Elementary Probability and Statistics  
MATH 1530

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Chapter 1
Introduction to Statistics

1-1 Overview  
1-2 Types of Data  
1-3 Critical Thinking  
1-4 Design of Experiments
Statistics

Two Meanings

- Method of analysis
- Specific numbers

Statistics

- Method of analysis
  a collection of methods for planning experiments, obtaining data, and then organizing, summarizing, presenting, analyzing, interpreting, and drawing conclusions based on the data

Statistic

- Specific number
  numerical measurement describing some characteristic of a sample

Example: Twenty-three percent of people polled believed that there are too many polls.
Definitions

❖ Data
observations (such as measurements, genders, survey responses) that have been collected.

Definitions

❖ Population
the complete collection of all elements (scores, people, measurements, and so on) to be studied. The collection is complete in the sense that it includes all subjects to be studied.

Definitions

❖ Census
the collection of data from every element in a population

❖ Sample
a subcollection of elements drawn from a population
1-2 Types of Data

Definitions

❖ Parameter
a numerical measurement describing some characteristic of a population

population

parameter

❖ Statistic
a numerical measurement describing some characteristic of a sample

sample

statistic
Definitions

- **Quantitative Data**
  - numbers representing counts or measurements

- **Qualitative (or categorical or attribute) Data**
  - can be separated into different categories that are distinguished by some nonnumerical characteristic.

Definitions

- **Quantitative Data**
  - the incomes of college graduates

- **Qualitative (or categorical or attribute) Data**
  - the genders (male/female) of college graduates

Definitions

- **Discrete**
  - data result when the number of possible values is either a finite number or a 'countable' number of possible values
    - 0, 1, 2, 3, ...

- **Continuous**
  - (numerical) data result from infinitely many possible values that correspond to some continuous scale that covers a range of values without gaps, interruptions, or jumps
    - 2, 3
Definitions

- **Discrete**
  The number of eggs that hens lay; for example, 3 eggs a day.

- **Continuous**
  The amounts of milk that cows produce; for example, 2.343115 gallons a day.

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Levels of Measurement

- **Nominal**
- **Ordinal**
- **Interval**
- **Ratio**

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Definitions

- **nominal level of measurement**
  characterized by data that consist of names, labels, or categories only. The data cannot be arranged in an ordering scheme (such as low to high)

Example: survey responses yes, no, undecided
Definitions

- **ordinal level of measurement**
  
involves data that can be arranged in some order, but differences between data values either cannot be determined or are meaningless

  Example: Course grades A, B, C, D, or F

Definitions

- **interval level of measurement**
  
like the ordinal level, with the additional property that the difference between any two data values is meaningful. However, there is no natural zero starting point (where none of the quantity is present)

  Example: Years 1000, 2000, 1776, and 1492

Definitions

- **ratio level of measurement**
  
the interval level modified to include the natural zero starting point (where zero indicates that none of the quantity is present). For values at this level, differences and ratios are meaningful.

  Example: Prices of college textbooks
Levels of Measurement

- Nominal - categories only
- Ordinal - categories with some order
- Interval - differences but no natural starting point
- Ratio - differences and a natural starting point

Section 1-3
Critical Thinking

- Almost all fields of study benefit from the application of statistical methods

Critical Thinking

- Bad Samples
  - self-selected survey
    - (or voluntary response sample)

  one in which the respondents themselves decide whether to be included
Critical Thinking

- Voluntary Response Samples
- Small Samples
- Graphs

Salaries of People with Bachelor’s Degrees and with High School Diplomas

![Bar Chart]

We should analyze the numerical information given in the graph instead of being mislead by its general shape.
Salaries of People with Bachelor’s Degrees and with High School Diplomas

(a) Bachelor Degree: $40,500
(b) High School Diploma: $24,400

Critical Thinking

- Voluntary Response Samples
- Small Samples
- Graphs
- Pictographs

Double the length, width, and height of a cube, and the volume increases by a factor of eight.
Critical Thinking

- Voluntary Response Samples
- Small Samples
- Graphs
- Pictographs
- Percentages
- Loaded Questions
- Order of Questions
- Refusals
- Etc.

Section 1-4
Design of Experiments

Two Major Points

- If sample data are not collected in an appropriate way, the data may be completely useless.
- *Randomness* typically plays a crucial role in determining which data to collect.
Definitions

- **Observational Study**
  observing and measuring specific characteristics without attempting to modify the subjects being studied

- **Experiment**
  apply some treatment and then observe its effects on the subjects

**Designing an Experiment**

- Identify your objective
- Collect sample data
- Use a random procedure that avoids bias
- Analyze the data and form conclusions
Definitions

- Confounding
  occurs in an experiment when the effects from two or more variables cannot be distinguished from each other

Definitions

- Replication
  used when an experiment is repeated on a sample of subjects that is large enough so that we can see the true nature of any effects (instead of being misled by erratic behavior of samples that are too small)

Randomization and Other Sampling Strategies

- Random Sample
  when members from the population are selected in such a way that each individual member has an equal chance of being selected.
Randomization and Other Sampling Strategies

- **Simple Random Sample**
  when size $n$ subjects is selected in such a way that every possible sample of the same size $n$ has the same chance of being chosen.

- **Random Sampling**
  selection so that each has an equal chance of being selected

- **Systematic Sampling**
  Select some starting point and then select every $K^{th}$ element in the population.
  Example: Every third person
Hey! Do you believe in the death penalty?

Convenience Sampling - use results that are readily available

Stratified Sampling - subdivide the population into subgroups that share the same characteristic, then draw a sample from each stratum

Cluster Sampling - divide the population into sections (or clusters); randomly select some of those clusters; choose all members from selected clusters
Methods of Sampling

- Random
- Systematic
- Convenience
- Stratified
- Cluster

Definitions

- Sampling Error
  the difference between a sample result and the true population result; such an error results from chance sample fluctuations.

- Non-sampling Error
  sample data that are incorrectly collected, recorded, or analyzed (such as by selecting a biased sample, using a defective instrument, or copying the data incorrectly).