

# Math 457. Spring 2017. Syllabus.

Instructor: Rajinder Mavi

Office: Wells Hall C321

Office Hours: M Tu 3:30 - 4:30pm

Lecture: MWF 12:40pm - 1:30pm, Wells Hall A332

**Assigned Text:** 'Mathematics for Finance: An Introduction to Financial Engineering' Marek Capiński and Tomasz Zastawniak. Second edition.

This course analyses the archtypal models of securities and contracts which are traded in markets today. In particular, the CAPM model, the binomial model and the Black Scholes model. The material will also help prepare the student for portions of the SoA MFE, but this is *not* a 'test prep' course.

## Grading:

- \* Two exams - 15% each.
- \* Cumulative final - 25%.
- \* Homework and Quizzes 25%: Homework will be assigned approximately every week. It will be collected, a fraction of the answers will be read by the grader to determine the score. Late homework may be turned in, for every day it is late, 5% of the total grade is lost. (Therefore if it is 2 days late and you score 85% you will earn 75%.)  
...  
If the material in the homework needs reinforcement I will make a quiz of it. If there is great popular demand for regular quizzes we can do that, otherwise quizzes will be given on an occasional basis. Notification of a quiz will be a week in advance.
- \* Computational project 10%: I will assign a project involving simulating a given stock and assessing values of options on that stock. Simulations can be done in Excel or Matlab (either of which are preferred), or programming language of your choice.
- \* Class participation - 10% : I will attempt to regularly ask questions in class from randomly chosen students, intelligent answers will earn points. (The questions will be gimmees - the purpose is to keep the class environment lively)

## Misc.

- \* Homework presentation. Take the time to write out the final homework well and neatly. Homework which is illegible/unclear will be severely marked down.
- \* Collaboration. You are encouraged to work in pairs and groups on the homework assignments, this will help you to do a better job on the homeworks as well as give you an opportunity to learn/practice the concepts and vocabulary terms used in this course (there will be many).
- \* Electronics. You are free to use what ever electronic aides you wish when you are working on the homework - calculators, computers etc. But none but the most basic (eg Casio SL-300SV) are allowed on the exams.
- \* Grading issues. If there is an issue with a grading outcome you must bring it to my attention in a timely manner. I will not entertain requests to regrade an assignment at the end of the semester.
- \* The text contains an introductory chapter and a discussion section in each chapter, we will not cover these in class, but I suggest you read over them on your own.

**Goals:**

- Model Securities on the market and price derivatives of the market.  
Here *securities* refer to Bonds, Stocks and Commodities, *derivatives* are instruments whose value are given by functions of values of securities.
- **EG:** Suppose we want to acquire 100 barrels of oil on Jan 1st 2018. The current price is \$50 per barrel. How much should we pay for right to buy oil at a price of \$50 per barrel on Jan 1st 2018.
  - \* We have to deal with interest, ie time value of money. That is, if interest rate is 1% then we have to invest ~\$4950 today to have money to exercise the contract at maturity.
  - \* We have to deal with volatility of price of oil. If price of oil is \$60 per barrel at maturity then we will exercise contract, if price of oil is \$40 per barrel at maturity then the contract is worthless. - We can buy the oil cheaper from someone else.

**Prerequisites:**

(MTH 309) 'Linear Algebra'

(MTH 235 or MTH 340 or MTH 347H) 'Ordinary Differential Equations'

(STT 441 or STT 351) 'Probability'

Probability concepts are fundamental to this course. We will deal with probability spaces where we will define one or more *probability measures*. The probability spaces are generally financial model over multiple time steps. We will consider the fixed time *marginals* of the measures. We will review material where necessary.

Differential equations are useful in this course as they provide the most fundamental example of the changing value of money over time - interest. Moreover it is our goal in this course to familiarize ourselves with powerful models of financial objects such as call options and these have incarnations as partial differential equations.

The basic models in this course (eg binomial model) generate systems of equations and it is therefore helpful to have facility to approach these found in a linear algebra course.

1. Linear Algebra
  - a. Eigenpairs of matrix
  - b. Diagonalization of matrix
2. ODEs
  - a. Time value of money - value of money changes with respect to time
  - b. Solve:  $\frac{d}{dt}y(t) = f(t)y(t)$ .
3. PDEs (Introduction)
  - a. Value of options - value of option changes with respect to time and value of underlying security
  - b. Solve (The heat equation):  $\frac{\partial}{\partial t}y(t, x) = f(x) \frac{\partial}{\partial x} \frac{\partial}{\partial x} y(t, x)$ .
4. Probability.
  - a. Probability space/ Random Values
  - b. Important examples: Bernoulli and Gaussian
  - c. Moments - (Expectations + Variance) / Joint distribution / Marginals / Independence / Covariance Conditionals / Central Limit Theorem

**Topics:**

1. Time value of money
2. Annuities etc.
3. (Coupon) Bonds
4. Risky Securities
5. CAPM
6. Arbitrage
7. Forward
8. Options
9. Binomial model (Simplest security model)
10. Pricing of Options 'Martingales'
11. General Security Models - completeness
12. Continuous value models
13. Stochastic Calculus
14. Black Scholes model
15. Greeks
16. Random interest rates

**Important dates**

- Monday (01/09/2017) First class.
- Monday (01/16/2017) Martin Luther King Day - University open, classes canceled.
- Monday (01/16/2017) to Friday 01/20/2016. Enrollment Changes. Students go to Undergraduate office, C212 Wells Hall for Mathematics enrollment changes. (Late adds, section changes)
- Monday (01/30/2017) First midterm
- Wednesday (03/01/2017) Middle of Semester. Last day to drop a course without a grade being reported.
- Monday (03/06/2017) to Friday (03/10/2016) Spring Break
- Monday (03/28/2017) Second midterm
- Friday (04/28/2017) Last day of classes.
- Thursday (05/04/2017) 12:45pm - 2:45pm, Final Exam, Location: A332 Wells Hall