

# MACHINE LEARNING

## COURSE OUTLINE

JS



August, 2022

**Course title** : Machine learning  
**Lecturer** : Jonas Striaukas. Email: [js.fi@cbs.dk](mailto:js.fi@cbs.dk) or [jonas.striaukas@gmail.com](mailto:jonas.striaukas@gmail.com)  
**Lecture time** : TBA  
**Auditorium** : TBA  
**Course website** : <https://jstriaukas.github.io/teaching.html> 

**Important** : please write *Machine learning class* in the subject line when you write to me regarding the course material/questions/etc. Please write questions after each lecture, I will allocate 10-15 minutes at the beginning of the following lecture to answer your questions.

**Prerequisites** : introduction to statistics, linear regression and some basic computing in statistical software (e.g., R, Python) is assumed, but otherwise, it is a self-contained course. I recommend reading through the introductory book (the first book in the list of recommended books) before the course to have a rough idea of what we will cover during the course.

**Books** : I try to make material self-contained so that you don't need to buy any book for the course. However, if you like the course and want to have a deeper understanding of a particular topic or machine learning methods in general, I suggest the following books:<sup>1</sup>

- (great introductory book) James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). *An introduction to statistical learning* (Vol. 112, p. 18). Springer (New York).  
 ► online copy: [pdf](#) .
- (moderate level overview book) Hastie, T., & Friedman, J. H., Tibshirani, R. (2009). *The elements of statistical learning: data mining, inference, and prediction* (Vol. 2, pp. 1-758). Springer (New York).  
 ► online copy: [pdf](#) .
- (main book for the course – covers more recent topics) Fan, J., Li, R., Zhang, C. H., & Zou, H. (2020). *Statistical foundations of data science*. Chapman and Hall/CRC.

**Software**: students need to either install statistical software R or some other software for different languages (Python, Matlab, Julia, Octave, ...). I will be showing examples mainly in R and Python. I advise you to install the software before the course starts (if you don't have it already). See below for the instructions on how to install R and Python. You are free to use Matlab/Julia/C++/etc. programming language of your choice to code the examples we cover in the class as well as homework assignment.

**Exam**: TBA

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<sup>1</sup>I list an additional set of books for students who want to learn more about statistical learning methods, statistical theory, introductory probability theory for high-dimensional problems, etc., at the end of this outline.

# Information about the course

## Topics

The course will cover the following main topics:

- **Topic 1:** Introduction to learning, multiple and nonparametric regression  
▶ Material: [slides shinyapps](#) [slides pdf](#) [tablet friendly slides pdf](#)
- **Topic 2:** High-dimensional linear regression  
▶ Material: [slides shinyapps](#) [slides pdf](#) [tablet friendly slides pdf](#)
- **Topic 3:** High-dimensional regression properties and generalized linear models (GLMs)  
▶ Material: [slides shinyapps](#) [slides pdf](#) [tablet friendly slides pdf](#)
- **Topic 4:** Prediction, loss functions and M-estimators  
▶ Material: [slides shinyapps](#) [slides pdf](#) [tablet friendly slides pdf](#)
- **Topic 5:** Introduction to deep learning  
▶ Material: [slides shinyapps](#) [slides pdf](#) [tablet friendly slides pdf](#)
- **Topic 6:** Introduction to causal machine learning  
▶ Material: [slides shinyapps](#) [slides pdf](#) [tablet friendly slides pdf](#)

## Details on each topic

**Topic 1:** *Introduction to learning, multiple and nonparametric regression.*

The section starts with reviewing challenges and advantages of *Big data* and a brief introduction to learning (theory).<sup>2</sup> The section then covers multiple and nonparametric regression methods which are central to learning.

**Topic 2:** *High-dimensional linear regression.*

The section develops high-dimensional methods for linear regression model. The estimators such as LASSO, Ridge, elastic net, etc., are discussed. Prediction, estimation and inference topics are covered for the LASSO estimator.

**Topic 3:** *High-dimensional regression properties and generalized linear models (GLMs).*

**Topic 4:** *Prediction, loss functions and M-estimators.*

**Topic 5:** *Introduction to deep learning.*

**Topic 6:** *Introduction to causal machine learning.*

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<sup>2</sup>**IMPORTANT:** I write *theory* in brackets – throughout the course all theoretical derivations will serve us the purpose of understanding certain learning techniques, how and why they work, and under which assumptions. I do not expect students to reproduce more complicated proofs, however, I expect that students understand and can interpret theory results, i.e., can argue why certain methods work for certain types of data, what properties should the data satisfy, etc.

## Instructions to install R

The main R software is available at <https://cran.r-project.org> [↗](#). Once on this website, you need to select an file to download for your operating system (OS), so if you work on Windows you need to download and install Window `.exe` file. Please install the most recent version of R. I also strongly advise to install RStudio (free version of it) from <https://rstudio.com> [↗](#). You need to install R prior to RStudio.

*Install R packages:* suppose you need to install an R package called ‘`forecast`’. You should write in RStudio console:

```
install.packages("forecast")
```

## Additional material

### List of useful books

- (introductory book on high-dimensional stats) Giraud, C. (2021). *Introduction to High-Dimensional Statistics* (Vol. 112, p. 18). Chapman & Hall/CRC Monographs on Statistics and Applied Probability.
- (great book for LASSO methods) Bühlmann, P., & Van De Geer, S. (2011). *Statistics for high-dimensional data: Methods, theory and applications*. Springer Science & Business Media.
- (more advanced book on high-dimensional stats) Wainwright, M. J. (2019). *High-dimensional statistics: A non-asymptotic viewpoint* (Vol. 48). Cambridge University Press.
- (introductory probability theory for high-dimensional problems) Vershynin, R. (2018). *High-dimensional probability: An introduction with applications in data science* (Vol. 47). Cambridge university press.
- (reference book for concentration inequalities) Boucheron, S., Lugosi, G., & Massart, P. (2013). *Concentration inequalities: A non-asymptotic theory of independence*. Oxford university press.
- (fun book on learning methods) Cesa-Bianchi, N., & Lugosi, G. (2006). *Prediction, learning, and games*. Cambridge university press.