

# Preface to the Second Edition

## What Is New in the Second Edition?

Students and instructors will notice significant changes in the second edition.

1. The chapters on probability have been removed. Abbreviated versions of these chapters appear as Appendices A, B, C, and D.
2. A new chapter (Chapter 3) on Poisson processes has been added. This is in response to the feedback that the first edition did not give this important class of stochastic processes the attention it deserves.
3. A new chapter (Chapter 7) on Brownian motion has been added. This is to enable instructors who would like the option of covering this important topic. The treatment of this topic is kept at a sufficiently elementary level so that the students do not need background in analysis or measure theory to understand the material.
4. The chapters on design and control of stochastic systems in the first edition have been deleted. Instead, I have added case studies in Chapters 2, 4, 5, and 6. The instructor can use these to talk about the design aspect of stochastic modeling. The control aspect is entirely deleted. This has necessitated a change of title for the new edition.
5. Several typos from the first edition have been corrected. If there are new typos in the second edition, it is entirely my fault. I would appreciate it if the readers would kindly inform me about them. A current list of corrections is available on the Web at [www.unc.edu/~vkulkarn/ugcorrections2.pdf](http://www.unc.edu/~vkulkarn/ugcorrections2.pdf).

## Who Is This Book For?

This book is meant to be used as a textbook in a junior-or senior-level undergraduate course on stochastic models. The students are expected to be undergraduate students in engineering, operations research, computer science, mathematics, statistics, business administration, public policy, or any other discipline with a mathematical core.

Students are expected to be familiar with elementary matrix operations (addition, multiplication, and solving systems of linear equations, but not eigenvalues or

eigenvectors), first-year calculus (derivatives and integrals of simple functions, but not differential equations), and probability. The necessary material on probability is summarized in the appendices as a ready reference.

## What Is the Philosophy of This Book?

As the title suggests, this book addresses three aspects of using stochastic methodology to study real systems.

1. **Modeling.** The first step is to understand how a real system operates and the purpose of studying it. This enables us to make assumptions to create a model that is simple yet sufficiently true to the real system that the answers provided by the model will have some credibility. In this book, this step is emphasized repeatedly by using a large number of real-life modeling examples.
2. **Analysis.** The second step is to do a careful analysis of the model and compute the answers. To facilitate this step, the book develops special classes of stochastic processes in Chapters 2, 3, 4, 5, and 7: discrete-time Markov chains, Poisson processes, continuous-time Markov chains, renewal processes, cumulative processes, semi-Markov processes, Brownian motion, etc. For each of these classes, we develop tools to compute the transient distributions, limiting distributions, cost evaluations, first-passage times, etc. These tools generally involve matrix computations and can be done easily in any matrix-oriented language (e.g., MATLAB). Chapter 6 applies these tools to queueing systems.
3. **Design.** In practice, a system is described by a small number of parameters, and we are interested in setting the values of these parameters so as to optimize the performance of the system. This is called “designing” a system. The performance of the system can be computed as a function of the system parameters using the tools developed here. Then the appropriate parameter values can be determined to minimize or maximize this function. This is illustrated by case studies in Chapters 2, 4, 5, and 6.

## How Is This Book Intended to Be Used?

Typically, the book will be used in a one-semester course on stochastic models. The students taking this course will be expected to have a background in probability. Hence, Appendices A through D should be used to review the material. Chapters 2, 3, 4, 5, and 6 should be covered completely. Chapter 7 should be covered as time permits.

There are many running examples in this book. Hence the instructor should try to use them in that spirit. Similarly, there are many running problems in the problem section. The instructor may wish to use a running series of problems for homework.

## What Is So Different about This Book?

This book requires a new mind-set: a numerical answer to a problem is as valid as an algebraic answer to a problem! Since computational power is now conveniently and cheaply available, the emphasis in this book is on using the computer to obtain numerical answers rather than restricting ourselves to analytically tractable examples.

There are several consequences of this new mind-set: the discussion of the transient analysis of stochastic processes is no longer minimized. Indeed, transient analysis is just as easy as the limiting analysis when done on a computer. Secondly, the problems at the end of each chapter are designed to be fairly easy, but may require use of computers to do numerical experimentation.

## Software to Accompany the Book

A software package called MAXIM is available for use with this textbook. It is a collection of over 80 programs written in MATLAB. These programs can be used directly as function files from MATLAB. The user's manual describing these programs is in a file called readme. These programs can be accessed via a graphical user interface (GUI). The GUI is designed to run on PCs with Windows software. Since the software is an evolving organism, I have decided not to include any information about it in the book for fear that it will become outdated very soon. The software and any relevant information can be downloaded from [www.unc.edu/~vkulkarn/Maxim/maximgui.zip](http://www.unc.edu/~vkulkarn/Maxim/maximgui.zip). The user will need to have MATLAB installed on his or her machine in order to use the software.

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