M.I.T. **15.456**
Sloan School of Management **Financial Engineering**
Kogan and Wang **Fall 2017**

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

- 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 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)