# Experiment 0:
# Sensor Calibration and Linear Regression

Denise Wang-

Lab performed on: April 10, 2018
Lab section: Lab 6- Tuesday 11am
TA: Narayana Gowda, Shashank
Partners' names:

Homework:

1. Cover sheet with following information created:

   Experiment 0: Sensor Calibration and Linear Regression
   Denise Wang 304927170
   Lab performed on: April 10, 2018
   Lab6- Tuesday 11am
   TA's name: Narayana Gowda, Shashank
   Lab partners' names: Wesley Sakutori, Wilny Duong

2. We know that:

   Velocity change $\Delta v = \Delta v_{best} \pm \delta \Delta v$
   Time duration $\Delta t = \Delta t_{best} \pm \delta \Delta t$
   Measured acceleration is given by $a = \Delta v / \Delta t$

   Taking partial derivatives:

   $$\frac{\partial a}{\partial v} = \frac{\partial}{\partial v}\left(\frac{v}{t}\right) = \frac{1}{t}$$
   $$\frac{\partial a}{\partial t} = \frac{\partial}{dt}\left(\frac{v}{t}\right) = -\frac{v}{t^2}$$

   Which gives us:

   $$\delta a = \left.\sqrt{(\frac{1}{t}\delta v)^2 + (-\frac{v}{t^2}\delta t)^2}\right|_{v_{best}, t_{best}}$$

   Evaluate the expression at v = $v_{best}$ and t = $t_{best}$ which gives us the proper expression for the uncertainty in the measured acceleration:

   $$\delta a = \left|\frac{v_{best}}{t_{best}}\right| \sqrt{(\frac{\delta v}{v_{best}})^2 + (\frac{\delta t}{t_{best}})^2}$$

3. The maximum number of digits Capstone will display is 15 after the decimal point. If the sensor precision is exactly 4 digits and you take data with 10 displayed digits, your actual measurement precision is 4 digits. In digits 5 through 10, you would expect to see fluctuating values. Turning down the the display precision far enough to completely eliminate sensor fluctuations might not be the best idea for taking good data because necessary data may be cut off, which would ultimately lead to in inaccurate measurements. Also, some of the fluctuating digits are the uncertainty that should be recorded for data.

4.

| Mass (g) | Force (N) | Sensor Voltage (V) |
|---|---|---|
| 0 | 0 | -0.003 |
| 50 | 0.49 | -0.08 |
| 100 | 0.98 | -0.156 |
| 150 | 1.47 | -0.232 |
| 200 | 1.96 | -0.309 |
| 250 | 2.45 | -0.385 |
| 300 | 2.94 | -0.462 |
| 350 | 3.43 | -0.539 |
| 400 | 3.92 | -0.616 |

**Table 1— Data Recorded**. This charts shows the data collected in the lab.

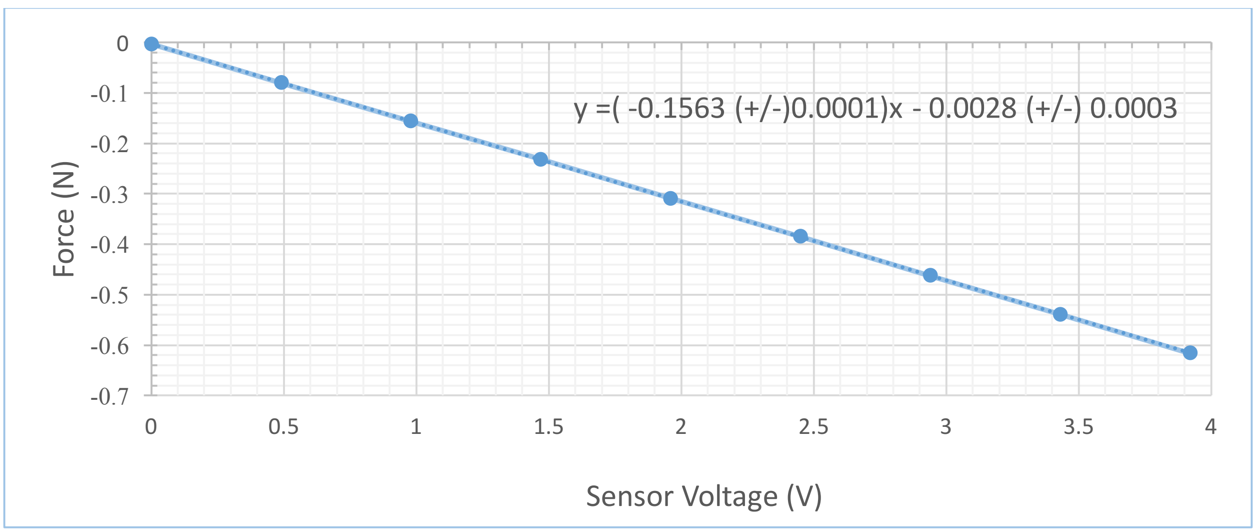


**Figure 1— Force Sensor Calibration**. This graph shows the linear relationship between the force and sensor voltage.

5. The x-axis presents the force (N) and the y-axis presents the sensor voltage (V). The fit line has a negative slope with the y intercept almost at 0.

   The equation of the fit line is $y =( -0.1563 \pm 0.0001)x - 0.0028\pm0.0003$, which is in the form of $V= aF + b$.

   The intercept and x variable and their standard errors are from Excel's linear regression.

a = -0.1563 $\pm$ 0.0001 V/N
b = -0.0028 $\pm$ 0.0003 V

The value of the nonzero y-intercept tells you that the taring procedure is not 100% accurate at zero, showing that it may not be absolutely effective. This may be the result of the sensitivity of the instrument.

6. In the form V = aF + b,
$\frac{(V-b)}{a} = F$
cV + d = F
so, $c = \frac{1}{a}$ and d = $\frac{-b}{a}$
which gives us c = -6.399 $\pm$ 0.005 N/V and d = -0.0182 $\pm$ 0.0019 N, using the formula:

$$\frac{\delta f}{|f_{best}|} = \sqrt{(\frac{\delta x}{|x_{best}|})^2 + \cdots + \left(\frac{\delta z}{|z_{best}|}\right)^2 + \left(\frac{\delta u}{|u_{best}|}\right)^2 + \cdots + (\frac{\delta w}{|w_{best}|})^2}$$

7. Frankie and Avril both have an average numerical score of 84, but Frankie gets a B+ in the course while Avril gets a C+. This is possible because Frankie and Avril are in different lab sections, and each section is curved individually. Because the course is graded on a curve, the numerical score does not correspond to a particular letter score. Rather, it is important how you do compared to your peers. It can be concluded about the mean numerical scores of the other students in their sections that the mean score in Avril's section was higher.