Preface

his book is an abridgment and modernization of *Statistics for Engineering Problem Solving* by Stephen Vardeman, which was published in 1994 by PWS Publishing and awarded the (biennial) 1994 Merriam-Wiley Distinguished Author Award by the American Society for Engineering Education recognizing an outstanding new engineering text. The present book preserves the best features of the earlier one, while improving readability and accessibility for engineering students and working engineers, and providing the most essential material in a more compact text.

Basic Engineering Data Collection and Analysis emphasizes real application and implications of statistics in engineering practice. Without compromising mathematical precision, the presentation is carried almost exclusively with references to real cases. Many of these real cases come from student projects from Iowa State University statistics and industrial engineering courses. Others are from our consulting experiences, and some are from engineering journal articles. (Examples bearing only name citations are based on student projects, and we are grateful to those students for the use of their data sets and scenarios.)

We feature the well-proven order and emphasis of presentation from *Statistics* for Engineering Problem Solving. Practical issues of engineering data collection receive early and serious consideration, as do descriptive and graphical methods and the ideas of least squares curve- and surface-fitting and factorial analysis. More emphasis is given to the making of statistical intervals (including prediction and tolerance intervals) than to significance testing. Topics important to engineering practice, such as propagation of error, Shewhart control charts, 2^p factorials and 2^{p-q} fractional factorials are treated thoroughly, instead of being included as supplemental topics intended to make a general statistics text into an "engineering" statistics book. Topics that seem to us less central to common engineering practice (like axiomatic probability and counting) and some slightly more advanced matters (reliability concepts and maximum likelihood model fitting) have been placed in an appendix, where they are available for those instructors who have time to present them but do not interrupt the book's main story line.

vi Preface

Pedagogical Features

Pedagogical and practical features include:

•••

- Precise exposition
- A logical two-color layout, with examples delineated by a color rule

Example 1	Heat Treating Gears
	The article "Statistical Analysis: Mack Truck Gear Heat Treating Experiments" by P. Brezler (<i>Heat Treating</i> , November, 1986) describes a simple application of engineering statistics. A process engineer was faced with the question, "How should gears be loaded into a continuous carburizing furnace in order to minimize distortion during heat treating?" Various people had various semi-informed opinions about how it should be done—in particular, about whether the gears should be laid flat in stacks or hung on rods passing through the gear bores. But no one really knew the consequences of laying versus hanging.

Use of computer output

www	Printout 6	Computations for the Joint Strength Data	
	General Linea	r Model	
	Factor Tv	ne levels Values	
	joint fixe	d 3 beveled butt lap	
	wood fixe	d 3 oak pine walnut	

Boxing of those formulas students will need to use in exercises

	Definition 1 identifies $Q(p)$ for all p between $.5/n$ and $(n5)/n$. To find $Q(p)$ for such a value of p, one may solve the equation $p = (i5)/n$ for i, yielding
Index (i) of the ordered data point that is Q(p)	i = np + .5 and locate the "($np + .5$)th ordered data point."

Teaching from the Text vii

 Margin notes naming formulas and calling attention to some main issues of discussion

Purposes of replication

The idea of replication is fundamental in experimentation. **Reproducibility of results** is important in both science and engineering practice. Replication helps establish this, protecting the investigator from unconscious blunders and validating or confirming experimental conclusions.

Identification of important calculations and final results in Examples

To illustrate convention (2) of Definition 1, consider finding the .5 and .93 quantiles of the strength distribution. Since .5 is $\frac{.5-.45}{.55-.45} = .5$ of the way from .45 to .55, linear interpolation gives

Q(.5) = (1 - .5) Q(.45) + .5 Q(.55) = .5(9,011) + .5(9,165) = 9,088 g

The Exercises

There are far more exercises in this text than could ever be assigned over several semesters of teaching from this book. Exercises involving direct application of section material appear at the end of each section, and answers for most of them appear at the end of the book. These give the reader immediate reinforcement that the mechanics and main points of the exposition have been mastered. The rich sets of Chapter Exercises provide more. Beyond additional practice with the computations of the chapter, they add significant insight into how engineering statistics is done and into the engineering implications of the chapter material. These often probe what kinds of analyses might elucidate the main features of a scenario and facilitate substantive engineering progress, and ponder what else might be needed. In most cases, these exercises were written *after* we had analyzed the data and seriously considered what they show in the engineering context. These come from a variety of engineering disciplines, and we expect that instructors will find them to be not only useful for class assignments but also for lecture examples to many different engineering audiences.

Teaching from the Text

A successful ISU classroom-tested, fast-paced introduction to applied engineering statistics can be made by covering most of Chapters 1 through 9 in a single, three-semester hour course (not including those topics designated as "optional" in section

or subsection titles). More leisurely single-semester courses can be made, either by skipping the factorial analysis material in Section 4.3 and Chapter 8 altogether, or by covering only Chapters 1 through 6 and Sections 7.5 and 7.6, leaving the rest of the book for self-study as a working engineer finds need of the material.

Instructors who are more comfortable with a traditional "do more probability and do it first, and do factorials last" syllabus will find the additional traditional topics covered with engineering motivation (rather than appeal to cards, coins, and dice!) in Appendix A. For those instructors, an effective order of presentation is the following: Chapters 1 through 3, Appendices A.1 through A.3, Chapter 5, Chapter 6, Section 4.1, Section 9.1, Section 4.2, Section 9.2, Chapter 7, Section 4.3, and Chapter 8.

Ancillaries

Several types of ancillary material are available to support this text.

- The CD packaged with the book provides PowerPointTM visuals and audio presenting solutions for selected Section Exercises.
- For instructors only, a complete solutions manual is available through the local sales representative.
- The publisher also maintains a web site supporting instruction using *Basic Engineering Data Collection and Analysis* at www.brookscole.com.

At www.brookscole.com, using the Book Companions and Data Library links, can be found the following:

- Data sets for all exercises
- MINITAB[®], JMP[®], and Microsoft[®] Excel help for selected examples from the book
- Formula sheets in PDF and LaTeX formats
- Lists of known errata

Acknowledgments

There are many who deserve thanks for their kind help with this project. People at Duxbury Thomson Learning have been great. We especially thank Carolyn Crockett for her encouragement and vision in putting this project together. Janet Hill has been an excellent Production Editor. We appreciate the help of Seema Atwal with the book's ancillaries, and are truly pleased with the design work overseen by Vernon Boes.

Acknowledgments ix

First class help has also come from outside of Duxbury Thomson Learning. Martha Emry of Martha Emry Production Services has simply been dynamite to work with. She is thorough, knowledgeable, possessed of excellent judgment and unbelievably patient. Thanks Martha! And although he didn't work directly on this project, we gratefully acknowledge the meticulous work of Chuck Lerch, who wrote the solutions manual and provided the answer section for *Statistics for Engineering Problem Solving*. We have borrowed liberally from his essentially flawless efforts for answers and solutions carried over to this project. We are also grateful to Jimmy Wright and Victor Chan for their careful work as error checkers. We thank Tom Andrika for his important contributions to the development of the PowerPoint/audio CD supplement. We thank Tiffany Lynn Hagemeyer for her help in preparing the MINITAB, JMP, and Excel data files for download. Andrew Vardeman developed the web site, providing JMP, MINITAB, and Excel help for the text, and we appreciate his contributions to this effort. John Ramberg, University of Arizona; V. A. Samaranavake, University of Missouri at Rolla; Paul Joyce, University of Idaho; James W. Hardin, Texas A & M; and Jagdish K. Patel, University of Missouri at Rolla provided helpful reviews of this book at various stages of completion, and we thank them.

It is our hope that this book proves to be genuinely useful to both engineering students and working engineers, and one that instructors find easy to build their courses around. We'll be glad to receive comments and suggestions at our e-mail addresses.

Steve Vardeman vardeman@iastate.edu J. Marcus Jobe jobejm@muohio.edu