MASTERS COURSE

CS350: Advanced Formal Analyses

TERM
Fall 2020

CREDIT
4

Course Description

Formal Analyses focuses on rigorous critical thinking. Students learn formal reasoning and logic, mathematical and statistical models, algorithms and introductory machine learning, and key elements of decision theory. A key component of the course is learning to identify the biases and other pitfalls that may color the formulation and interpretation of arguments, models, and decisions.

Note: this syllabus is subject to change.

Course Objectives & Learning Outcomes

Prerequisites & Working Knowledge

The *Summer Guide *that Minerva emailed out to you about two weeks ago included a description of the CS350 preparatory work you're expected to do over the summer (i.e., the "summer prep"). I'm repasting that summer prep info below to make sure that you're aware of it:

*All CS350 students are expected to have mastered a basic degree of proficiency in **R** programming BEFORE the first day of class. The first two weeks of class and the first CS350 assignment will draw heavily on these R skills.*
*To help you prepare forCS350, you have been granted free premium access to DataCamp's online tutorials (if you register with your **minerva.kgi.edu** email address)!****

CLICK HERE NOW FOR FREE PREMIUM ACCESS:

https://datacamp.com/groups/shared_links/3cc6691fdfd1291f2ec3e0b2478d84303b12bed7911ddc73ee85efdf2052478d

*****Use your .kgi email to register***** Do this right away, otherwise you will get locked out and the invite link will expire.***

*We expect you to be proficient with all skills and concepts covered by DataCamp's first 2 courses in the "Data Scientist with R" program ("Introduction to R"** and **"Intermediate R")** PLUS one additional intro course called **"Intro to Importing Data in R". * When you register for DataCamp you should see these courses as assignments on your dashboard.Total time required for all three online courses should not be more than 3 full-time days. It might be half that (or even less than 1 day) depending on your previous programming experience, motivation, and coding stamina. **Anyone who wants additional R coding exercises may contact me directly after completing the DataCamp sequence (because I have optional coding quizzes with answers that I can provide upon request).*

This summer I'm holding office hours on Mondays from 8:00 - 9:30 AM Eastern Time, by appointment, because I enjoy meeting students before the semester begins.If you'd like to meet, please emailadiamond@minerva.kgi.edu) at least 12 hours ahead of time.

Assignments

There are three types of HC assessments in Cornerstone courses: HC-scored class polls and activities, signature assignments, location-based assignments, and the final project. Assignments will be weighted relative to HC-scored class polls and activities based on the values shown in the table below. All assessments will be scored based on the quality of HC application. For more information, see the “Assessment” section in the policies below.

- **HC-scored Class Polls and Activities**: Each 90-minute class session will be taught on the Minerva Active Learning Forum. During each class,

students will answer a preparatory assessment poll and a reflection poll, which occur at the beginning and end of class respectively. These polls may be HC scored. In addition, some class activities will be selected for video scoring. Students will be alerted to scored activities when scores on polls and activities are released.

- **Signature Assignments:** These are original works (e.g., essays, short papers, problem sets or models) that consolidate the student's work on a combined set of HCs. The work is graded against a mandatory set of HCs that must be addressed. In addition, the student may address other HCs introduced earlier in this, or any other, Cornerstone course.
- **Final Project:** Each semester, students complete a single Final Project across all four cornerstone classes. Final Projects will appear as a separate course on the dashboard of the Active Learning Forum.

Note: Sunday is considered the beginning of the academic week for determining due dates.

ASSIGNMENT TITLE	WEIGHTING	IMPORTANT DATES
Logical Thinking	8x	**Released:** Week 1, Monday **Due:** Week 5, Sunday
Variables	8x	**Released:** Week 5, Monday **Due:** Week 9, Thursday
Final Project: Statistical Inference	8x	**Released:** Week 12, Friday **Due:** Week 15, Friday

Required Texts

DeLancey, C. (2017) *A Concise Introduction to Logic.* Geneseo, NY Open SUNY Textbooks

https://milnepublishing.geneseo.edu/concise-introduction-to-logic/

Diez, D., Barr, C., & Cetinkaya-Rundel, M. (2015). *OpenIntro Statistics (3rd ed.)*. OpenIntro.org.

https://drive.google.com/file/d/0B-DHaDEbiOGkc1RycUtIcUtIelE/view

Magnus, P. D. (2017). Chapter 1. In *forallx*: *An introduction to formal logic*. Retrieved from

https://www.fecundity.com/codex/forallx.pdf

Schedule of Topics and Readings

This course meets for 2 class sessions each week.

Unit 1: Logical Thinking

A crucial element of critical thinking is to form and evaluate arguments rigorously. In order to do this, one must distinguish between deductive and inductive arguments, and know how to determine the validity and soundness of deductive arguments and how to measure the strength of inductive arguments.

Session 1:
1.1 Critical Thinking

Learning Outcomes

HCs

Readings, Videos, and other preparation resources:

Session 2:
1.2 Logical Sentences

Learning Outcomes

HCs

#deduction : Analyze and apply deductive reasoning. (C) FA [Introduced]

Readings, Videos, and other preparation resources:

Magnus, P. D. (2017). Chapter 1. In *forallx*: *An introduction to formal logic*. Retrieved from
https://www.fecundity.com/codex/forallx.pdf

(Optional). DeLancey, C. (2017). Chapters 0 and 1. In *A Concise Introduction to Logic.* Geneseo, NY Open SUNY Textbooks. Available through Claremont Libraries, Database: Open Textbook Library.
https://milnepublishing.geneseo.edu/concise-introduction-to-logic/

(Optional). Thompson, A. (2015). Engineers of addiction. *The Verge*. Retrieved May 27, 2018 from
http://www.theverge.com/2015/5/6/8544303/casino-slot-machine-gambling-addiction-psychology-mobile-games

Read Assignment 1: Logical Thinking

Session 3:
2.1 Logical Connectives and Truth Tables

Learning Outcomes

HCs

#algorithms : Apply algorithmic thinking strategies to solve problems and effectively implement working code. (C) FA [Introduced]

#deduction : Analyze and apply deductive reasoning. (C) FA [Continued]

Readings, Videos, and other preparation resources:

Magnus, P. D. (2017). Chapters 2 and 3. In *forallx: An introduction to formal logic.* Retrieved from
https://www.fecundity.com/codex/forallx.pdf

Boolean Expressions. (Feb 9, 2017). *Non-Programmer's Tutorial for Python 3*. Retrieved June 14, 2018 from
https://en.wikibooks.org/wiki/Non-Programmer%27s_Tutorial_for_Python_3/Boolean_Expressions

(Optional). DeLancey, C. (2017) Chapters 2, 5, and 7. In *A Concise Introduction to Logic*. Geneseo, NY Open SUNY Textbooks. Available through Claremont Libraries, Database: Open Textbook Library.
https://milnepublishing.geneseo.edu/concise-introduction-to-logic/

(Optional). Spaniel, W. (2013). "Simple Sentences and Operations" and "Truth Tables" in *Logic 101*. Retrieved from
http://gametheory101.com/courses/logic-101/

Session 4:
2.2 De Morgan's Laws

Learning Outcomes

HCs

#algorithms : Apply algorithmic thinking strategies to solve problems and effectively implement working code. (C) FA [Introduced]

#deduction : Analyze and apply deductive reasoning. (C) FA [Continued]

Readings, Videos, and other preparation resources:

De Morgan's Laws. (n.d.). In *Wikipedia*. Retrieved July 13, 2016 from
https://en.wikipedia.org/wiki/De_Morgan%27s_laws

Negating the conditional if-then statement p implies q. (2017, June 03). Retrieved July 12, 2017, from
http://www.mathbootcamps.com/negating-conditional-statement-p-implies-q/

(Optional). GVSUmath. (Aug 10, 2012). Negations of conditional statements. [Video file]. Retrieved May 28, 2018 from
https://www.youtube.com/watch?v=eUDz2Cgoty0

The Economist explains. (Aug 30, 2017). What are algorithms? *The Economist*. Retrieved Jun 11, 2018 from
https://www.economist.com/the-economist-explains/2017/08/29/what-are-algorithms

(Optional). Spaniel, W. (2013). "DeMorgan's Law, Part 1" and "DeMorgan's Law, Part 2" in *Logic 101*. Retrieved from
http://gametheory101.com/courses/logic-101/

Session 5:
3.1 Deductive Validity

Learning Outcomes

HCs

#algorithms : Apply algorithmic thinking strategies to solve problems and effectively implement working code. (C) FA [Continued]

#deduction : Analyze and apply deductive reasoning. (C) FA [Extended]

Readings, Videos, and other preparation resources:

DeLancey, C. (2017). Chapters 3, 4, 5.3-5.4, 6, 7.5, and 8-10. In *A Concise Introduction to Logic.* Geneseo, NY Open SUNY Textbooks. Available through Claremont Libraries, Database: Open Textbook Library
https://milnepublishing.geneseo.edu/concise-introduction-to-logic/

Lau, J. & Chan, J. (2015). [Tutorial A05] Valid patterns. *Critical Thinking Web*. Retrieved from
http://philosophy.hku.hk/think/arg/valid2.php

(Optional). Magnus, P. D. (2017). Section 3.3 & Chapter 6: Introduction. In *forallx: An introduction to formal logic.* Retrieved from
https://www.fecundity.com/codex/forallx.pdf

(Optional, highly recommended). Spaniel, W. (2013 to 2016). "Rules of Inference" and "Proofs" in *Logic 101.* Retrieved from
http://gametheory101.com/courses/logic-101/

Session 6:
3.2 Induction

Learning Outcomes

HCs

#deduction : Analyze and apply deductive reasoning. (C) FA [Extended]

#induction : Analyze and apply inductive reasoning. (C) FA [Introduced]

Readings, Videos, and other preparation resources:

Wei-Ming, W. (2014). Deduction and induction. iLogic, section 1.3. Retrieved from
http://www.butte.edu/resources/interim/wmwu/iLogic/1.3/iLogic_1_3.html

Inductive reasoning. (Aug 19, 2018). In *Wikipedia*. Retrieved August 31, 2018, from
https://en.wikipedia.org/wiki/Inductive_reasoning

Deductive and inductive arguments. (n.d.). *Internet Encyclopedia of Philosophy*. Retrieved from
http://www.iep.utm.edu/ded-ind/

Session 7:
4.1 Fallacy Detection

Learning Outcomes

HCs

#deduction : Analyze and apply deductive reasoning. (C) FA [Extended]

#fallacies : Identify and correct logical fallacies. (C) FA [Introduced]

Readings, Videos, and other preparation resources:

Stark, P. (n.d.). Chapter 2: Reasoning and fallacies. In *SticiGui*. Retrieved from
http://www.stat.berkeley.edu/~stark/SticiGui/Text/reasoning.htm

(Optional) Vance, C. (2014). 3.3 Fallacies of Weak Induction. In *PHL 1440: Introduction to Logic*. Retrieved from
https://rintintin.colorado.edu/~vancecd/phil1440/weakinduction.pdf

(Optional). List of fallacies. (June 4, 2018). In *Wikipedia*. Retrieved June 5, 2018 from
https://en.wikipedia.org/wiki/List_of_fallacies

Reynolds, P. (June 6, 2018). San Francisco leads nation with ban on flavored vaping products. *San Francisco Chronicle*. Retrieved from
https://www.sfchronicle.com/opinion/openforum/article/San-Francisco-leads-nation-with-ban-on-flavored-12973828.php

(Optional), Rosenthal, M. (n.d.). A Look at Logical Fallacies. *Artists for Education*. Retrieved July 18, 2018 from
https://i1.wp.com/www.artistsforeducation.com/wp-content/uploads/2017/02/web-image-1.png?fit=800%2C1044

Leclerc, P. (Sept 2, 2010). Fallacies of Weak Induction. Retrieved from
http://www.ccri.edu/faculty_staff/socsci/paleclerc/logic/fallacies_wi.shtml

Session 8:
4.2 Logic Synthesis

Learning Outcomes

HCs

#fallacies : Identify and correct logical fallacies. (C) FA [Synthesized]

#deduction : Analyze and apply deductive reasoning. (C) FA [Synthesized]

#induction : Analyze and apply inductive reasoning. (C) FA [Synthesized]

Readings, Videos, and other preparation resources:

(Optional). Spaniel, W. (2013 to 2016). "Rules of Inference" and "Proofs" in *Logic 101*. Retrieved from
http://gametheory101.com/courses/logic-101/

(Optional). Rosdatter, B. (n.d.). Lessons 2-9 in *Introduction to Logic*. Retrieved from
http://www.uky.edu/~rosdatte/phi120/cntablea.htm

Session 9:
5.1 Estimation: Fermi Problems

Learning Outcomes

HCs

#estimation : Use estimation and approximation techniques appropriately. (H) FA [Introduced]

#deduction : Analyze and apply deductive reasoning. (C) FA [Synthesized]

#induction : Analyze and apply inductive reasoning. (C) FA [Synthesized]

#breakitdown : Organize problems into tractable components and design solutions. (H) EA

Readings, Videos, and other preparation resources:

Mitchell, M. (n.d.). A clever way to estimate enormous numbers. Ted Ed. Retrieved from
http://ed.ted.com/lessons/michael-mitchell-a-clever-way-to-estimate-enormous-numbers

Helfand, D. (n.d.). Chapter 2: Discoveries on the back of an envelope. In *Frontiers of Sciences: Habits of a Scientific Mind* . Retrieved from
http://ccnmtl.columbia.edu/projects/mmt/frontiers/web/index2.html

Muehlhauser, L. (Apr 11, 2013). Fermi estimates. Retrieved from
http://lesswrong.com/lw/h5e/fermi_estimates/

Scientific notation. (n.d.). [Video file]. *Khan Academy*. Retrieved from
https://www.khanacademy.org/math/pre-algebra/pre-algebra-exponents-radicals/pre-algebra-scientific-notation/v/scientific-notation-old

Orders of magnitude. (n.d.). [Video file]. *Khan Academy*. Retrieved from
https://www.khanacademy.org/math/pre-algebra/pre-algebra-exponents-radicals/pre-algebra-orders-of-magnitude/v/multiplying-multiples-of-powers-of-10

Rate conversion. (n.d.). [Video file]. *Khan Academy*. Retrieved from
https://www.khanacademy.org/math/algebra/introduction-to-algebra/units-algebra/v/dimensional-analysis-units-algebraically

(Optional). Eames Office. (2010, Aug 26). Powers of Ten™ (1977). [Video file]. Retrieved from
https://www.youtube.com/watch?v=0fKBhvDjuy0

Unit 2: Probability and Statistics

The emphasis of this unit is on using probability and statistics to extract useful information from data, including identifying the correct tool to be used for a given application and set of assumptions, along with interpreting the results. This unit begins with a focus on how to represent problems formally. Once the variables and parameters of a problem have been identified, one can create a model that uses relevant data to address the problem. Students investigate the use descriptive statistics to describe data and consider the uses and misuses of correlation models. This is followed by an introduction to probability and probability distributions, focusing on how to use them to make inferences about populations from samples.

Session 10:
5.2 Variables

Learning Outcomes

HCs

#variables : Identify and classify the relevant variables of a system, problem, or model. (H) FA [Introduced]

Readings, Videos, and other preparation resources:

Types of Variables in Statistics and Research. (n.d.). *Statistics How To*. Retrieved June 13, 2018 from
http://www.statisticshowto.com/types-variables/

C-ROADS World Climate Simulation. (n.d.). *Climate Interactive*. Retrieved June 13, 2018 from
https://croadsworldclimate.climateinteractive.org/

Read the new variables assignment available on your dashboard.

Session 11:
6.1 No class (Fall Break)

Learning Outcomes

HCs

Readings, Videos, and other preparation resources:

Session 12:
6.2 Descriptive Statistics

Learning Outcomes

HCs

#variables : Identify and classify the relevant variables of a system, problem, or model. (H) FA [Continued]

#descriptivestats : Calculate and interpret descriptive statistics appropriately. (H) FA [Introduced]

#algorithms : Apply algorithmic thinking strategies to solve problems and effectively implement working code. (C) FA [Synthesized]

Readings, Videos, and other preparation resources:

Stark, P. B. (2013). SticiGui, Chapter 3: Statistics.
http://www.stat.berkeley.edu/~stark/SticiGui/Text/histograms.htm

Stark, P. B. (2013). SticiGui, Chapter 4: Measures of location and spread, up to and including affine transformations.
http://www.stat.berkeley.edu/~stark/SticiGui/Text/location.htm

Histogram. (n.d.). In *Wikipedia, The Free Encyclopedia*. Retrieved August 9, 2016, from
https://en.wikipedia.org/wiki/Histogram

Sabo, M. (2016). Young people survey. *Kaggle*. Retrieved 3 October 2017 from
https://www.kaggle.com/miroslavsabo/young-people-survey/home

Session 13:
7.1 Correlation

Learning Outcomes

HCs

#fallacies : Identify and correct logical fallacies. (C) FA [Extended]

#correlation : Apply and interpret measures of correlation; distinguish correlation and causation. (C) FA [Introduced]

#variables : Identify and classify the relevant variables of a system, problem, or model. (H) FA

#induction : Analyze and apply inductive reasoning. (C) FA [Extended]

#dataviz : Interpret, analyze, and create data visualizations. (C) EA [Extended]

Readings, Videos, and other preparation resources:

Stark, P. B. (2013). SticiGui, Chapter 5: Multivariate data and scatterplots.
http://www.stat.berkeley.edu/~stark/SticiGui/Text/scatterplots.htm

Stark, P. B. (2013). SticiGui, Chapter 6: Association.
http://www.stat.berkeley.edu/~stark/SticiGui/Text/association.htm

Filmer, J. (2013). Correlation vs. causation: the analysis of data. Retrieved from
https://futurism.com/correlation-vs-causation-2/

Matejka, J. and Fitzmaurice, G. (2017). Same Stats, Different Graphs: Generating Datasets with Varied Appearance and Identical Statistics through Simulated Annealing. Autodesk Research. Retrieved from
https://www.autodeskresearch.com/publications/samestats

Session 14:
7.2 Probability I

Learning Outcomes

HCs

#probability : Apply and interpret fundamental concepts of probability, including conditional and bayesian probabilities. (C) FA [Introduced]

#deduction : Analyze and apply deductive reasoning. (C) FA [Extended]

Readings, Videos, and other preparation resources:

Diez, D., Barr, C., & Cetinkaya-Rundel, M. (2015). *OpenIntro statistics* (3rd ed.).
https://drive.google.com/file/d/0B-DHaDEbiOGkc1RycUtIcUtIelE/view

Stark, P. (2013, January 21). Probability: Philosophy and Mathematical Background. Retrieved from
http://www.stat.berkeley.edu/~stark/SticiGui/Text/probabilityPhilosophy.htm

Kunin, D. (n.d.). Basic Probability: Chance Events. *Seeing Theory*. Retrieved from
https://students.brown.edu/seeing-theory/basic-probability/index.html#section1

Introduction to Bayesian Statistics. (2016, May 7). In *Wikiversity*. Retrieved from
https://en.wikiversity.org/wiki/Introduction_to_Bayesian_Statistics

Ox educ. (Jul 25, 2014). Bayesian vs frequentist statistics probability - part 2. [Video file]. Retrieved from
https://www.youtube.com/watch?v=XJqOEvzUG38

Session 15:
8.1 Probability II

Learning Outcomes

HCs

#descriptivestats : Calculate and interpret descriptive statistics appropriately. (H) FA [Extended]

#probability : Apply and interpret fundamental concepts of probability, including conditional and bayesian probabilities. (C) FA [Extended]

#algorithms : Apply algorithmic thinking strategies to solve problems and effectively implement working code. (C) FA [Continued]

Readings, Videos, and other preparation resources:

Diez, D., Barr, C., & Cetinkaya-Rundel, M. (2015). *OpenIntro statistics* (3rd ed.).
https://drive.google.com/file/d/0B-DHaDEbiOGkc1RycUtIcUtIelE/view

Grinstead, C., & Snell, J. (2006). *Grinstead and Snell's introduction to probability* . Hanover, N.H.: The Chance Project.
https://www.math.dartmouth.edu/~prob/prob/prob.pdf

(Optional) Stark, P. (2013, January 21). The Long Run and the Expected Value. Retrieved November 19, 2015, from
http://www.stat.berkeley.edu/~stark/SticiGui/Text/expectation.htm

Kunin, D. (n.d.). Basic Probability: Expectation. *Seeing Theory*. Retrieved Oct 26, 2018, from
https://seeing-theory.brown.edu/basic-probability/index.html

Kunin, D. (n.d.). Probability Distributions: Random Variable. *Seeing Theory*. Retrieved Oct 26, 2018, from
https://seeing-theory.brown.edu/probability-distributions/index.html

Session 16:
8.2 Conditional Probability

Learning Outcomes

HCs

#probability : Apply and interpret fundamental concepts of probability, including conditional and bayesian probabilities. (C) FA [Introduced]

Readings, Videos, and other preparation resources:

Diez, D., Barr, C., & Cetinkaya-Rundel, M. (2015). *OpenIntro Statistics* (3rd ed.).
https://drive.google.com/file/d/0B-DHaDEbiOGkc1RycUtIcUtIelE/view

(Optional) Powell, V. (n.d.). Conditional probability. Retrieved from
http://setosa.io/conditional/

Confusion of the Inverse. (Apr 7, 2018). *In Wikipedia, The Free Encyclopedia*. Retrieved Jul 9, 2018, from
https://en.wikipedia.org/wiki/Confusion_of_the_inverse

Base rate fallacy. (Jan 29, 2018). *In Wikipedia, The Free Encyclopedia*. Retrieved Jul 9, 2018, from
https://en.wikipedia.org/wiki/Base_rate_fallacy

Gambler's fallacy. (Jun 13, 2018). *In Wikipedia, The Free Encyclopedia*. Retrieved Jul 9, 2018, from
https://en.wikipedia.org/wiki/Gambler%27s_fallacy

(Optional) Calculating Conditional Probability (n.d.). [Video file]. *Khan Academy*. Retrieved Feb 16, 2018, from
https://www.khanacademy.org/math/statistics-probability/probability-library/conditional-probability-independence/v/calculating-conditional-probability

Session 17:
9.1 Distributions I

Learning Outcomes

HCs

#probability : Apply and interpret fundamental concepts of probability, including conditional and bayesian probabilities. (C) FA [Extended]

#descriptivestats : Calculate and interpret descriptive statistics appropriately. (H) FA [Extended]

#distributions : Identify different types of distributions and make inferences based on samples from distributions appropriately. (C) FA [Introduced]

Readings, Videos, and other preparation resources:

Diez, D., Barr, C., & Cetinkaya-Rundel, M. (2015). *OpenIntro Statistics* (3rd ed.).
https://drive.google.com/file/d/0B-DHaDEbiOGkc1RycUtIcUtIelE/view

Ahdoot, R. (Aug 22, 2016). Binomial Distributions in Statistics, with David Beckam on StatsCenter (Ep. 11). [Video File]. In *Youtube*. Retrieved from
https://www.youtube.com/watch?v=dqd0yAvnP2g

Dudek, B. (Oct 9, 2017). Binomial Distribution Visualization. Retrieved from
https://shiny.rit.albany.edu/stat/binomial/

Session 18:
9.2 Distributions II

Learning Outcomes

HCs

#distributions : Identify different types of distributions and make inferences based on samples from distributions appropriately. (C) FA [Continued]

#probability : Apply and interpret fundamental concepts of probability, including conditional and bayesian probabilities. (C) FA [Extended]

Readings, Videos, and other preparation resources:

Diez, D., Barr, C., & Cetinkaya-Rundel, M. (2015). *OpenIntro Statistics* (3rd ed.).
https://drive.google.com/file/d/0B-DHaDEbiOGkc1RycUtIcUtIelE/view

Introduction to the normal distribution (n.d.). [Video file]. *Khan Academy*. Retrieved Dec 22, 2017 from
https://www.khanacademy.org/math/statistics-probability/modeling-distributions-of-data/normal-distributions-library/v/introduction-to-the-normal-distribution

Ahdoot, R. (Aug 22, 2016). Discrete and Continuous Distributions in Statistics, with Shaquille O'Neal on StatsCenter (Ep. 12). [Video file]. In *Youtube*. Retrieved from
https://www.youtube.com/watch?v=QRen4oqu56Y

Session 19:
10.1 The Central Limit Theorem

Learning Outcomes

HCs

#distributions : Identify different types of distributions and make inferences based on samples from distributions appropriately. (C) FA [Extended]

#modeling : Recognize how models can be used to describe a system, explain a set of data, and generate predictions. (C) EA [Extended]

Readings, Videos, and other preparation resources:

Central limit theorem. (n.d.). Retrieved December 11, 2015, from
https://www.khanacademy.org/math/probability/statistics-inferential/sampling_distribution/v/central-limit-theorem

Diez, D., Barr, C., & Cetinkaya-Rundel, M. (2015). OpenIntro Statistics (3rd ed.).
https://drive.google.com/file/d/0B-DHaDEbiOGkc1RycUtIcUtIelE/view

Kunin, D. (n.d.). Probability Distributions: Central Limit Theorem. *Seeing Theory*. Retrieved Aug 6, 2018, from
https://students.brown.edu/seeing-theory/probability-distributions/index.html#section3

Session 20:
10.2 Synthesis: Regression to the Mean

Learning Outcomes

HCs

#distributions : Identify different types of distributions and make inferences based on samples from distributions appropriately. (C) FA [Introduced]

#probability : Apply and interpret fundamental concepts of probability, including conditional and bayesian probabilities. (C) FA [Extended]

#correlation : Apply and interpret measures of correlation; distinguish correlation and causation. (C) FA

Readings, Videos, and other preparation resources:

Regression Toward the Mean: An Introduction with Examples. (n.d.). *Farnam Street*. Retrieved July 17, 2018 from
https://fs.blog/2015/07/regression-to-the-mean/

Lane, D. (n.d.). Regression toward the mean. *OnlineStatBook*. Retrieved December 20, 2015, from
http://onlinestatbook.com/2/regression/regression_toward_mean.html

(Optional). Regression toward the mean. (2018, July 3). In *Wikipedia*. Retrieved July 17, 2018, from
https://en.wikipedia.org/wiki/Regression_toward_the_mean

Session 21:
11.1 Confidence Intervals I

Learning Outcomes

HCs

#probability : Apply and interpret fundamental concepts of probability, including conditional and bayesian probabilities. (C) FA [Extended]

#confidenceintervals : Apply and interpret confidence intervals. (C) FA [Introduced]

#distributions : Identify different types of distributions and make inferences based on samples from distributions appropriately. (C) FA [Extended]

Readings, Videos, and other preparation resources:

Diez, D., Barr, C., & Cetinkaya-Rundel, M. (2015). *OpenIntro Statistics* (3rd ed.).
https://drive.google.com/file/d/0B-DHaDEbiOGkc1RycUtIcUtIelE/view

Lane, D. (n.d.). Estimation. *OnlineStatBook*. Retrieved December 30, 2015, from
http://onlinestatbook.com/2/estimation/estimation.html

Magnusson, K. (n.d.). Interpreting Confidence Intervals: An interactive visualization. *RPsychologist*. Retrieved Jan 14, 2018, from
http://rpsychologist.com/d3/CI/

(Optional) Bessel's correction. (2018, July 7). In *Wikipedia, The Free Encyclopedia*. Retrieved July 15, 2018, from
https://en.wikipedia.org/wiki/Bessel%27s_correction

(Optional) Sampling from finite populations. (n.d.). Retrieved January 10, 2016, from
http://www-ist.massey.ac.nz/dstirlin/CAST/customCAST/HrandomMean/randomMean7.html

(Optional) Dr Nic's Maths and Stats. (Jun 14, 2018). Understanding the Central Limit Theorem. *YouTube*. Retrieved from
https://www.youtube.com/watch?v=_YOr_yYPytM

(Optional) Dr Nic's Maths and Stats. (Mar 26, 2013). Understanding Confidence Intervals: Statistics Help. *YouTube*. Retrieved from
https://www.youtube.com/watch?v=tFWsuO9f74o&t=6s

(Optional) CrashCourse. (Jun 13, 2018). Confidence Intervals: Crash Course Statistics #20. *YouTube*. Retrieved from
https://www.youtube.com/watch?v=yDEvXB6ApWc

Session 22:
11.2 Confidence Intervals II

Learning Outcomes

HCs

#confidenceintervals : Apply and interpret confidence intervals. (C) FA [Extended]

#distributions : Identify different types of distributions and make inferences based on samples from distributions appropriately. (C) FA [Extended]

#probability : Apply and interpret fundamental concepts of probability, including conditional and bayesian probabilities. (C) FA [Extended]

Readings, Videos, and other preparation resources:

Diez, D., Barr, C., & Cetinkaya-Rundel, M. (2015). *OpenIntro Statistics* (3rd ed.).
https://drive.google.com/file/d/0B-DHaDEbiOGkc1RycUtIcUtIelE/view

Lane, D. (n.d.). Estimation. *OnlineStatBook*. Retrieved December 30, 2015, from
http://onlinestatbook.com/2/estimation/estimation.html

Confidence intervals. (n.d.). *Khan Academy.* Retrieved Nov 16, 2018, from
https://www.khanacademy.org/math/statistics-probability/confidence-intervals-one-sample

Institut de Recherche pour le Développement (IRD), Institut de Recherche en Sciences de la Santé (IRSS), HarvestPlus, and International Food Policy Research Institute (IFPRI). (2016). Food consumption and iron status survey in two provinces of rural Burkina Faso, V1. Retrieved from Harvard Dataverse:
https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/5CXCLX

Session 23:
12.1 Significance I

Learning Outcomes

HCs

#distributions : Identify different types of distributions and make inferences based on samples from distributions appropriately. (C) FA [Synthesized]

#significance : Apply, interpret, and distinguish practical and statistical significance. (C) FA [Introduced]

#confidenceintervals : Apply and interpret confidence intervals. (C) FA [Synthesized]

#probability : Apply and interpret fundamental concepts of probability, including conditional and bayesian probabilities. (C) FA [Synthesized]

Readings, Videos, and other preparation resources:

Diez, D., Barr, C., & Cetinkaya-Rundel, M. (2015). *OpenIntro Statistics* (3rd ed.).
https://drive.google.com/file/d/0B-DHaDEbiOGkc1RycUtIcUtIelE/view

Lane, D. (n.d.). Logic of Hypothesis Testing. *OnlineStatBook*. Retrieved December 30, 2015, from
http://onlinestatbook.com/2/logic_of_hypothesis_testing/logic_hypothesis.html

Hypothesis tests on one mean: T test or z test? (Feb 27, 2013). *JBStatistics*. Retrieved July 17, 2018, from
https://www.youtube.com/watch?v=vw2IPZ2aD-c

Smith, M. (n.d.). Type I and II Errors. Retrieved January 14, 2016, from
https://www.ma.utexas.edu/users/mks/statmistakes/errortypes.html

(Optional). Significance tests (hypothesis testing). (n.d.). *Khan Academy*. Retrieved Nov 16, 2018, from
https://www.khanacademy.org/math/statistics-probability/significance-tests-one-sample

Session 24:
12.2 No Class

Learning Outcomes

HCs

Readings, Videos, and other preparation resources:

Session 25:
13.1 Significance II

Learning Outcomes

HCs

#distributions : Identify different types of distributions and make inferences based on samples from distributions appropriately. (C) FA [Extended]

#probability : Apply and interpret fundamental concepts of probability, including conditional and bayesian probabilities. (C) FA [Extended]

#correlation : Apply and interpret measures of correlation; distinguish correlation and causation. (C) FA [Extended]

#significance : Apply, interpret, and distinguish practical and statistical significance. (C) FA [Extended]

#confidenceintervals : Apply and interpret confidence intervals. (C) FA [Extended]

Readings, Videos, and other preparation resources:

Diez, D., Barr, C., & Cetinkaya-Rundel, M. (2015). *OpenIntro Statistics* (3rd ed.).
https://drive.google.com/file/d/0B-DHaDEbiOGkc1RycUtIcUtIelE/view

Grambow, S. (2013, March 26). Multiple Comparisons. Retrieved January 19, 2016, from
https://www.youtube.com/watch?v=EMzcZFtGZZE

(Optional). Multiple comparisons problem. (2018, June 20). *In Wikipedia, The Free Encyclopedia*. Retrieved July 15, 2018, from
https://en.wikipedia.org/wiki/Multiple_comparisons_problem

(Optional). Significance tests (hypothesis testing). (n.d.). *Khan Academy*. Retrieved Nov 16, 2018, from
https://www.khanacademy.org/math/statistics-probability/significance-tests-one-sample

Session 26:
13.2 Effect Size I

Learning Outcomes

HCs

#significance : Apply, interpret, and distinguish practical and statistical significance. (C) FA [Introduced]

#probability : Apply and interpret fundamental concepts of probability, including conditional and bayesian probabilities. (C) FA [Synthesized]

#distributions : Identify different types of distributions and make inferences based on samples from distributions appropriately. (C) FA [Synthesized]

Readings, Videos, and other preparation resources:

Diez, D., Barr, C., & Cetinkaya-Rundel, M. (2015). *OpenIntro Statistics* (3rd ed.).
https://drive.google.com/file/d/0B-DHaDEbiOGkc1RycUtIcUtIelE/view

(Optional) Difference of sample means distribution. (n.d.). *Khan Academy*. Retrieved January 26, 2016, from
https://www.khanacademy.org/math/probability/statistics-inferential/hypothesis-testing-two-samples/v/difference-of-sample-means-distribution

(Optional) Hypothesis test for difference of means. (n.d.). *Khan Academy*. Retrieved January 26, 2016, from
https://www.khanacademy.org/math/probability/statistics-inferential/hypothesis-testing-two-samples/v/hypothesis-test-for-difference-of-means

Biddix, J. P. (2009). Effect Size. Retrieved January 26, 2016, from
https://researchrundowns.wordpress.com/quantitative-methods/effect-size/

Cohen's d (part 1). (2011, October 3). Retrieved January 26, 2016, from
https://www.youtube.com/watch?v=WMTxyWq4E2M

Cohen's d (part 2). (2011, October 3). Retrieved January 26, 2016, from
https://www.youtube.com/watch?v=sMc5eX4OKbI

(Optional) Effect size. (2018, June 16). In *Wikipedia, The Free Encyclopedia*. Retrieved July 15, 2018, from
https://en.wikipedia.org/wiki/Effect_size

Session 27:
14.1 Effect Size II

Learning Outcomes

HCs

#distributions : Identify different types of distributions and make inferences based on samples from distributions appropriately. (C) FA [Synthesized]

#significance : Apply, interpret, and distinguish practical and statistical significance. (C) FA [Synthesized]

#probability : Apply and interpret fundamental concepts of probability, including conditional and bayesian probabilities. (C) FA [Synthesized]

Readings, Videos, and other preparation resources:

Lesson 54: Power of a Statistical Test. (n.d.). Retrieved January 31, 2016, from
https://onlinecourses.science.psu.edu/stat414/node/245

Diez, D., Barr, C., & Cetinkaya-Rundel, M. (2015). *OpenIntro Statistics* (3rd ed.).
https://drive.google.com/file/d/0B-DHaDEbiOGkc1RycUtIcUtIelE/view

Magnussen, K. (n.d.). Understanding statistical power and significance testing. Retrieved from
http://rpsychologist.com/d3/NHST/

Cengage Learning, (n.d.). Statistical Power. Retrieved Feb 10, 2017, from
http://webquiz.ilrn.com/ilrn/quiz-public?name=stmr01q/stmr01q_chp18

(Optional). Type I Errors, Type II Errors, and the Power of the Test, (March 12, 2013). [Video file]. *JBStatistics*. Retrieved Feb 10, 2017, from
https://www.youtube.com/watch?v=7mE-K_w1v90

(Optional). Calculating Power and the Probability of a Type II Error (A One-Tailed Example). [Video File] (Feb 1, 2013). *JBStatistics*. Retrieved Feb 10, 2017, from
https://www.youtube.com/watch?v=BJZpx7Mdde4

Session 28:
14.2 Review and Synthesis: All HCs

Learning Outcomes

HCs

#confidenceintervals : Apply and interpret confidence intervals. (C) FA [Synthesized]

#deduction : Analyze and apply deductive reasoning. (C) FA [Synthesized]

#correlation : Apply and interpret measures of correlation; distinguish correlation and causation. (C) FA [Synthesized]

#probability : Apply and interpret fundamental concepts of probability, including conditional and bayesian probabilities. (C) FA [Synthesized]

#descriptivestats : Calculate and interpret descriptive statistics appropriately. (H) FA [Synthesized]

#distributions : Identify different types of distributions and make inferences based on samples from distributions appropriately. (C) FA [Synthesized]

#algorithms : Apply algorithmic thinking strategies to solve problems and effectively implement working code. (C) FA [Synthesized]

#estimation : Use estimation and approximation techniques appropriately. (H) FA [Synthesized]

#fallacies : Identify and correct logical fallacies. (C) FA [Synthesized]

#induction : Analyze and apply inductive reasoning. (C) FA [Synthesized]

#variables : Identify and classify the relevant variables of a system, problem, or model. (H) FA [Synthesized]

#significance : Apply, interpret, and distinguish practical and statistical significance. (C) FA [Synthesized]

Readings, Videos, and other preparation resources:

Misra, K. (2017). Kaggle dataset: *World Happiness Report*. Retrieved 6 December 2017 from
https://www.kaggle.com/unsdsn/world-happiness

Policies

Professional Behavior

Minerva expects students to follow guidelines of professional behavior. With respect to academics, this means you are required to prepare appropriately for each class and actively participate in them. You should read all assigned materials, watch assigned videos, and complete all

assigned pre-class work, including solving assigned problems and answering study guide questions. Because all of our classes are seminars, all students must be prepared to be full participants—to shirk on preparation not only short-changes you, it also undermines the experience for the other students. You are also required to adhere to assignment guidelines and deadlines, and to contact the appropriate administrator promptly should you wish to request an extension. Additional information, and consequences for failing to meet requirements are described below.

Absence Policy

See this flowchart for a visual summary of the absence policy.

Students are expected to be logged on to the ALF, ready to participate in class, by the class's scheduled start time. They should arrive a few minutes early to ensure that they have sufficient time to respond to any potential technical issues (see sections below for policies). A student is considered absent if the student arrives more than 2 minutes after the start of class time or leaves at any time during the class session.

All absences require make-up work. The make-up work is: (a) watch the video recording of the class; and (b) write a 400- to 500-word paper that summarizes how the HCs/LOs covered in the class session were applied in the activities, and that addresses the following questions:

1. What was the most interesting thing you learned from this class session and how does it connect to/expand upon the assigned preparatory material and pre-class work (if applicable)?
2. What aspect of the material covered in this session do you want to explore further and why?
3. What topic in this session did you find most confusing, and how do you plan to address your confusion?

The deadline for make-up work is determined by the dean of the master's program, with the date set a minimum of one week and a maximum of 1 month from the original deadline. Failure to complete satisfactory make-up work will result in the absence being counted as two absences.

For 4-unit courses (Advanced Empirical Analyses, Advanced Formal Analyses, and Advanced Complex Systems), students are allowed four absences per semester. For 2-unit courses (Research Methods), students are allowed two absences per semester. Any absences beyond the relevant limit will result in a student's being administratively withdrawn from the course.

Pre-Class Work Policy

During classes for which there was specific pre-class work to bring to class, students will be asked to show they have done the work by answering a related poll question, submitting their pre-class work (or some portion of it) as a poll response, or adding their pre-class work into a document in the main classroom or breakout notes. If a student has not completed the pre-class work, or has done so grossly inadequately, faculty will mark the student as absent for that session.

Late/Missing Assignment Policy

See this flowchart for a visual summary of the late/missing assignment policy.

All assignments are required. Students may request assignment deadline extensions, as long as the request is filed at least 48 hours prior to the assignment due date. To submit a request for an extension, please e-mail your professor and CC the Dean of Graduate Studies.

For 4-unit courses (Advanced Empirical Analyses, Advanced Formal Analyses, and Advanced Complex Systems), students are allowed two extensions per semester. For 2-unit courses (Research Methods), students are allowed one extension per semester.

Assignment deadline extensions may not be used for final projects or any other assignment due in week 15. Students with a documented emergency preventing them from submitting a final project by its deadline will be administratively withdrawn unless they petition for, and receive, an incomplete from the Academic Standards Committee (ASC).

A student who fails to submit all assignments by their original or extended deadlines will be administratively withdrawn from the course.

Policies for Technology and Network Issues

Disruptions of class due to widespread technical or network problems (e.g., ALF is down) will not be counted as absences. Absences due to a student's computer or internet failure will count as absences.

To minimize the chance of technical difficulty, students should follow these best practices:

- Restart the computer before class and close unnecessary apps and tabs
- Use the ALF app (as opposed to Chrome)
- Connect via ethernet (turn wifi off)
- Consult tech support immediately for any problems, via live chat if possible, or via email to helpdesk@minerva.kgi.edu in the worst case.
- Only attend class from locations in which your internet connection is reliable. If you are away from home or in a new location, run the A/V connection test while logged in at least 10 minutes prior to class to determine the suitability of the connection. Student-side connection failures do not constitute a valid reason for missing class.

Audio-Only Policy

Technical support staff, the professor, and the ALF system will have the ability to place a student on audio-only mode during class, should the student's bandwidth not be high enough to be on video.

Honor Code

The Minerva Honor Code rests on four pillars: honesty, integrity, mutual respect, and personal responsibility. Minerva students are expected to conduct themselves with the highest levels of these qualities both inside and outside the classroom. Each student serves as an ambassador to the community for Minerva. When one student exhibits inappropriate behavior outside the university, it reflects badly on every student and the institution as a whole (the public tends not to differentiate between individuals in these situations, and attributes bad behavior to the entire student body).

Minerva students are citizens of an academic community whose members are expected to challenge themselves and one another to achieve greatness with honesty, integrity, mutual respect, and personal responsibility. Each individual who joins the Minerva community accepts this commitment in an effort to sustain and enhance personal, professional and institutional reputations.

Principles inherent in this Honor Code include:

- Students shall treat all members of the community with respect and without malicious intent to ensure that all students share equal opportunities.
- Students shall conduct themselves in a manner that upholds their reputation for honesty and integrity in order to promote an environment of trust.

To assist students in understanding their responsibilities under the Honor Code, the following is a list of conduct pertaining to academic matters that violate the Honor Code. A more detailed guide for avoiding these violations can be found here.

Prohibited conduct includes, but is not limited to the following:

Plagiarism

- Knowingly appropriating another's words or ideas and representing them as one's own
- Use of another's words without acknowledging the source
- Paraphrasing the ideas of another without clear acknowledgment of the source
- Falsification or fabrication of a bibliography

Cheating

- Unauthorized collaboration on assignments
- Use of unauthorized resources during class and on coursework
- Use of previously submitted coursework for alternate purposes without prior approval

Obstruction of Honor Code

- Making false statements to an Honor Code investigator

Falsification of Information

- Knowingly making false statements or submitting misleading information related to academic concerns to Minerva faculty or staff
- Submission of falsified documents, such as transcripts, applications, petitions, etc.

It is not a defense to charges of violating this Honor Code for students to claim that they have not received, read or understood this Code, or is otherwise ignorant of its provisions. A student is held to have notice of this Honor Code by enrolling at Minerva. Students must fully cooperate with investigations into potential violations of the Honor Code.

Collaboration policy

We strongly encourage students to discuss the ideas they learn in class with their classmates. Learning in groups is always beneficial. However, although discussing pre-class work or assignments is acceptable, students must produce the work products they submit on their own unless otherwise indicated in the assignment instructions. For essay assignments and research papers, student must always draft their work products independently. Unless otherwise instructed, it is acceptable to give and receive peer feedback on assignments if drafts have been completed by all parties involved in producing and reviewing the work. For all other types of assignments, students may neither look at others' work products, nor share work products with any students who are not acting in an official Minerva capacity as a peer tutor unless indicated in the assignment instructions. For example, while it is acceptable to discuss different approaches to a coding assignment, it is not acceptable to look at another student's code or to share code with a student who is not acting as a peer tutor for the course. In addition to violating the Honor Code, if a student submits an assignment that is not the student's own work, it misrepresents the student's understanding of the concepts, and prevents faculty from giving beneficial feedback.

Students with Disabilities

Students with documented disabilities who would like to request accommodations are asked to submit an Accommodations for Disabilities Request form. The policy, guidelines, request form and other needed documents are found in Prepare at the beginning of each year, and on the Hub in the Student Center under Student Services. Students may request accommodations at any time during the year. The request and documentation are reviewed by our learning disability specialist, who determines whether accommodations are warranted, and contacts the student and assigned faculty members to facilitate all necessary arrangements. Please see the Student Handbook for more details. If you believe that you may have a disability that warrants accommodations but have not yet requested them, please contact Melissa Billings, Student Services Manager, for information (melissa@minerva.kgi.edu) or review the information on the Hub.

Video Recording Policies

In order to provide formative assessment of classroom discussion contributions in context, each Minerva class session will be video recorded. These recordings will be made available to students enrolled in the recorded class section so that students can view the personalized feedback/assessments written by the professor and later review the class discussion. These recordings are not to be shared/distributed by students without the explicit written permission of the course faculty member and college dean overseeing the course.

The video recording of a class section will be made available to the students enrolled in that section shortly after the class, and will remain accessible to the students until the first day of the following academic year. Access to a recording from previous academic years can be requested for the

purpose of appealing a grade or selecting video clips to include in a personal academic portfolio. Requests will be reviewed by the dean of the associated college. The Video Access Request Form is available on the registrar site, registrar.minerva.kgi.edu.

Assessment

Assessing Learning Outcomes

Letter grades are based entirely on outcome scores (on HCs or LOs) assigned using the mastery rubrics. The general template for these rubrics is as follows (see the HC Index on the ALF for rubrics specific to each HC):

1-(Lacks knowledge) Does not recall or use the skill or concept when prompted or does so mostly or entirely inaccurately.

2-(Superficial knowledge) Recalls or uses the skill or concept only somewhat accurately or uses the skill or concept in a way that fails to address the relevant problems or goals.

3-(Knowledge) Accurately or effectively uses the skill or concept in a way that addresses the relevant problems or goals.

4-(Deep knowledge) Accurately or effectively uses the skill or concept in a way that addresses the relevant problems or goals and demonstrates a deep grasp of the skill or concept by analyzing, explaining, or justifying the application in a way appropriate to the given context.

5-(Profound knowledge) Uses the skill or concept in a creative and effective way, relying on a novel perspective.

Students will receive HC/LO scores for in-class verbal contributions (approximately one activity a week will be scored), for preparatory assessment poll responses at the beginning of each class, and for reflection poll responses at end of each class. Preparatory assessment polls test understanding of pre-class readings and other assigned materials. Reflection polls provide students with the opportunity to synthesize the in-class activities and summarize a major take-away they learned from class. All in-class scores will have a weight of 1X. HC/LO scores for assignments will typically have a higher weighting, as specified in the Schedule of Assignments.

Grades

Final grades are based on a student's weighted mean of HC scores for the HCs introduced in that course, irrespective of the course in which the HC was assessed. That is, HC scores assigned in one course can influence the grade in another course. Letter grades according to the following scale:

Max (>)		Min (≥)	Grade
5.00	-	4.20	A+
4.20	-	3.75	A
3.75	-	3.50	A-
3.50	-	3.25	B+
3.25	-	3.00	B
3.00	-	2.8	B-
2.6	-	2.8	C+
2.5	-	2.6	C
2.25	-	2.5	C-
2	-	2.25	D
2	-	0	F

Grades for the Research Methods course are based on the weighted mean of scores earned in Course Objectives (COs). The score for each CO is the weighted mean of Learning Outcome (LO) scores falling under that CO.

Students must earn a C- or better in every course to qualify for the Master's degree.

Early Warning Notices

Each semester has a designated grading review period ending after six weeks. At this time, each student's progress will be reviewed by faculty to determine course standing. Students not making adequate progress in the course will be contacted and placed on Early Warning. See the Student Handbook for more details.

Makeup work

Make-up work policies for absences: Make-up work must be submitted no later than 7 days from the absence (by start of class period) using the Makeup Work Submission Form available at registrar.minerva.kgi.edu. If a student needs additional time to complete the makeup work because of an extenuating circumstance, they will need to submit a request using the Assignment & Makeup Work Extension Form at registrar.minerva.kgi.edu. This form must be submitted NO MORE than 7 days from the missing class session to allow time for the extension request to be examined and responded to by Academic staff. Instructors will not be granting makeup work extensions. ALL absences require satisfactory make-up work to be submitted in order to be excused. If an absence results from being late multiple times, work with your professor to determine the appropriate makeup work.

The **make-up work** for Cornerstone courses is:

1. Do all the assigned reading and pre-class work and watch the video recording of the class.

2. Answer the reflection poll question.
3. Submit pre-class work with your submission. (If no pre-class work is required for missed session, then a screenshot of Forum indicating “no pre-class work” from that session on the Forum should be submitted.
4. For each of the learning goals for the class, highlight one moment or comment that helped you achieve that learning goal. Be specific. For each moment/comment that you identified, explain how it will help you use the corresponding HC(s) more effectively in the future. Submit this as a 200-300 word document.

In rare cases where the class video is unavailable, the student should explain how the assigned pre-class readings and resources address the HC(s) or LO(s) that are the focus of the session (in addition to submitting the pre-class work, if applicable).