MAE 451 - Experimental Aerodynamics III
Lab 1 – Constant Temperature Anemometry
Final report due date: 09/30/2019

Objective: Using the Constant Temperature Anemometry (CTA) system:

- Create a calibration curve for the hot-wire anemometer.
- Calculate the percentage turbulence of the wind tunnel.

Theory: A hot wire anemometer is a tool used to measure airspeed. The hot wire is an exposed wire with an electrical current passing through it, which because of the resistance of the wire, produces heat. By creating equilibrium between the heat generation from the electrical current and the convective heat transfer to the air passing by the exposed wire.

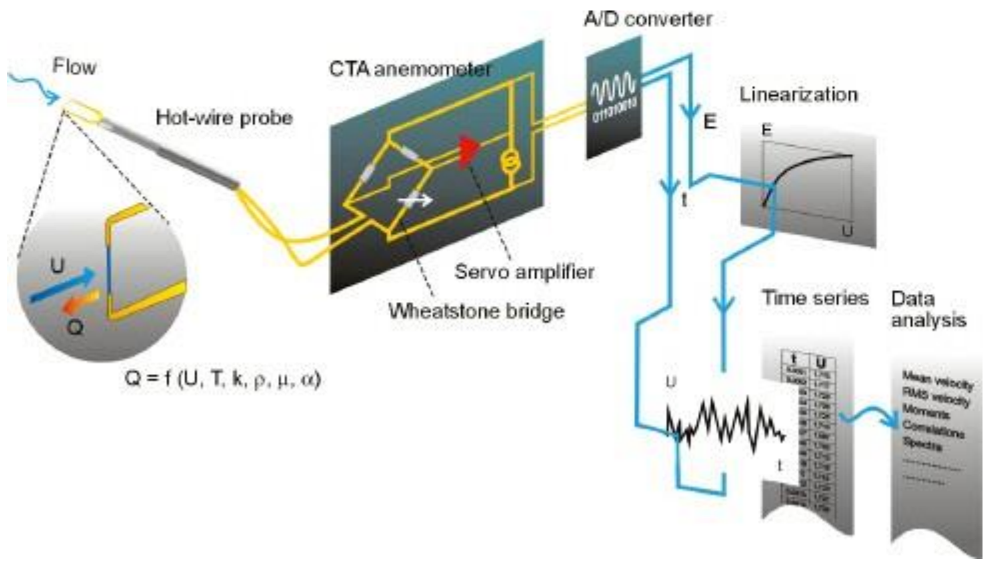

Figure 1: Schematic of the CTA measurement system
(Source: https://www.dantecdynamics.com/measurement-principles-of-cta).

The energy balance between the heat generation from the wire and the heat transfer to the air is given as,

$$Q_{wire} = h_{fluid} A_{wire} (T_{wire} - T_{ambient})$$
$$I^2 R_{wire} = h_{fluid} A_{wire} (T_{wire} - T_{ambient})$$

where, Q_{wire} is the convective heat transfer from the wire (in watts), h_{fluid} is the convective heat transfer coefficient (in watts/meter^2), A_{wire} is the wire surface area (in meters^2), T is the temperature (in degree Kelvin), I is the electrical current (in amps), and R_{wire} is electrical resistance (in ohms).

Experiment: The temperature and pressure transducers, pitot probe, and MiniCTA system will output the following data for different flow velocities at three locations in the test section:

Table 1: Data collected for the CTA experiment

$Q_{transducer}$ (psf)	Q_{pitot} (Pa)	T_{acq} (ºC)	T_{wire} (ºC)	T_{ref} (ºC)	E_{acq} (V DC)
from transducer	from pitot tube	from transducer	from data sheet	from data sheet	from MiniCTA

The following constants can be used to help with your analysis:

1. Air density: 1.14 kg/m^3

Part 1: You are required to create calibration curves (for the three locations) for the hot-wire anemometer ($E_{corrected}$ vs. V_∞) by evaluating a best fit polynomial through the collected data points. Note that,

$$E_{corrected} = \left(\frac{T_{wire} - T_{ref}}{T_{wire} - T_{acq}}\right)^{\frac{1}{2}} E_{acq}$$

Part 2: Calculate the wind tunnel percentage turbulence (as discussed in the lecture session) using the equation,

$$Tu\ (\%) = \left(\frac{V_{\infty,standard\ deviation}}{V_{\infty,mean}}\right) * 100$$

In the final report, as part of your results section:

- Plot the data points and the fitted curve for the three locations at which data was collected. Give appropriate reasoning for the chosen best-fit curve.
- Check for hysteresis.
- Provide the coefficients of the best-fit polynomial equations for all three positions with
- Plot the percentage turbulence (Tu) vs. freestream velocity (V_∞) for position 2.
- <u>*EXTRA CREDIT:*</u> The average percentage turbulence calculated based on the data from all three positions can be plotted for extra credit.

<u>References:</u> Jorgensen, F. E., "How to measure turbulence with hot-wire anemometers – a practical guide," Dantec Dynamics, 2002 (reference source: https://www.dantecdynamics.com/docs/support-and-download/research-and-education/practicalguide.pdf).