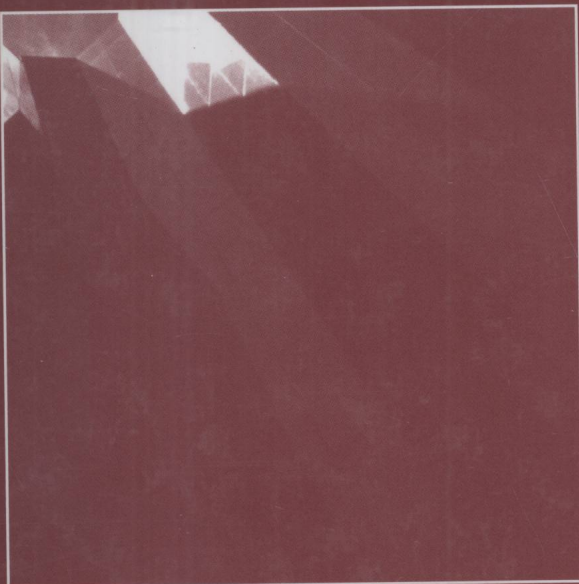
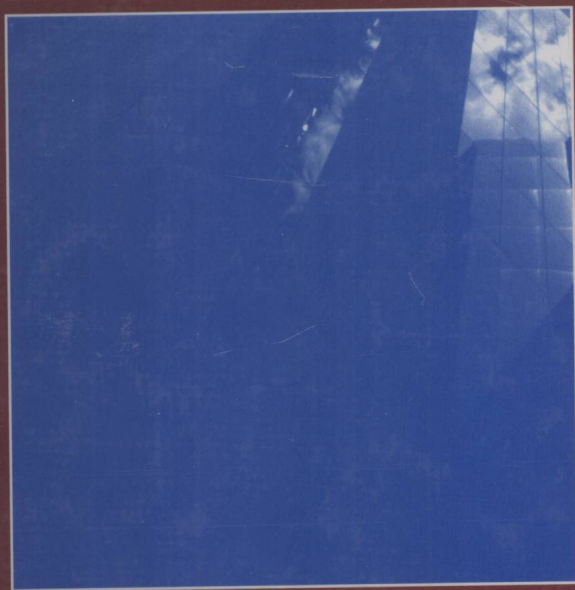
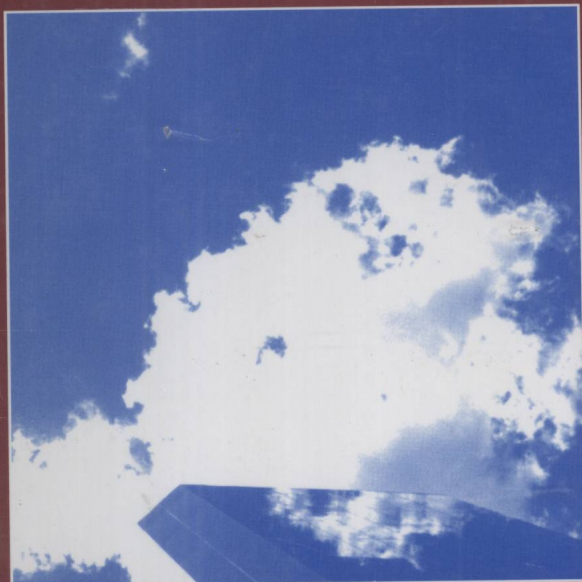

CREATIVE DESIGN OF PRODUCTS AND SYSTEM



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CREATIVE DESIGN OF PRODUCTS AND SYSTEMS

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CREATIVE DESIGN OF PRODUCTS AND SYSTEMS

*Dedicated to my loved ones, Shohreh, Adam, and Alan
for living with my creations
and for being my source of inspiration through their own creativity*

PREFACE

This book is the culmination of years of work, writing, and experience in teaching design to thousands of students at Cal Poly, San Luis Obispo. Like the design process it presents for solving any problem, the manuscript has been edited, modified, added to, and changed numerous times with each iteration. But as one of my students, whose name I have since forgotten, said, “During the design process, there comes a time when you need to shoot the designer and go into production.” This book, like any other book, is not perfect or complete. There are always more issues to discuss and present, more information to mention, and other techniques to utilize. But brevity is still an important matter, and expecting one book to cover everything anyone may desire to teach in a class is unrealistic. And to others, it is already too long.

However, this book covers a wide variety of subjects that are usually and customarily covered in design classes. In some schools this material is covered in a Sophomore or Junior class, in others in a Senior, capstone design class. Some schools leave out the engineering calculations and stress analysis, circuit design, and other analysis material to other courses, some cover all in a series of two or three classes, consecutively. This book is intended to be the primary source for most of these classes. It may be used for introductory classes, intermediate classes, or a capstone design class. Only one chapter discusses mechanical design analysis more appropriate to mechanical engineering, and that is because fatigue considerations are so important in so many design decisions. Otherwise, practically all other material is appropriate to the design of products and systems regardless of the type of product or system.

This book is intended for all designers, whether engineers, architects, industrial designers, landscape designers, or any others. It can also be used in all branches of engineering. The detail design of any particular field is taught separately in the rest of the curriculum. But the design process is the same in all fields. As such, mechanical, electrical, architectural, and many other examples are included throughout the book.

At Cal Poly, we teach most of this material in one Quarter-based, Junior-level class. The remainder is covered in a senior capstone class that includes an industry-based design-build-test project with one lecture and two labs per week. Therefore, there should be sufficient material, and enough time, to present most of this book in a one-semester class as well. Our Junior-level class is scheduled for two classes per week, each 1.5 hours long. We have found out that it is much more efficient to have longer classes to cover the material without breaking it into smaller units.

In our experience, we have found the following to work efficiently:

Week	Topic	Reading
1	Introduction Team Assignments, Creativity	Chapter 1 Chapter 1, 2
2	Mental Barriers Mental Barriers, Continued	Chapter 3 Chapter 3
3	Problem-Solving Techniques Design Process	Chapter 4 Chapter 5
4	Patents Visualization, Imagination	Chapter 14 Chapter 6
5	Drawing and sketching Aesthetics	Chapter 6 Chapter 9
6	Design Factors Testing of Midterm Project	Chapter 7
7	Quality in Design Product Liability	Chapter 12 Chapter 13
8	Human Factors Safety, Man–Machine Interfaces	Chapter 8 Chapter 8
9	Economics of Design Entrepreneurship	Chapter 11 (First-half) Chapter 15
10	Final Project Presentations Final Project Presentations	

Due to the present structure of our curriculum, Chapters 10 (Materials and Manufacturing) and 16 (Design Analysis), as well as the second part of Chapter 11 (Engineering Economy), are covered in other classes. Therefore, these chapters are not mentioned in this schedule.

The homework for the first class, due on the second day, is the design of a page-turner for the disabled. This is used as a benchmark for students to realize where they stand before this class, and what their perception of design is. They are also asked to take a personality test at a web-based site such as Humanmetrics. This information is used in the second class for forming affinity groups and assigning team members.

In addition to homework and short projects, we assign two major projects during the quarter, one as a midterm project, one as final project. The midterm project is assigned after the discussion on creativity, and is based on this subject. Students are asked to design some device that will perform a certain job, usually trivial, and make the device for testing in class. Samples of this type of project are given in Chapter 3 (such as a Rube

Goldberg-type project or the garbanzo carrying device). The second project is the design of a product, and follows the design process. It is intended to encompass all the issues discussed in class, from creative design to human factors to economics of the design. Student teams find a need, define it, design it, and at the end of the quarter, present it. Some groups make models of the product for presentation, but we do not require actual manufacture of the product in this class since there is not enough time. The teams are assigned at the beginning of the class, usually the second meeting, and remain in effect throughout the Quarter. Thanks to the National Collegiate Innovators and Inventors Alliance (NCIIA) and the Lemelson Foundation, we introduced the concept of Entrepreneurship Teams (E-Teams) into the class many years ago. The final deliverable is a presentation, a report, and the evaluation of others' projects. However, in our program, senior capstone design is a separate course in which industrially sponsored projects are assigned to teams. Teams of students design, build, test, and present their projects in an exhibit. The contents of this book are the basis for both the senior capstone class and the junior-level creative design class.

We also invite experts, both from the University and local community as well as industry experts, as guest lecturers. These include, whenever possible, entrepreneurs, artists who teach drawing and visualization, quality engineers, safety experts, and so on.

For semester-long classes, more chapters can be covered, for example, material selection, manufacturing techniques, and design analysis, or more free time can be devoted to team work for design projects. If the class does include industry-based projects, more time may be devoted to the design of the product or system while students read the book instead of lectures.

Chapter 2 is informative, interesting, and short. It may be skipped if necessary, or students may read it for their own information. It is intended as an introduction to Chapter 3.

I would like to thank the following individuals for their tremendous help in many different capacities, without whom the project would have been impossible or very different. First, Mr. Joe Hayton, the acquisition editor at Wiley at the time, through whom I received much feedback from colleagues who read the first drafts, as well as Dan Sayre and Michael McDonald, who continued Joe's work. My thanks to the delightful Anna Melhorn, Senior Production Editor. My thanks also go to all the reviewers who made constructive comments that made the book so much better, but (unfortunately) do not know their names to mention. But thank you to all of you. Of course, my thanks to my family who endured all the time I spent working on this, reading the manuscript for errors and providing interesting observations. My colleagues at Cal Poly, especially Jim Widmann, Joe Mello, and Chris Pascual who provided material for different chapters, and my students who allowed me to use some of their homework and projects as examples. Douglass Wilde of Stanford University provided material and valuable review for team formation, Mike Ashby of Oxford University provided graphs and information for material selection, Larry Staufer who provided an example for design for assembly, Bill Bellows of Pratt and Whitney Rocketdyne provided material for quality engineering, Scott Ganaja of Progressive Engineering provided material for design with plastics, Joe Boeddeker and Dennis Fernandez provided invaluable assistance for entrepreneurship, Sina Niku who provided an architectural example, and Rambod Jacoby who provided an electrical engineering example. My thanks also to Shohreh for her own way of breaking the rules, being creative as well helping with the food-related information and testing to Adam and Alan for much helpful editing. My thanks also to NCIIA and Phil Weilerstein for their support to integrate E-teams into our class. My thanks also to my old classmates at Stanford, Dennis Boyle, Pam Kenady, and Dave Kelley, who inspired me in 1975 to look at things differently, as well as James Adams and Jerry Henderson who taught me a lot.

Finally, I am indebted to countless other authors, developers, teachers, engineers, and scientists who have originally created and developed most of the material presented in this book.

I hope you and your students will enjoy this book and will learn from it.

Saeed Benjamin Niku
San Luis Obispo
2008

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CREATIVE PRODUCT AND SYSTEM DESIGN

I am always doing that which I cannot do in order that I may learn how to do it.

—Pablo Picasso

Whether you believe you can, or whether you believe you can't, you are absolutely right.

—Henry Ford

1.1 INTRODUCTION

One of my students, whose name I have long since forgotten, once said, "Design is like getting a hair cut; you do not tell the barber how to cut your hair. You just tell him how you want your hair to look." This implies that the barber (or hair stylist) knows how to accomplish the proper hair cut. No doubt, you or anyone else could also cut your hair. But you still go to a barber or hair stylist and pay him or her to cut your hair. You expect that the barber or hair stylist has learned how to do the job better, quicker, and more safely, even if hair cutting is fundamentally an intuitive project that anyone can perform.

So is design. Most people assume that they are designers. They can invent products, put together plans, and create systems that will do things and perform tasks; and they probably can. However, as with the barber or hair stylist, it takes learning the art and the science of design to actually create products and systems that work correctly and safely, are easy and inexpensive to produce, durable and efficient, and technologically appropriate. It takes much learning in many different fields, including different branches of engineering, sciences, psychology, arts, physical and medical sciences, and mathematics, to become a good designer.

And this is what this book is about. It is about the fundamental knowledge necessary to be a good designer, understand the different steps of the design process, be a more creative and efficient designer, understand the consequences of design decisions, and create products, systems, or plans, that are sound, good, innovative, safe, and useful. The fact that you may have created some products in your garage, or that you have fixed your car, or that you are a hands-on person, does not necessarily mean that you are also a (good) designer. You still need to learn the design process and what it takes to create good designs.

In this book we will try to learn what design means, how to be a more creative designer, and how to look for consequences of design decisions. This book is not a handbook or encyclopedia of all the knowledge you need to be a designer. You still need to learn all the other subjects that are taught in school. But this book will help you to be a good, creative, and forward-looking designer.