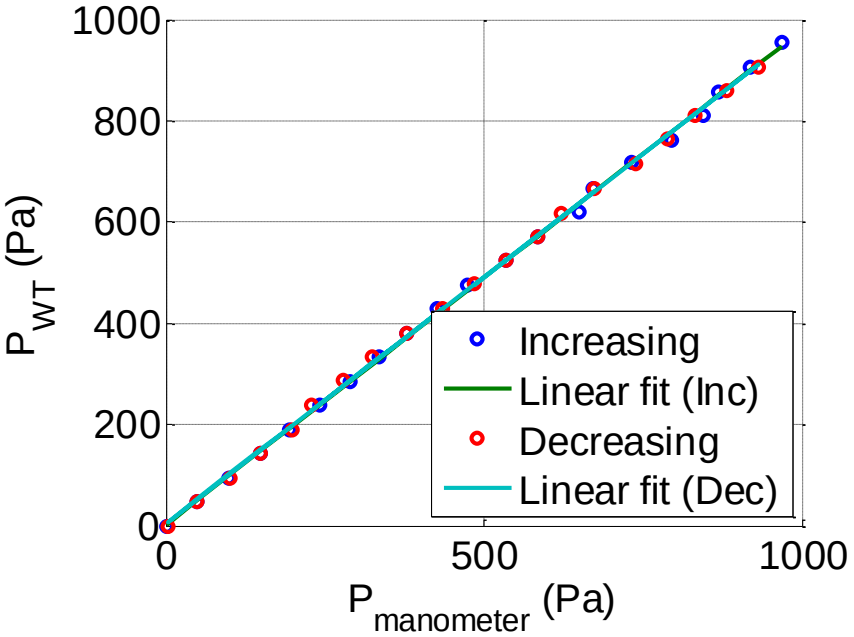


$$Increasing\ Velocity: I_{sensor} = 0.0121\ P_{manometer} + 4.1194$$

$$Decreasing\ Velocity: I_{sensor} = 0.0121\ P_{manometer} + 4.1501$$

Lab 1 - Solutions





Increasing Velocity:

$$I_{sensor} = 0.0124 P_{WT} + 4.0940$$

Decreasing Velocity:

$$I_{sensor} = 0.0124 P_{WT} + 4.0879$$

Increasing Velocity:

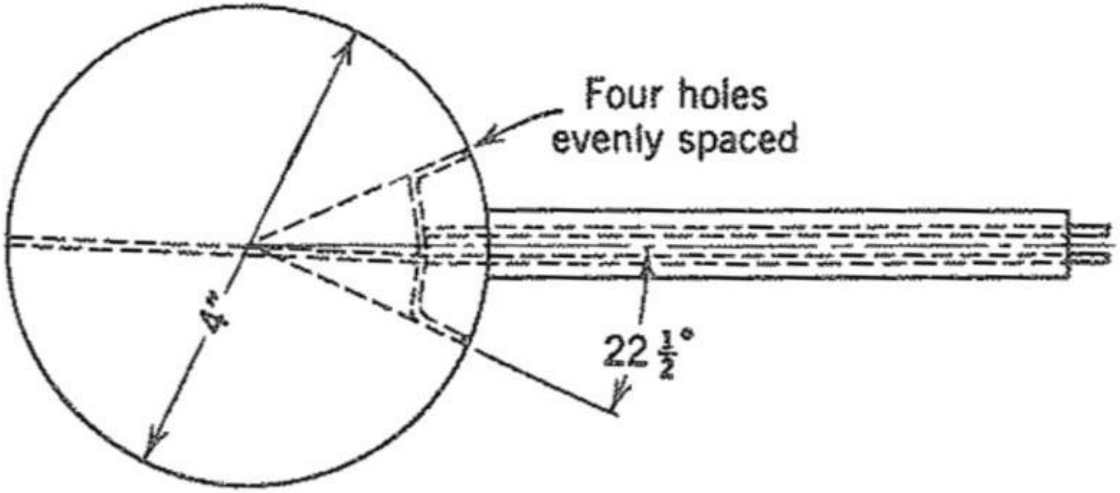
$$P_{WT} = 0.9767\ P_{manometer} + 2.0356$$

Decreasing Velocity:

$$P_{WT} = 0.9729\ P_{manometer} + 5.0159$$

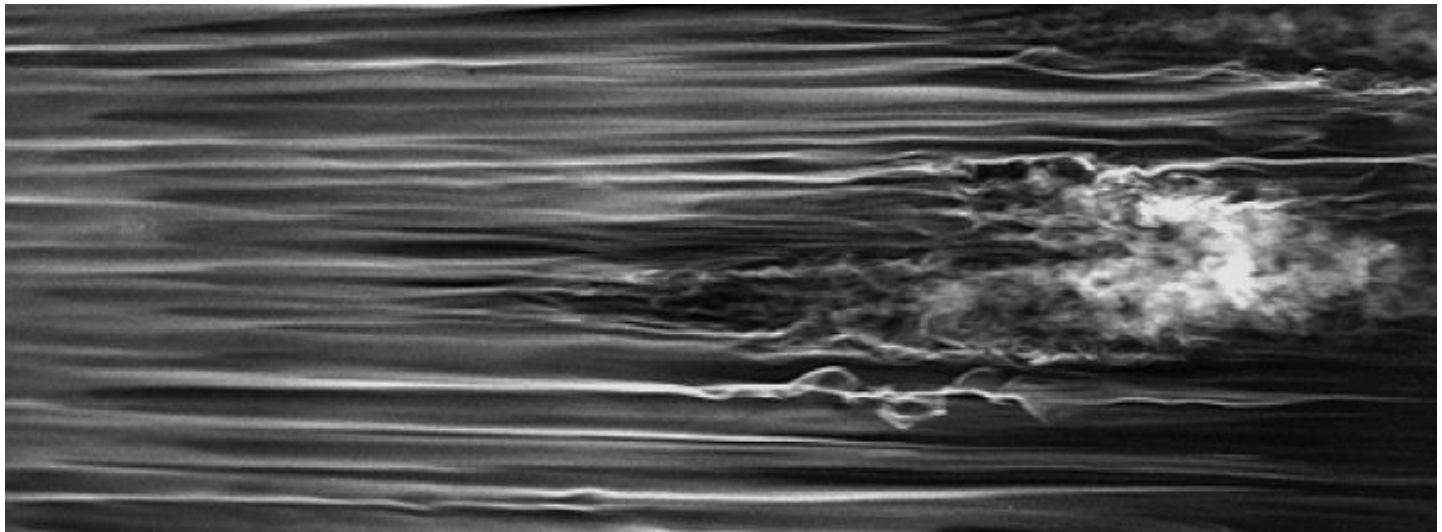
Lab 2 - Objective

- Understand the turbulence sphere set-up for measuring wind tunnel turbulence..
- Determine the turbulence factor and per cent turbulence of NCSU's subsonic wind tunnel.



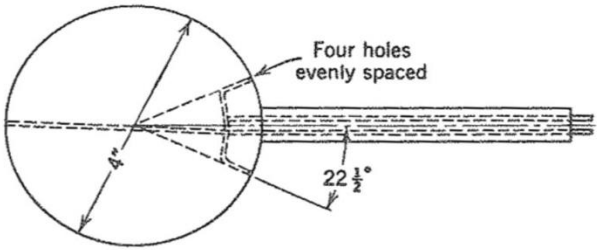
Lab 2 - Theory

- What is turbulence?
  - The level of unsteady velocity fluctuations about the flow's average velocity.
- The turbulence in a wind tunnel is mainly produced by the propeller, the guide vanes, and the vibration of the wind tunnel walls.
- The effective Reynolds number in the test section is generally higher than the freestream Reynolds number.



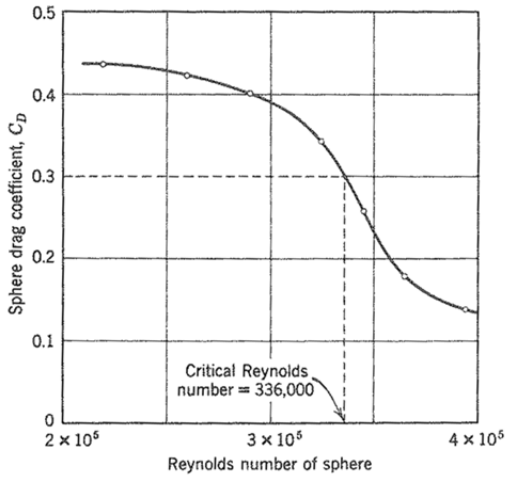
Lab 2 - Theory

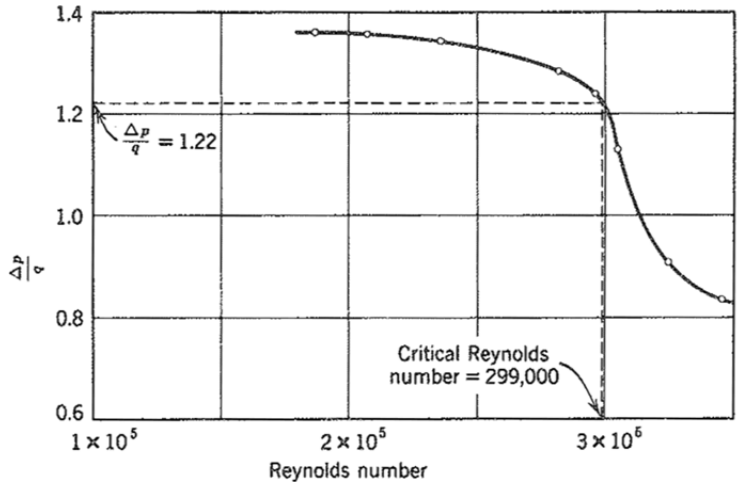
- Critical Reynolds number is the point at which flow over a bluff body transitions from laminar to turbulent.
  - higher degree of flow attachment.
  - reduction in drag.
- Flight measurements have shown that the critical Reynolds number of a sphere in free atmosphere is 385,000 and is independent of the turbulence structure in free air.
- For a sphere, the critical Reynolds number depends on the degree of turbulence in the wind tunnel.
  - a higher turbulence leads to faster transition.
- Before the use of hot-wire anemometry, a turbulence sphere was used to measure relative turbulence of a wind tunnel.



Lab 2 - Theory

- Critical Reynolds number of a sphere can be measured in two ways:
  - Drag method - determine the Reynolds number at which C_D = 0.30.
  - Pressure method - obtain the critical Reynolds number at $\Delta P/q$ = 1.22.
- The absence of force balances and associated calibrations to obtain drag makes the pressure method a more advantageous method than the drag option.
- $$TF = \frac{3.85 \times 10^5}{Re_{tunnel}}$$





Lab 2 – Expectations

- Data acquired:

$P_{transducer}$ (psf)	I_{sensor} (mA)

- Plot the variation of the pressure coefficient with Reynolds number for the turbulence sphere.
- Determine the turbulence factor of the wind tunnel.
- Determine the per cent turbulence of NCSU's subsonic wind tunnel.