UC Berkeley
Mechanical Engineering Department

ME103:: Experimentation and Measurements

Lecture #7

Successful experimentation is often iterative

This does not mean, however, that the whole experimental process should be by trial-and-error

- Start with a coarse screening, to identify parameters and ranges to focus on
- Do methodical design of experiments in the region of interest
- Don't do all your experiments in one go – plan perhaps 20% of your time budget to get preliminary results, analyze, then revise next steps of plan based on what you've learned

Some Observations from Lab this week

1. When reporting any measurements be sure to express your uncertainty of that measurement

    - If multiple measurements are made, calculate the average and Standard Deviation. Decide whether to express your result within 1σ, 2σ, 3σ (Assuming normal distribution corresponds to ~68%, ~95%, ~99.7%

Some Observations from Lab this week

2. When using instruments and taking a single measurement

- Rule of thumb – look at the right most digit of the display that is not flickering – your uncertainty will be ± 0.5 of that digit. A conservative 3σ estimate.

Some Observations from Lab this week

3. Understand your objective – seek possible alternative methods

Propagation of Error

Our goal here is to determine the total error of something that is a function of a number of independent variables

$$y\,(x_1 \pm u_1,\ x_2 \pm u_2,\ x_3 \pm u_3,\ \ldots)$$

u_n = uncertainty or error for x_n

$$\text{total error} = u_y = \sqrt{\left(\frac{\partial y}{\partial x_1} u_1\right)^2 + \left(\frac{\partial y}{\partial x_2} u_2\right)^2 + \cdots}$$

Intuitively, where does this come from?

$$\text{total error} = u_y = \sqrt{\left(\frac{\partial y}{\partial x_1} u_1\right)^2 + \left(\frac{\partial y}{\partial x_2} u_2\right)^2 + \cdots}$$

- Partial derivative is a “weighting factor” that gives us the importance of that particular term

- Each variable and corresponding error is an independent vector ➔ adding vectors to get magnitude

A Few More Comments

- We have focused on random errors, which leads to data being a Gaussian distribution➔**Precision**
- You can also have systematic errors (**Biased**)?
- What if you have **both precision and biased errors**?

$$u_y = \sqrt{P_y^2 + B_y^2}$$