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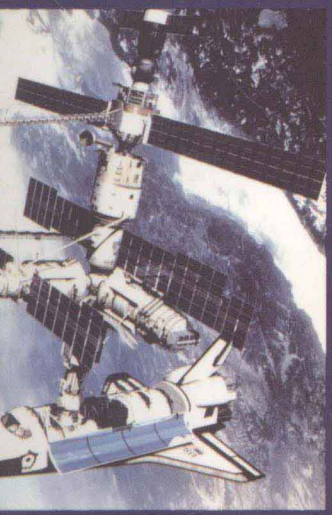
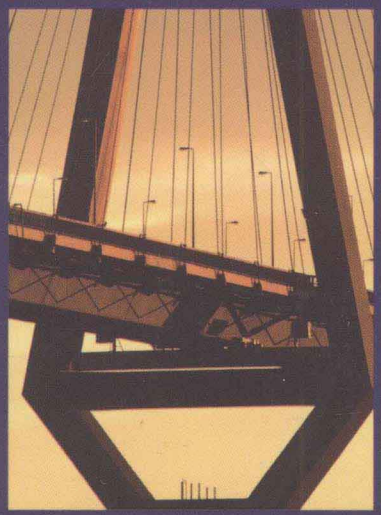
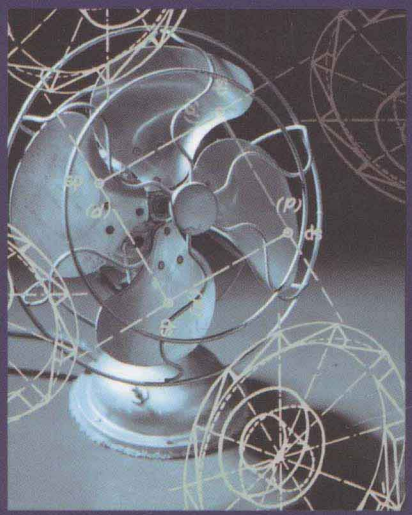
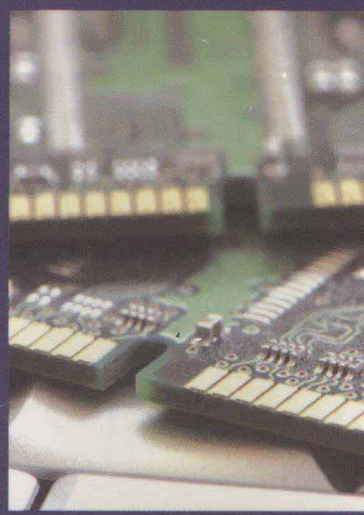

Engineering Fundamentals

An Introduction to Engineering

Saeed Moaveni

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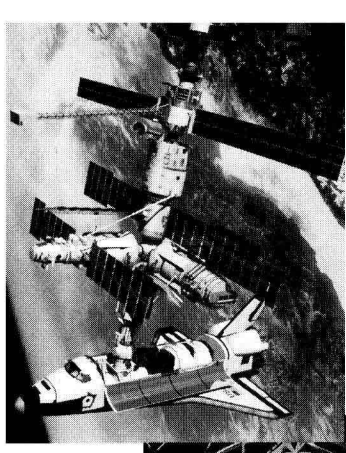

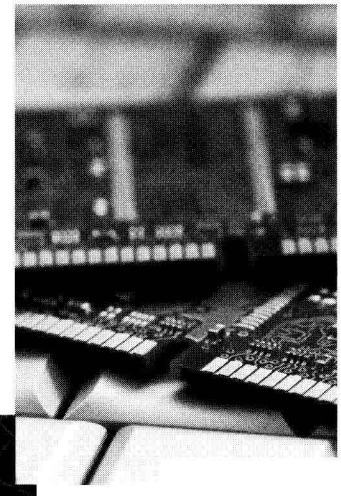

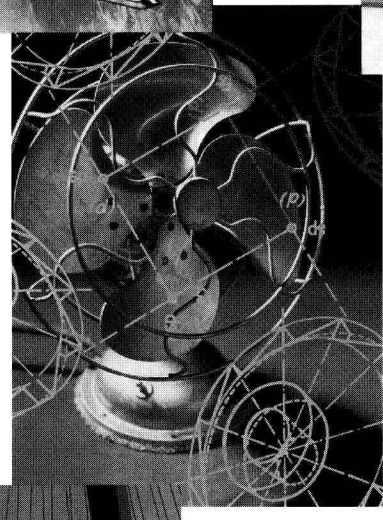

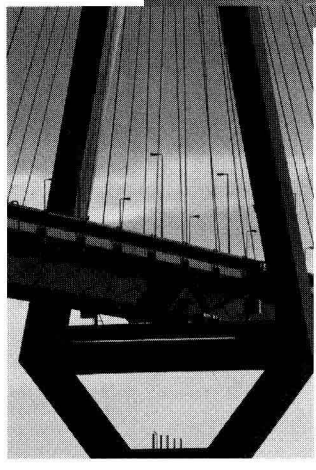

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An Introduction to Engineering

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To the memories of my brother

Preface

CHANGES IN THE THIRD EDITION

The third edition, consisting of 20 chapters, includes a number of new additions that were incorporated in response to suggestions and requests made by professors and students using the second edition of the book. The major changes include:

- A new section on Engineering Technology
- Additional Ethics Case Studies
- Additional sections on MATLAB
- Additional Professional Profiles
- Additional Impromptu Designs
- Additional Engineering Marvels Case Studies
- Additional problems
- A new website to offer additional information for instructors and students including PowerPoint slides for each chapter

ORGANIZATION

This book is organized into six parts and 20 chapters; Each chapter begins by stating its objectives and concludes by summarizing what the reader should have gained from studying that chapter. I have included enough material for two semester-long courses. The reason for this approach is to give the instructor sufficient materials and the flexibility to choose specific topics to meet his or her needs. Relevant, everyday examples with which students can associate easily are provided in each chapter. Many of the problems at the conclusion of each chapter are hands-on, requiring the student to gather and analyze information. Moreover, information collection and proper utilization of that information are encouraged in this book by asking students to do a number of assignments that require information gathering by using the Internet as well as employing traditional methods. Many of the problems at the end of each chapter require students to make brief reports so that they learn that successful engineers need to have good written and oral communication skills. To emphasize the importance of teamwork in engineering and to encourage group participation, many of the assignment problems require group work; some require the participation of the entire class.

The main parts of the book are:

Part One: Engineering—An Exciting Profession

In Part One, consisting of Chapters 1 through 5, we introduce the students to the engineering profession, how to prepare for an exciting engineering career, the design process, engineering communication, and ethics. Chapter 1 provides a comprehensive introduction to the engineering profession and its branches. It introduces the students to what the engineering profession is and explains some of the common traits of good engineers. Various engineering disciplines and engineering organizations are discussed. In Chapter 1, we also emphasize the fact that engineers are problem solvers. They have a good grasp of fundamental physical and chemical laws and mathematics, and apply these fundamental laws and principles to design, develop, test, and supervise the manufacture of millions of products and services. Through the use of examples, we also show that there are many satisfying and challenging jobs for engineers. We pointed out that although the activities of engineers can be quite varied, there are some personality traits and work habits that typify most of today's successful engineers:

- Engineers are problem solvers.
- Good engineers have a firm grasp of the fundamental principles that can be used to solve many different problems.
- Good engineers are analytical, detailed oriented, and creative.
- Good engineers have a desire to be life-long learners. For example, they take continuing education classes, seminars, and workshops to stay abreast of new innovations and technologies.
- Good engineers have written and oral communication skills that equip them to work well with their colleagues and to convey their expertise to a wide range of clients.
- Good engineers have time management skills that enable them to work productively and efficiently.
- Good engineers have good "people skills" that allow them to interact and communicate effectively with various people in their organization.
- Engineers are required to write reports. These reports might be lengthy, detailed, and technical, containing graphs, charts, and engineering drawings. Or the may take the form of a brief memorandum or an executive summary.
- Engineers are adept at using computers in many different ways to model and analyze various practical problems.
- Good engineers actively participate in local and national discipline-specific organizations by attending seminars, workshops, and meetings. Many even make presentations at professional meetings.
- Engineers generally work in a team environment where they consult each other to solve complex problems. Good interpersonal and communication skills have become increasingly important now because of the global market.

In Chapter 1, we also explain the difference between an Engineer and an engineering technologist, and the difference in their career options. In Chapter 2, the transition from high school to college is explained in terms of the need to form good study habits and suggestions are provided on how to budget time effectively. In Chapter 3, an introduction to engineering design, teamwork, and standards and codes is provided. We show that engineers, regardless of their background, follow certain steps when designing the products and services we use in our everyday lives. In Chapter 4, we explain that presentations are an integral part of any engineering project. Depending on the size of the project, presentations might be brief, lengthy, frequent,

and may follow a certain format requiring calculations, graphs, charts, and engineering drawings. In Chapter 4, various forms of engineering communication, including homework presentation, brief technical memos, progress reports, detailed technical reports, and research papers are explained. A brief introduction to PowerPoint is also provided. In Chapter 5, engineering ethics is emphasized by noting that engineers design many products and provide many services that affect our quality of life and safety. Therefore, engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct. A large number of engineering ethics related case studies are also presented in this chapter.

Part Two: Engineering Fundamentals–Concepts Every Engineer Should Know

In Part Two, consisting of Chapters 6 through 13, we focus on engineering fundamentals and introduce students to the basic principles and physical laws that they will see over and over in some form or other during the next four years. Successful engineers have a good grasp of Fundamentals, which they can use to understand and solve many different problems. These are concepts that every engineer, regardless of his or her area of specialization, should know.

In these chapters, we emphasize that, from our observation of our surroundings, we have learned that we need only a few physical quantities to fully describe events and our surroundings. These are length, time, mass, force, temperature, mole, and electric current. We also explain that we need not only physical dimensions to describe our surroundings, but also some way to scale or divide these physical dimensions. For example, time is considered a physical dimension, but it can be divided into both small and large portions, such as seconds, minutes, hours, days, years, decades, centuries, and millennia.

We discuss common systems of units and emphasize that engineers must know how to convert from one system of units to another and always show the appropriate units that go with their calculations.

We also explain that the physical laws and formulas that engineers use are based on observations of our surroundings. We show that we use mathematics and basic physical quantities to express our observations.

In these chapters, we also explain that there are many engineering design variables that are related to the fundamental dimensions (quantities). To become a successful engineer a student must first fully understand these fundamental and related variables and the pertaining governing laws and formulas. Then it is important for the student to know how these variables are measured, approximated, calculated, or used in practice.

Chapter 6 explains the role and importance of fundamental dimension and units in analysis of engineering problems. Basic steps in the analysis of any engineering problem are discussed in detail.

Chapter 7 introduces length and length-related variables and explains their importance in engineering work. For example, the role of area in heat transfer, aerodynamics, load distribution, and stress analysis is discussed. Measurement of length, area, and volume, along with numerical estimation (such as trapezoidal rule) of these values, are presented.

Chapter 8 considers time and time-related engineering parameters. Periods, frequencies, linear and angular velocities and accelerations, volumetric flow rates and flow of traffic are also discussed in Chapter 8.

Mass and mass-related parameters such density, specific weight, mass flow rate, and mass moment of inertia, and their role in engineering analysis, are presented in Chapter 9.

Chapter 10 covers the importance of force and force-related parameters in engineering. What is meant by force, pressure, modulus of elasticity, impulsive force (force acting over time), work (force acting over a distance) and moment (force acting at a distance) are discussed in detail.

Temperature and temperature-related parameters are presented in Chapter 11. Concepts such as temperature difference and heat transfer, specific heat, and thermal conductivity also are covered in Chapter 11.

Chapter 12 considers topics such as direct and alternating current, electricity, basic circuits components, power sources, and the tremendous role of electric motors in our every day life.

Chapter 13 presents energy and power and explains the distinction between these two topics. The importance of understanding what is meant by work, energy, power, watts, horsepower, and efficiency is emphasized in Chapter 13.

Part Three: Computational Engineering Tools— Using Available Software to Solve Engineering Problems

In Part Three, consisting of Chapters 14 and 15, we introduce Microsoft Excel and MATLAB —two computational tools that are used commonly by engineers to solve engineering problems. These computational tools are used to record, organize, analyze data using formulas, and present the results of an analysis in chart forms. MATLAB is also versatile enough that students can use it to write their own programs to solve complex problems.

Part Four: Engineering Graphical Communication— Conveying Information to Other Engineers, Machinists, Technicians, and Managers

In Part Four, consisting of Chapter 16, we introduce students to the principles and rules of engineering graphical communication and engineering symbols. A good grasp of these principles will enable students to convey and understand information effectively. We explain that engineers use technical drawings to convey useful information to others in a standard manner. An engineering drawing provides information, such as the shape of a product, its dimensions, materials from which to fabricate the product, and the assembly steps. Some engineering drawings are specific to a particular discipline. For example, civil engineers deal with land or boundary, topographic, construction, and route survey drawings. Electrical and electronic engineers, on the other hand, could deal with printed circuit board assembly drawings, printed circuit board drill plans, and wiring diagrams. We also show that engineers use special symbols and signs to convey their ideas, analyses, and solutions to problems.

Part Five: Engineering Material Selection— An Important Design Decision

As engineers, whether you are designing a machine part, a toy, a frame of a car, or a structure, the selection of materials is an important design decision. In Part Five, Chapter 17, we look

more closely at materials such as metals and their alloys, plastics, glass, wood, composites, and concrete that commonly are used in various engineering applications. We also discuss some of the basic characteristics of the materials that are considered in design.

Part Six: Mathematics, Statistics, and Engineering Economics—Why Are They Important?

In Part Six, consisting of Chapters 18 through 20, we introduce students to important mathematical, statistical, and economical concepts. We explain that engineering problems are mathematical models of physical situations. Some engineering problems lead to linear models, whereas others result in nonlinear models. Some engineering problems are formulated in the form of differential equations and some in the form of integrals. Therefore, a good understanding of mathematical concepts is essential in the formulation and solution of many engineering problems. Moreover, statistical models are becoming common tools in the hands of practicing engineers to solve quality control and reliability issues, and to perform failure analyses.

Civil engineers use statistical models to study the reliability of construction materials and structures, and to design for flood control, for example. Electrical engineers use statistical models for signal processing and for developing voice-recognition software. Manufacturing engineers use statistics for quality control assurance of the products they produce. Mechanical engineers use statistics to study the failure of materials and machine parts.

Economic factors also play important roles in engineering design decision making. If you design a product that is too expensive to manufacture, then it can not be sold at a price that consumers can afford and still be profitable to your company.

CASE STUDIES–ENGINEERING MARVELS

To emphasize that engineers are problem solvers and that engineers apply physical and chemical laws and principles, along with mathematics, to *design* products and services that we use in our everyday lives, seven case studies are placed throughout the book. These projects are truly engineering marvels. Following Chapter 7, the design of New York City Water Tunnel No. 3 is discussed. The design of the Caterpillar 797 Mining Truck, the largest mining truck in the world, follows Chapter 10. Following Chapter 13, relevant information about the design of the Hoover Dam is discussed. The design of the Boeing 777 is presented in a case study following Chapter 16. Finally, the Pratt and Whitney Jet Engine is discussed at the end of Chapter 17. There are assigned problems at the end of those case studies. The solutions to these problems incorporate the engineering concepts and laws that are discussed in the preceding chapters. There are also a number of engineering ethics case studies, from the National Society of Professional Engineers, in Chapter 5, to promote the discussion on engineering ethics.

IMPROMPTU DESIGNS

I have included seven inexpensive impromptu designs that could be done during class times. The basic idea behind some of the Impromptu Designs have come from the ASME.

REFERENCES

In writing this book, several engineering books, Web pages, and other materials were consulted. Rather than giving you a list that contains hundreds of resources, I will cite some of the sources that I believe to be useful to you. I think all freshman engineering students should own a handbook in their chosen field. Currently, there are many engineering handbooks available in print or electronic format, including chemical engineering handbooks, civil engineering handbooks, electrical and electronic engineering handbooks, and mechanical engineering handbooks. I also believe all engineering students should own chemistry, physics, and mathematics handbooks. These texts can serve as supplementary resources in all your classes. Many engineers may also find useful the ASHRAE handbook, the *Fundamental Volume*, by the American Society of Heating, Refrigerating, and Air Conditioning Engineers.

In this book, some data and diagrams were adapted with permission from the following sources:

Baumeister, T., et al., *Mark's Handbook*, 8th ed., McGraw Hill, 1978.
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Thank you for considering this book and I hope you enjoy the third edition.

Saeed Moaveni

Contents

Part 1

ENGINEERING

AN EXCITING PROFESSION