

Syllabus: Intermediate Statistics, 36-705 (Fall 2019)

1 Overview

This course covers the fundamentals of theoretical statistics. Topics include: concentration of measure, basic empirical process theory, convergence, point and interval estimation, maximum likelihood, hypothesis testing, Bayesian inference, nonparametric statistics and bootstrap re-sampling. This course is excellent preparation for advanced work in Statistics and Machine Learning. See below for a detailed schedule.

Some course objectives for students in machine learning include: (1) Predict which kinds of existing machine learning algorithms will be most suitable for which sorts of tasks, based on formal properties and experimental results. (2) Evaluate and analyze existing learning algorithms.

There are several textbooks that we will use material from. The main textbook for the course will be Larry Wasserman's "All of Statistics". We will cover Chapters 1-12 from the text plus some supplementary material. There are several other useful references:

1. Casella, G. and Berger, R. L. (2002). Statistical Inference, 2nd ed.
2. Rice, J. A. (1977). Mathematical Statistics and Data Analysis, Second Edition.
3. (**Advanced**) van der Vaart, A. (2000). Asymptotic Statistics
4. (**Advanced**) Bickel, P. J. and Doksum, K. A. (1977). Mathematical Statistics.

We will sometimes follow Larry Wasserman's version of this course, and you can find lecture notes and even lecture videos online at www.stat.cmu.edu/~larry/=705.

2 Background and Prerequisites

I assume that you are familiar with basic probability and mathematical statistics. You should already know the following concepts: probability, distribution functions, density functions, moments, transformation of variables, and moments generating functions.

2.1 Is This The Right Course For You? 36-705 versus 36-700

We have another course, 36-700, that covers similar material but assumes less background. In 705 I assume you are already familiar with basic probability. **This course moves extremely fast.** If you want a course that requires less background, you should take 36-700 instead.

3 Grading

- 25% : Test I (Friday September 20th)
- 25% : Test II (Friday November 1st)
- 30% : Final Exam (Date set by the University)
- 20% : Homework

3.1 Exams

All exams are closed book. Do NOT buy a plane ticket until the final exam has been scheduled.

3.2 Homework

Homework assignments will be posted (roughly weekly) on the web. You should submit your HW via Gradescope before 3pm Thursday (except HW1 which will be due on Friday at 3pm). If you need an extension due to illness, email me BEFORE the homework deadline.

We will frequently re-use material including old homework assignments. The homeworks are meant for you to practice solving problems, do not search for HW solutions online (they are quite easy to find).

3.3 Reading and Class Notes

Class notes will be posted on the web regularly. The notes are not meant to be a substitute for the book and hence are generally quite terse. Read both the notes and the text before lecture. Sometimes I will cover topics from other sources.

3.4 Group Work

You are encouraged to work with others on the homework. But write-up your final solutions on your own. Please credit the students that you work with clearly.

4 More important information

4.1 Course Information

All course material, including assignments and lecture notes will be posted on the website:

www.stat.cmu.edu/~siva/705/main.html

4.2 Piazza

We will use Piazza to answer questions. Please sign-up at the following website:

<https://piazza.com/cmu/fall2019/36705/home>

4.3 Office Hours

1. **Instructor Office Hours:** Wednesday 1:30-2:30pm, BH 132K.
2. **Ilmun Kim:** TBA.
3. **Sasha Podkopaev:** TBA.

5 Accommodations for Students with Disabilities

If you have a disability and have an accommodations letter from the Disability Resources office, I encourage you to discuss your accommodations and needs with me as early in the semester as possible. I will work with you to ensure that accommodations are provided as appropriate. If you suspect that you may have a disability and would benefit from accommodations but are not yet registered with the Office of Disability Resources, I encourage you to contact them at access@andrew.cmu.edu.

6 Statement of Support

Take care of yourself. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress.

All of us benefit from support during times of struggle. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is almost always helpful.

If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website at <http://www.cmu.edu/counseling/>. Consider reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help.

If you or someone you know is feeling suicidal or in danger of self-harm, call someone immediately, day or night:

1. CaPS: 412-268-2922
2. Re:solve Crisis Network: 888-796-8226
3. If the situation is life threatening, call the police. On campus: CMU Police: 412-268-2323. Off campus: 911

If you have questions about this or your coursework, please let me know. Thank you, and have a great semester.

7 Calendar

This is a tentative list of topics.

| Date | Lecture Topic |
|----------------|---|
| August 26th | Review |
| August 28th | Concentration Inequalities |
| August 30st | Concentration Inequalities |
| September 2nd | No Class (Labor Day) |
| September 4th | Convergence |
| September 6th | Convergence |
| September 9th | Central Limit Theorem |
| September 11th | Uniform Laws and Empirical Process Theory |
| September 13th | Uniform Laws and Empirical Process Theory |
| September 16th | Uniform Laws and Empirical Process Theory |
| September 18th | Review |
| September 20th | EXAM 1 |
| September 23rd | Likelihood and Sufficiency |
| September 25th | Point Estimation (MLE) |
| September 27th | Point Estimation (Method of Moments, Bayes) |
| September 30th | Decision Theory |
| October 2nd | Decision Theory |
| October 4th | Asymptotic Theory for MLE |
| October 7th | Asymptotic Theory for MLE |
| October 9th | Hypothesis Testing |
| October 11th | Hypothesis Testing |
| October 14th | Goodness-of-fit, two-sample, independence |
| October 16th | Multiple testing |
| October 18th | No Class (Mid-Semester Break) |
| October 21st | Multiple testing |
| October 23rd | Confidence Intervals |
| October 25th | No Class (Community Engagement) |
| October 28th | Confidence Intervals |
| October 30th | Review |
| November 1st | EXAM 2 |
| November 4th | Bootstrap |
| November 6th | Bootstrap |
| November 8th | Bayesian Inference |
| November 11th | Bayesian Inference |
| November 13th | Linear Regression |
| November 15th | Non-parametric Regression |
| November 18th | Minimax Lower Bounds |
| November 20th | Minimax Lower Bounds |
| November 22nd | High-dimensional Statistics |
| November 25th | High-dimensional Statistics |
| November 27th | No Class (Thanksgiving Break) |
| November 29th | No Class (Thanksgiving Break) |
| December 2nd | Model Selection |
| December 4th | Causal Inference |
| December 6th | Causal Inference |

Some additional topics we may cover include metrics on distributions and a more detailed treatment of exponential families.