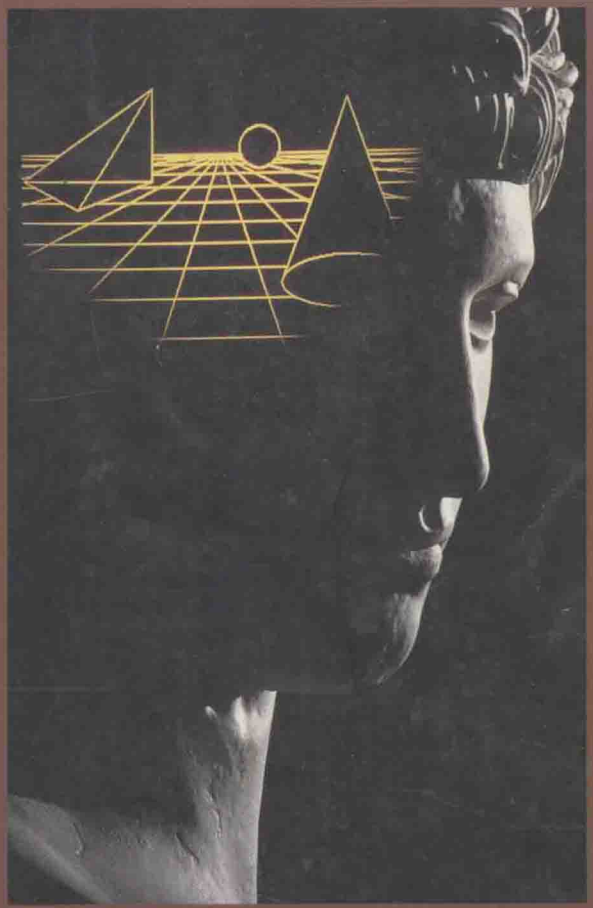

M. DAVID BURGHARDT

Introduction to the Engineering Profession

Second Edition

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Preface

Introduction to the Engineering Profession is designed to help beginning engineering students decide on their field of engineering, gain a perception of the history of engineering and their place in it, and develop the survival skills necessary for an education and career in engineering. An underlying theme of the text is that society needs people who are educated as engineers to assist in the governance of this technologically complex social system, which in turn requires that engineers become more socially and politically aware and active.

Many students use an introduction to engineering course to better define a field of study about which they are uncertain. They are seeking reasons for studying engineering. A number have preconceived ideas about the profession, though few understand the breadth available to them. Of those students with prior knowledge, some truly want to be design engineers, and most want to earn a good income and eventually to move into management. This latter issue is addressed early on in the text.

Introductions to engineering courses are highly individualized, varying significantly from school to school. Therefore, this text provides the key elements for a variety of introductory courses.

The character of engineering education is changing, reflecting a greater professional concern about the social and political consequences of technological change. Certainly this message must be transmitted to future generations of engineers, and it is one of the philosophical underpinnings of the text, reinforced in virtually every chapter. Not only is the character of the profession changing, but the people entering the profession are different from those who entered it in the past. The stereotypical white male engineer is being joined by people from all races and both genders. The engineering workplace will benefit from the infusion of people with different backgrounds, and our educational programs must address new issues necessary to incorporate these students into the engineering profession.

In the past, engineering educators often presumed students had a personal familiarity with the engineering profession, either through family members or friends. The students entering engineering education today often have no immediate role models that define what an engineer is. In this text we attempt to provide such role models.

The underlying purpose of Chapter 1 is to give students techniques for succeeding in college and realizing their potential. Frequently, students who leave the engineering field do so because of inadequate study habits rather than lack of aptitude or desire. Acquiring good study habits at the outset of their education could help them succeed in engineering. Incorporated

throughout the text are comments from practicing engineers regarding the profession, on topics ranging from work habits to communicative ability to the joy of designing a new product.

To understand the engineering profession today, we need to have a historical view of its development. Not only does the material in Chapter 2 trace the evolution of civilized society, but it also describes the evolution of the engineering profession as seen through the formation of engineering professional societies in the United States in the late 1800s and early 1900s. The dual allegiance to society as well as an employer caused much conflict in those times and still creates moral dilemmas for engineers today. Furthermore, in the early 1900s engineers were expected to provide solutions to society's problems, and this theme is reemerging today. Perhaps recognizing past pitfalls will help us avoid similar ones in the future

No introductory course in engineering would be complete without a section on ethics and professional responsibility. Chapter 4 presents problems and guidelines that can serve as a springboard for class discussion. An expanded discussion of risk assessment including factors perceived as causing risk also is included in Chapter 4.

Some engineering majors decline to think of communication (represented by their humanities and social science courses) as being essential to their success as engineers. Chapter 5 attempts to debunk this view and also supports recent publications of the National Society of Professional Engineers (NSPE) regarding the need for engineers to be able to communicate well. Because English composition courses often do not address technical report writing, this topic is covered in Chapter 5 to give students the background necessary to write the many reports required in their undergraduate careers. Following graduation, engineers often communicate through memorandums, so a discussion of memo writing is included, with emphasis on the design memo.

At first glance it may seem that the topic of résumé preparation is out of place in an introductory course; however, an engineer's career begins with this course, not after completion of the last course during senior year. The résumé assists in career planning starting in the freshman year. Chapter 5 also covers technical library usage, another valuable asset to students.

An essential element to virtually all introductory engineering courses is a discussion of the importance of engineering design. The various aspects of the design process are detailed in the new Chapter 9, Engineering Design. This chapter examines some techniques and procedures that help in creating new designs and includes a section on design for the environment. Homework problems include use of the design memo.

Concurrent engineering is discussed in the text with examples drawn from industry illustrating its advantages as well as the problems involved in getting management and workers to adopt this system.

A new appendix, Algebraic and Trigonometric Problem Solving, has been added as well. Many engineering students have difficulties with algebraic word problems, not with engineering concepts. The numerous example problems in the appendix as well as others in the text use a stylized engineering problem solving format. The hope is that by formulating the problem in

their own words, drawing sketches of the problem, and stating assumptions, students will improve their algebraic and engineering problem solving abilities.

The overall focus of the text is to interest and excite students about the various opportunities afforded by an engineering education: the creative challenge and reward of engineering design, the use of analytic skills in problem formulation and solution in engineering and management, and the skills and attitudes necessary for a rewarding and stimulating college education and for a satisfying career after graduation.

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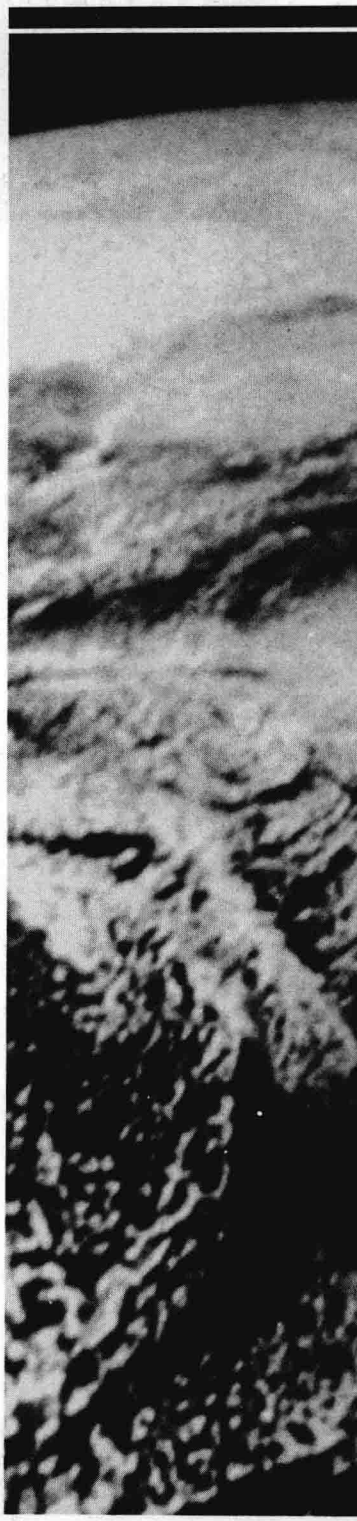
CHAPTER 1

Succeeding in Engineering



CHAPTER OBJECTIVES

To learn what engineering is and is not.

To identify creativity as an essential element of an engineering education.

To distinguish between the concepts of technology and engineering.

To understand why your course of study in engineering is structured as it is and contains the courses it does.

To make use of techniques that will minimize and improve your study time.

(Photo courtesy of NASA.)

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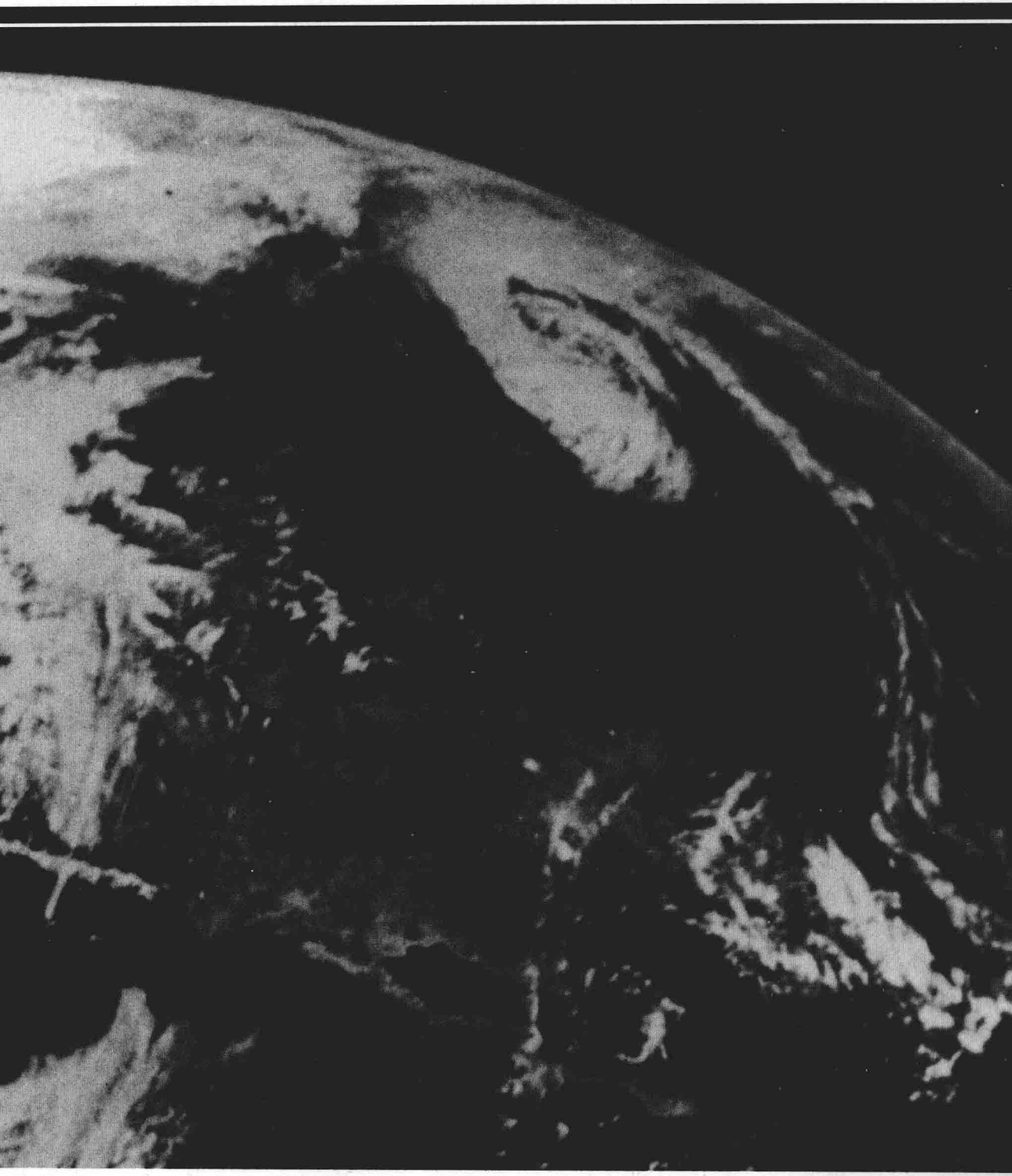


You are on the threshold of a very exciting career in engineering, at a time when the world needs the best technologically aware and creative people possible. People who can solve the multitude of environmental problems that confront us and who can bring us closer together in a world community will lead our future.

1.1 INTRODUCTION

What is engineering? How do you succeed at it? You are embarking on a potential career in engineering, and with the help of this course and text and all the other courses and texts you will have, a definition of engineering will evolve. It may be one of the most useful majors a student can select among all the choices available at most colleges and universities. It is a course of study followed by a professional life devoted to the creative solution of problems. To succeed in any endeavor you must fully utilize your natural abilities, and in the end you will judge your own success on how well you accomplished this. The world that envelops us is a technological one. Think about all the technology you encountered before you left home this morning.

The alarm clock wakes you. Not only is the clock run by electricity, which must be produced somehow, somewhere, but someone, somewhere, designed the alarm mechanism.

You take a shower. The faucets are valves, which were designed by an engineer. The water comes through piping from a central water supply. The entire water distribution system was conceived and designed by engineers.

Opening the refrigerator for milk and juice, you realize that the refrigerator had to have been designed and built according to engineering specifications.

You can expand this list and should do so to gain a perspective of how totally our lives are surrounded by and dependent on technology. No longer do we rise with the sun and depend on manual labor in the fields or forest for our livelihoods; a more sophisticated existence is required. If one does not understand the technology that governs so much of our support systems, a sense of unease or helplessness develops. An underlying advantage of your engineering education is that you will understand the myriad technologies that govern so much of our lives, and thus not be controlled by them.

We all have a limited understanding of what an engineer is. Through education and with the practice of engineering our perception of engineering and what it means to be an engineer will expand. The term *engineer* conjures up many images. Who is your favorite engineer? An aunt or uncle, a parent, cousin, or friend? A famous inventor from history? An unusual engineer whose works are enjoyed by many is Alfred Hitchcock. Although he is best

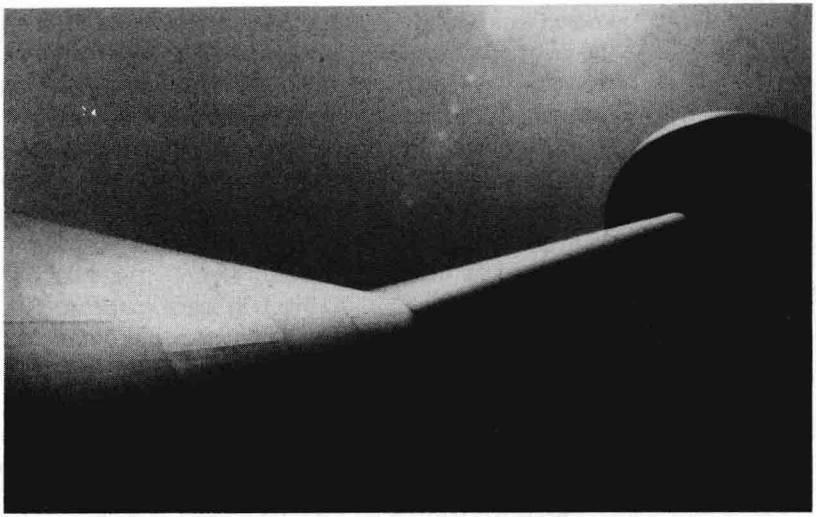
known as a movie director, he was trained as a mechanical engineer. Contrast the crisp sequencing in a movie like *The 39 Steps* or *North by Northwest* with the more ephemeral movie, *A Man and a Woman,* directed by Claude Lelouch. The influence of engineering is apparent. We will better understand the close link that engineering has to other creative fields later in this chapter.

One of the difficulties we often face when uncertain about selecting a course of action, such as studying engineering, is that others can dissuade us from that course with thoughtless remarks. It is demoralizing to suffer comments such as "Why do you want to study that?" or "That's too hard," or even "Engineers are nerds." As we will learn more fully in Chapter 3, part of the reason for this perception is that engineers often do not remain practicing engineers, and hence people do not directly see the value of an engineering education. Would anyone question your desire to follow in the footsteps of engineers such as Thomas Jefferson, Benjamin Franklin, David Sarnoff, Neil Armstrong, Lee Iacocca, or Jimmy Carter? Society needs people educated as engineers to help solve the problems that daily confront our lives. Historically engineers have been trained not only to solve technical problems but also to have the techniques and the understanding at their disposal to solve nontechnical problems as well. This will be part of your challenge in life. This will provide your response to provocative comments, your reason why the hard work of an engineering education is well worth the effort.

1.2 CREATIVITY IN ENGINEERING

One of the reasons a career in engineering can be so rewarding is that you are compensated very well for creating. Creating is one of the fundamental acts of our existence that gives us great pleasure. Observe small children, or reflect back on your own early childhood, and see the excitement and the development of self-esteem that creating provides. Children are constantly making things—necklaces, castles, cars, rockets—in endless variety. As we mature we become more self-aware and self-critical, fearing to create because others will think it not worthy. The effects of peer pressure in our teens can be very detrimental to creative development. The desire to create remains, however. Your engineering education encourages you to be creative in designing a new product, be it a building, a machine, an electronic circuit, or computer software. With the techniques and knowledge gained in your course of engineering study and with your innate creative ability, something that never existed before can be designed—created. Thus, the general purpose of your engineering education will be to provide you with technical tools and to encourage the use of your own creativity, culminating in a new design that will solve a given problem.

Engineering is strongly associated with other creative fields, particularly the fine arts. Chapter 2 analyzes engineering from a historical perspective, but here let's leap back in time for just a moment to more primitive eras, before recorded history, when engineering existed in a very fundamental form. We must look to the beginnings of civilization and the forms of creativity exhibited.



Art or engineering? In actuality this is a water tower used in a municipality's water supply system. (Courtesy of Sidney B. Bowne and Son)

How did people create? What is the definition of art? Art is simply something we create, the results of our creativity. Fine art, often confused with the more general term *art,* is a manifestation of creativity with no functional purpose, only aesthetic purpose. Crafts are manifestations of creativity with both functional and aesthetic purpose. The originators of engineering were craftspeople, such as flint knappers, whose understanding of different types of material, such as flint, and its intrinsic properties allowed them to refine nature and create weapons and tools. In the fine art of painting, artists must learn the technical skills of color usage, different application techniques, painting on different surface textures, and the ability to see what exists, before connecting with their innate creative powers and producing what is called a work of art.

Engineers face a similar problem, in that the techniques are the analytic tools with which we must be comfortable, before connecting with our creative powers and producing what is called a new design. Just as the most difficult part of an art student's education is to learn to see what is, rather than their precognition of what is, the most difficult part of an engineering student's education is to learn and feel comfortable with the analytic tools of engineering. When this is accomplished, connecting with your creative being readily occurs.

1.3 TECHNOLOGY AND ITS POLITICAL IMPLICATIONS

The term *technology* is often confused with *engineering,* probably because engineers create it. Technology is the manifestation of engineering creativity; it results from creativity with a purpose, or engineering design. Consider the problem of sending someone to the moon and returning to earth in 1968. The technology to do so did not exist; it had to be created. Created by engineers.