2.4 The Global and Societal Impact of Engineering

Engineering has had an impact on all aspects of society. Look around you and notice all of the things that have been made by humans. Through designing, manufacturing, testing, or selling, an engineer probably had something to do with most of these human-made items.

Great Engineering Achievements

Activity

> Can you think of some great engineering achievements? Take a few moments to make a list of some of the most important things engineers have developed. It might help to think of things that have changed the way that people live. For example, a century ago people relied on candles and lanterns for light. How has this changed? When you are finished making a list, share it with someone else and find out what they think are the most important engineering accomplishments.
>
> Now that you have a list of great engineering achievements, see what others have identified as the most important accomplishments of this century. In the following, you will find several figures, each representing a significant engineering accomplishment of the twentieth century. Look at each figure carefully and try to determine what engineering accomplishment it represents. Check to see if you have the accomplishment on your list. If it is not there, add it. Each accomplishment is briefly discussed after the figure.

The National Academy of Engineering (NAE) has identified the top twenty engineering achievements of the twentieth century. The NAE has created a webpage (http://www.greatachievements.org/) which describes these achievements and the impacts that these achievements have in the everyday lives of people. Many of these achievements are so commonly used in our society that we take them for granted. We describe ten of the twenty achievements; the other ten achievements can be found at the NAE webpage.

Figure 8, showing the bright lights of the Pudong New Area in Shanghai, China, and Figure 9, showing lights visible from space at night, represent electrification. Electrification is the process of making electricity available to large numbers of people. We use electricity not only for light, but also to power machinery, instruments, and appliances. How many electric or battery powered devices do you use in a day? Without electrification, we would not have any of these devices today.

Figure 10 shows a rather high-tech looking automobile. The first cars produced in the United States were sold in 1901, primarily as novelties to the wealthy. However, by 1920 automobiles were mass-produced. Prior to the automobile people worked close to where they lived; one had to live in the city in order to work in the city, as the largest distance that it was practical to travel regularly was only a few miles. A farm or a factory that was not close to a city could not easily transport goods to market. Thus the automobile is credited with freeing people from the limitations of geography and with greatly contributing to raising incomes and wealth.

Figure 11 shows a jet aircraft and its contrails as it flies high in the sky. Airplanes further freed people from the constraints of geography by making rapid long-distance travel possible. Airplanes are also responsible for advancing a global economy.

FIGURE 2.8

The skyline of the Pudong New Area in Shanghai China at night.

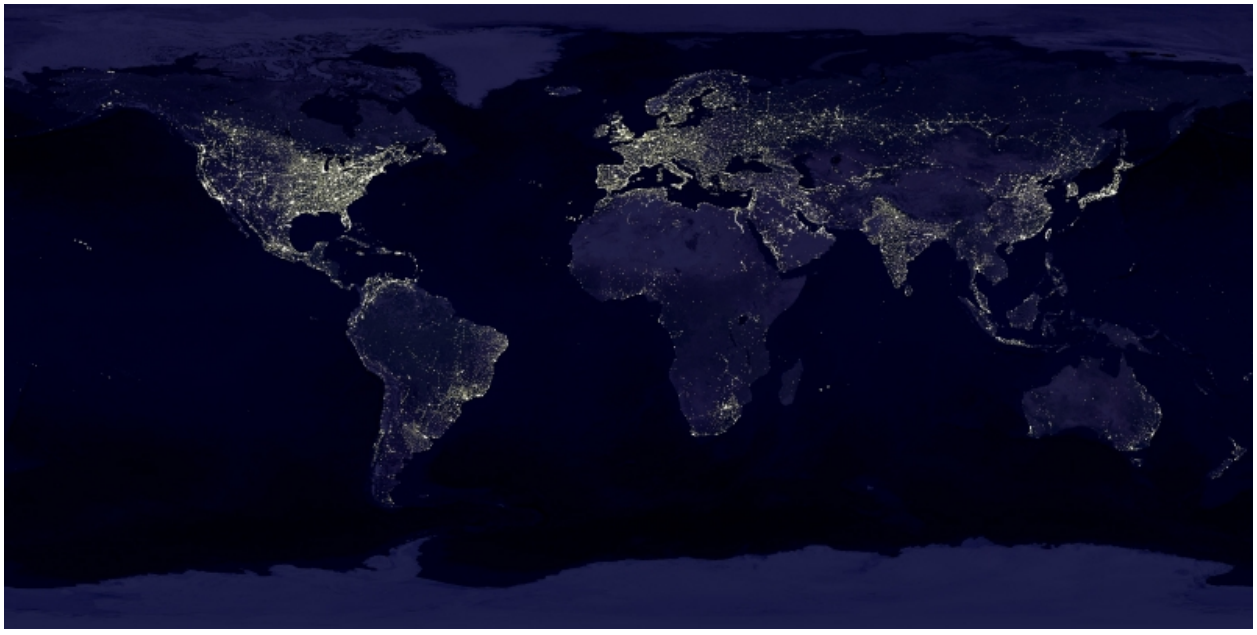

FIGURE 2.9

The lights of major cities around the world are visible from space at night.

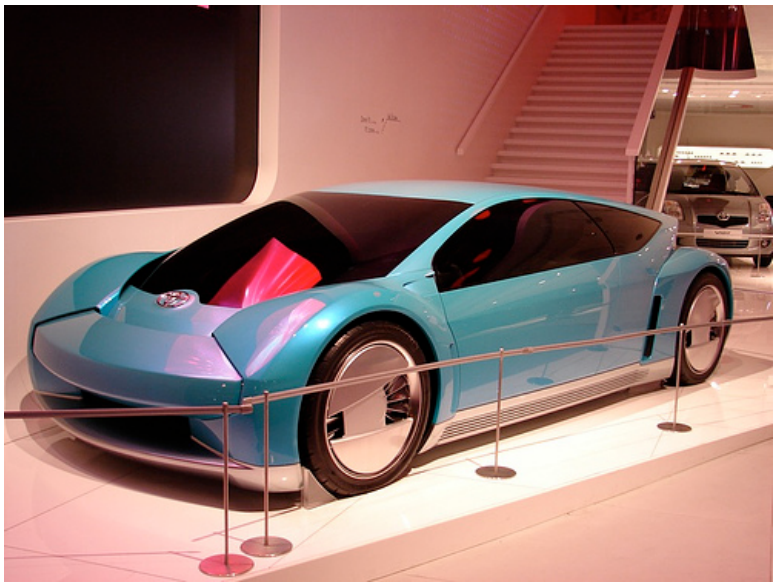

FIGURE 2.10
A Toyota concept car.

FIGURE 2.11
A high flying jet aircraft leaves contrails in the sky. A contrail is the white streak *or cloud* formed behind a high-flying aircraftś engines.

FIGURE 2.12

Clean drinking water flowing from a faucet.

Figure 12 shows a water faucet, and represents the supply and distribution of clean water. Clean water has had a significant impact on human life. During the 1700s and 1800s, thousands of people died from diseases including cholera, typhus, and waterborne typhoid fever, and thousands upon thousands became ill. A clean water supply and good distribution not only improved health, but also contributed to the growth of new cities, the development of hydropower, the improvement of crop growth, and the availability of water recreation.

FIGURE 2.13
An electronics workbench.

Figure 13 shows an electronics workshop. Our world is filled with electronic devices, including computers, mobile phones, music players, cameras, calculators, ATMs, and televisions to name a few. We use electronics for communication, entertainment, manufacturing, to diagnose disease, to help us drive our cars, and for thousands of everyday activities.

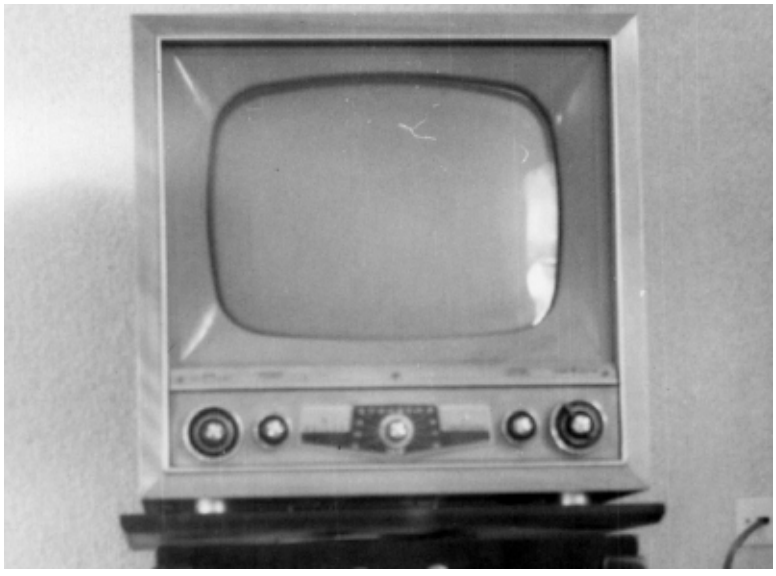

FIGURE 2.14
A television that was manufactured in 1953.

Figure 14 shows an early television, manufactured in 1953. Radio and television are electronic devices that deserve special attention because of their impact on the way news and information are communicated. Prior to the development of these technologies, news and information traveled slowly, through written forms of communication. Today, the television allows people to view world events in real time. With its hundreds of channels, people can also experience other lands and cultures and be entertained.

FIGURE 2.15

An irrigation system waters growing cotton plants.

Figure 15 shows an irrigation system for a large farm, and represents agricultural mechanization (the development of machines that help farmers produce crops). Prior to the development of farm equipment, farmers relied on animals to help them plow their fields. The planting, watering, and harvesting of crops was all done by hand. The amount of work required to produce crops limited the crops that individual farmers could grow. This also meant that many people were employed in farming and many families grew their own produce. Machines made it possible for a single farmer to produce larger quantities of crops, as well as a more consistent quality of crops. This, in turn, provided greater supplies of food for society, and reduced its cost.

FIGURE 2.16

An HB85B computer manufactured in the early 1980s.

Figure 16 shows an early computer. Computers change the way we communicate. Computers help us write; this chapter has been written, formatted, and distributed by computer. In engineering and science they perform complex computations; there are many problems, such as weather prediction, that require billions of computations. Without computers, we could not do these complex calculations. Computers are also used to control machines. Computers help guide and fly airplanes; they control the engine in your car. Computers can store vast amounts of information that is readily available, and they connect us to the world through the Internet. Computers facilitate learning, and provide us with a great source of entertainment.

FIGURE 2.17

The LifeStraw is a water purification device designed to filter bacteria out of water and is powered by suction. Water is passed through an iodine-coated bead chamber that kills bacteria and parasites. It costs around $3.75 and can last for a total of 700 liters of water.

Figure 17 shows a woman drinking water through a filtration straw, and represents an example of healthcare technology. The specialized straw is capable of filtering harmful bacteria and parasites from polluted water supplies. In the past decades, there have been numerous healthcare technologies developed that have decreased **mortality rates**, increased life spans, and contributed to a better quality of life. These technologies include advanced surgical techniques, artificial organs, instruments that can diagnose ailments, and preventive healthcare devices.

Figure 18 may be the most difficult to discern. The picture shows the side of a large building with air-conditioning units on many windows. Air-conditioning was originally developed to help cool manufacturing processes. In the mid-1900s, home air-conditioning was developed, fueling an explosive growth in Sunbelt cities such as Las Vegas, Houston, and Phoenix. Air-conditioning has changed our work environments, permitting us to work in greater comfort. It has also shifted the patterns of seasonal work and play.

The ten other great engineering accomplishments of the twentieth century identified by the NAE include highways, spacecraft, the Internet, imaging, household appliances, health technologies, petroleum and petrochemical technolo-

FIGURE 2.18

Walls of apartment buildings.

gies, laser and fiber optics, nuclear technologies, and high-performance materials.

Enrichment Activity (Medium)

Write a brief report about one of the great engineering achievements of the twentieth century from the list earlier in this chapter. Give some specific examples of how the achievement has changed the way that people live and explain why the achievement is important.

FIGURE 2.19

Before the telegraph telephone and automobile messages were sent by horseback. This figure shows the official seal of the Post Office Department the predecessor of the United States Postal Service.

The Impact of Engineering

To understand the impact of engineering on society we can imagine how people lived 100 years ago before these technologies existed. For example, how did people communicate without telephones and the Internet? The primary method of long-distance communication was letters. While letters are a wonderful means of communication, they take time to write and even more time to be delivered. If the distance between sender and recipient was great, it may have taken months to deliver a letter via Pony Express (Figure 19).

Advancements in communication have also helped change the way many companies work today. Remember the profile of Ashley, our first engineer? Ashley works at home managing two engineering teams from across the world. That would not have been possible with letters. Engineering solutions have continually improved the quality of life, added business value, and significantly influenced the **global economy**.

Engineering has both intended and unintended consequences. For example, air-conditioning makes comfortable life possible in much of southern United States. However, sometimes the unintended consequences of new technologies can be negative. About a decade ago, scientists discovered that Freon and similar gasses used in air conditioners were contributing to damage to the Earth's protective ozone layer. As a result, new gasses and technology had to

be developed. Consider as well the impact on culture from air conditioners. Prior to air-conditioning, many people sat on their front porch in the evenings, in part because their homes were too hot. Also, people often had very high ceilings—a design intended to help with home cooling.

Another example of unintended consequences is several years ago a company developed corn seeds that were highly resistant to weed killers and insects so that farmers would not need to spray poisons on their fields. An unintended consequence was that the new type of corn seed, after it had been growing for several years, started growing in fields where it had not been planted. Farmers tried to kill the unwanted corn plants but were unable to do it because the corn was resistant to the poisons.

The Future of Engineering

It is very difficult to predict the future of engineering, but engineers attempt this whenever they design new products. Engineers try to determine what people will want and need—both now and in the future—and then they design things to fulfill those wants and needs.

While we do not know exactly what will happen in the future, we can examine some possible scenarios. Consider natural catastrophes. There have been many significant catastrophes in the past decade including powerful hurricanes, earthquakes, and tsunamis that have killed hundreds of thousands of people and destroyed a great deal of property. If we go back further in the history of the world we also find that major volcanic eruptions and rare collisions with meteorites have impacted the entire planet. Engineers are working on ways to protect people and property from these disasters as well as ways to predict and respond rapidly to these types of disasters.

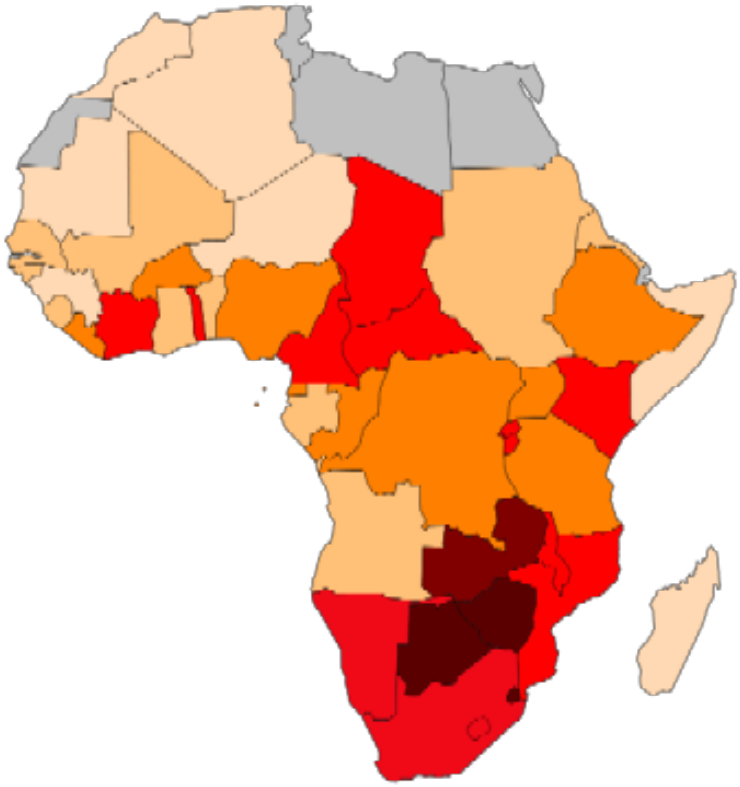

FIGURE 2.20

Percentage of adults *ages* $15-49$ in Africa infected with the HIV/AIDS virus in 1999. Percentage of adults *ages* $15-49$ in Africa infected with the HIV/AIDS virus in 1999. The countries highlighted in light colors had less than 2% infected while the countries highlighted in dark colors had over 20% and up to 30% infected. Grey countries had no data available.

Another threat to people's well being comes from disease. Between 1300 and 1500, the bubonic plague killed

between one-third and one-half of Europe's population. Later, cholera killed large numbers as well. Today, these diseases have been largely eradicated in the developed world through engineering of clean water and sanitation systems. However, the world currently faces an AIDS epidemic (Figure 20), and there are likely to be new disease threats in the future. Engineers will work with scientists, governments, and health workers to develop and implement technologies that will prevent and respond to these threats.

Another certain need that will be met by engineering is energy. Because all people in the world need energy, the world production and use of energy is growing at a rapid pace. You might recall that both electrification and the automobile were listed as great engineering achievements of the twentieth century. Fossil fuels, the source of energy used most often to produce electricity and to power automobiles, also causes pollution and contributes to global warming. Also, supplies of fossil fuels are limited and becoming more expensive. Some wonder if the world can sustain the current energy growth and consumption patterns. With only a few countries owning the majority of energy resources, there is further concern about the supply of energy at prices that most people can afford. Engineers and scientists are working on developing new energy technologies for the future.

Some emerging trends in engineering are in the areas of biotechnology and nanotechnology. In the area of biotechnology, engineers are working on designs that impact the human body, animals, and plant life. Engineers and scientist are working on technologies to help the blind to see, the hearing impaired to hear, and the disabled to walk. Biotechnology has also opened the possibility of controversial areas such as cloning. Engineers are also working with scientist to develop crops and processes that can be used as fuels for energy.

Nanotechnology refers to the development of products and components that are very small, typically between 1 and 100 nanometers. A nanometer is $1 \times 10^{[U+0088][U+0092]9}$ meters. A nanometer is so small that it takes a very powerful microscope to see an object of that size. While the area of nanotechnology is very new, it shows promise to provide new technologies ranging from lighter and stronger materials to nanorobots that can repair individual cells to new treatments for cancer.

Enrichment Activity (Long)

> Envision the future by designing and drawing a picture of a new product. Explain what need or purpose the new design is fulfilling. Ask others to review your design and give you some feedback. Then use the feedback to redesign your product.

Review Questions

The following questions will help you assess your understanding of the Discovering Engineering Section. There may be one, two, three or even four correct answers to each question. To demonstrate your understanding, you should find all of the correct answers.

1. An emerging area of engineering is
    a. nanotechnology
    b. geotechnology
    c. aerotechnology
    d. retrotechnology
2. Electrification is
    a. generating and distributing electricity to many different users
    b. being shocked by electricity
    c. powering machinery, instruments, and appliances with electricity
    d. not an important engineering accomplishment
3. The automobile and jet airliner

a. have freed people from the limitations of geography
b. are both important engineering accomplishments
c. have the same type of engines
d. are dangerous and should be abandoned

4. Computers

a. provide us with entertainment
b. control machines
c. perform complex computations
d. store vast amounts of information

5. Air-conditioning

a. has not had any unanticipated negative consequences
b. contributed to damage of the Earth's ozone layer
c. was originally developed for use in automobiles
d. makes life comfortable in the southern United States

6. The future of engineering is

a. easy to predict
b. determined by engineers trying to design things to fulfill peoples wants and needs
c. tied to energy production
d. not affected by natural disasters