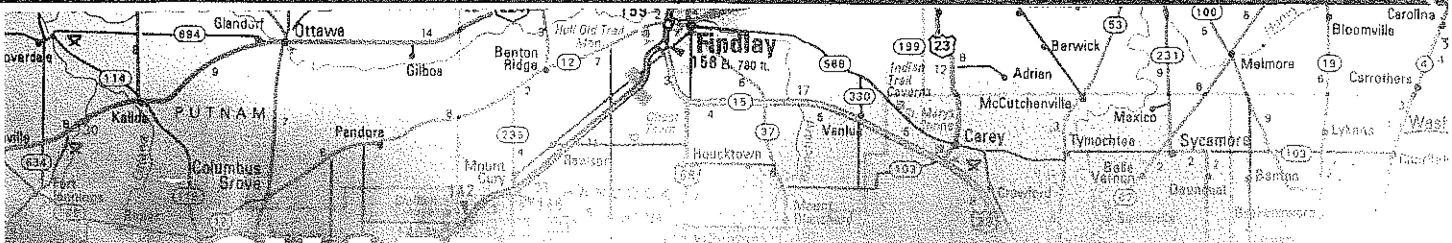

CHAPTER 1

Overview and History of Engineering

GPS DELUXE

Menu | START LOCATION | DISTANCE | END LOCATION

Before You Begin

Think about these questions as you study the concepts in this chapter.

1. When did engineering begin?
2. What were some of the first engineering designs?
3. Who were the important pioneers in the field of engineering, and what did they contribute?
4. What are the first steps to becoming an engineer today?
5. How have advances in technology spurred growth in engineering fields?

INTRODUCTION

Are you a problem solver? Are you curious about how things work? Do you enjoy looking for ways to make things better and more efficient? If you answered "yes" to any of these questions, maybe you should consider a career in the field of engineering.

An engineer applies knowledge of science and math to solve problems. Many people confuse the work of engineers with the work of scientists. As a student of engineering, you should learn how to define these separate disciplines. **Scientists** ask and answer questions, discovering new knowledge about how the world works. **Engineers** use the knowledge that scientists discover to solve problems and create technologies that satisfy human wants and needs.

People have been studying how the world works and using their powerful minds to improve the quality of life since prehistoric times. Prehistoric men and women used their ingenuity to survive hunger, climate conditions, and the occasional attack from enemies. In order to hunt, farm, fish, and fight, these people needed to think like engineers do today. In fact, many simple tools developed by prehistoric humans, such as the wedge, lever, and wheel, are still used in engineering today (Figure 1-1).

The pace of engineering developments quickened around 3000 B.C.E. The Egyptians built canals to control flooding and provide irrigation to feed their growing population. The Chinese invented paper, enabling architects to sketch masterpieces of the Middle Ages and allowing world explorers to develop navigational maps. Modern civilization—its sophistication, its diversity, and its vast reach—was built on many small improvements achieved throughout human history. In the course of about 15,000 years, humans have advanced from living in caves to inhabiting an international space station (Figure 1-2).

This chapter will take a brief look at the long history of engineering and show you some of the key moments in its astonishing evolution. The great scientist Isaac Newton once wrote to a friend, "If I have seen further

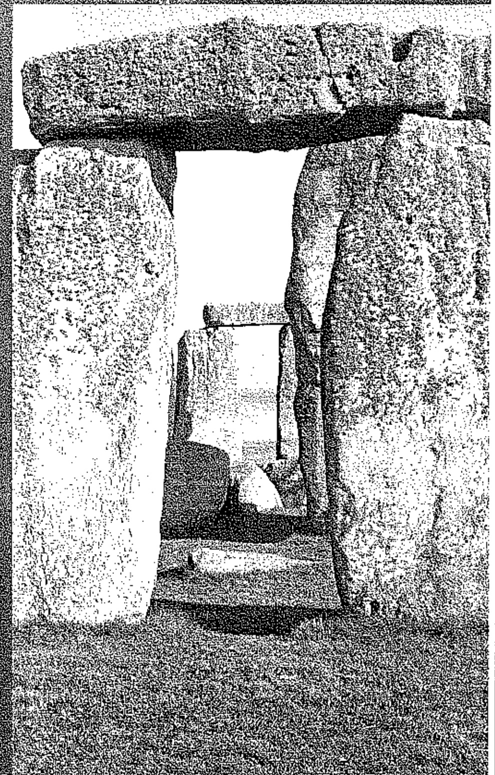

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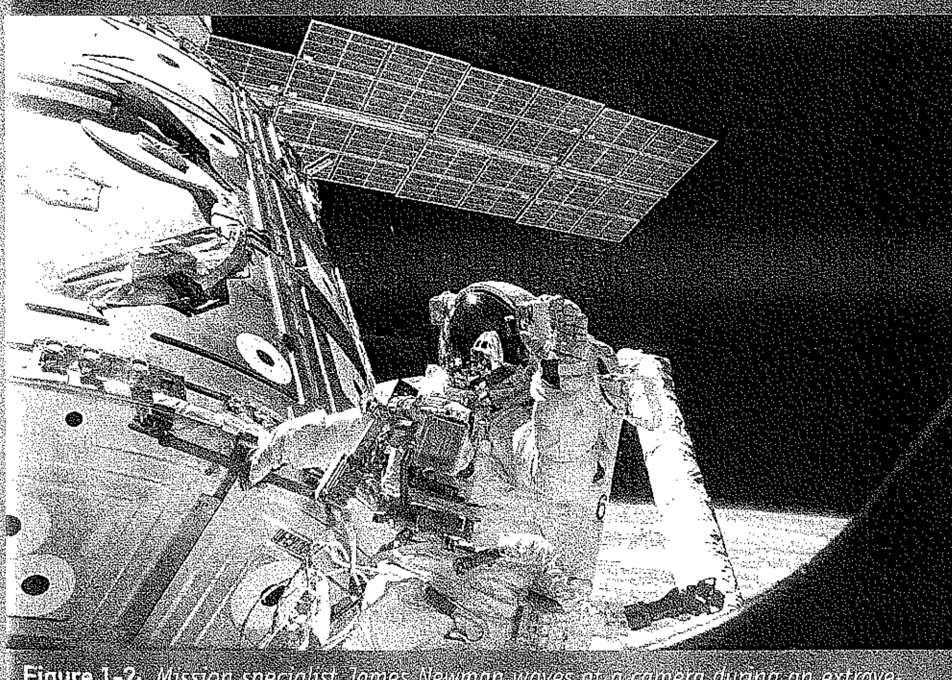
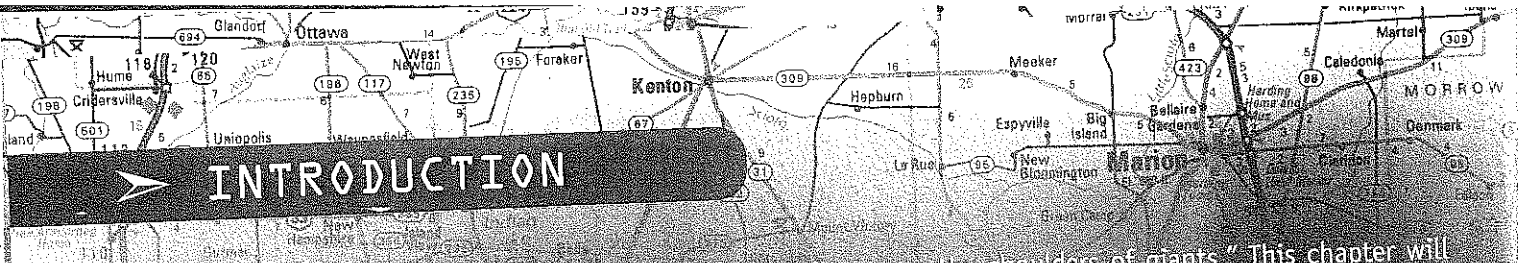
Figure 1-1: *Archeologists can only guess at the tools and technology that prehistoric engineers used to construct Stonehenge in England 5,000 years ago. The builders probably used some of the same simple tools that we use in engineering today such as wheels, wedges, and levers.*



Courtesy of NASA

Figure 1-2: *Mission specialist James Newman waves at a camera during an extravehicular activity (EVA) performed at the International Space Station.*

Engineer:
a person trained and skilled in the design and development of technological solutions to human problems.



INTRODUCTION

than others, it is by standing upon the shoulders of giants." This chapter will introduce you to some of those giants—people who enjoyed solving problems, were curious about how things worked, and wanted to make them work more efficiently. As you read this chapter, you will see how their achievements still affect the quality of your daily life.

Engineering touches every aspect of our daily living. It helps us communicate, work, travel, and stay healthy. It is such a large discipline that it is broken into a few major categories: civil, electrical, chemical, and mechanical engineering. These general disciplines are further divided into specialized areas such as biomechanical, aerospace, and computer engineering. In this chapter, we will explore many of the career opportunities available to today's engineering students.

THE MESOPOTAMIANS

Thousands of years ago, the land between the Tigris and Euphrates Rivers was called Mesopotamia. Today, this land is within the country of Iraq (Figure 1-3). The invention of the wheel is said to have taken place in this area, along with the wheeled cart. In the southern part of Mesopotamia at the beginning of recorded history, Sumerians built canals, walls, and temples. These were the first known engineering accomplishments.

Astronomy was also explored in Mesopotamia. The oldest astrolabe, dated to around 2,000 B.C.E, was found there. An astrolabe (see Figure 1-4) is an instrument used to measure the altitude of the sun or stars. The Mesopotamian astrolabe was created by engraving three concentric circles divided into 12 sections

Point of Interest

The Code of Hammurabi

The Code of Hammurabi, inscribed in cuneiform script, is still studied in law schools. Modern scholars have translated portions of the code as follows:

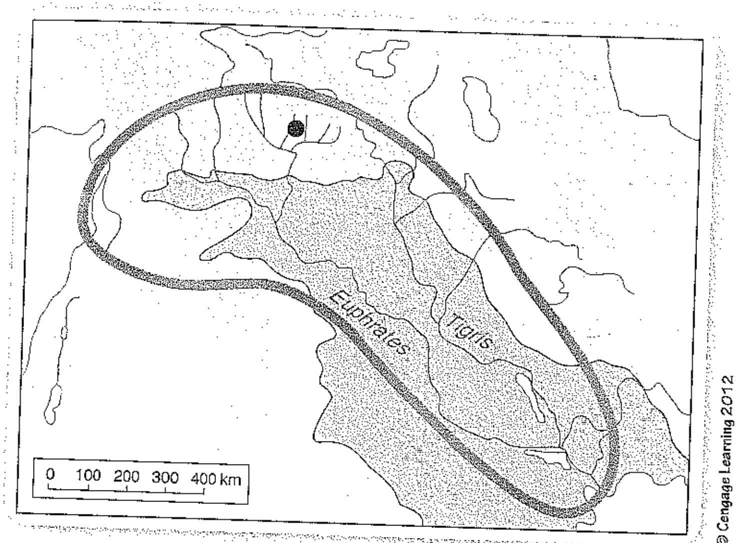
229. If a builder build a house for someone and does not construct it properly, and the house which he built fall in and kill its owner, then that builder shall be put to death.
230. If it kill the son of the owner, the son of that builder shall be put to death.
231. If it kill a slave of the owner, then he shall pay slave for slave to the owner of the house.
232. If it ruins goods, he shall make compensation for all that has been ruined, and inasmuch as he did not construct properly this house which he built and it fell, he shall re-erect the house from his own means.
233. If a builder builds a house for someone, even though he has not yet completed it, if then the walls seem toppling, the builder must make the walls solid from his own means.

Adapted from translation by L. W. King. Source: http://avalon.law.yale.edu/ancient/hamframe.asp, © 2008 Lillian Goldman Law Library, 127 Wall Street, New Haven, CT 06511; accessed 3/17/2010.

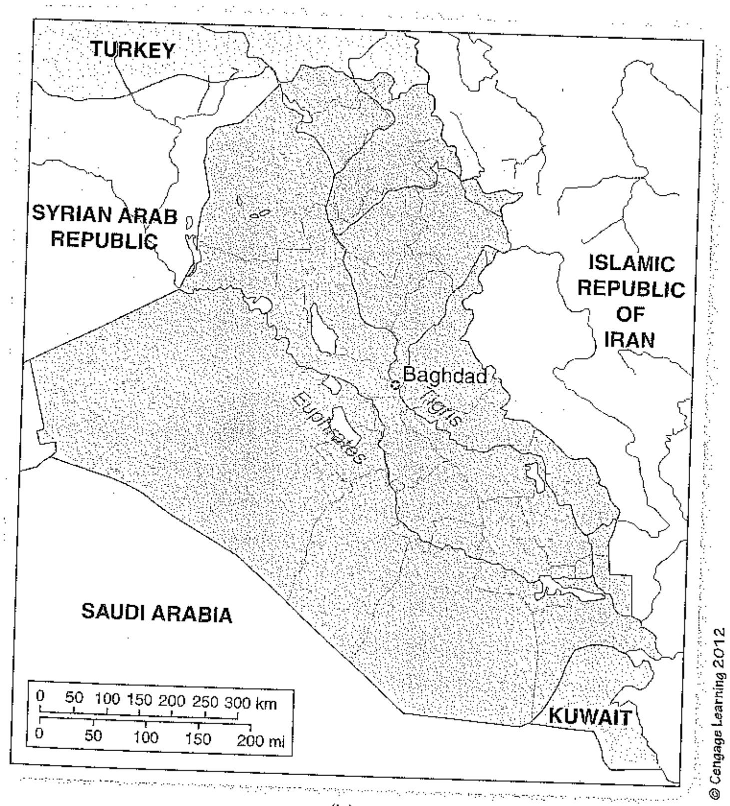
on clay tablets. Astrolabe technology was used to solve astronomical or navigational problems and wasn't replaced by a more precise instrument until the Middle Ages.

The best-known rulers in Mesopotamia at this time were the Assyrians and the Babylonians. Hammurabi was one of Babylonia's great kings. He created what some say was the first building code, providing a system for administering penalties for poor construction. The "Code of Hammurabi" established a set of building ethics, reinforced the importance of quality, and specified consequences for breaking the code.

FIGURE 1-3a and b: *The Mesopotamians lived and worked in present-day Iraq, occupying the land between the Tigris and Euphrates Rivers. They achieved some of the earliest known engineering accomplishments.*

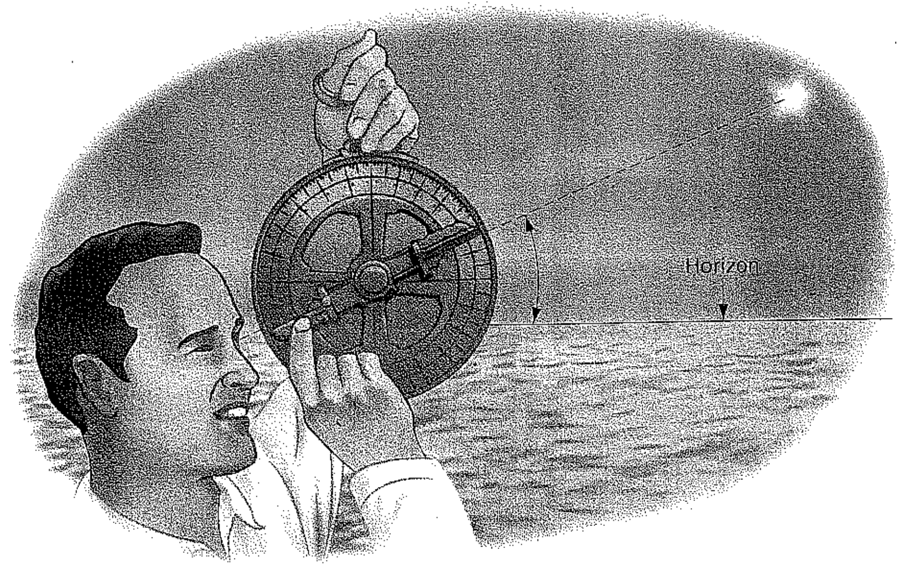


(a)



(b)

FIGURE 1-4: Mesopotamians used clay tablets to make astronomical measurements; this ancient instrument is known as an *astrolabe.* Although different materials were used in later centuries, this instrument wasn't replaced by a newer technology until the Middle Ages.



The people of Mesopotamia developed ways to control floods and irrigate fields. Evidence of these irrigation systems is still present today. The remains of the Nahrwan Canal, a canal system that paralleled the Tigris, is one example. The canal was 400 feet wide and extended about 200 miles.

Around 700 B.C.E., the Assyrians completed the first public water supply. They constructed a freshwater canal system that extended from the mountains of Tas to the existing Khosr River. The river then carried the water to Nineveh, a total of 45 miles. In Jerwan, an aqueduct was built from cut stone, designed to carry the freshwater over an existing stream. The cut stone aqueduct was 863 feet long, 68 feet wide, and 28 feet at its highest point. The channel through which the water flowed was 50 feet wide and 5 feet deep. The channel was lined with concrete and is the first known use of concrete for construction.

THE EGYPTIANS

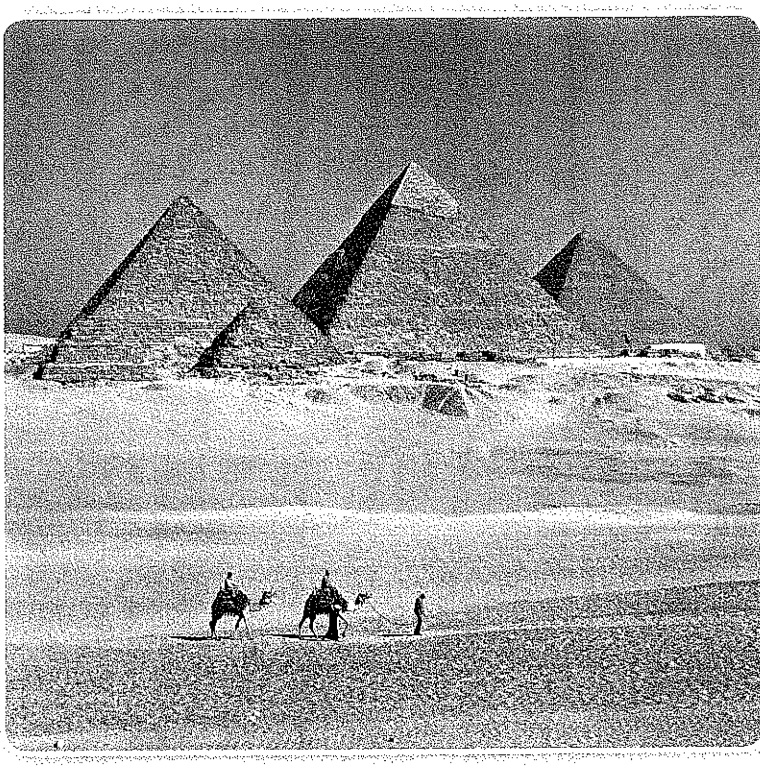
The Egyptians used the natural wealth of the Nile River to support their complex technological society. Each year, the Nile rose in the spring and flooded the valley. When the flood waters receded during the dry season, the river left behind a new layer of silt. The silt was filled with rich nutrients that made the Nile River valley an especially fertile place for growing food. By developing a controlled **irrigation** system, the Egyptians were able to use the rich soil in the valley to grow food during the dry season.

Irrigation: the application of water to crop-producing land through artificial means.

The Egyptians' ability to adapt to the Nile's flooding cycle was a key to their success. With an ample food supply, Egyptians could focus on social and cultural development. We can still see evidence of their complex culture in their construction projects.

The Egyptians used many different building styles during their 2,000-year history, but they are best known for the pyramids. Three famous examples are still standing at Giza (Figure 1-5). The largest one is known as the Great Pyramid

FIGURE 1-5: *The Greeks considered the Great Pyramid at Giza to be one of the seven wonders of the ancient world. It is the only one of those structures that remains intact.*



or the Pyramid of Cheops. It stands 481 feet high and covers 13 acres at its base. It is amazing to consider that these architectural wonders were built without power tools.

In ancient Egypt, the king chose a trusted individual to serve as "chief of works." An expert in general construction, the chief advised the king on plans for irrigation, flood control, and surveying. In today's world, an analogy would be the appointment of the secretary of the U.S. Department of Transportation by the president of the United States. This trusted individual leads the organization whose mission is to "[s]erve the United States by ensuring a fast, safe, efficient, accessible and convenient transportation system that meets our vital national interests and enhances the quality of life of the American people, today and into the future." In the United States, the appointment is approved by Congress.

THE GREEKS 2

The Greek landscape forced its inhabitants to live near the sea. By focusing their efforts on harbor construction and ship building, the Greeks became the navigational leaders of their time. They were the first to construct a lighthouse, built at the port of Alexandria in what is now Egypt around 300 B.C.E. (Figure 1-6). The Pharos lighthouse stood 370 feet tall and was named one of the seven wonders of the ancient world.

During the rule of Pericles, Athens' leaders sought to make their city the most beautiful metropolis. Pericles rounded up the best artists, architects, and builders to create well-known shrines, statues, and structures. They used simple machines, timber frames, and hand-powered lifts (similar to those used today) to construct the columns, beams, and pillars that we still identify with classical Greek architecture.

FIGURE 1-6: The Greeks built the Pharos lighthouse at the port of Alexandria about 2,300 years ago and called it one of the seven wonders of the ancient world.

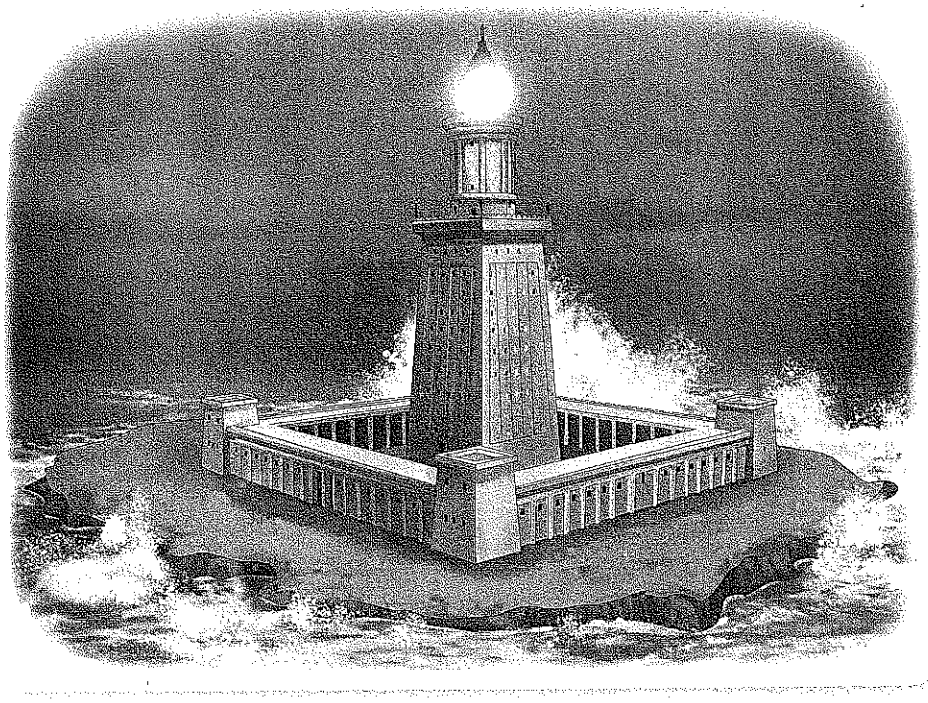
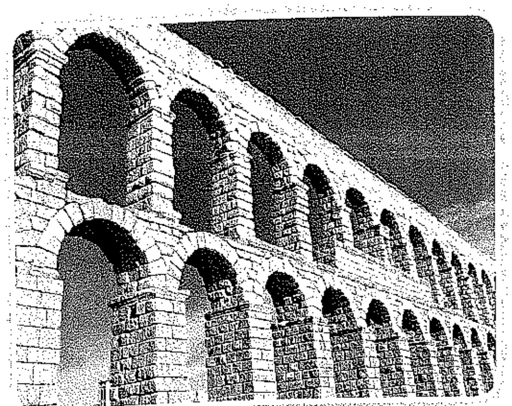


FIGURE 1-7: Roman engineers focused on building functional structures such as aqueducts, which carried water to municipalities miles away from the source. The Segovia aqueduct in what is now Spain carried water from the Frío River 10 miles away.



THE ROMANS

The Romans had realistic engineering goals. They kept things simple in design and form but massive in scale. They were less concerned with artistic appeal than with the function of the structures they built; see Figure 1-7.

The civil engineers of ancient Rome focused on public works projects built by slaves. The Romans are known for their bath houses, arenas, roadways, temples, and public forums.

Some of the greatest Roman engineering feats are the new construction methods and techniques they invented. They developed cement and numerous construction machines such as the treadmill hoist, pile driver, and the wooden bucket wheel (Figure 1-8).

THE MIDDLE AGES

Historians describe the time after the fall of the Roman Empire as the Middle Ages. This was a slow time for engineering developments. Even so, we do attribute some advances in structural design to medieval inventors. They also developed energy-efficient machines and power-saving devices.

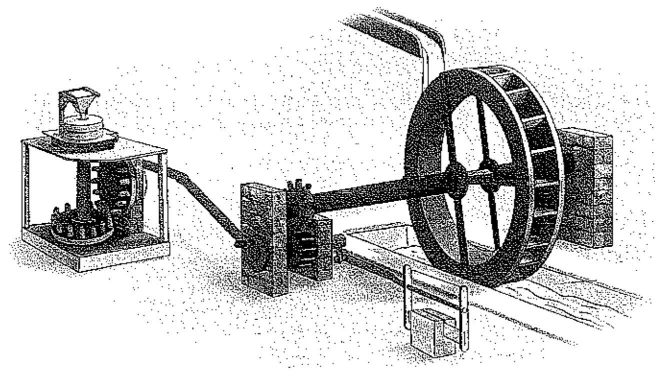
Many useful inventions that are still a part of our daily life came from China during the Middle Ages. These inventions include gun powder, papermaking, iron casting, and textiles.

3

ENGINEERING PIONEERS

Many advances were made in science and technology during the 15th, 16th, and 17th centuries that held tremendous promise for the industrial development of the world. In the next section, we will introduce a few of this era's important pioneers

FIGURE 1-8: The Romans developed the wooden bucket wheel, which they used to convert energy from flowing water into useful forms of power. It was commonly used to mill flour and is considered a precursor to modern hydroelectric dams.



in science and technology and explain how their achievements remain relevant to the study and practice of engineering today.

Technology That Continues to Improve

During the late Middle Ages, Johann Gutenberg (1398–1468) invented the movable type mold (Figure 1-9). Gutenberg is credited with the first printed book in A.D. 1450.

Gutenberg's printing press was the spark that ignited the flame of widespread communication. His invention came at a time when societies felt a growing need for a convenient way to share information. People still have this need today, and the printing industry remains a large business even as methods for sharing information have adapted to a digital environment.

Various forms of the printing press already existed at the time of Gutenberg's invention. As early as the 11th century, the Chinese had developed a set of movable letters from a baked mixture of clay and glue. The letter pieces were stuck onto a plate where impressions could be taken by pressing paper onto the stationary letters. Because the letters were glued to the plate, the plate could be heated and the letters removed and resituated. The process was not used in any form of mass production, but it did form a basis for the future invention of Gutenberg's printing press. In Europe, would-be printers had attempted to create presses that could produce cheap playing

FIGURE 1-9: Johann Gutenberg's printing press allowed societies to share a growing body of information about science and engineering.

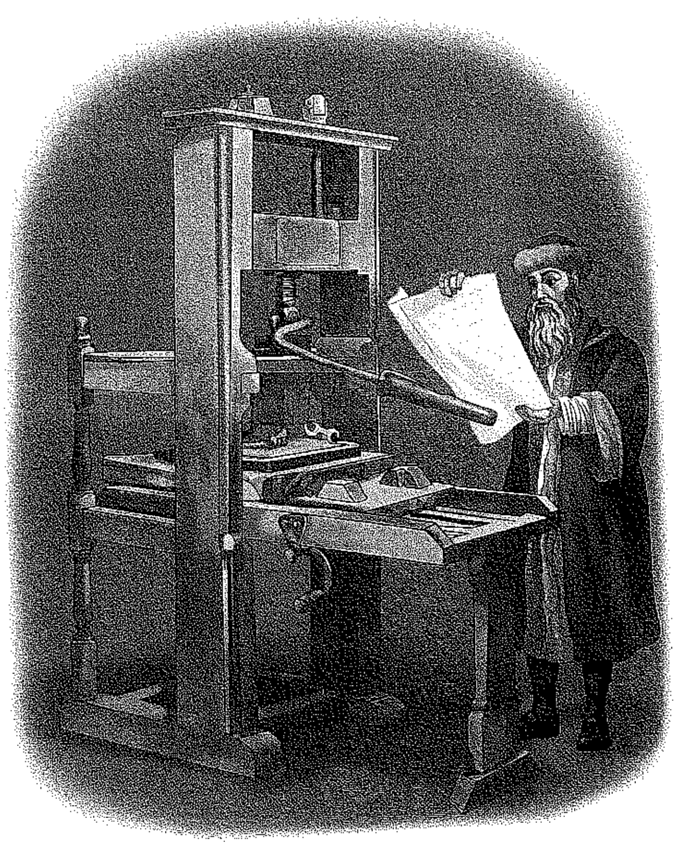
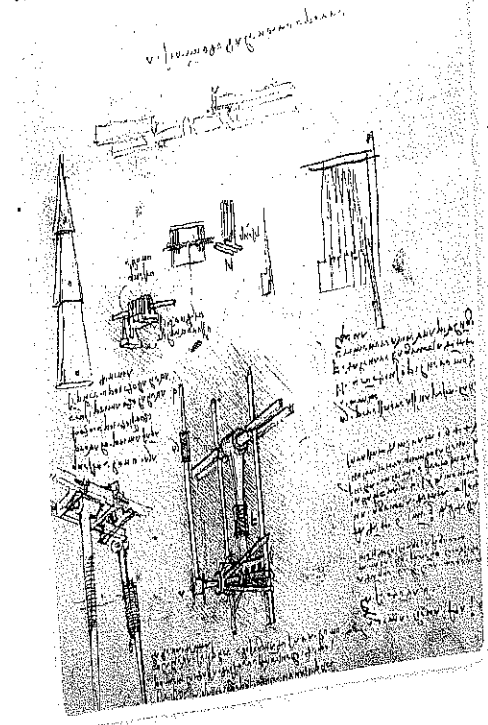


FIGURE 1-10: Leonardo da Vinci made numerous engineering sketches for inventions that were well before their time.



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cards and frivolous items, but Gutenberg saw the practical need for a press that could provide common people with reading material. Having the ability to print and store information in written form allowed for the fast spread of knowledge. By 1500, books on chemistry, mining, metallurgy, and many other science and engineering topics were in print.

Today, there are many printing methods available to address commercial and consumer needs. In your own home, you probably have an ink-jet printer that sprays tiny drops of ink onto paper. Or maybe you have a laser printer, which uses static electricity to force toner to stick to the paper until it is fused by heated rollers. A variety of methods exist today to print newspapers, packaging, and even t-shirts.

Technology Before Its Time

Leonardo da Vinci (1452–1519), the Renaissance painter of the *Mona Lisa*, used his artistic talent to observe and illustrate how machines work. With the knowledge he gained, Leonardo was able to make mechanical improvements and invent new machines. That is exactly what engineers do today. Leonardo's inventions included musical instruments, hydraulic pumps, reversible crank mechanisms, finned mortar shells, and a steam cannon; see Figure 1-10.

Point of Interest

A Bridge to the Future

Not all of Leonardo's inventions were practical, and many were before their time. For example, in 1502, Leonardo produced a drawing for a single-span, 720-foot bridge crossing the Bosphorus River. The project was part of a civil engineering contract with Sultan Bajazet II of Constantinople, in what is now Turkey. The bridge was never built—Leonardo's ideas for its construction were about 300 years ahead of generally accepted engineering practices. Nearly 500 years later, Leonardo's simple but powerful drawing drew the attention of Norwegian artist Vebjørn Sand. Sand was inspired by the drawing to create the Leonardo Project to bring Leonardo's vision to life. Five hundred years after Leonardo created these drawings, the Leonardo Bridge was constructed and opened for pedestrians and bicyclists on October 31, 2001, in Ås, Norway. Sand is currently considering several sites in the United States for the next Leonardo bridge project. You can read more about the Leonardo Project at www.vebjorn-sand.com and view a slide show of its construction at www.leonardobridgeproject.org.

Source: www.vebjorn-sand.com. Accessed 1/26/2010.

Connections Between Science and Engineering

Many scientific laws are named for the notable scientists who discovered them. Boyle's law, for example, was named after Robert Boyle, who lived in Ireland and England from 1627 until 1691. Boyle's law states that if the volume of a gas is decreased at constant temperature, the pressure increases proportionally. This law, along with the results of Boyle's other gas experiments, formed an important body of knowledge underlying many pneumatic inventions.

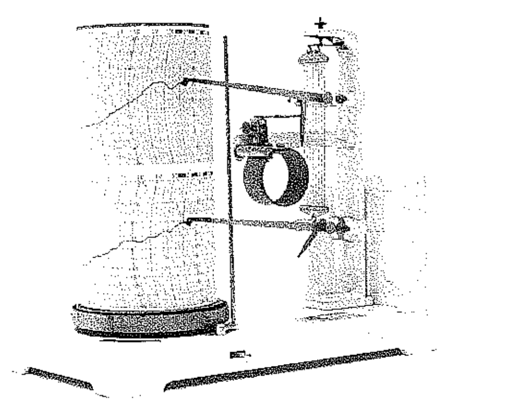
Robert Hooke (1635–1703) worked for Robert Boyle. Among Hooke's many engineering achievements, he created the air pump on which Boyle's experiments could be conducted. Hooke and Boyle's working relationship provides an excellent example of how science and engineering minds work together. Much of Boyle's work on gases might have been inspired by, if not strongly based on, work carried out by Hooke's work with clocks, springs, and gases.

Hooke published an important book titled *Micrographia*, which became the foundation for the science of **microscopy**. Hooke's use of the microscope to investigate a previously invisible world led to more fascinating discoveries and new inventions. For example, Hooke observed through the microscope that hairs from the beard of a goat would bend when dry and straighten when wet. This understanding led to his invention of the **hygrometer**, a device we still use today to measure water vapor content in the air (Figure 1-11).

Microscopy: the use of a microscope for investigation.

Hygrometer: an instrument used to measure the water vapor content in the air.

FIGURE 1-11: Hygrometers are used to measure humidity and help control indoor environmental air quality. These instruments still rely on principles Hooke discovered more than 300 years ago while studying goat hairs under a microscope.



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Connections Between Math and Engineering

Math is an indispensable tool in the engineer's toolbox of skills. Engineers and scientists rely on calculus to solve complex problems. Although many mathematicians all over the world contributed to the development of calculus, Gottfried Wilhelm Leibniz (1646–1716) and Isaac Newton (1642–1727) are both credited its invention (Figure 1-12).

There are two branches of calculus. *Differential calculus* determines the slope or steepness of a complicated curve. For example, we can calculate the slope of a mountain that might become a new ski area or determine the speed of a new roller coaster using differential calculus.

FIGURE 1-12: Sir Isaac Newton is one of the most influential mathematicians and scientists in history. His invention of calculus enabled engineers to solve problems that regular mathematics could not address.

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Integral calculus helps us find the area or the volume of a complex figure. For example, we can use integral calculus to determine the amount of water needed to fill an unusually shaped pool.

THE AGE OF TRANSPORTATION

Since the invention of the wheeled cart, engineers have been continuously improving how people travel. In the 1760s, James Watt's working model of a steam engine led indirectly to the age of transportation.

Steam Engines as Power for Transportation

Collaborating with Matthew Boulton, a well-known manufacturer, Watt produced hundreds of steam engines. These early machines had little to do with transportation. The Boulton and Watt engines were used in England during the 1800s to pump water out of mines and to drive machinery that helped power textile mills and iron works.

Experimentation led to advances in steam engine technology. These advances made steam engines useful for transportation in applications such as steam boats and locomotives. The first commercially run steam boat, *The Clermont*, was created by Robert Fulton in 1807 and ran between New York City and Albany on the Hudson River. Fulton's first trip took 32 hours.

In 1823, Englishman George Stephenson demonstrated the feasibility of a steam-powered railroad transportation system. His invention sparked the growth of railway systems everywhere. By the end of the Civil War, the United States had 35,000 miles of railway; that increased to more than 190,000 miles by 1900.

Canals as Conduits for Transportation

Other forms of transportation systems were also growing quickly. Extensive canal systems were being constructed in England from 1780 through 1900 and in the United States during the first half of the 19th century (see Figure 1-13).

FIGURE 1-13: **Important U.S. Canals, 1800–1850**
Several important canals improved transportation in the United States in the first half of the 19th century.

Erie Canal	1817–1825	New York state cities between Buffalo and Albany
Ohio and Erie Canal	1828–1836	Cleveland to Portsmouth on the Ohio River
Chesapeake and Ohio Canal	1828–1850	Washington, D.C., to Cumberland, Maryland

Although the commercial use of these canals declined in the 20th century, we still rely on the Panama Canal to facilitate international trade. The Panama Canal was one of the most important engineering projects of the 20th century. Finished in 1914, the canal is 50 miles long, 110 feet wide, and 70 feet deep. It reduced the distance ships had to travel by about 5,000 miles when sailing from the East Coast of the United States to the West Coast (Figure 1-14).

The Need for Better Roads for Transportation

The evolution of the automobile in the early 1900s transformed our society. The number of autos on the road exploded in 1904 when Henry Ford implemented his vision of the assembly line to mass produce high-quality, affordable vehicles (Figure 1-15). By the end of the 20th century, 90 percent of U.S. homes had automobiles.

FIGURE 1-14: The Panama canal was a 50-mile project that could shorten a ship's journey from the U.S. East Coast to West Coast by 5,000 miles.

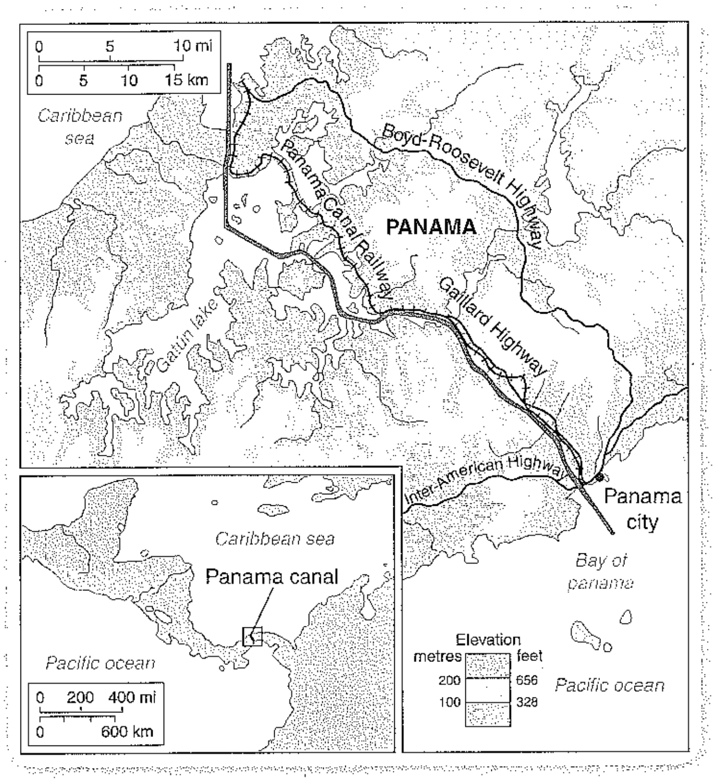
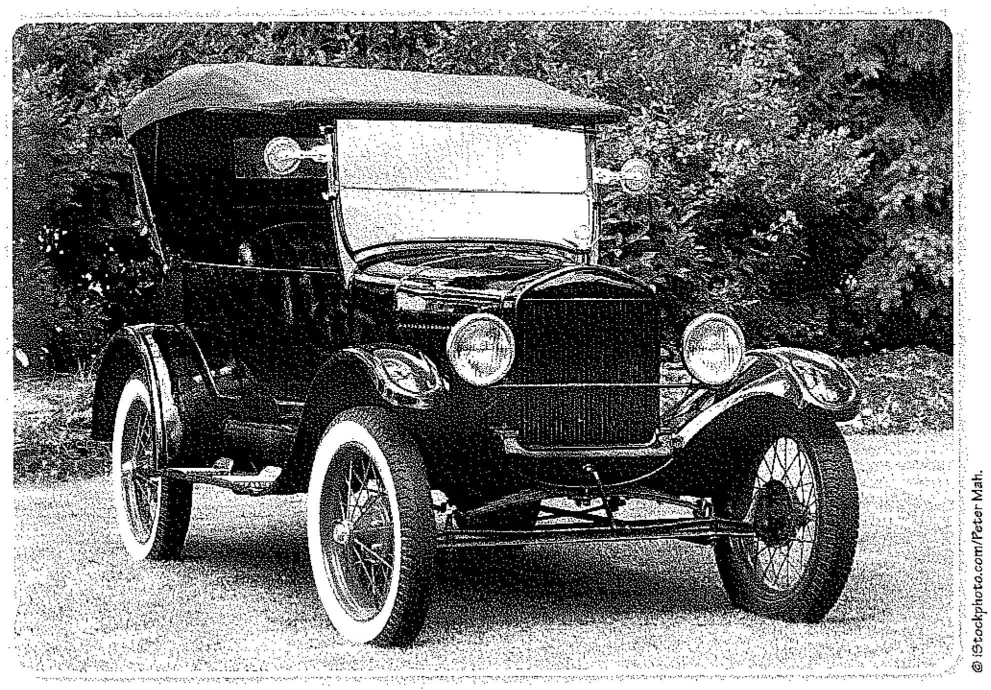


FIGURE 1-15: Henry Ford's innovations to assembly-line technology allowed his company to produce a high-quality, affordable product. The Model T remains a symbol of mass production.



As cars became more affordable and people wanted to travel farther, it was necessary to build better roads. The era of road building was first influenced by John MacAdam (Scotland, 1756–1836), who devised a method for compacting broken and crushed stone. MacAdam used his methods of construction to pave 180 miles of turnpike. MacAdam's Scottish compatriot, Thomas Telford, used large, flat stones set on edge and wedged them together to form a solid, flat surface. Telford's innovation created smoother, more durable roadways.

The Federal Aid Highway Act of 1956 authorized federal funding to build more than 45,500 miles of paved roads in the United States. The total cost of the resulting interstate highway system was estimated in 1991 to be $128.9 billion (Figure 1-16). Engineers still play an important role in maintaining existing roads and building new ones.

FIGURE 1-16: **Mass-produced automobiles had a transforming effect on U.S. society, leading indirectly to the development of the interstate highway system.**

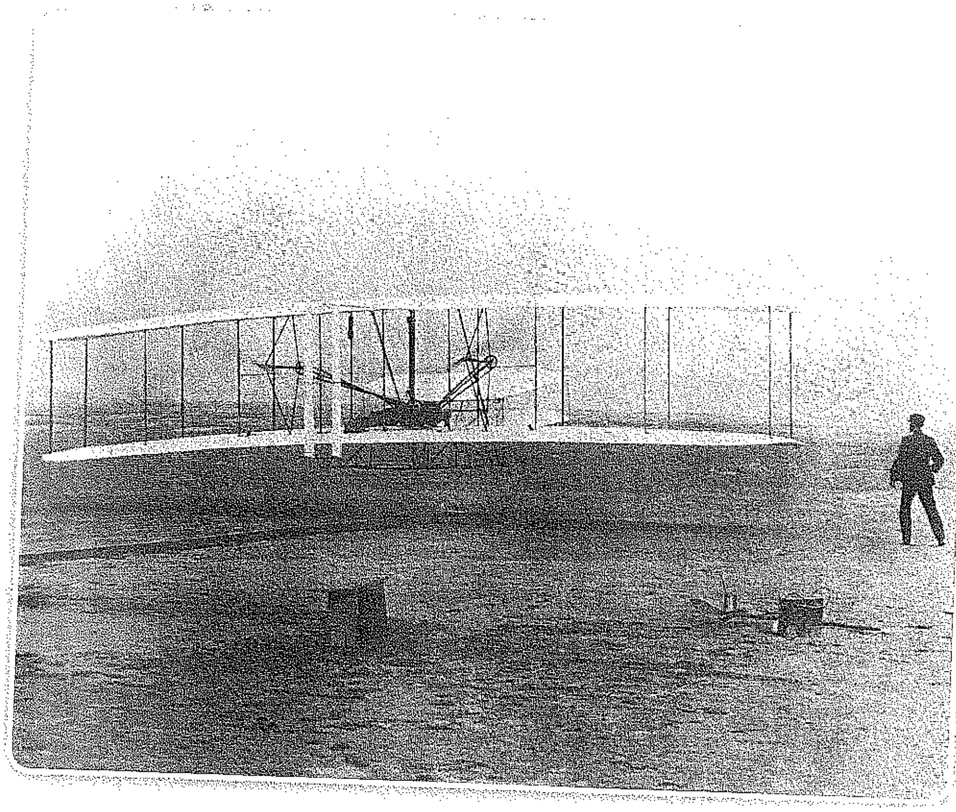
Taking to the Sky

At the beginning of the 20th century, many inventors were focused on a single goal: heavier-than-air flight. Brothers Orville and Wilbur Wright first achieved success in 1903 with a 12-second, 120-foot flight (Figure 1-17). In 1905, Charles and Gabriel Voisin started the first aircraft company in France, building custom planes. The first American aircraft company was formed in 1911 by Glenn Curtiss in Hammondsport, New York. Curtiss switched from manufacturing motorcycles to manufacturing airplanes and is the inventor of the seaplane. Today, air transportation makes long-distance travel practical and affordable.

Moving Underground

Engineers first envisioned the **Channel Tunnel**, or "Chunnel," in the early 1800s. Several attempts to construct an underwater passage from England to France failed before the Chunnel opened in 1994. Construction started in 1988 with 11 boring machines tunneling their way toward each other from France to Britain and from Britain to France. Think of the mathematical calculations of speed and distance that had to be so accurate that the two opposite tunnels could join at the exact same point successfully. Today, high-speed trains travel this modern marvel of engineering.

FIGURE 1-17: Wilbur and Orville Wright's first flight lasted 12 seconds over 120 feet of North Carolina beach.



Courtesy of NASA.

THE AGE OF ELECTRICITY

The fundamental nature of electricity was first studied by physicists in the early 1800s. Countless scientists have worked to develop **electricity** as a source of power. Over the years, engineers have harnessed electrical energy to solve many problems.

Electricity: the transfer of energy through the flow of electrons along a conductor.

Can you imagine what your life would be like without batteries? Just consider how many batteries are at work in your home right now, supplying power to watches, cell phones, remote controls, and other portable electronics (Figure 1-18). When you use battery-powered devices, you are using electricity in the form of direct current (DC) (Figures 1-19 a and b). In direct current, electrons move in the same direction.

Alessandro Volta invented the first electric battery in 1827. To honor his contribution to science and technology, Volta's name was chosen to describe the electromotive force that moves electric current: the volt.

In alternating current (AC), electrons move forward and backward at extremely high speeds. AC is the form of electricity that power supply companies deliver to U.S. homes. Household appliances such as refrigerators, clothes dryers, and televisions plug directly into wall sockets and use alternating current (Figures 1-19c and d).

FIGURE 1-18: What would your life be like without batteries?

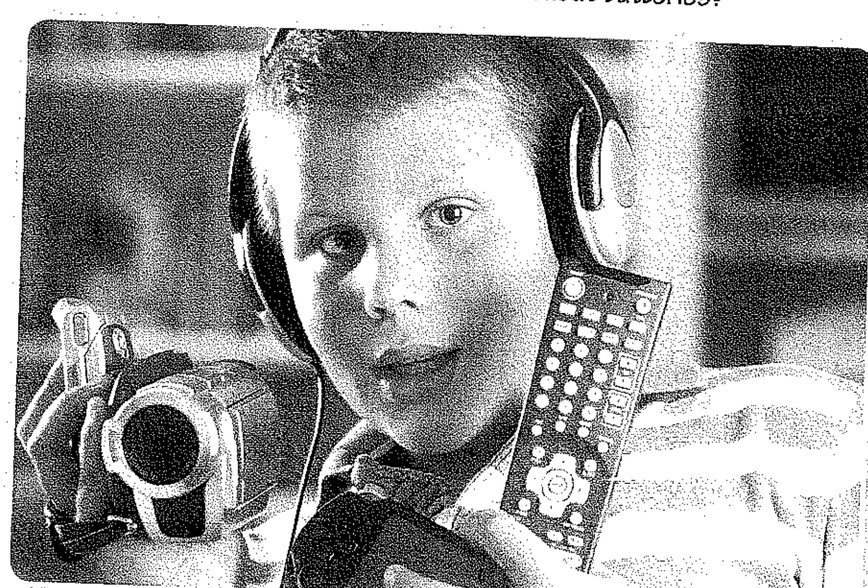


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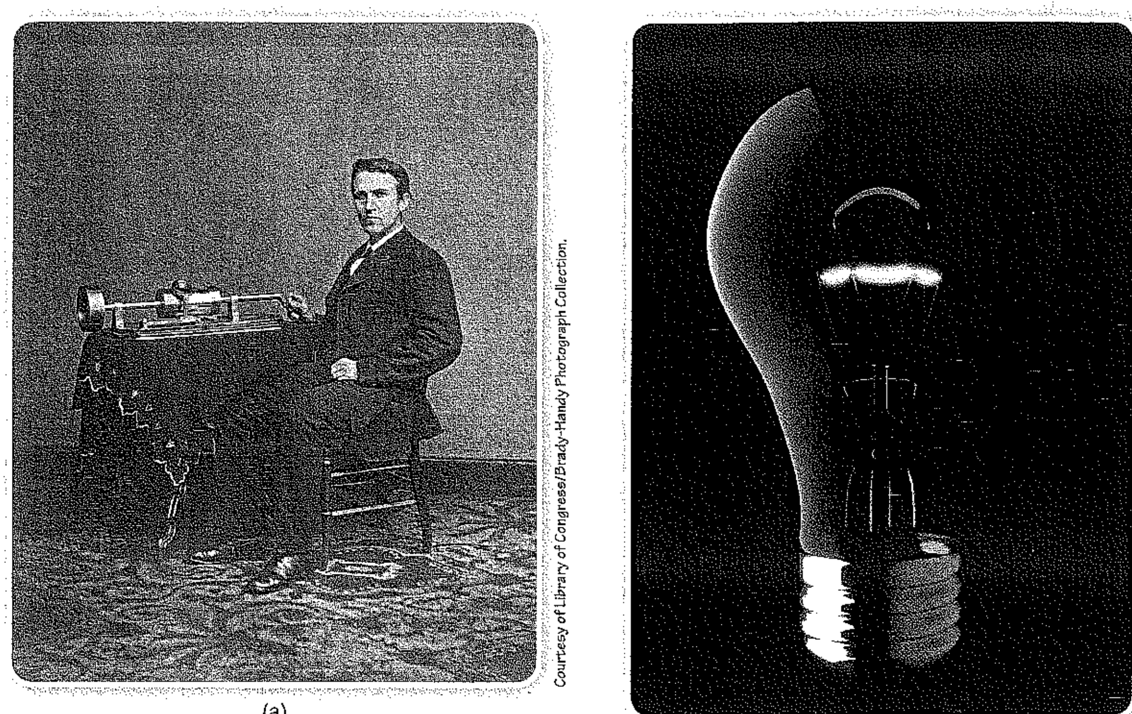
FIGURE 1-19: *Products that rely on batteries for power use direct current to drive internal motors. An (a) electric toothbrush and (b) car starter both use DC. A household appliance that plugs in such as (c) a hair dryer or (d) a refrigerator uses alternating current to drive motors.*

(a) (b) (c) (d)

Nikola Tesla played a major role in deciding how we use AC today. Tesla's inventions influenced how electricity is generated, transmitted, and converted to mechanical power today. He invented the AC induction motor and designed the Niagara Falls Power Station, which was completed in 1895 and lit up Broadway in New York City about 400 miles away.

We all know Thomas Edison as the inventor of the incandescent bulb (Figure 1-20), but he also holds an astounding 1,093 U.S. patents. Edison developed many of the principles of mass production and is credited with creating the first industrial research laboratory. Electric power generation and the distribution of electricity to factories and homes were first commercially implemented in New York City thanks to Edison's work.

FIGURE 1-20: **Thomas Edison's 1,093 patents cover a wide range of familiar and unfamiliar endeavors including electric lighting systems, the phonograph, movies, batteries, automobiles, cement, rubber, the telegraph, the telephone, and a method for preserving fruit.**



(a) Courtesy of Library of Congress/Brady-Handy Photograph Collection.

(b) © iStockphoto.com/Felix Möckel

Inventors and innovators in the 20th century took full advantage of the power of electricity to create numerous applications that would vastly improve the quality of life. In fact, we use so much electricity that we are now creating technologies to help us use energy more efficiently. ENERGY STAR is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy. The ENERGY STAR mission is to help consumers save money and to protect the environment by using energy-efficient products and practices. This program encourages manufacturers to design energy-efficient household appliances and home-building materials such as windows and lighting. ENERGY STAR challenges engineers to design new products that use less energy without sacrificing comfort or quality.

When the Burj Khalifa opened in downtown Dubai, United Arab Emirates, in January 2010, it took the title of world's tallest building. The Burj stands 2,625 feet tall and holds more than 160 stories (Figure 1-21). Investigate the world's tallest building on the Internet and identify some of the challenges and solutions the numerous engineers needed to solve during this 6-year project.

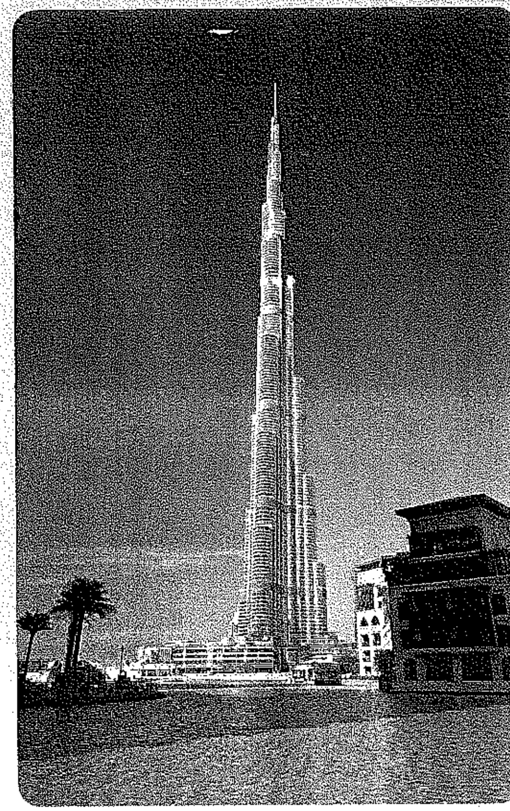


FIGURE 1-21: The Burj Khalifa is the tallest building in the world, a towering 2,625 feet.

Engineers have improved the quality of life by designing systems for supplying clean water, developing genetically modified crops, and creating better medicines and medical procedures. By improving the human condition, engineers play a vital role in our society. Let's take a closer look at some important engineering disciplines and at the kind of education and training that students need to become engineers.

ENGINEERING SOCIETIES

Engineering first achieved formal recognition as a profession in the late 19th century. John Smeaton was the first person to call himself a civil engineer. Hoping to attract others with similar interests, Smeaton created an engineering society in 1771. He realized that such an organization would help validate the profession. In 1881, the Institution of Civil Engineers was formed, and Thomas Telford, the great road builder, was elected as its first president. Soon after that, the Institute of Mechanical Engineers was formed with George Stephenson, the man associated with the introduction of steam-powered rail, as its first president.

By 1908, civil, mechanical, electrical, chemical, mining, and metallurgical engineering all had societies in the United States (Figure 1-22).

FIGURE 1-22: Engineering Societies in the United States

1852	American Society of Civil Engineers
1871	American Institute of Mining, Metallurgical, and Petroleum Engineers
1880	American Society of Mechanical Engineers
1884	Institute of Electrical and Electronics Engineers
1908	American Institute of Chemical Engineers

PREPARING FOR THE FIELD OF ENGINEERING

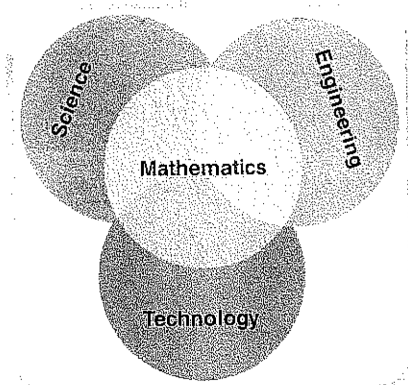
When should you start thinking seriously about your education and how it can shape your future? Now! High school is a great place to prepare for a future in engineering. Many schools offer engineering programs or STEM—science, technology, engineering, and mathematics—classes. STEM classes often provide collaboration between these discplines that reinforces the connections between them (Figure 1-23). Your guidance department can help you identify the courses that will best prepare you for the field of engineering.

To seek employment as an engineer, you will need to earn a bachelor of science (BS) degree from a college or university. This degree might take four or five years to complete, depending on where you choose to study. Spend some time researching which college is right for you. Plan a visit to the school to ask professors questions. More important, ask the students some questions. Ask them why they are pursuing a degree in engineering and what made them choose the school they are attending.

Engineering programs are accredited through the Accreditation Board of Engineering & Technology (ABET), an organization that helps standardize requirements among colleges and universities

After receiving your degree, you will most likely do one of two things. You might enter the workforce within your area of specialization, or you might pursue a secondary degree in your area of specialization. In many states, a test is required for you to become a licensed engineer. Some colleges offer a co-op or work-study program. These programs give students valuable real-world experience that can be helpful in landing that first job. Many times, a student co-op leads to a full-time job.

FIGURE 1-23: STEM classes help students see how their studies of math and science can support the projects they do in engineering and technology.



WHAT DO ENGINEERS DO?

As you study engineering principles and their applications in this textbook, you will discover that engineers have many possible career paths that lead to a wide variety of engineering disciplines. The major engineering categories are civil, electrical, chemical, and mechanical. These disciplines are so broad that some engineers pursue a specialty within the category; others blend two categories together. For example, aerospace engineering is considered a subcategory of mechanical engineering, whereas an industrial engineer blends electrical and mechanical disciplines together. Let's take a look at what some engineers do.

Aerospace Engineer

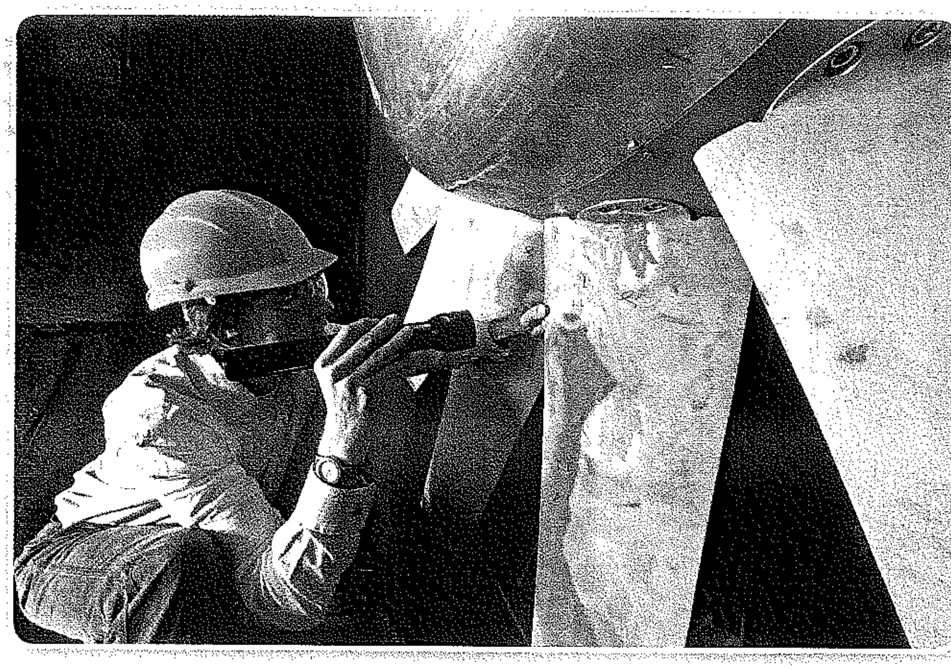
Aerospace engineering is concerned with engineering applications in the area of aeronautics (the science of air flight) and astronautics (the science of space flight). Aerospace engineering deals with flight of every kind: balloon flight, sailplanes, propeller- and jet-powered aircraft, missiles, rockets, and satellites, as well as advanced interplanetary concepts such as ion-propulsion rockets and solar-wind vehicles (Figure 1-24). Aerospace engineering will be responsible for making future interplanetary travel possible. The challenge is to produce vehicles that can traverse the long distances of space in ever-shorter periods of time. New propulsion systems will require that engineers venture into areas never before imagined.

Agricultural Engineering

At the turn of the 20th century, a large majority of the working population was engaged in **agriculture**. As farming efficiency increased and people left farming

Agriculture: the activity of producing crops or raising animals.

FIGURE 1-24: ***This aerospace engineer is inspecting the blades of an industrial wind tunnel.***



for jobs in industry, fewer farmers were needed. Contemporary farmers are able to feed about 10 times as many families as their ancestors did 100 years ago. Today, less than 5 percent of the U.S. population works on farms. How are fewer farmers able to feed a larger population? The application of new technologies and engineering to agricultural practices has vastly increased farmers' efficiency and productivity. Agricultural engineers design machinery to plant, fertilize, and harvest food crops. They design structures for crop storage and develop methods to conserve soil and water. They even produce new seeds and plants that are genetically engineered to resist pests (Figure 1-25).

FIGURE 1-25: ***Some agricultural engineers use genetic engineering to improve crop resiliency.***

FIGURE 1-26: *Farmers today rely heavily on chemical engineering.*

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Chemical Engineering

Chemistry has been studied for centuries, but chemical engineering began its rise to prominence shortly after World War I. Chemical engineering uses the science of chemistry to change the composition or properties of materials and make them more useful for industrial processes. Chemical engineers are involved in manufacturing polymers, drugs, paints, pesticides, cosmetics, and food (Figure 1-26). They work in oil refining, paper products and textiles manufacturing, and the extraction of metals from ores. Many specialty areas within chemical engineering are growing rapidly.

Civil Engineering

Civil engineers provide communities with structures such as buildings, bridges, dams, and roads (Figure 1-27). Civil engineers are concerned with planning, designing, and supervising the construction of structures. Consider the challenges that civil engineers have as they design and build structures that can withstand earthquakes and extreme weather.

Today, civil engineering focuses on structures and structural systems such as bridges, skyscrapers, tunnels, canals, rapid-transit systems, highway systems, recreational facilities, industrial plants, dams, nuclear power plants, railroad lines, harbors, and off-shore oil and gas facilities. When civil engineers improve the movement of people on roadways, they are also protecting society and the environment. Reducing traffic can reduce toxic emissions from individual vehicles, and improvements in highway design can minimize the number of accidents. The civil engineer is always at the center of discussions when municipalities are planning new buildings and transportation systems.

FIGURE 1-27: *The Oresund Bridge between Denmark and Sweden is the world's longest single bridge carrying both road and railway traffic. Civil engineers worked on this project from 1991 to 1999.*

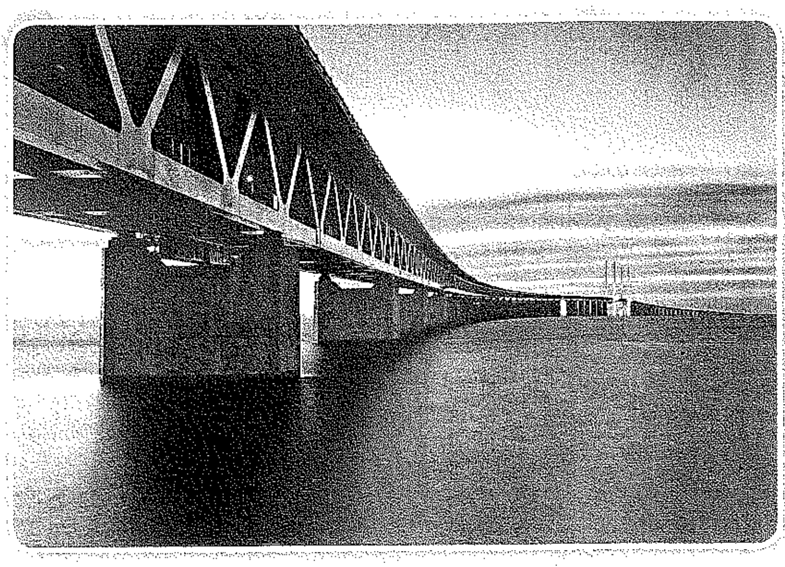

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FIGURE 1-28: *Computer engineers research, design, and test hardware components.*

© iStockphoto.com/Marina Bartel

Computer Hardware Engineering

Large, medium, and small organizations alike all depend on computers to manage inventories, create invoices, record sales, and communicate with customers. The amount of data storage possible makes the computer indispensable. Computers of the past were the size of a room; today's computers have been downsized to the size of your fist with computing speeds that were unthinkable just a year ago. The world has become almost completely computer centered, and the computer's role should only increase, thanks to engineers who focus their efforts on the research, design, and testing of computer hardware components (Figure 1-28).

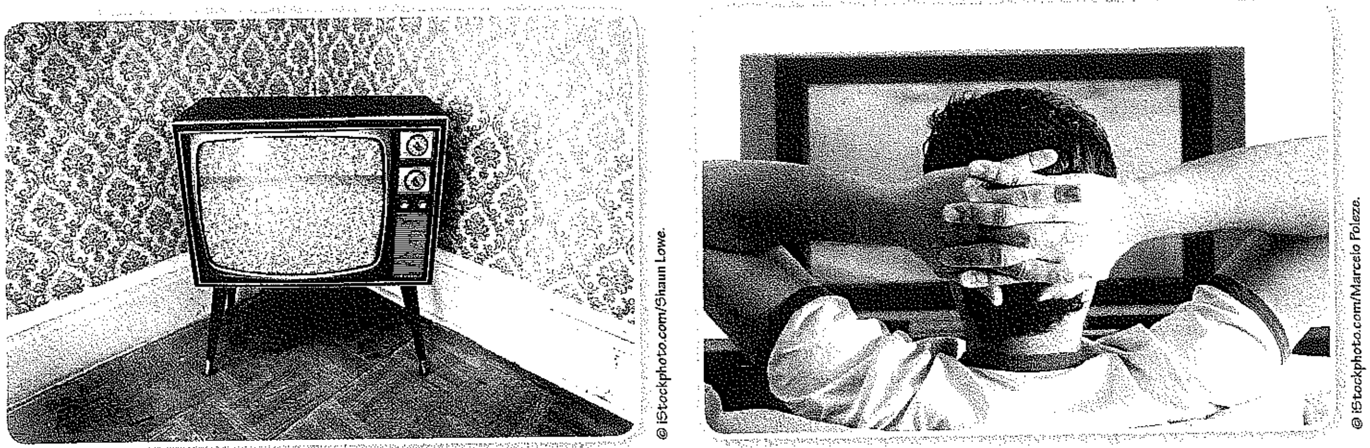
Electrical Engineering

Electrical engineers solve problems using electrical principles. These principles are relatively new to us—Georg Ohm and Michael Faraday were only beginning to build our understanding of this science in the 19th century. Our first electrical engineers included inventors such Thomas Edison, who supplied DC to New York City residents in 1882, and Guglielmo Marconi, who made the first wireless radio transmission in 1896. Imagine how many alterations there have been to take us from the first electronic television using cathode ray tubes in 1931 to today's liquid crystal display (LCD) and plasma flat-screen TVs (Figure 1-29a and b). Every household gadget has been transformed by electrical engineers.

Industrial Engineering

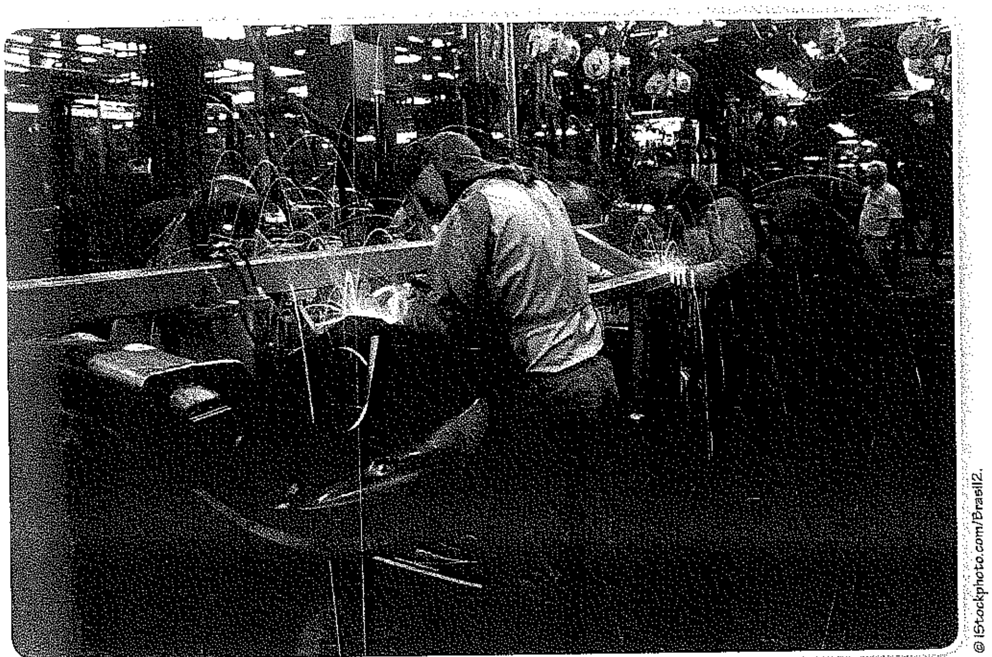
Industrial engineering is a growing branch of the engineering family. Industrial engineers study engineering principles and techniques that can help make manufacturing processes more efficient and more profitable. These innovators are skilled at finding ways to do more with less. Their efforts can help improve customer service and product quality, make workplaces safer, and make the work easier. Industrial engineers must design, install, and improve systems that integrate people, materials, and equipment to efficiently produce goods (Figure 1-30). They must coordinate their understanding of the physical and social sciences with the activities of workers to design areas in which workers will produce the best results.

FIGURE 1-29: From the (a) cathode ray tubes of the 1950s to (b) today's flat screens, television technology has enjoyed a dramatic evolution.



(a) (b)

FIGURE 1-30: Industrial designers consider the efficiency of manufacturing process and the safety of industry workers.



Mechanical Engineering

Automobiles, engines, heating and air-conditioning systems, gas and steam turbines, air and space vehicles, trains, ships, servomechanisms, transmission mechanisms, radiators, mechatronics, and pumps are a few of the systems and devices that require knowledge of mechanical engineering. Mechanical engineering deals with power, its generation, and its application. Power affects the rate of change or "motion" of something. This can be a change in temperature or a change in motion because of outside stimulus.

Mechatronics: the study of the combination of computer engineering, electronic engineering, and mechanical engineering.

Mechanical engineers use their knowledge of how things move to accomplish a variety of tasks. The breadth of study required to become a mechanical engineer allows students to diversify into many other engineering areas. The major specialty areas of mechanical engineering are applied mechanics, control, design, engines and power plants, energy, fluids, lubrication, materials, pressure vessels and piping, transportation and aerospace, and heating, ventilation, and air conditioning (HVAC). Are you interested in continuing to shape the world to become a better place? If you are up to a challenge and your curiosity can be harnessed to solve problems, consider a career in engineering.

SUMMARY

- Our world has been shaped by people from ancient civilizations who thought and behaved like engineers.
- Modern civilization was built on many small improvements throughout human history to satisfy human wants and needs.
- Mesopotamians invented the wheel, established a building code, and developed ways to control floods and irrigate fields.
- The Nile River's cyclical flooding and the use of irrigation allowed the Egyptians to develop highly productive agricultural systems. An abundant food supply gave the ancient Egyptians freedom to develop a complex technological culture and build great structures such as the pyramids.
- The coastal-dwelling Greeks became navigational leaders and built the first lighthouse.
- The Greeks valued aesthetics in building projects. They used simple machines, timber frames, and hand-powered lifts to build classical works of architecture.
- The Romans valued function over form in building projects. They were the first to use cement to construct public works projects.
- Medieval inventors advanced structural design and created energy-efficient machines and power-saving devices.
- Gunpowder and paper were introduced by the Chinese during the Middle Ages.
- Many important pioneers in science contributed to our current knowledge about engineering. The work of these pioneers often shows the connections between engineers, scientists, and mathematicians.
- Over the course of 200 years, engineers have improved transportation by harnessing the power of steam to move boats and trains and by mastering heavier-than-air flight. They have decreased travel time by building canals, better roads, and tunnels.
- Alessandro Volta invented the first electric battery, and his name was chosen to describe the electromotive force that moves electric current: the volt.
- Battery-powered devices use electricity in the form of direct current (DC), whereas household appliances plug directly into wall sockets and use alternating current (AC).
- Engineering societies provide an opportunity for people with like interests and skills to share ideas.
- Preparing for the field of engineering starts in high school by taking courses that introduce problem solving using science, math, and engineering concepts.
- The field of engineering is divided into the broad categories of civil, electrical, chemical, and mechanical engineering. Engineers often pursue specialties within these broad categories.

BRING IT HOME

1. Describe the difference between a scientist and an engineer.
2. What type of standards did the Code of Hammurabi establish, and how are they used today?
3. What important agricultural invention did the Mesopotamians and Egyptians develop?
4. How did the landscape in Greece affect the ancient Greeks' development of technology?
5. Describe two aspects of ancient Roman engineering that distinguish it from ancient Greek engineering.
6. What civilization invented gunpowder, and when?
7. What invention allowed scholars to spread their knowledge more quickly during the 15th, 16th, and 17th centuries?
8. What were the first uses of the steam engine?
9. How did the steam engine adapt to use in transportation systems?
10. What major construction projects were completed during the 19th and 20th centuries that led to better and faster travel?
11. Name some important figures in the history of flight.
12. What did Alessandro Volta invent to provide direct current to today's portable electronic devices?
13. What did Nikola Tesla do that influenced the way alternating current is used today?
14. Who was first person to call himself a civil engineer? How did he help bring formal recognition to the profession?
15. When should you start researching engineering as a potential career path?
16. Name the four broad branches of engineering.
17. What specific engineering discipline interests you the most? Why?

EXTRA MILE

Identify an engineer in your community and conduct an informational interview. Your objective is to:

- Discover why he or she wanted to be an engineer and when.
- Summarize the person's education.
- Determine who the engineer works for and what his or her responsibilities include.
- Define the skills needed for their job.
- Inquire what advice the engineer would give to an aspiring engineer.