Math 5760/6890: Introduction to Mathematical Finance

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Mathematical Finance

This course concerns the *science* of the financial world:

- financial instruments and securities: loans, bonds, stocks, options, derivatives, etc.
- determination of the past/present/future value of securities
- models that predict the future value of securities

This science is exercised worldwide by banks, traders, governments, companies, researchers, etc.

Skills you'll learn/exercise

- Language
  Mathematical finance itself involves learning a nontrivial vocabulary.
- Models
  Financial instruments are, or can be valued, through numerous types of models.
- Mathematics
  Mathematics is a set of tools that are used to examine/probe/understand models.
- Simulations
  Many models are more easily explorable using computer simulations, involving coding.

In this course, we will

- become familiar with the modern financial system and markets
- understand foundational concepts in investment and risk
- internalize the time value of money, and its implications on markets and investments
- model investments and quantitatively determine returns and risks
- gain capabilities to model financial portfolios
- understand and exercise the binomial options model
- explore the Black-Scholes-Merton model for options

What is out-of-bounds

You will NOT learn the following:

- Easy ways to make money
- How to accurately predict trajectories of stocks (or any other risky security)
- How to become a sophisticated securities investor
- Identification of real-world arbitrage involving risky securities
- Advanced financial models and mathematics

Where to get information about the course?

There are two online sources of information for this course:

- Canvas
  - Syllabus
  - Homework+project assignments
  - Homework+project submission (Gradescope)
  - Grades
- Public-facing webpage
  `http://www.sci.utah.edu/~akil/math5760`
  - Syllabus
  - Slides
  - Homework+project assignments
  - Any other handouts

Prerequisites + expectations

You should be familiar with the following to feel comfortable in this class:

- probability basics (random variables, fundamental operations)
- linear algebra (linear systems, eigenvalues)
- differential equations (solutions to linear differential equations)

It will be (very) helpful if you have some background/interest in at least some real-world concepts surrounding finance:

- loans / mortgages
- stocks / bonds
- filing taxes in the US

Class logistics

This class meets Mon + Wed + Fri from 9:40am-10:30am here (WEB L126).

This will mostly involve lectures (loosely speaking: I hope for discussion!)

Attendance is not a factor in your grade.

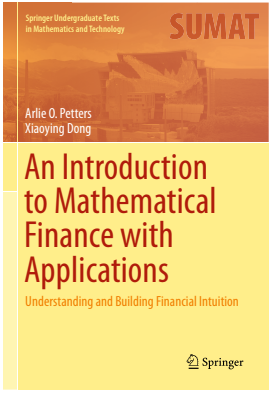
During class, I will occasionally supplement slides with handwritten notes/computations.

All slides will be made available on the publicly facing website.

The graded assessments for this course are homework assignments, projects, and a final exam.

We'll nail down office hours on Friday.

Textbook



Access to this book is mandatory.

This book is offered through the Inclusive Access program.

See the syllabus for other useful supplements.

Homework

Homework will work in the following way for this course:

- Assignments will be collected approximately weekly (starting week 2 of class)
- Assignments will be due by 11:59pm MT on Fridays
- Submissions will be electronic through Gradescope (accessible via Canvas)
- Solutions will be posted after assignments are collected
- Late assignments will be accepted with a 25% penalty levied per day late
  Exceptions will be made only with prior approval or with documentation of extenuating circumstances.
- Your lowest homework score over the semester will be dropped

See the syllabus for how homework factors into the final grade.

You are welcome (and encouraged) to work in groups for homework assignments, but each person much turn in their own individual, original work.

Projects

There will be two projects over the course of the semester.

The projects aim to be more holistic projects around finance (interpretation, simulation, explanation).

You will have approximately two weeks to complete each project.

- The first project has a (tenative) due date of Friday, October 18.
- The second project has a (tenative) due date of Thursday, December 5.

Projects will again be submitted through Gradescope.

See the syllabus for how projects factor into the final grade.

Exam

There is a single, final exam for this course. Per university schedule, this exam will take place on

Friday, December 12, 8:00am - 10:00am
Location: WEB L126 (the normal classroom)

The final exam will be a comprehensive, open-book, open-notes exam.

See the syllabus for how the exam factors into the final grade.

The tentative plan

Semester calendar
(Subject to change!)

Day	Date	Text Section(s)	Topic
Monday	August 19, 2024	1.1	Hello + basics
Wednesday	August 21, 2024	1.2, 1.3	Securities
Friday	August 23, 2024	1.2, 1.3	Markets
Monday	August 26, 2024	2.1-2.4	Interest
Wednesday	August 28, 2024	2.5-2.7	Net present value
Friday	August 30, 2024	2.5-2.7	Stocks and bonds
Monday	September 2, 2024	—	No class: Labor Day
Wednesday	September 4, 2024	7.5	Options basics
Friday	September 6, 2024	—	Review: Probability, linear algebra, and differential equations
Monday	September 9, 2024	—	Review: Probability, linear algebra, and differential equations
Wednesday	September 11, 2024	3.1	Markowitz portfolios
Friday	September 13, 2024	3.1	Markowitz portfolios
Monday	September 16, 2024	3.1-3.4	Markowitz portfolios
Wednesday	September 18, 2024	3.4-3.7	N-security portfolios
Friday	September 20, 2024	3.4-3.7	N-security portfolios
Monday	September 23, 2024	3.4-3.7	N-security portfolios
Wednesday	September 25, 2024	3.4-3.7	N-security portfolios
Friday	September 27, 2024	3.4-3.7	N-security portfolios
Monday	September 30, 2024	4.1	Capital market theory
Wednesday	October 2, 2024	4.2	Risk measures
Friday	October 4, 2024	4.2	Risk measures
Monday	October 7, 2024	—	No class: Fall Break
Wednesday	October 9, 2024	—	No class: Fall Break
Friday	October 11, 2024	—	No class: Fall Break
Monday	October 14, 2024	4.3	Linear factor models
Wednesday	October 16, 2024	4.3	Linear factor models
Friday	October 18, 2024	4.3	Linear factor models
Monday	October 21, 2024	5.1	Binomial tree models
Wednesday	October 23, 2024	5.1-5.2	Binomial tree models
Friday	October 25, 2024	5.1-5.2	Binomial tree models
Monday	October 28, 2024	5.2-5.3	Continuous-time models
Wednesday	October 30, 2024	5.3-5.4	Continuous-time models
Friday	November 1, 2024	5.3-5.4	Continuous-time models
Monday	November 4, 2024	5.4	Continuous-time models
Wednesday	November 6, 2024	6.7-6.8	The Itô integral
Friday	November 8, 2024	6.7-6.8	The Itô integral
Monday	November 11, 2024	6.7-6.8	Itô's formula
Wednesday	November 13, 2024	6.9	Geometric Brownian motion
Friday	November 15, 2024	6.9	Geometric Brownian motion
Monday	November 18, 2024	7.2-7.3	Forward and futures
Wednesday	November 20, 2024	7.5	Options, redux
Friday	November 22, 2024	8.1	The Black-Scholes-Merton model
Monday	November 25, 2024	8.1	The Black-Scholes-Merton model
Wednesday	November 27, 2024	—	No class: Thanksgiving break
Friday	November 29, 2024	—	No class: Thanksgiving break
Monday	December 2, 2024	8.2	Options pricing
Wednesday	December 4, 2024	8.4	Risk-neutral pricing
Thursday	December 12, 2024	8:00am-10:00am	**FINAL EXAM**

References I

 Petters, Arlie O. and Xiaoying Dong (2016). *An Introduction to Mathematical Finance with Applications: Understanding and Building Financial Intuition*. Springer. ISBN: 978-1-4939-3783-7.