

3:30-4:50 Tu, Th, Mary Gates Hall 287

Course Website: <http://www.amath.washington.edu/courses/423-winter-2008/>

Key Reference

Taylor, H.M. and Karlin, S. An Introduction to Stochastic Modeling. 3rd Edition, Academic Press, Inc., 1998.

Tentative Course Outline

Lecture 1-2 (**HQ**) **Introduction to Stochastic Models:** Probabilistic and deterministic models; Statistical analysis and stochastic modeling.

Review of Basics of Probability: Discrete and continuous random variables (RVs); Probability mass function (pmf) $p_X(x_i)$; Probability density function (pdf) $f_X(x)$; Cumulative distribution function (cdf) $F_X(x)$; Expected value (EV), variance, and moments; Joint and marginal distribution, and conditional probability; Function of random variable(s); Probability generating function; Characteristic function; Convolution and sum of random variables; Random sum of RVs.

Lecture 3-4 (**MK**) **Markov Chain:** Markov processes and Markov chain; Discrete time, finite state homogeneous Markov process; Transition probability matrix; Matrix eigenvalues and matrix powers.

Lecture 5-6 (**MK**) **Behavior of Markov Chains:** Classification of states; Transient properties; Long time behavior; Recurrence and first return time.

Lecture 7-8 (**MK**) **Markov Chains with Absorbing States:**

Lecture 9-10 (**MK**) **One-Dimensional Random Walks:** Symmetric random walk; Asymmetric random walk; Gambler's ruin problem;

Lecture 11-12 (**MK**) **Branching Process:** Probability generating functions revisited; Survival probability; Bellman-Harris process; Renewal equation.

Lecture 13-14 (**HQ**) **Poisson Process:** Radioactive decay; Exponential distribution; Poisson counting process and Gamma distribution.

Lecture 15-16 (**HQ**) **Continuous Time Markov Process:** Transition rate (Q-) matrix; Discrete state continuous time Markov process; Differential equations and Markov chains.

Applications: Linear chemical reaction systems. Reversible reactions and stationary fluctuations; Irreversible reactions and time of absorption;

Lecture 17-18 (**HQ**) **Birth and Death Process:** The chemical master equation; Stochastic nonlinear chemical reactions; Michaelis-Menten kinetics revisited, flux versus time; Phosphorylation-dephosphorylation cycle revisited; Dynamic cooperativity.

Lecture 19-20 (**HQ**) **Brownian Motion and Diffusion:** Definition; Random walks; Brownian motion with a constant drift; White noise; Stochastic differential equations.

Applications: Brownian motion and diffusion in biology.

General Reference Books

1. L.J.S. Allen (2003) *An Introduction to Stochastic Processes with Applications to Biology*. Pearson Prentice Hall.
2. N.T.J. Bailey (1964) *The Elements of Stochastic Processes with Application to the Natural Sciences*. Wiley.
3. D.J. Bartholomew (1967) *Stochastic Models for Social Processes*. 2nd Ed., Wiley.
4. A.T. Bharucha-Reid (1960) *Elements of the Theory of Markov Processes and Their Applications*. McGraw-Hill.
5. D.R. Cox (1962) *Renewal Theory*. Methuen.
6. G.R. Grimmett and D.R. Stirzaker (1992) *Probability and Random Processes*. 2nd Ed., Clarendon Oxford University Press.
7. S. Karlin and H.M. Taylor (1975) *A First Course in Stochastic Processes*. 2nd Ed., Academic Press.
8. K. Lange (2004) *Applied Probability*. Springer.
9. D.A. McQuarrie (1968) *Stochastic Approach to Chemical Kinetics*. Methuen.
10. A. Papoulis (1991) *Probability, Random Variables, and Stochastic Processes*. McGraw-Hill.
11. H.C. Tijms (2003) *A First Course in Stochastic Models*. Wiley.

Biological Stochastic Modeling Reference Books

1. H.C. Berg (1993) *Random Walks in Biology*. Princeton University Press.
2. D. Brown and P. Rothery (1993) *Models in Biology: Mathematics, Statistics and Computing*. John Wiley & Sons.
3. F. Hoppensteadt (1975) *Mathematical Theories of Populations: Demographics, Genetics, and Epidemics*. SIAM, Philadelphia, PA.
4. P. Jagers (1975) *Branching Processes with Biological Applications*. John Wiley & Sons.
5. M. Kimmel and D.E. Axelrod (2002) *Branching Processes in Biology*. Springer-Verlag.
6. K. Lange (1997) *Mathematical and Statistical Methods for Genetic Analysis*. Springer.
7. D. Ludwig (1974) *Stochastic Population Theories*. VI, Vol 3, Springer-Verlag.
8. R.M. May (1973) *Stability and Complexity of Model Ecosystems*. Princeton, NJ.
9. J.K. Percus (2002) *Mathematics of Genome Analysis*. Cambridge University Press, New York.
10. J. Schnakenberg (1981) *Thermodynamic Network Analysis of Biological Systems*. 2nd Ed., Springer-Verlag, New York.
11. M.S. Waterman (1995) *Introduction to Computational Biology: Maps, Sequences and Genomes*. Chapman & Hall/CRC.
12. N. Wax (1954) *Noise and Stochastic Processes*. Dover Pub.
13. D.J. Wilkinson (2006) *Stochastic Modelling for Systems Biology*. Chapman & Hall/CRC.