Instructor information:

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Catalog description:

A modern introduction to the scientific application of mathematical principles to the collection, analysis, and presentation of numerical data. Probability concepts, models, and applications; point/interval estimation and statistical inference through parametric, nonparametric, and simulation/randomization methods; maximum likelihood; Bayesian methods. Calculus-based supplements for majors in mathematics and secondary mathematics education.

Prerequisites:

MATH 171 or above, or ACT Math score ≥ 28. Students should have facility with algebra and a comfort with mathematical concepts and notation. No previous knowledge of probability or statistics is assumed.

By the end of this course, students will...

- Develop statistical literacy
  - Use correct statistical notation
  - Define statistical terms
  - Make valid conclusions from visual displays of data
  - Accurately interpret output from several statistical applications
- Develop statistical reasoning
  - Develop and evaluate competing hypotheses
  - Explain statistical processes
  - Fully interpret results of analyses
  - Choose appropriate analysis methods
  - Identify and explain sources of variation
  - Explain and evaluate assumptions for analysis methods
  - Apply knowledge in novel situations
- Develop statistical thinking
  - Explain the need for data and analysis
  - Explain the importance of data production
  - Develop models to simulate and explore random phenomena
  - Recognize how, when, and why inferential tools can be used
  - Make appropriate conclusions from statistical analyses
  - Quantify variability
  - Explore data numerically and graphically
  - Evaluate visual displays
  - Estimate probabilities
- Develop statistical computation skills
  - Derive formulas and calculate probabilities through application of Calculus skills
  - Describe data using appropriate and meaningful numerical summaries
  - Use formulas to calculate basic probabilities and to carry-out statistical analyses
- Develop statistical communication skills
  - Communicate statistical analyses and results using appropriate terminology and notation
  - Develop appropriate, meaningful, and effective visual displays of data

Note: To help you study for exams, learning objectives for this course are listed on pages 6-9 (ordered by in-class activities)

Course materials:

Required: Wackerly, M. et al. *Mathematical Statistics with Applications (7th edition)* -- ISBN: 978-0-49511081-1
Print out activities prior to each class (posted on Blackboard or www.bradthiessen.com)
Calculator (TI-8x recommended)
Binder for class activities and notes

Optional: Devore, J.L. *Probability & Statistics for Engineering & the Sciences (7th edition)* -- ISBN: 978-0-495038217-1
(Homework and solutions will be posted online)
Dekking, F.M., A Modern Introduction to Probability and Statistics -- ISBN: 978-1-8523-3896-1
(Cheaper textbook that provides a more modern approach)

Optional Apps: *Stata* (powerful, easy to use; $49/year; $179 lifetime): http://www.stata.com/coursegp.html
SPSS (easy to use; available in our computer labs): http://www.spss.com/
R (powerful, free; takes some time to learn): http://cran.r-project.org/
http://www.statcrunch.com/ (6 months for $12; 12 months for $23)

Grading methods & criteria:

This course consists of three major units: (1) Probability, (2) Applied probability/inference, (3) Hypothesis testing
The weights I use to calculate your score in each unit will depend on the work you choose to do:

	Complete everything	**No homework**	**No homework/assignments**
Unit exam	75%	85%	100%
Assignments, quizzes, in-class	15%	15%	----
Homework or unit project	10%	----	----

Exams will assess your statistical literacy, reasoning, thinking, computation, and communication skills in relation to content covered in class. The exams will contain a variety of question-types designed to measure your performance on a representative sample of the course objectives. While exams are not open-book, you are allowed to use your notes, in-class activities, completed homework, and calculators. See the "extra credit / exam retake policy" for more information.

In-class activities, quizzes, and assignments are designed to help you evaluate your understanding of course content. Because of this, I will not score your performance on these activities and assignments. Instead, students completing assignments will receive credit and will be emailed fully worked-out solutions. It is expected that you will review these solutions to assess your understanding prior to the unit exams. Students who choose not to complete in-class activities, quizzes, and assignments will not be penalized; their unit exam scores will simply count for a greater percentage of their overall grade.

Homework provides another opportunity for you to assess your understanding of course content. If you choose not to buy the textbook, you can find a set of homework problems and solutions on the website. If you do buy the textbook, you will see that I primarily assigned odd-numbered problems that have solutions provided in the book. Under normal circumstances, we will not spend any time in class reviewing homework problems. You will be expected to check your own work and seek assistance if needed. Students who choose not to complete the homework problems will not be penalized; their unit exam scores will simply count for a greater percentage of their overall grade.

Your final grade will be calculated as the average of your 3 unit scores using the following grading scale:
A (100-90%) B (90-80%) C (80-70%) D (70-60%) F (60-0%)

Extra credit / exam retake policy:

As we work through the in-class activities, I may think of novel mini-projects to extend your learning. We will discuss these extra credit opportunities as they arise, but do not count on extra credit points to pass this course. All extra credit will simply reduce the weight of course exams on your overall grade.

Students can demonstrate mastery of course objectives through a variety of methods (exams, in-class activities, assignments, projects). The easiest way for you to succeed in this course is to successfully pass the unit exams.

If you are not satisfied with the score you receive on an exam, you can do the following to improve (or lower) your score:

1) Identify 1-2 student learning outcomes you have yet to master (based on your test score)
2) Solve **all** the problems on the test related to those outcomes. Show all your work. Briefly explain why you missed each problem (identify your misconceptions or explain why your approach did not work).
3) Demonstrate that you have put significant effort into mastering those outcomes. Significant effort must include reading about the topic (textbook or online), completing practice problems (10+ problems from homework or online sources), and writing/solving 3+ original problems.
4) Identify how you would like to demonstrate your learning. You could take a short test on the topic (without notes), complete a project, teach a short lesson to me, or identify another way to demonstrate your learning

Completing the above tasks will update your grade to reflect your mastery of course outcomes. Note that evaluating problems, creating tests, and reviewing projects are all time consuming. The ability to retry any student learning outcomes is subject to my availability. Make sure you have mastered the outcomes before attempting to retry!

Attendance policy:

Many concepts and methods will be presented in class through activities that cannot be fully reproduced outside of class. Because of this, it is important that you attend class and arrive on-time. While I will not deduct points from your grade for absences, I have found that students with poor attendance generally do poorly in the class.

If you must miss class, I'd appreciate it if you let me know in advance. You **must** get approval before missing exams.

Accommodations policy:

Students with disabilities who believe they may need accommodations in this class are encouraged to contact the Office of Services for Students with Disabilities at 333-6275 as soon as possible to better ensure that such accommodations are implemented in a timely fashion.

Academic integrity policy:

I encourage you to collaborate in studying or completing in-class activities, homework, or projects. **You must work alone on exams**. Review the SAU policy at http://web.sau.edu/Registration/documents/AcademicIntegrityPolicy.pdf

Policy on the use of electronic equipment:

Calculators and computers will be used extensively in this course. Out of courtesy to other students, please turn off the volume on any device you have.

Course procedures and expectations:

This course will introduce students to modern conceptualizations, applications, and methods of probability (the mathematical study of uncertainty or randomness) and statistics (the science of gaining insight from data).

> *I keep saying that* ***the sexy job in the next 10 years will be statisticians****. The ability to take data – to be able to understand it, to process it, to extract value from it, to visualize it, to communicate it – that's going to be a* ***hugely important skill in the next decades****, not only at the professional level but even at the educational level for elementary school kids, for high school kids, for college kids.*
>
> -- Hal Varian, Chief Economist at Google (The McKinsey Quarterly, 1/09)

Each topic will be introduced through guided classroom activities (available on the course website). We will work together to learn and apply important concepts. During these activities, I will ask LOTS questions. If you attend class, read about the topic ahead of time, participate in these activities, and review your notes periodically, you **will** learn the material. In addition, you will be able to use these activities (and any notes you write on them) during the unit exams.

The calendar outlines the activities, assigned readings, problems, and homework exercises you will complete. If you read about the topic (in your textbook or online) and try the homework problems before class, you will get more out of the in-class activities. You can download the homework problems and solutions from the website, so you will be able to immediately check your answers. If you have questions about any homework problems, let me know.

You will have at least one week to complete the take-home assignments that are assigned each unit. I encourage you to work with other students, but make sure you understand and write-up your own solutions

Exams will be open-note but not open-book. You can expect a variety of items designed to check your mastery of the objectives listed at the end of this syllabus. The test questions will only sample content we cover in class. Students choosing to complete homework problems will show me their work following the exams.

I am not terribly interested in your ability to memorize formulas and "statistical recipes." I want you to learn concepts, logic, applications, and pitfalls of statistics. To do this, you will need to come prepared to class everyday. This means reading about the topics, completing assignments, participating in class discussions, and reviewing notes periodically.

Do not fall behind in this class! If you have any questions or need assistance, feel free to work with other students, send me questions (via email, twitter, Blackboard post, or voicemail), or visit my office during my posted office hours.

Week	Topics/Activities	Online homework	Textbook homework
8/23	Course overview and introductions Activity 1: Intro to statistical inference via randomization	2.1: 2, 9 2.2: 11, 12, 13, 15, 17, 21, 25	Read sections 1.1, 1.4, 1.5 2.1-2.5: 1, 2, 3, 8, 13, 14, 33
8/28 8/30	Activity 2: Basic probability theory Activity 3: Counting rules	**Assign: Tricky Problems** 2.3: 29, 30, 31, 33, 39, 41	**Assign: Tricky Problems** 2.6: 37, 38, 41, 43, 49, 51, 55
9/4 9/6	Activity 3a: Permutation tests Activity 4: Conditional probability	**School bus inspector** **Permutation tests** **Randomizations** 2.4: 45, 47, 49, 50, 53, 55, 59 **Practice probability problems**	**School bus inspector** **Permutation tests** **Randomizations** 2.7: 71, 74, 77 2.8: 93, 95, 101 **Practice probability problems**
9/11 9/13	Activity 5: Independence Activity 6: Discrete random variables Activity 7: Binomial Distribution (chance for 1,000,000 points)	2.5: 71, 80, 83, 108 **Georgia Shipyard Cancer Rates** 3.1: 1, 7 3.2: 11, 13, 17 **Presidential Election** 3.2: 11, 13, 17 3.3: 29, 31, 44	2.9-2.10: 110, 115, 121, 124, 125, 129, 133 **Georgia Shipyard Cancer Rates** 3.1-3.3: 1, 5, 14, 19 **Presidential Election** 3.4: 41, 43, 45, 53
9/18 9/20	Activity 7a: Binomial test; Sign test Review for exam (7b: dog resemblance activity)	3.4: 46, 47, 49, 50, 55, 57 **Supreme Court**	Page 748: Problem 15.3 **Supreme Court**
9/25 9/27	**Exam #1: Probability** Activity 8: Discrete Distributions Activity 9: Continuous Random Variables	3.5: 69, 71, 73, 75 3.6: 79, 81, 83, 95 **Base Coach, Quiz, Practice** 4.1: 1, 3, 5 4.2: 11, 15 **Industrial Robot; Battery Prob.**	3.5-3.8: 67, 73, 79, 90, 97, 105, 113, 127, 135 **Base Coach, Quiz, Practice** 4.1-4.3: 11, 17, 31 **Industrial Robot; Battery Prob.**
10/2 10/4	Activity 10: Exponential Distribution Activity 11: Normal Distribution	4.4: 59, 61 4.3: 28, 31, 33, 35, 37, 47 **Fishing Problem; Normal Pract.**	4.5: 59, 63, 66, 73, 77 **Fishing Problem; Normal Pract.**
10/9 10/11	Activity 12: Central Tendency Activity 13: Exploratory Data Analysis (intro to Tableau?) Activity 14: Point estimates	Extra credit: Sections 4.5-4.6 1.3: 33, 37, 39 1.4: 47, 49, 51	1.2: 3, 5, 7 1.3: 1, 3 (mean & std. deviation) 8.1-8.3: 3, 21
10/16 10/18	Activity 15: Maximum Likelihood (optional) Activity 16: Sampling Distributions Activity 17: Central Limit Theorem	6.1: 1, 3, 5 6.2: 20 (optional) 5.3: 37 5.4: 46, 47, 49, 53	Read 9.1 9.7: 83 (optional) 7.1-7.4: 1, 5, 11, 13, 41, 43, 45
10/23 10/25	Activity 17b: Central Limit Theorem Bootstrap Method Demonstration (via Stata) **Exam #2: Applied Probability**	5.5: 59, 65 **Practice Exam**	**Practice Exam**
10/30 11/1	Activity 18: Confidence Intervals Activity 19: Student's t-distribution	7.1: 1, 3, 5 7.2: 13, 17, 19, 23 7.3: 29, 30, 33, 35, 37	8.5: 58, 60 8.8: 81, 82, 85
11/6 11/8	Activity 20: Hypothesis Testing Activity 21: t-tests	8.1: 1, 3, 5, 7 8.2: 17, 19, 21, 23, 25 **t-test exercises, practice, quiz**	10.1-10.7: 1, 2, 17, 21, 43, 45, 51, 53 10.8: 65, 67, 72, 75 **t-test exercises, practice, quiz**
11/13 11/15	Activity 22b: Test for proportions Activity 23: Independent samples t-test theory	8.4: 45, 47, 51, 53 9.1: 1 8.3: 35, 37, 39	8.6: 57, 59
11/20-22	Thanksgiving Break - No classes		
11/27 11/29	Activity 24: Independent samples t-test Activity 25: Dependent samples t-test	**Darwin Problem** **Practice Problems** 9.2: 21, 23c, 25, 27 9.3: 39, 41 **2-group randomization test**	**Darwin Problem** **Practice Problems** 12.3: 10, 15 **2-group randomization test**
12/4 12/6	Review for final exam		
Final Exam			

Unit 1:

Overview (Activity #1)

1. Define the terms *probability, statistics (descriptive statistics),* and *Statistics (statistical inference)*
2. Make decisions based on reported probabilities
3. Explain why random assignment is important in designing studies
4. Calculate simple proportions, odds, relative rates, and odds ratios from a contingency table
5. Given the general definition of a null hypothesis, write the null hypothesis for a specific study
6. Use a simulation method (randomization) to estimate the p-value of a statistical test
7. Explain the difference between a probability and a likelihood

Probability Basics (Activities 2-3)

8. Write out the sample space for simple and compound experiments
9. Apply the slots method (multiplication, factorial, permutation rules) or combinations to calculate the potential outcomes of an experiment
10. Explain the difference between a combination and a permutation using an example of each
11. Recognize when outcomes from an experiment are equally likely (or are not equally likely) to occur
12. Use the complement rule to calculate probabilities of disjoint (mutually exclusive) events
13. Give an example of two or more events that are disjoint; give an example of two events that are not disjoint
14. Draw Venn Diagrams to represent probability rules (such as the general addition rule or the complement rule)
15. Use Venn Diagrams or the general addition rule to calculate probabilities
16. Write out probability statements using correct set notation
17. Given a frequency table, determine probabilities; given a list of probabilities, fill-in a frequency table
18. Use combinations and the definition of probability to solve simple probability problems (beginning hypergeometric probabilities)
19. Use a simulation to estimate probabilities from an experiment
20. Explain solutions to the birthday problem (probability of at least 2 people sharing a birthday) and the Let's Make a Deal problem
21. Explain the following problem (sample space comprehension): Amy has 2 children; the older child is a female. Barb has 2 children; one child is female. The probability that the youngest child is female is 1/2 for Amy and 1/3 for Barb.

Randomization Methods (Activity 3a)

22. Explain the difference between an experimental study and an observational study
23. Write out the null and alternate hypotheses for a given study
24. Write out all possible randomizations from a study
25. Use combinations to determine the number of ways of randomly assigning X people into G groups
26. Use randomization methods to calculate a p-value for a given hypothesis
27. Write the potential consequences of Type I and Type II errors in a given study
28. Write out an interpretation of a p-value in a given study
29. Given a simple data set, complete an analysis using simulation or randomization methods

Discrete Random Variables & Conditional Probability (Activities 4, 5, 5a)

30. Given a list of probabilities, sketch a probability mass function and cumulative distribution function
31. Given a cumulative distribution function, calculate specific probabilities: What is $P(X<3)$?
32. Explain why a cumulative distribution function always starts at zero and ends at 1.0
33. Explain what is meant by a *conditional* probability
34. Write conditional probabilities using correct set notation: $P(A \mid B)$
35. Use Venn Diagrams or the conditional probability rule to calculate conditional probabilities
36. Use the general multiplication rule to calculate probabilities: $P(A \cap B)$
37. Given a frequency table, calculate conditional and joint probabilities (like the Alan & Beth movie example)
38. Explain what it means for two events to be independent
39. Use the conditional probability rule or the general multiplication rule to show that two events are independent
40. Use the law of total probability to calculate the probability of an event
41. Use Bayes' Theorem to calculate posterior probabilities
42. Verify de Morgan's Laws by sketching and shading Venn Diagrams

Discrete Random Variables, Expectation, and Variance (Activity #6)

43. Use the formula to calculate the expected value and variance of a random variable
44. Explain what the expected value and variance of a random variable represent
45. Explain the difference between an expected value and our expectation (of an outcome of an experiment)
46. Use the properties of expected values to determine what will happen if each value of X undergoes a linear transformation
47. Use the formula to calculate the standard deviation of a random variable
48. Use the properties of variances to determine what will happen if each value of X undergoes a linear transformation

Binomial Distribution (Activity #7 & Dog Experiment)

49. Define a discrete random variable
50. Explain the properties of a Bernoulli random variable
51. Derive the expected value and variance of a Bernoulli random variable
52. Evaluate a situation to see if the Binomial distribution applies (independent trials, constant probability of success)
53. Derive the pmf of a binomial distribution
54. Use the pmf to calculate binomial probabilities: $P(X<a)$ $P(X=a)$ $P(X>a)$

55. Derive the expected value of a binomial distribution
56. Calculate the expected value and variance of a binomial random variable
57. Use a calculator to calculate binomial probabilities
58. Use a binomial table to find binomial probabilities
59. Use the complement rule and a calculator to calculate P(X>a) under a binomial distribution
60. Verify the results of a published research article

Binomial Test & Sign Test (Activity #7a)

61. Write null and alternate hypotheses (for the binomial or sign tests) using correct probability notation
62. Assuming the null hypothesis is true, calculate the p-value of an experiment (probability of observing something as or more extreme)
63. Draw an appropriate conclusion from a p-value
64. Conduct a complete analysis using the binomial test
65. Conduct a complete analysis using the sign test

If time permits...

66. Calculate the desired probability using information typically collected under the method of randomized responses (in surveys)
67. Calculate false positive, false negatives (sensitivity, specificity) rates for a given situation (drug testing, polygraph)

Unit 2:

Discrete Distributions (Activities 8, 8a, 8b, 8c)

68. Define the term *random*
69. Derive pmf's for variables following geometric, negative binomial, hypergeometric, or poisson distributions
70. Derive formulas for the expected value and variance under geometric, negative binomial, hypergeometric, and poisson distributions
71. Use the formulas to calculate probabilities, expected values, and variances under these distributions
72. Sketch the pmf and cdf for a specific case under each distribution
73. Interpret the probabilities, expected values, and variances in an application of each distribution
74. Given an application, determine the appropriate discrete probability distribution to use
75. Explain how hypergeometric random variables differ from binomial random variables (sampling w/o replacement)
76. Explain the conditions under which each distribution can be used to model probabilities
77. Calculate probabilities for each distribution using a calculator (or computer)
78. Apply discrete distributions to solve realistic problems (hypergeometric probabilities, odds ratios, relative rates)
79. Use the multinomial distribution to calculate probabilities

Continuous Distributions (Activities 9, 9a, 9b)

80. Define a continuous random variable
81. Classify variables as either discrete or continuous
82. Given a histogram, calculate probabilities
83. Given a histogram, explain how probability is equivalent to the area under the histogram
84. Explain how to calculate probabilities (area under curves) or continuous random variables
85. Explain the conditions needed to demonstrate that a pdf is legitimate (area sums to 1.0; always positive)
86. Using either geometry or integration, calculate the area under a variety of curves
87. Explain why P(X=a) is always zero with continuous random variables
88. Derive the formulas for the expected value and variance of continuous random variables
89. Given a valid pdf, calculate expected values, variances, and percentiles of continuous distributions
90. Define the pth percentile of a distribution
91. Apply pdfs, area calculations, expected values, and percentiles to solve a realistic problem (industrial robot problem)

Special Continuous Distributions (Activity 10)

92. Calculate probabilities and expected values for variables following a uniform distribution
93. Explain the conditions under which exponential distributions may be appropriate
94. Given the pdf of an exponential distribution, derive the cdf
95. Model a situation using an exponential distribution and calculate probabilities
96. Provide an example of the memoryless property of exponential distributions
97. Use the gamma, beta, and weibull distributions to calculate probabilities
98. Determine the appropriate continuous distribution to model a given situation

Normal Distribution (Activity 11)

99. Describe the visual characteristics of a normal curve
100. Compare and contrast normal distributions for a variety of variables (location, spread)
101. Determine the appropriateness of using a normal distribution to model given random variables
102. Sketch symmetric, positively skewed, and negatively skewed distributions
103. Given the pdf for a standard normal distribution, prove the inflection points are at +/- 1
104. Sketch normal distributions given an expected value and variance
105. Explain why we cannot integrate to calculate normal curve probabilities
106. Use the empirical rule to state what percentage of observations lie within 1, 2, and 3 standard deviations of the mean
107. Interpret a z-score from a normal distribution
108. Calculate z-scores from a normal distribution

109. Explain what happens to the shape of a normal distribution when we transform it to a standard normal distribution
110. Calculate probabilities from a normal distribution
111. Use a calculator to calculate normal distribution probabilities
112. Calculate the pth percentile of a normal distribution
113. Standardize scales using z-scores and interpret the results (identify limitations)

Data Collection (Activity 12)

114. Classify variables into quantitative, qualitative, nominal, ordinal, interval, and ratio
115. Explain simple random, stratified, cluster, systematic, and convenience sampling methods
116. Determine whether a sampling method introduced bias (selection, response, measurement, nonresponse biases)
117. Define *independent* and *dependent* variables
118. Identify the sampling method, independent variable(s), and dependent variable(s) from a given research article

Exploratory Data Analysis (Activities 12a, 13)

119. Derive various methods to determine the "center" of a distribution
120. Demonstrate how the median minimizes the sum of absolute deviations
121. Prove (using calculus or graphical methods) how the sample mean minimizes the sum of squared deviations
122. Given a dataset, create a visual display (stemplot, histogram, and boxplot)
123. Given a visual display, draw conclusions about a dataset
124. Calculate the mean, median, and mode of a dataset
125. Determine which measure of central tendency is most appropriate for a given dataset
126. Determine the impact of an outlier (or linear transformation) on measures of central location
127. Calculate the pth percentile of a sample dataset
128. Calculate the IQR, range, variance, and standard deviation of a sample dataset
129. Calculate the population variance and unbiased estimate of the population variance
130. Determine the impact an outlier (or linear transformation) on measures of spread
131. Derive formulas to show the impact of a linear transformation on the mean and variance

Estimates and Estimators (Activities 14, 15)

132. Use correct notation to define population parameters (Greek letters) and point estimators
133. Use intuition to select the most appropriate point estimator of a parameter
134. Explain what is meant by a biased point estimate
135. Prove that the sample mean and sample proportion are unbiased estimators for the population mean and proportion
136. Explain why we want the variance of a point estimate to be minimized
137. Derive the variance of the sample mean and variance
138. Interpret the components of the mean square error of a point estimate
139. Explain why the unbiased estimate of the population variance has (n-1) in the denominator
140. Explain the term *degrees of freedom*
141. Explain the concept of *maximum likelihood*
142. Maximize the likelihood function in a simple (binomial) case
143. Use maximum likelihood to estimate item parameters in an Item Response Theory example

Sampling Distributions (Activity 16)

144. Given a small population, simulate the sampling distribution of the sample mean through repeated sampling
145. Given a population with a normal distribution, explain the shape and center of the sampling distribution for the sample mean
146. Define the term *standard error*
147. Explain what happens to the standard error as our sample size increases
148. Prove that the expected value of the sample mean is equal to the population mean
149. Prove that the variance of the sample means is equal to the population variance divided by the square root of the sample size
150. Given a population mean and standard deviation, sketch the sampling distribution of the sample mean for various sample sizes

Sampling Distributions (Activities 17, 17a, 17b)

151. Write out the Central Limit Theorem (explain it in your own words)
152. $P(\bar{X} < a)$ Explain the conditions under which the CLT "works"
153. Calculate probabilities from the sampling distribution:
154. Run a computer simulation to verify the CLT

Unit 3:

Confidence Intervals & t-distribution (Activities 18, 19)

155. Derive the formula for a confidence interval for the population mean
156. Interpret a confidence interval
157. Explain why we cannot say, "We are xx% confident that the population mean falls in our interval."
158. Explain how our chosen level of confidence impacts the width of a confidence interval
159. Explain how the sample size impacts the width of a confidence interval
160. Given a desired confidence interval width, determine the necessary sample size
161. Calculate confidence intervals for given situations

162. Derive the formula for a confidence interval for the population proportion
163. Explain the formula for the standard error of the sampling distribution of the proportion
164. Calculate confidence intervals for the proportion in a given situation
165. Explain why a t-distribution must be used when the population standard deviation is unknown
166. Determine the degrees of freedom for a confidence interval for the population mean
167. Calculate confidence intervals using the t-distribution
168. Evaluate different interpretations of confidence intervals (determine which are correct/incorrect)
169. Explain why a confidence interval may be meaningless with a nonrepresentative sample

Hypothesis Testing (general concepts) (Activity 20)

170. Given a study, identify the research goal, target population, sample, sampling procedure, parameter of interest, observed estimator, dependent variable, and independent variable
171. Determine if a given study is observational or experimental
172. Write out the null and alternate hypotheses
173. Explain why hypotheses are written with respect to parameters (and not statistics)
174. Determine if a 1-tailed or 2-tailed test should be used in a given study
175. Define Type I (alpha) error and Type II (beta) error
176. Define power
177. Explain the potential consequences of alpha and beta errors in a given study
178. Set an appropriate level for alpha
179. Explain the logic of statistical inference (hypothesis testing)
180. Explain why we must assume the null hypothesis is true in order to conduct a hypothesis test
181. For a given study, sketch the sampling distribution and locate the critical value (z-score)
182. Convert a critical value in the z-score metric to the sample mean metric
183. Convert an observed sample mean into a z-score
184. Determine whether to retain or reject the null hypothesis by comparing observed and critical values
185. Explain why we never accept the null hypothesis
186. Calculate and interpret the p-value from a hypothesis test
187. Given distributions for both the null and alternate hypotheses, shade the areas corresponding to alpha, beta, and power
188. Calculate the probability of a Type II error and power for a given study

One-sample hypothesis tests for the mean and proportion (Activities 21, 21b, 21c, 22, 22a)

189. Explain the conditions under which we use a t-test rather than a z-test
190. Estimate the p-value under a t-test
191. Given a specified Type I error rate and a p-value, determine whether to retain or reject the null hypothesis
192. Explain the difference between *statistical significant* and *practically significant* results
193. Determine the impact of alpha error rate on power
194. Determine the impact of sample size on power
195. Given a set of data, complete a hypothesis test and write the conclusions
196. Explain the relationship between hypothesis testing and confidence intervals
197. Conduct hypothesis tests on a calculator or computer
198. Interpret results from computer output of a hypothesis test
199. Derive formulas in order to test hypotheses about a population proportion

Independent samples hypothesis tests for the mean and proportion (Activities 23, 24, 24a, 24b)

200. Write appropriate hypotheses regarding the means from two independent samples
201. Derive and sketch the sampling distribution of the difference in means
202. Derive the formula for s_{pooled} (weighted average standard deviation)
203. Determine when to pool variances (equal variance assumption) or to use the Welch-Satterthwaite Method
204. Derive the formula for the confidence interval of the difference in means
205. Conduct an independent samples hypothesis test (z-test and t-test)
206. Determine the appropriate degrees of freedom from a given study
207. Write appropriate conclusions from an independent samples t-test
208. Explain the assumptions needed to conduct an independent samples t-test (independence, equal variances, normal distributions)
209. Explain how to test if two populations have equal variances
210. Explain how to test the normality of a distribution (p-p plots, histograms, chi-square tests)

Dependent samples (matched-pairs) hypothesis tests for the mean (Activity 25)

211. Given a study, determine if the groups are independent or dependent (matched)
212. Derive the formulas and sampling distribution for a dependent samples t-test
213. Conduct a complete dependent samples t-test
214. Explain why dependent samples tests have higher power than independent samples tests