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| **Block 1: Probability and Probability Distributions** | | | | | |
| 1 | **Syllabus Setup** | **OBJECTIVES** | **READING** |  |  |
| **QUESTIONS** | **VIDEOS** |
| 2 | **Introduction to Data** | 1. Categorize variables of the following types: numerical, categorical, discrete, continuous, ordinal, nominal, independent, dependent, explanatory, response, and confounding. 2. Distinguish between a population and a sample. 3. Select a sample using simple random sampling, stratified sampling, cluster sampling, and multistage sampling. 4. Given a scenario, identify the appropriate sampling methodology. 5. Explain the principles of experimental design and the purpose of each principle. | **Mendenhall - Ch 1-3, 7.1-2**  **OpenIntro - Ch 1.1-1.4** |  |  |
| 1. What is the difference between a nominal and ordinal categorical variable? 2. What is the statistic way of saying “independent” and “dependent” variables? 3. Why does sampling methodology matter? 4. What is a confounding variable? 5. Running an experiment more than once to verify the results is known as what? | Examining Numerical Data (3:10)  [**https://bit.ly/1KimCjg**](https://bit.ly/1KimCjg)  Principle of Exp Design (5:01)  [**https://bit.ly/2RkJAT8**](https://bit.ly/2RkJAT8)  Samples and Surveys (10:05)  [**https://bit.ly/1ovxobB**](https://bit.ly/1ovxobB) |
| 3 | **Summarizing Data** | 1. Describe distributions using the appropriate statistical terms. 2. Identify several techniques to summarize and display data. 3. Determine the most appropriate graph, chart, or table to represent a given variable. 4. Interpret graphs and charts of numerical and categorical data, including scatterplots, histograms, bar charts, box plots, and contingency tables.   Calculate and interpret mean, median, mode, range, variance, standard deviation, and interquartile range. | **Mendenhall - Ch 1-3**  **OpenIntro - Ch 2.1-2.3** | **Lab 1 – Introduction to Data** |  |
| 1. To describe a distribution what three things do we primarily look at? Is there a possible fourth? 2. What is a “skewed” distribution? 3. What distribution occurs when all outcomes are equally likely? Example? 4. What are the 3 primary descriptions for the center? 5. When would likely use the mean instead of the median? Why? 6. What is the Interquartile Range? 7. What is the 2nd quartile better known as? 8. How are variance and standard deviation related? | What is Statistics (6:23)  [**https://bit.ly/1qHfgQN**](https://bit.ly/1qHfgQN)  Shape, Center, and Spread (11:02)  [**https://binged.it/2KoUo22**](https://binged.it/2KoUo22) |
| 4 | Defining Probability | 1. Distinguish between mutually exclusive and independent events. 2. Calculate probability for a given scenario, either numerically or using a Venn diagram. 3. Apply the General Addition Rule to solve probability problems. 4. Apply the Rules for Probability Distributions to create a probability distribution for a given scenario. 5. Use the complement of an event to solve probability problems. 6. Apply the Multiplication Rule for Independent Processes to solve probability problems. | **Mendenhall - Ch 4 (4.1-4.5)**  **OpenIntro - Ch 3 (3.1)** |  |  |
| 1. What is a probability? 2. What does it mean if two events are disjoint? What is another phrase for disjoint? 3. What is a probability distribution? 4. What is the complement of an event? 5. What does it mean if two events are independent? | Basics of probability (15:15)  [**https://bit.ly/2Ilxd6u**](https://bit.ly/2Ilxd6u)  Probability Models (10:33)  [**https://bit.ly/2KnX00a**](https://bit.ly/2KnX00a) |
| 5 | Conditional Probability | 1. Create contingency tables with both raw values and proportions. 2. Calculate conditional probability, both by using logic and by using the definition of conditional probability. 3. Explain the difference between marginal and joint probabilities. 4. Apply the General Multiplication Rule to solve probability problems. 5. Describe event relations in the context of a problem using the appropriate terminology. | **Mendenhall – Ch 4 (4.4)**  **OpenIntro - Ch 3 (3.2)** |  |  |
| 1. What is a contingency table? 2. What is the formula for computing the conditional probability ? 3. What is a marginal probability? 4. What is a joint probability? 5. What is conditional probability? | Introduction to Conditional Probability (12:00)  <https://bit.ly/31N60RW> |
| 6 | Conditional Probability (Bayes’s Rule) | 1. Solve joint and conditional probability problems by using a tree diagram. 2. Recognize probability inversion and apply Bayes’ Theorem to calculate the appropriate conditional probability. | **Mendenhall - Ch 4 (4.5)**  **OpenIntro Ch 3 (3.2)** | **Lab 2 - Simulation** |  |
| 1. What is a tree diagram? 2. How can tree diagrams be used to solve probability problems? 3. What is an inverted conditional probability and how does it differ from conditional probability? | Probability Trees (8:23)  <https://bit.ly/2WAAmmV>  Bayes’ Rule – How it led to Artificial Intelligence: (5:27)  <https://binged.it/2WJoow8> |
| 7 | Sampling from a small population | 1. Explain the difference between “with replacement” and “without replacement”. 2. Describe the impact of replacement on probability. | **OpenIntro - Ch 3 (3.3)** |  | CTA #1 |
| 1. What is rough cutoff between a small and large sample? 2. What is meant by “without replacement”? 3. If we sample “without replacement” from a small population, what changes about our observations? | How to Calculate Probability With and Without Replacement: (7:37)  <https://bit.ly/2MtSRrI> |
| 8 | Introduction to Random Variables | 1. Define “random variable”, “discrete random variable”, and “continuous random variable”. 2. Given a scenario, calculate and interpret the expected value of an event. 3. Explain how “expected value” is different from “average”. 4. Calculate the variance and standard deviation for a random variable. 5. Use linear combinations of random variables to solve problems. | **Mendenhall - Ch 4 (5.1)**  **OpenIntro - Ch 3 (3.4)** |  |  |
| 1. What are random variables (RV) and how are they denoted? 2. What are the two flavors of RVs? 3. What are expected values and how are they denoted? 4. How is the expected value of a random variable different than the average? In words, what is the variance? 5. What is the formula for the variance? 6. What is a linear combination of RVs? When might we want to consider a linear combination of RVs instead of a single RV? | Introduction to Discrete Random Variables: (11:54)  <https://bit.ly/1Pgz1cB>  Expectation and Variance of Discrete Random Variables: (7:56)  <https://bit.ly/2r2aRfd>  Space Shuttle Challenger accident (11:09)  <https://bit.ly/2XsyscB> |
| 9 | Continuous Distributions | 1. Describe the properties of a probability density function. 2. Distinguish between Probability Density Functions and Cumulative Density Functions 3. Calculate probabilities of continuous random variables using a probability density curve. | **Mendenhall - Ch 6 (6.1)**  **OpenIntro - Ch 3 (3.5)** |  |  |
| 1. How are continuous and discrete random variable different? 2. What is a probability density function (pdf)? And what is the total area under its curve? 3. How do you compute probabilities for a continuous random variable? 4. For a continuous random variable, what is the probability of the random variable equaling one specific value? Why? | PDFs and CDFs: (6:24)  [**https://bit.ly/2RoQF55**](https://bit.ly/2RoQF55)  Continuous random variables: (5:51)  [**https://bit.ly/2ZlFwov**](https://bit.ly/2ZlFwov) |
| 10 | Normal Distribution | 1. Describe the characteristics of the Normal Distribution. 2. Explain the difference between the Normal and Standard Normal Distributions. 3. Calculate and interpret standardized (z) scores. 4. Determine Normal Distribution probabilities, mean, and standard deviation. | **Mendenhall - Ch 6 (6.2, 6.3)**  **OpenIntro - Ch 4 (4.1)** | **Lab 3 – Normal Distribution** |  |
| 1. What are some of the different names associated with the normal distribution? 2. What are the parameters for this distribution? What values can they take? 3. What are the mean and variance for a standard normal distribution? 4. What is a z-score? Why are z-scores important to statisticians? 5. What is the 68-95-99.7 rule? | An Introduction to the Normal Distribution: (5:26)  <https://binged.it/2F5bhKM>  Standardizing Normally Distributed Random Variables: (6:37)  <https://binged.it/2KNNPpe>  Normal Calculations (12:49)  <https://bit.ly/1R0K4Zt> |
| 11 | Binomial Distribution | 1. Identify distributions that have a binomial distribution. 2. Explain the assumptions for binomial distributions. 3. Calculate binomial probabilities, means, and standard deviations. 4. Distinguish between combinations and permutations | **Mendenhall - Ch 5 (5.2)**  **OpenIntro - Ch 4 (4.3)** |  |  |
| 1. What has a binomial distribution? When do we use it? 2. What are the assumptions of a Binomial random variable? 3. What is the formula for a binomial distribution? 4. What are the mean and variance of the Binomial distribution? | Binomial Distributions – Finding Probabilities: (8:45)  <https://bit.ly/31G8xxg>  Normal Approximation to Binomial: (3:37)  <https://bit.ly/2WGv66b>  Binomial Distribution: (7:08)  <https://binged.it/2MMNLIH> |
| 12 | Poisson Distribution | 1. Identify distributions that have a Poisson distribution. 2. Explain the assumptions for Poisson distributions. 3. Calculate Poisson probabilities, means, and standard deviations. | **Mendenhall – Ch 5 (5.3)**  **OpenIntro - Ch 4 (4.5)** |  | CTA #2 |
| 1. What does the Poisson random variable count? 2. What are the assumptions of the Poisson distribution? 3. What is the formula for a Poisson distribution? 4. What are the mean and variance of the Poisson distribution? | Poisson Distribution: (watch until 7:24)  <https://binged.it/2IDYRL1> |
| 13 | Block I Review |  |  | **Milestone 1 Due** |  |
| **14** | **GR 1** | **Lessons 1 - 12** |  |  | **GR 1** |

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| **Block 2: Statistical Inference** | | | | | | |
| 15 | Point Estimates and Sampling Variability | | 1. Define each of the following terms: point estimate, parameter, sampling error, and unbiased. 2. Identify whether the parameter of interest in a given situation is a mean or a proportion. 3. Explain how a sampling distribution is created. 4. Describe the characteristics of the center, spread, and shape of a sampling distribution. 5. Explain how sample size affects a sampling distribution. | **Mendenhall – Ch 7 (7.2), Ch 8 (8.2)**  **OpenIntro - Ch 5 (5.1)** | **Lab 4 – Intro to Inference** |  |
| 1. What is a point estimate? A parameter? 2. The difference between a point estimate and a parameter is called what? 3. What two pieces make up this term? 4. What is the sampling distribution of a statistic? 5. What impact does sample size have? | The Sampling Distribution of the Sample Proportion (9:48)  <https://bit.ly/2L31Qzm>  Sampling Distributions: (12:01)  <https://bit.ly/1vtJ1GV> |
| 16 | | The Central Limit Theorem | 1. Explain the concept of the Central Limit Theorem and why it is important to inferential statistics. 2. Explain the effect of the population distribution and sample size on a sampling distribution. 3. Determine if the Central Limit Theorem applies in a given scenario, using the success-failure condition. 4. Calculate and interpret the point estimate and standard error of a given scenario. | **Mendenhall - Ch 7 (7.3-7.4)**  **OpenIntro - Ch 5 (5.1)** |  |  |
| 1. What is the idea of the Central Limit Theorem? 2. Our statistical inference procedures will be based on what type of distribution? 3. What is the mean of the sampling distribution for the sample average? 4. What is the standard deviation of the sampling distribution of the sample average? 5. Why is sample size important when applying the Central Limit Theorem? | Bunnies and Dragons (3:38)  <https://bit.ly/1StItNK>    Introduction to the Central Limit Theorem (13:13)  <https://bit.ly/2FR7BOi>  Online applet:  <https://bit.ly/1b2MH3M> |
| 17 | | Confidence Intervals for a Sample Proportion | 1. Explain why statisticians use confidence intervals. 2. Differentiate between standard error (SE) and margin of error (MOE). 3. Calculate and interpret a confidence interval for a proportion. 4. Explain the relationship between the confidence level chosen and the width of the confidence interval. | **Mendenhall – Ch 7 (7.2), Ch 8 (8.2-8.3)**  **OpenIntro - Ch 5 (5.2)** | **Lab 5 – Confidence Intervals** |  |
| 1. What do we construct confidence intervals for? 2. What is a confidence level? 3. Regarding confidence intervals, there’s a tradeoff between the \_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_. 4. What is the margin of error? 5. What is the form of the confidence interval? | Introduction to Confidence Intervals: (6:41)  <https://binged.it/2KgQ7h9>  Confidence Intervals: (10:02)  <https://bit.ly/2RfYPN3> |
| 18 | | Hypothesis Testing for a Proportion | 1. Create the null and alternative hypotheses for a given scenario. 2. Distinguish between Type I and Type II errors, and interpret what each error means in a given scenario. 3. Describe scenarios where one might choose different levels of significance. 4. Explain the difference between statistical significance and practical significance. | **Mendenhall - Ch 9 (9.1 – 9.2)**  **OpenIntro - Ch 5 (5.3)** |  |  |
| 1. In a hypothesis test, what are the two competing ideas? 2. What is a p-value? 3. What is a Type 1 error? 4. What is the significance level? | The Most Simple Introduction to Hypothesis Testing: (10:59)  <https://binged.it/2XsihMb>  Shakespeare (16:43)  <https://bit.ly/2WTKFT2> |
| 19 | | Inference for a Single Proportion | 1. Identify when a sample proportion is nearly normal by using the success-failure condition. 2. Conduct a hypothesis test for a single proportion using confidence intervals. 3. Conduct a hypothesis test for a single proportion using p-values. 4. Determine the correct sample size required to achieve a specified MoE | **Mendenhall - Ch 9 (9.4)**  **OpenIntro - Ch 6 (6.1)** | **Lab 6 – Inference for Categorical Data** |  |
| 1. What is the “success-failure” condition? 2. What value of “p” gives the largest MoE? Why use this? | Find the Sample Size (7:44)  <https://bit.ly/2WI8Eto>  Inference for a Proportion (8:39)  <https://bit.ly/2ItIDoU>  Inference for Proportions (10:46)  <https://bit.ly/2N37nbM> |
| 20 | | Difference of Two Proportions | 1. Determine if the sampling distribution for a difference in proportions can be modeled using a normal distribution. 2. Calculate and interpret the confidence interval for a difference in proportions. 3. Conduct a hypothesis test for a difference in proportions. 4. Identify when to use pooled proportions. | **Mendenhall - Ch 9 (9.5)**  **OpenIntro - Ch 6 (6.2)** |  | CTA #3 |
| 1. What is the standard error for a difference in proportions? 2. When can we use a pooled proportions 3. Why do we use a pooled proportion? | An Introduction to Inference for Two Proportions (15:09)  <https://bit.ly/2XkKF2T> |
| 21 | | One-Sample Means with the t-distribution | 1. Identify when a one-sample t-test is appropriate. 2. Perform the normality check for sample means. 3. Calculate and interpret a t-confidence interval for a single mean. 4. Conduct a single mean hypothesis t-test. | **Mendenhall - Ch 10 (10.1 – 10.2)**  **OpenIntro - Ch 7 (7.1)** |  |  |
| 1. What purpose does a large sample serve? 2. When do we use the t-distribution? 3. How is the t-distribution similar to the z-distribution we’ve been using? Different? Parameters? 4. If the sample size is low, is it easier or harder to reject the null hypothesis? | Small Sample Inference for One Mean (12:29)  <https://bit.ly/2KvHsaH>  t-distribution: (7:20)  <https://bit.ly/31sNoGC>  Guinness (16:58)  <https://bit.ly/2WXgbEs> |
| 22 | | Paired Data | 1. Identify when observations are paired. 2. Conduct and interpret a t-test for paired data. 3. Calculate and interpret paired confidence intervals for means. | **Mendenhall - Ch 10 (10.4)**  **OpenIntro - Ch 7 (7.2)** |  |  |
| 1. What does it mean when data are “paired”? 2. To analyze paired data, what is an often-useful way to look at the data? 3. What previous hypothesis test is this similar to? | t-distribution (7:20):  <https://bit.ly/31sNoGC> |
| 23 | | Difference of Two Means | 1. Explain the difference between independent and dependent groups. 2. Identify when a hypothesis test for the difference of two means is appropriate. 3. Conduct and interpret a t-test for the difference in means. 4. Calculate and interpret confidence intervals for the difference in means. 5. Identify when pooling the standard deviation is appropriate. | **Mendenhall - Ch 10 (10.3)**  **OpenIntro - Ch 7 (7.3)** | **Lab 7 – Inference for Numerical Data** |  |
| 1. What is the difference between this lesson and the previous lesson? 2. What do we use for degrees of freedom? 3. When can we pooled standard deviation? Why do this? | Difference of two independent means (8:56)  <https://bit.ly/2KC6mFN> |
| 1. What is the difference between independent and dependent groups? 2. What do we use for degrees of freedom when conducting a test for the difference between two means?   When can we pooled standard deviation? Why do this? | Power Calculations for difference of two means (11:03)  <https://bit.ly/2Fqa1C7> |
| 24 | | Power Calculations for a Difference in Means | 1. Describe the considerations when planning an experiment. 2. Explain the idea of power and why it is important to consider when conducting hypothesis testing. 3. Describe what effect size is and interpret a given effect size. 4. Determine the sample size required to achieve the desire power. | **OpenIntro - Ch 7 (7.4)** |  | **CTA #4** |
| 1. Oftentimes, in experimental planning, what are the two competing considerations you have to balance? 2. In your own words, what do we mean by “power”? 3. What power is typically considered common practice? | Power Calculations for difference of two means (11:03)  <https://bit.ly/2Fqa1C7> |
| 25 | | Block II Review |  |  | **Milestone 2 Due** |  |
| **26** | | **GR 2** | **Lessons 15 - 24** |  |  | **GR 2** |

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| **Block 3: Variance and Regression** | | | | | |
| 27 | Comparing Many Means with ANOVA | 1. Identify when Analysis of Variance (ANOVA) is the appropriate analysis to conduct. 2. State the appropriate null and alternative hypotheses for ANOVA. 3. Explain how and why the total variation is partitioned in ANOVA. 4. Correctly interpret the components of an ANOVA table. | **Mendenhall - Ch 11 (11.1-11.2)**  **OpenIntro - Ch 7 (7.5)** |  |  |
| 1. When do you use ANOVA vs t-test? 2. What is the null hypothesis for all ANOVA experiments? 3. What is the Bonferroni correction? What’s the point? 4. What is the idea behind analysis of variance? 5. The larger the F ratio is the more likely... 6. When most of the variance comes from \_\_\_\_\_\_\_\_\_\_\_\_, there is most likely a difference in the effect. | How to Calculate and Understand Analysis of Variance (ANOVA): (14:29)  <https://bit.ly/2T1t8bt>  ANOVA Introduction (9:34)  <https://bit.ly/2WIaY3A>  Conditions for ANOVA (2:58)  <https://bit.ly/2Wzt0A0> |
| 28 | Fitting a Line, Residuals, and Correlation | 1. Identify when a linear regression is appropriate. 2. Interpret the coefficients in a regression equation. 3. Describe residuals are and interpret residual output. 4. Describe the relationship between two variables using correlation. 5. Estimate the strength and identify the direction of a correlation from a scatterplot. 6. Interpret a numerical correlation. | **Mendenhall - Ch 12 (12.1)**  **OpenIntro - Ch 8 (8.1)** |  |  |
| 1. What is a residual? 2. How are residuals helpful? 3. What is a correlation coefficient? What values can this take? 4. What is the difference between the dependent and independent variables' roles? What’s another name for these? 5. How do you interpret the coefficient of the independent variable? 6. What does our linear equation look like in stats notation? | Line Fitting, Residuals, and Correlation (4:04)  <https://bit.ly/2F2OW0v> |
| 29 | Least Squares Regression | 1. Explain the conditions necessary for the least squares line. 2. Create a least square line equation from summary statistics. 3. Interpret regression model parameter estimates. 4. Explain the concept of extrapolation and how it affects our interpretation of a linear model. 5. Use R^2 to evaluate the quality of a model. 6. Appropriately use indicator variables in a regression analysis. | **Mendenhall - Ch 12 (12.1-12.3)**  **OpenIntro - Ch 8 (8.2)** | **Lab 8 – Linear Regression** |  |
| 1. What four things do we require for fitting a least squares line? 2. How can we estimate the slope of a least squares line? 3. How do you interpret the parameters estimated by least squares? 4. What is extrapolation? 5. In your own words, what exactly is “R-squared”? 6. How do you incorporate indicator variables into a regression model? | Fitting a Line with Least Squares Regression (6:48)  <https://bit.ly/2Zj4vZq> |
| 30 | Types of Outliers in Linear Regression | 1. Identify outliers from scatterplots and residual plots. 2. Explain the concept of leverage and how it impacts regression results. 3. Explain when it is appropriate to remove outliers. | **OpenIntro - Ch 8 (8.3)** |  |  |
| 1. What is an influential point? 2. When is it ok to remove outliers? | Types of Outliers in Linear Regression (2:52)  <https://bit.ly/2MWuwMO>  Inference for Linear Regression (4:20)  <https://bit.ly/2MM9D70>  Checking Assumptions video  <https://bit.ly/2IGhUUO> |
| 31 | Inference for Linear Regression | 1. Conduct the hypothesis test for a linear regression. 2. Create a least squares regression equation from statistical output. 3. Interpret the meaning of regression coefficients. | **Mendenhall - Ch 12 (12.3)**  **OpenIntro - Ch 8 (8.4)** |  |  |
| 1. Conceptually, what is the hypothesis test for a linear regression? 2. What is the hypothesis pair for a linear regression? | Simple Linear Regression in R (5:37)  <https://bit.ly/339nCIr> |
| 32 | Introduction to Multiple Regression | 1. Explain the difference between simple and multiple regression. 2. Conduct a regression analysis with multi-level categorical predictors. 3. Conduct a multiple regression analysis for a given scenario. 4. Explain the difference between “R-squared” and “adjusted R-squared”. 5. Calculate and interpret the adjusted R-squared for a given scenario. | **Mendenhall - Ch 13 (13.1 – 13.4)**  **OpenIntro - Ch 9 (9.1)** |  |  |
| 1. If a categorical variable has k levels, how many new columns are needed? 2. What is a reference level? 3. What do the coefficients represent in a multiple regression model? 4. What is “adjusted R-squared”? 5. What’s the difference between “R-squared” and “adjusted R-squared”? | Introduction to Multiple Regression (4:52)  <https://bit.ly/2Zu6SsJ>  Multiple Linear Regression in R (5:18)  <https://bit.ly/2ToFYTP> |
| 33 | Model Selection | 1. Explain the concepts of “parsimonious” and “full model” and how they are related. 2. Describe backward elimination and forward selection methods for choosing a multiple regression model. 3. Construct multiple regression models using both backward elimination and forward selection. | **Mendenhall - Ch 13 (13.6 – 13.10)**  **OpenIntro - Ch 9 (9.2)** | **Lab 9 – Multiple Regression** | CTA #5 |
| 1. What metric do we typically use to compare and therefore pick the “best” model? 2. What is an alternative approach to model selection? 3. How do you decide which one to use? 4. How do you perform a “Backward elimination” strategy? 5. How do you perform a “Forward selection” strategy? | Model Selection (4:29)  https://bit.ly/2MMY9Aq |
| 34 | Checking Model Conditions Using Graphs | 1. Describe and apply the four conditions required for a multiple regression. 2. Use diagnostic plots to identify concerns with a model. 3. Identify common options to improve model fit and describe when each would be appropriate to use. | **Mendenhall - Ch 13 (13.6)**  **OpenIntro - Ch 9 (9.3)** |  |  |
| 1. What plot provides a check for constant variance? 2. What are some options to improve model fit? Why even use these? 3. Is there a downside to using any of these improvements? 4. What’s the most important thing to remember about a model? | Checking Model Assumptions Using Graphs (3:21)  <https://bit.ly/2MLYTFV> |
| 35 | Block III Review |  |  | **Milestone 3 Due** |  |
| **36** | **GR 3** | **Lessons 27 - 34** |  |  | **GR 3** |
| 37 | Projects | Groups present Project results and recommend a decision |  | **Group Projects** | **Project Report Due at Beginning of Class** |
| 38 | Projects | Groups present Project results and recommend a decision |  | **Group Projects** |  |
| 39 | Projects | Groups present Project results and recommend a decision |  | **Group Projects** |  |
| 40 | Projects / Review | Groups present Project results and recommend a decision |  | **Group Projects** |  |
| **Finals Week** | **Final Exam** | **Lessons 1 - 40** |  |  | **Final Exam** |