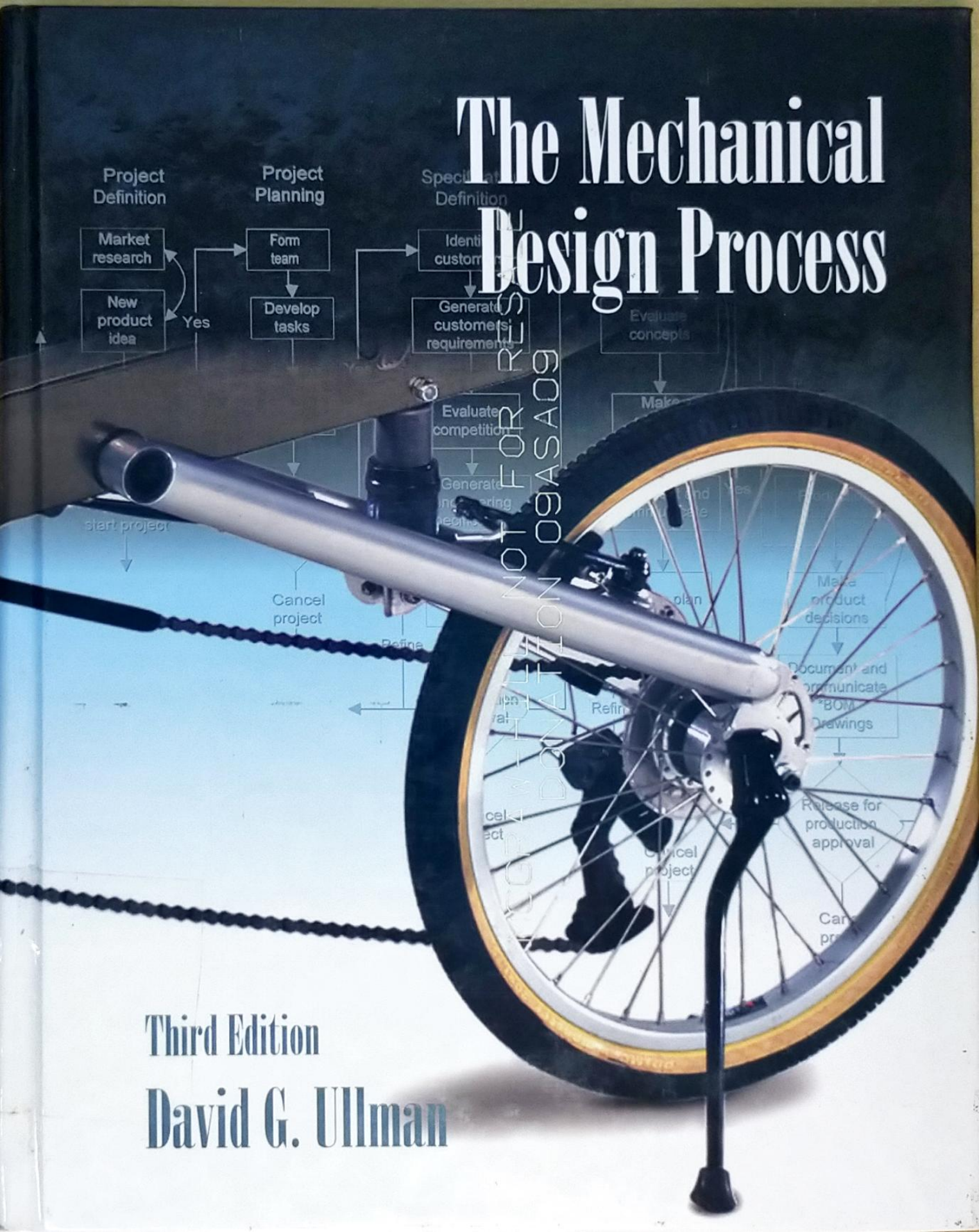
The Mechanical Design Process



The Mechanical Design Process

Third Edition

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ABOUT THE AUTHOR

David G. Ullman is an active product designer who has taught, researched, and written about design for over twenty-five years. He is president of Robust Decisions, Inc., a supplier of software products and training for product development and decision support. He is Emeritus Professor of Mechanical Design at Oregon State University, and founder of BikeE Corp., a leading producer of recumbent bicycles. He was BikeE's lead mechanical designer for nine years. He has professionally designed fluid/thermal, control, and transportation systems. He has published over twenty papers focused on understanding the mechanical product design process and the development of tools to support it. He is on the editorial board of four journals in this field and is founder of the American Society Mechanical Engineers (ASME)—Design Theory and Methodology Committee and is a Fellow in the ASME. He holds a Ph.D. in Mechanical Engineering from the Ohio State University.

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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.