

A Review of Research in Mechanical Engineering Design. Part I: Descriptive, Prescriptive, and Computer-Based Models of Design Processes

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Abstract. This is the first of a two-part paper summarizing and reviewing research in mechanical engineering design theory and methodology. Part I includes: 1) descriptive models; 2) prescriptive models; and 3) computer-based models of design processes. Part II, which will appear in the next issue of this journal, will include: 4) languages, representations, and environments for design; 5) analysis in support of design; and 6) design for manufacture and the life-cycle. For each major area, we discuss the current topics of research and the state of the art, emphasizing recent significant advances. We also discuss the important open research issues in each area. The six categories are certainly not mutually exclusive nor even collectively exhaustive; however, some organization is necessary, and these categories have been effective in making sense of a body of research that is expanding rapidly in many exciting and promising directions. The mechanical engineering design research community has made major advances over the last few years. The research community in mechanical engineering design has made significant progress not only in advancing our knowledge of design, but also in clarifying the research methods necessary to study design. Great progress is being made toward a better understanding of design, and hence toward better design tools.

1 Introduction

This paper, the first in a series of reviews that will be published in *Research in Engineering Design*, summarizes and reviews the state of research in engineering design theory and methodology, concentrating on mechanical engineering design. Subsequent reviews will concentrate on other areas of engineering design or on special sub-topics. The goal of the series is to inform the community at large of advances in the developments in engineering design research. We also hope that it will enable

researchers to place their work in context and thus guide continuing work. The series of papers is also intended to be an efficient starting place for those who wish to become familiar with the engineering design literature relevant to their interests.

1.1 Scope

There are, of necessity, limits to the nature and scope of this review. First, the review is not intended to be a substitute for reading complete papers; it is intended only as a brief summary of, and guide to, the literature. Although we have made every reasonable effort to be complete, omissions are inevitable. There can also be errors of commission caused by misinterpretation or lack of full understanding on our part of papers included in the review. We apologize to both readers and researchers for these errors.

The scope is limited in several ways. We intend only to include research in engineering design, and then only that portion of engineering design broadly called "mechanical," which includes products, machines, structures, and the like. Research in geometric modeling, architectural design, manufacturing, expert systems, and optimization are included only when the research is directly relevant to design of mechanical systems. We have also not attempted to cover the many new, commercial computer-aided design (CAD) systems which have begun to incorporate the research ideas discussed in this review.

The research discussed in this review paper has been conducted primarily in the United States. Work outside the U.S. has not been excluded, but is not covered systematically. Finally, research on mechanical design in very specific technical domains (e.g., mechanisms and heat exchangers) is not covered unless it is clearly extendible to other mechanical design domains.

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Table of Contents Mechanical Engineering Research Papers

1. Understanding the eBook Mechanical Engineering Research Papers
 - The Rise of Digital Reading Mechanical Engineering Research Papers
 - Advantages of eBooks Over Traditional Books
2. Identifying Mechanical Engineering Research Papers
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Mechanical Engineering Research Papers
 - User-Friendly Interface
4. Exploring eBook Recommendations from Mechanical Engineering Research Papers
 - Personalized Recommendations
 - Mechanical Engineering Research Papers User Reviews and Ratings
 - Mechanical Engineering Research Papers and Bestseller Lists
5. Accessing Mechanical Engineering Research Papers Free and Paid eBooks
 - Mechanical Engineering Research Papers Public Domain eBooks
 - Mechanical Engineering Research Papers eBook Subscription Services
 - Mechanical Engineering Research Papers Budget-Friendly Options
6. Navigating Mechanical Engineering Research Papers eBook Formats

- ePub, PDF, MOBI, and More
- Mechanical Engineering Research Papers Compatibility with Devices
- Mechanical Engineering Research Papers Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Mechanical Engineering Research Papers
 - Highlighting and Note-Taking Mechanical Engineering Research Papers
 - Interactive Elements Mechanical Engineering Research Papers
- 8. Staying Engaged with Mechanical Engineering Research Papers
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Mechanical Engineering Research Papers
- 9. Balancing eBooks and Physical Books Mechanical Engineering Research Papers
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Mechanical Engineering Research Papers
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Mechanical Engineering Research Papers
 - Setting Reading Goals Mechanical Engineering Research Papers
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Mechanical Engineering Research Papers
 - Fact-Checking eBook Content of Mechanical Engineering Research Papers
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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