### APPM/STAT/MATH 4520/5520 Mathematical Statistics

Instructor: Brian Zaharatos Office: ECOT 338 Office Hrs: Tues, 9:45am-11:15am; Wed, 3pm-4:30pm; or by apt Email: brian.zaharatos@colorado.edu

"There are three types of statisticians: (1) those that (prefer to) work with real data, (2) those that (prefer to) work with simulated data, and (3) those that (prefer to) work with the symbol X." – User603, stats stack exchange

## **Course Description**

Welcome to a first course in Mathematical Statistics! Unlike many other statistics courses, this is not a data oriented course. Instead, it is a course about the probability and statistical thinking needed in order to do statistics. As such, the course will focus on theoretical results—and often, proofs of those results. Consequently, a basic probability course (e.g., APPM 3570 Applied Probability) is an important



prerequisite. After a brief review of some notation and definitions from basic probability, we will cover a number of topics, including different methods for deriving and assessing statistical estimators (both point and interval estimators), theoretical results relevant to hypothesis testing, and other important tools for statistical inference. All that to say, we will be statisticians of type (3) this semester (as defined above by User603 on Stats Stack Exchange!). The ultimate goal for many of us will be to become statisticians of type (1)—few people are employed to be *mathematical* statisticians; however, a type (1) statistician who knows how to "work with *X*" will be much better for it. That is the overarching goal of this course—to learn the mathematics, probability, and statistical theory to make us all better statisticians and data scientists.

## Learning Goals

By the end of this course, students should be able to:

- 1. Compute the distribution of a transformation of random variables (univariate, bivariate, and multivariate), minima, and maxima.
- 2. Define a moment generating function, and use it to compute moments (e.g., the mean and variance), and to derive other theoretical results.
- 3. Define, derive, and interpret estimators of different quantities of interest (e.g., maximum likelihood estimator, method of moments estimator).

- 4. State, prove, and apply important results related to the quality of an estimator (e.g., is the estimator *unbiased*?).
- 5. Define, derive, interpret, and evaluate interval estimates (both frequentist and Bayesian) for means, differences of means, proportions, and variances.
- 6. Derive and evaluate the quality of hypothesis tests (both frequentist and Bayesian) for means, differences of means, proportions, and variances.

## Course Webpage

Course materials, such as this syllabus, the course schedule, homework assignments, solutions, and general updates will be uploaded to our Canvas page. Your grades will also be posted to Canvas. Please check Canvas frequently! Some of this information will also

### Texts:

- 1. *An Introduction to Mathematical Statistics* by J.N. Corcoran (pdf provided).
- 2. *Statistical Inference*, Second Edition by George Casella and Roger L. Berger **(Optional)**

be on our applied math webpage. To find this page, visit <u>math.colorado.edu</u>, click the Course Pages tab, and find APPM/STAT 4520/5520.

## Distance Degree (Online) Students

Success in this course will require you to keep up to date with our course and lecture schedule (see Canvas for a tentative schedule). To keep up to date, you have two options: (1) you may join our lectures using Zoom; or (2) you may watch the recorded lecture later that day (or the next day) via link posted to Canvas. For option (1), note that the Zoom Meeting ID is 512-707-572. You have a few connection options: Join via web browser: https://cuboulder.zoom.us/j/512707572; join via Zoom app (using meeting ID); join via iPhone one-tap: US: +16699006833,,512707572# or +16465588656,,512707572#; join via telephone: US: +1-669-900-6833 or +1-646-558-8656 (Note: for higher quality, dial a number based on your current location).

## **Assignments**

### Homework (35%)

Homework will be due (roughly) once a week at the beginning of the class (dates appear on the course schedule). Late homework will **not** be accepted or graded, except in extraordinary circumstances. You will turn in a paper copy of the assignment at the beginning of class on the due date. You can collaborate with your classmates on the homework assignments, but you must write up the results independently of each other.

### Exams (20% each)

There will be two **evening** midterm exams and one final exam. The first midterm will be on **Wednesday October 3 in the evening**. The second midterm will be **Wednesday November 14 in the evening.** (exact time TBA, but will be at or after 5pm). The final exam date and time will be announced in class during the early part of the semester. **If the evening or final exams conflict with another university obligation, you must notify me by the end of the second week of the semester.** 

### Participation (5%)

Participation in this course is essential for doing well. We will frequently have opportunities for class participation. The majority of this portion of your grade will come from in-class exercises, attendance (you are allowed to miss four classes with no penalty to your grade), online discussion, attending office hours, and, potentially, pop quizzes. Those who participate in these activities will earn high participation grades; students who do not actively participate but seem reasonable well prepared for most lectures can expect to earn a B- for participation. Students, who regularly show up unprepared, or attempt to text, do work for other classes, etc., can expect a very low (most likely failing) participation grade.

# Grade Determination

The standard final grade scheme is as follows: 93-100% = A; 90-92% = A-; 87-89% = B+; 83-86% B; 80-82% = B-; etc. I reserve the right to lower the percentage points needed to obtain the corresponding letter grade.

## **Policies**

#### Accommodation for Disabilities

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition or injury, see Temporary Medical Conditions under the Students tab on the Disability Services website.

#### **Religious Observances**

Campus policy regarding religious observances requires that faculty make every effort to reasonably and fairly deal with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, please send me e-mail or visit me in office hours to notify me of such a situation at least two weeks in advance of the event. See full details at http://www.colorado.edu/policies/observance-religious-holidays-and-absen...

#### <u>Classroom Behavior</u>

Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. For more information, see the policies on classroom behavior and the Student Code of Conduct.

#### Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation

The University of Colorado Boulder is committed to fostering a positive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct (including sexual assault, exploitation, harassment, dating or domestic violence, and stalking), discrimination, and harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or cureport@colorado.edu. Information about the OIEC, university policies, anonymous reporting, and the campus resources can be found on the <u>OIEC website</u>.

#### Honor Code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code (honor@colorado.edu); 303-492-5550). Students who are found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found at the Honor Code Office website.