Financial Engineering

Course Description

This course provides an introduction to financial engineering. The course covers the following topics: asset pricing theory and its applications, stochastic calculus, financial optimization, market equilibrium, market frictions, dynamic trading strategies, and risk management.

Pre-requisites

Prerequisites include 15.401 or 15.415. In addition to formal prerequisites, this course assumes solid background in calculus, probability, statistics, and programming at the advanced undergraduate level. It also contains a substantial coding component. Course materials and review sessions will primarily use R. Students are encouraged but not required to use R for assignments and projects.

Class Time and Location

Fall 2017, 2:30-4PM, Monday and Wednesday, E62-223.

Lecture Notes

Lecture notes will be available on Stellar (http://stellar.mit.edu) before each class. Additional readings will be suggested for each topic.

Reference books


Course Requirements and Grading

Course requirements include class attendance and participation, homework assignments, a midterm exam and a final exam. The following weighting scheme will be used to determine the course grade:
10%  Class participation
25%  Assignments
20%  Midterm exam
45%  Final exam

Recitations

The TA will hold regular recitations to review class material and assignments and to present additional exercises.

Instructors

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Administrative Assistants

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Teaching Assistant

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Course Outline
(This version: September 6, 2017)

H1: Wang –

1. Asset Pricing Theory and Applications
   - Stochastic modeling in finance
     - State-space model
     - Securities market
     - Trading strategies
     - Complete markets and state prices
     - Arbitrage
   - Monte Carlo simulations
   - Arbitrage pricing
     - Fundamental Theory of Asset Pricing (FTAP)
     - Pricing by arbitrage
     - State price density (SPD)
     - Risk-neutral pricing
     - Relating physical and risk-neutral probabilities
     - Martingales
   - Applications
     - Return, risk and dynamic trading
     - Derivative pricing, hedging and replication
     - Stochastic volatility
     - Credit risk and pricing
     - Interest rate models
     - Linear factor models

2. Stochastic Calculus and Financial Modeling
   - Brownian motion
   - Stochastic calculus
   - Financial modeling in continuous-time
• Dynamic trading, replication and hedging in continuous-time
• FTAP in continuous-time
• Risk-neutral pricing in continuous-time
• Applications
  – Black-Scholes-Merton model for option pricing
  – Arbitrage pricing
  – Interest rate models

3. Financial Optimization

• Expected utility theory
• Consumption-saving/portfolio decisions
• Optimal consumption-portfolio choice under complete markets
• Optimal consumption-portfolio decision in continuous time
• Simulation approach to dynamic optimization
• Optimization with constraints
• Applications
  – Dynamic portfolio choice
  – Asset-liability management
  – Trading strategies with constraints: margin/leverage, draw-downs

Midterm Exam: Monday, October 30, 2017 (in class)

H2: Kogan –

4. Market Equilibrium in Frictionless Markets

• Equilibrium analysis
• Equilibrium asset-pricing models
  – Capital Asset Pricing Model (CAPM)
  – Intertemporal Capital Asset Pricing Model (ICAPM)
  – Consumption-based Capital Asset Pricing Model (CCAPM)
• Applications
  – Fundamental determinants of interest rates
  – Equilibrium dynamics of wealth distribution and return predictability

5. Equilibrium Models with Frictions

• Asymmetric information
  – Rational expectations and market efficiency: Grossman-Stiglitz model
  – Market micro-structure: Kyle model, Glosten-Milgrom model

• Incomplete markets and constraints
  – Liquidity risk
  – Limits to arbitrage
  – Background risk
  – Models with disagreement and mispricing

6. Dynamic Strategies and Market Frictions

• Dynamic programming

• Numerical approach to dynamic programming: finite-difference and simulation methods

• Applications:
  – Optimal order execution
  – Markov Chain Monte Carlo for derivatives with early exercise
  – Dynamic portfolio strategies with margin constraints and liquidity risk
  – Robust optimization

• Risk management

**Final Exam** (MIT Final Exam schedule)