

## ECES 490: Special Topics: Financial Engineering III: Optimal strategies for repeated games (Spring, 2011)

---

*It is almost always gambling that enables one to form a fairly clear idea of a manifestation of chance; it is gambling that gave birth to the calculus of probability; it is to gambling that this calculus owes its first faltering utterances and its most recent developments; it is gambling that enables us to conceive of this calculus in the most general way; it is, therefore, gambling that one must strive to understand, but one should understand it in a philosophic sense, free from all vulgar ideas.*

(Louis Bachelier (1870 – 1946))

### Class locations and times

Instructor	Steven Weber (Dept. of ECE)
Instructor email	sweber@ece.drexel.edu
Lecture times	9-9:50am on Monday, Wednesday, Friday
Lecture room	Alumni Engineering Labs 279
Instructor office hour	Thursdays 9am (Bossone 211)

### Description

Covers strategies for repeated games, from gambling at casinos to playing the stock market to auction bidding. Topics include:

- The gambler's ruin problem: difference equations, first-step analysis (Packel §7.4) and the martingale (Epstein Chapter 3)
- Red-black roulette wheel betting: optimality of bold play for subfair games (Dubins and Savage Chapter 5)
- Optimal portfolio growth: the Kelly criterion, log utility and the log-optimal strategy, connections with the Black-Scholes equation (Luenberger Chapter 15)
- Multi-armed bandit (Epstein Chapter 5)
- Parrondo's paradox (Epstein Chapter 4)
- Auction theory (Krishna Chapter 2)

### Optional supplemental resources (listed roughly in order of relevance):

- *The doctrine of chances*, S. N. Ethier, Springer, 2010.
- *The theory of gambling and statistical logic*, 2nd ed., R. A. Epstein, Academic Press, 2009.
- *Auction theory*, V. Krishna, Academic Press, 2002.
- *The mathematics of games and gambling*, 2nd ed. E. Packel, Mathematical Association of America, 2006.
- *Investment science*, D. G. Luenberger, Oxford University Press, 1998.
- *An elementary introduction to mathematical finance*, 2nd ed., S. M. Ross, Cambridge University Press, 2003.
- *Inequalities for stochastic processes – how to gamble if you must*, L. E. Dubins and L. J. Savage, Dover, 1965.

## Course logistics

- Website
  - We will use Drexel's **BB/Vista** course management website for this class extensively.
  - I will mail you important information regarding the class through this system. Please make sure you setup the system to forward BB/Vista emails to an account you check regularly.
  - Lecture notes, homework, solutions, etc. will be posted on the main course page, grouped by week.
  - The gradebook will hold your homework and midterm exam scores.
- Lectures
  - **Partial** lecture notes will be posted on the website **after** the lecture.
  - **Please** ask questions. If you are confused, then there is a very good chance someone else in the class is confused as well. Without questions I have little insight regarding class comprehension.
  - **Laptops** are not to be used during lecture without prior approval by the instructor. **Cell phones** are to be turned off or put in silent mode.
- Homework
  - HW is due **in class** one week after it is assigned.
  - HW may be handed in up to one week after the due date at a 50% penalty.
- Midterm and final exam
  - There will be two midterm exams on Friday April 22 and Friday May 20.
  - There will be no final exam.
  - Exams will consist of problems for you to solve that are similar to or extensions of homework problems.
  - Exams are closed-book and closed notes. You are allowed to bring in one  $8.5 \times 11$  inch page with notes on the front and back. This sheet of paper will be collected along with your exam.
  - I **strongly** prefer not to reschedule exams. If you have a compelling case you should give me as much notice as possible. Rescheduling requests will be reviewed on a case by case basis.
- Office hours
  - Office hours are available to you each week on Thursdays 9-10am.
  - Please come to office hours. Office hours are often a very under-utilized resource.

**Grading**

Your final numerical grade will be computed as follows.

Homework	40%
Midterm Exam	30%
Final Exam	30%

Your course letter grade will be assigned based on your final numerical grade as follows. The instructor may at his discretion curve course grades up (but not down).

95	100	A
90	94	A-
87	89	B+
83	86	B
80	82	B-
77	79	C+
73	76	C
70	72	C-
65	69	D+
60	64	D
0	59	F

**Academic Policies**

Academic integrity, plagiarism, cheating policy:	<a href="http://www.drexel.edu/provost/policies/academic_dishonesty.asp">http://www.drexel.edu/provost/policies/academic_dishonesty.asp</a> <a href="http://www.drexel.edu/studentlife/judicial/honesty.html">http://www.drexel.edu/studentlife/judicial/honesty.html</a>
Students with Disability Statement:	<a href="http://www.drexel.edu/ods/student_reg.html">http://www.drexel.edu/ods/student_reg.html</a>
Course drop policy:	<a href="http://www.drexel.edu/provost/policies/course_drop.asp">http://www.drexel.edu/provost/policies/course_drop.asp</a>

## Course calendar

D	Date	Lecture	Topic	HW due	HW assigned
M	3/28	Lecture1M	Course logistics and probability review		
W	3/30	Lecture1W	Probability review		
F	4/1	Lecture1F	Gambler's ruin (random walk)		HW1 assigned
M	4/4	Lecture2M	Gambler's ruin (random walk)		
W	4/6	Lecture2W	Gambler's ruin (random walk)		
F	4/8	Lecture2F	Gambler's ruin (random walk)	HW1 due	HW2 assigned
M	4/11	Lecture3M	Red-black roulette (subfair: bold play optimal)		
W	4/13	Lecture3W	Red-black roulette (subfair: bold play optimal)		
F	4/15	Lecture3F	Red-black roulette (subfair: bold play optimal)	HW2 due	HW3 assigned
M	4/18	Lecture4M	Red-black roulette (subfair: bold play optimal)		
W	4/20	Lecture4W	Red-black roulette (subfair: bold play optimal)		
F	4/22	Lecture4F	Red-black roulette (subfair: bold play optimal)		
M	4/25	Exam	Midterm Exam #1		
W	4/27	Lecture5W	Betting systems: the Martingale		
F	4/29	Lecture5F	Betting systems: the Martingale	HW 3 due	HW5 assigned
M	5/2	Lecture6M	Kelly betting (superfair: optimal growth rate)		
W	5/4	Lecture6W	Kelly betting (superfair: optimal growth rate)		
F	5/6	Lecture6F	Kelly betting (superfair: optimal growth rate)	HW5 due	HW 6 assigned
M	5/9	NO CLASS			
W	5/11	NO CLASS			
F	5/13	NO CLASS			
M	5/16	Lecture8M	The multi-armed bandit (two slot machines)		
W	5/18	Lecture8W	The multi-armed bandit (two slot machines)		
F	5/20	Exam	Midterm Exam #2	HW6 due	HW8 assigned
M	5/23	Lecture9M	Parrondo's paradox (subfair to superfair)		
W	5/25	Lecture9W	Parrondo's paradox (subfair to superfair)		
F	5/27	Lecture9F	Auction theory (format, bidding, payment, revenue)	HW8 due	HW9 assigned
M	5/30	NO CLASS	MEMORIAL DAY HOLIDAY		
W	6/1	Lecture10W	Auction theory (format, bidding, payment, revenue)		
F	6/3	Lecture10F	Auction theory (format, bidding, payment, revenue)	HW9 due	
M	6/6	Lecture11M	Auction theory (format, bidding, payment, revenue)		