# FRE 7773,
# Machine Learning in Financial Engineering

## Instructor Information


- Dr. Rajesh T. Krishnamachari, Adjunct Faculty
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## Course Information

- **Course Number**: FRE 7773
- **Title**: Machine Learning in Financial Engineering
- **Description**: Overview of statistical learning and its applications to finance.
- **Pre-requisite:** None in particular. Undergraduate level understanding of probability and linear algebra; alongside experience with Python programming is expected.
- **Class**: Monday 6-8:30 PM via Zoom

## Course Overview and Goals

Course offers an introduction to techniques of statistical learning and covers its application to finance. We start with covering mathematical (e.g. linear algebra / probability) and computer science preliminaries (e.g. Python/Pandas). We then survey the principal algorithms – from lasso/ridge to support vector machines to random forests. We then provide overview of systematic investing and explore how machine learning can be integrated into the process. We will end the course with an introduction to deep learning and natural language processing.

### Upon completion of this course, students will be able to:

- Explore new data sets, form hypthosis and use machine learning to predict.
- Find alpha signals for asset selection/timing using ML
- Compete in data science competitions – and handle industry requirements around predictive analytics.

## Course Requirements

## Class Participation

Students are expected to attend all classes and participate in class discussions.

## Assignments

There will be 2 assignments. First will cover mathematical topics relevant to ML. Second will be an actual data science challenge, where students have to program and solve using ML algorithms.

## Tests & Quizzes

There will be one final project. Students have to solve a data science challenge and present results to class.

## Assigned Readings

Big Data and AI Strategies by Marko Kolanovic and Rajesh Krishnamachari. (Available online)

## Grading of Assignments

The grade for this course will be determined according to the following formula:

| Assignments/Activities | % of Final Grade |
|---|---|
| Assignment One | 25% |
| Assignment Two | 25% |
| Final Project | 50% |

# Letter Grades

Letter grades for the entire course will be assigned as follows:

| Letter Grade | Points | Percent |
|---|---|---|
| **A** | 4.00 | 92.5% and higher |
| **A-** | 3.67 | 90.0 – 92.49% |
| **B+** | 3.33 | 87.5% - 89.99% |
| **B** | 3.00 | 82.5% - 87.49% |
| **B-** | 2.67 | 80% - 82.49% |
| **C+** | 2.33 | 77.5% - 79.99% |
| **C** | 2.00 | 70.0% - 77.49% |
| **F** | .00 | 69.99% and lower |

## View Grades

Grades are available to students on NYU Classes.

# Course Schedule

## Topics and Assignments

| Week/Date | Topic | Reading | Assignment Due |
|---|---|---|---|
| Feb 1 | Overview of Machine Learning | 1st Chapter of Big Data and AI Strategies | None |
| Feb 8 | Mathematical Preliminaries for ML: Linear Algebra + Probability/Statistics + Numerical Analysis | Select portions of<br>• Matrix Analysis by Horn & Johnson<br>• Probability by Athanasios Papoulis | None |
| Feb 15 | Mathematical Preliminaries for ML : Convex Optimization +n Information Theory + Signal Processing. | Select Portions of<br>• Convex Optimization by Stephen Boyd and Lieven Vandenbergh e<br>• Information Theory by Thomas Cover and Joy Thomas<br>• Signal Processing by Alan Oppenheim and Ronald Schafer | None |
| Feb 22 | Computer Science Preliminaries for ML | Python for Data Analysis by Wes McKinney | None |

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|---|---|---|---|
| Mar 1 | Computer Science Preliminaries for ML | Elements of Statistical Learning by Trevor Hastie and Robert Tibshirani | Assignment One is Due |
| Mar 8 | Statistical Learning using SkLearn | • Elements of Statistical Learning by Trevor Hastie and Robert Tibshirani<br>• Sklearn documentation | None |
| Mar 15 | Deep Dive into Decision Trees | • Elements of Statistical Learning by Trevor Hastie and Robert Tibshirani<br>• Fast.AI material. | None |
| Mar 22 | Prominent Statistical Learning Algorithms | • Elements of Statistical Learning by Trevor Hastie and Robert Tibshirani | None |
| Mar 29 | Overview of Systematic Investing | Systematic Investing Across Asset Classes by Marko Kolanovic and Zhen Wei | None |
| Apr 5 | Use of ML in Systematic Trading | Big Data and AI Strategies by Marko Kolanovic and Rajesh Krishnamachari | None |

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|---|---|---|---|
| Apr 12 | Deep Learning | Deep Learning by Ian Goodfellow et al. | Assignment Two is Due |
| Apr 19 | Deep Learning | Deep Learning by Jeremy Howard et al. | None |
| Apr 26 | Natural Language Processing | Speech and Language Processing by Daniel Jurafsky and James Martin | None |
| May 3 | Project Presentation | None | Project Report is Due |
| May 10 | Project Presentation | None | Project Report is Due |

## Tests and Quizzes

- Assignment One: Tests mathematical competency needed to analyze ML algorithms.
- Assignment Two: Builds competency in solving actual data science challenge question.
- **Final Project:** Students to pick Kaggle competition of their choice. Conduct exploratory data analysis, demonstrate data-driven insight, conduct horse-race of different machine learning algorithms on data, and demonstrate high accuracy on predictive output. Project is designed in a way to be useful for job interviews as well.

# Course Materials

## Required Textbooks & Materials

- Big Data and AI Strategies – by Marko Kolanovic and Rajesh Krishnamachari – Available free online.
- Elements of Statistical Learning – by Trevor Hastie and Robert Tibshirani – Available free online.

## Resources

- **Access your course materials**: NYU Classes (nyu.edu/its/classes)
- **Databases, journal articles, and more**: Bern Dibner Library (library.nyu.edu)
  NYU Virtual Business Library (guides.nyu.edu/vbl)
- **Obtain 24/7 technology assistance:** Tandon IT Help Desk (soehelpdesk@nyu.edu, 646.997.3123)
  NYU IT Service Desk (AskIT@nyu.edu, 212-998-3333)

# Policies

## Academic Misconduct

A. Introduction: The School of Engineering encourages academic excellence in an environment that promotes honesty, integrity, and fairness, and students at the School of Engineering are expected to exhibit those qualities in their academic work. It is through the process of submitting their own work and receiving honest feedback on that work that students may progress academically. Any act of academic dishonesty is seen as an attack upon the School and will not be tolerated. Furthermore, those who breach the School's rules on academic integrity will be sanctioned under this Policy. Students are responsible for familiarizing themselves with the School's Policy on Academic Misconduct.

B. Definition: Academic dishonesty may include misrepresentation, deception, dishonesty, or any act of falsification committed by a student to influence a grade or other academic evaluation. Academic dishonesty also includes intentionally damaging the academic work of others or assisting other students in acts of dishonesty. Common examples of academically dishonest behavior include, but are not limited to, the following:
    1. Cheating: intentionally using or attempting to use unauthorized notes, books, electronic media, or electronic communications in an exam; talking with fellow students or looking at another person's work during an exam; submitting work prepared in advance for an in-class examination; having someone take an exam for you or taking an exam for someone else; violating other rules governing the administration of examinations.
    2. Fabrication: including but not limited to, falsifying experimental data and/or citations.

3. Plagiarism: Intentionally or knowingly representing the words or ideas of another as one's own in any academic exercise; failure to attribute direct quotations, paraphrases, or borrowed facts or information.
4. Unauthorized collaboration: working together on work that was meant to be done individually.
5. Duplicating work: presenting for grading the same work for more than one project or in more than one class, unless express and prior permission have been received from the course instructor(s) or research adviser involved.
6. Forgery: altering any academic document, including, but not limited to, academic records, admissions materials, or medical excuses.

## Disability Disclosure Statement

Academic accommodations are available for students with disabilities. Please contact the **Moses Center for Students with Disabilities** (212-998-4980 or mosescsd@nyu.edu) for further information. Students who are requesting academic accommodations are advised to reach out to the Moses Center as early as possible in the semester for assistance.

## Inclusion Statement

The NYU Tandon School values an inclusive and equitable environment for all our students. I hope to foster a sense of community in this class and consider it a place where individuals of all backgrounds, beliefs, ethnicities, national origins, gender identities, sexual orientations, religious and political affiliations, and abilities will be treated with respect. It is my intent that all students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. If this standard is not being upheld, please feel free to speak with me.