STAT 745: Computational Methods in Statistics

Alfred "Grant" Schissler, Ph.D.

Email: aschissler@unr.edu (mailto:aschissler@unr.edu)

Office Phone: (775) 784-4661

Office Location: DMS 224

Office Hours: TBD

Web: www.grantschissler.com (https://www.grantschissler.com)

Class Location: Zoom / AB 110

Class Hours: TuTh 4:30pm to 5:45pm

Course Description

Techniques of advanced computational statistics. Numerical optimization and integration pertinent for statistical calculations; simulation and Monte Carlo methods including Markov chain Monte Carlo (MCMC); bootstrapping; smoothing/density estimation; and other modern topics. Computing using statistical software. Resampling and simulation: bootstrap, Monte Carlo, and Markov chain methods. Numerical inference for non-standard models. Bayesian inference. Advanced graphics.

Instructor's role

- Help explain and guide student understanding and skill development.
- Organize the course structure and assignments.
- Lead weekly class discussions.
- Evaluate student work and provide feedback.

Student's role

- Complete the readings before the week's discussion meeting.
- Submit completed assignments on time.
- Participate in discussions.
- Prepare for and complete course exams.

Course Prerequisites

STAT 667 or STAT 754 or STAT 726; Recommended Preparation: STAT 645; MATH 330.

Student Learning Outcomes

Upon completion of this course, students will be able to:

1. organize and present information in graphical and numerical forms to support concise, comprehensible, and scientifically defensible written conclusions/knowledge to research problems.
2. create computational solutions to answer statistical questions for traditional and non-standard models using a high-level programming language.
3. organize computational research findings in a professional report suitable for presentation to a variety of audiences.

Required textbook

Statistical Computing with R, Second Edition, by Maria L. RIZZO.
Textbook website (https://www.routledge.com/Statistical-Computing-with-R-Second-Edition/Rizzo/p/book/9781466553323).

MAKE SURE TO GET THE 2nd EDITION

Github with resources

```
git clone https://github.com/mariarizzo/SCR.git
```

Errata SCR/SCR-2e/SCR2e-errata.pdf

Supplemental texts / resources

Classical Introduction to `R` programming:
https://cran.r-project.org/doc/contrib/Owen-TheRGuide.pdf (https://cran.r-project.org/doc/contrib/Owen-TheRGuide.pdf)

Modern best practices for coding and reporting `R` analyses:
R for data science: import, tidy, transform, visualize, and model data, Hadley WICKHAM and Garrett GROLEMUND. Online textbook (https://r4ds.had.co.nz/)

Mastering `R` and `RStudio`

https://education.rstudio.com/learn/beginner/ (https://education.rstudio.com/learn/beginner/)

https://education.rstudio.com/learn/intermediate/ (https://education.rstudio.com/learn/intermediate/)

https://education.rstudio.com/learn/expert/ (https://education.rstudio.com/learn/expert/)

WebCampus/Canvas

WebCampus/Canvas will be used for the majority of class business. Students are responsible for monitoring Announcements, Assignments/Due Dates, Course Files, and the Gradebook. The preferred mode of commuication for course-related discussion with the instructor is through

Canvas messaging.

https://unr.instructure.com/login/canvas (https://unr.instructure.com/login/canvas)

Attendance

Students are expected to attend class. If important circumstances prevent this, it is the student's responsibility to find out what was covered in class, what was assigned for reading or homework, and what special announcements (if any) were made. "Excessive absence" in this class will be construed to be absence from more than 10 percent of the scheduled class sessions, whether excused or unexcused.

Assignments

Problem sets

Problem sets will be assigned each week, due on Fridays. You are encouraged to discuss assignments between each other and with instructor. However, the assignment must be completed and submitted individually.

Midterms

There will be one take-home midterm, due Friday, 26 Feb 2021.

Final exam

There will be a take-home final exam, due Friday, 7 May 2021.

Exam policy

Exams will be released roughly a week to before the due date. You must complete the exams without help. See Canvas for more details on take-home examination procedures.

Makeup, Late Policy

- Problem sets solutions and completed exams are due on Fridays.
- Late assignments/exams will be given a 20% penalty per business day received late. (i.e., Saturday -0%, Sunday -0%, Monday -20% , Tuesday -40%, …, Friday -100%).
- Exceptions will be made when a student misses work due to a documented (doctor's note) illness or an extraordinary situation (up to the discretion of the instructor).
- There will be no early or make-up exams.
- If you need to miss an exam due to participation in a religious holiday or an official university activities (including athletics and other sanctioned activities), you must make arrangements with the instructor at least two weeks prior to the exam in question.

I'll drop (trim) your 2 lowest grades in the "Problem Set" category to protect against 1-2 outlying points having too much weight (e.g., a 0).

Grading

We'll use a weighted categorical system to evaluate student learning. There are three categories of assignments. Table 1 shows the percentages for each category and the number of assignments (n). Table 2 displays the letter grade conversion for the total score from Table 1.

Table 1. Grading scheme.

Assignment	n	%
Problem set	13	60
Midterm	1	15
Final Exam	1	25

Table 2. Percentage range to letter grade conversion.

Letter grade	% Range
A	89.9 - up
A-	87.9 - 89.8
B+	84.9 - 87.8
B	79.9 - 84.8
B-	77.9 - 79.8
C+	74.9 - 77.8
C	69.9 - 74.8
C-	67.9 - 69.8
D	59.9 - 67.8
F	below - 59.8

The instructor reserves the right to deviate from Table 2.

Additional statements

Diversity Statement

The University of Nevada, Reno is committed to providing a safe learning and work environment for all. If you believe you have experienced discrimination, sexual harassment, sexual assault, domestic/dating violence, or stalking, whether on or off campus, or need information related to immigration concerns, please contact the University's Equal Opportunity & Title IX Office at (775) 784-1547. Resources and interim measures are available to assist you. For more information, please visit http:www.unr.edu/equal-opportunity-title-ix (http:www.unr.edu/equal-opportunity-title-ix).

Disability Statement

Any student with a disability needing academic adjustments or accommodations is requested to speak with the http:www.unr.edu/drc (Disability%20Resource%20Center) as soon as possible to arrange for appropriate accommodations.

Academic Conduct

Please be professional. Prepare for and engage in class. Be on time and submit timely work. Please visit http:www.unr.edu/student-conduct (http:www.unr.edu/student-conduct) for our official student code of conduct.

Academic Success Services

Your student fees cover usage of the University Math Center, University Tutoring Center, and University Writing Center. These centers support your classroom learning; it is your responsibility to take advantage of their services. Keep in mind that seeking help outside of class is the sign of a responsible and successful student.

University Recording Policy

Surreptitious or covert videotaping of class or unauthorized audio recording of class is prohibited by law and by Board of Regents policy. This class may be videotaped or audio recorded only with the written permission of the instructor. In order to accommodate students with disabilities, some students may have been given permission to record class lectures and discussions. Therefore, students should understand that their comments during class may be recorded.

Academic Dishonesty

Cheating, plagiarism, or otherwise obtaining grades under false pretenses constitutes academic dishonesty according to the code of this university. Academic dishonesty will not be tolerated and penalties can include canceling a student's enrollment without a grade or giving an F for the assignment or for the entire course. See the University Academic Standards policy: UAM 6,502 (https://www.unr.edu/administrative-manual/6000-6999-curricula-teaching-research/instruction-research-procedures/6502-academic-standards).

Statement on content accessibility:

This course may leverage 3rd party web/multimedia content, if you experience any issues accessing this content, please notify your instructor.

Statement on COVID-19 Training Policies

Students must complete and follow all guidelines as stated in the Student COVID-19 Training modules, or any other trainings or directives provided by the University.

Statement on COVID-19 Face Coverings:

In response to COVID-19, and in alignment with State of Nevada Governor Executive Orders, Roadmap to Recovery for Nevada plans, Nevada System of Higher Education directives, the University of Nevada President directives, and local, state, and national health official guidelines face coverings are required at all times while on campus, except when alone in a private office. This includes the classroom, laboratory, studio, creative space, or any type of in-person instructional activity, and public spaces.

A "face covering" is defined as a "covering that fully covers a person's nose and mouth, including without limitation, cloth face mask, surgical mask, towels, scarves, and bandanas" (State of Nevada Emergency Directive 024).

Students that cannot wear a face covering due to a medical condition or disability, or who are unable to remove a mask without assistance may seek an accommodation through the Disability Resource Center.

Statement on COVID-19 Social Distancing:

Face coverings are not a substitute for social distancing. Students shall observe current social distancing guidelines where possible in accordance with the Phase we are in while in the classroom, laboratory, studio, creative space (hereafter referred to as instructional space) setting and in public spaces. Students should avoid congregating around instructional space entrances before or after class sessions. If the instructional space has designated entrance and exit doors students are required to use them. Students should exit the instructional space immediately after the end of instruction to help ensure social distancing and allow for the persons attending the next scheduled class session to enter.

Statement on COVID-19 Disinfecting Your Learning Space:

Disinfecting supplies are provided for you to disinfect your learning space. You may also use your own disinfecting supplies.

Statement on COVID-19, COVID-19 Like Symptoms, and Contact with Someone Testing Positive for COVID-19:

Students must conduct daily health checks in accordance with CDC guidelines. Students testing positive for COVID 19, exhibiting COVID 19 symptoms or who have been in direct contact with someone testing positive for COVID 19 will not be allowed to attend in-person instructional activities and must leave the venue immediately. Students should contact the Student Health Center or their health care provider to receive care and who can provide the latest direction on quarantine and self-isolation. Contact your instructor immediately to make instructional and learning arrangements.

Statement on Failure to Comply with Policy (including as outlined in this Syllabus) or Directives of a University Employee

In accordance with section 6,502 of the University Administrative Manual, a student may receive academic and disciplinary sanctions for failure to comply with policy, including this syllabus, for failure to comply with the directions of a University Official, for disruptive behavior in the classroom, or any other prohibited action. "Disruptive behavior" is defined in part as behavior, including but not limited to failure to follow course, laboratory or safety rules, or endangering the health of others. A student may be dropped from class at any time for misconduct or disruptive behavior in the classroom upon recommendation of the instructor and with approval of the

college dean. A student may also receive disciplinary sanctions through the Office of Student Conduct for misconduct or disruptive behavior, including endangering the health of others, in the classroom. The student shall not receive a refund for course fees or tuition.

Tentative course schedule

Students please study the materials before the assigned class session. Class readings and assignments are subject to change, contingent on mitigating circumstances and the progress we make as a class.

Week 01, 01/25 - 01/29: Introduction to STAT 745, Ch. 1

- Readings: Read Rizzo Ch. 1.
- Practice: Work on Ch. 1 Problem Set and compiling `rmarkdown` documents.
- Exams: None.
- Notes: None.

Tuesday topic: Welcome to 745! We'll discuss the structure of the course and expectations for students/instructor.
Thursday topic: Ch. 1 Introduction and computing tools / workflows

Week 02, 02/01 - 02/05: Probability and Statistics Review, Ch. 2

- Readings: Read Rizzo Ch. 2.
- Practice: Work on Ch. 1 Problem Set and compiling `rmarkdown` documents.
- Exams: None.
- Notes: None.

Tuesday topic: Ch. 2 Random variables, multivariate normal
Thursday topic: Ch. 2 Limit theorems, statistics, Bayes' theorem, Markov chains

Week 03, 02/08 - 02/12: Methods for generating random varibles, Ch. 3

- Readings: Read Rizzo Ch. 3.
- Practice: Please complete Ch. 1 Problem Set and submit `rmd` and `html` files in Canvas by the end of the week.
- Exams: None.
- Notes: None.

Tuesday topic: Ch. 3 Inverse transform, accept-reject, transformations
Thursday topic: Ch. 3 Sums and mixtures, multivariate

Week 04, 02/15 - 02/19: Generating random processes, Ch. 4

- Readings: Read Rizzo Ch. 4.
- Practice: Please complete Ch. 3 Problem Set and submit in Canvas by the end of the week.
- Exams: Midterm 1 released.
- Notes: None.

Tuesday topic: Ch. 4 Stochastic processes, Brownian motion
Thursday topic: Ch. 4 Stochastic processes, Brownian motion

Week 05, 02/22 - 02/26: Multivariate Viz, Ch. 5

- Readings: Read Rizzo Ch. 5.
- Practice: Please complete Ch. 4 Problem Set and submit in Canvas by the end of the week.
- Exams: Midterm due Friday 26 2021
- Notes: None.

Tuesday topic: Ch. 5 Multivariate visualization
Thursday topic: Reading Day. No class.

Week 06, 03/01 - 03/05: Monte Carlo integration and variance reduction, Ch. 6

- Readings: Read Rizzo Ch. 6.
- Practice: Please complete Ch. 5 Problem Set and submit in Canvas by the end of the week.
- Exams: None.
- Notes: None.

Tuesday topic: Ch. 6 MC Integration, variance reduction

Thursday topic: Ch. 6 Antithetic variables, control variates, importance sampling, stratified sampling

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Week 07, 03/08 - 03/12: Monte Carlo methods in inference, Ch. 7

- Readings: Read Rizzo Ch. 7.
- Practice: Please complete Ch. 6 Problem Set and submit in Canvas by the end of the week.
- Exams: None.
- Notes: None.

Tuesday topic: Ch. 7 MC estimation, testing, power

Thursday topic: Ch. 7 MC estimation, testing, power

Week 08, 03/15 - 03/19: Bootstrap and jackknife, Ch. 8

- Readings: Read Rizzo Ch. 8.
- Practice: Please complete Ch. 7 Problem Set and submit in Canvas by the end of the week.
- Exams: None.
- Notes: None.

Tuesday topic: Ch. 8 Bootstrap and jackknife

Thursday topic: Ch. 8 Bootstrap and jackknife

Week 09, 03/22 - 03/26: Resampling applications Ch. 9

- Readings: Read Rizzo Ch. 9.
- Practice: Please complete Ch. 8 Problem Set and submit in Canvas by the end of the week.
- Exams: None.
- Notes: None.

Tuesday topic: Ch. 9 jackknife-after-bootstrap, regression

Thursday topic: Ch. 9 influence

Week 10, 03/29 - 04/02: Permutation tests, Ch. 10

- Readings: Read Rizzo Ch. 10.
- Practice: Please complete Ch. 9 Problem Set and submit in Canvas by the end of the week.
- Exams: None.
- Notes: None.

Tuesday topic: Ch. 10 Tests of equal distribution, multivariate tests

Thursday topic: Ch. 10 Applications

Week 11, 04/05 - 04/09: Markov Chain Monte Carlo Methods, Ch. 11

- Readings: Read Rizzo Ch. 11.
- Practice: Please complete Ch. 10 Problem Set and submit in Canvas by the end of the week.
- Exams: None.
- Notes: None.

Tuesday topic: Ch. 11 Intro, Bayesian inference, MCMC integration

Thursday topic: Ch. 11 Metropolis-Hastings, Gibbs, Convergence

Week 12, 04/12 - 04/16: Probability Density Estimation, Ch. 12

- Readings: Read Rizzo Ch. 12.
- Practice: Please complete Ch. 11 Problem Set and submit in Canvas by the end of the week.
- Exams: None.
- Notes: None.

Tuesday topic: Ch. 12 Univariate density estimation, kernal density estimation

Thursday topic: Ch. 12 Bi/multivariate estimation, other

Week 13, 04/19 - 04/23: Numerical methods in R, Ch. 13

- Readings: Read Rizzo Ch. 13.
- Practice: Please complete Ch. 12 Problem Set and submit in Canvas by the end of the week.
- Exams: None.
- Notes: None.

Tuesday topic: Ch. 13 root finding, integration
Thursday topic: Ch. 13 maximum likelihood

Week 14, 04/26 - 04/30: Optimization, Ch. 14

- Readings: Read Rizzo Ch. 14.
- Practice: Please complete Ch. 13 Problem Set and submit in Canvas by the end of the week.
- Exams: Final exam released.
- Notes: None.

Tuesday topic: Ch. 14 1D optimization, MLE
Thursday topic: Ch. 14 2D, EM, simplex method

Week 15, 05/03 - 05/07: Programming topics, Ch. 15

- Readings: Read Rizzo Ch. 15.
- Practice: Please complete Ch. 14 Problem Set and submit in Canvas by the end of the week.
- Exams: Final exam due 7 May 2021.
- Notes: None.

Tuesday topic: Ch. 15 benchmarking, profiling,
Thursday topic: Ch. 15 `rcpp`, applications