Learning Objectives for Stat 225

08/20/12

**Introduction to Probability:**
Get some general ideas about probability, and learn how to use sample space to compute the probability of a specific event.

**Set Theory:**
Know the relationship between set, subset, and elements. Also, get some ideas about union, intersection, and complement. Finally, understand the situation when several sets are mutual exclusive, and several sets are exhaustive.

**Sample Space:**
Know the definition, and look at some examples writing down the sample space.

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**Addition Law:**
Know the formula, understand how to derive it, and be able to work some examples out.

**Venn Diagram:**
Be able to solve some problems using two-way Venn Diagram, and some using three-way Venn Diagram.

**DeMorgans Law:**
Know the formulae for both union and intersection cases. Two sets are involved will be enough. Moreover, understand how to derive the formulae using Venn Diagram, and be prepared to solve some probability problems using DeMorgans Law in the future.

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**Conditional Probability:**
Understand the ideas about conditional probability, followed by knowing the formulae. Also, be able to work out some relative examples.

**Multiplication Law:**
Know how to derive this from conditional probability formula, and understand when to utilize this law by looking at one example.
Independence:
Learn three equivalent criteria to verify whether two events are independent, and get some ideas about the meaning of independence.

Bayes Rule:
Understand some situations where we apply Total Probability Law and Bayes Rule to solve the problem. Also, learn how to use tree diagram to calculate the total probability and the posterior probability.

Basic Counting Rule:
Know that the motivation to learn counting method is to compute the probability later. Moreover, get the ideas about basic counting rule, and apply it to plenty of examples.

Permutation:
First, learn the definition of permutation, and how it is different from combination. Second, learn the notation and the formula, and practice several examples. Finally, know how to use calculator to compute permutation.

Combination:
Learn the definition of combination, and distinguish this from permutation. Also, be able to realize in which situation we should use combination to solve the problem, and practice plenty of examples. Finally, know the notation and formula, but also learn how to compute combination using the calculator.

Discrete Random Variable:
Learn what random variable is, and be capable of identifying whether a given random variable is discrete or continuous. Moreover, know what Probability Mass Function, PMF, is and know the properties of a valid PMF, and be able to write down the PMF of a random variable in a given scenario. Finally, given a random variable X and its PMF, be able to write down the PMF for the transformation of X.
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**Expected Value, E[X]:**
Get the ideas about the expected values of a random variable, and learn how to calculate the E[X] using some examples. Also, know the properties of E[X], which is a linear operator.

**Variance, Var[X]:**
Get the idea about variance of a random variable, and learn how to calculate it using some examples. Also, learn the properties of the variance, such as Var[aX+b]=a^2Var[X]

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**General Expectation for the functions of Random Variables:**
After knowing how to work on the expected value of a random variable, learn how to compute the expected values for the functions of random variables, such as $E[X^3]$ or $E[\frac{1}{X-2}]$.

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**Bernoulli Random Variable:**
Learn in which situation we can observe Bernoulli Random Variable, and understand what the parameter means. Also, learn the Probability Mass Function (PMF) for Bernoulli, and its expected value and variance.

**Binomial Random Variable:**
Get some ideas about identically independent distributed (iid), trials, and understand in which situation the random variable is Binomial. Moreover, understand what the parameter means in Binomial, learn the PMF for Binomial, be able to calculate the probability for Binomial Distribution, and know the expected value and Variance for Binomial.

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**Hypergeometric Distribution:**
Get the ideas about which situations we can see Hypergeometric Distribution, understand what its three parameters are, and be able to distinguish this from Binomial. Also, learn the PMF and how to calculate the probability. Finally, know E[X] and Var[X] for Hypergeometric.
Binomial Approximation to Hypergeometric:
For Hypergeometric, when \( N > 20n \), it can be approximated by Binomial. Notice what the parameters are for Binomial after the approximation.

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Poisson Distribution:
Understand in which circumstances Poisson Distribution will occur, and learn the meaning of the parameter. In addition, know how to compute the probability using the PMF, and know the \( E[X] \) and \( Var[X] \) for Poisson. Also realize the fact that the sum of independent Poisson is still Poisson.

Poisson Approximation to Binomial:
In a Binomial Distribution, when \( n \) is large (\( n > 50 \)), \( p \) is small (\( p < 0.05 \)) such that \( np \) is a moderate number (\( 0 < np < 5 \)), Binomial can be approximated by Poisson. Notice what the parameter is for Poisson after the approximation.

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Geometric Distribution:
Geometric is the number of trials needed until the first success, and the parameter is the probability of success. Learn the PMF and how to calculate the probability for Geometric, and notice the Lack of Memory Property. In addition, know the \( E[X] \) and \( Var[X] \) for Geometric.

Negative Binomial Distribution:
Understand the relationship between Geometric and Negative Binomial, and the difference between Negative Binomial and Binomial. Learn the PMF and how to calculate the probability for Negative Binomial, and notice the Lack of Memory Property. In addition, know the \( E[X] \) and \( Var[X] \) for Negative Binomial.

10/05/12
Nested Problems:
These are most often Binomial, Geometric, or Negative Binomial distributions, but the probability of success is going to be found using another distribution. Look at more examples during the lecture and example day.
Continuous Random Variables:
First, understand the characteristics of continuous random variables, and know the criterion for a valid PDF. Also, learn Probability Density Function (PDF) and Cumulative Distribution Function (CDF) for continuous random variable, being able to use them, PDF and CDF, to compute the probability and percentile. Furthermore, learn how to use PDF to calculate the expected value and variance for continuous random variable.

Uniform Distribution:
Understand in which situation the random variable is Uniform, and learn how to calculate the probability and percentile for Uniform. Also, get the ideas about its notation and parameters, and know the PDF, CDF, $E[X]$, and $Var[X]$. Finally, be able to do Max/Min problems using two different Uniform Distributions, like $P(\text{Max} > 4)$.

Exponential Distribution:
Understand in which situation the random variable can be regarded as Exponential, and understand its parameterization. Moreover, learn how to compute the probability and percentile. Finally, notice the Lack of Memory Property for Exponential.

Normal Distribution:
Get some ideas about Normal Distribution, and its special characteristics including Empirical Rule. Learn the notation, mean, and variance of Normal Distribution. Also, know what standard normal distribution is, and know what z-value is, and learn how to use the standard normal table to calculate the probability and percentile.

Normal Approximation to Binomial:
Understand what motivates us to use Normal Distribution to compute Binomial probability, and know in which situation this kind of approximation is valid. Furthermore, notice the fact that we need to use continuity correction while doing approximation in this case, and learn how to do it.
11/02/12

**Poisson Processes:**
Understand the structure of the Poisson Processes, and the special properties such as the interarrival time follows Exponential distribution. Also, given that there is a specific number of events in a time interval, the arrival times are uniformly distributed in that interval. Hence, given the total number of events, the conditional distribution of the number of events in a smaller time interval can be regarded as Binomial.

11/12/12

**Mean, Median, Mode:**
Understand the definition, and be able to find this statistics in the real data. Also, learn how to determine if the distribution is symmetric, right-skewed, or left-skewed.

**Percentile:**
Calculate the index first, and then get the percentile among the real data.

**Quartile:**
Understand the definition, and be able to compute the first and third quartiles in real data. In this class, computing the first quartile by calculating the median of the first half of the data, and the third quartile is the median of the second half of the data.

**IQR, Outliers:**
Know the definition of IQR, and learn how to calculate the upper and lower limits while identifying the outliers. Moreover, be able to find the 5-number summary. Practice this skill using real data, too.

**Box plot:**
Know what Box Plot is, and learn how to draw the Box Plot. Remember to identify outliers if they exist.

**Measure of Location and Variability:**
Learn which statistics are the Measure of Location, and which are the Measure of Variability. In addition, know the fact that some measures are only appropriate for symmetric distributions and some are more appropriate for skewed distribution.
Stat Applications and Types of Data:
Get some ideas about the following terminologies: Data, Data Set, Elements, Variables, and Observations. Know what Nominal, Ordinal, Interval, and Ratio Data are. Learn what Quantitative and Qualitative data are, and their difference. Compare Cross-Sectional Time Series Data.

In addition, learn Data Representations like Frequency Distribution Percent Frequency Distribution, Bar Graphs, and Histograms.

Notice Sources of Data which includes Existing Sources, Surveys, Experiments, and Observational Studies. Keep an eye on the difference between Experiments and Observational Studies.

For Sampling Methods, we need to know Stratified Sampling, Cluster Sampling, Systematic Sampling, Convenience Sampling, and Judgment Sampling.

For Statistical Inference, get the idea about Population, Sample, Survey, and Census. Also, know the source of bias in the survey.

Summarizing Quantitative and Qualitative Data:
Learn how to summarize the Quantitative Data and Qualitative Data. For summarizing Qualitative Data, we can use Frequency Distribution, Relative Frequency, Bar Graphs, and Pie Charts. For summarizing Quantitative Data, we can use, Relative Frequency, Percentage Frequency, Dot plot, Histograms, and Cumulative Distribution.

Stem and Leaf Plot:
Be able to read Stem and Leaf Plot, and learn how to draw it for real data. Also, compare the difference between Histogram and Stem and Leaf Plot.

Cross Tabulations:
Know how to read Cross Tabulation, and learn how to solve probability problem using this table, and finally be able to identify whether the derived probability is joint, marginal, or conditional probability.
11/26/12

Chi-Square Test of Independence between Categorical Variables:
Understand the purpose for doing this test. Know how to do this test step by step, and learn how to utilize the Chi-Square Table before making the conclusion in the test.

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Variance, Covariance, and Correlation:
First, briefly understand these concepts in population perspective. Then focus on learning how to calculate the sample variance and sample standard deviation. In addition, know the relationship between Correlation, Standard Deviations, and Covariance when two variables are in the discussion. Finally, get the ideas about the correlation between two variables.

11/30/12

Scatter Plot and Trend Line:
First, understand which situation we use scatter plot. Second, be able to judge between no association, positive association, and negative association while looking at the scatter plot. Third, get the ideas about the strength and form of the relationship. In this class, however, we focus on the situations where two quantitative variables have linear relationship.

In addition, be able to use the correlation to determine the direction and strength of the relationship.

For the Trend Line, learn how to interpret the r-square and the slope. Also, know how to use this Trend Line to make prediction, but notice the issue of extrapolation.