Syllabus
Mathematical Foundations of Finance
Spring 2016

Instructor:	Professor Johan Walden
office:	F655
email:	walden@haas.berkeley.edu
web:	http://www.haas.berkeley.edu/faculty/walden.html
class time:	Tuesdays, 6 p.m. – 9:30 p.m.

gsi: TBA

email: HAASMFE.MATH@gmail.com

overview: The aim of this course is to bridge the gap between mathematics at the undergraduate level, and the more advanced mathematical treatments often used in quantitative finance. The course covers mathematical formalism of calculus, linear algebra, differential equations and probability theory, with applications to several important areas of finance. The mathematical rigor is "one step beyond" what is typical in undergraduate courses. The overall goal of the course is to provide a good financial and economic understanding of several key mathematical concepts that are important in quantitative finance. After the course, students should be able to read and follow the mathematical arguments of many (not too technical) research papers in finance journals, such as the Journal of Finance, Journal of Financial Economics, and Journal of Portfolio Management. Students will also be prepared to digest more advanced courses of quantitative finance that cover, e.g., risk management, portfolio optimization, derivatives, and computational methods.

The course requires a background in calculus and linear algebra at the advanced undergraduate level. Especially given the scope and limited number of hours of the course, a working knowledge of standard concepts, like derivatives and integrals, is a prerequisite; these are concepts that we will then cover in further detail. Statistics and empirical methods will be touched upon when discussing applications, but are not the course's focus.

Reference texts:

- Rudin W., Principles of Mathematical Analysis, 3rd Edition, McGraw Hill.
- Golub G.H. and Van Loan C.F., Matrix Computations, 4th Edition, Johns Hopkins
- Simmons G.F. and Robertson J.S., Differential Equations with Applications and Historical Notes, 2nd Edition, McGraw Hill.

These are all excellent text books, which I recommend. Building a library of good reference books is one of the wisest investments a student can make! However, the books are listed in order of priority for this course: The material in Rudin will be most extensively covered; we will use some parts of Golub and Van Loan, and will spend less than a lecture on the material covered by Simmons. The fairly comprehensive course slides (together with the Internet) may even be sufficient, although this is not a recommended approach.

The material (assignments, slides, source code, solutions, and all other material) in the course is proprietary. Posting of material on the web is strictly prohibited and will lead to legal action.

In addition to the aforementioned references, we will discuss several classical and more recent published papers, to see how the mathematical concepts in the course relate to finance and economics. These papers are linked to here but also available for purchase on Study.Net:

1. Pratt J.W. Risk aversion in the small and in the large, *Econometrica*, 32, 1964, 122-136.
2. Lamont O. A. and Thaler R. H., Can the market add and subtract? Mispricing in tech stock carve-outs, *Journal of Political Economy*, *111(2)*, 2003, 227-268.
3. Litterman R. and Scheinkman J., Common factors affecting bond returns, *Journal of Fixed Income*, 1991, 55-61.
4. Ross S. The recovery theorem, *Journal of Finance*, 70, 2015, 615-648.
5. Nash J., Non-cooperative games, *Annals of Mathematics*, 54, 1951, 286-295.
6. Markowitz H., Portfolio selection, *Journal of Finance*, 7(1), 1952, 77-91.
7. Samuelson P.A., General proof that diversification pays, *Journal of Financial and Quantitative Analysis*, 2(1), 1967, 1-13 (requires JSTOR membership for download).
8. Black F. and Scholes M., The Pricing of Options and Corporate Liabilities, *Journal of Political Economy*, 81, 1973, 637-654.
9. Cox J.C., Ross S., and Rubinstein M., Option pricing: a simplified approach, *Journal of Financial Economics*, 7, 1979, 229-263.

homepage: We will use bCourses and Study.Net

assignments: There are eight mandatory assignments, which usually cover exercises related to finance, although their focus is mathematical You are encouraged to solve and hand in assignments individually, since this has proven to lead to the most thorough learnings experience. However, you are allowed to work in a group of two students (no more than two!), should you wish to. If you choose to work in a team, you **must** provide this information on the front page of your assignment. Otherwise you will receive **no credit. Both students in a group are responsible for the complete assignment. Working in a group should foster joint problem solving, *not* be a way of dividing the assignment in half!** Assignments should be submitted electronically, and on time, via **bCourses**. Detailed instructions are provided on the front page of each assignment.

Students are allowed to consult all the material provided in the course (lecture notes, text books, etc.), as well as the Internet, but are not allowed to use any material that – even remotely – resembles a "solution" to the assignment. If there is any doubt, please contact the instructor. Also, students are allowed, and encouraged, to discuss the material and assignments, e.g., in the bCourses chat room. However, assignments should be solved individually (or in a teams of two, see above), and the provision of solutions or detailed tips to another student is strictly prohibited.

We have a strict policy on submission deadlines. Assignments received up to 24 hours late get a point deduction of 50%. Assignments received more than 24 hours late get a 100% deduction.

The following concepts will be covered in the assignments:

1. Sets, number systems and functions
2. Sequences and series, continuity and differentiation
3. Linear algebra and matrices
4. Eigenvectors and spectral theory
5. Integration
6. Multidimensional calculus and optimization
7. ODEs and PDEs
8. Probability theory and stochastic calculus

grades: The grades are Pass/No Pass. Students who complete the assignments satisfactorily and on time will receive a certificate that they have passed the course. All other students will not receive such a certificate. There is thus no “fail grade” in the course. Students who decide to “audit” the course therefore do not need to take any formal action, but are encouraged to send an e-mail to inform the professor about their decision.

exam: There is no exam.

gsi sessions: There will be no formal GSI sessions. Students should contact the GSI via email or through the bCourses chat forum with their questions.

lecture plan:	For simplicity, topics and readings are presented as full lectures. Some topics may run over to the next lecture. Consequently, we may fall behind the listed schedule a bit at some points and then catch up soon thereafter.	
January 19	topic: Sets, number systems, functions, and metric spaces. Rudin, ch. 1-2	**Lecture 1**
January 26	Due: **Assignment 1** topic: Sequences and series, continuity, limits, differentiation Taylor series Rudin, ch 3-5 Pratt (1964)	**Lecture 2**
Fabruary 2	Due: **Assignment 2** topic: linear algebra and matrices, eigenvalues Lamont and Thaler (2003)	**Lecture 3**
February 9	Due: **Assignment 3** topic: Eigenvalues, spectral theory, stochastic matrices Litterman and Scheinkman (1991) Ross (2014)	**Lecture 4**
February 16	Due: **Assignment 4** topic: Integration, multidimensional calculus Rudin, ch 6, 9 Nash (1952)	**Lecture 5**
February 23	Due: **Assignment 5** topic: Multidimensional calculus continued, optimization Rudin, ch 9 Markowitz (1952) Samuelson (1967)	**Lecture 6**
March 1	Due: **Assignment 6** topic: ODEs and PDEs Simmons Black and Scholes (1973)	**Lecture 7**
March 8 (may change)	Due: **Assignment 7** topic: Probability theory and stochastic calculus Cox, Ross, Rubinstein (1979)	**Lecture 8**
March 15	Due: **Assignment 8**	