Preface

This book is a result of teaching stochastic processes to junior and senior undergraduates and beginning graduate students over many years. In teaching such a course, we have realized a need to furnish students with material that gives a mathematical presentation while at the same time providing proper foundations to allow students to build an intuitive feel for probabilistic reasoning. We have tried to maintain a balance in presenting advanced but understandable material that sparks an interest and challenges students, without the discouragement that often comes as a consequence of not understanding the material. Our intent in this text is to develop stochastic processes in an elementary but mathematically precise style and to provide sufficient examples and homework exercises that will permit students to understand the range of application areas for stochastic processes.

We also practice active learning in the classroom. In other words, we believe that the traditional practice of lecturing continuously for 50 to 75 minutes is not a very effective method for teaching. Students should somehow engage in the subject matter during the teaching session. One effective method for active learning is, after at most 20 minutes of lecture, to assign a small example problem for the students to work and one important tool that the instructor can utilize is the computer. Sometimes we are fortunate to lecture students in a classroom containing computers with a spreadsheet program, usually Microsoft's Excel. For a course dealing with random variables, Excel is an ideal tool that can be used both within the classroom and for homework to demonstrate probabilistic concepts. In order to take full advantage of this, we have moved the chapter on simulation to the second chapter in the book. It is not necessary to cover all the sections of the simulation chapter, but we suggest covering at least Sects. 2.1 and 2.3 so that simulation can then be easily used with Excel throughout the course to demonstrate random processes and used during the lecture to actively engage the students in the lecture material.

The only prerequisites for an undergraduate course using this textbook is a previous course covering calculus-based probability and statistics and familiarity with basic matrix operations. Included at the end of most chapters is an appendix covering the use of Excel for the problems of the chapter; thus, a familiarity with Excel would be helpful but not necessary. For students needing a review of matrices, some of the basic operations are given in Appendix A at the end of the book.

This book could also be used for an introductory course to stochastic processes at the graduate level, in which case an additional prerequisite of linear programming should be required if the chapter on Markov decision theory is to be covered. It would also be helpful to expect graduate students to be competent programmers in some scientific programming language. There are two chapters covering advanced topics that would be skipped in an undergraduate course: Chap. 12 — Markov Decision Theory — and Chap. 13 — Advanced Queueing Theory. Knowledge of linear programming is necessary for Chap. 12, and a programming language or VBA would be very helpful in implementing the concepts in Chap. 13.

The book is organized as follows: The first three chapters are background material to be used throughout the book. The first chapter is a review of probability. It is intended simply as a review; the material is too terse if students have not previously been exposed to probability. However, our experience is that most students do not learn probability until two or three exposures to it, so this chapter should serve as an excellent summary and review for most students. The second chapter is an introduction to simulation so that it can be used to demonstrate concepts covered in future chapters. Included in this chapter is material covering random number generation (Sect. 2.2) which we sometimes skip when teaching our undergraduate course in stochastic processes since Excel has its own generator. The third chapter is a review of statistics which is only presented because some statistical concepts will be covered in later chapters, but this in not central to the text. We expect students to have already been exposed to this material and we generally skip this chapter for our undergraduate course and refer to it as needed.

The fourth chapter begins the introduction to random processes and covers the basic concepts of Poisson processes. The fifth chapter covers Markov chains in some detail. The approach in this chapter and in Chap. 6 is similar to the approach taken by Çinlar (*Introduction to Stochastic Processes*, Prentice-Hall, 1975). The homework problems cover a wide variety of modeling situations as an attempt is made to begin the development of "modelers". Chapter 6 is an introduction to continuous time Markov processes. The major purpose of the chapter is to give the tools necessary for the development of queueing models; therefore, the emphasis in the chapter is on steady-state analyses. The final section of Chapter 6 is a brief treatment of the time-dependent probabilities for Markov processes. This final section can be skipped for most undergraduate classes. Queueing theory is covered in Chaps. 7 and 8, where Chap. 7 deals with the basics of single queues and Chap. 8 introduces queueing networks. As in the Markov chain chapter, an attempt has been made to develop a wide variety of modeling situations through the homework problems.

Chapter 9 has two sections: the first deals with the specifics of event-driven simulations while the second introduces some of the statistical issues for output analysis. If the mechanical details of simulation (like future events lists) are not of interest to the instructor, the first section of Chap. 9 can be skipped with no loss of continuity. Chapter 2 together with the second section of Chap. 9 should yield an excellent introduction to simulation. No programming language is assumed since our purpose is not to produce experts in simulation, but simply to introduce the concepts and develop student interest in simulation. If simulation is covered adequately by other courses, Chap. 9 can be easily skipped.

Chapters 10 and 11 introduce a change in tactics and present two chapters dealing with specific problem domains: the first is inventory and the second is replacement. Applied probability can be taught as a collection of techniques useful for a wide variety of applications, or it can be taught as various application areas for which randomness plays an important role. The first nine chapters focus on particular techniques with some applications being emphasized through examples and the homework problems. The next two chapters focus on two problem domains that have been historically important in applied probability and stochastic processes. It was difficult to decide on the proper location for these two chapters. There is some Markov chain references in the last section of the inventory chapter; therefore, it is best to start with Chaps. 1, 2, 4, and 5 for most courses. After covering Markov chains, it would be appropriate and easily understood if the next chapter taught was either Markov processes (Chap. 6), inventory theory (Chap. 10), or replacement theory (Chap. 11). It simply depends on the inclination of the instructor.

Chapters 12 and 13 are only included for advanced students. Chapter 12 covers Markov decision processes, and Chap. 13 is a presentation of phase-type distributions and the matrix geometric approach to queueing systems adopted from the work of Neuts (*Matrix-Geometric Solutions in Stochastic Models*, Johns Hopkins University Press, 1981).

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