Course Description
This is a 3 credit course. This course provides an introduction to continuous-time finance for graduate students who are interested in learning classical math finance, and major in Statistics, Economics, Mathematics, or Business Finance. My goals are (i) to help students develop necessary mathematical tools to understand continuous-time finance models; (ii) to review some major results of continuous-time finance; (iii) to introduce students to some active research areas in financial statistics, including machine learning and Bayesian analyses. The topics that are planned to be covered include: (more details are given in the second page)

- Chapter 1: Review of Stochastic Calculus
- Chapter 2: Black-Scholes option pricing model
- Chapter 3: Option Pricing with Stochastic Volatility and Jumps
- Chapter 4: Term Structure of Interest Rates
- Chapter 5: Dynamic Term Structure Models and Heath-Jarrow-Morton
- Chapter 6: Credit Risk Modeling: The Structural Approach
- Chapter 7: Financial Modeling Using Levy Processes
- Chapter 8: Machine Learning and Markov Chain Monte Carlo Methods for Asset Pricing

Prerequisites
Stat 641, or Stat 642, or a stochastic process course (like Stat 554). Students with equivalent background should request permission of the instructor.

Course Materials
I will draw materials from different books and articles in my lectures. Therefore, there is no single textbook that is required for this course. Studying original academic articles is an integral part of Ph.D. education. I will recommend some important articles for each major topic covered in the course to read in the reference list. The following books are classical math finance books, and are recommended for this course.


Grading
Your grade of the course will be based on 5-6 homework assignments (80%) and a final course presentation (20%) of important articles in the area.
Chapter 1: Review of Stochastic Calculus
  1.1 Introduction to stochastic modeling
  1.2 Brownian Motion
  1.3 Stochastic integration
  1.4 Ito’s formula
  1.5 Applications of Ito’s formula

Chapter 2: The Black-Scholes Option Pricing Model
  2.1 Dynamic hedging and the Black-Scholes PDE
  2.2 Girsanov theorem and martingale pricing
  2.3 Feynman-Kac solution
  2.4 Black-Scholes action

Chapter 3: Option Pricing with Stochastic Volatility and Jumps
  3.1 Limitations of the log-normal model
  3.2 Jump-diffusion models
  3.3 Stochastic volatility (SV) model
  3.4 Stochastic volatility and jump (SVJ) models

Chapter 4: Term Structure of Interest Rates
  4.1 Spot rates, forward rates
  4.2 Gaussian spot rate models
  4.3 Cox, Ingersoll and Ross model

Chapter 5: Dynamic Term Structure Models and Heath-Jarrow-Morton
  5.1 Affine term structure models
  5.2 Quadratic term structure models
  5.3 Heath-Jarrow-Morton models
  5.4 LIBOR market models

Chapter 6: Credit Risk Modeling: The Structural Approach
  6.1 Merton (1974)’s model
  6.2 Models with stochastic interest rates and stationary leverage ratios

Chapter 7: Financial Modeling Using Levy Processes
  7.1 Motivation
  7.2 Time-changed Levy processes
  7.3 Option pricing under Levy processes
  7.4 Some empirical evidences

Chapter 8: Machine Learning and Markov Chain Monte Carlo Methods for Asset Pricing
  8.1 Briefly introduce some MCMC methods implemented in asset pricing
  8.2 Briefly introduce some machine learning methods implemented in asset pricing