# MATH/STAT 355: Statistical Theory

Professor: Taylor Okonek (she/her)

Email: tokonek@macalester.edu

Office: Olin Rice 126

---

Class Time: MWF 2:20 - 3:20pm, OLRI 241

Final Exam Time: Friday May 9th, 1:30 - 3:30pm, OLRI 241

---

**Office Hours:**

The following hours will be priority for MATH/STAT:

- Mondays 10:00 - 11:00 am
- Thursdays 3:00 - 4:00 pm

The following hours will be priority for STAT 155*:

- Mondays 11:00 am - Noon
- Tuesdays 4:00 - 5:00 pm
- Thursdays 2:00 - 3:00 pm

Note: Office hours are typically first-come, first-served. However, I will do my best to include everyone present in the conversation. If the office hour times listed above don't work for you, I am **available by appointment**; email me to set up a time to meet. More expectations on communication are in the Course Communication section.

---

**Preceptors**

We have two phenomenal preceptors for Statistical Theory this semester: Lucia Luo and Adam Schroeder! The course Moodle site contains detailed information for preceptor office hour times/locations.

The role of an MSCS preceptor is to help students with content questions, assist in the navigation of available resources, advise on studying approaches for classes, and assist with concepts, tools, and skills needed for problem sets. Students are accountable for their own learning; as such, preceptors are not allowed to share answers to assignments (unless specifically directed by the instructor), are not expected to immediately know the right approach, or provide assistance outside of office hours.

Additional guidelines and expectations on how to interact with preceptors can be found here.

---

**Textbook**

**There is no official required textbook\* for this course.** Instead, these Course Notes (which will be updated throughout the semester) will serve as a pseudo-textbook. Each chapter of the Course Notes contains (at a minimum):

1. Topic Introduction

2. Learning Objectives

3. Concept Questions

4. Definitions

5. Theorems

6. Worked Examples

I will occasionally assign you to read the Topic Introduction section for a chapter before class, and we will often go over Worked Examples during class time. The "Chalk-Talk" style lecture for this class will contain *only* material from these Course Notes, so you can consider these a replacement for both a textbook and "slides" from class.

The *best* resources for this course are the Course Notes, attending and participating in class, problem sets, and office hours. I am happy to talk about possible additional materials / strategies for effective learning at any time throughout the semester!

\*Previous iterations of this course have used *An Introduction to Mathematical Statistics and Its Applications* by Richard Larsen and Morris Marx (6th Edition).

---

**Learning Objectives**

Upon completion of this course, students should be able to...

- Implement and understand common estimation methods in a variety of settings and models
- Compare and compute properties of estimators, and explain why you might choose one type of estimator over another
- Derive finite and asymptotic results based on distributional forms of estimators
- Conduct computational simulations to support results from theoretical statistics

---

**Tentative Schedule**

A slightly more detailed, day-to-day schedule will be filled in throughout the semester in the Schedule tab of this website. A rough outline by week number is as follows.

Please note that this is *highly* tentative! We'll slow down (or speed up) as needed throughout the semester).

1. Intro Day

2. Probability Review & Maximum Likelihood Estimation

3. Maximum Likelihood Estimation & Method of Moments

4. Properties of Estimators

5. Properties of Estimators

6. Consistency, **MSCS Capstone Days**

7. Asymptotics & the Central Limit Theorem

8. Asymptotics & the Central Limit Theorem

**Spring Break**

9. Asymptotics & the Central Limit Theorem

10. Hypothesis Testing

11. Bayesian Inference

12. Decision Theory

13. Simulation Studies

14. Computational Statistics

15. **Last Day of Class**

---

### Course Communication

**Course Website:** All course materials will be posted on the course website. The Schedule tab of this website will contain information about due dates, and general day-to-day going-ons.

**Moodle:** Moodle will be used to post grades, problem set feedback, announcements, and more. Please check the course Moodle page every day before class, to make sure you aren't missing any assignments!

**Email:** Outside of office hours, email is the best way to discuss topics of a personal nature (e.g., grades, missing class) or to ask other questions you don't feel comfortable asking in a group setting. **Note that I will not send same-day responses to messages sent after 6:00pm.** You can email me about an extension day after 6:00pm, I will respond the next day.

Please communicate respectfully with your classmates and myself, and let me know if there are ways classroom communication can be made more accessible to you.

---

### Classroom Environment

I am committed to helping you learn and succeed. Part of this means facilitating environments that support you in the ways that you need. Everyone comes from a different path through life, and it is our duty to listen to each other without judgment, and to respect one another. There will be **no tolerance** for discrimination based on race, ethnicity, gender, religion, sexual orientation, disability, or other identities.

Statistics is used to understand the world around us as it pertains to many relevant and timely issues. While this class focuses primarily on the various theoretical underpinnings of statistical inference, it is important to recognize and critique the circumstances under which this theory was developed. As an example (that we will discuss in this course), many famous statisticians who founded much of modern statistical theory were involved in the eugenics movement. Ethical considerations come into play in both applied *and* theoretical statistics. If you feel that you may not be able to complete a certain activity, do a reading, or partake in a discussion due to the nature of the topic at hand, please reach out to me so that you can help

me understand your situation, and so that we can discuss the possibility of replacing the item with an alternative. I am more than happy to work with each of you to ensure that you feel comfortable in your learning.

---

**Grades**

**Evaluations / Assessments**

Quizzes: There will be approximately 7, in-class quizzes throughout the course of the semester. Quizzes will be entirely *closed-note*, other than a distributions note sheet (provided by me). You may not use any other resources (including calculators). Opportunities for revision will be built into the structure of the quizzes, with two opportunities to demonstrate your understanding of each topic. If you are unable to take a quiz during the scheduled class period, **you must notify me at least one week in advance**.

Quiz topics will be as follows:

- Probability

- Maximum Likelihood Estimation

- Method of Moments

- Properties of Estimators (Bias, Variance, Efficiency)

- Properties of Estimators (Sufficiency)

- Consistency

- Asymptotics & the Central Limit Theorem

- Hypothesis Testing

- Bayesian Inference

For each Quiz topic, you can receive a "Needs Improvement", "Pass", or "High Pass". Your *best* performance on a topic (across both quizzes it appears on) will be the one considered for final grading. For example, if you receive a "Needs Improvement" for the Method of Moments topic on Quiz 2, and a "High Pass" for that same topic on Quiz 3, I will consider that a "High Pass".

Problem Sets: There will be 6 Problem Sets throughout the course, due roughly every other Friday, consisting of derivations that apply course concepts in novel settings, proofs that extend and deepen your understanding, and (occasionally) questions that challenge you to conduct simulations to support your mathematical understanding. Problem sets must be typed using LaTeX (see the subcategory below for resources), and simulations (when required) must be

done using R (Markdown or otherwise). You may choose to type all of your problem sets using a combination of LaTeX/RMarkdown if you wish.

For each question on a Problem Set, you can receive a "Needs Improvement", "Pass", or "High Pass". These will be converted to 0, 1, or 2 points per question. Your final Problem Set grade will then be calculated as a percentage of total question points throughout the semester, and converted to a letter grade using the table below.

There is *no* opportunity to make-up points on Problem Sets. This is primarily because you are *highly* encouraged to work together on Problem Sets, ask myself and the preceptor questions, and even *google* the questions to help you answer them (so long as you cite your sources). See the section below on Academic Integrity for more on this.

Final Exam: There will be one, cumulative, final exam during the final exam period. As with quizzes, the final exam will be entirely closed-note. You are encouraged to study and work together to prepare for the exam. Note that **in order to pass this course**, you *must* sit for the final exam, and demonstrate effort on a majority of the problems in the exam.

---

**Late Policy**

Throughout the quarter, you may use up to **three**, three-day extensions. These three extensions can be used on Problem Sets *only*, not quizzes. The purpose of deadlines (and extensions) are to keep you accountable for your own learning, to keep you on track with the pace of the course (which builds upon itself throughout the semester), and to provide preceptors and myself with the ability to provide you with timely feedback on assignments. Since the Problem Sets are due every two weeks, you *must* begin working on them early if you want to succeed.

Extensions can be used automatically, without letting me know in advance. The Moodle dropboxes for assignments will close exactly 3 days after the original deadline, and I will not accept work submitted after that point unless there are extenuating circumstances that you have communicated with me about *ahead of the original deadline.* If you email me a completed assignment after a 3-day extension is up, I may have the preceptors provide you with feedback, but you will **not receive credit** for the assignment (equivalent to "Needs Improvement" on every question of the relevant assignment).

I expect you to keep track of how many extensions you've used. I will email you a reminder if you have used all three of your extensions and have none remaining.

If you have run out of extensions and/or an extenuating circumstance occurs that impacts your ability to submit assignments on time, please email me to discuss the situation. I am happy to be flexible as long as you communicate!

---

**Academic Integrity**

As a globally- and community-oriented institution, Macalester College expects respectful exchange of ideas. Students are expected to be familiar with the college standards on academic integrity (link). You are encouraged to work with your classmates on assignments and activities, but in order to receive individualized feedback on your own learning, **all submitted work (including code and LaTeX) must be written in your own words**. Issues of academic integrity will be taken very seriously, and any concerns about this policy being violated will be followed up on individually.

Much of the content covered in Statistical Theory is "googleable." Many of the questions that I ask you on problem sets have been answered on stackoverflow posts. My philosophy on this is that stackoverflow posts, wikipedia, etc. are resources that you are welcome to use, but do not replace the benefit of working through problems on your own, nor is directly copying an answer from one of these resources acceptable. If you choose to google an answer for a problem, I expect you to **cite the source** you used, fill in additional algebraic details that have been left out of the answer, and comment thoughtfully on the steps involved in obtaining the solution. Note that for all quizzes and the final exam, you will be expected to solve problems without such online resources. It is my firm belief that it will be to your benefit to at least attempt to solve problems without looking up the answers online. As such, we will not be utilizing google during class time. Please ask me questions about this if you have questions regarding the course policy *or* my suggested study/learning techniques.

---

**Course Grading System**

In order to earn a given letter grade, **all** requirements listed under that column need to be met.

|  | A | B | C |
|---|---|---|---|
| Problem Sets | $\geq 85\%$ | $\geq 70\%$ | $\geq 50\%$ |
| Quizzes | At most 2 "Pass", 0 "Needs Improvement" | At most 4 "Pass", at most 1 "Needs Improvement" | At most 4 "Needs Improvement" or *all* "Pass" |

Your final letter grade will be an "average" of the letter grades for the Problem Set and Quiz components, modified by your Final Exam score.

| Grade Component 1 | *D | *D | *D | C | C | C | B | B | A |
|---|---|---|---|---|---|---|---|---|---|
| Grade Component 2 | C | B | A | C | B | A | B | A | A |
| Overall Course Grade | C- | C | C+ | C | B- | B | B | A- | A |

*Please see the section below titled "What if I get below a C in a category?"

Rather than contributing a direct percentage/component to your course grade, the final exam will be used to adjust your "baseline" grade. If you score above a 90% on the final, you will be bumped up a half letter grade (i.e., B -> B+) with the exception of A to A+. If you score between 70 and 90%, your grade will remain the same. If you score below 70%, you will be bumped down a half letter grade (i.e., B -> B-). These cutoffs are subject to change if the exam goes poorly for all individuals, but the cutoffs will **not** be raised from here (e.g., you would never need to get *even more* than 90% to be bumped up).

> Example: Suppose you get
>
> - 80% on Problem Sets
>
> - 2 "Pass" and 7 "High Pass" on Quizzes
>
> - 95% on the Final Exam
>
> Then your baseline grade would be a B A –> A-, which would be raised to an A for your overall course grade based on your Final Exam performance.

---

## What if I get below a C in a category?

Problem Set category:

So long as you do not *also* get a D in the Quiz category of the class *and* you score above 70% on the Final Exam, **you will still pass** the course (note that passing at Macalester is generally considered a C- or above). The grade "averages" listed above are for these cases.

If you score a D in the Problem Set category, a C in the Quiz category, and below a 70% on the Final Exam, you will receive a D for your overall course grade.

Quiz category:

If on **five or more Quiz topics** (out of 9 total) you score "Needs Improvement" (after both attempts for each topic), you will receive a D for your overall course grade. The quizzes are the only way I can effectively assess your *individual* understanding of the course material, and if you cannot demonstrate mastery of half or more of the course content, you will not have earned a passing grade.

---

**Statistical Software**

We will occasionally use the free, R programming language throughout this course. RStudio (an interface for R) will facilitate our use of R. You may use RStudio in one of two ways:

1. Online: Go to https://rstudio.macalester.edu, and log in with your full Mac email address and your usual Mac password to get access
2. Desktop version: Download for Windows or Mac at https://posit.co/downloads/. **Note**: You first need to download and install R on your computer in order to use the desktop version of RStudio

More detailed instructions on downloading, installing, and getting started with R and RStudio is available on the R Resources tab.

---

**LaTeX**

LaTeX is a document preparation system used to create high-quality scientific and technical communications. We will be using LaTeX to typeset mathematical notation. It is freely available, and we will primarily be using it in Overleaf to create compiled pdf documents. Note that you will need to make an Overleaf account to get started, but making an account is free.

Note that you can also create LaTeX documents directly in RMarkdown, which allows you to format mathematical notation alongside code, when needed. As the coding component of this class is minimal, I will not be suggesting directly that you use LaTeX within RMarkdown, though you may choose to do so if you wish. In order to use LaTeX within RMarkdown and be able to knit to pdfs, you need to download TinyTex, and either MacTex (Apple) or MiKTeX (Windows). Additional LaTeX and Overleaf resources are available on Moodle.

Prof. Kristin Heysse has a nice guide on getting started with Overleaf that you are welcome (encouraged!) to use as a resource, linked here. All sections of the document other than the TIKz one are relevant for this course.

---

**Accommodations**

I am committed to ensuring access to course content for all students, including those with disabilities. If you have a disability, please meet with me early in the semester to discuss your accommodation plan. If you have not yet obtained a plan or are unsure if you have a disability that requires accommodation, please contact Disability Services: disabilityservices@macalester.edu, or call 651-696-6275.

---

**Religious Observance**

Students may wish to take part in religious observances that occur during the semester. If you have a religious observance/practice that conflicts with your participation in the course, please contact me before the end of the second week of the semester to discuss appropriate accommodations.

In an effort to respect religious diversity, I request that students who plan to observe a religious holiday during scheduled class meetings/ class requirements talk to me about reasonable consideration by the end of the second week of the course.

---

**Title IX**

Macalester is committed to providing a safe and open learning and living environment for all students, staff, and faculty. Any community member experiencing sexual harassment, sexual violence, relationship violence, or stalking, is encouraged to seek help and support.

**Please be aware that as a faculty member, it is my responsibility to report disclosure about sexual harassment, sexual misconduct, relationship violence, and stalking to the Title IX Office.** The purpose of this report is to ensure that anyone experiencing harm receives the resources and support they need. I will keep this information private, and it will not be shared beyond this required report.

You may also contact Macalester's Title IX Coordinator directly (phone: 651-696-6258; e-mail: titleixcordinator@macalester.edu); she will provide you with supportive measures, resources, and referrals. Additional information about how to file a report (including anonymously) is available on the Title IX website.

If you prefer to speak with someone confidentially, or need 24/7 support, there are resources available on- and off-campus to assist you:

- [Counseling Services](#) at the Hamre Center – on-campus counseling resource for students **Free, Urgent, Phone Counseling (Press 2) is available to Macalester students anywhere in the world, 24/7/365.** Speak to a licensed mental health counselor 24 hours a day by calling Hamre Center at 651-696-6275, then press or say option 2 when prompted.

- [Center for Religious and Spiritual Life](#) – chaplains may be reached via 651-696-6298 or email religiouslife@macalester.edu

- [SOS Sexual Violence Services of Ramsey County](#) 651-266-1000 (24-Hour Crisis Hotline staffed by trained advocates)

- [Rape, Assault, and Incest National Network (RAINN)](#) 1-800-656-4673 (24-Hour Hotline and Live Chat)

- Additional local and national resources can be found at[https://www.macalester.edu/title-ix/find-support/](https://www.macalester.edu/title-ix/find-support/)

---

## Land Acknowledgement

I would like to honor the fact that we are on Dakota land. This is the ancestral homeland of the Dakota people who were forcibly exiled from the land because of aggressive and persistent settler colonialism. I make this acknowledgment to honor the Dakota people, ancestors, and descendants, as well as the land itself.

---

## About Your Professor

Hi! Please call me Taylor or Professor Okonek (never Dr. Okonek, it sounds weird to me). My pronouns are she/her/hers. I was born on Madeline Island, Wisconsin, and grew up partially there / partially in White Bear Lake, Minnesota. I went to St. Olaf College for undergrad, and double majored in Mathematics and Religion, with a concentration in Statistics. I am a first-generation college student from a low-income background and was a part of the TRIO McNair program at St. Olaf. I completed my Ph.D. in Biostatistics at the University of Washington, Seattle in 2023. My research interests are in demography, mortality estimation, spatial and survey statistics, and survival analysis (and their intersections!).

When I'm not thinking about / doing Statistics, I like to rock climb, hike, cook, read, play video games (currently Path of Exile, but my favorite game of all time is probably Celeste), and hang out with my two cats, Alice and Ellie. I'm always happy to talk about research

if you have any questions, and happy to chat about your interests/goals as well, be they statistics-adjacent or not!

---

**Note**

This syllabus is subject to change at any time! Announcements of changes will be made in class or via email.