Practical Engineering Design
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Edited by
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Design gives engineering students an opportunity to practice their profession by designing a real-world solution to an engineering problem in a way that can best be likened to an apprenticeship. In the early days of engineering education, virtually the entire curriculum consisted of students working with faculty and practitioners from industry in an apprenticeship setting to solve problems that were identified by local industry as critical. Thus, many engineering schools began as mining, agriculture, or technical colleges to serve local needs.

Following World War II and the enormous number of technological innovations spawned during the war years, engineering schools shifted to an engineering science model of engineering education in which all courses became science based instead of experience based. Although the pendulum is swinging back in the direction of an experience-based engineering education, today’s students are left with practically no exposure to the real problems facing industry and society if they do not have a formal program in engineering design.

The main benefit of the design project you are about to undertake is the opportunity to recapture the practical experience that is now regrettably missing from the rest of the engineering curriculum. Students can have the satisfaction of carrying a project through from the early design stage to a working prototype. In the process, you will learn about working in teams, scheduling, budgeting (both time and dollars), fabrication, documentation, and presentation. You will have the pride that comes from a job well done and, as an added bonus, an entry on your resume that will help in getting a good job. For those who envision their future in an entrepreneurial track, the experiences and knowledge that you will gain from a well-done design project can accurately mirror the process of running your own company.

At the outset, a design project is intimidating: you are required to either take a project description from an industry or faculty advisor or come up with your own project idea and find an advisor. You then must complete the project design and documentation and turn in a completed prototype in a relatively short amount of time. It is no wonder, when you have very little practical training, that this may seem to be a difficult, if not impossible, task. However, a successful design project is certainly achievable if you break the project into subtasks, turn to faculty or industry advisors for assistance, and keep yourself and your team organized.

Most universities have some form of engineering design in order to allow students practice in completing an entire extensive project. A formal course gives you the room to explore and experience the design process at
relatively little risk (other than a low grade) before you are plunged into your first real job and are entirely responsible for the development of a product or design.

Even if you have had solid work experience through co-op jobs or other means, a formal course in design gives you the opportunity to hone the skills necessary for success in any work position. In both course-based design and real jobs you will typically work in a group, and therefore you will have to be able to successfully allocate duties and resolve intra-group conflicts. A design project gives you the chance to experience working in a team whose members have different working styles and personalities, with an advisor available to help if there are any difficulties. The design process will also help you to hone your engineering skills, the problem-solving skills that have been subtly inserted into all of your classes since you were a freshman. In this way it brings together everything you have learned — not the obscure mathematical transforms or chemical processes required in undergraduate classes but rather the thought processes required to arrive at conclusions from a starting set of ideas or hypotheses by examining the trade-offs and alternative paths. Finally, it is almost impossible to be a good engineer today without possessing good communication skills. Unfortunately, oral and written communications are among the topics that are often overlooked or underemphasized in engineering curricula. By producing written (and often oral) reports of your project, you can obtain immediate feedback and learn how to fine-tune your presentation skills. This will benefit you immensely when you take a job in industry and are required to write project proposals or present ideas to your managers. While it is often the case that the number of requirements for a design project are great, and the allotted time very short, it is an almost unanimous opinion of graduating seniors that the design experience was valuable and, in most cases, enjoyable.

This handbook is an outgrowth of a set of senior design guidelines used in the Electrical and Computer Engineering Department, and as an extension of the Senior Design Handbook written in 1996 by James E. Mitchell for the Civil and Architectural Engineering Department at Drexel University. This handbook is aimed at students in design classes as well as novice engineers who are taking on their first project as a co-op assignment or on their first permanent job. It was written to answer some of the most pressing and most often repeated questions that we have heard from seniors or novice engineers as we have either taught various courses on design or served as project advisors. Unfortunately, there is no formal checklist by which you can complete a design process; however, this handbook provides a set of guidelines and includes examples of different aspects of the process. This is by no means a complete manual for the design process, and thus at the end of every chapter we have included what we feel are some of the best references on the topics covered. We strongly urge you to turn to these references for further information and simply use this book as a set of guidelines for your project.

The topics are arranged in the order in which you are likely to encounter them during your project. In the first chapter an overview of the design process is given. If you are at a loss as to where to start your project, you should read this chapter in detail. If, however, you already have a solid idea in mind, have formed a team, and have begun the design, this chapter will refresh your memory of important design aspects.

The second chapter briefly discusses how to consider the impact of your project on society. Often, the ethics and social impacts of projects are subtle and require considerable reflection to discern. The chapter provides a series of questions that you and your team members can ask yourselves to help
determine the benefits and risks of your project and can serve as a guideline as you move from the world of academia into industry after graduation.

The third, fourth, and fifth chapters cover project scheduling, management, and budgeting. While these chapters contain useful tips on these topics, not all of the material presented will be required for all design projects. For instance, in Chapter 5, three types of project budgets are discussed. Your design course may only require that you produce a budget for your prototype. However, it may be interesting for you to scan the remainder of the chapter to see how budgets might be produced for a project in industry.

The sixth and seventh chapters contain guidelines for written and oral presentation of your work and discuss how to make your project appealing to a variety of audiences. Obviously there is no clear-cut formula for doing so; much effort has to be put into writing and speaking, and many revisions performed to obtain fine-tuned results. These chapters provide important, but by no means exhaustive, tips for arranging the written documents and the oral presentation.

The eighth and ninth chapters are included as extra material for those who have unique projects with intellectual property that should be protected or that can be expanded into a business. Again, these chapters are not complete discussions of the topics, but are designed to answer basic questions such as what is intellectual property and what steps would be needed if you wanted to use your ideas to start a business. If you think your ideas should be protected, we encourage you to contact your organization's intellectual property office (most companies, colleges, and universities have such an office, typically as part of their research offices, or at least have a full- or part-time lawyer who can advise on these issues). If you are a student and think you may want to start a business based on your project (we know many students who have done so), you should contact the entrepreneurial or incubator center at your university. If your university does not have facilities such as these, you should consider finding a faculty member who has experience in starting a company and ask for ideas or assistance. It is also a good idea to take a business or management course or two so that you will know what to expect as you start to deal with the complex issues of finding financing and managing employees.

We have included in the Appendix a set of excerpts from senior design reports and presentations that you can refer to in order to obtain ideas about style and content of different documents. These documents were selected to represent different types of projects and are what we consider to be both excellent selections of project topic and well-written documents. These reports will be referred to throughout the document and both their qualities and faults will be discussed. The faults and omissions of the reports were not necessarily due to laziness on the part of the authors; they were in part due to the changing requirements as the Senior Design course evolved at Drexel University. These documents emphasize the fact that no matter how well designed and presented, a project and its documentation can always be improved. We thank the authors of these reports: David Broudu and Kevin Lenhart for The Talking Book and Keith Christman, Adam O'Donnell, Chayil Timmerman, and Suma Varghese for Coreware IPv4 to IPv6 Bridge. Without their generosity in sharing their work, this book would have been missing a vital section.

You will find that there are some points that are emphasized over and over again, or repeated through every chapter (such as getting an early start, keeping backups and good notes, asking people for help, taking care to consider all aspects of the design, documentation, and presentation). This is not because there is a lack of topics to cover, but rather because all of the authors have learned through experience how important these points are.
Finally, as mentioned above, this handbook is not an exhaustive list of design procedures and requirements and does not contain solutions to all of the problems and challenges you will encounter during your design project. You should work with your manager, advisors, or mentors such as other faculty in your department or senior staff in your company to ensure that you are meeting the requirements of the course and have not omitted significant steps in the design process. You should also consult your peers and ask for candid opinions of your project ideas and presentation, since (just as in a mechanical or electronic system) feedback is often the most valuable tool in improving the output. Often it only takes another perspective to obtain insight into the solution of a difficult problem, or your peers may know of someone who can assist you. You should also consult the books and Web sites in the suggestions for further reading, since they contain more complete discussions of the topics.

We wish you success during your design project. With time, care, and attention, everyone can produce an excellent design or prototype while gaining experience in the many aspects of the design process.

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