

The Hong Kong University of Science and Technology

Course Syllabus

Optimization in Financial Engineering

IEDA 4000H

3 Credits

Pre-requisites: IEDA 2520 AND MATH 2111

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Lectures: MoWe 12:00 - 13:20, LG4103

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Course Description

This course introduces fundamental optimization techniques and their applications in financial engineering. Students will learn how to model and solve financial problems using linear programming, convex optimization, and robust optimization. Topics include portfolio selection, sensitivity analysis, risk management, option pricing, currency exchange, and optimal execution. The course emphasizes practical implementation with Python solvers and case studies to bridge theory and real-world applications.

Key topics covered are:

- Convex Optimization: Applications in risk-return trade-offs and Markowitz portfolio formulation.
- Robust Optimization: Worst-case risk analysis for handling market uncertainty.
- Financial Applications: Option pricing, optimal execution, bond pricing, and model predictive control.

Intended Learning Outcomes (ILOs)

By the end of this course, students should be able to:

1. Formulate and solve financial optimization problems – Students will be able to model real-world financial scenarios (e.g., portfolio selection, risk management) using linear and convex optimization techniques.
2. Implement optimization models computationally – Students will gain hands-on experience using Python solvers (e.g., CVXPY, SciPy) to analyze and optimize financial decision-making processes.

3. Analyze sensitivity and robustness in financial models – Students will learn to assess how changes in market conditions impact optimization results and apply robust optimization to mitigate uncertainty.

4. Apply optimization techniques to advanced financial topics – Students will explore applications in option pricing, optimal execution, bond pricing, and predictive control, connecting theory to practical financial engineering challenges.

Assessment and Grading

This course will be assessed using criterion-referencing and grades will not be assigned using a curve. Detailed rubrics for each assignment are provided below, outlining the criteria used for evaluation.

Assessments:

- There are 4 assignments. Each of them has the same weight.
- There is an in-person midterm exam. The time limit is 90 minutes. It will test whether you understand the first half of course materials or not.
- There is a final (group) project. The score is based on the quality of the report and the final presentation.
- Grade percentage: Assignments 30%; midterm exam 30%; final project 40%.

Summary Table:

Assessment Task	Contribution to Overall Course grade (%)
Mid-Term	30%
Assignments	30%
Final project & presentation	40%

Course Calendar:

Date	Lecture	Topic	Homework
2-Sep	1	Introduction and Applications to Financial Optimization	
7-Sep	2	Simple Portfolio Selection Model	
9-Sep	3	Case Study of Portfolio Selection by Python	1 out
14-Sep	4	Convex Optimization I	
16-Sep	5	Convex Optimization II	
21-Sep	6	Convex Optimization III	
23-Sep	7	Applications in Finance (Portfolio Optimization I)	1 due, 2 out
28-Sep	8	Applications in Finance (Portfolio Optimization II)	
30-Sep	9	Applications in Finance (Portfolio Optimization III) (Case Study)	

5-Oct	10	Applications in Finance (Portfolio Optimization IV) (AI agent in Fin)	
7-Oct	11	Back Testing	2 due, 3 out
12-Oct	12	Introduction to Robust Optimization	
14-Oct	13	Option Pricing I	
19-Oct	14	Holiday Option Pricing II	
21-Oct	15	Option Pricing II	
26-Oct	16	Midterm Exam	
28-Oct	17	Currency Exchange Problem (*)	3 due, 4 out
2-Nov	18	Optimal Execution I	
4-Nov	19	Optimal Execution Problem II	
9-Nov	20	Optimal Consumption (*)	
11-Nov	21	Alternative Investment Planning (*)	4 due
16-Nov	22	Blending Forecasts (*)	
18-Nov	23	Bond Pricing (*)	
23-Nov	24	Final Presentation	
25-Nov		Final Exam Week	

Note: Lecture marked with (*) denotes an interactive, project-based lecture. In these sessions, students will tackle an open-ended problem using a provided dataset. After a collaborative brainstorming session to propose various modeling methodologies, the class will collectively test and evaluate the approaches. This format is designed to mirror the collaborative and iterative nature of data science work in industry.

Mapping of Course ILOs to Assessment Tasks

Assessed Task	Mapped ILOs	Explanation
Mid-Term	ILO1, ILO3	This task assesses students' ability to formulate financial optimization problems using linear and convex optimization techniques (ILO1) and analyze sensitivity/robustness in financial models under market uncertainty (ILO3). The exam focuses on theoretical understanding and problem-solving without computational implementation.
Assignments	ILO1, ILO2, ILO3, ILO4	These tasks evaluate students' proficiency in modeling financial scenarios (e.g., portfolio selection) with optimization techniques (ILO1), implementing models computationally using Python solvers like CVXPY (ILO2), assessing robustness against market changes (ILO3), and applying techniques to

		advanced topics (e.g., option pricing) (ILO4). Assignments bridge theory and practical implementation.
Final project & presentation	ILO1, ILO2, ILO3. ILO4	The project assesses students' ability to integrate course concepts by formulating a real-world financial optimization problem (ILO1), implementing a computational solution (ILO2), analyzing model sensitivity/robustness (ILO3), and presenting applications to advanced topics (e.g., optimal execution or bond pricing) (ILO4). The presentation evaluates clarity, depth, and practical relevance.

Grading Rubrics

Use the following rubrics to guide you for the assessment tasks that you submit in this course.

Midterm Exam Rubric

Criteria	Excellent (A)	Good (B)	Satisfactory (C)	Marginal (D)	Fail (F)	Mapping to ILOs
Problem Formulation	Accurately defines financial optimization problems (e.g., Markowitz portfolio) with clear assumptions and context.	Defines problems correctly but lacks depth in assumptions or financial context.	Basic problem formulation with minor errors or oversimplifications.	Problem statement is vague or missing key elements (e.g., constraints).	Fails to formulate the problem or misinterprets requirements.	ILO1
Mathematical Rigor	Derives solutions with precise mathematical reasoning (e.g., Lagrange multipliers, convexity proofs).	Correctly applies methods but with minor logical gaps or notation errors.	Uses valid techniques but struggles with derivations or justification.	Limited mathematical coherence; major errors in methodology.	No valid mathematical approach or solution.	ILO1, ILO3
Sensitivity Analysis	Thoroughly analyzes how	Identifies key sensitivities but lacks	Basic sensitivity discussion with	Minimal or incorrect	No analysis of	ILO3

	changes in parameters (e.g., risk tolerance) impact optimal solutions.	depth in interpretation.	superficial insights.	sensitivity analysis.	parameter impacts.	
Clarity & Organization	Solutions are logically structured, notationally consistent, and professionally presented.	Clear presentation with minor organizational issues.	Disorganized or unclear in parts but readable.	Poorly structured; difficult to follow.	Incoherent or illegible work.	--

Assignments Rubric

Criteria	Excellent (A)	Good (B)	Satisfactory (C)	Marginal (D)	Fail (F)	Mapping to ILOs
Theoretical Solutions	Correctly formulates problems and justifies methods with rigor (e.g., duality, KKT conditions).	Valid solutions but limited justification or minor errors.	Solutions are functionally correct but lack depth or contain errors.	Major flaws in problem setup or methodology.	No valid theoretical solution.	ILO1, ILO3
Coding Implementation	Efficient Python code (CVXPY/SciPy) with robust error handling, visualization, and documentation.	Functional code with minor inefficiencies or sparse comments.	Code runs but lacks optimization or clarity (e.g., hardcoded values).	Partial or buggy implementation; no documentation.	No working code or irrelevant submission.	ILO2
Analysis & Insights	Deep sensitivity analysis, robustness checks, and real-world interpretations (e.g., trade-offs).	Adequate analysis but limited exploration of edge cases.	Basic results summary without critical insights.	Superficial or incorrect conclusions.	No analysis provided.	ILO3, ILO4

Final Presentation Rubric

Criteria	Excellent (A)	Good (B)	Satisfactory (C)	Marginal (D)	Fail (F)	Mapping to ILOs
Problem Relevance	Addresses a complex, real-world financial problem with clear motivation and scope.	Practical problem but narrower scope or less innovative.	Generic problem with limited novelty or applicability.	Problem is trivial or lacks financial relevance.	No identifiable problem or off-topic.	ILO1, ILO4
Technical Depth	Combines advanced optimization techniques (e.g., robust MPC) with rigorous analysis.	Appropriate methods but simpler analysis (e.g., basic convex optimization).	Standard techniques with superficial analysis.	Overly simplistic or incorrect technical approach.	No valid technical content.	ILO1, ILO2, ILO3
Computational Quality	Polished Python implementation with scalable design, visualizations, and reproducibility.	Functional code with minor bugs or lacking scalability.	Code meets requirements but is messy or undocumented.	Partial or non-functional code.	No code or irrelevance.	ILO2
Presentation Clarity	Engaging delivery, professional slides, and clear articulation of trade-offs/insights.	Clear presentation with minor pacing or clarity issues.	Basic delivery; struggles to explain technical details.	Disorganized or unclear presentation.	No coherent presentation.	ILO4
Q&A Performance	Confidently addresses questions, defends methodology, and discusses limitations.	Answers questions adequately but lacks depth.	Basic responses with gaps in understanding.	Unable to answer most technical questions.	No meaningful engagement.	ILO3, ILO4

Final Grade Descriptors:

Grades	Short Description	Elaboration on subject grading description
A	Excellent Performance	Demonstrates mastery in formulating and solving financial optimization problems (e.g., portfolio selection, robust risk analysis) with precision. Implements Python solvers (CVXPY/SciPy) efficiently and creatively, exceeding assignment requirements. Exhibits deep sensitivity analysis and robustness

		insights, with exceptional clarity in connecting theory to real-world applications (e.g., option pricing, optimal execution). Final project showcases originality, rigor, and professional-grade solutions.
B	Good Performance	Shows strong understanding of optimization techniques (linear/convex) and their financial applications. Competently implements models in Python, meeting assignment criteria. Analyzes market uncertainty and sensitivity adequately but with minor gaps. Final project demonstrates solid analysis and execution, though with limited innovation or depth in advanced topics (e.g., bond pricing).
C	Satisfactory Performance	Achieves basic competency in modeling financial problems and using optimization tools. Python implementations are functional but lack efficiency or elegance. Struggles with robustness analysis or advanced applications. Final project addresses core requirements but lacks thoroughness or real-world relevance.
D	Marginal Pass	Displays threshold knowledge of optimization concepts (e.g., Markowitz portfolio) but struggles with formulations or computational implementation. Limited ability to assess sensitivity or adapt models to uncertainty. Final project meets minimal standards but contains significant errors or omissions.
F	Fail	Fails to model or solve basic financial optimization problems. Python implementations are incomplete or non-functional. No meaningful analysis of robustness or financial applications. Final project is inadequate or missing. Does not meet course learning outcomes.

Course AI Policy

The use of Generative AI is permitted and requested to assist students with brainstorming, drafting, and writing their papers.

Communication and Feedback

Assessment marks for individual assessed tasks will be communicated via Canvas within two weeks of submission. Feedback on assignments will include comments on strengths and areas for improvement. Students who have further questions about the feedback including marks should consult the instructor within five working days after the feedback is received.

Required Texts and Materials

Convex Optimization, Stephen Boyd and Lieven Vandenberghe, Cambridge University Press (Publicly available online)

Daniel P. Palomar (2025). Portfolio Optimization: Theory and Application. Cambridge University Press. [portfoliooptimizationbook.com]

Yiyong Feng and Daniel P. Palomar. A Signal Processing Perspective on Financial Engineering. Foundations and Trends in Signal Processing, Now Publishers, 2016.

[<https://palomar.home.ece.ust.hk/papers/2016/Feng&Palomar-FnT2016.pdf>]

Academic Integrity

Students are expected to adhere to the university's academic integrity policy. Students are expected to uphold HKUST's Academic Honor Code and to maintain the highest standards of academic integrity. The University has zero tolerance of academic misconduct. Please refer to [Academic Integrity | HKUST – Academic Registry](#) for the University's definition of plagiarism and ways to avoid cheating and plagiarism.