

# ONE-WAY ANOVA

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## Analysis of Variance (ANOVA)

- **What is ANOVA**
  - A test of the statistical significance of the differences among the mean scores of two or more groups on one or more design factors
  - Partition the total variability in the response variable into components that are consistent with a statistical model for the experiment
- **One-Way (Single-Factor) ANOVA**
  - There is one design factor
- **One-Way ANOVA Versus Two-Sample T-test**
  - When two population means are compared
    - Both one-way ANOVA and t-test can be used
    - Unpaired two-sample t-test corresponds to one-way ANOVA with two levels
    - Paired two-sample t-test corresponds to one-way ANOVA for repeated measures with two levels
  - When more than two population means are compared
    - It is possible to do pairwise comparisons with t-test, but conducting multiple t-tests can lead to severe inflation of the type I error rate
    - ANOVA can be used without increasing the type I error rate

2

## Random Vs. Fixed Effects

### ■ Fixed Effects Model

- The levels of each design factor are fixed in advance of the experiment and we are interested in differences in responses among those specific levels

Hardness Example. The two levels of the quenching medium design factor – oil and saltwater – are fixed

### ■ Random Effects Model

- The factor levels are meant to be representative of a general population of possible levels
- We are interested in drawing conclusions about the entire population of levels, not just those used in the experiment design

Suppose the experimenter is interested in investigating the variability in the thickness of test specimens due to the different batches where they are produced, so he chooses a random sample of batches as being representative of the total population of batches. The “batch” factor is a random effect

### ■ Mixed Effects Model

- Both fixed and random effects are present

3

**Plasma Etching Experiment.** An engineer is interested in investigating the relationship between the RF power setting and the etch rate for this tool. The objective of an experiment like this is to model the relationship between etch rate and RF power, and to specify the power setting that will give a desired target etch rate. The response variable is etch rate.

She is interested in a particular gas (C<sub>2</sub>F<sub>6</sub>) and gap (0.80 cm), and wants to test four levels of RF power: 160W, 180W, 200W, and 220W. She decided to test five wafers at each level of RF power.

**Design Factor and its levels?**

RF Power with 4 levels: 160W, 180W, 200W, and 220W

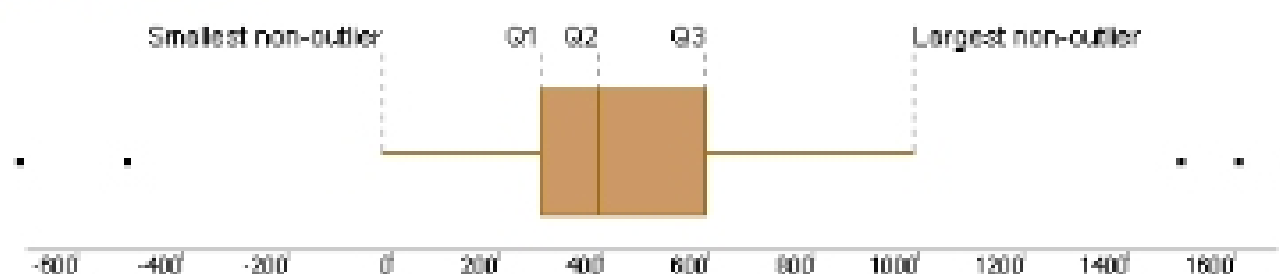
**Sample size (the number of replicates)?**

5 replicates for each level

4

## Graphic Summary of Data

- Histogram
- Boxplots (Box Plots or Box-and-Whisker Diagram)
  - Graphically depict important information of groups of numerical data through five statistics: the smallest non-outlier point, lower quartile (Q1, 25th percentile), median (Q2), upper quartile (Q3, 75th percentile), and largest non-outlier point



**Interquartile range (IQR):** The middle half the data, from Q1 to Q3 (from 300 to 600 in the figure)

**Outliers:** At least 1.5 times of the IQR below Q1 or at least 1.5 times of the IQR above Q3

**Skewness:** the non-symmetry of the data distribution (right skewed in the figure; more data points on the lower end of the distribution)

5

