SI EDITION

ENGINEERING FUNDAMENTALS

AN INTRODUCTION TO ENGINEERING

6TH EDITION

SAEED MOAVENI

CONVERSION FACTORS		
Quantity	**SI → U.S. Customary**	**U.S. Customary → SI**
Length	1 mm = 0.03937 in. 1 mm = 0.00328 ft 1 cm = 0.39370 in. 1 cm = 0.0328 ft 1 m = 39.3700 in. 1 m = 3.28 ft	1 in. = 25.4 mm 1 ft = 304.8 mm 1 in. = 2.54 cm 1 ft = 30.48 cm 1 in. = 0.0254 m 1 ft = 0.3048 m
Area	1 mm^2 = 1.55E-3 in^2 1 mm^2 = 1.0764E-5 ft^2 1 cm^2 = 0.155 in^2 1 cm^2 = 1.0758E-3 ft^2 1 m^2 = 1550 in^2 1 m^2 = 10.76 ft^2	1 in^2 = 645.16 mm^2 1 ft^2 = 92,903 mm^2 1 in^2 = 6.4516 cm^2 1 ft^2 = 929.03 cm^2 1 in^2 = 6.4516E-4 m^2 1 ft^2 = 0.0929 m^2
Volume	1 mm^3 = 6.1024E-5 in^3 1 mm^3 = 3.5315E-8 ft^3 1 cm^3 = 0.061024 in^3 1 cm^3 = 3.5315E-5 ft^3 1 m^3 = 61,024 in^3 1 m^3 = 35.315 ft^3	1 in^3 = 16,387 mm^3 1 ft^3 = 28.317E6 mm^3 1 in^3 = 16.387 cm^3 1 ft^3 = 28,317 cm^3 1 in^3 = 1.6387E-5 m^3 1 ft^3 = 0.028317 m^3
Second Moment of Area $(length)^4$	1 mm^4 = 2.402E-6 in^4 1 mm^4 = 115.861E-12 ft^4 1 cm^4 = 24.025E-3 in^4 1 cm^4 = 1.1586E-6 ft^4 1 m^4 = 2.40251E6 in^4 1 m^4 = 115.86 ft^4	1 in^4 = 416.231E3 mm^4 1 ft^4 = 8.63097E9 mm^4 1 in^4 = 41.623 cm^4 1 ft^4 = 863,110 cm^4 1 in^4 = 416.231E-9 m^4 1 ft^4 = 8.631E-3 m^4

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***Engineering Fundamentals: An Introduction to Engineering*, Sixth Edition, SI Edition**

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Cover Image: iStockPhoto.com/loveguli

Manufacturing Planner: Doug Wilke

Library of Congress Control Number: 2019931191

ISBN: 978-0-357-11215-1

Cengage
20 Channel Center Street
Boston, MA 02210
USA

Printed in the United States of America
Print Number: 01 Print Year: 2019

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Preface

Changes in the Sixth Edition

The Sixth Edition, consisting of twenty chapters, includes a number of new features, additions, and changes that were incorporated in response to pedagogical advances, suggestions, and requests made by professors and students using the Fifth Edition of the book. The major changes include:

- Six new Chapter Discussion Starters
- New sections on basic human needs, sustainability, the Earth Charter, life cycle analysis, and renewable energy
- Reorganized chapter on ethics (Chapter 5)
- Updated MATLAB examples
- New pictures to enhance student understanding of concepts
- Over thirty new example problems
- Over thirty brand new problems, as well as many more updated problems

Active Learning Features

To promote active learning, we have maintained eight features first introduced in the fifth edition of this book. These features include: (1) Learning Objectives (LO), (2) Discussion Starter—What Do You Think? (3) Before You Go On, (4) Highlighted Key Concepts, (5) Summary, (6) Key Terms, (7) Apply What You Have Learned, and (8) Lifelong Learning Exercises.

1. Learning Objectives (LO)

   Each chapter begins by stating the learning objectives (LO).

2. Discussion Starter

   Pertinent articles serve as chapter openers to engage students and promote active learning. The discussion starters provide a current context for why the content that the students are about to learn is important. An instructor can start class by asking students to read the Discussion Starter and then ask the students for their thoughts and reactions.

3. Before You Go On

   This feature encourages students to test their comprehension and understanding of the material discussed in section(s) by answering questions before they continue to the next section(s).

   Vocabulary—It is important for students to understand that they need to develop a comprehensive vocabulary to communicate effectively as well-educated engineers and intelligent citizens. This feature promotes growing vocabulary by asking students to state the meaning of new words that are covered in section(s).

4. Highlighted Key Concepts

   Key concepts are highlighted in orange boxes and displayed throughout the book.

5. Summary

   Each chapter concludes by summarizing what the student should have gained from studying the chapter. Moreover, the learning objectives and the summary are tied together as a refresher for the students.

6. Key Terms

   The key terms are indexed at the end of each chapter so that students may return to them for review.

7. Apply What You Have Learned

   This feature encourages students to apply what they have learned to an interesting problem or a situation. To emphasize the importance of teamwork and to encourage group participation, many of these problems require group work.

8. Lifelong Learning Exercises

   Problems that promote lifelong learning are denoted by .

Organization

This book is organized into six parts and twenty chapters. Each chapter begins by stating its objectives and concludes by summarizing what the student should have gained from studying the 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 easily associate are provided in every chapter. Each chapter includes many hands-on problems, requiring the student to gather and analyze information. Moreover, information collection and proper use of information are encouraged in this book by asking students to complete a number of assignments that require information gathering by using the Internet as well as by employing traditional methods. Many of the problems 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 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 explains some of the common traits of good engineers. Various engineering disciplines and engineering organizations are discussed. In Chapter 1, we also emphasize that engineers are problem solvers. Engineers have a good grasp of fundamental physical and chemical laws and mathematics, and they apply these fundamental laws and principles to design, develop, test, and supervise the manufacture of millions of products and services. The examples provided demonstrate the many satisfying and challenging jobs for engineers. We point 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, detail oriented, and creative.
- Good engineers have a desire to be lifelong 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 they 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.

Chapter 1 explains 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. Chapter 3 provides an introduction to engineering design, sustainability, teamwork, and standards and codes. We show that engineers, regardless of their background, follow certain steps when designing products and services. Chapter 4 shows that presentations are an integral part of any engineering project. Depending on the size of the project, presentations might be brief, lengthy, frequent, or infrequent. They may follow a certain format requiring calculations, graphs, charts, and engineering drawings. In Chapter 4, various forms of engineering communication, including homework presentations, brief technical memos, progress reports, detailed technical reports, and research papers are explained. Chapter 5 emphasizes engineering ethics 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 presented in this chapter.

Part Two: Engineering Fundamentals—Concepts Every Engineer Should Know

Chapters 6 through 13 focus on engineering fundamentals and introduce students to the basic principles and physical laws that they will encounter repeatedly during the next four years. Successful engineers have a good grasp of the 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 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 not only need 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 their 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 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, and used in practice.

Chapter 6 explains the role and importance of fundamental dimensions 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, we discuss the role of area in heat transfer, aerodynamics, load distribution, and stress analysis. 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 variables. Periods, frequencies, linear and angular velocities and accelerations, volumetric flow rates, and flow of traffic are also discussed.

Chapter 9 covers mass and mass-related variables such as density, specific weight, mass flow rate, and mass moment of inertia, as well as their role in engineering analysis.

Chapter 10 discusses the importance of force and force-related variables in engineering. The important concepts in mechanics are explained conceptually. What is meant by force, internal force, reaction, pressure, modulus of elasticity, impulsive force (force acting over time), work (force acting over a distance) and moment (force acting at a distance) are covered in detail.

Chapter 11 presents temperature and temperature-related variables. Concepts such as temperature difference and heat transfer, specific heat, and thermal conductivity are also covered. As future engineers, it is important for students to understand some simple-energy-estimation procedures given current energy and sustainability concerns. Because of this fact, we have a section on Degree-Days and Energy Estimation.

Chapter 12 considers topics such as direct and alternating current, electricity, basic circuit components, power sources, and the tremendous role of electric motors in our everyday lives. Lighting systems account for a major portion of electricity use in buildings and have received much attention lately. Section 12.5 introduces the basic terminology and concepts in lighting systems. All future engineers, regardless of their area of expertise, need to understand these basic concepts.

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. Energy sources, generation, and consumption in the United States are also discussed in this chapter. With the world's growing demand for energy being among the most difficult challenges that we face today, as future engineers, students need to understand two problems: energy sources and emission. Section 13.5 introduces conventional and renewable energy sources, generation, and consumption patterns.

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

In Chapters 14 and 15, we introduce Microsoft Excel™ and MATLAB™—two computational tools that are commonly used by engineers to solve engineering problems. These computational tools are used to record, organize, and analyze data using formulas, and to 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

Chapter 16 introduces 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, 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. Chapter 17 looks 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?

Chapters 18 through 20 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, while others are 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 cannot 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, we include case studies throughout the book. Chapter 5 contains a number of engineering ethics case studies from the National Society of Professional Engineers to promote the discussion on engineering ethics.

Impromptu Designs

I have included seven inexpensive impromptu designs that could be developed during class times. The basic ideas behind some of the impromptu designs have come from the ASME.

References

In writing this book, several engineering books, websites, and other materials were consulted. Rather than giving you a list that contains hundreds of resources, I cite some of the sources that I believe may be useful to you. All freshmen engineering students should own a reference 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 for all your classes. Many engineers may 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.
- *Electrical Wiring*, 2nd ed., AA VIM, 1981.
- *Electric Motors*, 5th ed., AA VIM, 1982.
- Gere, J. M., *Mechanics of Materials*, 6th ed., Thomson, 2004.
- Hibbler, R. C., *Mechanics of Materials*, 6th ed., Pearson Prentice Hall.
- *U.S. Standard Atmosphere*, Washington D.C., U.S. Government Printing Office, 1962.
- Weston, K. C., *Energy Conversion*, West Publishing, 1992.

Instructor Resources

Lecture Note PowerPoints and the full Instructor's Solutions Manual are available online via a secure, password-protected Instructor's Resource Center at http://login.cengage.com.

Acknowledgments

I would like to express my sincere gratitude to the editorial and production team at Cengage, especially Timothy Anderson and Alexander Sham. I am also grateful to Rose Kernan of RPK Editorial Services, Inc. I would also like to thank Dr. Karen Chou of Northwestern University, Mr. James Panko, and Paulsen Architects, who provided the section on civil engineering design process and the related design case study, and the late Mr. Pete Kjeer and Johnson Outdoors, who provided the mechanical/electrical engineering case study. I am also thankful to all the reviewers who offered general and specific comments including Whitney Blackburn-Lynch, University of Kentucky, Lance Crimm, Kennesaw State University, Ali Eydgahi, Eastern Michigan University, David Feinauer, Norwich University, Sungwon Kim, Minnesota State University—Mankato, Jennifer O'Neil, Rochester Institute of Technology, Farhad Reza, Minnesota State University—Mankato, Abiye Seifu, Columbus State University, and Chengyang Wang, Montgomery County Community College.

I would also like to thank the following individuals for graciously providing their insights for our Student and Professional Profiles sections: Nahid Afsari, Jerry Antonio, Celeste Baine, Suzelle Barrington, Steve Chapman, Karen Chou, Ming Dong, Duncan Glover, Dominique Green, Lauren Heine, John Mann, Katie McCullough, Susan Thomas, and Nika Zolfaghari.

Thank you for considering this book, and I hope you enjoy the Sixth Edition.

Saeed Moaveni

Preface to the SI Edition

This edition of ***Engineering Fundamentals: An Introduction to Engineering*** has been adapted to incorporate the International System of Units (*Le Système International d'Unités* or SI) throughout the book.

Le Système International d'Unités

The United States Customary System (USCS) of units uses FPS (foot–pound–second) units (also called English or Imperial units). SI units are primarily the units of the MKS (meter–kilogram–second) system. However, CGS (centimeter–gram–second) units are often accepted as SI units, especially in textbooks.

Using SI Units in this Book

In this book, we have used both MKS and CGS units. USCS units or FPS units used in the US Edition of the book have been converted to SI units throughout the text and problems. However, in the case of data sourced from handbooks, government standards, and product manuals, it is not only extremely difficult to convert all values to SI, it also encroaches upon the intellectual property of the source. Some data in figures, tables, and references, therefore, remain in FPS units. USCS units are also retained in several cases to expose students to this system of units and offer additional conversion practice.

To solve problems that require the use of sourced data, the sourced values can be converted from FPS units to SI units just before they are to be used in a calculation. To obtain standardized quantities and manufacturers' data in SI units, the readers may contact the appropriate government agencies or authorities in their countries/regions.

Digital Resources

WEBASSIGN
From Cengage

New Digital Solution for Your Engineering Classroom

WebAssign is a powerful digital solution designed by educators to enrich the engineering teaching and learning experience. With a robust computational engine at its core, WebAssign provides extensive content, instant assessment, and superior support.

WebAssign's powerful question editor allows engineering instructors to create their own questions or modify existing questions. Each question can use any combination of text, mathematical equations and formulas, sound, pictures, video, and interactive HTML elements. Numbers, words, phrases, graphics, and sound or video files can be randomized so that each student receives a different version of the same question.

In addition to common question types such as multiple choice, fill-in-the-blank, essay, and numerical, you can also incorporate robust answer entry palettes (mathPad, chemPad, calcPad, physPad, pencilPad, Graphing Tool) to input and grade symbolic expressions, equations, matrices, and chemical structures using powerful computer algebra systems. You can even use Camtasia to embed "clicker" questions that are automatically scored and recorded in the GradeBook.

WebAssign Offers Engineering Instructors the Following

- The ability to create and edit algorithmic and numerical exercises.
- The opportunity to generate randomized iterations of algorithmic and numerical exercises. When instructors assign numerical WebAssign homework exercises (engineering math exercises), the WebAssign program offers them the ability to generate and assign their students differing versions of the same engineering math exercise. The computational engine extends beyond and provides the luxury of solving for correct solutions/answers.
- The ability to create and customize numerical questions, allowing students to enter units, use a specific number of significant digits, use a specific number of decimal places, respond with a computed answer, or answer within a different tolerance value than the default.

Visit https://www.webassign.com/instructors/features/ to learn more. To create an account, instructors can go directly to the signup page at http://www.webassign.net/signup.html.

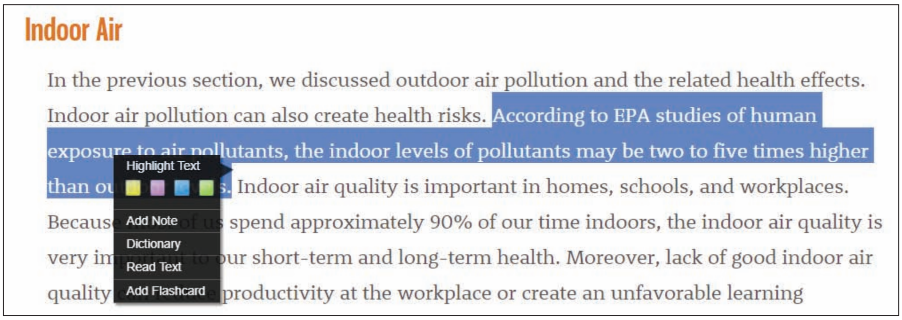
MindTap Reader

Available via WebAssign, **MindTap Reader** is Cengage's next-generation eBook for engineering students.

The MindTap Reader provides more than just text learning for the student. It offers a variety of tools to help our future engineers learn chapter concepts in a way that resonates with their workflow and learning styles.

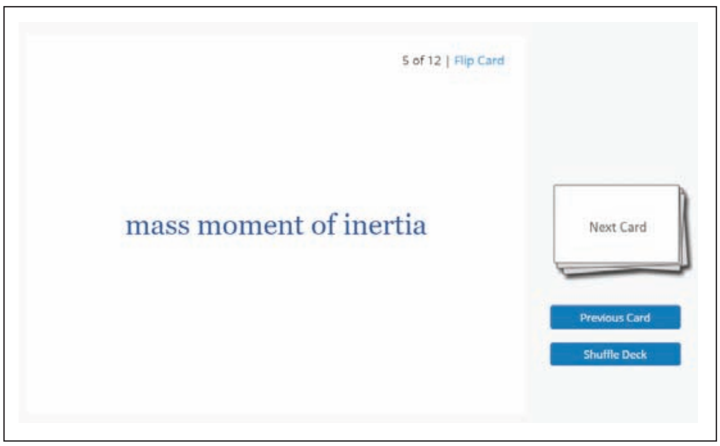
- **Personalize their experience**

Within the MindTap Reader, students can highlight key concepts, add notes, and bookmark pages. These are collected in My Notes, ensuring they will have their own study guide when it comes time to study for exams.



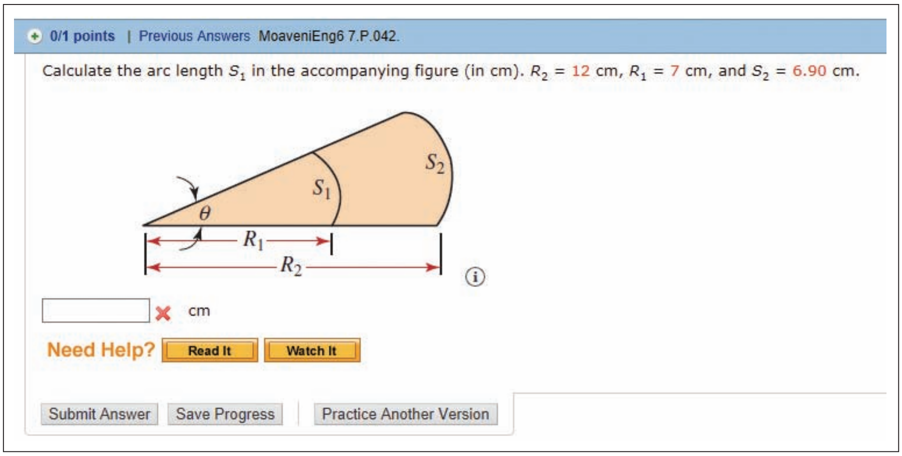
- **Flexibility at their fingertips**

With access to Merriam-Webster's Dictionary and the book's internal glossary, students can personalize their study experience by creating and collating their own custom flashcards. The ReadSpeaker feature reads text aloud to students, so they can learn on the go—wherever they are.



- **Review concepts at point of use**

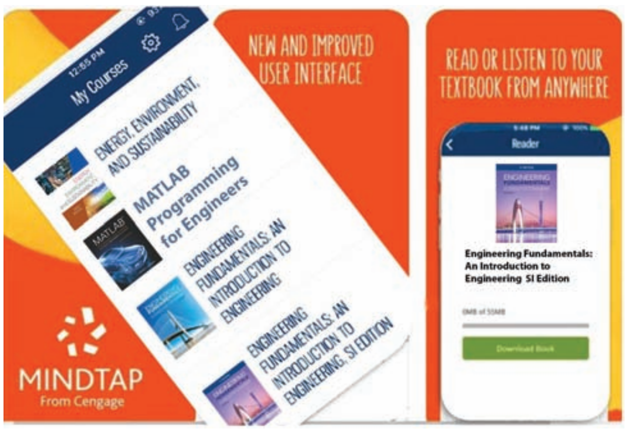
Within WebAssign, a “Read It” button at the bottom of each question links students to corresponding sections of the textbook, enabling access to the MindTap Reader at the precise moment of learning. A “Watch It” button allows a short video to play. These videos help students understand and review the problem they need to complete, enabling support at the precise moment of learning.



The Cengage Mobile App

Available on iOS and Android smartphones, the Cengage Mobile App provides convenience. Students can access their entire textbook anyplace and anytime. They can take notes, highlight important passages, and have their text read aloud whether they are online or off.

To download the mobile app, visit https://www.cengage.com/mobile-app.



ENGINEERING FUNDAMENTALS

AN INTRODUCTION TO ENGINEERING

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Engineering

An Exciting Profession

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PART 1

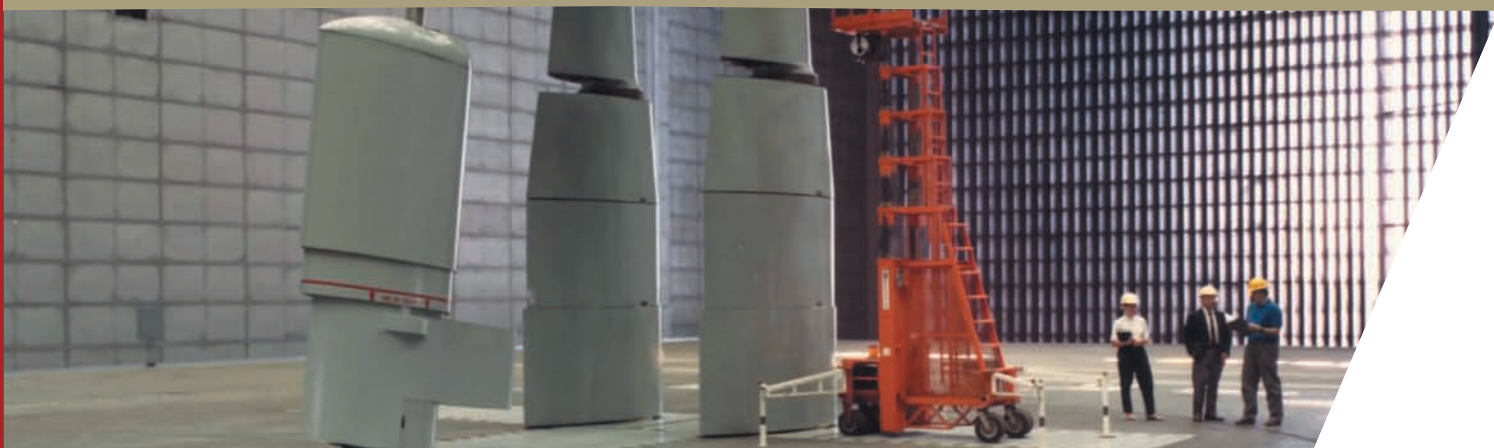
In Part One of this book, we will introduce you to the engineering profession. Engineers are problem solvers. They have a good grasp of fundamental physical and chemical laws and mathematics and apply these laws and principles to design, develop, test, and supervise the manufacture of millions of products and services. Engineers, regardless of their background, follow certain steps when designing the products and services we use in our everyday lives. Successful engineers possess good communication skills and are team players. Ethics plays a very important role in engineering. As eloquently stated by the National Society of Professional Engineers (NSPE) code of ethics, "Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior which requires adherence to the highest principles of ethical conduct." In the next five chapters, we will introduce you to the engineering profession, how to prepare for an exciting engineering career, the design process, engineering communication, and ethics.

Good engineers are problem solvers and have a firm grasp of mathematical, physical, and chemical laws and principles. They apply these laws and principles to design products and services that we use in our everyday lives. They also have good written and oral communication skills.

CHAPTER

1

Introduction to the Engineering Profession



LEARNING OBJECTIVES

LO[1] Engineering Work is All Around You: give examples of products and services that engineers design that make our lives better

LO[2] Engineering as a Profession: describe what engineers do and give examples of common careers for engineers

LO[3] Common Traits of Good Engineers: describe the important traits of successful engineers

LO[4] Engineering Disciplines: give examples of common engineering disciplines and how they contribute to the comfort and betterment of our everyday lives

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Engineers are problem solvers. Successful engineers possess good communication skills and are team players. They have a good grasp of fundamental physical and chemical laws and mathematics. Engineers apply physical and chemical laws and mathematics to design, develop, test, and supervise the manufacture of millions of products and services. They consider important factors such as efficiency, cost, reliability, and safety when designing products. Good engineers are dedicated to lifelong learning and service to others.

Discussion Starter

WHO ARE ENGINEERS?

We all want to make the world a better place, but how do we do it, and where do we start? Leo Tolstoy, a Russian novelist and philosopher, once said:

> *Everyone thinks of changing the world, but no one thinks of changing oneself.*

Increasingly, because of worldwide socioeconomic trends, environmental concerns, and the Earth's finite resources, more is expected of all of us. As future engineers, you are expected to consider the link among the Earth's finite resources and environmental, social, ethical, technical, and economical factors as you make decisions regarding the services that you provide and the products you design. This book is designed to introduce you—someone who is interested in studying engineering regardless of your area of specialization, personal interests, and future career path—to important concepts that every engineer should know.

Engineers are problem solvers. They have a good grasp of fundamental physical and chemical laws and mathematics and apply these laws and principles to design, develop, test, and supervise the manufacture of millions of products and services. ***Engineers***, regardless of their background, follow certain steps when designing the products and services we use in our everyday lives. Successful engineers possess good communication skills and are team players.


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Ethics plays a very important role in engineering. As eloquently stated by the National Society of Professional Engineers (NSPE) code of ethics, "Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness and equity, and must be dedicated to the protection of the public health, safety and welfare. Engineers must perform under a standard of professional behavior which requires adherence to the highest principles of ethical conduct."

To the Students: Why do you want to study engineering? Name at least two products or services that are not available now that you think will be readily available in the next 20 years. Which engineering disciplines do you think will be involved in design and development of these products and services?

Possibly some of you are not yet certain you want to study engineering during the next four years in college and may have questions similar to the following:

Do I really want to study engineering?
What is engineering and what do engineers do?
What are some of the areas of specialization in engineering?
How many different engineering disciplines are there?
Do I want to become a mechanical engineer, or should I pursue civil engineering? Or would I be happier becoming an electrical engineer?
How will I know that I have picked the best field for me?
Will the demand for my area of specialization be high when I graduate, and beyond that?

The main objectives of this chapter are to provide some answers to these and other questions you may have and to introduce you to the engineering profession and its various branches.

LO1 1.1 Engineering Work Is All Around You

Engineers make products and provide services that make our lives better (see Figure 1.1). To see how engineers contribute to the comfort and the betterment of our everyday lives, tomorrow morning when you get up, just look around you more carefully. During the night, your bedroom was kept at the right temperature thanks to some mechanical engineers who designed the heating, air-conditioning, and ventilating systems in your home. When you get up in the morning and turn on the lights, be assured that thousands of mechanical and electrical engineers and technicians at power plants and power stations around the country are making certain the flow of electricity remains uninterrupted so that you have enough power to turn the lights on or turn on your TV to watch the morning news and weather report for the day. The TV you are using—to

FIGURE 1.1 Examples of products and services designed by engineers.

get your morning news or to see how your favorite team did—was designed by electrical and electronic engineers. There are, of course, engineers from other disciplines involved in creating the final product; for example, manufacturing and industrial engineers. When you are getting ready to take your morning shower, the clean water you are about to use is coming to your home thanks to civil engineers. Even if you live out in the country on a farm, the pump you use to bring water from the well to your home was designed by mechanical and civil engineers. The water could be heated by natural gas that is brought to your home thanks to the work and effort of chemical, mechanical, civil, and petroleum engineers. After your morning shower, when you get ready to dry yourself with a towel, think about what types of engineers worked behind the scenes to produce the towels. Yes, the cotton towel was made with the help of agricultural, industrial, manufacturing, chemical, petroleum, civil, and mechanical engineers. Think about the machines that were used to plant and pick the cotton, transport the cotton to a factory, clean it, and dye it to a pretty color that is pleasing to your eyes. Then other machines were used to weave the fabric and send it to sewing machines that were designed by mechanical engineers. The same is true of the clothing you are about to wear. Your clothing may contain some polyester, which was made possible with the aid of petroleum and chemical engineers. “Well,” you may say, “I can at least sit down and eat my breakfast and not wonder whether some engineers made this possible as well.” But the food you are about to eat was made with the help and collaboration of various engineering disciplines, from agricultural to mechanical. Let’s say you are about to have some cereal. The milk was kept fresh in your refrigerator thanks to the efforts and work of mechanical engineers who designed the refrigerator components and chemical engineers who investigated alternative refrigerant fluids with appropriate thermal and other environmentally friendly properties that can be used in your refrigerator. Furthermore, electrical engineers designed the control and the electrical power units.

Now you are ready to get into your car, take the bus, or ride the subway to go to school. The car you are about to drive was made possible with the help and collaboration of automotive, mechanical, electrical, electronic, industrial, material, chemical, and petroleum engineers. So, you see there is not much that you do in your daily life that has not involved the work of engineers. Be proud of the decision you have made to become an engineer. Soon you will become one of those whose behind-the-scenes efforts will be taken for granted by billions of people around the world. But you will accept that fact gladly, knowing that what you do will make people’s lives better.

Engineers Deal with an Increasing World Population and Sustainability Concerns

We as people, regardless of where we live, need the following things: food, clothing, shelter, clear air, and clean water.

We Need Clean Air Every day, human activities through *stationary* and *mobile* sources contribute to the pollution of outdoor air. Power plants, factories, and dry cleaners are examples of stationary sources that create outdoor air pollution. The *mobile* sources of air pollution, such as cars, buses, trucks, planes, and trains, also add to the level of outdoor air pollution. In addition to these man-made sources, natural air pollution also occurs due to forest fires, windblown dust, and volcanic eruptions. Moreover, because most of us spend approximately 90 percent of our time indoors, the indoor air quality is also very important to our short-term and long-term health. In recent years, we have been using more synthetic materials in newly built homes that can give off harmful vapors. We also use more chemical pollutants, such as pesticides and household cleaners.

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We Need Clean Water Our next essential need is water. Droughts are good reminders of how significant water is to our daily lives. In addition to quantity, quality is also a concern. As you would expect, human activities and naturally occurring microorganisms contribute to the contaminant level in our water supply. For example, in agriculture, fertilizers, pesticides, and animal waste from large cattle, pig, or poultry farms contribute to water pollution. Other human activities, such as mining, construction, manufacturing goods, landfills, or wastewater treatment plants, are also major contributors.

We Need Food To lead a normal active life, we need to consume a certain number of calories that come from eating beef, lamb, pork, poultry, fish, eggs, dairy products, fruits, grains, and vegetables. In the American diet, carbohydrates, protein, and fat are the main sources of calories.

The total number of food calories a person needs each day to lead an active and healthy life depends on factors such as gender, age, height, weight, and level of physical activity. Moreover, in order to maintain a healthy body weight, calories consumed from food and drinks must equal calories expended

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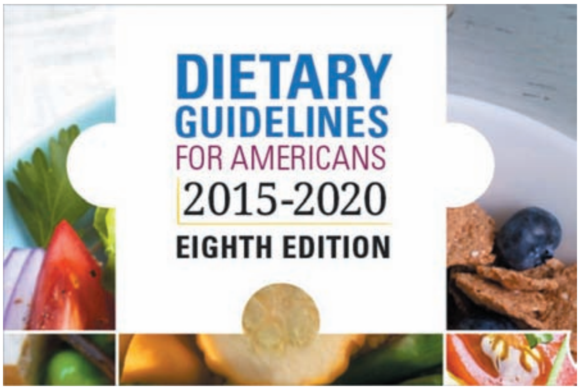
To maintain a healthy body weight, calories consumed from food and drinks must equal calories expended through daily activities.

through daily activities. Therefore, if you consume more calories than you expend, you will gain weight. As we later explain in Chapter 13, the energy content of food is typically expressed in Calories (with an uppercase C). For example, a banana has about 100 Calories, whereas a medium serving of French fries has around 400 Calories. One Calorie is equal to 1,000 calories (with a lowercase c), and one calorie is formally defined as the amount of energy required to raise the temperature of one gram (1 g) of water by one degree Celsius (1°C). For now, don't worry if you don't fully understand what one calorie represents; this and other concepts will be explained in greater detail in Chapters 6 and 13.



ODPHP, 2015–2020 Dietary Guidelines for Americans, http://health.gov/dietaryguidelines/2015/

In the United States, by law, dietary guidelines for Americans are reviewed and published every five years by the U.S. Department of Agriculture (USDA) and the U.S. Department of Health and Human Services (HHS). Table 1.1 shows the estimated total calorie needs for weight maintenance based on age, gender, and physical activity level. This data is from the *Dietary Guidelines for Americans 2015* USDA and HHS report. As shown in Table 1.1, adult women need to consume between 1,800 and 2,400 Calories per day, while adult men may require 2,400 to 3,200 Calories. The low values represent caloric intake for sedentary conditions, whereas the higher values are for active individuals.

TABLE 1.1 Estimated Calorie Needs per Day by Age, Gender, and Physical Activity Level.

Estimated amounts of calories[a] needed to maintain calorie balance for various gender and age groups at three different levels of physical activity. The estimates are rounded to the nearest 200 calories for assignment to a USDA food pattern. An individual's calorie needs may be higher or lower than these average estimates.

	Male			Female		
Activity Level[b] (Age)	**Sedentary**	**Moderately Active**	**Active**	**Sedentary**	**Moderately Active**	**Active**
2	1,000	1,000	1,000	1,000	1,000	1,000
3	1,200	1,400	1,400	1,000	1,200	1,400
4	1,200	1,400	1,600	1,200	1,400	1,400
5	1,200	1,400	1,600	1,200	1,400	1,600
6	1,400	1,600	1,800	1,200	1,400	1,600
7	1,400	1,600	1,800	1,200	1,600	1,800
8	1,400	1,600	2,000	1,400	1,600	1,800
9	1,600	1,800	2,000	1,400	1,600	1,800
10	1,600	1,800	2,200	1,400	1,800	2,000
11	1,800	2,000	2,200	1,600	1,800	2,000

(continues)