

Conceptual Statistics

Chambersburg Area School District

Course Curriculum Map

Unit	Suggested Timeline
Unit 1: Statistical Design	2 weeks
Unit 2: Displaying Distributions	2 weeks
Unit 3: Describing Distributions	3 weeks
Unit 4: Regression and Correlation	3 weeks
Unit 5: Probability and Counting Techniques (simple events)	5 weeks
Unit 6: Binomial Probability Distributions	4 weeks
Unit 7: Normal Distributions	5 weeks
Unit 8: Sampling Distributions	1 weeks
Unit 9: Estimation	4 weeks
Unit 10: Hypothesis Testing	7 weeks

Course Description: Probability and Statistics is devoted to students learning about four key areas of study: experimental design, descriptive statistics, probability, and inferential statistics. Students will learn the principles of experimental design, how to draw a valid sample, and how to create a survey. Students will learn about and practice processes involving descriptive statistics, that is, the gathering, summarizing, and visually displaying one-variable and two-variable data. Students will also use rules of probability to find the likelihood that certain events or combinations of events occur. Students will gain knowledge of different types of distributions, such as the binomial distribution and the normal distribution, and use these distributions to find probabilities in real-world scenarios. Students will use both formula and calculator processes to find confidence intervals and run various hypothesis tests. They will also learn how to interpret the results of their findings.

Standards for Mathematical Practice

- *Make sense of problems and persevere in solving them.*
- *Reason abstractly and quantitatively.*
- *Look for and make sense of regularity in repeated reasoning.*
- *Construct viable argument and critique the reasoning of others.*
- *Model with mathematics.*
- *Use appropriate mathematical tools.*
- *Attend to precision.*
- *Look for and make use of structure.*
- *Look for and express regularity in repeated reasoning.*

Unit 1: Statistical Design

Key Learning: Collection of data, how to design an experiment, parts of an experiment, bias, how to prevent bias are all components of a basic knowledge of statistics.

Unit Essential Questions:

- What is data and how do we understand and communicate data?
- How do we obtain data, why is it important, and how can bias be identified and prevented?

Concept:
Data Basics

Concept:
Designing Data Collection

Concept:
Gathering Data

PA Core Standards:

2.4 HS Measurement, Data, and Probability

CC.2.4.HS.B.1 – Summarize, represent, and interpret data on a single count or measurement variable.
 CC.2.4.HS.B.2 – Summarize, represent, and interpret data on two categorical and quantitative variables.
 CC.2.4.HS.B.4 – Recognize and evaluate random processes underlying statistical experiments.
 CC.2.4.HS.B.5-Make inferences and justify conclusions based on sample surveys, experiments, and observational studies.

College and Career Ready Standards:

CCR.Math.Content.HSS-ID.A.1 - Represent data with plots on the real number line (dot plots, histograms, and box plots).

Lesson Essential Question(s):

- What is the nature of data?
- How can the study of Statistics be used in real life scenarios?
- What are the benefits of interpreting data?

Lesson Essential Question(s):

- How do we decide how to collect data?
- How do we design ways to collect data?
- What are other sampling techniques used to collect data?

Lesson Essential Question(s):

- How do we actually collect the data?
- How can we draw a random sample?
- What potential pitfalls are there in sampling and surveying?

Vocabulary:
Statistics, individual, variable, quantitative variable, qualitative variable, population, sample, nominal, ordinal, interval, ratio, descriptive statistics, inferential statistics

Vocabulary:
SRS, random number table, stratified sampling, systematic sampling, cluster sampling, convenience sampling

Vocabulary:
simulation, sampling with replacement, census

Resources/Activities/Projects**Primary Resource:**

- *Understanding Basic Statistics, 6th Edition*, Brase and Brase

Additional Resources for Connected Projects and Activities:

- Real World Statistical Problem Solving- <https://www.janestreet.com/real-numbers/>
- NCTM High School Statistics Lessons - <https://illuminations.nctm.org/Search.aspx?view=search&type=ls&gr=9-12>
- The U.S. Census Bureau: Statistics in Schools – Examining Career Statistics for High Schoolers - https://www.census.gov/programs-surveys/sis/2020census/2020-resources/k-12.Grades_9-12.html

Unit 2: Displaying Distributions

Key Learning: An integral part of statistics is being able to create and read visual representations of data.

Unit Essential Questions:

- How do we organize data to make it useful?
- What conclusions can be drawn from these displays?

Concept:
Histograms

Concept:
Bar Graphs, Circle Graphs, and Time –Series Graphs

Concept:
Stem-and-Leaf Displays

PA Core Standards:**2.4 HS Measurement, Data, and Probability**

CC.2.4.HS.B.1 – Summarize, represent, and interpret data on a single count or measurement variable.
CC.2.4.HS.B.2 – Summarize, represent, and interpret data on two categorical and quantitative variables.

College and Career Ready Standards:

CCR.Math.Content.HSS-ID.A.1 - Represent data with plots on the real number line (dot plots, histograms, and box plots). CCR.Math.Content.HSS-ID.A.1 - Represent data with plots on the real number line (dot plots, histograms, and box plots).

Lesson Essential Question(s):

- How can we construct histograms and relative frequency histograms?
- How can histograms be used to analyze shapes and distributions?

Lesson Essential Question(s):

- How can we select graphs appropriate for given data sets?
- How do we organize, display, and describe data?

Lesson Essential Question(s):

- How can we construct a stem-and-leaf plot?
- How can stem plots be used to analyze shapes and distributions?

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Vocabulary: Frequency histogram, relative frequency histogram	Vocabulary: bar graphs, Pareto charts, circle graphs, time plots	Vocabulary: Stem-and-leaf display, back-to-back stem plot
<u>Resources/Activities/Projects</u> Primary Resource: <i>Understanding Basic Statistics, 6th Edition</i>, Brase and Brase Additional Resources for Connected Projects and Activities: - Real World Statistical Problem Solving- https://www.janestreet.com/real-numbers/ - NCTM High School Statistics Lessons - https://illuminations.nctm.org/Search.aspx?view=search&type=ls&gr=9-12 - The U.S. Census Bureau: Statistics in Schools – Examining Career Statistics for High Schoolers - https://www.census.gov/programs-surveys/sis/2020census/2020-resources/k-12.Grades_9-12.html		

Unit 3: Describing Distributions

Key Learning: To be able to compare multiple sets of data, the spread of the data and measures of central tendency help describe certain aspects about the data set.

Unit Essential Questions:

- How is single variable analysis used in today's society?
- What conclusions can be drawn using measures of central tendency and spread?

Concept: Measures of Center	Concept: Measures of Variation	Concept: Box Plot and Outliers
PA Core Standards: 2.4 HS Measurement, Data, and Probability CC.2.4.HS.B.2 – Summarize, represent, and interpret data on two categorical and quantitative variables.		College and Career Ready Standards: CCR.Math.Content.HSS-ID.A.2 - Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets. CCR.Math.Content.HSS-ID.A.3 - Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers)

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Lesson Essential Question(s): - What are the commonly used measures of central tendency? - How are they compared?	Lesson Essential Question(s): - How do variance and standard deviation measure data spread? - How is range and standard deviation interpreted?	Lesson Essential Question(s): - How do we construct a box-and-whisker plot? - What does it tell us about the spread of the data?
Vocabulary: Mode, median, mean, resistant measures, trimmed mean	Vocabulary: Range, sample standard deviation, sample variance, sum of squares, population mean, population standard deviation, coefficient of variation	Vocabulary: Percentiles, Quartiles, interquartile range, 5 number summary, Box-and-Whisker Plot, outlier
<u>Resources/Activities/Projects</u> Primary Resource: <i>Understanding Basic Statistics, 6th Edition</i>, Brase and Brase Additional Resources for Connected Projects and Activities: - Real World Statistical Problem Solving- https://www.janestreet.com/real-numbers/ - NCTM High School Statistics Lessons - https://illuminations.nctm.org/Search.aspx?view=search&type=ls&gr=9-12 - The U.S. Census Bureau: Statistics in Schools – Examining Career Statistics for High Schoolers - https://www.census.gov/programs-surveys/sis/2020census/2020-resources/k-12.Grades_9-12.html		

Unit 4: Regression and Correlation

Key Learning: Data sets can be modeled by many mathematical models, linear regression being one of them.		
Unit Essential Questions: - How do we analyze paired data? - How linear regression is applied to real life situations?		
Concept: Scatterplots	Concept: Linear regression	Concept: Correlation and Coefficient of Determination

PA Core Standards: 2.4 HS Measurement, Data, and Probability CC.2.4.HS.B.2 – Summarize, represent, and interpret data on two categorical and quantitative variables. CC.2.4.HS.B.3 – Analyze linear models to make interpretations based on the data.		College and Career Ready Standards: CCR.Math.Content.HSS-ID.B.6 - Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. CCR.Math.Content.HSS-ID.B.6a - Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models. CCR.Math.Content.HSS-ID.B.6c - Fit a linear function for a scatter plot that suggests a linear association. CCR.Math.Content.HSS-ID.C.7 - Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data. CCR.Math.Content.HSS-ID.C.8 - Compute (using technology) and interpret the correlation coefficient of a linear fit. CCR.Math.Content.HSS-ID.C.9 - Distinguish between correlation and causation.
Lesson Essential Question(s): - When looking at data collected between two variables, how can we judge their relationship? - How are scatterplots created?	Lesson Essential Question(s): - How is the least-squares line mathematically determined? - How is the least-squares line used to make predictions?	Lesson Essential Question(s): - When looking at data collected between two variables, how can we judge their correlations? - How is the correlation coefficient mathematically determined? - How are correlation and causation related to each other?
Vocabulary: Scatterplot	Vocabulary: explanatory variables, response variables, interpolation, extrapolation	Vocabulary: Correlation coefficient, coefficient of determination
<u>Resources/Activities/Projects</u> Primary Resource: <i>Understanding Basic Statistics, 6th Edition</i>, Brase and Brase Additional Resources for Connected Projects and Activities: - Real World Statistical Problem Solving- https://www.janestreet.com/real-numbers/ - NCTM High School Statistics Lessons - https://illuminations.nctm.org/Search.aspx?view=search&type=ls&gr=9-12 - The U.S. Census Bureau: Statistics in Schools – Examining Career Statistics for High Schoolers - https://www.census.gov/programs-surveys/sis/2020census/2020-resources/k-12.Grades_9-12.html		

Unit 5: Probability and Counting Techniques (simple events)

Key Learning: Basic probability concepts are used to make predictions and analyze data.

- What are the methods of calculating probabilities?
- How can real life problems be solved using probabilities?

Concept: Basic Probability Rules	Concept: Contingency Tables and Conditional Probability	Concept: Counting
PA Core Standards: 2.4 HS Measurement, Data, and Probability CC.2.4.HS.B.6 – Use the concepts of independence and conditional probability to interpret data. CC.2.4.HS.B.7 – Apply the rules of probability to compute probabilities of compound events in a uniform probability model.		College and Career Ready Standards: CCR.Math.Content.HSS-ID.B.5 - Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.
Lesson Essential Question(s): • What are methods of calculating probabilities? • How?	Lesson Essential Question(s): • What are the basic definitions and rules of probability? • How are contingency tables used to calculate probabilities for two categorical variables?	Lesson Essential Question(s): • How are counting techniques used in everyday life? • How are permutations and combinations computed?
Vocabulary: $\cap$ - and, $\cup$ - or	Vocabulary: Independent, dependent, contingency table, conditional probability	Vocabulary: multiplication rule, permutations and combinations

Resources/Activities/Projects

Primary Resource:

- *Understanding Basic Statistics, 6th Edition*, Brase and Brase

Additional Resources for Connected Projects and Activities:

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Unit 6: Binomial Probability Distributions

Key Learning: Probability distributions including the Binomial Probability Distribution aid in calculating probabilities.

Unit Essential Questions:

- How are probability distributions generated and applied?
- How is the Binomial Probability Distribution used to solve problems?

Concept:
Probability distributions

Concept:
Binomial Probability Distribution

PA Core Standards:

2.4 HS Measurement, Data, and Probability

CC.2.4.HS.B.2 – Summarize, represent, and interpret data on two categorical and quantitative variables.
CC.2.4.HS.B.4 – Recognize and evaluate random processes underlying statistical experiments.

College and Career Ready Standards:

CCR.Math.Content.HSS-ID.A.4 - Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.

Lesson Essential Question(s):

- What is a Random Variable?
- How do we compute μ and σ for a discrete RV?

Lesson Essential Question(s):

- How does the binomial probability distribution help us compute the probability of getting r successes in n trials?
- How do we compute μ and σ for the binomial distribution?

Vocabulary:

Discrete random variable, continuous random variable, probability distribution, μ and σ , expected value

Vocabulary:

Binomial probability distribution μ , σ , for binomial probability distribution

Resources/Activities/Projects

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Additional Resources for Connected Projects and Activities:

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Unit 7: Normal Distributions

Key Learning: Many sets of data can be normalized to aid in computing probabilities.

Unit Essential Questions:

- How are Normal Distributions used to solve problems?
- How can we find examples of normal distribution in real world scenarios?

Concept:
Normal Curve

Concept:
Z-Scores

Concept:
Standardized Normal Distribution

PA Core Standards:

2.4 HS Measurement, Data, and Probability

CC.2.4.HS.B.2 – Summarize, represent, and interpret data on two categorical and quantitative variables.

CC.2.4.HS.B.4 – Recognize and evaluate random processes underlying statistical experiments.

College and Career Ready Standards:

CCR.Math.Content.HSS-ID.A.4 - Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.

Lesson Essential Question(s):

- What are some of the characteristics of a normal distribution?
- What does the empirical rule tell us about the data spread around the mean?

Lesson Essential Question(s):

- What are z scores and how are they applied?
- What is the standard normal distribution?

Lesson Essential Question(s):

- How do we find probabilities of “standardized events”?
- How does the z-score relate to the standard normal distribution?

Vocabulary:
Normal curve, Empirical rule, control chart,

Vocabulary:
Z – Score, raw score, Standard Normal Distribution

Vocabulary:
Standardized events

Resources/Activities/Projects

Primary Resource:

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Additional Resources for Connected Projects and Activities:

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Unit 8: Sampling Distributions

Key Learning: Sample distributions and their properties allow us to calculate meaningful probabilities.

Unit Essential Questions:

- How are Sampling Distributions useful?
- Why does the Central Limit Theorem play such a big role in statistics?

Concept:

Sampling Distributions

PA Core Standards:

2.4 HS Measurement, Data, and Probability

CC.2.4.HS.B.2 – Summarize, represent, and interpret data on two categorical and quantitative variables.

CC.2.4.HS.B.4 – Recognize and evaluate random processes underlying statistical experiments.

College and Career Ready Standards:

CCR.Math.Content.HSS-ID.A.4 - Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.

Lesson Essential Question(s):

- What is the Central Limit Theorem?
- How is it applied to a data set?

Vocabulary:

Random sample, parameter, statistic, sampling distribution, Central Limit Theorem

Resources/Activities/Projects

Primary Resource:

- *Understanding Basic Statistics, 6th Edition*, Brase and Brase

Additional Resources for Connected Projects and Activities:

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- NCTM High School Statistics Lessons - <https://illuminations.nctm.org/Search.aspx?view=search&type=ls&gr=9-12>
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Unit 9: Estimation

Key Learning: Finding intervals for which a value should fall is a good estimation tool.

Unit Essential Questions:

- How is estimation used to solve Real-World problems?
- How can we express the level of confidence we have for a value falling within a certain range of values?

Concept: Confidence Intervals for Means	Concept: Confidence Intervals for Proportions
PA Core Standards: 2.4 HS Measurement, Data, and Probability CC.2.4.HS.B.5 - Make inferences and justify conclusions based on sample surveys, experiments, and observational studies.	College and Career Ready Standards: CCR.Math.Content.HSS-ID.A.4 - Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.
Lesson Essential Question(s): • How do we construct a Confidence Interval for the mean from a large sample? • How much confidence should we place in the process? • How do we construct a Confidence Interval for the mean from a small sample?	Lesson Essential Question(s): • How do we construct a confidence interval to estimate a population proportion p? • How is a sample size calculated to estimate a population parameter?
Vocabulary: Confidence Interval, Critical Value, Degrees of freedom	Vocabulary: Error of estimate, margin of error
<u>Resources/Activities/Projects</u> Primary Resource: • <i>Understanding Basic Statistics, 6th Edition</i>, Brase and Brase Additional Resources for Connected Projects and Activities: • Real World Statistical Problem Solving- https://www.janestreet.com/real-numbers/ • NCTM High School Statistics Lessons - https://illuminations.nctm.org/Search.aspx?view=search&type=ls&gr=9-12 • The U.S. Census Bureau: Statistics in Schools – Examining Career Statistics for High Schoolers - https://www.census.gov/programs-surveys/sis/2020census/2020-resources/k-12.Grades_9-12.html	

Unit 10: Hypothesis Testing

Key Learning: Stating and testing a hypothesis is an essential part of statistical analysis.

Unit Essential Questions:

- How is statistical inference used to draw conclusions from data?
- How is probability used to express the strength of our conclusions?
- How do you determine if there is a statistically significant difference between claims?

Concept:
Hypothesis Basics

Concept:
Hypothesis Testing - Means

Concept:
Hypothesis Testing - Proportions

PA Core Standards:

2.4 HS Measurement, Data, and Probability

CC.2.4.HS.B.5 - Make inferences and justify conclusions based on sample surveys, experiments, and observational studies.

College and Career Ready Standards:

CCR.Math.Content.HSS-ID.A.4 - Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.

Lesson Essential Question(s):

- What is hypothesis testing?
- What is the value in using hypothesis testing when trying to validate a claim?
- What types of technology is used for statistical analysis?
- In what ways can technology be useful when designing your own experiment?

Lesson Essential Question(s):

- What makes an argument statistically convincing?
- To what extent are significance tests reliable?

Lesson Essential Question(s):

- How does one distinguish among the various tests of significance?
- How do you interpret the significance of the margin of error?

Vocabulary:

Hypothesis testing, statistical inference, conclusions, Null hypothesis, Alternative hypotheses, alpha levels, significance levels, errors, P-value, test statistic

Vocabulary:

biased statistic, unbiased statistic, sample size, sampling distribution, degrees of freedom

Vocabulary:

two sample hypothesis testing, paired sample hypothesis testing, independent sample hypothesis testing, common proportion

Concept: Hypothesis Testing - Association	Concept: Hypothesis Testing – Differences in Parameters	Concept: Hypothesis Testing - ANOVA
Lesson Essential Question(s): - Why is it important to understand hypothesis testing prior to using Chi-Square? - What does it mean for two data sets to be considered independent? - What is the difference between an observed and expected value?	Lesson Essential Question(s): - Why might it be necessary to determine if there is a difference between two data sets? - How does one test for difference in means and proportions in independent samples? - How does one test for differences between dependent samples?	Lesson Essential Question(s): - How is a hypothesis test conducted for several means? - What makes an argument statistically convincing?
Vocabulary: χ^2 (Chi squared) test, one way frequency table, expected cell count, observed cell count, Goodness-of-fit Test, Homogeneity Test, contingency table, Independence Test.	Vocabulary: Paired t-test, blocking, mean difference,	Vocabulary: ANOVA
<u>Resources/Activities/Projects</u> Primary Resource: <i>Understanding Basic Statistics, 6th Edition</i>, Brase and Brase Additional Resources for Connected Projects and Activities: - Real World Statistical Problem Solving- https://www.janestreet.com/real-numbers/ - NCTM High School Statistics Lessons - https://illuminations.nctm.org/Search.aspx?view=search&type=ls&gr=9-12 - The U.S. Census Bureau: Statistics in Schools – Examining Career Statistics for High Schoolers - https://www.census.gov/programs-surveys/sis/2020census/2020-resources/k-12.Grades_9-12.html		