

# Advanced Topics in Statistical Learning: Spring 2024

## Stat 241B / CS 281B

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**Course website:** <https://www.stat.berkeley.edu/~ryantibs/statlearn-s24/>

(See course website for lecture times, room, office hours, etc.)

In *Advanced Topics in Statistical Learning*, we will take a guided tour of both basic and advanced methods in statistical and machine learning, and the accompanying analysis tools that enable us to understand them theoretically. Theorems are presented together with practical aspects of methodology and intuition to help students develop a broad sense of the rationale (pros and cons) behind choosing to use a given method/approach in a particular problem setting. Topics to be covered will most likely include: high-dimensional estimation, nonparametric regression and testing, uncertainty quantification, overparametrization and interpolation, among others (see below for a more detailed list).

## Prerequisites

While there are no formal pre-requisites, this course will proceed at a fast pace and assume a good degree of mathematical sophistication. We will also assume that familiarity with introductory graduate-level material on probability theory, statistical theory, and statistical methodology, including:

- Notions of convergence (almost sure, in probability, in distribution)
- Law of large numbers, CLT, Glivenko-Cantelli theorem
- Basic concentration inequalities (Markov, Hoeffding, etc.)
- Maximum likelihood, GLMs, regression, classification
- Basic concepts in regularization (e.g.,  $\ell_1$  and  $\ell_2$  penalties)
- Asymptotic notation and statements ( $O(\cdot)$ ,  $O_P(\cdot)$ , etc.)
- Fundamentals of calculus, linear algebra, optimization

## Topics

In more detail, the topics that we will cover will likely include:

- Nonparametric regression
- Minimax theory

- Lasso
- Ridge
- Implicit regularization
- Conformal prediction
- Forecasting theory

Other possible topics include:

- Nonparametric classification
- Nonparametric testing
- Online learning
- Model aggregation
- Boosting and slow learning
- Sequential decision making

## Evaluation

Evaluation will be based on be four homeworks and one course project. The project will be done in a small group, and will culminate in a 10-or-so page writeup on a topic of the groups choosing. The grading breakdown is as follows (each homework assignment is worth an equal amount):

- Homeworks: 60%
- Project: 40%

Details on the due dates for the homework, and more details on the project, will be provided on the course website.

## Homework

The homeworks are structured to give you experience in written mathematical exercises, and to a lesser extent, programming exercises. As we may reuse problems from other, similar courses that have been taught in the past, you **must not to copy, refer to, or look at** previous solutions in preparing your answers.

Also, while it is completely acceptable for you to collaborate with other students in order to solve the homework problems, we assume that you will be taking **full responsibility in terms of writing up your own solutions and implementing your own code**. You must indicate on each homework the students with whom you collaborated.

In general, late homework will not be accepted. In the case you are busy preparing for a conference deadline or something like that, you must give us at least **5 days notice** if you are requesting an extension, and we can give you +2 or +3 days. In the case of an emergency (sudden sickness, family problems, etc.), no notice is needed, and we can work with you to give you a reasonable extension. But we emphasize that this is reserved for true emergencies.

## **Take care of yourself**

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

All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus. You can find these linked from the Academic Accomodations Hub <https://evcp.berkeley.edu/programs-resources/academic-accommodations-hub>.