Term Information

Effective Term	Autumn 2023
Previous Value	*Autumn 2014*

Course Change Information

What change is being proposed? (If more than one, what changes are being proposed?)

Remove unbiased estimation, complete and ancillary statistics (redundant with Stat 6802); remove density estimation; add concentration inequalities and topics in high-dimensional estimation.

What is the rationale for the proposed change(s)?

Unbiased estimation, complete and ancillary statistics are redundant with the 1st year Stat 6802 course; concentration inequalities and high-dimensional estimation are more relevant to contemporary applications.

What are the programmatic implications of the proposed change(s)?

(e.g. program requirements to be added or removed, changes to be made in available resources, effect on other programs that use the course)?

Biostatistics Ph.D program uses this course.

Is approval of the requrest contingent upon the approval of other course or curricular program request? Yes

Please identify the pending request and explain its relationship to the proposed changes(s) for this course (e.g. cross listed courses, new or revised program)

This course change is part of a revision in the Ph.D. program in Statistics. This will also affect the content of courses taught in the interdisciplinary Ph.D. program in Biostatistics.

Is this a request to withdraw the course? No

General Information

Course Bulletin Listing/Subject Area	Statistics
Fiscal Unit/Academic Org	Statistics - D0694
College/Academic Group	Arts and Sciences
Level/Career	Graduate
Course Number/Catalog	7301
Course Title	Advanced Statistical Theory
Previous Value	*Advanced Statistical Theory I*
Transcript Abbreviation	Adv Stat Theory
Previous Value	*Adv Stat Theory 1*
Course Description	Fundamental concepts from mathematical statistics, derivation/classification of estimators, large sample asymptotic analysis, and non-asymptotic analysis of high-dimensional estimation. Intended for Ph.D. students in Statistics or Biostatistics.
Previous Value	*Exponential families, sufficiency, Rao-Blackwell theorem, information, efficiency, maximum likelihood estimation, M-estimation, asymptotics, density estimation. Intended primarily for PhD students in Statistics or Biostatistics.*
Semester Credit Hours/Units	Fixed: 3

Offering Information

Length Of Course	14 Week, 12 Week, 8 Week, 7 Week, 6 Week, 4 Week
Previous Value	*14 Week, 12 Week, 8 Week, 7 Week, 6 Week*

Flexibly Scheduled Course	Never
Does any section of this course have a distance education component?	No
Grading Basis	Letter Grade
Repeatable	No
Course Components	Lecture
Grade Roster Component	Lecture
Credit Available by Exam	No
Admission Condition Course	No
Off Campus	Never
Campus of Offering	Columbus

Prerequisites and Exclusions

Prerequisites/Corequisites	Prereq: Stat 6802, or permission of instructor.
Previous Value	*Prereq: 6802 (622), or permission of instructor.*
Exclusions	
Previous Value	Not open to students with credit for 821.
Electronically Enforced	No

Cross-Listings

Cross-Listings

Subject/CIP Code

Subject/CIP Code	27.0501
Subsidy Level	Doctoral Course
Intended Rank	Masters, Doctoral

Requirement/Elective Designation

Required for this unit's degrees, majors, and/or minors
The course is an elective (for this or other units) or is a service course for other units

Course Details

Course goals or learning objectives/outcomes

- Understand important and fundamental concepts of mathematical statistics.
- Formulate new and classify existing estimators in a variety of statistical problems.
- Analyze theoretical properties of estimators in large sample settings using asymptotics.
- Analyze theoretical properties of estimators in high-dimensional settings using concentration inequalities.
- Understand the assumptions that underly basic tools of theoretical analysis, and how those assumptions affect the use and results of these tools.

Previous Value

- *These will be provided later, once a review of all learning outcomes of all courses in the Department of Statistics is carried out.*

Content Topic List

- Statistical models and basics of decision theory
- Sufficiency and minimal sufficiency
- Exponential families
- Rao-Blackwell theorem
- Fisher Information and Information Inequality
- Methods of estimation including moments, maximum likelihood, and M-estimation
- Large sample asymptotic analysis
- Asymptotic efficiency
- Concentration inequalities
- Non-asymptotic analysis
- High-dimensional estimation
- High-dimensional sparse linear models
- High-dimensional covariance estimation

Previous Value

- *Exponential families*
- *Sufficiency*
- *Basu's lemma*
- *Rao-Blackwell theorem*
- *Information*
- *Asymptotic efficiency*
- *Efficient likelihood estimation*
- *M-estimation*
- *Asymptotics*
- *Density estimation*
- *Maximum likelihood in infinite dimensional parameter spaces*

Sought Concurrence

No

Attachments

- STAT7301_syllabus.pdf: Syllabus

  (Syllabus. Owner: Craigmile,Peter F)

- au22-stat-7301-vu.pdf: Old syllabus

  (Syllabus. Owner: Craigmile,Peter F)

Comments

- When changing a course, please also submit the original syllabus so that the panel can see what changed. *(by Vankeerbergen,Bernadette Chantal on 12/03/2022 09:15 PM)*

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Craigmile,Peter F	12/02/2022 08:30 AM	Submitted for Approval
Approved	Craigmile,Peter F	12/02/2022 05:26 PM	Unit Approval
Revision Requested	Vankeerbergen,Bernadette Chantal	12/03/2022 09:15 PM	College Approval
Submitted	Craigmile,Peter F	12/03/2022 09:28 PM	Submitted for Approval
Approved	Craigmile,Peter F	12/03/2022 09:28 PM	Unit Approval
Approved	Vankeerbergen,Bernadette Chantal	12/04/2022 05:43 PM	College Approval
Pending Approval	Cody,Emily Kathryn Jenkins,Mary Ellen Bigler Hanlin,Deborah Kay Hilty,Michael Vankeerbergen,Bernadette Chantal Steele,Rachel Lea	12/04/2022 05:43 PM	ASCCAO Approval

THE OHIO STATE UNIVERSITY
College of Arts & Sciences
Department of Statistics

SYLLABUS: STAT 7301

Advanced Statistical Theory
Autumn 2023 (full semester)
3 credit hours

COURSE OVERVIEW

Instructor

<NAME TO BE ANNOUNCED>

Email address: <TO BE ANNOUNCED>

Lectures: Mondays, Wednesdays, and Fridays for 55 minutes each

<LOCATION TO BE ANNOUNCED>

Office hours: <TO BE ANNOUNCED>

Graduate teaching assistant

<NAME>

Email address: <TO BE ANNOUNCED>

Office hours: <TO BE ANNOUNCED>

Prerequisites

STAT 6802 or permission of the instructor.

Course description

This is a course on statistical theory with a focus on multivariate point estimation. It covers fundamental concepts from mathematical statistics, derivation/classification of estimators, large sample asymptotic analysis, and non-asymptotic analysis of high-dimensional estimation problems. The course is intended primarily for Ph.D. students in Statistics or Biostatistics and is meant to introduce them to a mathematically rigorous (proof-based) approach to

understanding and analyzing statistical estimation problems using classical and contemporary theoretical tools.

Course learning outcomes

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

- Understand important and fundamental concepts of mathematical statistics.
- Formulate new and classify existing estimators in a variety of statistical problems.
- Analyze theoretical properties of estimators in large sample settings using asymptotics.
- Analyze theoretical properties of estimators in high-dimensional settings using concentration inequalities.
- Understand the assumptions that underly basic tools of theoretical analysis, and how those assumptions affect the use and results of these tools.

COURSE MATERIALS AND TECHNOLOGIES

Textbooks

Course material will be drawn from three books that are freely accessible from the OSU on-campus network or off-campus using the OSU Library proxy service.

Required

- Keener, R.: *Theoretical Statistics: Topics for a Core Course*. Springer. (https://link.springer.com/book/10.1007%2F0-387-30623-4)
- Vershynin, R.: *High-Dimensional Probability: An Introduction with Applications in Data Science*. Cambridge University Press. (https://doi.org/10.1017/9781108231596)
- Wainwright, M.: *High-Dimensional Statistics: A Non-Asymptotic Viewpoint.* Cambridge University Press. (https://doi.org/10.1017/9781108627771)

Necessary Software

- This class requires you to use the statistical software packages called R (The R Project for Statistical Computing; http://www.r-project.org/) and RStudio (https://posit.co). These software packages are available as Free Software. More details will be given in lectures.

GRADING AND FACULTY RESPONSE

Homework	22
Exam 1 (9/29)	22
Exam 2 (11/3)	22
Final Exam	32
Lecture scribing	2
Total	100

Homework will generally be assigned on a weekly basis, on CarmenCanvas, and collected in-class on the due date. All exams are closed book and given in-class. Students will be required to scribe two lectures using LaTeX and a template provided by the instructor. Students may use Overleaf or RStudio for working with LaTeX. Additional instructions and a sign-up sheet will be provided on CarmenCanvas.

Late assignments

<Policy will be added when the course is offered>

Instructor feedback and response time

<Policy will be added when the course is offered>

COURSE SCHEDULE

Refer to the Carmen course for up-to-date assignment due dates. Recommended reading is listed in parentheses following the topics.

Week	Dates	Topics
1	8/23, 8/25	Statistical models, decision theory overview; sufficiency and minimal sufficiency (Keener 3.1-3.4)
2	8/28, 8/30, 9/1	Exponential families: definitions, minimality, mean parameters (Keener 2.1-2.4)
3	9/6, 9/8	Convex losses, Jensen's inequality; Rao-Blackwell Theorem (Keener 3.6)
4	9/11, 9/13, 9/15	Fisher Information; Information Inequality (Keener 4.5-4.6)
5	9/18, 9/20, 9/22	Methods of estimation: plug-in, method of moments (MOM), maximum likelihood (ML) (Notes)
6	9/25, 9/27, 9/29	MOM/ML in exponential families; M- and Z-estimators (Keener 8.3, Notes); **[Exam 1]**
7	10/2, 10/4, 10/6	Convergence in probability/distribution; consistency; continuous mapping theorems; multivariate CLT; stochastic O notation (Keener 8.1-8.2)
8	10/9, 10/11	Delta method and its application to MLE in exponential families (Keener 8.2)
9	10/16, 10/18, 10/20	Uniform law of large numbers for C(K); consistency of M-estimators; consistency of MLE for (in)correctly specified models (Keener 9.1-9.2)
10	10/23, 10/25, 10/27	Asymptotic Normality of Z-estimators; asymptotic efficiency of MLE and one-step estimators (Keener 9.3, 9.7)
11	10/30, 11/1, 11/3	Hoeffding's and Chernoff's Inequalities; sub-Gaussian distributions and norms; sub-Gaussian inequality (Vershynin 2.1-2.3, 2.5; Wainwright 2.1); **[Exam 2]**
12	11/6, 11/8	Estimation of a sparse high-dimensional mean vector (Notes)
13	11/13, 11/15, 11/17	Sparse linear models in high dimensions (Wainwright 7.1,7.3; Vershynin 10.6)
14	11/20	Sparse linear models in high dimensions (continued)
15	11/27, 11/29, 12/1	Operator norm and covariance estimation, random matrices; Bernstein's and sub-exponential inequalities; epsilon nets (Vershynin 2.7-2.8, 4.2; Wainwright 6.1)
16	12/4, 12/6	High-dimensional covariance estimation (Vershynin 4.7; Wainwright 6.3)

OTHER COURSE POLICIES

Academic integrity policy

It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct **http://studentlife.osu.edu/csc/**.

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.

Other sources of information on academic misconduct (integrity) to which you can refer include:

- Committee on Academic Misconduct web page (go.osu.edu/coam)
- Ten Suggestions for Preserving Academic Integrity (go.osu.edu/ten-suggestions)

Copyright for instructional materials

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 at titleix@osu.edu

Commitment to a diverse and inclusive learning environment

The Ohio State University affirms the importance and value of diversity in the student body. Our programs and curricula reflect our multicultural society and global economy and seek to provide opportunities for students to learn more about persons who are different from them. We are committed to maintaining a community that recognizes and values the inherent worth and dignity of every person; fosters sensitivity, understanding, and mutual respect among each member of our community; and encourages each individual to strive to reach his or her own potential. Discrimination against any individual based upon protected status, which is defined as age, color, disability, gender identity or expression, national origin, race, religion, sex, sexual orientation, or veteran status, is prohibited.

Land Acknowledgement

We would like to acknowledge the land that The Ohio State University occupies is the ancestral and contemporary territory of the Shawnee, Potawatomi, Delaware, Miami, Peoria, Seneca, Wyandotte, Ojibwe and Cherokee peoples. Specifically, the university resides on land ceded in the 1795 Treaty of Greeneville and the forced removal of tribes through the Indian Removal Act of 1830. I/We want to honor the resiliency of these tribal nations and recognize the historical contexts that has and continues to affect the Indigenous peoples of this land.

More information on OSU's land acknowledgement can be found at https://mcc.osu.edu/about-us/land-acknowledgement

Your mental health

As a student you may experience a range of issues that can cause barriers to learn, 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 24/7 by dialing 988 to reach the Suicide and Crisis Lifeline.

ACCESSIBILITY ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES

Requesting accommodations

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, 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

[DELETE ANY OF THE FOLLOWING IF NOT REQUIRED]

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

- Canvas accessibility (go.osu.edu/canvas-accessibility)
- Streaming audio and video
- CarmenZoom accessibility (go.osu.edu/zoom-accessibility)
- Collaborative course tools

Autumn 2022

STAT 7301 Advanced Statistical Theory I

lecture:	MWF 9:10–10:05 in Enarson Classroom Building 258
instructor:	Vincent Q. Vu (vqv at stat osu edu)
office:	Cockins Hall 428B
office hours:	Thursdays 2:00–3:00 (Zoom)
web:	Class schedule, assignments, and course announcements will be posted on Carmen (carmen.osu.edu)
prerequisites:	STAT 6802, or permission of the instructor

1 Overview

Statistics 7301 is a course on the fundamentals of statistical theory and is intended for second-year Ph.D. students in statistics. The course is based in part on chapters 2–4,8–9 of the required book *Theoretical Statistics: Topics for a Core Course*, chapters 2 and 6 of the required book *All of Nonparametric Statistics*, and notes provided by the instructor. The topics of the course include:

1. Fundamentals
    - Statistics, sufficiency, and completeness
    - Exponential families
    - Rao-Blackwell theorem
    - Fisher information
2. Methods of estimation
    - Unbiased estimation
    - Maximum likelihood
    - Minimum contrast estimation
3. Asymptotic approximations (a.k.a. large sample theory)
    - Consistency
    - Delta method
    - Asymptotic normality and efficiency
4. Nonparametric estimation
    - Estimating the CDF and statistical functionals
    - Influence functions and nonparametric Delta method
    - Density estimation

Although there will be overlap in the topics covered in STAT 7301 and STAT 6801/6802, some of the most important differences between this class and the 680x classes is that STAT 7301

- presents the theory in greater depth and detail;
- involves mathematically rigorous proofs;
- requires more sophisticated mathematical analysis.

2 Textbook

The in-class lectures and notes are the canonical source for the course. The following books are also required for supplemental reading:

- Keener, R.: *Theoretical Statistics: Topics for a Core Course*. Springer.
  - https://link.springer.com/book/10.1007%2F978-0-387-93839-4
- Wasserman, L.: *All of Nonparametric Statistics*. Springer.
  - https://link.springer.com/book/10.1007%2F0-387-30623-4

The notation and nomenclature used in lecture and the depth of coverage of material will occasionally deviate from these books. The instructor will try to alert students to these differences, but ultimately students are expected to pay attention to these differences themselves.

The follows books are optional references:

- Bickel, P. J. and Doksum, K. A.: *Mathematical Statistics: Basic Ideas and Selected Topics, Vol. 1*. CRC Press.
- van der Vaart, A. W.: *Asymptotic Statistics*. Cambridge University Press.
- Lehman, E. L. and Casella, G.: *Theory of Point Estimation*, second edition.

3 Prerequisites

Statistics 6802, or permission of the instructor. Mathematical analysis and probability theory are the primary tools of statistical theory. **Students are expected to be able to read and write rigorous mathematical proofs.**

4 Coursework & Grading

There will be homework assignments, two in-class exams, a final exam, and scribing.

- 22% Homework
- 22% Midterm Exam 1 (October 10)
- 22% Midterm Exam 2 (November 14)
- 32% Final Exam (December 12, 10:00 – 11:45)
- 2% Scribing of two lectures

Inform the instructor of any scheduling conflicts at least three weeks in advance.

4.1 Homework

Homeworks will generally be assigned on a weekly basis and are due in class on the due date. If you cannot attend class on the due date of the homework, then either ask a classmate to submit the homework for you or place the homework under my office door in advance. Late homework will not be accepted and returned without grading.

4.2 Exams

All exams are closed book. No make-up exams will be given. The in-class exams will largely be based on the content of the homeworks preceding them. The final exam will be cumulative but will emphasize more recent material.

4.3 Scribing

Students will be required to scribe two lectures using LaTeX and a template provided by the instructor. Additional instructions will be given by the instructor.

4.4 Fine print

4.4.1 Academic Misconduct

It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct http://studentlife.osu.edu/csc/.

4.4.2 Accommodations for Students with Disabilities

Students with disabilities (including mental health, chronic or temporary medical conditions) that have been certified by the Office of Student Life Disability Services will be appropriately accommodated and should inform the instructor as soon as possible of their needs. The Office of Student Life Disability Services is located in 098 Baker Hall, 113 W. 12th Avenue; telephone 614-292-3307, slds@osu.edu; slds.osu.edu.

4.4.3 Disclaimer

This syllabus is a approximate guide to the course content and dates, however the instructor reserves the right to deviate from the syllabus. An updated version of the syllabus will be maintained on the course webpage.