IE 2117: Foundations of Statistics
Spring 2025
Course Syllabus

General Information

Meeting Dates and Times:	1/09/2025 – 4/24/2025 Tuesdays and Thursdays (6:00 PM – 7:15 PM)
Location:	1047 Benedum Hall
Course Website:	https://canvas.pitt.edu/courses/301001 Course syllabus and all grades will be posted on canvas.
Text:	
Instructor:	Amin Rahimian https://aminrahimian.github.io/ rahimian@pitt.edu Office: 1003 Benedum Hall
Teaching Assistants:	Mahjabin Rahman (mar660@pitt.edu) Office: 1016 Benedum Hall
Units:	3.00
Office Hours:	**Instructor** Thursdays 5:00 PM – 6:00 PM 1003 Benedum Hall **Teaching Assistant** Tuesdays 5:00 PM – 6:00 PM 1016 Benedum Hall

Course Rationale and Description

This course equips first year PhD students with essential tools for statistical modeling and analysis. The main focus of this course is on mathematical statistics and bringing out different features of Frequentist, Fisherian, and Bayesian approaches to statistical inference, as well as foundations of modern statistics as it interfaces with machine learning and other data-driven paradigms. Students will also get exposure to decision theory and related paradigms for evaluating statistical procedures.

Pre-Requisites / Co-Requisites

IE 2084 is a pre-requisite and strong background in probability theory and undergraduate statistics is assumed.

PhD Qualifier

This course prepares you for the following topics on which you are going to be tested in the IE statistics PhD qualification:

1. <u>Introduction</u>: Lady tasting tea, efficacy of a vaccine, and quality of a lot (hypergeometric), Fisher's permutations test
2. <u>Confidence intervals</u>: pivots, polling with and without replacement, mean of a normal population (with known or unknown variance), differences of means of normal, variance of normal (with known or unknown mean), ratio of variances of two normal samples
3. <u>ANOVA</u>: linear model, fixed effect model (additive models), identifiably, ANOVA assumptions, homoscedasticity, ANOVA inference, Sum of Squares Partition, ANOVA F test, two-way ANOVA
4. <u>Experimental design</u>: estimating main effects and interactions of factors, contrast, factorial design and fractional factorial designs, confounding, randomization and blocking
5. <u>Hypothesis testing</u>: Fisherian significance testing, Neyman-Pearson paradigm, Frequentist inference, type 1 and type 2 errors, likelihood ratio tests (Neyman-Pearson lemma), simple and composite hypotheses, critical region, significance level, one-sided and two-sided tests,
6. <u>Point estimation</u>: Maximum Likelihood Estimation (MLE), Fisher information, Cramer-Rao lower bound, estimating mean and variance of a normal population, maximality conditions, invariance property, evaluating statistical procedures, Mean Squared Error, Bias-Variance decomposition, estimating the Bernoulli parameter, Best (uniformly minimum variance) unbiased estimator, estimating the Poisson parameter, sufficient statistics, factorization theorem, Rao-Blackwell theorem, ancillary statistic
7. <u>Bayesian statistics</u>: prior, posterior, loss function, Bayes estimates, risk function, Bayes risk, Bayes estimates for the quadratic and absolute loss functions, conjugate family, inferring the Bernoulli parameter with a Beta prior, Bayesian updating in the normal family, minimax estimator,
8. <u>Linear regression</u>: least squares, Best linear unbiased estimators of the regression coefficients, statistical models (conditional and bivariate normal models), Regression to the mean, correlation coefficient, MLEs for regression coefficients and regression standard error, unbiased estimates for the regression parameters, confidence intervals, estimation and inference on repression parameters, Regression sum of squares and ANOVA table, coefficient of determination, inferring population mean, simultaneous inference and confidence bands, prediction intervals

Grading

The final semester grade will be determined as follows (The letter grades are meant to follow the Canvas grading scheme). All grading components will be on canvas. If there are any discrepancies please refer to Canvas.

Graded Item	% Weight
Homework	15%
Quizzes	15%
Peer Evaluation	15%
Active attendance	15%
Midterm	20%
Final	20%

Grade	Range (%)		Grade	Range (%)
A+	97-100		C	74.00-76.99
A	94.00-96.99		C-	70.00-73.99
A-	90.00-93.99		D+	67.00-69.99
B+	87.00-89.99		D	64.00-66.99
B	84.00-86.99		D-	60.0-63.99
B-	80.00-83.99		F	<60.0
C+	77.00-79.99			

Homework (15%) - Thursdays

Agenda and Deliverable paper for each week will include reading assignments and problems for solution from C&B will be handed in on Thursdays and should be returned **in hardcopy** Thursday the week after at 6 pm. Homework assignments should be submitted **in hardcopy** to receive credit and should have the Agenda and Deliverable paper as the cover with your name printed in the space provided on the Agenda and Deliverable page. You can work on Homework assignments together but each student is responsible for their own submission. If you receive help in a homework assignment, then please note that in your submission cover page.

Quizzes (15%) - Tuesdays

Quizzes are given every Tuesday at the beginning of the class and solved and collected afterward.

Midterm and final (20% & 20%)

I**n-class, time-limited midterm exam on 3/18/25** and an **in-class, time-limited final exam on 4/24/25**. The exams are closed book and notes. The Final Exam content is not cumulative.

Peer evaluations (15%)

Homework will be peer-evaluated through random assignment. Each week you are responsible for grading one of your classmate's works assigned at random. **It is important that you provide feedback on solution of the problems where your peers have missed points. Both your homework and peer evaluation will be graded.**

Active attendance (15%)

Lectures rely on the Socratic method. It is essential that you be willing to think about and engage with the questions asked during the lectures. **Note taking during the lectures should be active and should reflect your thoughts.**

Reference Materials

In addition to your textbook you are encouraged to consult the following books for topics in modern applied statistics (both come with companion websites and are excellent for applied statisticians):
- Compute Age Statistical Inference (CASI), Student Edition, Efron and Hastie, ISBN: 978-1108823418.
    o https://hastie.su.domains/CASI/index.html and https://hastie.su.domains/CASI_files/PDF/casi.pdf
- Regression and Other Stories (ROS), 1st Edition, Gelman, Hill and Vehtari, ISBN: 978-11070239871.
    o https://avehtari.github.io/ROS-Examples/ and https://users.aalto.fi/~ave/ROS.pdf

For more in-depth treatment of the mathematical statistics (covering asymptotic efficiency of MLEs, Wilks theorem for likelihood ratios, Rao-Blackwell, Lehman-Scheffe, Cramer-Rao, and Bernstein–von Mises theories) the following books are good (the first one is classical reference for mathematical statistics courses):
- Mathematical Statistics: Basic Ideas and Selected Topics, Volume I, Second Edition (Chapman & Hall/CRC Texts in Statistical Science), Bickel and Doksum, ISBN: 978-1498723800.
- Essentials of Statistical Inference (Cambridge Series in Statistical and Probabilistic Mathematics, Series Number 16), Young and Smith, ISBN: 978-0521548663.

Course Schedule

The course will follow the schedule listed below (subject to change).

Week	Day	Date	Topic	Notes
1	Thu-Tue	1/09/25-1/14/25	Chapter 5	Homework 1 (Due 1/16/25)
2	Thu-Tue	1/16/25-1/21/25	Chapter 5	Homework 2 (Due 1/23/25) Quiz 1 (1/21/25)
3	Thu-Tue	1/23/25-1/28/25	Chapter 9	Homework 3 (Due 1/30/25) Quiz 2 (1/28/25)
4	Thu-Tue	1/30/25-2/04/25	Chapter 6	Homework 4 (Due 2/06/25) Quiz 3 (2/04/25)
5	Thu-Tue	2/06/25-2/11/25	Chapter 8	Homework 5 (Due 2/13/25) Quiz 4 (2/11/25)
6	Thu-Tue	2/13/25-2/18/25	Chapter 8	Homework 6 (Due 2/20/25) Quiz 5 (2/11/25)
7	Thu-Tue	2/20/25-2/25/25	Chapter 11	Homework 7 (Due 2/27/25) Quiz 6 (2/25/25)
8	Thu-Tue	2/27/25-3/11/25	Spring Break (3/04-3/06) Design of Experiments	Homework 8 (Due 3/13/25) Quiz 7 (3/11/25)
9, 10	Thu-Tue	3/13/25-3/18/25-3/20/25-3/25/25	Chapter 7 ✎**Midterm exam (**3/18/25**)**	Homework 9 (Due 3/27/25) Quiz 8 (3/25/25)
11	Thu-Tue	3/27/25-4/01/25-	Chapter 7	Homework 10 (Due 4/03/25) Quiz 9 (4/01/25)
12	Thu-Tue	4/03/25-4/08/25	Chapter 11	Homework 11 (Due 4/10/25) Quiz 10 (4/08/25)
13, 14	Thu-Tue	4/10/25-4/15/25-4/17/25-4/22/25	Chapter 11 Review session on Tuesday (4/22)	Homework 12 (Due 4/22/25) Quiz 11 (4/22/25)
15	Thu	4/24/25	✎**Final exam**	

Academic Integrity

All students are expected to adhere to the standards of professional conduct and academic honesty. Any student engaged in cheating, plagiarism, or other acts of academic dishonesty would be subject to disciplinary action. Any student suspected of violating this obligation for any reason during the semester will be required to participate in the procedural process, initiated at the instructor level, as outlined in the SSOE Academic Integrity Policy found at: https://www.engineering.pitt.edu/Academic-Integrity-Guidelines/.

Disability Services

If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services (DRS), 140 William Pitt Union, (412) 648-7890, drsrecep@pitt.edu, (412) 228-5347 for P3 ASL users, as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course.

Student Opinion of Teaching Surveys

Students in this class will be asked to complete a *Student Opinion of Teaching Survey*. Surveys will be sent via Pitt email and appear on your Canvas landing page during the last three weeks of class meeting days. Your responses are anonymous. Please take time to thoughtfully respond, your feedback is important to me. Read more about *Student Opinion of Teaching Surveys*.

Religious Observance

The observance of religious holidays (activities observed by a religious group of which a student is a member) and cultural practices are an important reflection of diversity. As your instructor, I am committed to providing equivalent educational opportunities to students of all belief systems. At the beginning of the semester, you should review the course requirements to identify foreseeable conflicts with assignments, exams, or other required attendance. If at all possible, please contact me within the first two weeks of the semester to allow time for us to discuss and make fair and reasonable adjustments to the schedule and/or tasks.

Diversity and Inclusion

The University of Pittsburgh does not tolerate any form of discrimination, harassment, or retaliation based on disability, race, color, religion, national origin, ancestry, genetic information, marital status, familial status, sex, age, sexual orientation, veteran status or gender identity or other factors as stated in the University's Title IX policy. The University is committed to taking prompt action to end a hostile environment that interferes with the University's mission. For more information about policies, procedures, and practices, see: https://www.diversity.pitt.edu/policies-procedures-and-practices.

I ask that everyone in the class strive to help ensure that other members of this class can learn in a supportive and respectful environment. If there are instances of the aforementioned issues, please contact the Title IX Coordinator, by calling 412-648-7860, or e-mailing titleixcoordinator@pitt.edu. Reports can also be filed online: https://www.diversity.pitt.edu/make-report/report-form. You may also choose to report this to a faculty/staff member; they are required to communicate this to the University's Office of Diversity and Inclusion. If you wish to maintain complete confidentiality, you may also contact the University Counseling Center (412-648-7930).

Seating Chart Statement

Please try not to change your sitting positions throughout the course.

On Time Attendance Statement

Homework submission on Thursdays and Quizzes on Tuesdays depend on your on-time attendance. It is critical that you be in class on time to receive credit for those components.

Communication to Instructor Pertaining to Illness

Student who becomes ill is responsible for communicating with the instructor regarding course absences. Please contact the instructor and provide documentation. This should be done via email as soon as possible.