

## Course Overview - CS-433

Machine learning and data analysis are becoming increasingly central in many sciences and applications. In this course, fundamental principles and methods of machine learning will be introduced, analyzed and practically implemented.

### Course Goals

Define the following basic ML problems and explain the main differences between them: Regression, classification, clustering, dimensionality reduction.

Implement and apply machine learning methods to real-world problems, and rigorously evaluate their performance using cross-validation.

Optimize the main trade-offs such as overfitting, and computational cost vs accuracy.

Experience common pitfalls and how to overcome them.

Explain and understand the fundamental theory presented for ML methods.

### Syllabus

We will cover the following ML methods and concepts:

- Basic regression and classification concepts and methods:  
Linear models, overfitting, linear regression, Ridge regression, logistic regression, and k-NN.
- Fundamental concepts:  
Cost-functions and optimization, cross-validation and bias-variance trade-off, curse of dimensionality.
- Unsupervised learning:  
k-Means Clustering, Gaussian mixture models and the EM algorithm.
- Dimensionality reduction:  
PCA and matrix factorization, word embeddings for natural language processing.
- Advanced methods:  
Generalized linear models, SVMs and Kernel methods, graphical models, neural networks and deep learning.

The syllabus provided on the website is more precise but subject to change, especially for the later parts of the lecture.

### What not to expect

You will not learn ALL advanced methods.

You will not learn ALL the details.

This course is not specifically about big data or large-scale methods.

This is not a course about numerical optimization, neither is it about statistics. We will use both of these but focus on the fundamental techniques only.

Pre-requisites are stated below and in the coursebook. You have to learn that on your own.

This course does not teach you all that you need to know to be able to apply machine learning, but this course will get you started for sure.

## Labs

Weekly every Thursday 14:15 - 16:00, in the following rooms:

INF119 (A-Ch); INJ218 (Ci-Kj); INM11 (Ko-Pe); INM202 (Pi-Z), according to last-name.

All labs and projects will be in *Python*. See the first lab to get started. Don't worry if you have no experience in it yet, but in that case you should take enough time to thoroughly work on the first (and second) lab.

## Prerequisites

We will revise some of the concepts in the first and second weeks of the course. However, you are recommended to go through the list of pre-requisites here to make sure your knowledge is up to date.

*Vector and Matrix Algebra*. Vector and matrix multiplication, matrix inverse, rank, eigenvalue decomposition. Refer to first year courses, or the linear algebra handout on the website, or Gilbert Strang's book for example.

*Vector and Matrix Calculus*. Important: The definition of derivative with respect to vectors and matrices. For reference, see the Matrix Cookbook for example.

*Scientific Computing Languages*. Python Basics (see tutorial in the first lab).

*Probability and Statistics*. Conditional and joint distribution, independence, Bayes' rule, random variable and expectation, law of large numbers. For example, see Chapter 2 of Chris Bishop's book.

*Gaussian Distribution*. Univariate and multivariate, conditional, joint and marginals.

*Writing Scientific Documents using Latex* (not necessary but preferred). Many tutorials are available online, and we provide more resources when we come to Project 1.

## Resources

### Course Webpage

We will use the course website for all material, except code

[mlo.epfl.ch/page-146520.html](http://mlo.epfl.ch/page-146520.html)

Code templates and solutions for the labs will be made available on our github repository

[github.com/epfml/ML\\_course](https://github.com/epfml/ML_course)

### Active Participation / Clicker / Discussions

For some active participation in the lectures, please point your browser to this speak-up room (clicker in the web browser or phone app).

### Lecture Notes

PDF notes for each lecture will be available on the website (and github) before the day of the lecture, and will often be annotated during the lecture. For revisions in case of errors, see also on github.

### Recommended Textbooks

There are many relevant books. None of them are strictly mandatory for this course. The following examples contain parts which are relevant to the course:

- S. Shalev-Shwartz and S. Ben-David: Understanding Machine Learning - From Theory to Algorithms.
- G. James, D. Witten, T. Hastie and R. Tibshirani: An introduction to statistical learning.
- T. Hastie, R. Tibshirani and J. Friedman: Elements of statistical learning.
- C. Bishop: Pattern Recognition and Machine Learning.

- K. Murphy: Machine Learning: A Probabilistic Perspective.
- Michael Nielsen: Neural Networks and Deep Learning.

The first three and the last books are available online for free. You do not have to buy any books, since we will only refer to few chapters in these. Some physical copies are available in the library.

## Assessment and Practical Projects

- Project 1 (10%), due Oct 30<sup>th</sup>
- Project 2 (30%), due Dec 21<sup>st</sup>
- Final exam (60%)

### Project 1 (10%)

The goal of this project is to help you prepare for Project 2.

In this first project, you will work in a small group of 3 students (2 only in exceptional cases, pending approval).

You will implement the most important methods covered in the lectures and labs so far.

Additionally, we will provide you with an interesting real-world dataset, and organize our own competition here:

[inclass.kaggle.com/c/epfml-project-1](https://inclass.kaggle.com/c/epfml-project-1)

A detailed project description will be posted on the website very soon.

Team assignment: Your choice. We recommend working in interdisciplinary teams, since the projects require many aspects. Use the forum or speak-up to find team-mates and form a group of 3.

You will also submit your Python code, and a 2 page PDF report. *Deadline: Oct 30<sup>th</sup>.*

### Project 2 (30%)

Project 2 is the final project and gives you more freedom and responsibilities.

Again, you will work in a group of 3 people.

You can freely choose between three challenges with real-world data problems:

[inclass.kaggle.com/c/epfml-rec-sys](https://inclass.kaggle.com/c/epfml-rec-sys)  
[inclass.kaggle.com/c/epfml-text](https://inclass.kaggle.com/c/epfml-text)  
[inclass.kaggle.com/c/epfml-segmentation](https://inclass.kaggle.com/c/epfml-segmentation)

Submitting your predictions to the kaggle platform allows you to get immediate feedback on your performance.

Finally, you will also submit your Python code, and a 4 page PDF report. *Deadline: Dec 21<sup>st</sup>.*

### Final exam (60%)

A very standard final exam.

It will contain questions on what you have learned during the lectures and exercise sessions.

We will give you a sample exam before for you to practice.

You are allowed to bring one cheat sheet (A4 size paper, both sides can be used), either handwritten or 11 point minimum font size.

No calculator, No collaborations. No cell phones. No laptops etc.

## Contact Us

Email us at [epfmlcourse@gmail.com](mailto:epfmlcourse@gmail.com) for any questions on the course or exercises.

### Teaching Assistants:

Barbier Jean	<a href="mailto:jean.barbier@epfl.ch">jean.barbier@epfl.ch</a>
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The assistants will be helping you during the exercise sessions and projects.

## Credits

Teaching material by Emtiyaz Khan, Rüdiger Urbanke, Martin Jaggi.

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