

Prefix, Number and Name of Course: ACM 651 Markov Chains

Credit Hours: 1

In Class Instructional Hours: 1 **Labs:** 0 **Field Work:** 0

Catalog Description:

Prerequisite: MAT 202 or equivalent

Transition matrices, classification of states, limiting probabilities, applications.

Reasons for revision:

To create a one-semester-hour module for the graduate Professional Applied and Computational Mathematics program in Intermediate Probability.

Student Learning Outcomes: Students will:	Content Reference:	Assessment:
1. develop and analyze theoretical models of real-world random phenomena.	I, II, III, V	Group work in class, individual homework assignments, examinations, and computer projects.
2. apply the analysis of theoretical models to real-world random phenomena.	III, IV, V	Group work in class, individual homework assignments, examinations, and computer projects.
3. create computer simulations to calculate important features of Markov chains.	I, II, IV, VI	Group work in class, individual homework assignments, examinations, and computer projects.

Course Content:

I. Definitions and basic results

- A. Discrete-time, discrete-state Markov chains
- B. Finite and infinite transition matrices
- C. Chapman-Kolmogorov equations
- D. Multiple-step transition matrices

II. Classification of states

- A. Accessibility and communication
- B. Closed sets of states and irreducibility
- C. Recurrence and transience
- D. First return and first passage probabilities
- E. Null and positive recurrence
- F. Periodicity and aperiodicity
- G. Ergodicity

III. Limiting probabilities

- A. Doubly stochastic transition matrices

IV. Mean number of times in a transient state

V. Classical applications

- A. Diffusion models (e.g. Ehrenfest & Bernoulli-Laplace)
- B. Social class mobility (e.g. lower-middle-upper classes)
- C. Genetics (e.g. brother-sister mating)
- D. Branching processes (e.g. extinction of family surnames)

VI. Calculating with technology

- A. Multiple-step transition matrices (multiplying matrices)
- B. Limiting probabilities (solving systems of linear equations)
- C. Mean number of times in a transient state (inverting matrices)

Resources:

Scholarships in the Field:

Baldi, P., Mazliak, L. and Priouret, P., *Martingales and Markov Chains: Solved Exercises and Elements of Theory*, Chapman & Hall / CRC, 2002.

Bremaud, P., *Markov Chains*, Springer, 2008.

Ching, W. and Ng, M., *Markov Chains: Models, Algorithms and Applications*, Springer, 2005.

Chung, K., *Markov Chains with Stationary Transition Probabilities*, Springer, 1960.

Freedman, D., *Markov Chains*, Holden-Day, 1971.

Gamerman, D. and Lopes, H., *Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference*, 2nd edition, Chapman & Hall / CRC, 2006.

Hägström, O., *Finite Markov Chains and Algorithmic Applications*, Cambridge University Press, 2002.

Isaacson, D. and Madsen, R., *Markov Chains: Theory and Applications*, Wiley, 1976.

Kemeny, J. and Snell, J., *Finite Markov Chains*, Springer, 1983.

Kemeny, J., Snell, J., Knapp, A. and Griffeth, D., *Denumerable Markov Chains*, 2nd edition, Springer 1976.

Kemperman, J., *The Passage Problem for a Stationary Markov Chain*, University of Chicago Press, 1961.

Norris, J., *Markov Chains*, Cambridge University Press, 1998.

Nummelin, E., *General Irreducible Markov Chains and Non-negative Operators*, Cambridge University Press, 2004.

Ross, S., *Stochastic Processes*, 2nd edition, Wiley, 1995.

Revuz, D., *Markov Chains*, North Holland, 1984.

Seneta, E., *Non-negative Matrices and Markov Chains*, 2nd edition, Springer, 1981 (2007 reprint).

Stewart, W., *Introduction to the Numerical Solution of Markov Chains*, Princeton University Press, 1994.

Stroock, D., *An Introduction to Markov Processes*, Springer, 2005.

Suhov, Y. and Kelbert, M., *Probability and Statistics by Example: Volume 2, Markov Chains: A Primer in Random Processes and Their Applications*, Cambridge University Press, 2008.

Yin, G. and Zhang, Q., *Discrete-Time Markov Chains: Two-Time-Scale Methods and Applications*, Springer, 2004.

Periodicals:

Advances in Applied Probability

Annals of Applied Probability, The

Annals of Probability, The

Applied Stochastic Models and Data Analysis

Bernoulli

Chance

Electronic Journal of Probability

Journal of Applied Probability

Methodology and Computing in Applied Probability

Probability in the Engineering and Informational Sciences

Probability Theory and Related Fields

Scandinavian Actuarial Journal

Stochastic Analysis and Applications

Stochastic Processes and Their Applications

Theory of Probability and Its Applications

Theory of Stochastic Processes

Electronic and/or Audiovisual Resources:

Electronic Journal of Statistics

Link to electronic journals web site (<http://www.e-journals.org/>)