[STAT 311] Statistical Inference

Spring 2024

Section:	STAT 311	**Professor:**	Becky Tang (she/her)
Class hours:	TRF 9:45-10:35AM	**Office:**	Warner 214
Room:	Warner 011	**E-mail:**	btang@middlebury.edu
Preregs:	MATH/STAT 310	**Office Hours:**	M 2-4pm, R 3-4pm (tentative)

Course Description

An introduction to the mathematical methods and applications of statistical inference focused mainly on classical methods. Several statistical concepts and methods will be developed in a mathematical framework. The course is broken largely into three parts: parameter estimation, interval estimation and hypothesis tests, and linear least squares. Topics for parameter estimation include Bayes estimators, methods of maximum likelihood and moments, sufficiency, and efficiency. Classical tests within the normal theory such as F-test, t-test, and chi-square test will also be considered. Methods of linear least squares are used for the study of analysis of variance and regression. There will be some emphasis on applications to other disciplines. This course is taught using R.

Key Learning Outcomes

- ❏ Obtain, compare, critique, and optimize different estimators from both frequentist and Bayesian perspectives.
- ❏ Understand how to conduct hypothesis tests and construct confidence intervals within the frequentist framework.
- ❏ Determine which statistical inference procedure is most appropriate for a given task, implement the procedure effectively, and interpret the results accurately.
- ❏ Build confidence in deriving results using probability theory and statistical assumptions.
- ❏ Continue to develop proficiency in coding in R by implementing and analyzing simulations for estimation and inference using R.

Textbooks and Course Materials

Textbook: Morris H. DeGroot and Mark J. Schervish, *Probability and Statistics*, 4th edition. *Note: A copy is on reserve at the Davis library (2 hour loan period).*

Optional resources:

- John A. Rice, *Mathematical Statistics and Data Analysis*, 3rd edition.
- George Casella and Roger L. Berger, *Statistical Inference*, 2nd edition.

Course website: Most of our course content will be housed on the course website: https://midd-stat311-spring2024.github.io/. Please bookmark this page

for easy navigation.

- **R**: Please make sure you have access to R (and RStudio) prior to the end of the first week of courses. If possible (or when prompted), update RStudio to the most recent version.

Course Structure

A typical class day involves the following:

1. Daily assignment: Every class meeting time will have an assigned reading from the textbook or recorded video. You are expected to do the reading/watch the video before class. By 8:45am on the day of class where we cover the assigned material, you will answer a set of brief reflection questions on the topics covered. You are also encouraged to submit any questions or clarifications from the assigned material.
2. Class session: Our 50-minute meetings will consist of lecture for the first 35-40 minutes of class, followed by group work session with your peers for the remaining 10-15 minutes. The lecture is intended to deepen and/or supplement your understanding of the material covered in the daily assignment, and the group work session is intended for you to explore the topics more deeply.
3. Homework problems: After each class session, a few homework problems will be assigned to the weekly problem set. Some these problems will require the use of R.

A prepared student will attend the 50-minute class, and spend roughly two-four hours per day of class on work outside the classroom (reading, watching videos, doing homework, studying, etc.). As this course meets three days a week, this represents a minimum 9-15 hour weekly commitment.

Class Expectations

- **You are expected to physically show up to class and actively participate**, conditional on classes being in-person. You are an integral part of the class community! Exceptions include previously-communicated illness or planned absence.
- **Please arrive on time.** I expect everyone, myself included, to arrive on time and dedicate full attention during the class. In turn, I will do my best to always end class at the designated time.
- **Laptops.** The use of laptops will will often be necessary and I will let you know in advance when you should bring in a laptop. In these cases, ensure that your laptop has sufficient battery for the duration of the class.
- **Cell phones should be turned to silent**. I don't mind cell phones in class, but please silence them so as to not disrupt the class.
- **Please ask questions!**
- **I encourage discussion amongst yourselves**, especially for clarification or help! However, please be mindful of volume so that the conversations will not be disruptive to the class.
- I expect all members of the class to make participation a harassment-free experience for everyone, regardless of race, creed, color, place of birth, ancestry, ethnicity, national origin, religion, sex, sexual orientation, gender identity or expression, age, marital status, service in the armed forces of the United States, positive HIV-related blood test results, genetic information, or against qualified individuals with disabilities on the basis of disability and/or any other status or

characteristic as defined and to the extent protected by applicable law. We will not tolerate the use of violence against any individual.

Resources

- ❑ **Office hours**. This time is meant for you! Please come by to ask questions, chat with me, or work on homework. You should never worry about disturbing me during this time.
- ❑ **One-on-one meetings**. If you would like to meet with me one-on-one, please send me an e-mail or approach me after class so we can schedule a time.
- ❑ **Your peers**. Unless otherwise noted, I encourage students to work together and discuss material! However, unless the assignment explicitly states that it is to be completed as group work, the submitted material must be your own.

Tips on how to succeed

- Come to every class and attend office hours.
- Attempt some problems individually before working with others.
- Complete the pre-class assignment in a timely fashion. A lot of the concepts in this class take time to sink in.
- The assigned readings are not lengthy, but they convey a lot of information.
  - Read through the material at least twice. Once without taking notes for an overall overview, then a second time to take notes.
  - Do not skim past the Examples in the readings. Make sure you understand the solutions presented in the Example problems.
- Do not try to find answers on the internet or ChatGPT. Struggling through problems is how you learn!
- **Brush up on your probability (Math/Stat 310) skills.** Or at least find your notes from that class!

College policies and resources

Academic Integrity

As an academic community devoted to the life of the mind, Middlebury requires every student to reflect complete intellectual honesty in the preparation and submission of all academic work. Details of our Academic Honesty, Honor Code, and Related Disciplinary Policies are available in Middlebury's handbook.

Using AI tools (e.g., ChatGPT, Bard) is forbidden in this class. You may not use them to assist in any part of your homework or other assignments. Any use of generative AI tools will be treated as a violation of Middlebury's Honor Code.

Honor Code Pledge

The Honor Code pledge reads as follows: "I have neither given nor received unauthorized aid on this assignment." It is the responsibility of the student to write out in full, adhere to, and sign the Honor Code pledge on all examinations, research papers, and laboratory reports. Faculty members reserve the right to require the signed Honor Code pledge on other kinds of academic work.

Disability Access and Accommodation

Students who have Letters of Accommodation in this class are encouraged to contact me as early in the semester as possible to ensure that such accommodations are implemented in a timely fashion. For those without Letters of Accommodation, assistance is available to eligible students through the Disability Resource Center (DRC). https://www.middlebury.edu/office/disability-resource-center. The DRC provides support for students with disabilities and facilitates the accommodations process by helping students understand the resources and options available and by helping faculty understand how to increase access and full participation in courses. DRC services are free to all students. Please contact ADA Coordinators Jodi Litchfield and Peter Ploegman of the DRC at ada@middlebury.edu for more information. All discussions will remain confidential.

Center for Teaching, Learning, and Research (CTLR)

The CTLR provides academic support for students in many specific content areas and in writing across the curriculum through both professional and peer tutors. The Center is also the place where students can find assistance in time management and study skills. These services are free to all students. go.middlebury.edu/connect

Types of assignments

- **Daily assignments**. Assigned before each class session and turned in individually on Canvas. These small assignments include readings from the textbook plus a few assessment questions that are designed to help you reflect on your understanding of the readings. I will review all the assignments prior to each class period. These assignments are graded on good-faith effort so you can receive feedback quickly. Daily assignments are due on Canvas by 8:45am the day of each class (to give me time to review them before class). For example, the daily assignment for Thursday 2/15 should be completed by 8:45am on Thursday 2/15.
  - No extensions on daily assignments will be given, but up to two assignments may be missed without penalty.
  - It is not my intention or desire for you to stay up late or wake up early to complete the daily assignment. Daily assignments will be released at least three days in advance so you can plan ahead.
- **Problem sets**. Assigned weekly and turned in individually (though feel free to work with your peers). In the problem sets, you will apply what you have learned during lecture to dive deeper into the material and explore more interesting probability problems. Most weeks, the problem sets will require R. Problems will be assigned after every class, but each week's problem set is due at 11:59pm the following Tuesday to Canvas.
- **Midterm exams**. Two midterm exams are designed as an opportunity to assess the knowledge you've learned. At least one of the midterms will be take-home. The *tentative* dates for the exams are:
  - Midterm 1: Friday 4/05
  - Midterm 2: Friday 5/03

  Except in the cases of extreme illness or family emergency, students must take the in-person portion (if applicable) of the midterms on the scheduled date and time.
- **Final project**. A final project presents the opportunity to demonstrate your learning from the entire semester. You will be asked to 1) write a brief paper about a topic and 2) present your findings to the rest of the class. More details will be given after Spring Break. The presentations will take place on the college-assigned final exam date for this course, which is to be determined. Please do not book travel until the final exam date has been confirmed.

Grading

- Late work will always be considered within one week of the original due date. Unless otherwise stated, the late policy is as follows: for every 24-hour period the assignment is late, 10% from the maximum possible grade will be deducted.
- I will do my best to return assignments within one week of submission.
- Regrade requests: I do allow regrade requests, which must be submitted to be in-person within one week of when the assignment is returned. Keep in mind that regrade requests do not guarantee points back.
- **You must take each midterm and present the final project in order to pass the course.**

Component	Percentage
Daily assignments	10%
Problem sets	30%
Midterm I	20%
Midterm II	20%
Final Project	20%

- Letter grades will be assigned based on the following course percentages, with the upper 3% and lower 3% of each category corresponding to + and −, respectively:
  - A: 90-100%
  - B: 80-89%
  - C: 70-79%
  - D: 60-69%
  - F: <60%

  In the case of decimal points, grades will not be rounded up. For example, an 92.9% will correspond to a A-, not an A.

Tentative Course Content

(Last updated: 02/12/23)
NOTE: The following dates and content may be modified due to the requirements of the class may be moved backward or forward depending on class progress and my conference travel. **Midterm dates are tentative.**

Week	Date	Topic
1	2/13	T - Welcome! Course logistics, Intro to Inference R - Core terminology F - Prior and Posterior Distributions, Likelihood function
2	2/20	T - Computing posteriors - Problem Set 01 due R - Conjugate Prior Distributions F - Bayes estimators
3	2/27	T - Maximum Likelihood Estimators (MLEs), 1-D - Problem Set 02 due R - MLEs cont. F - MLE activity
4	3/05	T - Properties of MLEs - Problem Set 03 due R - Method of Moments F - Properties of estimators: consistency, bias, variance
5	3/12	T - MSE - Problem Set 04 due R - Comparing estimators F - Comparing estimators (cont.)
	3/19	Spring Break
6	3/26	T - Sampling distribution of an estimator - Problem Set 05 due R - χ^2 distribution, Joint dist. of sample mean and variance F - t distribution F - Midterm I
7	4/02	T - Confidence Intervals (CIs) R - CIs (cont.) F - Bootstrapping
8	4/09	T - Bootstrapping (cont.) - Problem Set 06 due

		R - Intro to Hypothesis Tests F - HT essentials: significance level, power, p-values - Last day to drop classes
9	04/16	T - HT essentials (cont.) - Problem Set 07 due R - HT essentials (cont.) F - Spring symposium: no class
10	4/23	T - Equivalence of confidence sets and HT - Problem set 08 due R - Likelihood ratio test F - t-test
11	4/30	T - Two-sample t-test - Problem set 09 due R - F-distribution, F-test F - F-test F - Midterm I
12	5/07	T - Method of least squares, Simple Linear regression (SLR) R - Inference for SLR F - Inference for SLR (cont.)
	5/13	M - Peer review
	Finals week	Project presentations