

STA 410 – Mathematical Statistics –

And it's always good to be wrong. It means that you are learning something.

— Sir Martyn Poliakoff

Contact Info

Instructor: Grigory Sokolov (he/him/his)

E-mail*: Canvas Messages or email sokolovg@tcnj.edu

Office: Science Complex P-245

* **Please start your email subject with "STA 410".**

If you need to contact me or have any questions or want to schedule a meeting, please send me a message from Canvas or e-mail me. *If I do not respond to your e-mail within 24 hours, send me a reminder about the original!!* I will do my best to stay on top of electronic communications, but it is possible that I might unintentionally miss some of them.

Course Prerequisites/Corequisites

STA 215 – Statistical Inference and Probability, and MAT 316 – Probability.

Course Purpose

Mathematical Statistics introduces students to the underlying theory of statistics. In this course they will learn to prove all of the theorems and derive all of the formulas that they learned to use in their introductory statistics courses. To do this they will need to learn probability transformation techniques to derive the sampling distributions of the most commonly used statistics. They will also learn the theory of point estimation, interval estimation, and hypothesis testing, which will allow them to do statistical inference when sampling from populations that do not have an approximately normal distribution.

Topics include: transformations of variables; sampling distributions of common statistics; method of moments and maximum likelihood estimation; properties of point estimates including bias, MSE, consistency, and sufficiency; confidence intervals; and hypothesis testing, including Type I and II Errors and power.

Course Learning Objectives. After completing this course, you will be able to:

- appreciate the maximum likelihood principle;
- derive sampling distributions and prove theorems by using transformation of variables techniques, including the CDF, MGF, and transformation methods;
- derive the distributions of order statistics;
- understand the theory of point estimation;
- derive different point estimators for parameters, including the UMVUE, and compare them using different properties;

- form confidence intervals for a variety of distribution parameters using the pivotal method;
- derive hypothesis tests using the likelihood ratio technique;
- compare hypothesis tests using Type I and II errors and power.

Materials

Required Reading: Instructor's "Handbook on Mathematical Statistics", available through Canvas.

Required Textbook: "John E. Freund's Mathematical Statistics with Applications" (8th ed.) by Miller, I. and Miller, M.

Student Support Hours

Regular: MoTh 11–12:20 and 5–5:20; We 11–11:50 and 4–5:20
Other times: by appointment (made via e-mail).

Just stop by my office during those times if you have questions or just want to chat. No appointment necessary. If the timing does not work for you, we can schedule Zoom meetings on another day (see below).

For online meetings, the following Zoom handle will be used throughout the semester:

Meeting ID: **98557751942**

Password: **1729**

Web link: <https://tcnj.zoom.us/j/98557751942>

Please use "login via SSO" feature and "tcnj.zoom.us" as host coupled with your TCNJ login/password; personal accounts will *not* work!

Student Responsibilities

In-class Use of Electronic Devices. Cell phones and other electronic devices should be turned off during every class (unless specified otherwise). Keep the cell-phones in the backpack, out of sight, and out of physical contact with you (i.e., not in the pockets). The only exception to this rule is if you are using electronic device(s) for note-taking.

If You Miss a Class. In case you miss a class (for whatever reason), it is your responsibility to inform the instructor on or before the day of the class, get notes from your classmates, complete all the assignments/reading for the next class, and come to class *fully prepared* and caught up on the material you missed. If an assignment is due for the class you missed, you should contact the instructor and make sure they get a copy of the assignment before or by the due date.

Canvas Grade Calculation. Canvas grade calculation is *not* indicative of your current standing in the course. The only grade that matters is the grade that is calculated once the semester has concluded. Prior to that, one has to estimate (or upper/lower-bound) one's future grades based off of their past experience. Canvas *does not do that*.

Standard School Policies. A comprehensive list of college's policies can be found at <https://policies.tcnj.edu>. Here are some highlights.

- **Absence and Attendance.** Students are expected to attend class regularly, and absences are handled between students and instructors. This policy contains guidelines related to short term and long term absences. Students are encouraged to contact the Dean of Students office for support related to absences, particularly extended absences.
- **Academic Integrity.** Students are expected to demonstrate academic integrity. Suspected violations of the Academic Integrity policy cannot be resolved (or “adjudicated”) by instructors and instead must be reported following the Academic Integrity procedures (<https://academicintegrity.tcnj.edu/academic-integrity-procedural-standards>).
- **Americans with Disabilities Act.** This policy includes information about the Americans with Disabilities Act and outlines the role of the Accessibility Resource Center (<https://arc.tcnj.edu>) for students seeking accommodations or services.
- **Final Assessment Conflict.** Students must notify the instructor two weeks before the final assessment if they have a conflict as defined by the Final Assessment and Reading Day policy.

Evaluation and Course Requirements

Your final grade will be determined as follows.

Office hours: 10%

Class participation: 10%

Homework: 15%

Aptitude Test (Algebra): 5% (all or nothing, no partial credit)

Aptitude Test (Set Theory): 5% (all or nothing, no partial credit)

In-class Exam 1: 15%

In-class Exam 2: 15%

Final Exam: 25%

Office Hours. Students are responsible for coming to office hours at least once on an approximately bi-weekly basis. Even if you have no questions, I would like to have a brief chat with you on how you are doing regarding the material.

Aptitude Tests. Aptitude tests are a take-home assignment and consist of a sequence of questions. For each test you will only get credit if you get *everything* right.

You can turn them in *as many times as you want* until the deadline. The instructor will grade your submission until the first incorrect answer is encountered. The erroneous step will be marked, and the paper returned back to the student. It is the student’s responsibility to figure out why and how to fix the issue.

Homework. Assignments may come in various forms:

- (electronic) problems from the textbook that will have be linked through Canvas;
- (written) problems similar to the ones we work on in class.

Some assignments may require the usage of the **R** programming language.

You are welcome to work together on problems, however *all homework assignments must be completed/written individually without copying each other’s work.*

Late homework policy. Late homework turned in up to one class after it is due will receive a 25% penalty. No credit will be given for homework after this time.

Extra-credit assignments. Extra-credit assignments/projects may be posted on Canvas throughout the semester. They may contribute to the specific portion of the grade (such as homework assignments) or the overall grade directly, as will be outlined in their description. There will be *no* other opportunities to improve your grade.

Letter grade

Overall letter grade will be determined by the point grade on the following scale:

A* from 90 to 100 (A- for 90, 91, 92)

B* from 80 to 89 (B- for 80, 81, 82; B+ for 87, 88, 89)

C* from 70 to 79 (C- for 70, 71, 72; C+ for 77, 78, 79)

D* from 63 to 69 (D+ for 67, 68, 69)

If your average ends up on the border of two letter grades, very good participation can bump up your final grade by one-third a letter grade. In addition, the instructor reserves the right to change the grading scheme as they see fit. Any other grading scheme the instructor uses will only be beneficial to the student's grade as compared to the above standard.

Schedule

Tentative detailed schedule. Note: exam dates are **not** tentative, so please plan accordingly. Reading: 'T' refers to the textbook; 'P' refers to the instructor's handbook on Probability Theory; 'S' refers to the instructor's handbook on Mathematical Statistics.

Meeting	Date	Day	Topic	Reading
1	January 28	Tuesday	Introduction and Probability Theory	T2, P2.1, 2.2
2	January 31	Friday	Discrete Random Variables	T3.1, 3.2, P2.3
4	February 4	Tuesday	Continuous Random Variables	T3.3, P2.4.1, 2.4.2
3	February 7	Friday	Named Distributions	T4, P2.4.3
5	February 11	Tuesday	Joint Distributions	T3.5, P2.6
6	February 14	Friday	Practice	
7	February 18	Tuesday	Parametrization and Likelihood Functions	S1.1, 1.2
8	February 21	Friday	Maximum Likelihood Principle	S1.3
9	February 25	Tuesday	Practice	
10	February 28	Friday	Shape-Preserving Property	S1.3
11	March 4	Tuesday	Sufficiency and Fisher-Neyman Theorem	T10.5, S1.3
12	March 7	Friday	Practice	
13	March 11	Tuesday	Review	
14	March 14	Friday	Exam 1	
	March 18	Tuesday	Spring Break	
	March 21	Friday	Spring Break	
15	March 25	Tuesday	Point Estimation and MLE's	S1.4, T10.1, 10.2, 10.8
16	March 28	Friday	Method of Moments Estimators	S1.4, T10.7
17	April 1	Tuesday	Rao-Blackwell Theorem	S1.4,
18	April 4	Friday	Fisher Information & Cramér-Rao Bound	S1.4, T10.3
19	April 8	Tuesday	Interval Estimation and Pivotal Distributions	S1.5, T11
20	April 11	Friday	Exam 2	
21	April 15	Tuesday	Hypothesis Testing	S1.6, T12.1
22	April 18	Friday	Error Probabilities and Power Function	S1.6, T12.2, 12.5
23	April 22	Tuesday	Neyman-Person Lemma	S1.6, T12.4
24	April 25	Friday	Practice	
	April 29	Tuesday	Celebration of Student Achievement (COSA)	
25	May 2	Friday	Monte-Carlo Method	
26	May 6	Tuesday	Sequential Estimation	
27	May 9	Friday	Review	

Commitment to Diversity, Equity, Inclusion, Access, and Belonging

The campus community of The College of New Jersey is composed of people with diverse backgrounds, perspectives, and experiences. Given the increasing diversity of the population of the United States and the cultural effects of globalization, we must continually build upon our efforts to ensure that all perspectives can be expressed. Our commitment to inclusiveness means that the campus community will constantly evaluate college policies, procedures and practices to remove those barriers that may affect our ability to be a welcoming and safe environment.

The college's Campus Diversity Statement can be viewed here: <https://diversity.tcnj.edu/campus-diversity-statement>

Classroom Environment and Commitment to Student Success, Safety, and Well-Being

The TCNJ community is dedicated to the success, safety and well-being of each student. TCNJ strictly follows key policies that govern all TCNJ community members rights and responsibilities in and out of the classroom. In addition, TCNJ has established several student support offices that can provide the support and resources to help students achieve their personal and professional goals and to promote health and well-being. You can find more information about these policies and resources at the "TCNJ Student Support Resources and Classroom Policies" webpage here: <https://academicaffairs.tcnj.edu/tcnj-syllabus-resources>

Students who anticipate and/or experience barriers in this course are encouraged to contact the instructor as early in the semester as possible. The Accessibility Resource Center (ARC) is available to facilitate the removal of barriers and to ensure reasonable accommodations. For more information about ARC, please visit: <https://arc.tcnj.edu/>

Disclaimer

This syllabus is intended to give the student guidance in what may be covered during the term and will be followed as closely as possible. However, the instructor reserves the right to modify, supplement and make changes as the course needs arise. Students will be notified on Canvas of such changes.