**EE 512**

**STOCHASTIC PROCESSE FOR FINANCIAL ENGINEERING**

**(4 units) SPRING 2023**

**Instructor**: George P. Papavassilopoulos

**Office**: EEB 114

**Email:**

yorgos@usc.edu

**Office Hours**: Monday 1:00pm-3:00pm

Location: EEB 114

Please make appointment by email at least 3hrs earlier.

**TAs**:

|  |  |
| --- | --- |
| Wang, Yun Cheng | yunchenw@usc.edu |

Office Hours: Wednesday from 3pm to 5pm at PHE320

**Graders**:

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**Lecture**: Tue, Thu, 12:30-2:20pm, OHE 132 and DEN@Viterbi

**Discussion:** Friday 12:00am-12:50pm, [OHE](https://maps.usc.edu/?id=1928&reference=OHE)132 and DEN@Viterbi

**Webpages**:

DEN

**Prerequisites**: [EE 503](https://classes.usc.edu/term-20231/course/ee-503/) and 1 from ([EE 441](https://classes.usc.edu/term-20231/course/ee-441/) or [EE 510](https://classes.usc.edu/term-20231/course/ee-510/) or [EE 518](https://classes.usc.edu/term-20231/course/ee-518/))

**Grading**:

Assignments 20pts

Two Midterm Exams 25 pts+25pts=50pts

Final Exam 30pts

Letter Grade Distribution:

100.00-93.00 A 73.00 - 76.99 C

90.00 - 92.99 A- 70.00 - 72.99 C-

87.00 - 89.99 B+ 67.00 - 69.99 D+

83.00 - 86.99 B 63.00 - 66.99 D

80.00 - 82.99 B- 60.00 - 62.99 D-

77.00 - 79.99 C+ 59.99- F

The letter grade distribution table guarantees the minimum grade each student will receive based on their total final score.

**Catalogue Description**: Theory and applications of stochastic processes relevant to financial engineering. Stochastic processes, Brownian motion, martingales, stochastic calculus, Monte Carlo Simulations with financial application examples.

**Course Objectives**: The course focuses on reasoning with probabilistic uncertainty on problems of financial engineering. This involves acquiring the basic notions of stochastic processes especially those related to financial engineering and applying these skills to a wide range of problems.

**Exam Dates**:

**Midterm Exam** **1:** Thursday February 16, 12:30-2:20pm

**Midterm Exam** **2:** Thursday March 23, 12:30-2:20pm

**Final Exam**: Wednesday, May 10, 2-4pm

**Textbook**:

There is no required textbook for this class. The following textbooks are recommended. We will use mainly 1 and 4. We will also use some parts of 2,3, and 5. Handouts on certain topics will be distributed.

**Stochastic Processes and Probability**

1.Gubner, J. A., Probability and Random Processes for Electrical and Computer Engineers, Cambridge University Press, 2006. (Material from Chapters 10-14).

2. Louis-Pierre Arguin - A First Course in Stochastic Calculus-American Mathematical Society,2021. (Material from Chapters 2,3,4,7,10).

3.Durrett, R., Essentials of Stochastic Processes. Springer, 2016. (Material from Chapters 5,6).

Other books on Stochastic Processes and Probability:

S. R. S. Varadhan, Probability Theory, Courant Institute of Mathematical Sciences, New York University, August 31, 2000 (Notes)

Ross, S. M. Stochastic Processes.

Hsu, H. P. Schaum's outline of theory and problems of probability, random variables, and random processes. 2nd Ed. McGraw-Hill, 2014.

Ross, S. M. Simulation. Academic Press, 2013.

Athanasios Papoulis, S. Unnikrishnan Pillai - Probability, Random Variables and Stochastic Processes, McGraw-Hill ,4th ed.

Efron, B., Hastie, T., Computer Age Statistical Inference: Algorithms, Evidence, and Data Science, Cambridge University Press, 2016.

**Stochastic processes with emphasis on Financial Engineering**

4.Thomas Mikosch, Elementary stochastic calculus with finance in view, World Scientific Publications ,1998. (Material from Chapters 2-4).

5. Glasserman, P. Monte Carlo methods in financial engineering. Springer, 2013. (Material from Chapter 1.1,3,3.2,6.1).

Other books on Stochastic processes with emphasis on Financial Engineering:

Louis-Pierre Arguin, A First Course in Stochastic Calculus-American Mathematical Society,2021. (Material from Chapters 2,3,4,7,10).

Neftci Ali Hirsa and Salih N. (Auth.), An Introduction to the Mathematics of Financial Derivatives, Academic Press ,2014.

Kijima, Masaaki, Stochastic processes with applications to finance, CRC Press Taylor & Francis Group ,2013.

Shreve S., Stochastic Calculus for Finance I The Binomial Asset Pricing Model, Springer ,2005.

Shreve S., Stochastic calculus for finance II Continuous-time models-Springer (2004)

Efron, B., Hastie, T., Computer Age Statistical Inference: Algorithms, Evidence, and Data Science, Cambridge University Press, 2016.

**Homework**

Homework is assigned on a weekly /biweekly basis. No late homework will be accepted.

**Exam Policy**

No make-up exams.

Exceptions: In case of emergency a signed letter from your manager or physician must be submitted. This letter must include the contact of your physician or manager.

Midterms and final exams will be closed book and notes. No calculators are allowed nor are computers and cellphones or any devices that have internet capability. One letter size cheat sheet (back and front) is allowed for the midterms. Two letter size cheat sheets (back and front) are allowed for the final.

All exams are cumulative, with an emphasis on material presented since the last exam.

**Attendance:**

Students are expected to attend the lectures and discussion sessions and actively participate in class discussions.

**Important Notes**:

***Textbooks are secondary to the lecture notes and homework assignments.***

***By “Material covered and examined” is meant what is taught in class.***

Handouts and course material will be distributed.

**COURSE OUTLINE**

1.Overview of probability: Probability spaces, random variables, distribution functions, moment generating functions, expectation, conditional probability and expectation, probability inequalities, examples

2. Stochastic processes: Examples, notions of convergence, definition of a stochastic process, independence, zero-one laws, laws of large numbers, central limit theorems, stable laws

3. Wiener process, Poisson Process: Definitions and basic properties.

4. Renewal theory: Limit theorems, Wald’s identity, key renewal theorem, branching processes, regenerative processes\*, stationary point processes\*.

5. Discrete-time Markov chains: Definitions, Properties. Chapman-Kolmogorov equations, limit theorems, Ergodicity, time-reversible Markov chains,

6. Continuous-time Markov chains: Examples, birth-death processes, Kolmogorov differential equations, limiting probabilities, time reversibility,

7. Martingales: Definition, martingale differences, level crossings, stopping times, sub-martingales, super-martingales, and the martingale convergence theorem

8. Random walks: Definition, analysis using martingales, ruin problems, application in financial engineering.

9. Brownian motion and other Markov processes: Definition, continuity and non-differentiability of paths, hitting times, maximum variable and arc sin laws\*

10. Variations on Brownian motion: Examples of diffusions, backward and forward diffusion equations\*.

11. Stochastic integration: Definition of Itô integral, Itô lemma, Chain rule of differentiation, Stratonovich integral\*.

12. Stochastic differential equations and finance applications: Itô stochastic differential equations, solution by the Itô, Girsanov’s change of measure technique, Black-Scholes formula.

13.  Simulation: General techniques for simulating continuous random variables, simulating stochastic point processes, variance reduction techniques, sample complexity bounds, generating from the stationary distribution of a Markov chain, Markov Chain Monte Carlo.

**Note**: Items marked by \* will be covered only if time permits.

**Statement for Students with Disabilities**

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.– 5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776. IV. Statement on Academic Integrity USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one’s own academic work from misuse by others as well as to avoid using another’s work as one’s own. All students are expected to understand and abide by these principles. Scampus, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: http://www.usc.edu/dept/ publications/SCAMPUS/gov/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/. Academic Conduct Plagiarism - presenting someone else's ideas as your own, either verbatim or recast in your own words - is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Section 11, Behavior Violating University Standards https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriatesanctions/. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, http://policy.usc.edu/ scientific-misconduct/. Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the Office of Equity and Diversity http://equity.usc.edu/ or to the Department of Public Safety http://capsnet.usc.edu/department/department-public-safety/ online-forms/contact-us. This is important for the safety whole USC community. Another member of the university community - such as a friend, classmate, advisor, or faculty member - can help initiate the report, or can initiate the report on behalf of another person. The Center for Women and Men http://www.usc.edu/student-affairs/cwm/ provides 24/7 confidential support, and the sexual assault resource center webpage sarc@usc.edu describes reporting options and other resources.

**Support Systems**

A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the American Language Institute http://dornsife.usc.edu/ali, which sponsors courses and workshops specifically for international graduate students. The Office of Disability Services and Programs http://sait.usc.edu/academicsupport/centerprograms/dsp/ home\_index.html provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, USC Emergency Information http://emergency.usc.edu/ will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.