APMA 1650 – Statistical Inference I

Spring 2023

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Meeting Time: 9:00 - 10:20 a.m. TTh
Location: 85 Waterman Street, Room 130

Teaching Assistants:

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Contact: Email is the best way to contact me; I will always respond within 24 hours (but likely much fewer). I am also happy to schedule an impromptu Zoom meeting whenever you cannot attend the predetermined office hours or if you prefer to meet virtually. Feel free to send me an email at any point in the semester to set a time.

Office Hours: *(Short answer: Check the Canvas homepage!)* Long answer: Office hours will begin the week of February 6. During the second week of class, I will survey your availability and schedule office hours such that every student can attend at least one per week. There will be multiple office hours hosted by me, as well as a session of office hours hosted by each of our TAs. Feel free to attend any session you prefer. The official schedule for office hours will be posted on our Canvas homepage by February 6.

Course Content: APMA 1650 is an integrated first course in mathematical statistics. The first half of APMA 1650 covers probability and the last half is statistics, integrated with its probabilistic foundation. Specific topics include probability spaces, discrete and continuous random variables, methods for parameter estimation, confidence intervals, and hypothesis testing.

Course Goals: In successfully completing this course, you will:

- Summarize the possible outcomes of a random occurrence and determine the likelihood of each result
- Draw conclusions about the behavior of a random variable by adapting the properties of a class of distributions
- Construct mathematical representations of stochastic events and adapt the results to the original scientific framework

Prerequisites: One full year of single-variable Calculus. At Brown this corresponds to MATH 0100, MATH 0170, or MATH 0180. A score of 4 or 5 on the AP Calculus BC exam is also sufficient. In other words, a large amount of single-variable calculus will be assumed, so be sure that you are up-to-date on derivative and integration techniques.

Course Structure: The course is comprised of regular problem sets, online "quizzes," two midterm exams, and a comprehensive final exam. The problem sets will be assigned nearly every week and are usually due on Thursdays. In addition, we will have regular reflections/check-ins throughout the semester so that you can share your progress with me, ask questions about the material, and guide the direction of our in-class time. These will be graded on completion.

Canvas homepage: All course materials will be posted on our Canvas homepage: syllabus, office hours schedule, homework assignments, solutions, class notes, exam prep, and practice problems. Additionally, course announcements and updates will be posted regularly on Canvas. Be sure to turn on notifications so that you do not miss any important information.

Problem Sets: The problem sets will be graded and returned with detailed feedback wherever necessary. These assignments will be made available on our Canvas homepage and then turned in on Gradescope. Collaboration with other students on the problems sets is encouraged! However, all students must write up and turn in their own work. For reference, no such collaboration will be allowed on quizzes or exams.

Practice Sessions: *(For the schedule: Check the Canvas homepage!)* We will have two to three weekly practice sessions held outside of class. These sessions will be a place to work through practice problems, ask questions, and discuss the material with our TAs and the other students. At its core, mathematics is a hands-on experience, not something that should be watched from afar. Since most class time will be used for lecturing, the weekly practice sessions are an important extension of the learning experience. In these sessions, you will be able to try the concepts on your own and practice the process before submitting any graded work. A worksheet will always be provided and you may work in groups or alone. *These worksheets will not be graded!* They exist only for you. Feel free to use them (and the sessions in general) to your benefit!

The practice sessions will begin the week of February 6. Similar to the schedule for office hours, I will use your availability to schedule the two practice sessions on the days and times that allow every student to attend at least one per week. Note that one practice session per week is sufficient. The worksheet will be the same at all sessions. I am only scheduling multiple sessions per week to ensure that every student can attend.

"Quizzes": During the course we will have periodic quizzes, but note that I use the term "quiz" very loosely. These quizzes are designed for your benefit (read: they are meant to help you!). Each quiz will contain approximately five questions on the material that we are currently studying in class and they will be returned to you with thorough feedback on your answers whenever necessary. I strongly recommend that you complete the entire quiz without referring to your notes. This is a great way to check your understanding at a given point in the semester and then observe which sections might need further study. Nevertheless, quizzes are graded on effort and completion only. Since things come up and students may not be able to complete every quiz, I will drop your lowest quiz score.

Keep in mind: the quiz questions will not be tricky or difficult. Instead, they are chosen for a few reasons: (1) to illustrate the topics which are most important from our current material; (2) to provide practice with the material in a question-and-answer format and then detailed feedback on your understanding early in the learning process; (3) recall, recall, recall! *Active recall* (that is, question-and-answer, as opposed to passive reading) is one of the best ways to build long-term retention. Try to ask yourself lots of questions while you study (e.g., "why is this true?", "when do we apply this formula?", "how do we know this works?", etc.) to identify remaining holes in your understanding. The quizzes are one way to do this with the added benefit of immediate feedback. If you are unsure of your answer, write out your thoughts, your ideas, your doubts... This is a chance to work things out as you learn new material.

Textbook: We will follow the material in *"Mathematical Statistics with Applications,"* 7th edition, by Wackerly, Mendenhall, and Scheaffer, 2008. However, this textbook is *not* required! I will go over all of the necessary course material in class and there will not be any problems assigned from the textbook. If you would like to follow along with the book, you can find our text in the bookstore. Although, a quick scan of the table of contents tells me that the sixth edition bears little difference from the seventh. Just an observation!

Here is a short list of other useful references:

- *"A Modern Introduction to Probability and Statistics: Understanding Why and How,"* by Dekking, Kraaikamp, Lopuhaä, and Meester, 2005.
- *"Probability and Statistics,"* 4th edition, by DeGroot and Schervish, 2011.

Assessment: The graded assignments will be weighted as follows:

> "Quizzes" & Reflections – 5%
> Problem Sets – 25%
> First Midterm – 20%
> Second Midterm – 20%
> Final Exam – 30%

Here is the grading scale based on final scores in the course:

Grade	Percentage
A	90-100 %
B	80-89.99 %
C	70-79.99 %
NC	$< 70\%$

The ranges listed above will not change. However, in borderline cases (i.e., a total grade that is less than one point away from the next letter grade), the final letter grade *may* be subject to adjustment when both of the following are present: (1) an extreme improvement in performance over the semester, and (2) strong participation throughout the course.

Keep in mind that there will be one optional problem set late in the semester that can be used to replace your lowest problem set score. Additionally, your lowest quiz score will be dropped. Aside from these adjustments, there will be no other opportunities for make-up work. Be sure to stay on top of the assignments throughout the semester. If anything is making it difficult for you to do your best work this semester, please reach out to me as soon as possible.

Workload: A possible breakdown of the time required to complete this course is as follows: lectures = 3 hours per week for 14 weeks (42 hours); homework assignments, reading, and studying for midterm exams = 9 hours per week for 14 weeks (126 hours); studying for the final exam = 12 hours. Total: 180 hours of work. Note that the amount of time actually spent on each activity (particularly homework and exam preparation) will vary greatly among students, so do not use this as a strict formula or expectation.

Best Practices:

- *Lecture Attendance:* I highly recommend attending each lecture. This allows you to see the material in a far more dynamic manner than the text provides and ask questions as they arise. Additionally, there will be small-group discussions and ungraded work to allow you the chance to address conceptual misunderstanding together in a hands-on environment.
- *Participation:* Note that while we will have in-class discussions and/or practice work, neither your participation nor your performance during these small group sessions is counted toward your grade. These sessions are designed for you! They are meant to offer you practice with the concepts before working on the homework and exams.
- *Late Homework:* Late assignments will not be given credit unless I am notified ahead of time with a valid excuse. Please speak to me directly (whether by email, in office hours, or before/after class) if you cannot turn in an assignment on time.
- *Missed exams:* Midterm exams will not be given outside of the predetermined time slot unless you speak to me directly (as soon as possible) with a note of excuse and verification (medical or personal emergency). In such a case, a make-up exam different from the original will be given. However, you cannot receive credit for the course without taking the final exam.

Key Dates: This is a tentative schedule; the dates could shift as the course develops.

> Midterm 1 – March 2, 2023
>
> Midterm 2 – April 6, 2023
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> Final Exam – May 18, 2023, 2 p.m. - 5 p.m.
>
> Last Day of Class – April 27, 2023

Problem set due dates:

1 – February 9, 2023
2 – February 16, 2023
3 – February 23, 2023
4 – March 16, 2023
5 – March 23, 2023
6 – April 20, 2023
7 – April 28, 2023
– May 3, 2023 *(Optional – Replaces lowest problem set grade on sets 1-7)*

No class or office hours on:

February 20 - 21, 2023
March 27 - 31, 2023
April 28, 2023

Accessibility and Accommodation: Brown University is committed to full inclusion of all students. Please inform me early in the term if you may require accommodations or modification of any of these course procedures. You may speak with me after class, during office hours, or by appointment. If you need in-class accommodations or want more information in general, please be sure to contact Student and Employee Accessibility Services (SEAS) at 401-863-9588 or SEAS@brown.edu.

Diversity and Inclusion: The mathematical sciences have a long-standing and systemic representation problem. As an instructor, my foremost goal is to reject this exclusivity and build a learning environment that supports a diversity of perspectives, thoughts, and identities (including gender, sexuality, ethnicity, race, ability, socioeconomic status, religion, nationality, and culture). I do not believe that an individual must shed any part of their identity or personal background to *become* a mathematician. Instead, I aim to support a diversity of mathematicians each with their own approach, identity, and learning needs.

I recognize that these goals require persistent and intentional effort in a mathematics classroom. I remain committed to you through regular training; this semester I am a member of the Junior Faculty Teaching Fellows Program which addresses the gaps in inclusive teaching. In addition, your suggestions are welcome and encouraged here. If there is any way in which I can better support your learning experience, please feel free to let me know. If you have feedback when I am not successfully achieving these goals, please feel free to let me know. You may reach out to me directly or anonymously at any point in the semester. If you prefer to speak to someone outside of the course, the Brown Senior Associate Dean for Diversity and Inclusion, Maitrayee Bhattacharyya, is an excellent resource.

Class Recording and Distribution of Materials: Lectures and other course materials are copyrighted. Students are prohibited from reproducing, making copies, publicly displaying, selling, or otherwise distributing the recordings or transcripts of the materials. The only exception is that students with disabilities may have the right to record for their private use if that method is determined to be a reasonable accommodation by Student and Employee Accessibility Services (SEAS); see the contact information in the paragraph above. Disregard of the University's copyright policy and federal copyright law is a Student Code of Conduct violation.

Tentative Schedule of Topics

I. Probability Essentials

(a) Sample spaces, events, and subsets

(b) Basic set operations

(c) Discrete uniform distribution

(d) Conditional probability & independence

II. Discrete Random Variables

(a) Descriptors: Random variables, expected value, and variance

(b) Discrete distributions: binomial, geometric, hypergeometric, Poisson

III. Continuous Random Variables

(a) Probability density functions, cumulative distribution functions

(b) Descriptors: Median, expectation, and variance

(c) Continuous distributions: uniform, normal, exponential

Midterm 1 – March 2

IV. Multivariate Distributions

(a) Two discrete random variables

(b) Two continuous random variables

(c) Descriptors: expected value of a function of two random variables

V. Sampling Distributions

(a) Statistics

(b) Sampling distributions for normally distributed populations

(c) Central limit theorem

Midterm 2 – April 6

VI. Estimation

(a) Point estimators

(b) Interval estimators

VII. Hypothesis Testing

(a) Large sample hypothesis tests

(b) Type II error

(c) Sample size selection and p-values

Final Exam – May 18