

PREFACE

I have been a designer all my life. I have designed bicycles, medical equipment, furniture, and sculpture, both static and dynamic. Designing objects has come easy for me. I have been fortunate in having whatever talents are necessary to be a successful designer. However, after a number of years of teaching mechanical design courses, I came to the realization that I didn't know how to teach what I knew so well. I could show students examples of good-quality design and poor-quality design. I could give them case histories of designers in action. I could suggest design ideas. But I could not tell them what to do to solve a design problem. Additionally, I realized from talking with other mechanical design teachers that I was not alone.

This situation reminded me of an experience I had once had on ice skates. As a novice skater I could stand up and go forward, lamely. A friend (a teacher by trade) could easily skate forward and backward as well. He had been skating since he was a young boy, and it was second nature to him. One day while we were skating together, I asked him to teach me how to skate backward. He said it was easy, told me to watch, and skated off backward. But when I tried to do what he did, I immediately fell down. As he helped me up, I asked him to tell me exactly what to do, not just show me. After a moment's thought, he concluded that he couldn't actually describe the feat to me. I still can't skate backward, and I suppose he still can't explain the skills involved in skating backward. The frustration that I felt falling down as my friend skated with ease must have been the same emotion felt by my design students when I failed to tell them exactly what to do to solve a design problem.

This realization led me to study the design process, and it eventually led to this book. Part has been original research, part studying U.S. industry, part studying foreign design techniques, and part trying different teaching approaches on design classes. I came to four basic conclusions about mechanical design as a result of these studies:

1. The only way to learn about design is to do design.
2. In engineering design, the designer uses three types of knowledge: knowledge to generate ideas, knowledge to evaluate ideas, and knowledge to structure the design process. Idea generation comes from experience and natural ability. Idea evaluation comes partially from experience and partially from formal training, and is the focus of most engineering education. Generative and evaluative knowledge are forms of domain-specific knowledge. Knowledge about the design process is largely independent of domain-specific knowledge.
3. A design process that results in a quality product can be learned, provided there is enough ability and experience to generate ideas and enough experience and training to evaluate them.

4. A design process should be learned in a dual setting: in an academic environment and, at the same time, in an environment that simulates industrial realities.

I have incorporated these concepts into this book, which is organized so that readers can learn about the design process at the same time they are developing a product. The first few chapters present background on mechanical design, define the terms that are basic to the study of the design process, and discuss the human element of product design. Chapters 4–13, the body of the book, present a step-by-step development of a design method that leads the reader from the realization that there is a design problem to a solution ready for manufacture and assembly. This material is presented in a manner independent of the exact problem being solved. The techniques discussed are used in industry, and their names have become buzzwords in mechanical design: quality function deployment, decision-making methods, concurrent engineering, design for assembly, and Taguchi's method for robust design. These techniques have all been brought together in this book. Although they are presented sequentially as step-by-step methods, the overall process is highly iterative, and the steps are merely a guide to be used when needed.

As mentioned earlier, domain knowledge is somewhat distinct from process knowledge. Because of this independence, a successful product can result from the design process regardless of the knowledge of the designer or the type of design problem. Even students at the freshman level could take a course using this text and learn most of the process. However, to produce any reasonably realistic design, substantial domain knowledge is required, and it is assumed throughout the book that the reader has a background in basic engineering science, material science, manufacturing processes, and engineering economics. Thus, this book is intended for upper-level undergraduate students, graduate students, and professional engineers who have never had a formal course in the mechanical design process.

ADDITIONS TO THE THIRD EDITION

Knowledge about the design process is increasing rapidly. A goal in writing the third edition was to incorporate this knowledge into the unified structure that was one of the strong points of the first two editions. Throughout the new edition, topics have been updated and integrated with other best practices in the book. Some specific additions to the new edition include:

1. Over 50 design aphorisms have been added. These are simple statements that are important to design and are easy to remember.
2. Chapter 7 on concept generation has been reorganized for easier reading and introductions to TRIZ and axiomatic design have been added.
3. Chapter 8 on concept evaluation has added material on team decision making with uncertain and evolving information.

4. Chapter 11 on product evaluation for performance has been totally restructured to emphasize the need for considering variation in all evaluation considerations.
5. The example that flows through Chapters 4–11 has been changed to one that comes from the author’s design experience.
6. An appendix has been added highlighting TRIZ’s 40 inventive principles. These are invaluable when generating ideas.

Beyond these, many small changes have been made to keep the book current and useful.

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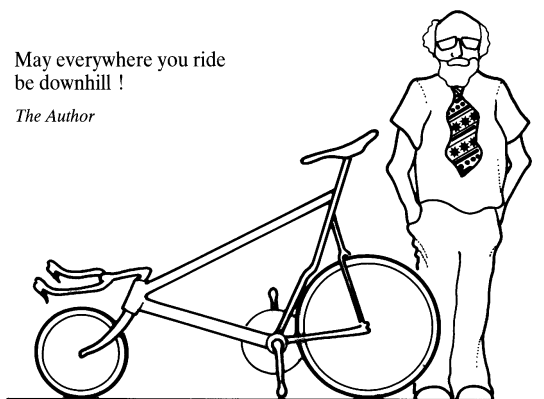
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The preface for the first edition ended with a caricature of me standing next to a fanciful bicycle as shown here. At that time I had a strong interest in nontraditional bicycles. This preface ends with a photograph of me sitting on a production bicycle I designed in 1992 after the release of the first edition. It bears a striking and purely coincidental similarity to the caricature bike below.

May everywhere you ride
be downhill !
The Author



(Figure with permission of Chuck Meitle)



(Photo compliments of BikeE Corporation, Corvallis, Oregon)