ABE6017 Stochastic modeling in ecology and hydrology

Time: Mondays—Period 5 (11:45 AM - 12:35 PM)
Wednesdays—Period 5-6 (11:45 AM - 1:40 PM)
Rogers Hall 211 and online

FALL 2025

Instructor: Rachata Muneepeerakul, PhD
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Frazier Rogers Hall 227; Office Hours: by appointments
Graduate Teaching Assistants (email, office hours and location): N/A

Course Description

Stochastic modeling is introduced through a problem-based approach. Selected papers are studied in depth; derivation of their main results unpacked. Examples include stochastic models of biodiversity, soil moisture, and rainfall. Students pick stochastic models to study for final projects. Students enjoy deeper understanding from unpacking these otherwise seemingly mysterious results. 3 credit hours.

Notes on the online sections: Students enrolled in an online session will participate in lessons through Zoom, which is accessible on Canvas.

Notes on the 80-99% online section: Students enrolled in the 80-99% online session will participate in lessons through Zoom, which is accessible on Canvas, for most of the semester, but will be required to make their final project presentations in person.

Pre-requisites: Basic calculus and college-level probability courses; MAC2312 or equivalent

Course Objectives:

Upon completion of this course, students will be able to:

- Unpack and explain the derivations of the basic results of stochastic models
- Apply the analytical techniques discussed in class to solve problems in other stochastic models
- Articulate the effects of stochastic fluctuation on the resulting dynamics based on the analysis of stochastic models

Materials and Supply Fees: N/A

Sample Readings (No textbook required)

(Notes: we would likely *not* have time to cover all papers listed below; we may cover them in a different order; and we may even switch to different papers, depending on the interest and progress of the class.)

Leigh , E.G. Jr. 2007. Neutral theory: a historical perspective. *Journal of Evolutionary Biology* **20**: 2075-2091.

Volkov, I., J.R. Banavar, S.P. Hubbell, & A. Maritan. 2003. Neutral theory and relative species abundance in ecology. *Nature* **424**: 1035-1037.

McKane, A.J., D. Alonso, & R. V. Solé. 2004. Analytical solution of Hubbell's model of local community dynamics. *Theoretical Population Biology* **65**: 67-73.
Chave, J. & E.G. Leigh Jr. 2002. A spatially explicit neutral model of β-diversity in tropical forests. *Theoretical Population Biology* **62**: 153-166.
Rodriguez-Iturbe, I., A. Porporato, L. Ridolfi, V. Isham, & D.R. Cox. 1999. Probabilistic modeling of water balance at a point: the role of climate, soil and vegetation. *Proceedings of the Royal Society, London, A* **455**: 3789-3805.
Laio, F., A. Porporato, L. Ridolfi, & I. Rodriguez-Iturbe. 2001. Mean first passage times of processes driven by white shot noise. *Physical Review E* **63**, 036105.
Leigh , E.G. Jr. 1981. The average lifetime of a population in a varying environment. *Journal of Theoretical Biology* **90**: 213-239.
Rodriguez-Iturbe, I., D.R. Cox, & V. Isham. 1987. Some models for rainfall based on stochastic point processes. *Proceedings of the Royal Society, London, A* **410**: 269-288.

Required Computer

Recommended Computer Specifications: https://it.ufl.edu/get-help/student-computer-recommendations/

HWCOE Computer Requirements: https://www.eng.ufl.edu/students/advising/fall-semester-checklist/computer-requirements/

Course Schedule (Tentative):

Week	TOPIC*
1	**Basic concepts in probability theory:** random variables, expected value, variance, probability mass function (PMF), probability density function (PDF); Properties of selected standard random variables (binomial, exponential, Gaussian)
2	**Basic concepts** continued: Moment generating function (MGF) **Examples of simple stochastic processes:** Markov chain, 1st-order autoregressive (AR) model
3	***Leigh, EG Jr.* (2007)—Neutral theory of diversity:** Relative species abundance (RSA)
4	RSA (cont'd); Probability of two random individuals belonging to the same species (*F*)
5	*F* under spatial settings; Generating function of the branching process
6	***Rodriguez-Iturbe et al.* (1999)—Soil moisture dynamic:** Introduction and intuitive understanding of the process; Marked Poisson process; Memorylessness of exponential pulses; loss function
7	Combining the discussed elements; Derive forward Kolmogorov equation
8	Solve forward Kolmogorov equation for steady-state probability density function for soil moisture; Crossing properties
9	**Wiener process:** Introduction; Forward & backward Kolmogorov eqs; First passage time (FPT)
10	First passage time (FPT) ***Rodriguez-Iturbe et al.* (1987)—Rectangular pulse models of rainfall:** Introduction; Derive expected value and variance of the process
11	Moment generation function of the rainfall process *PROJECT PROGRESS REPORTS*
12	Derive autocorrelation coefficient, PDF of the number of active rain cells

13	Neyman-Scott process: Introduction; Derive expected value, variance, autocovariance
14	*PROJECT PROGRESS REPORTS* *WORKSHOPS TO HELP WITH FINAL PROJECTS*
15	**FINAL PROJECT PRESENTATIONS****

* The schedule is tentative. Actual schedule would depend on progress and interest in class.

** For the final project, students will form groups based on their common interest. Each group will select, with the instructor's guidance and approval, a stochastic modeling paper in their field, in which some basic results of the stochastic model are reported the derivation of those results are omitted or unclear. The group's main task is to work out the detailed derivation of these results and report to the class. Throughout the semester, each group will present 2 or 3 progress reports to inform the instructor and the class on where they are and, importantly, what difficulty they are facing in deriving the results in their selected paper, so that the instructor can provide assistance in a timely manner.

Important Dates

Assignments are usually due within 1-1.5 weeks after the date they are assigned.
Students are expected to present their final projects in the last week of class

Evaluation of Grades

Class participation: 15% | Assignments: 55% | Final project: 30%

Grading Policy

Final grade will be rounded to the nearest integer; 85.5 will be rounded to 86.

91-100 = A | 86-90 = A- | 81-85 = B+ | 76-80 = B | 71-75 = B- | 66-70 = C+ | 61-65 = C |56-60 = C- | 51-55 = D+ | 46-50 = D | 41-45 = D-| 0-40 = E

Academic Policies & Resources

For information about academic policies and resources, please visit:
https://go.ufl.edu/syllabuspolicies
https://syllabus.ufl.edu/syllabus-policy/uf-syllabus-policy-links/

Commitment to a Positive Learning Environment

The Herbert Wertheim College of Engineering values varied perspectives and lived experiences within our community and is committed to supporting the University's core values.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

• Your academic advisor or Graduate Coordinator

• HWCOE Human Resources, 352-392-0904, student-support-hr@eng.ufl.edu

• Pam Dickrell, Associate Dean of Student Affairs, 352-392-2177, pld@ufl.edu