Chapter 1: Introduction

Introductory Statistics for Engineering Experimentation

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Introduction

The first chapter of the text is concise and well-written. I recommend you read it. Things to notice are:

- The orientation in this course is to analyze and present data from scientific investigations. Such data can be used to
  - Summarize a situation
  - Model experimental outcomes
  - Quantify uncertainty
  - Make decisions
- Our general model is that the data we observe are a *sample* from a *population* of items we could have observed.
- Analysis also leads us to questions of *experimental design*: what to measure, how to measure it, and at what settings of various experimental factors.
- In statistical inference we formulate models for the *variability* in our observations. In practice variability can result from *measurement error* (the variability in the measurement process) or from *random variability* that would occur if we repeated the experiment.

Experimental design

- Considering how the data are to be collected is called *experimental design*. We want our designs to be both robust and efficient.
- Multi-factor designs, where more than one experimental settings are changed from run to run are particularly sensitive. We will advocate the use of *factorial designs*, as opposed to *one-at-a-time* designs.
- Many of the data sets we will examine come from studies analyzed by one of the authors, Karen Copeland, who is a statistical consultant in industry. Most of these studies involved factorial designs.

Random sampling

- When we are sampling from a finite population we want to ensure that the sample is representative of the population.
- If we know the population we can use *random sampling* to achieve this.
- We do need to be careful that we are indeed sampling from the population of interest. Consider sampling potential voters by selecting telephone numbers from a directory - you will only get people with land lines who choose to have their numbers listed.

Randomization

- Often there are environmental factors beyond our control in an experiment. Sometimes we don't even know what they are but frequently they are connected with something like the order in which we do the runs. (We pretend that our process is stationary but almost every process drifts in some way.)
- We cannot eliminate the variability induced by such factors but we can try to avoid confounding it with factors of interest by randomizing the allocation of experimental units to treatments and, when possible, randomizing the order of the runs.

Replication versus repeated measures

- When we refer to *replicate* measurements we mean measurements at the same set of factor levels incorporating the full extent of the random variability in the process. That is, we assume that the experiment was repeated.
- This is in contrast to *repeated measures* where the experiment is performed only once but there are multiple assays of the final product. The variability in repeated measures only reflects the measurement error, not the random variability.