Lecture 1

ROLES OF STATISTICS IN ENGINEERING

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Department of Mathematics

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Contents

1. Engineering Method and Statistical Thinking

What is Statistics?

Statistics, a mathematical branch, encompasses *collecting*, *analyzing*, *interpreting*, *presenting*, and *organizing data*. It offers methods for extracting insights and drawing conclusions, playing a pivotal role in decision-making and predictions across science, business, economics, and the social sciences.

Key concepts in statistics include:

Descriptive Statistics involves the methods for summarizing and presenting data.

Inferential statistics allows conclusions and predictions to be made about a population based on a sample of data.

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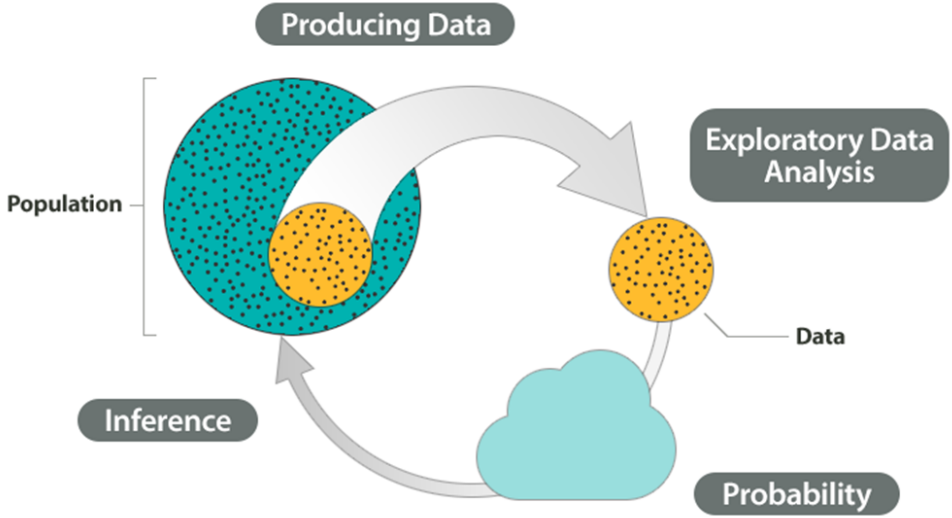
Big picture of Statistics



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Why is Statistics?

- Statistics allows you to understand a subject much more deeply.
- Statistics helps us make discoveries in science, make decisions based on data, and make predictions.
- Statisticians and statistical methods are important parts of pharmaceutical industry, social science, business practice, etc.

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Statistical concepts

- **Population**: The entire set of individuals, items, or data of interest. It represents the complete group under study.
- **Sample**: A subset of the population selected for analysis. Samples are used to make inferences about the entire population.
- **Data**: consist of information coming from observations, counts, measurements, or responses.
- **Parameter**: a numerical measurement describing some characteristic of a population.
- **Statistic**: a numerical measurement describing some characteristics of a sample.

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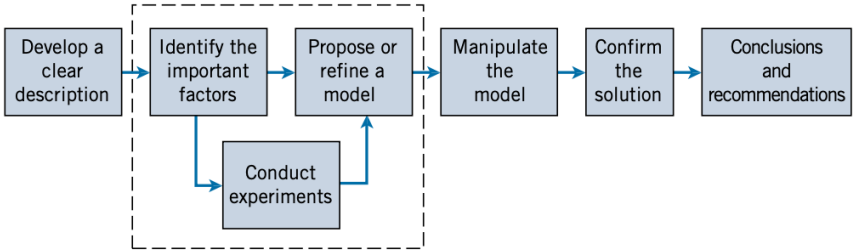
Engineering Method & Statistical Thinking

The **engineering, or scientific, method** is the systematic approach employed in defining and resolving these societal challenges through the effective application of scientific principles.



The **field of statistics** deals with the collection, presentation, analysis, and use of data to make decisions, solve problems, and design products and processes.

2. Collecting Engineering Data

Types of Data

1. **Qualitative Data** (Categorical Data) Qualitative data represents categories or labels and cannot be measured numerically. It is divided into two subtypes:
   - **Nominal Data** e.g., colors, gender, types of fruits, or marital status.
   - **Ordinal Data** e.g., educational levels (high school, college, graduate), customer satisfaction ratings ("poor," "average," "good").

2. **Quantitative Data** (Numerical Data) Quantitative data consists of numerical values that can be measured and counted. It is divided into two subtypes:
   - **Discrete Data** the number of cars in a parking lot, the number of students in a class, or the count of defects in a manufacturing process.
   - **Continuous Data** height, weight, temperature, or time.

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Collecting data

- **Retrospective study**: Analyzing historical data to identify associations or patterns.
- **Observational study**: A researcher observes and measures characteristics of interest of part of a population.
- **Designed experiment**: A treatment is applied to part of a population and responses are observed.

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3. Mechanistic and Empirical Models

Mechanistic Models

Definition

Mechanistic models are based on a fundamental understanding of the underlying mechanisms and principles governing a system.

Examples:

- Newton's laws of motion in mechanics.
- Differential equations modeling chemical reactions.
- Mathematical models of fluid dynamics.

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Empirical models

Definition

Empirical models, also known as phenomenological or statistical models, are based on observed data and correlations without necessarily considering the underlying mechanisms.

Examples:

- Regression models predicting sales based on marketing spending.
- Machine learning algorithms trained on historical data for predictive analytics.
- Statistical models for economic forecasting.

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4. Probability & Probability Models

Probability and Probability Models

Probability is a measure of the likelihood that a particular event will occur. It quantifies uncertainty and is expressed as a number between 0 and 1, where 0 indicates impossibility, 1 indicates certainty, and values in between represent degrees of likelihood. In other words, probability is a way of quantifying the chance or likelihood of different outcomes in a given situation.

Probability models are mathematical representations used to describe and quantify uncertain events or phenomena. These models help in understanding the likelihood of different outcomes in a given situation and are a fundamental component of probability theory.

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Thank you!

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