# FE630 Portfolio Theory and Applications
# Fall 2023 Syllabus

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# 1 Course description

## 1.1 Course Goals

This course is an introduction to quantitative portfolio theory, practice, optimization, and management. It addresses investor choice, market opportunities, and optimal portfolio selection. It examines security covariance and return models, performance analysis, and return attribution. It provides also an introduction to some basic methods for robust portfolio construction. The course will also include a computational component in which students will construct optimal portfolios, track their behavior, and analyze their performance.

## 1.2 Student Learning Outcomes

After successful completion of this course, students will be able to

- Compute Absolute Risk Aversion (ARA), Certainty Equivalent of Risky (CER) of risky gamble and Risk-premiums;
- Solve Optimal Decision Problems arising in Modern Portfolio Theory and implement the solution using a high level language such as R, Matlab or Python;
- Design Markowitz efficient portfolios and use the One-fund Theorem and the Two-fund theorem to build efficient Portfolios with Target Return or Target Risk;
- Use CAPM, APT and Factor Model to compute security Expected Returns and Risk and Covariance;
- Apply Markowitz Allocation to design, implement and backtest Optimal Portfolios using historical price time series, analyze the sensitivity to various inputs, and manage Fixed Income portfolios.

# 2 Prerequisites

- Background in Algebra, Optimization, Stochastic Calculus. Most of what we will need in Algebra and Optimization will be covered. It is assumed that you are comfortable with the material presented in FE 543 or FE610 (Stochastic Calculus for Financial Engineering) and FE620 (Pricing and Hedging).

- Students must have some familiarity with Matlab and R, (and / or Python). These languages will be used extensively and interchangeably in the course.

## 3 Pedagogy

This course will be taught in a hybrid manner including lectures and Socratic method discussions. Each week, there will be assigned readings. Students must do the readings before class. I will call on on-campus students frequently to explain concepts from the readings. Students' answers will count toward their grade. Web-campus students who cannot attend classes in real-time will be given small written assignments in lieu of in-class answers. There will be also a number of quizzes that may be taken in class during lecture or remotely.

## 4 Books

The following books are recommended, but not required:

- Francis and Kim, *Modern Portfolio Theory,* Wiley, 2013. ISBN: 111837052X.
- Grinold and Kahn, *Active Portfolio Management, 2e*, McGraw Hill, 1999. ISBN:0070248826.
- Hubert, *Essential mathematics for Market Risk Management, 2e*, Wiley, 2012. ISBN 9781119979524
- Prigent, *Portfolio Optimization and Performance Analysis*, Chapman & Hall/CRC Financial Mathematics Series, , ISBN 1-58488-578-5
- Other Readings: Journal Papers or any material of interest, as needed.

## 5 Assessment

Grades will be based on a combination of quizzes, exams, homework, a project, attendance, and participation.

1. **Quizzes.** There will be between four to eight 15-minute multiple choice quizzes.
2. **Exams.** There will be a mid-term exam, and final project.

3. **Homework.** There will be four to six homework assignments in which students will do theoretical analysis and write programs for portfolio management in both Matlab, R or Python.

4. **Project.** Students will form groups of three or less, and each group will be required to design, implement, backtest and run a comparative analysis of quantitative investment strategies according to modern portfolio management principles.

5. **Attendance and Participation.** Attendance is mandatory. The class will be interactive. Students are required to participate and answer questions on the reading assignments.

**Weights: The final weighting will be approximately:**

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| Quizzes | 15% |
| Homeworks | 20% |
| Midterm | 20% |
| Final Exam or Project | 35% |
| Attendance and Participation | 10% |
| Total | 100% |

Instructor reserve the right to modify the weighting to "curve" the grades.

# 6 Topics top be covered and schedule

Below is the tentative week-by-week breakdown of topics. This tentative schedule is subject to change as the pace may be modified to ensure proper mastering of covered topics. The exact schedule of assignments including readings, homework, project due dates, and exam dates will be published in Canvas, as relevant. I will inform students of changes to this schedule by making a posting in the announcement section of Canvas.

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| **Weeks 1 & 2**<br>Orientation & One Period Utility | Course Introduction, Course Overview. Student Introduction and Initial Assessment. First Motivating Examples. One-Period Utility Analysis. Absolute and Relative Risk Aversion, Certainty Equivalent and Risk Premium. |
| **Weeks 3 & 4**<br>Computational Tools, Algebra<br>& Optimization for Portfolio | Portfolio expected return and risk. Portfolio weights. Attainable regions of risk-return space. Risk reduction and diversification. Review of algebra for Portfolio and matrix calculus. Convex and Nonlinear optimization basics. Equality and Inequality Constraints. KKT conditions and closed-form solution to Markowitz Allocation. |
| **Weeks 5, 6 & 7**<br>The opportunity Set<br>Mean-Variance<br>Efficient Frontiers<br>CAPM, APT<br>Multi-Factor Models | Mean-variance Frontier Portfolios. The Markowitz Efficient Frontiers with and without Risk-free security. One and two-fund theorems. Market Price of Risk and Security Market Line, CAPM, APT, Single index and Multi-Index models. Pricing and Arbitrage opportunities. |
| **Week 7** | Mid-semester Review |
| **Week 8** | Midterm Project |
| **Week 9**<br>Sensitivity to Inputs<br>& Robust Allocation | Models of uncertainties of Expected Returns and Risk Matrices. Models of Robust Allocation. Worst Case Optimization. Matrix Calibration. Black Litterman Allocation.. |
| **Weeks 10 & 11**<br>Portfolio Characteristics<br>& Applications | Portfolio Characteristics, Active and Passive Portfolios Management, Performance attribution. Asset Versus Risk Allocation. Portfolio construction to mitigate interest rate risk sensitivity. |
| **Weeks 10 & 11**<br>Dynamic Portfolio Allocation | Risk Sensitive Asset Allocation. Maximum Principle, HJB Equation, Feedback using Riccati Equation. |
| **Weeks 13 & 14**<br>Finals | Final review, Course evaluation and presentation of Final Projects |

# 7 Academic Integrity

## 7.1 Undergraduate Honor System

Enrollment into the undergraduate class of Stevens Institute of Technology signifies a student's commitment to the Honor System. Accordingly, the provisions of the Stevens Honor System apply to all undergraduate students in coursework and Honor Board proceedings. It is the responsibility of each student to become acquainted with and to uphold the ideals set forth in the Honor System Constitution. More information about the Honor System including the constitution, bylaws, investigative procedures, and the penalty matrix can be found online at http://web.stevens.edu/honor/ The following pledge shall be written in full and signed by every student on all submitted work (including, but not limited to, homework, projects, lab reports, code, quizzes and exams) that is assigned by the course instructor. No work shall be graded unless the pledge is written in full and signed. "I pledge my honor that I have abided by the Stevens Honor System." Reporting Honor System Violations. Students who believe a violation of the Honor System has been committed should report it within ten business days of the suspected violation. Students have the option to remain anonymous and can report violations online at .

## 7.2 Graduate Student Code of Academic Integrity

All Stevens graduate students promise to be fully truthful and avoid dishonesty, fraud, misrepresentation, and deceit of any type in relation to their academic work. A student's submission of work for academic credit indicates that the work is the student's own. All outside assistance must be acknowledged. Any student who violates this code or who knowingly assists another student in violating this code shall be subject to discipline. All graduate students are bound to the Graduate Student Code of Academic Integrity by enrollment in graduate coursework at Stevens. It is the responsibility of each graduate student to understand and adhere to the Graduate Student Code of Academic Integrity. More information including types of violations, the process for handling perceived violations, and types of sanctions can be found at .

# 8 Special Provisions for Undergraduate Students in 500-level Courses

The general provisions of the Stevens Honor System do not apply fully to graduate courses, 500 level or otherwise. Any student who wishes to report an undergraduate for a violation in a 500-level course shall submit the report to the Honor Board following the protocol for undergraduate courses, and an investigation will be conducted following the same process for an appeal on false accusation described in Section 8.04 of the Bylaws of the Honor System. Any student who wishes to report a graduate student may submit the report to the Dean of Graduate Academics or to the Honor Board, who will refer the report to the Dean. The Honor Board Chairman will give the Dean of Graduate Academics weekly updates on the progress of any casework relating to 500-level courses. For more information about the scope, penalties, and procedures pertaining to undergraduate students in 500-level courses, see Section 9 of the Bylaws of the Honor System document, located on the Honor Board website.