1. **Course Description**

One part of this course is an introduction to theoretical continuous time non-arbitrage theory, while the other part covers some methodologies used in empirical asset pricing literature. Emphasis is given to the fixed income literature. The topics covered are:

1) Ito’s lemma. Brownian motion. Markov processes. PDE’s. F-K.
2) No-arbitrage. Black and Scholes-Merton model. The equivalence between non-arbitrage and the existence of an equivalent martingale measure.
3) The non-parametric estimation of the SPD.
4) Mathematical tools used to price derivatives: Monte Carlo Simulation, Partial Differential Equations, and Binomial Trees.

The course is intended for Ph.D. students interested in asset pricing. This course is very quantitative and requires basic familiarity with a variety of mathematical concepts, such as partial differential equations.

2. **Course Objectives**

After completing this course you should be able to:

1) Use the general non-arbitrage framework to price derivatives.
2) Apply continuous time techniques to models in Finance.
3) Use econometric techniques such as Monte Carlo simulation, GMM, kernel regression, maximum likelihood.
4) Describe the current issues in the term structure and in the derivatives literature

3. **Prerequisites**

Students must be comfortable with calculus and statistics. Many homework assignments will require the use of some statistical package. You may use any statistical package you wish. For those of you that intend to do serious research in this field, I recommend Gauss or Matlab. The course is very demanding.

4. **Course Requirements**

The course requirements consist of problem sets and a take home final exam.
5. **Problem Sets**

Problem sets contain questions and computer exercises meant to help you practice on your own. The problem sets are individual. You may discuss the homework questions with your colleagues; however, you are required to turn in your individual homework. A penalty of 10% of the problem set grade will be applied to late problem sets.

I expect you to read all the required reading material. If you do not have time to read all the required readings then you should consider sharing paper summaries with your colleagues. I will ask questions about the papers in the exam and in the problem sets.

6. **Questions and Office Hours**

You can ask questions by e-mail (jduarte@u.washington.edu).

I welcome your feedback on every aspect of the course. If you would prefer to be anonymous drop a note in my MKZ 268 mailbox. Send me e-mails with questions any time you wish. If you think that you will need extended help, please e-mail me to make an appointment.

I encourage you to participate in the class. Don’t be shy about asking questions to clarify what we are discussing. Every lecture and the course as a whole builds on what we learned previously, so being lost gets very costly very quickly. At the other extreme, a good sign that you are asking too many questions is when the rest of the class starts noticing and the value of the class gets reduced for the other student.

7. **Exams and Grading**

The final will be graded from 0 to 40 points. Your course grade is:

\[
\frac{0.5 \times \text{final grade} + 0.5 \times \text{problem sets grade}}{10}
\]

The final exam is a take home exam. The questions for this exam will be given to you in the last class of the course (Wednesday, March 12th). The final exam is strictly individual. You must turn in your answers directly to me until Wednesday, March 19th at 5:00pm. If you cannot find me, you may leave your answers below the door of my office (MKZ 267).

The re-grading policy for the exam or problem set is:

1) If you think that a question in your exam or problem set was graded incorrectly, then write a very precise description of your concern and give it to me with your exam.
2) I will re-grade your entire exam (problem set). There is no guarantee that the grade initially assigned will not be lowered.
3) Re-grading will only be considered within seven days of your receiving your grade back.

8. **Class Attendance and Administrative Notes**

Class attendance is not mandatory. I expect you to arrive on time for the class but if you arrive late, please do so in way that does not disturb the class.

You may get class handouts in my web page.

9. **Academic Accommodations**

To request academic accommodations due to disability, please contact disabled Student Services, 448 Schmitz, (206) 543-8914 (V/TTY). If you have a letter from Disabled Student Services indicating that you
have a disability that requires academic accommodations, please present the letter to me so we can discuss the accommodations you might need in this class.

10. Texts

The following material is highly recommended in this course:


Duffie D., 2001, Dynamic Asset Pricing Theory 3rd edition (A book that all Ph.D. students interested in continuous time finance should have)

Hull, J., 2002, Options, Futures and Other Derivatives, 5th edition (A book that anyone interested in derivatives should have.)

Duffie D. and Singleton K., 2003, Credit Risk: Pricing, Measurement, and Management, 1st edition (a very recent book in a topic that has been receiving a lot of attention)


Campbell and Viceira, 2002, Strategic Asset Allocation, Portfolio Choice for Long Term Investors. (A good survey of a classic financial problem)

Reference books for researchers in empirical Finance

Hamilton, Time Series Analysis

Greene, Econometric Analysis

11. Course Outline and Readings

The readings marked with the sign “•” are required.

0) SAS by Lewis Thorson

1) Tools
   Probability Space Definitions, Indicator Functions, Expectations, LIE; Filtration, Stochastic process, Adapted process, Martingale, Brownian Motion; Markov process, Diffusion, SDE, Ito’s Lemma, Feynman-Kac, Fokker-Planck PDE, conditional density.

   Duffie Appendix C to E
   Hamilton, 8.1, 8.3 14.1-14.2, 5.1-5.2

2) Market Efficiency. Consumption-based models and the equity premium puzzle.


   Constantinides, G., 2002, Rational Asset Pricing, JF, vol LVII, no.4

   Campbell et. al., 1996  p. 304 to p. 314.


Brav, Constantinides, Geczy, 2002 Asset Pricing with Heterogeneous Consumers and Limited Participation: Empirical Evidence, *JPE*, vol. 110, no. 4


3) A First Attack into the Black and Scholes formula

   - Continuous time derivation of the formula
   - Limitations of the Model and Extensions
   - Estimating Volatility Parameter


   - Merton, 1976, Option Pricing When the Underlying Stock Returns are Discontinuous, *JFE*.

   - Campbell et. al. chapter 9

   - Duffie chapter 5


4) Risk Neutral Probability Measure or Equivalent Martingale Measure

   - A generalized method of derivative pricing
   - The Risk Neutral Density
   - Implications for Binomial Trees
   - Nonparametric Estimation of the Risk Neutral Density

   - Aït-Sahalia and Duarte, 2003, Nonparametric Option Pricing under Shape Restrictions, forthcoming in the Journal of Econometrics

   - Breeden and Litzenberger, 1978, “Prices of State-Contingent Claims Implicit in Option Prices”, *Journal of Business*


   - Duffie chapter 6
5) Numerical Methods

- Trees
- Discretization of PDE’s
- Methods based on F-K

- Duffie chapter 12 from A to H

6) One Factor Term Structure Models

- Vasicek and CIR models
- Non-parametric estimation of the short-term interest rate
- Monte Carlo simulation as a tool to test estimators

- Duffie chapter 7 from A to G

- Campbell et. al., chapter 10


- Aït-Sahalia, Testing Continuous-Time Models of the Spot Interest Rate, 1996, RFS, 9, 385-426

- Pritsker, 1998, RFS, 11, 3, 449-487

7) Multifactor models

- PCA
- Multifactor affine models
- Generalization of the CIR model, Vasicek, general affine models
- Quadratic Term Structure Models
- Tests of Affine Term Structure Models
- Objective of HJM

- Duffie chapter 7 from H to K


8) Some Interest Rate Derivatives: Swaptions and Caps Puzzle


9) Corporate Securities


- Duffie Chapter 11