**ENGR 1330 – Computational Thinking with Data Science Final Project**

**Objective:**

You will calibrate two independent pressure measurement systems: an analog gauge and an electronic pressure transducer with an Analog to Digital computer interface using the deadweight tester measurements. The purpose of calibrating the systems is to relate the sensor output to the quantity we are attempting to measure, to minimize any bias error and to quantify the random error associated with using each system. Measurement is a process of comparison: the measured quantity is compared to a known standard. Before we measure, we must establish the relationship between the readout values of our instrument and known input values of the measurand. This process is called as calibration.

**Procedure:**

We will regard the pressures produced by the tester as shown by the values stamped on the weights as the exact true pressures. The true pressure, the pressure indicated on the analog gauge, and the voltage output by the pressure transducer are given to you, respectively. Figure 1 shows an operational diagram and a picture of the Deadweight tester equipment. The measurements data given to you consists of 3 columns:

1. The true applied pressures from 5 psig to 105 psig (psig is a pressure unit which means gauge pressure in pounds per square inch). This is the column that you will do the calibration with respect to. In other words, this is the data that we know that it is true.
2. The analog pressures read from the gauge.
3. The voltages read from the transducer.

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Figure 1 Deadweight Tester Calibration Equipment

**Methodology:**

In many cases, we may know in advance that there is a linear relationship between the measurand and the readout of our instrument.

For example,



or



where “indicated” refers to the readout values and “true” refers to the true values of the measurand. These relationships are our **goal as calibration equations**.

For each of the two measurement systems:

**Step 1:** Plot the data (as symbols) by using the more precisely known data for the abscissa and the data we are attempting to calibrate for the ordinate.

**Step 2:** Find the linear curve fit coefficients, using method of least squares as described below. In general, we express a linear equation as:



The Method of Least-Squares finds the coefficients, c1 and c2, that minimize the sum of the squares of the deviations between the data, yi , and the fit, c1xi + c2.

The deviation between the data and the fit can be found as:



The square of the deviation:



And sum of squares of deviations at all sampling points:



Solve for c1 and c2 to find coefficients which minimizes the sum of squares of deviations for the best fit:



Where, n is the number of data pairs in the curve-fit. The yi ’s are the ordinate values (the less precisely known). The xi ’s are the abscissa values (the more precisely known).

**Step 3:** Now on the same plot on which you have plotted the data, plot the line representing the curve fit. It should appear as a best fit if you've done everything correctly.

**Step 4:** Now rearrange your curve fit equation to find the so-called field equation, which would allow us to determine true pressure measurements based on indicated measurements were we to use our measurement system in the field. (Not sure to add that is why it is red)

**Step 5:** Find the standard error, S, and propagate the error to obtain a final field equation that includes an error estimate such as:



