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Mathematical Statistics

by Lawrence M. Leemis. The College of William and Mary Williamsburg, VA; ISBN: 978-0-982-91746-6, 2020; ix + 507 pp., $50.

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used to model and prevent failures, reduce unplanned maintenance, and other potentially more harmful failures.

The authors conclude with Chapter 8 which discusses various statistical methods for product lifetime data analysis. They address all the important aspects for the correct statistical analysis of lifetime data, as well as the assumptions of the analysis. Different models are discussed for reliability and lifetime data, as well as different types of data that may be encountered in reliability studies. The chapter is a very good summary of the important statistical models and data analysis approaches for analyzing reliability data. The authors provide many references which the interested reader can acquire for a more detail understanding of the statistical theory and methods.

I thoroughly enjoyed reading *Achieving Product Reliability*, and recommend it to engineers, technical and management level, and statisticians, both lecturers and research fellows, who are interested in reliability theory and data analysis.

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Mathematical Statistics, by Lawrence M. Leemis. The College of William and Mary Williamsburg, VA; ISBN: 978-0-982-91746-6, 2020; ix + 507 pp., $50.

With the publication of this text, the author has provided a valuable addition to his much-admired *Probability* (2018, 2nd Ed.; the 1st edition was reviewed in *Technometrics*, Volume 62, 2020 – Issue 2). Dr. Leemis is a seasoned professor and textbook author, as can be discerned by a cursory glance at his webpage, *http://www.math.wm.edu/~leemis/*. His pedagogical experience in covering both the breadth and depth of the topic in a student-accessible manner shines through here as in his *Probability* text. This new text fills a definite need by undergraduates in mathematics and statistics and graduate students in most, if not all, fields of mathematics, science, and engineering. This 500+ page text does a masterful job of explaining all the necessary background required to study any area which relies on mathematical statistics. It assumes a solid background in the mathematics of probability, provided in outstanding fashion by the *Probability* text, but is still easily accessible to students other than mathematicians. In our opinion, most texts in mathematical statistics either spend too many pages on the basics of probability and do not cover the more advanced topics in statistics or they are beyond the level appropriate for students in the applied fields of the assurance sciences and engineering. By publishing this *Mathematical Statistics* text to accompany *Probability*, the author addresses these issues quite well.

The essential elements which strengthen the new book include:

- A clever introductory chapter which sets the stage for the rest of the text, drawing the reader in, with examples from many diverse and fascinating aspects of life
- Careful detail shown in developing the formulas and equations used in mathematical statistics
- The informal and amusing nature of some of the illustrative examples and exercises
- Use of Venn diagrams to illustrate the various sets and subsets of estimators and confidence intervals
- Inclusion of statements in the R language to solve examples, create graphical displays, and conduct simulations
- Use of Monte Carlo simulation throughout to elucidate the concepts
- Pedagogical maturity – the book reads as a textbook with the math-oriented student in mind, providing the most important topics at this level while resisting the urge to rabbit trail on the author's favorite obscure topics
- Obvious passion for the benefits which mathematical statistics can provide and the reasons it is such an important area of study

The text is comprised of four rather lengthy chapters with the following sections:

Chapter 1. Random Sampling

1.1 Statistical Graphics
1.2 Random Sampling, Statistics, and Sampling Distributions
1.3 Estimating Central Tendency
1.4 Estimating Dispersion
1.5 Sampling from Normal Populations
1.6 Exercises (numbered 1.1 through 1.86)

Chapter 2. Point Estimation

2.1 Introduction
2.2 Method of Moments
2.3 Maximum Likelihood Estimators
2.4 Properties of Point Estimators
2.5 Exercises (numbered 2.1 through 2.84)

Chapter 3. Interval Estimation

3.1 Exact Confidence Intervals
3.2 Approximate Confidence Intervals
3.3 Asymptotically Exact Confidence Intervals
3.4 Other Interval Estimators *(including Prediction Intervals, Tolerance Intervals, Bayesian Credible Intervals and Confidence Regions)*
3.5 Exercises (numbered 3.1 through 3.70)

Chapter 4. Hypothesis Testing

4.1 Elements of Hypothesis Testing
4.2 Significance Tests
4.3 Sampling from Normal Populations
4.4 Sample Size Determination
4.5 Confidence Intervals, Hypothesis Tests, and Significance Tests
4.6 Most Powerful Tests
4.7 Likelihood Ratio Tests
4.8 Exercises (numbered 4.1 through 4.91)

Thus, it can be seen that this new text provides a full and complete coverage of the subject, lucidly explained, with many examples and challenging exercises. The back cover of the book states "*Mathematical Statistics* (Foundations of Statistical Inference) …describes the mathematical underpinnings associated with the practice of statistics. The pre-requisite for this book is

a calculus-based course in probability. Nearly 200 figures and dozens of Monte Carlo simulation experiments help develop the intuition behind the statistical methods. Real-world problems from a wide variety of fields help the reader apply the statistical methods. Over 300 exercises are used to reinforce concepts and make this book appropriate for classroom use."

There are no obvious omissions, and all the necessary material is included. After completing a study of this text, the student or researcher will be well prepared to move onto more advanced statistical topics. These include regression and correlation analysis, the design and analysis of experiments, time series analysis and applied topics such as reliability engineering, quality assurance, and simulation. Unlike some other texts in statistics, there are no obvious biases displayed. Evidence of this is the even-handed treatment of Bayesian Analysis which this text provides, explaining its potential benefits, without overselling the somewhat controversial topic as a panacea for all applications.

As an example of the thorough treatment of a topic, the text addresses one of the most fundamental and important applications of mathematical statistics: estimating the parameter of a Bernoulli population using the results of a random sample to create a confidence interval (Section 3.2). Several practical examples of the areas of application are provided as motivating material, then the mathematical treatment demonstrates the fundamentals of creating a confidence interval. This is done using the Clopper-Pearson approach, calculated both by using the F inverse and by using the somewhat more convenient beta inverse. R code and functions are illustrated using the `qbeta` function and also the `binom.test` function. Next the issue of actual coverage is discussed. R code and a plot are provided to illustrate the conservative nature of the Clopper-Pearson method. Several competitors to the Clopper-Pearson method are discussed, including Wald (normal approximation to the binomial), Wilson-score, Jeffreys, Agresti-Coull, and Arcsine, along with graphs of their coverage for the same example (the famous Lady Tasting Tea experiment from Sir R.A. Fisher). An especially appreciated quote from the text is found in the summary for this section: "…the Wald interval, even though it is easy to compute and appears in many elementary statistics texts, should never be used, and this is particularly the case for small values of n."

There are only a few minor suggestions which might improve future editions of this outstanding work. The first would be to include more examples and exercises based on articles published in technical journals, as exemplified in the many texts by Douglas Montgomery and co-authors. A colleague who has classroom experience teaching from a draft of *Mathematical Statistics* has suggested that most of the first section of Chapter 1 concerning graphical displays might be placed instead as an appendix. Unlike most texts, there are no references cited in the text. The author states in the Preface that this is for readability and then provides three pages of notes providing most of the necessary references for examples and suggestions for further study.

In summary, while there are a large number and wide variety of mathematical statistics textbooks already available, this new text differs from, and has many advantages over, existing books in this area. It should speak much better to today's students and professionals than most of the others. One of the many outstanding features which separates this new text from the rest is the extensive illustration of how Monte Carlo simulation can be applied to check the reasonableness of results from purely calculation-based approaches. In addition, demonstrating the use of the language R for calculations, graphs, and simulation throughout is a definite strength. Other positive features are that the solutions manual is excellent, accurate and well written, and the fact that the book is self-published, which was intentional on Dr. Leemis's part, in order to make it more affordable for students.

When one combines this text with *Probability*, *Learning Base R* (2016) and some of Leemis's other texts, it is easy to see that he has made important contributions to these topics and provided a way for students and researchers to gain the knowledge and skills they need to apply statistics along with the computer tools necessary to do so successfully and efficiently.

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Linear and Non-Linear System Theory,

by T. Thyagarajan and D. Kalpana, CRC Press, Taylor & Francis Group, 2021, ISBN: 978-0367340148, 2021, 405 pp. £112.00.

Linear and Non-Linear System Theory, by T. Thyagarajan and D. Kalpana, is a timely and substantive contribution to the literature for system theory. *Linear and Non-Linear System Theory* is a textbook that is definitely designed and written with the student in mind. And any sophisticated reader who attempts to use this book as a reference book may have a mixed reaction regarding the format. This also includes the lecture concepts and style. This book is full of educational philosophy and a wealth of both linear and nonlinear systems and their control concepts. The basic prerequisite of understanding linear and non-linear system theories is strong mathematical background.

The book has numerous features that make it unique and special. The book covers a strong comprehensive treatment of matrix fraction descriptions, the theories of rational and polynomial matrices. It covers state feedback compensator design and state observer theory thoroughly. Generally, it also covers control fundamentals to anchor, deepen, reinforce, and to emphasize the value of the observability, controllability, and realization concepts that are well introduced in different chapters. The authors have given good summaries of mathematical concepts to the systems concepts. They achieved this through intricate interplay of different mechanisms of presentation. The earlier popular texts on the theory of systems like Desoer (1970)