STAT9700 – MATHEMATICAL STATISTICS

Fall 2026

Instructor:	**Yuting Wei** `ytwei@wharton.upenn.edu`
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	Office hours and location: TBA
Teaching Assistant:	TBA
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Lecture time:	MW 3:30 - 4:59pm
Location:	SHDH 105
Course website:	Canvas; assignments will be submitted through Gradescope.
Textbook:	*Theory of Point Estimation*, 2nd Edition, Erich L. Lehmann and George Casella, Springer, 1998.

Course description. This is a graduate-level course on mathematical statistics, with an emphasis on statistical estimation, decision theory, and large-sample analysis. The course develops general principles for constructing and evaluating estimators, as well as the mathematical tools used to establish their optimality. The main topics include unbiased estimation, sufficiency and completeness, exponential families, information inequalities, maximum likelihood, Bayes and minimax estimation, admissibility, shrinkage, and selected modern applications.

The precise choice and ordering of advanced topics may change as the semester progresses. Depending on time and the interests of the class, examples may be drawn from mixture models, network models, sparse normal means, nonparametric inference, and hypothesis testing.

This is a theory-driven class: calculations and proofs are important, but the primary goal is to understand why statistical procedures work, what assumptions they require, and in what sense they are optimal.

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

- formulate estimation problems in a decision-theoretic framework and compare procedures through their risk functions;
- identify and use sufficient, minimally sufficient, ancillary, and complete statistics, especially in exponential families;
- construct and analyze unbiased, maximum likelihood, Bayes, minimax, and shrinkage estimators;
- derive and apply information lower bounds, including the Cramér–Rao and Bayesian information inequalities;
- establish consistency, asymptotic normality, and asymptotic efficiency under suitable regularity conditions;

- understand foundational examples of admissibility, the James–Stein phenomenon, empirical Bayes methods, and thresholding estimators.

Prerequisites. Graduate probability theory, taken previously or concurrently (STAT9300 at Penn or equivalent); statistical methodology (STAT4310/5110 or STAT5200 at Penn, or equivalent); and real analysis (MATH5080 at Penn or equivalent). Students should be comfortable with rigorous proofs, multivariable calculus, and basic measure-theoretic probability.

Additional references.

- P. J. Bickel and K. A. Doksum, *Mathematical Statistics: Basic Ideas and Selected Topics, Volume I*, 2nd Edition.
- E. L. Lehmann and J. P. Romano, *Testing Statistical Hypotheses*, 3rd Edition.
- A. W. van der Vaart, *Asymptotic Statistics.*
- I. M. Johnstone, *Gaussian Estimation: Sequence and Wavelet Models.*

Administrative Remarks

Grades

The final numerical grade will be determined by two midterm examinations and a final examination:

$$\text{Numerical Grade} = 30\% \times \text{Midterm } 1 + 30\% \times \text{Midterm } 2 + 40\% \times \text{Final Exam.}$$

There will also be two substantial homework assignments. Homework will be graded and returned with feedback, but it will not contribute directly to the final numerical grade. No late homework will be accepted. The homework is nevertheless an essential part of the course and will provide important preparation for the examinations.

Final letter grades will be based on overall performance in the course. The instructor may take the difficulty of the examinations and the performance of the class as a whole into account when determining grade cutoffs.

Examinations

Midterms. There will be two in-class midterm examinations, tentatively scheduled for **Oct 5** and **Nov 9**. The midterms will be closed book, but students may bring their own class notes and homework solutions. Laptops, tablets, phones, and other electronic devices may not be used.

Final examination. There will be a 24 hour take-home final exam at the end of the semester. The date and time of the final exam will be announced later. The final examination must be completed independently; no collaboration or consultation with other people is permitted.

Missed examinations. Students who anticipate a conflict with an examination must contact the instructor as early as possible. Makeup examinations will be arranged only for documented emergencies, approved University conflicts, or formal accommodations.

Software

The course is primarily theoretical, but we may occasionally use numerical experiments to illustrate asymptotic approximations, likelihood computation, the EM algorithm, Bayes procedures, or shrinkage estimators. Students may use `R`, `Python`, or another suitable scientific-computing environment. Any required code or tutorials will be provided through Canvas.

Important University dates. The Fall 2026 term begins on August 25. Fall Break is October 1-4, the course drop deadline is October 5, the withdrawal deadline is November 2, Thanksgiving Break is November 26-29, the last day of classes is December 7.