MATH4512 Fundamentals of Mathematical Finance
Course Outline
Spring Semester 2024-2025

1. **Instructor**

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   Office hours: (Fri) 5:00p.m.- 6:30p.m.

2. **Meeting time and Venue**

   Lecture: *Tues 4:30p.m.- 6:50p.m. @Room 4619
   Thurs 4:30p.m. - 5:50p.m. @Room 4619
   (*The tutorial on Tuesday is combined with the lecture)

3. **Course Description**

   Credit point: 3 credits
   Prerequisites: Multivariable Calculus (MATH2010, MATH2011, MATH2021 or MATH2023), Linear Algebra (MATH2111, MATH2121, MATH2131 or MATH2350), Basic knowledge in probability and statistics (IELM2510, ISOM2500, LIFS3150 or MATH2411) and basis knowledge in finance (FINA2203 or FINA2303).

   In this course, we develop different mathematical models for studying optimal investment strategies in different scenarios. Topics include bond portfolio management and immunization, Markowitz mean-variance portfolio theory, capital asset pricing models, investment performance analysis, utility optimization in investment decisions.

4. **Intended Learning Outcome (ILOs)**

   Upon successful completion of this course, students should be able to understand the following topics:

   1. Duration and horizon rate of return, bond portfolio management and immunization, application of bond immunization in asset-liability management
   2. Mean-variance formula of portfolio choices of risky assets. Two-fund theorem and one-fund theorem.
   3. Asset pricing under the capital asset pricing model (CAPM) and factor models. Investment performance analysis.
   4. Utility optimization in investment decisions and stochastic dominance.

   In addition, students would also acquire the following abilities:

   5. Appreciate the use of various quantitative methods to analyse issues related to portfolio choice problems and investment performance analysis.

6. Recognize the importance of applying rigorous and numerate approach to analyse and solve problem in financial economics.
7. Apply mathematical modelling and analytic proofs, as well as statistical analyses, to describe and explain phenomena in financial economics models.
8. Communicate the solutions of mathematical models of financial economics using mathematical terminology and English language.

5. Student Learning Resources

We will use our own Lecture notes in this course. Additional problem sets (optional) will be provided. All materials can be found in canvas: (https://canvas.ust.hk)

The following reference books are also useful:

1. "Investment Science" by D.G. Luenberger.
2. "Fundamentals of Corporate finance" by J. Berk, P. DeMarzo and J. Harford

6. Teaching and Learning Activities

Lectures (4 hours per week)

7. Tentative Course Schedule

Chapter 1: Bond immunization

- A quick review on bond pricing (using yield rate and term structure of interest rate)
- Duration and Convexity
- Bond investment analysis: Bond immunization and Contingent immunization
- Application of bond immunization in asset-liability management.

Chapter 2: Mean-Variance portfolio theory

- Mean and variance of portfolio return
- Markowitz's mean-variance formulation
- Two-fund theorem and one-fund theorem
- Risk-tolerance model

Chapter 3: Capital asset pricing model and performance analysis

- Capital asset pricing model (CAPM) and beta values
- Interpretations and uses of capital asset pricing model
- Investment performance analysis

Chapter 4: Utility optimization in investment decisions

- Axiomatic approach to the construction of utility function
- Maximum expected utility criterion
- Stochastic dominance (if time permitted)

8. Assessment Scheme

There are 2 assessment tasks in this course:

	Weight	CILOs assessed
Assignment	25% + Bonus	1, 2, 3, 4, 6, 7
Final examination	75%	1, 2, 3, 4, 5, 6, 7, 8

(a) Assignment (25% of the total grade + Bonus score)

There are required problems and optional problems in each of the assignments. You are required to complete all required problems. Also, you may complete some of the optional problems for bonus score (which may improve your final grade).

(b) Final Examination (75% of the total grade)

It will be a 3 hour closed-book exam and the exam will cover all materials covered in this course.

- The final exam will be scheduled within the final exam period and the exact date of the final examination will be confirmed by the university.
- You may use standard calculator (scientific or financial one) in the exam.
- No formula sheet/cheat sheet is allowed.

Determining the final grade

We will adopt criterion-referencing scheme when assigning your final grade: Your final grade will be assigned based on your overall performance in this course only.

- You are guaranteed to pass the course and receive C- or above if you obtain at least **40%** in overall total (including bonus score).
- You are guaranteed to receive B- or above if you obtain at least **60%** in overall total (including bonus score).
- You are guaranteed to pass the course and receive A- or above if you obtain at least **80%** in overall total (including bonus score).
- You are guaranteed to get the highest grade A+ of the course if you can obtain at least **88%** in overall total (including bonus score).

Grade Descriptors:

Letter Grades	Short Description	Elaboration of subject grading description
A+/A/A-	Excellent Performance	The student has mastered all knowledge and techniques taught in this course. In particular, the student is able to understand all concepts taught and is able to apply those knowledge in solving various real life problems related to investment theory.
B+/B/B-	Good Performance	The student has good understanding on knowledge and techniques taught in this course. The student is able to apply the knowledge in solving some common real life problems related to investment theory.

C+/C/C-	Satisfactory Performance	The student meets the minimum expectation of the instructor: He has acquired good understanding on basic concepts and techniques taught in this course. In addition, the student is able to apply the knowledge in solving some simple real life problems related to investment theory
D	Marginal Pass	The student only know some very basic concepts related to investment theory. He is able to complete some simple calculation only.
F	Fail	

Regarding Use of GenAI policy

- The students are allowed to use GenAI to support their study in this course. However, they are expected to write the assignments on their own.
- On the other hand, the use of GenAI is not allowed in the on-campus final exam