Review
Reviewed Work(s): Reliability: Probabilistic Models and Statistical Methods by Lawrence M. Leemis
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however, that no simple answer to this question exists (p. 204). They emphasize that circumstances exist, particularly in early phases of research, in which control factor interactions cannot be eliminated because they may be intrinsic to the phenomena being studied. This is particularly true in the chemical sciences.

The authors discuss a simple chemical example (Table 5.5, p. 77) containing a mild interaction between two control factors. They used a log transformation of the response (yield) to give S/N's that were additive. This approach simplified the analysis because *there was no fundamental interaction* between the two control factors. I am not aware, however, of the use of S/N transforms in designed experiments of more complicated chemical systems in which interactions are important. The use of "sliding" control factors is another experimental approach that can be used to minimize the effects of interactions on response variables (pp. 193–196). Again, I am not aware of any actual chemical examples. Although interactions can amplify loss of robustness, the authors concede that some levels of robustness can only be achieved by taking advantage of synergistic interactions.

More and more statistics articles and books are recognizing the importance of choosing response variables that represent functional phenomena (Barker 1994; Coleman and Montgomery 1993; Nair 1992; Phadke 1989). The authors also emphasize that a goal of robust design is to transform energy as much as possible into targeted output performance representing useful energy. The catapult experiment, frequently discussed in the book, demonstrates the translation of potential energy due to elastic elongation of rubber bands into kinetic energy in the form of projectile velocity. The authors present an excellent discussion of the criteria that should be used to identify such quality characteristics.

After an introduction to quality engineering, the book is divided into three main sections. The first section, "Quality Engineering Metrics," presents detailed and excellent discussions about the quality loss function and the S/N. Both static and dynamic S/N's are detailed. The second section, "The Parameter Design Process," is a detailed description of a nine-step parameter-design process. Because I believe that this process is very useful and relevant to many different areas of research and engineering, the steps are given here:

1. Selection of the quality characteristic
2. Selection of the noise factors
3. Conducting the noise experiment
4. Analysis of the results and compounding of the noise factors
5. Selection of the control factors
6. Conducting the main experiment
7. Analysis of the results, determining optimum levels
8. Predicting optimum performance
9. Conducting the verification experiment

This section concludes with parameter design examples and case studies.

The third section, "Advanced Topics," discusses the modification of orthogonal arrays, the nature of interactions in robust design, the analysis of variance (ANOVA), and the relationship of robust design to other quality processes. The F-test guidelines, discussed in the ANOVA chapter, are probably unnecessary. These guidelines mention nothing about either confidence levels or sample-size requirements. Because the book is targeted toward engineering practitioners, they will be able to easily use F-ratio tables.

At the end of most chapters are exercises designed to test understanding of the concepts discussed in the chapters. At the end of text, an excellent list of references is documented in Appendix D.

A demonstration disk, WinRobust Lite, which is run on Microsoft Windows 3.1, is included. The full-featured disk is available ($74). This software package is an excellent complement to the book.

The demo is easily installed, and I used this software to go through one of the parameter-design examples involving an L4 array in the book ("Ice Water Experiment," Chap. 13). Instructions for using this user-friendly software are in Appendix B of the book. The demo illustrates very well the concepts discussed. Because the demo only contains the L4, L12, and L18 arrays, however, the serious experimenter will have to purchase the full-featured disk that contains a variety of two-level and three-level arrays.

I liked this book and strongly recommend that it be part of the personal technical library of any investigator using parameter designs to achieve product/process robustness.

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Reliability: Probabilistic Models and Statistical Methods, by Lawrence M. LEEMIS, Englewood Cliffs, NJ: Prentice-Hall, 1995, xv + 319 pp., $71.

The preface of this book states that its goal is to give an elementary introduction to the probabilistic models and statistical methods used by reliability engineers and provide readers with enough background to read most reliability journals and advanced textbooks. It is intended as a classroom textbook and is recommended for a one-semester course by advanced undergraduates or first-year graduate students. The prerequisite is a two-semester sequence in calculus-based probability and mathematical statistics and a familiarity with Markov models. The book forms the basis for a tutorial, with the same title, for which Leemis won the 1995 Alan O. Plait Award for Excellence at the Annual Reliability and Maintainability Symposium. The book, as is the case with Leemis's tutorial, is clear and concise. I believe that it satisfies its intended purpose well, but I would not recommend it for reading by practicing engineers who do not have the prerequisite course in mathematical statistics. Leemis uses the book for a first-year graduate course for industrial engineers or operations research analysts.

The book consists of 10 chapters and 6 appendixes, which can be easily covered in a one-semester course. Chapters 2–6 emphasize probabilistic models used in reliability, and Chapters 7–10 emphasize statistical methods. The author divides the book along these lines because he feels that students often confuse probability and statistical aspects. The contents are as follows:

Chapter 1 is an introductory and motivational chapter that presents a case study of the space-shuttle O-ring risk analysis and a brief overview of the rest of the book. Chapter 2 presents coherent systems analysis. Chapter 3 is a general discussion of lifetime-distribution-models reliability (called the survivor function in this book) and hazard functions. Chapter 4 discusses the exponential, Weibull, and gamma lifetime models. Chapter 5 presents the special models for competing risks, mixtures, accelerated life, and proportional hazards. Chapter 6 discusses repairable systems. Chapter 7 discusses estimation theory for lifetime data, including a succinct and lucid presentation of likelihood methods. Chapter 8 discusses maximum likelihood (ML) estimation specifically for the exponential and Weibull distributions. Chapter 9 discusses estimation with covariates such as accelerated life or proportional hazards. Finally Chapter 10 discusses nonparametric estimation of the survivor function and Kolmogorov–Smirnov tests for goodness of fit.

As the preface of the book states, there are many interesting topics in reliability engineering that have been left out to make the length manageable. Therefore an instructor who likes to pick and choose topics from a longer book might not be satisfied with this one. At the end of each chapter, however, there is a further-reading section that is an annotated bibliography with one paragraph devoted to each section in the chapter. Here the author mentions other textbooks and a few selected articles where the student or instructor can find more detail on a particular topic, or an introduction to related topics. The topics that are covered in this book are presented clearly. There is a summary of notation used in each chapter (similar to articles in *IEEE Transactions on Reliability*) conveniently located inside the front and back covers. Definitions are numbered and set off with bold headings whenever they appear in the text, and there are ample and clear examples illustrated well with black-and-white figures. In my reading of the book, I did not find any annoying typographical errors.

The emphasis of this book is more on the theoretical concepts than the practical reliability engineering. There are only four small datasets presented in Chapter 8 that are used repeatedly for examples of statistical analysis in the remainder of the book. The graphical methods, often used by engineers for parameter estimation and emphasized extensively in other books, are mentioned only briefly for the Weibull distribution in an appendix describing initial estimates for ML. Practical topics on reliability management, FMEA, or planning reliability test programs are not discussed. A clear description of accelerated-life and proportional-hazards models is given, but link models such as the Arrhenius equation or Eyring model, often used in the analysis of accelerated-test data, were not presented.

This emphasis on the theoretical, however, may be a good feature of the book if it is used for a first course. The book is not intimidating for a professor of mathematics or statistics who has little practical experience in reliability. Engineers taking a course using this book could gain a good basic theoretical foundation. It is possible for engineers to learn practical aspects of reliability engineering on the job or through their own self-study, although it would be more difficult to learn the theoretical foundations through self-study. For this reason, Leemis's emphasis on the theoretical aspects may be justified.

The book does have an excellent and concise presentation of likelihood theory at a level appropriate for the intended audience. I consider this to be one of the strong points of the book, and I would like to see more coverage like this in other elementary mathematical statistics books. This book shows specific applications of the ML principle for estimation of exponential and Weibull parameters in Chapter 8, and for the extreme value distribution in an appendix. There are excellent examples with graphics that make it easy for students to comprehend how the ML estimates work and how to obtain confidence intervals and regions for estimated parameters. Using the simultaneous and homogeneous nonlinear equations that result when the first derivatives of the Weibull log-likelihood are equated to 0, the author shows a solution for one parameter in terms of the other. This reduces the task of finding the ML estimators for Weibull parameters from that of solving two simultaneous nonlinear equations numerically to that of finding the 0 or root of one equation. This can be done approximately with a graphing calculator such as an HP48 or numerically by using the solver tool in a modern spreadsheet.

Although the book's presentation of likelihood methods was excellent, I was disappointed by the problems at the end of Chapter 8. Of the 27 exercises in this chapter, 19 dealt with the exponential distribution. Three exercises asked the student to write computer programs. Only one problem asks students to actually compute parameter estimates for the Weibull distribution, and this problem requests that the student write a computer program to estimate the parameters for one of the small datasets that was used for an example in the text. Because there are excellent programs available, such as SAS or NCSS, that have ML estimation procedures available, an instructor who has a computer lab will probably want to provide supplementary exercises for students with practical estimation problems. Furthermore, I was somewhat disappointed with the exercises throughout the book, and this is one area in which the next edition of this book could be improved.

There are many exercises located at the end of each chapter, but about 60% of them are in Chapters 2–4, which have over 45 exercises each. The author states that the reason for more exercises in the early chapters is so that continual reviews of subjects covered early in the text can be made through homework problems. Nevertheless, I would like to see more exercises, especially of a practical nature, in the later chapters. Possibly the next edition of this book could fill this gap. There is a complete and well-put-together solutions manual for instructors but there are no partial answers to exercises at the back of the book for students to check their work in progress. Because instructors vary in their opinion of the value of putting answers in the back of a book, the author has purposefully left them out. He has a complete hard copy of the answers, however, that he will mail to an interested instructor.

For the most part, I feel that the exercises are at an appropriate level for the text, but there are several (especially in the later chapters) that require programming to solve. For example, Exercise 8.8 requests the student to write a computer program to compute point and interval estimates of the mean, variance, and percentiles of the exponential distribution for complete or Type II censored samples, and the solution to Exercise 4.37 (which asks the student to find parameter values for a log-logistic distribution that result in 1 for the coefficient of variation) presents the results of a FORTRAN program that calls IMSL subroutines. Because programming is not a stated prerequisite for the class and most reliability calculations can now be accomplished with existing statistical packages or spreadsheet programs, I feel that these programming exercises are inappropriate.

All in all, I liked the book. I think its scope and purpose fulfill a need. I would recommend it for a first course in reliability to graduate students with the appropriate prerequisite.

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Reliability, Maintainability and Availability Assessment (2nd ed.), by Mitchell O. LOCKS, Milwaukee: ASQC Quality Press, 1995, xxvii + 348 pp., $65.

The author of this book attempts to provide a textbook that may be used in a formal educational setting such as a classroom or industrial short course as well as being a reference for industrial applications. He accomplishes his goal. This book may be used as a classroom textbook by students who have a background in basic probability. It is also an excellent reference for practitioners who need to go beyond the basics of reliability assessment. Background material is presented in a clear manner. Meaningful examples are presented that aid the reader or student in understanding the basic concepts of reliability, maintainability, and availability. Proofs and derivations are kept to a minimum and are only presented as background material to the concepts being presented.

The book consists of 5 parts, each containing several related chapters. Of the 13 chapters, the authors provides problem sets for the first 9 chapters. Solutions to the problem sets are provided in the back of the book. All necessary tables are provided in the appendix.

The first part of the book is "Basic Probability Theory." It is a quick review of the basic concepts of probability that will be used in the following parts of the book. A quick review of probability distributions is also covered in the first part. A basic knowledge of the subject is a great help in understanding the material presented in this part.

Part 2, "Families of Probability Distributions," contains a more in-depth presentation of many of the basic probability distributions. The author covers the binomial, negative binomial, beta, normal lognormal, chi-squared, Student-t, and exponential distributions. In the appendix to Chapter 5, he presents the relationships between the exponential, gamma, chi-squared, and Poisson distributions. This section is well written, and I feel that the author did a very good job in presenting the goodness-of-fit tests.

Reliability and confidence are addressed in the third part of this book. Much of the material that is presented in the four chapters of this section is not normally covered in a basic reliability textbook. As with the previous sections, the author does a fine job in presenting complex topics in a clear fashion with many examples. The chapters that compose this section are "Statistical Assessment: The Bernoulli and Poisson Processes," "Bayesian Reliability Analysis: Attributes and Life Testing," "Normal Theory Tolerance Analysis," and "Hazard Analysis and the Weibull Distribution."

The "Maintainability and Availability" part of this book, Part 4, is a basic review of these topics. I found that much of the material can be found in other published works. It is convenient, however, to find it in this one handy reference.

The final part of this book covers system reliability. The author provides several methods for assessing the reliability of complex systems. He presents the standard approach to system reliability, the reduction of the system to a simple problem in series and parallel paths. Beyond this standard approach, topics such as inclusion-exclusion and the ALR algorithm, along with minimal paths and minimal cuts, are also presented well.