THE OHIO STATE UNIVERSITY

COLLEGE OF ARTS AND SCIENCES

SYLLABUS: STAT 7301
ADVANCED STATISTICAL THEORY I
AUTUMN 2025

Course overview

Instructor

Instructor: Subhadeep Paul
Email address: paul.963@osu.edu
Lectures: Mondays, Wednesdays and Fridays, 9:10–10:05 am at Cockins Hall 228.
Office hours: In-person hours in my office at Cockins Hall 231 (Wednesdays 2:00 PM -3:00 PM). (Subject to change if the time does not work for several people)

Grader or Teaching Assistant

Kiljae Lee (lee.10428@buckeyemail.osu.edu)

Course description

Statistics 7301 is a course on statistical theory and is intended to provide students a holistic background on fundamentals of mathematical statistics and asymptotic theory. This course is primarily intended for second-year Ph.D. students in statistics. The topics to be covered include,

1. Fundamentals of Mathematical Statistics
   - Statistical Models, Decision Theory
   - Sufficiency, Minimal Sufficiency, Ancillary and complete statistics
   - Exponential families
   - Rao-Blackwell theorem
   - Fisher information and Cramer-Rao lower bound

2. Methods of estimation
   - Unbiased estimation, UMVUE
   - Maximum likelihood Estimation
   - Method of moments and M estimation

3. Asymptotic approximations/ large sample theory
   - Consistency
   - Delta method
   - Asymptotic normality and efficiency
   - Consistency and asymptotic normality of M and Z estimators
   - One-step efficient estimators

4. Non-asymptotic theory for High dimensional Statistics
   - Concentration inequalities, Sub-Gaussian distributions
   - Hoeffding's inequality, Chernoff bound
   - Estimation of sparse high dimensional mean vector (if time permits)

Prerequisite or corequisite:

STAT 6802, or permission of the instructor

Course learning outcomes

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

- Understand important concepts of mathematical statistics

- Derive maximum likelihood and other estimators in a variety of statistical problems
- Theoretically analyze estimators in terms of consistency, asymptotic normality and efficiency properties.
- Analyze theoretical properties of estimators in high-dimensional settings using concentration inequalities.

Course materials

Required

The required textbooks for this course is:

Keener, R.*: Theoretical Statistics: Topics for a Core Course.* Springer.
https://link.springer.com/book/10.1007%2F978-0-387-93839-4
Free e-book available from OSU library
Vershynin R. *High-Dimensional Probability: An Introduction with Applications in Data Science*. Cambridge University Press; 2018.
(Access freely through OSU library here:
https://www.cambridge.org/core/books/highdimensional-probability/797C466DA29743D2C8213493BD2D2102)

Optional materials

Related text books (not required, but highly useful)

Lehman, E. L. and Casella, G.: *Theory of Point Estimation,* second edition.
https://link.springer.com/book/10.1007/b98854
Free e-book available from OSU library

Wainwright MJ. *High-Dimensional Statistics: A Non-Asymptotic Viewpoint*. Cambridge University Press; 2019.
(Access freely through OSU library from this link:
https://www.cambridge.org/core/books/highdimensional-statistics/8A91ECEEC38F46DAB53E9FF8757C7A4E)

Course technology

For help with your password, university e-mail, Carmen, or any other technology issues, questions, or requests, contact the OSU IT Service Desk. Standard support hours are available at https://ocio.osu.edu/help/hours, and support for urgent issues is available 24x7.

- **Self-Service and Chat support:** http://ocio.osu.edu/selfservice
- **Phone:** 614-688-HELP (4357)
- **Email:** 8help@osu.edu

- **TDD:** 614-688-8743

Technology skills necessary for this specific course

- CarmenZoom

Necessary equipment

- Computer: current Mac (OS X) or PC (Windows 10+) with high-speed internet connection
- Webcam: built-in or external webcam, fully installed
- Microphone: built-in laptop or tablet mic or external microphone

Course delivery

The course will be primarily delivered in person (Please see this for details on the in-person delivery mode: https://keeplearning.osu.edu/understanding-instruction-modes). In accordance with the policy, we aim to keep approximately 90% of the classes in-person, with occasional recorded or synchronous online class delivered via CarmenZoom.

Each week we will cover approximately 165 minutes of content in total. You will be responsible for attending in person (or occasional recorder or live online) classes as well as studying the material that is assigned. You will be given ample time to complete the assignments.

Grading

Assignment or category	Percentage
Homework	**40**
Midterm Exam	**20**
Final Exam	**25**
Final take home assignment	**15**
Total	**100**

Assignment information

Homework: There will be a total of 5 homework assignments which will be assigned regularly throughout the course. It will consist of written problems. You are encouraged to work together on the problems, but each student must submit their own work, written in their own words. **Please make sure your solutions are clear and legible. I encourage you (but not require you) to submit typed solutions. Please type your homework solution using either latex or any document processing software homework.**

Please note late submission of assignments will not be accepted unless prior exception has been sought. if you are unable to complete an assignment on time, please get in touch with me as soon as possible so we can discuss your situation.

Exams: There will be two exams --**one in class midterm exam and a final exam/exam 2**. Coverage includes lecture materials, assigned reading, and homework. All exams are closed book/closed notes. **Both the exams will be delivered in class in person.** Further details will be given in advance of each exam.

Tentative Date for midterm exam: Wednesday, October 29, 2025, during class time.
Final Exam Date: Monday Dec 15, 2025, between 10:00am-11:45am (University scheduled)

Makeup exams require a valid excuse, official proof (in some cases), and an advanced notice.

Final take home assignment: There is a final take home assignment which is a paper-reading assignment. You will be asked to choose a paper in mathematical statistics and summarize it in a specific format. More details will be provided through Carmen course website.

Grading scale

93–100: A
90–92.9: A-
87–89.9: B+
83–86.9: B
80–82.9: B-
77–79.9: C+
73–76.9: C
70 –72.9: C-
67 –69.9: D+
60 –66.9: D
Below 60: E

There will be additional bonus points with most assignments and exams. However, the above scale will be strictly followed for final grades.

Attendance, participation, and discussions

Students are expected to regularly participate, discuss, and answer questions in in-person lectures. However, students may miss class, for a variety of reasons, including those related to COVID-19 pandemic. As much as possible, please stay in contact with the instructor so that we can discuss accommodations should they be needed.

Academic integrity policy

Academic integrity is essential to maintaining an environment that fosters excellence in teaching, research, and other educational and scholarly activities. Thus, The Ohio State University and the Committee on Academic Misconduct (COAM) expect that all students have read and understand the University's Code of Student Conduct, and that all students will complete all academic and scholarly assignments with fairness and honesty. Students must recognize that failure to follow the rules and guidelines established in the University's Code of Student Conduct and this syllabus may constitute Academic Misconduct.

The Ohio State University's Code of Student Conduct (Section 3335-23-04) defines academic misconduct as: Any activity that tends to compromise the academic integrity of the University, or subvert the educational process. Examples of academic misconduct include (but are not limited to) plagiarism, collusion (unauthorized collaboration), copying the work of another student, and possession of unauthorized materials during an examination. Ignorance of the University's Code of Student Conduct is never considered an excuse for academic misconduct, so I recommend that you review the Code of Student Conduct and, specifically, the sections dealing with academic misconduct.

If I suspect that a student has committed academic misconduct in this course, I am obligated by University Rules to report my suspicions to the Committee on Academic Misconduct. If COAM determines that you have violated the University's Code of Student Conduct (i.e., committed academic misconduct), the sanctions for the misconduct could include a failing grade in this course and suspension or dismissal from the University.

If you have any questions about the above policy or what constitutes academic misconduct in this course, please contact me.

Copyright disclaimer

The materials used in connection with this course may be subject to copyright protection and are only for the use of students officially enrolled in the course for the educational purposes

associated with the course. Copyright law must be considered before copying, retaining, or disseminating materials outside of the course.

Statement on title IX

Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights offenses subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories (e.g., race). If you or someone you know has been sexually harassed or assaulted, you may find the appropriate resources at http://titleix.osu.edu or by contacting the Ohio State Title IX Coordinator, Kellie Brennan, at titleix@osu.edu

Accessibility accommodations for students with disabilities

The university strives to make all learning experiences as accessible as possible. In light of the current pandemic, students seeking to request COVID-related accommodations may do so through the university's request process (slds.osu.edu/covid-19-info/covid-related-accommodation-requests/), managed by Student Life Disability Services. If you anticipate or experience academic barriers based on your disability (including mental health, chronic, or temporary medical conditions), please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. SLDS contact information: slds@osu.edu; 614-292-3307; slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue.

Accessibility of course technology

This online course requires use of Carmen (Ohio State's learning management system) and other online communication and multimedia tools. If you need additional services to use these technologies, please request accommodations with your instructor.

- Carmen (Canvas) accessibility
- Streaming audio and video
- Synchronous course tools

Your mental health

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know are suffering from any of the aforementioned conditions, you can learn more about the broad range of confidential mental

health services available on campus via the Office of Student Life's Counseling and Consultation Service (CCS) by visiting ccs.osu.edu or calling 614- 292-5766. CCS is located on the 4th Floor of the Younkin Success Center and 10th Floor of Lincoln Tower. You can reach an on call counselor when CCS is closed at 614-292-5766 and 24 hour emergency help is also available through the 24/7 National Suicide Prevention Hotline at 1-800-273- TALK or at suicidepreventionlifeline.org

Disclaimer

This syllabus should be taken as a fairly reliable guide for the course content. However, you cannot claim any rights from it and in particular we reserve the right to change due dates or the methods of grading and/or assessment if necessary. Any changes will be communicated to you through official course announcements.

Course schedule (tentative)

Week	Dates	Topics
1	Aug 27, 29	Statistical Model, Decision Theory
2	Sep 3, 5	Decision Theory examples, minimax estimator, Sufficient statistics
3	Sep 8, 10, 12	Sufficient statistics, Minimal Sufficiency
4	Sep 15, 17, 19	Exponential families
5	Sep 22, 24, 26	Convex loss functions, Rao Blackwell theorem
6	Sep 29, Oct 1, 3	Ancillary Statistics, completeness, UMVUE
7	Oct 6, 8, 10	UMVUE, Fisher information, Cramer-Rao bound
8	Oct 13, 15	Asymptotic analysis, consistency
9	Oct 20, 22, 24	Convergence in distribution, multivariate CLT, Delta method
10	Oct 27, 29, 31	Delta method, Midterm Exam (Oct 29)
11	Nov 3, 5, 7	Maximum likelihood estimation
12	Nov 10, 12	Uniform law of large numbers, Consistency of M estimators and MLE
13	Nov 17, 19, 21	Asymptotic normality of Z estimators, asymptotic efficiency of MLE and 1 step estimators
14	Nov 24	Non-asymptotic theory, Sub-gaussian distributions,
15	Dec 1, 3, 5	Concentration inequalities, Hoeffding's and Chernoff's inequality

16	Dec 8, 10	Sparse high-dimensional mean vector
Final Exam	Monday, December 15	Final Exam during finals week