



Mc  
Graw  
Hill

高等院校双语教学适用教材

工商管理

# Product Design and Development

(Fourth Edition)

*Karl T. Ulrich*

*Steven D. Eppinger*

(第4版)

## 产品设计与开发

---

(美) 卡尔·T. 犹里齐 斯蒂芬·D. 埃平格 著

杨德林 译注

 东北财经大学出版社  
Dongbei University of Finance & Economics Press



Mc  
Graw  
Hill

高等院校双语教学适用教材

工商管理

# Product Design and Development

(Fourth Edition)

*Karl T. Ulrich*

*Steven D. Eppinger*

(第4版)

# 产品设计与开发

---

(美) 卡尔·T. 犹里齐 斯蒂芬·D. 埃平格 著

杨德林 译注



东北财经大学出版社  
Dongbei University of Finance & Economics Press

大连

© 东北财经大学出版社 2008

## 图书在版编目 (CIP) 数据

产品设计与开发 (第4版) / (美) 犹里齐 (Ulrich, K. T.), (美) 埃平格 (Eppinger, S. D.) 著; 杨德林译注. —大连: 东北财经大学出版社, 2008. 11  
(高等院校双语教学适用教材·工商管理)  
书名原文: Product Design and Development, Fourth Edition  
ISBN 978-7-81122-422-1

I. 产… II. ①犹…②埃…③杨… III. ①产品—设计—双语教学—高等学校—教材—英文②产品—技术开发—双语教学—高等学校—教材—英文 IV. TB472

中国版本图书馆 CIP 数据核字 (2008) 第 156778 号

辽宁省版权局著作权合同登记号: 图字 06-2007-77 号

Karl T. Ulrich, Steven D. Eppinger; Product Design and Development (4e).  
Copyright © 2008 by The McGraw-Hill Companies, Inc.

DUFEP is authorized by McGraw-Hill/Irwin to publish and distribute exclusively this bilingual edition. This edition is authorized for sale in the People's Republic of China only (excluding Hong Kong, Macao SAR and Taiwan). Unauthorized export of this edition is a violation of the Copyright Act. No part of this publication may be reproduced or distributed by any means, or stored in a database of retrieval system, without the prior written permission of the publisher.

All rights reserved.

本书双语影印版由麦格劳—希尔出版公司授权东北财经大学出版社独家出版发行。此版本仅限在中华人民共和国境内 (不包括中国香港、澳门特别行政区及中国台湾) 销售。未经授权的本书出口将被视为违反版权法的行为。未经出版者预先书面许可, 不得以任何方式复制或发行本书的任何部分。

版权所有, 侵权必究。

本书封面贴有 McGraw-Hill 公司防伪标签, 无标签者不得销售。

东北财经大学出版社出版

(大连市黑石礁尖山街 217 号 邮政编码 116025)

总编室: (0411) 84710523

营销部: (0411) 84710711

网址: <http://www.dufep.cn>

读者信箱: [dufep@dufe.edu.cn](mailto:dufep@dufe.edu.cn)

大连图腾彩色印刷有限公司印刷 东北财经大学出版社发行

幅面尺寸: 200mm × 270mm

印张: 24 3/4

插页: 1

2008 年 11 月第 1 版

2008 年 11 月第 1 次印刷

责任编辑: 李 季

封面设计: 冀贵收

ISBN 978-7-81122-422-1

定价: 42.00 元

# 出版者的话

当前,在教育部的大力倡导下,财经和管理类专业的双语教学在我国各大高校已经逐步开展起来。一些双语教学开展较早的院校积累了丰富的经验,同时也发现了教学过程中存在的一些问题,尤其对教材提出了更高的要求;一些尚未进入这一领域的院校,也在不断探索适于自身的教学方式和方法以及适用的教材,以期时机成熟时加入双语教学的行列。总之,对各类院校而言,能否找到“适用”的教材都成为双语教学成功与否的关键因素之一。

然而,国外原版教材为国外教学量身定做的一些特点,如普遍篇幅较大、侧重于描述性讲解、辅助材料(如习题、案例、延伸阅读材料等)繁杂,尤其是许多内容针对性太强,与所在国的法律结构和经济、文化背景结合过于紧密等,却显然不适于国内教学采用,并成为制约国内双语教学开展的重要原因。因此,对国外原版教材进行本土化的精简改编,使之变成更加“适用”的双语教材,已然迫在眉睫。

东北财经大学出版社作为国内较早涉足引进版教材的一家专业出版社,秉承自己一贯服务于财经教学的宗旨,总结自身多年的出版经验,同麦格劳—希尔教育出版公司、培生教育出版集团和圣智出版集团等国外著名出版公司通力合作,在国内再次领先推出了会计、工商管理、经济学等专业的“高等院校双语教学适用教材”。这套丛书的出版经过了长时间的酝酿和筛选,编选人员本着“品质优先、首推名作”的选题原则,既考虑了目前我国财经教育的现状,也考虑了我国财经高等教育所具有的学科特点和需求指向,在教材的遴选、改编和出版上突出了以下一些特点:

- 优选权威的最新版本。入选改编的教材是在国际上多次再版的经典之作的最新版本,其中有些教材的以前版本已在国内部分高校中进行了试用,获得了一致的好评。

- 改编后的教材在保持英文原版教材特色的基础上,力求内容精要,逻辑严密,适合中国的双语教学。选择的改编人员既熟悉原版教材内容,又具有本书或本门课程双语教学的经验。

- 改编后的教材配有丰富的辅助教学支持资源,教师可在网上免费获取。

- 改编后的教材篇幅合理,符合国内教学的课时要求,价格相对较低。

本套教材是在双语教学教材出版方面的一次新的尝试。我们在选书、改编及出版的过程中得到了国内许多高校的专家、教师的支持和指导,在此深表谢意,也期待广大读者提出宝贵的意见和建议。

尽管我们在改编的过程中已加以注意,但由于各教材的作者所处的政治、经济和文化背景不同,书中的内容仍可能有不妥之处,望读者在阅读中注意比较和甄别。

东北财经大学出版社

# Preface

This book contains material developed for use in the interdisciplinary courses on product development that we teach. Participants in these courses include graduate students in engineering, industrial design students, and MBA students. While we aimed the book at interdisciplinary graduate-level audiences such as this, many faculty teaching graduate and undergraduate courses in engineering design have also found the material useful. *Product Design and Development* is also for practicing professionals. Indeed, we could not avoid writing for a professional audience because most of our students are themselves professionals who have worked either in product development or in closely related functions.

This book blends the perspectives of marketing, design, and manufacturing into a single approach to product development. As a result, we provide students of all kinds with an appreciation for the realities of industrial practice and for the complex and essential roles played by the various members of product development teams. For industrial practitioners, in particular, we provide a set of product development methods that can be put into immediate practice on development projects.

A debate currently rages in the academic community as to whether design should be taught primarily by establishing a foundation of theory or by engaging students in loosely supervised practice. For the broader activity of product design and development, we reject both approaches when taken to their extremes. Theory without practice is ineffective because there are many nuances, exceptions, and subtleties to be learned in practical settings and because some necessary tasks simply lack sufficient theoretical underpinnings. Practice without guidance can too easily result in frustration and fails to exploit the knowledge that successful product development professionals and researchers have accumulated over time. Product development, in this respect, is like sailing: proficiency is gained through practice, but some theory of how sails work and some instruction in the mechanics (and even tricks) of operating the boat help tremendously.

We attempt to strike a balance between theory and practice through our emphasis on methods. The methods we present are typically step-by-step procedures for completing tasks, but rarely embody a clean and concise theory. In some cases, the methods are supported in part by a long tradition of research and practice, as in the chapter on product development economics. In other cases, the methods are a distillation of relatively recent and *ad hoc* techniques, as in the chapter on design for manufacturing. In all cases, the methods provide a concrete approach to solving a product development problem. In our experience, product development is best learned by applying structured methods to ongoing project work in either industrial or academic settings. Therefore, we intend this book to be used as a guide to completing development tasks either in the context of a course project or in industrial practice.

An industrial example or case study illustrates every method in the book. We chose to use different products as the examples for each chapter rather than carrying the same example through the entire book. We provide this variety because we think it makes the

book more interesting and because we hope to illustrate that the methods can be applied to a wide range of products, from bowling equipment to syringes.

We designed the book to be extremely modular—it consists of 16 independent chapters. Each chapter presents a development method for a specific portion of the product development process. The primary benefit of the modular approach is that each chapter can be used independently of the rest of the book. This way, faculty, students, and practitioners can easily access only the material they find most useful.

This fourth edition of the book includes revisions throughout the book, updated examples and data, expanded explanations, and new insights from recent research and innovations in practice.

To supplement this textbook, we have developed a web site on the Internet. This is intended to be a resource for instructors, students, and practitioners. We will keep the site current with additional references, examples, and links to available resources related to the product development topics in each chapter. Please make use of this information via the Internet at [www.ulrich-eppinger.net](http://www.ulrich-eppinger.net).

The application of structured methods to product development also facilitates the study and improvement of development processes. We hope, in fact, that readers will use the ideas in this book as seeds for the creation of their own development methods, uniquely suited to their personalities, talents, and company environments. We encourage readers to share their experiences with us and to provide suggestions for improving this material. Please write to us with your ideas and comments at [ulrich@wharton.upenn.edu](mailto:ulrich@wharton.upenn.edu) and [eppinger@mit.edu](mailto:eppinger@mit.edu).

# Acknowledgments

Hundreds of people contributed to this book in large and small ways. We are grateful to the many industrial practitioners who provided data, examples, and insights. We appreciate the assistance we have received from numerous academic colleagues, research assistants, and support staff, from our sponsors, and from the McGraw-Hill team. Indeed we could not have completed this project without the cooperation and collaboration of many professionals, colleagues, and friends. Thank you all.

Financial support for much of the development of this textbook has come from the Alfred P. Sloan Foundation, from the MIT Leaders for Manufacturing Program, and from the MIT Center for Innovation in Product Development.

Many industrial practitioners helped us in gathering data and developing examples. We would particularly like to acknowledge the following: Richard Ahern, Liz Altman, Lindsay Anderson, Terri Anderson, Mario Belsanti, Mike Benjamin, Scott Beutler, Bill Burton, Michael Carter, Jim Caruso, Pat Casey, Victor Cheung, David Cutherell, Tim Davis, Tom Davis, John Elter, George Favaloro, David Fitzpatrick, Marc Filerman, Gregg Geiger, Anthony Giordano, David Gordon, Kamala Grasso, Matt Haggerty, Rick Harkey, Matthew Hern, Alan Huffenus, Art Janzen, Randy Jezowski, Carol Keller, Matt Kressy, Edward Kreuzer, David Lauzun, Peter Lawrence, Brian Lee, David Levy, Albert Lucchetti, Paul Martin, Doug Miller, Leo Montagna, Al Nagle, John Nicklaus, Hossain Nivi, Chris Norman, Paolo Pascarella, E. Timothy Pawl, Amy Potts, Earl Powell, Jason Ruble, Virginia Runkle, Nader Sabbaghian, David Shea, Wei-Ming Shen, Leon Soren, Paul Staelin, Michael Stephens, Scott Stropkay, Larry Sullivan, Malcom Taylor, Brian Vogel, David Webb, Bob Weisshappel, Dan Williams, and Mark Winter.

We have received tremendous assistance from our colleagues who have offered frequent encouragement and support for our somewhat unusual approach to teaching and research, some of which is reflected in this book. We are especially indebted to the MIT Leaders for Manufacturing (LFM) Program and to the MIT Center for Innovation in Product Development (CIPD), two exemplary partnerships involving major manufacturing firms and MIT's engineering and management schools. We have benefited from collaboration with the faculty and staff associated with these programs, especially Gabriel Bitran, Kent Bowen, Don Clausing, Tom Eagar, Charlie Fine, Woodie Flowers, Steve Graves, John Hauser, Rebecca Henderson, Maurice Holmes, Tom Magnanti, Kevin Otto, Don Rosenfield, Warren Seering, Shoji Shiba, Anna Thornton, Jim Utterback, Eric von Hippel, Dave Wallace, and Dan Whitney. We have received financial support from LFM, CIPD, and the Gordon Book Fund. Most important, LFM and CIPD partner companies have provided us with unparalleled access to industrial projects and research problems in product development and manufacturing.

Several faculty members have helped us by reviewing chapters and providing feedback from their in-class trials in teaching with this material. We are particularly grateful to these reviewers and "beta testers": Alice Agogino, Don Brown, Steve Brown, Charles

Burnette, Gary Cadenhead, Roger Calantone, Cho Lik Chan, Kim Clark, Morris Cohen, Michael Duffey, William Durfee, Josh Eliashberg, David Ellison, Woodie Flowers, Gary Gabriele, Abbie Griffin, Marc Harrison, Rebecca Henderson, Tim Hight, Mike Houston, Marco Iansiti, Kos Ishii, R. T. Johnson, Viswanathan Krishnan, Yuyi Lin, Richard Locke, Bill Lovejoy, Jeff Meldman, Farrokh Mistree, Wanda Orlikowski, Louis Padulo, Robert Pelke, Warren Seering, Paul Sheng, Robert Smith, Carl Sorensen, Mark Steiner, Christian Terwiesch, Chuck Turtle, Marcie Tyre, Dan Whitney, Kristin Wood, and Khim-Teck Yeo.

Several industrial practitioners and training experts have also assisted us by reviewing and commenting on draft chapters: Wesley Allen, Geoffrey Boothroyd, Gary Burchill, Eugene Cafarelli, James Carter, David Cutherell, Gerard Furbershaw, Jack Harkins, Gerhard Jünemann, David Meeker, Ulrike Närger, B. Joseph Pine II, William Townsend, Brian Vogel, and John Wesner.

We also wish to acknowledge the more than 1,000 students in the classes in which we have tested these teaching materials. These students have been in several teaching programs at MIT, Helsinki University of Technology, Rhode Island School of Design, STOA (Italy), University of Pennsylvania, and Nanyang Technological University (Singapore). Many students provided constructive comments for improving the structure and delivery of the material finally contained here. Also, our experiences in observing the students' use of these methods in product development projects have greatly helped us refine the material.

Several MIT students served as research assistants to help investigate many of the development methods, examples and data contained in the first edition of this book. These individuals are Paul Brody (Chapter 10), Tom Foody (Chapter 13), Amy Greenlief (Chapter 12), Christopher Hession (Chapter 3), Eric Howlett (Chapter 7), Tom Pimmler (Chapter 11 Appendices), Stephen Raab (Chapter 14), Harrison Roberts (Chapter 11 Appendices), Jonathan Sterrett (Chapter 4), and Gavin Zau (Chapter 6).

Other MIT students have also contributed by assisting with data collection and by offering comments and stimulating criticisms related to some of the chapters: Tom Abell, E. Yung Cha, Steve Daleiden, Russell Epstein, Matthew Fein, Brad Forry, Mike Frauens, Ben Goss, Daniel Hommes, Bill Liteplo, Habs Moy, Robert Northrop, Leslie Prince Rudolph, Vikas Sharma, and Ranjini Srikantiah. We also appreciate the cheerful and able assistance of the MIT support staff, Stephen Arnold, Cara Barber, Anna Piccolo, Kristin Rocheleau, and Kathy Sullivan.

The staff throughout the McGraw-Hill/Irwin organization has been superb. We are particularly grateful for the support of our sponsoring editor Andy Winston. We also appreciate the efforts of developmental editor Kelly Pekelder, project manager Bruce Gin, copy editor Gretlyn Cline, photo editor Jeremy Cheshareck, photographer Stuart Cohen, and designer Jillian Lindner.

Finally, we thank our families for their love and support. Our parents provided much encouragement. Nancy, Julie, Lauren, Andrew, Jamie, and Nathan have shown endless patience over the years of this ongoing product development project.

*Karl T. Ulrich*  
*Steven D. Eppinger*



# 目 录

<b>第1章 引论</b>	1
1.1 成功的产品开发的特点	2
1.2 谁来设计和开发产品?	3
1.3 产品开发的时间和成本	5
1.4 产品开发的挑战	6
1.5 本书的思路	6
<b>第2章 开发流程和组织</b>	11
2.1 产品的基本开发流程	12
2.2 概念开发: 前端过程	16
2.3 采用基本的产品开发流程	18
2.4 产品开发过程的流程	22
2.5 AMF 公司的开发流程	22
2.6 产品开发组织	23
2.7 AMF 组织	28
2.8 小结	30
<b>第3章 产品规划</b>	33
3.1 产品规划过程	34
3.2 步骤1: 识别机会	37
3.3 步骤2: 项目评价和优先级排序	38
3.4 步骤3: 资源分配和时间计划	43
3.5 步骤4: 完成项目前计划	45
3.6 步骤5: 对结果和流程做出反应	49
3.7 小结	50
<b>第4章 识别顾客需要</b>	53
4.1 步骤1: 从顾客那里获取原始数据	56
4.2 步骤2: 从顾客需要的角度理解原始数据	61

4.3	步骤3: 组织需要的等级	63
4.4	步骤4: 建立需要的相对重要性	66
4.5	步骤5: 对结果和流程做出反应	67
4.6	小结	68
第5章	产品规格说明	71
5.1	什么是规格说明?	72
5.2	何时建立规格说明?	73
5.3	建立目标规格说明	74
5.4	确定最终规格	83
5.5	小结	91
第6章	概念生成	97
6.1	概念生成活动	98
6.2	步骤1: 阐明问题	100
6.3	步骤2: 外部研究	104
6.4	步骤3: 内部研究	107
6.5	步骤4: 系统开发	110
6.6	步骤5: 对结果和流程做出反应	119
6.7	小结	120
第7章	概念选择	123
7.1	概念选择是产品开发过程的一个必要环节	124
7.2	所有的开发小组都使用某些方法选择概念	125
7.3	结构化方法的优点	128
7.4	方法概要	129
7.5	概念甄别	130
7.6	给概念打分	134
7.7	警示	137
7.8	小结	139
第8章	概念验证	145
8.1	步骤1: 定义概念验证的目的	147
8.2	步骤2: 选择调查人群	147
8.3	步骤3: 选择调查形式	148
8.4	步骤4: 概念表达	149
8.5	步骤5: 测定顾客反应	155
8.6	步骤6: 结果解释	155
8.7	步骤7: 对结果和流程做出反应	158
8.8	小结	159
第9章	产品构造	163
9.1	什么是产品构造?	164
9.2	产品构造的内涵	167
9.3	建立产品构造	171

9.4	多样化和供应链方面的考虑 .....	177
9.5	平台规划 .....	180
9.6	系统设计的有关事项 .....	182
9.7	小结 .....	184
<b>第 10 章</b>	<b>工业设计 .....</b>	<b>187</b>
10.1	什么是工业设计? .....	189
10.2	对工业设计需要的评价 .....	191
10.3	工业设计的影响 .....	193
10.4	工业设计过程 .....	197
10.5	工业设计过程的管理 .....	201
10.6	评估工业设计的质量 .....	204
10.7	小结 .....	206
<b>第 11 章</b>	<b>制造设计 .....</b>	<b>209</b>
11.1	制造设计的定义 .....	211
11.2	步骤 1: 估计制造成本 .....	212
11.3	步骤 2: 降低零部件成本 .....	220
11.4	步骤 3: 降低装配成本 .....	223
11.5	步骤 4: 减少直接费用 .....	226
11.6	步骤 5: DFM 决策对其他因素的影响 .....	228
11.7	成果 .....	229
11.8	小结 .....	231
<b>第 12 章</b>	<b>原型化 .....</b>	<b>245</b>
12.1	原型的基础知识 .....	247
12.2	原型化原理 .....	253
12.3	原型化技术 .....	257
12.4	原型计划 .....	259
12.5	小结 .....	262
<b>第 13 章</b>	<b>稳健设计 .....</b>	<b>267</b>
13.1	什么是稳健设计 .....	268
13.2	步骤 1: 确定控制因素、噪声因素和性能度量 .....	271
13.3	步骤 2: 构造目标函数 .....	272
13.4	步骤 3: 规划实验计划 .....	273
13.5	步骤 4: 实施实验 .....	277
13.6	步骤 5: 进行分析 .....	277
13.7	步骤 6: 选择并确认因素设定点 .....	279
13.8	步骤 7: 反思和重复 .....	279
13.9	警示 .....	280
13.10	小结 .....	280
<b>第 14 章</b>	<b>专利和知识产权 .....</b>	<b>287</b>
14.1	什么是知识产权 .....	288

14.2	步骤 1: 拟定策略和计划 .....	292
14.3	步骤 2: 研究先前专利 .....	294
14.4	步骤 3: 勾勒权利要求 .....	295
14.5	步骤 4: 撰写发明描述 .....	296
14.6	步骤 5: 提炼权利要求 .....	299
14.7	步骤 6: 进行申请 .....	302
14.8	步骤 7: 对结果和过程进行反思 .....	304
14.9	小结 .....	304
<b>第 15 章</b>	<b>产品开发项目的经济分析 .....</b>	<b>309</b>
15.1	经济分析要素 .....	310
15.2	步骤 1: 建立一个基本财务模型 .....	312
15.3	步骤 2: 敏感性分析 .....	315
15.4	步骤 3: 用敏感性分析来理解项目的权衡取舍 .....	318
15.5	步骤 4: 考虑定性因素对项目成功的影响 .....	322
15.6	小结 .....	325
<b>第 16 章</b>	<b>产品开发项目管理 .....</b>	<b>333</b>
16.1	理解和描述任务 .....	334
16.2	基本项目计划 .....	339
16.3	加速项目进程 .....	345
16.4	项目执行 .....	348
16.5	项目后评估 .....	352
16.6	小结 .....	353

# Brief Contents

<b>1</b>	Introduction	1	<b>9</b>	Product Architecture	163
<b>2</b>	Development Processes and Organizations	11	<b>10</b>	Industrial Design	187
<b>3</b>	Product Planning	33	<b>11</b>	Design for Manufacturing	209
<b>4</b>	Identifying Customer Needs	53	<b>12</b>	Prototyping	245
<b>5</b>	Product Specifications	71	<b>13</b>	Robust Design	267
<b>6</b>	Concept Generation	97	<b>14</b>	Patents and Intellectual Property	287
<b>7</b>	Concept Selection	123	<b>15</b>	Product Development Economics	309
<b>8</b>	Concept Testing	145	<b>16</b>	Managing Projects	333
			<b>Index</b>		359

# Contents

## Chapter 1

### Introduction 1

Characteristics of Successful Product Development	2
Who Designs and Develops Products?	3
Duration and Cost of Product Development	5
The Challenges of Product Development	6
Approach of This Book	6
<i>Structured Methods</i>	7
<i>Industrial Examples</i>	7
<i>Organizational Realities</i>	7
<i>Roadmap of the Book</i>	8
References and Bibliography	10
Exercises	10
Thought Question	10

## Chapter 2

### Development Processes and Organizations 11

A Generic Development Process	12
Concept Development: The Front-End Process	16
Adapting the Generic Product Development Process	18
<i>Technology-Push Products</i>	18
<i>Platform Products</i>	20
<i>Process-Intensive Products</i>	20
<i>Customized Products</i>	20
<i>High-Risk Products</i>	20
<i>Quick-Build Products</i>	21
<i>Complex Systems</i>	21
Product Development Process Flows	22
The AMF Development Process	22
Product Development Organizations	23
<i>Organizations Are Formed by Establishing Links among Individuals</i>	23

*Organizational Links May Be Aligned with Functions, Projects, or Both* 25

*Choosing an Organizational Structure* 26

The AMF Organization 28

Summary 30

References and Bibliography 30

Exercises 31

Thought Questions 32

## Chapter 3

### Product Planning 33

The Product Planning Process 34

*Four Types of Product Development Projects* 35

*The Process* 36

Step 1: Identify Opportunities 37

Step 2: Evaluate and Prioritize Projects 38

*Competitive Strategy* 38

*Market Segmentation* 39

*Technological Trajectories* 40

*Product Platform Planning* 40

*Evaluating Fundamentally New Product Opportunities* 42

*Balancing the Portfolio* 43

Step 3: Allocate Resources and Plan Timing 43

*Resource Allocation* 44

*Project Timing* 45

*The Product Plan* 45

Step 4: Complete Pre-Project Planning 45

*Mission Statements* 47

*Assumptions and Constraints* 48

*Staffing and Other Pre-Project Planning Activities* 49

Step 5: Reflect on the Results and the Process 49

Summary 50

References and Bibliography 50

Exercises 52

Thought Questions 52

**Chapter 4****Identifying Customer Needs 53**

- Step 1: Gather Raw Data from Customers 56
  - Choosing Customers* 58
  - The Art of Eliciting Customer Needs Data* 59
  - Documenting Interactions with Customers* 60
- Step 2: Interpret Raw Data in Terms of Customer Needs 61
- Step 3: Organize the Needs into a Hierarchy 63
- Step 4: Establish the Relative Importance of the Needs 66
- Step 5: Reflect on the Results and the Process 67
- Summary 68
- References and Bibliography 68
- Exercises 69
- Thought Questions 70

**Chapter 5****Product Specifications 71**

- What Are Specifications? 72
- When Are Specifications Established? 73
- Establishing Target Specifications 74
  - Step 1: Prepare the List of Metrics* 75
  - Step 2: Collect Competitive Benchmarking Information* 79
  - Step 3: Set Ideal and Marginally Acceptable Target Values* 79
  - Step 4: Reflect on the Results and the Process* 83
- Setting the Final Specifications 83
  - Step 1: Develop Technical Models of the Product* 85
  - Step 2: Develop a Cost Model of the Product* 86
  - Step 3: Refine the Specifications, Making Trade-Offs Where Necessary* 88
  - Step 4: Flow Down the Specifications as Appropriate* 89
  - Step 5: Reflect on the Results and the Process* 91
- Summary 91
- References and Bibliography 92
- Exercises 93
- Thought Questions 93
- Appendix**
- Target Costing 94**

**Chapter 6****Concept Generation 97**

- The Activity of Concept Generation 98
  - Structured Approaches Reduce the Likelihood of Costly Problems* 99
  - A Five-Step Method* 99
- Step 1: Clarify the Problem 100
  - Decompose a Complex Problem into Simpler Subproblems* 101
  - Focus Initial Efforts on the Critical Subproblems* 103
- Step 2: Search Externally 104
  - Interview Lead Users* 104
  - Consult Experts* 105
  - Search Patents* 105
  - Search Published Literature* 106
  - Benchmark Related Products* 107
- Step 3: Search Internally 107
  - Both Individual and Group Sessions Can Be Useful* 108
  - Hints for Generating Solution Concepts* 109
- Step 4: Explore Systematically 110
  - Concept Classification Tree* 112
  - Concept Combination Table* 114
  - Managing the Exploration Process* 117
- Step 5: Reflect on the Solutions and the Process 119
- Summary 120
- References and Bibliography 121
- Exercises 122
- Thought Questions 122

**Chapter 7****Concept Selection 123**

- Concept Selection Is an Integral Part of the Product Development Process 124
- All Teams Use Some Method for Choosing a Concept 125
- A Structured Method Offers Several Benefits 128
- Overview of Methodology 129
- Concept Screening 130
  - Step 1: Prepare the Selection Matrix* 130
  - Step 2: Rate the Concepts* 131
  - Step 3: Rank the Concepts* 132

- Step 4: Combine and Improve the Concepts* 132
- Step 5: Select One or More Concepts* 132
- Step 6: Reflect on the Results and the Process* 133

#### Concept Scoring 134

- Step 1: Prepare the Selection Matrix* 134
- Step 2: Rate the Concepts* 135
- Step 3: Rank the Concepts* 136
- Step 4: Combine and Improve the Concepts* 136
- Step 5: Select One or More Concepts* 136
- Step 6: Reflect on the Results and the Process* 137

#### Caveats 137

#### Summary 139

#### References and Bibliography 139

#### Exercises 140

#### Thought Questions 141

#### Appendix A Concept-Screening Matrix

##### Example 142

#### Appendix B

##### Concept-Scoring Matrix Example 143

## Chapter 8

### Concept Testing 145

- Step 1: Define the Purpose of the Concept Test* 147
- Step 2: Choose a Survey Population* 147
- Step 3: Choose a Survey Format* 148
- Step 4: Communicate the Concept* 149
  - Matching the Survey Format with the Means of Communicating the Concept* 153
  - Issues in Communicating the Concept* 153
- Step 5: Measure Customer Response* 155
- Step 6: Interpret the Results* 155
- Step 7: Reflect on the Results and the Process* 158

#### Summary 159

#### References and Bibliography 159

#### Exercises 160

#### Thought Questions 160

#### Appendix

##### Estimating Market Sizes 161

## Chapter 9

### Product Architecture 163

#### What Is Product Architecture? 164

- Types of Modularity* 166
- When Is the Product Architecture Defined?* 167

#### Implications of the Architecture 167

- Product Change* 167
- Product Variety* 168
- Component Standardization* 169
- Product Performance* 169
- Manufacturability* 170
- Product Development Management* 171

#### Establishing the Architecture 171

- Step 1: Create a Schematic of the Product* 172
- Step 2: Cluster the Elements of the Schematic* 173
- Step 3: Create a Rough Geometric Layout* 175
- Step 4: Identify the Fundamental and Incidental Interactions* 176

#### Delayed Differentiation 177

#### Platform Planning 180

- Differentiation Plan* 180
- Commonality Plan* 181
- Managing the Trade-Off between Differentiation and Commonality* 182

#### Related System-Level Design Issues 182

- Defining Secondary Systems* 183
- Establishing the Architecture of the Chunks* 183
- Creating Detached Interface Specifications* 184

#### Summary 184

#### References and Bibliography 185

#### Exercises 186

#### Thought Questions 186

## Chapter 10

### Industrial Design 187

#### What Is Industrial Design? 189

#### Assessing the Need for Industrial Design 191

- Expenditures for Industrial Design* 191
- How Important Is Industrial Design to a Product?* 191
- Ergonomic Needs* 192
- Aesthetic Needs* 193

#### The Impact of Industrial Design 193

- Is Industrial Design Worth the Investment?* 193
- How Does Industrial Design Establish a Corporate Identity?* 196

#### The Industrial Design Process 197

1. *Investigation of Customer Needs* 197
2. *Conceptualization* 197



3. Preliminary Refinement	198
4. Further Refinement and Final Concept Selection	198
5. Control Drawings or Models	200
6. Coordination with Engineering, Manufacturing, and External Vendors	200
The Impact of Computer-Based Tools on the ID Process	200
Management of the Industrial Design Process	201
Timing of Industrial Design Involvement	202
Assessing the Quality of Industrial Design	204
1. Quality of the User Interface	204
2. Emotional Appeal	204
3. Ability to Maintain and Repair the Product	204
4. Appropriate Use of Resources	206
5. Product Differentiation	206
Summary	206
References and Bibliography	207
Exercises	208
Thought Questions	208

## Chapter 11

### Design for Manufacturing 209

Design for Manufacturing Defined	211
DFM Requires a Cross-Functional Team	211
DFM Is Performed throughout the Development Process	211
Overview of the DFM Process	212
Step 1: Estimate the Manufacturing Costs	212
Fixed Costs versus Variable Costs	215
The Bill of Materials	215
Estimating the Costs of Standard Components	216
Estimating the Costs of Custom Components	217
Estimating the Cost of Assembly	218
Estimating the Overhead Costs	219
Step 2: Reduce the Costs of Components	220
Understand the Process Constraints and Cost Drivers	220
Redesign Components to Eliminate Processing Steps	221
Choose the Appropriate Economic Scale for the Part Process	221
Standardize Components and Processes	222
Adhere to "Black Box" Component Procurement	223

Step 3: Reduce the Costs of Assembly	223
Keeping Score	224
Integrate Parts	224
Maximize Ease of Assembly	225
Consider Customer Assembly	226
Step 4: Reduce the Costs of Supporting Production	226
Minimize Systemic Complexity	227
Error Proofing	227
Step 5: Consider the Impact of DFM Decisions on Other Factors	228
The Impact of DFM on Development Time	228
The Impact of DFM on Development Cost	228
The Impact of DFM on Product Quality	229
The Impact of DFM on External Factors	229
Results	229
Summary	231
References and Bibliography	232
Exercises	233
Thought Questions	234
Appendix A	
Materials Costs	235
Appendix B	
Component Manufacturing Costs	236
Appendix C	
Assembly Costs	242
Appendix D	
Cost Structures	243

## Chapter 12

### Prototyping 245

Understanding Prototypes	247
Types of Prototypes	247
What Are Prototypes Used For?	250
Principles of Prototyping	253
Analytical Prototypes Are Generally More Flexible than Physical Prototypes	253
Physical Prototypes Are Required to Detect Unanticipated Phenomena	253
A Prototype May Reduce the Risk of Costly Iterations	254
A Prototype May Expedite Other Development Steps	256