The statistics curriculum that is incorporated into BME 244L is intended to introduce BME students to the basic concepts of statistics and how to use statistics effectively in analyzing and interpreting experimental data. Students are lead through self-learning in statistics modules and apply the concepts learned there on homework, exams, and experimental data they collect in the laboratory. After completing BME 244L the students should be able to do the following (broken down by topic):

**Descriptive Statistics and Propagation of Error**

- Explain the concepts behind simple random sampling.
- Define a parameter and a statistic.
- Identify common statistical notation describing measures of central tendency.
- Quantify the amount of variation in a data set.
- Be able to calculate the following sample statistics (given the equations):
  - mean, median, mode, range, variance, standard deviation, and standard error of the mean.
- Describe probability distributions (including uniform and cumulative probability distributions).
- Define a random variable.
- Use the normal equation to plot the normal distribution over a range given an estimate of the population mean and standard deviation.
- Be able to describe:
  - Standard normal distribution.
  - When propagation of error is required.
- Given an appropriate data set (replicate measurements of the dependent variables) and equation, propagate the error to determine the standard deviation/error of the dependent variable in the equation.
- Use the propagation or error equation to estimate the uncertainty in a calculated value given an equation and uncertainty in measured quantities.
- Create effective graphical representations of sample data.

**Intro to Hypothesis Testing (t-tests)**

- Given an experimental design or goal, develop an appropriate null hypothesis.
- Explain when it is appropriate to use a t-test.
- Understand and apply the t-distribution.
- Transform a random variable into a t-score and apply it to a standard normal distribution table.
- Given a data set, determine if it is appropriate to perform a one-sample or two-sample t-test.
- Describe the difference between a 2-sample and a paired-sample t-test.
- Test the data to determine if it meets the required assumptions to perform a t-test.
- Identify an appropriate statistical test when the data fails to meet an assumption.
- Perform one- and two-sample t-tests by hand (i.e. Describe the differences in the equations, how to calculate standard error (denominator of t-equation) and Degrees of Freedom).
- Find the appropriate critical t value from t-tables.
- Describe decision rules for rejecting the null hypothesis (i.e. determine if the null hypothesis should be rejected or not by comparing the p-value to the α-value or by comparing the t-statistic (t-score) to the t-critical).
- Describe the difference between and identify when to use one- and two-tailed tests
- Construct a confidence interval.
- Explain type I and type II error, and describe how type I error is related to significance level and how type II error is related to power.

**Regression and Correlation**

- Calculate and interpret a correlation coefficient (r).
- List the prerequisites/assumptions for simple linear regression.
- Know the formula and the properties of the regression line.
- Calculate a linear regression equation.
- Define and determine the coefficient of determination ($R^2$).
- Calculate and plot residuals.
- Determine goodness-of-fit using diagnostic plots (residual plot, experimental vs. expected values).
- Describe the difference between outliers and influential points and identify these in a data set.
- Perform a hypothesis test on slope to determine if there is a significant linear relationship between an independent and a dependent variable.
- Calculate the standard error of the slope.
- Determine the test statistic for the regression slope.
- Determine if a non-linear regression equation is a good fit for the data.
- Determine the $R^2$ for non-linear regression equations.

**One and Two-way ANOVA including Repeated Measures and Post Hoc Testing**

- Explain why, in terms of type I error, multiple t-tests are not optimal for comparing more than two groups.
- Explain the usefulness of ANOVA.
- Given an experimental design, state the null and alternate hypotheses associated with performing ANOVAs.
- Based on the experimental design/data set, identify when its appropriate to perform one-way, two-way, and repeated measures ANOVA; especially as compared to choosing a t-test.
- List the necessary conditions/assumptions of one- and two-way ANOVA, including those for the case of repeated measures.
- Test the validity of the assumptions necessary to perform ANOVA.
- Identify an appropriate statistical test when the data fails to meet an assumption for ANOVA.
- Explain all values in an ANOVA output table and how these values were calculated (i.e. between group SS/MSS, Within-group (Error) SS/MS, F-statistic, interaction, etc.).
- Find the critical F-value using an F-table.
- Calculate the F-statistic from MSS values.
- Describe why multiple comparison (post hoc) tests are performed rather than multiple individual t-tests.
- Identify an appropriate post hoc test for a given data set/experimental design.
- State an appropriate null hypothesis for a post hoc test.
- Perform a Tukey post hoc test.
- Determine a q-critical from studentized range distribution tables (q-tables).
- Explain the Bonferroni correction.
Power Analysis and Experimental Design

- Describe the relationship between significance level, type I error, type II error, and power.
- Describe the power of a statistical test.
- Identify the variables that affect the power of a test.
- Given a data set or experiment design, estimate the power of the test, the minimal detectable significant difference, or the necessary sample size.
- Explain how power analysis can aid in experimental design.
- Describe different types of experiments and their designs.
- Describe the qualities of a well-designed experiment (i.e. proper controls, randomization, replication, etc.).
- Identify confounding variables in an experiment design.