M.I.T. **15.460**
Sloan School of Management **Financial Engineering**
Kogan, Lo and Wang **Fall 2016**

Financial Engineering

Course Description

This course provides an introduction to financial engineering. The course covers the following topics: asset pricing theory and its applications, financial optimization, market equilibrium, market frictions, dynamics trading strategies, risk management, and selected advanced topics in financial engineering and technology.

Pre-requisites

Pre-requisites include 15.401 or 15.415; 15.437 is a co-requisite (except with the waiver permission from the instructor of 15.437). In addition to formal prerequisites, this course assumes solid undergraduate-level background in calculus, probability, statistics, and programming. It also contains a substantial coding component. Course materials and review sessions use R. Students are encouraged but not required to use R for assignments and projects.

Class Time and Location

Fall 2016, 2:30-4:00PM, 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

- Danthine, Jean-Pierre and John Donaldson, *Intermediate Financial Theory* (3e), Elsevier Academic Press.
- Shreve, Steven, *Stochastic Calculus for Finance I*, Springer, 2004.
- Back, Kerry, *A Course in Derivative Securities: Introduction to Theory and Computation*, Springer, 2005.
- Shreve, Steven, *Stochastic Calculus for Finance II*, Springer, 2010.

Course Requirements and Grading

Course requirements include attendance and participation in class, homework assignments, and a final exam. The following weighting scheme will be used to determine the course grade:

10%	Class participation
15%	Assignments
25%	Midterm exam
50%	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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Teaching Assistant

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Course Outline

(This version: September 6, 2016)

1. **Asset Pricing Theory and Applications** (Wang)

   - 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 (SDP)
     - Risk-neutral pricing
     - Relating physical and risk-neutral probabilities
     - Martingale
   - Continuous-time models
     - Brownian motion
     - Stochastic calculus
     - Payoff and price processes in continuous-time
     - Dynamic trading, replication and hedging in continuous-time
     - FTAP in continuous-time
     - Risk-neutral pricing in continuous-time
   - Applications
     - Return, risk and dynamic trading
     - Derivative pricing, hedging and replication
     - Stochastic volatility
     - Credit risk and pricing
     - Interest rate models
     - Linear factor models

2. Financial Optimization (Wang)

- Expected utility theory
- Consumption-saving/portfolio decisions
- Dynamic programming
- Optimal consumption-portfolio choices under complete markets
- Optimal consumption-portfolio decision in continuous time
- Optimization with constraints
- Applications
  - Dynamic portfolio choices
  - Optimal order execution
  - Optimal trading strategy with constraints: margin/leverage, draw-downs
  - Asset-liability management

3. Market Equilibrium (Wang)

- 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
  - Equilibrium models for interest rates (Cox-Ingersoll-Ross etc)
  - Equilibrium implications on market leverage, asset allocation, risk premium and volatility

Midterm Exam: October 31 (Monday), 2016

4. Equilibrium Models with Frictions (Kogan)

- 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
  - Heterogeneous beliefs and mispricing

5. Dynamic Strategies and Market Frictions (Kogan)

- Methodology: numerical approach to dynamic programming
- Optimal order execution
- Dynamic portfolio strategies with margin constraints and liquidity risk
- Risk management: basis risk, liquidity risk

6. Advanced Topics in Financial Engineering and Technology (Lo)

- Spectral portfolio theory
- The psychophysiology of trading behavior
- The role of financial engineering in the financial crisis of 2008
- Systemic risk measurement and macroprudential policy
- Can financial engineering cure cancer?

Final Exam (MIT Final schedule)