6.0 Systems have an impact on our society.

Automated assembly lines build many of the cars of today.

What You Will Learn

In this chapter, you will:

- identify various non-mechanical systems and describe the components of these systems that allow them to function efficiently
- examine alternative ways of meeting current needs and assess their impact on society and the environment
- determine how society and the environment have been affected by the automation of systems

Skills You Will Use

In this chapter you will:

- investigate the information and support that is provided to the consumer to ensure that a system functions safely and efficiently
- use criteria to evaluate a system

Why This Is Important

School systems, communication systems, transit systems, and health-care systems are just a few examples of systems that have both immediate and long-term effects on your life.

Before Writing

Thinking Literacy

Problem & Solution

Writers use different organizational patterns to communicate information to readers. Knowing these patterns helps readers "see" the relationship(s) among ideas. Much of the information in this chapter is presented in a Problem & Solution pattern. Think about a problem you have had and how you solved it.

Key Terms

- automated system
- non-mechanical system
- quantitative assessment
- productivity
- criteria
- qualitative assessment

6.0 Getting Started

Figure 6.1 A garbage truck is a mechanism used to collect waste products.

Here in Ontario, the City of Toronto alone produces about 500 000 tonnes of garbage every year. Mechanical systems, such as levers and hydraulics, are used to lift the waste bins and dump them into the truck (Figure 6.1). On the truck, other mechanical systems compact the materials to make more room in the truck.

However, it takes more than just mechanical systems to operate an efficient waste management program that reduces and recycles waste (Figure 6.2). The staff and the procedures used to collect and dispose of waste are part of the non-mechanical system involved in waste management. **Non-mechanical systems** include the procedures, processes, and people needed to perform a task.

A complete waste management program includes both mechanical and non-mechanical systems in its task to reduce, recycle, or dispose of waste. The non-mechanical system for waste disposal consists of several components. The city hires workers and buys trucks. Some workers develop a schedule of pick-up times and publish collection calendars for delivery to the public. Residents sort their waste into garbage, recyclables, and organic material (including leaf and yard waste) and put out the bins on the appropriate collection day for pick-up. The trucks offload recyclables at a recycling plant, the organic material at a compost-processing facility, and the rest of the waste at a landfill. Other workers operate the recycling plant and compost facility and maintain the landfill site.

Like mechanical systems, each component of a non-mechanical system plays a role in the successful completion of the task. In this chapter, you will study many types of systems and their impact on both the environment and society.

Figure 6.2 The workers, along with the procedures for collecting and handling recyclable products, represent some of the non-mechanical components of a recycling program.

B35 *Quick Lab*

Your School's Waste Management

Purpose

To examine how your school community manages its garbage

Materials & Equipment

- pen and paper
- resource person such as the custodian or principal

Procedure

1. On a single piece of paper, draw a T-chart with the headings "Non-recyclable" and "Recyclable."
2. Make a list of the types of garbage in your school. Remember: recyclable materials include metal cans, plastics, cardboard, paper, and organic materials.
3. Find out what materials your school recycles and put a checkmark beside those materials on your list.

Questions

4. Choose one item from your non-recyclable list. Describe what you think happens to this piece of garbage after you throw it away.
5. Choose one item from your recyclable list. Describe what you think happens to this item after you throw it away.
6. Suggest one change that you believe would improve the current system of waste management in your school.

6.1 Non-mechanical Systems in Society

Here is a summary of what you will learn in this section:

- As in mechanical systems, the components of a non-mechanical system interact to perform a task.
- Many non-mechanical systems are designed because of the needs of society.
- Information and support are required to keep a system working efficiently.

Figure 6.3 Students, desks, and books are just a few of the components that make up a school system.

In Chapters 4 and 5, you learned that mechanical systems use forces to do work and transfer energy. In this chapter, we will look at non-mechanical systems, which perform tasks without transferring forces. A non-mechanical system that you are familiar with is the school system (Figure 6.3). The school system involves more than just students and teachers. Principals, custodians, administrative staff, bus drivers, and school boards are all part of the system. The school system is not just people. It is also all of the objects such as books, desks, buildings, playgrounds, and equipment. Subjects (such as science), timetables, and even the rules are part of the school system.

In order for any system to perform its task successfully, the **components** of the system must interact. The components are the parts of the system. Most non-mechanical systems have an overall plan so that each component of the system has a purpose or role. For example, teachers, timetables, and books each have very different roles in the system, but each contributes to the overall success.

The school system is just one example of a non-mechanical system. Many other non-mechanical systems provide services to you, your community, your province, and your country.

B36 *Starting Point* Skills P C

Non-mechanical Systems in Society

Non-mechanical systems usually include an organizational system that provides a service to some part of society. Work with a partner and brainstorm as many non-mechanical systems as you can think of. Keep this list for a future activity.

Thinking Literacy

A Problem, Its Causes, and Some Solutions

Society has many systems that improve our lives, but some may also cause problems. As you read, identify a problem in our society. What causes this problem? What solutions do we use to solve this problem? Develop a graphic organizer and record this problem, its cause, and its possible solutions.

Can you find any signal words on this page that tell you the writers used a "Problem & Solution" pattern to organize their ideas?

Systems Require Organization

In order for a non-mechanical system to function properly, the components of the system must work together in an organized manner. This organization is usually done by a person, a company, or a government, who oversees the operation of the system. Once all of the procedures and components are put in place, the system can perform the desired task.

Suppose the desired task is helping people travel without taking their own vehicles. Most cities in Ontario have organized a transportation system to perform such a task. Both mechanical and non-mechanical systems make up such a system (Figure 6.4). The mechanical components are the buses, trains, or subways. The non-mechanical components include the drivers, routes, and schedules (Figure 6.5). By themselves, none of these components could provide an adequate transportation system. Instead, the components interact in such a way that people are moved from one location to another efficiently and safely. If you were in charge, how would you organize such a transportation system?

One method may be to organize the non-mechanical components of the system first. You would design the bus routes that best meet the needs of the riders. A schedule of when the bus will arrive at each stop is next. Bus drivers must be informed of their routes and time lines. Finally, the mechanical system (the bus) is used to complete the task.

A transportation system is just one example of a non-mechanical system that is used to organize our society. The same analysis can be done with any system.

Figure 6.4 A transportation system involves both mechanical and non-mechanical systems.

Figure 6.5 Bus routes and schedules represent a non-mechanical component of a transportation system.

Figure 6.6 Day-care facilities like this are one component of the child care system.

Take It Further

As new products are developed to meet the needs of society, a system is needed to evaluate the safety of these products. The Canadian Standards Association (CSA) is a non-government association that tests and approves new products to make sure that they are safe for the consumer and the environment. Find out how the CSA evaluates consumer products. Begin your search at ScienceSource.

Systems Develop from a Need

Our society has many systems that improve our standard of living. You might wonder how non-mechanical systems become part of our society. Most are the result of a need.

A transportation system is just one example of a system that was developed in response to a need. Another example is child care. Over the past 40 years, the number of families with both parents working away from the home has increased. This meant that society had a need for a system that could take care of these parents' children. To meet this need, a child care system was developed (Figure 6.6).

In 2004, Ontario initiated its Best Start child care program. The demand for child care has continued to increase, and in 2007, the Ontario government added an extra $142.5 million to meet the demands of the child care system. In order for a system to continue to meet the needs of society, it must be evaluated and upgraded continuously.

Keeping the System Working Efficiently

Once a system is in place, it needs to be monitored frequently to make sure that it is meeting the needs of its consumers. A **consumer** is an individual who uses the goods or services provided by a system. In order for the system to work efficiently, the consumer must be provided with information and support on how to use it.

Suppose that you recently purchased a new computer system. The manufacturers of that computer system need to communicate to you, the consumer, how you can use that system. Often, the manufacturer provides an instruction manual (Figure 6.7), either as a booklet or on-line.

Not all systems work continuously without developing problems. When a problem arises, the consumer may need to get help. Most systems have a service component that deals with such problems. In the school system, your school counsellor might be one component that can help when you are having problems in school. Most companies offer "tech support" to make sure that you can get help if their product needs service.

Figure 6.7 Instruction manuals like this provide information to the consumer.

Assembly Not Included

Instruction manuals are one type of support that a manufacturer might provide to a consumer. In order for a manual to be useful, it must convey the information clearly and accurately.

Purpose

To evaluate assembly instructions

Materials & Equipment

- paper and pencils

Procedure

1. You have just bought a bookshelf at a furniture store. It came with the directions shown in the box at the right and a diagram to show you how it should be assembled (Figure 6.8).
2. Copy Table 6.1 into your notebook. Use it to record your evaluation of the instructions. Rate the Construction Steps as follows:
   - 4 = very good
   - 3 = good
   - 2 = satisfactory
   - 1 = unsatisfactory
3. In the Comments column, provide a reason for your rating. Include a least two suggestions for improving the directions.

Questions

4. Most instruction manuals contain both diagrams and written instructions. Explain why you think it is important to include both.
5. You used three categories when evaluating these assembly instructions. Which of these three categories do you think is most important to the consumer? Suggest another category that could be used in the evaluation.

Construction Steps

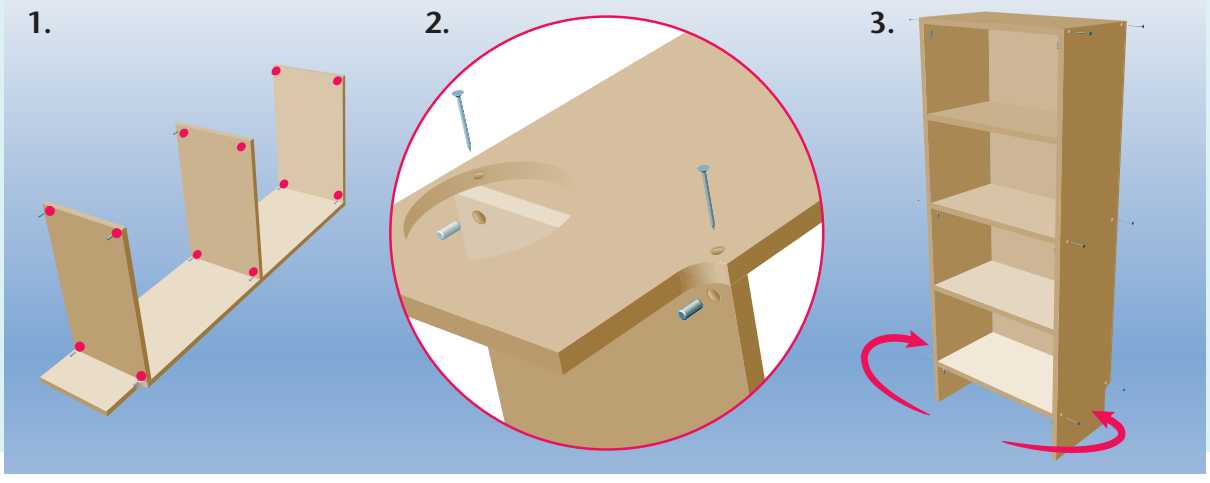
Assembling the bookcase

1. Locate the holes for insert A.
2. Screw connector B into insert A. There are 2 for each side.
3. Do the same for the other side.

Table 6.1

Category	4	3	2	1	Comments
Clarity of directions					
Thoroughness					
User-friendliness					

Figure 6.8 Bookcase assembly



Providing a Service to Society

Similar to mechanical systems, non-mechanical systems consist of several components that work together to perform a task or function. Often these components perform several tasks. At the beginning of this chapter, you created a list of different types of non-mechanical systems. In this activity, you will examine one system from your list.

Purpose

To examine a non-mechanical system that provides a service to society

Materials & Equipment

- paper and pencils

Procedure

1. With a partner, choose a non-mechanical system from the list you made earlier.
2. Write the name of your system at the top of a blank piece of paper.
3. Identify all of the components of this system that you can think of. Write the names of these components anywhere on the paper.
4. Draw lines between components that interact with each other. On each line, write a short description of how those components interact. Figure 6.9 shows a small example.

Questions

5. What societal need does the system you chose fulfill?
6. Some of your components may interact with more than one other component. Which component had the largest number of interactions?
7. If you removed the component that you identified in question 6 from the system, what might happen to the system?
8. Describe one part of the system that you believe is responsible for making sure the system works efficiently.
9. Suggest one improvement that you think would increase the effectiveness of this system.

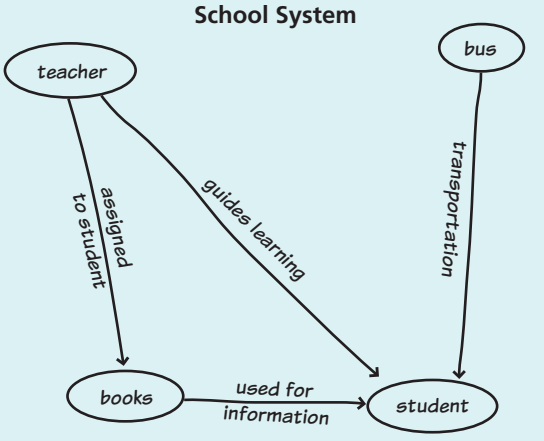


Figure 6.9

6.1 CHECK and REFLECT

Key Concept Review

1. In Canada, our government is considered a "democratic system." Is this a mechanical or a non-mechanical system? Explain.
2. Identify three components of the school system.
3. Explain what the concept "systems need organization" means to you.
4. What is the relationship between a need in society and a system?
5. Define "consumer."
6. In order for a system to work efficiently, what two services should be provided to the consumer?

Connect Your Understanding

7. Your company has been hired to install an automatic sprinkler system for a large park. The mechanical and non-mechanical components of the job are listed in random order below. Organize the components in the correct sequence.
   - Dig trenches to bury the water pipes.
   - Set the timer for the watering times.
   - Identify the areas that need watering.
   - Sketch a plan of the locations of the water pipes and sprinkler heads.
   - Connect the pipes to the water supply.
   - Connect the pipes to the sprinkler heads and bury them in the trenches.
8. What societal needs do you believe each of the following systems fulfills?
   (a) merchandise distribution system
   (b) provincial electrical system

Practise Your Skills

9. The photograph below shows part of a library system.
   (a) What societal need does a library system fulfill?
   (b) Identify the components of this library system.
   (c) Describe the interaction between any two components you have identified.
   (d) Describe one aspect of this system that keeps it working efficiently.

For more questions, go to ScienceSource.

B40 *Thinking about Science, Technology, and Society*

You: The Consumer

A consumer is a person who purchases the goods or services provided by a system. Many companies advertise their products to specifically attract teenage consumers.

With a group or the whole class, make a list of products that you think are intended for teenage consumers. Discuss the methods of advertising that companies use to make their products more attractive to teenagers.

6.2 Assessing the Impact of Automation and Alternative Systems

Here is a summary of what you will learn in this section:

- Increasing productivity allows a task to be accomplished faster or allows more tasks to be done at the same time.
- An automated system replaces human workers with machines that operate without human intervention.
- Automation has had an impact on our society, the environment, and our economy.
- The criteria for assessing a system include efficiency, safety, cost, and impact on the environment.
- When considering alternative ways of meeting the needs of society, we must assess both the current system and the proposed system.

Today you finally buy those shoes that you have been saving for. You may begin your search at the mall, involving many stores, styles, and prices (Figure 6.10). For some people, shopping is a dream come true, but others see it as a huge waste of time. If the only purpose for going to a mall is to buy shoes, then walking from store to store and trying on several styles seems very inefficient. There must be a way to be more productive.

Figure 6.10 A mall provides many options to the shopper.

B41 *Starting Point*

Skills A C

To Mall or Not to Mall: That Is the Question

Working with a partner or as a whole class, create a "Pros" and "Cons" list for shopping on-line versus shopping at a mall. Once the list is completed, classify each of the items as being:

- economic: deals with money issues
- environmental: has an impact on the environment (e.g., pollution)
- social: deals with the interaction of people

Thinking Literacy

Organizing Writing Ideas

The automation of the car industry has changed the way we live. The freedom of movement that comes with widespread use of the car has both positive and negative consequences.

Copy Table 6.2, leaving lots of room to add information. As you read this section, think about and record some of the positive and negative impacts of the increasing use of the car. For each negative impact, suggest a possible solution. Use this information to write a few paragraphs about the impact of the car. Use a Problem & Solution pattern for your writing.

Table 6.2 The Impact of the Car

Type of Impact	Positive Impacts	Negative Impacts	Solutions for Negative Impacts
Social			
Economic			
Environmental			

Productivity

Productivity is the amount of output that is produced per unit of time. If you can increase productivity, you can accomplish a task faster or do more tasks in the same amount of time. So how can you make the task of buying shoes more productive? One way would be to shop on-line (Figure 6.11), where you can search for different styles and even pay for your purchase. On-line shopping is much more productive because you do not waste time getting to the mall and walking from store to store.

Figure 6.11 On-line shopping may increase the productivity of shopping.

Increasing Productivity

In this unit we have studied how both mechanical and non-mechanical systems are used to do work or complete a task. Well-designed systems can improve productivity, allowing the work to be done faster or more tasks to be done at the same time.

Consider the amount of work required to dig a tunnel under a river or through a mountain. In 1854, construction of the Brockville Tunnel began under the City of Brockville, Ontario (Figure 6.12, next page). Workers used simple machines, such as shovels, picks, and ramps, to construct this 527-m-long railway tunnel.

Figure 6.12 The Brockville Tunnel, Canada's first railway tunnel, took more than six years to construct.

Figure 6.13 Modern tunnel-boring machines allow tunnels to be dug much faster than in the past.

In 2005, 150 years later, construction of the Niagara Tunnel began. This tunnel channels water under the City of Niagara Falls. Today, mechanisms such as the tunnel-boring machine (TBM) (Figure 6.13) have replaced the simple machines used on the Brockville Tunnel. If the Brockville Tunnel had been dug by the TBM used under Niagara Falls, it would have been completed in just over a month.

The building of the Brockville Tunnel employed hundreds of people for several years. Modern methods of tunnelling do not require the same number of workers. In situations like this, increased productivity has decreased the number of jobs available.

Often it is a combination of mechanical and non-mechanical systems that increase productivity. For example, some libraries now have self-checkout machines (Figure 6.14). These machines allow the consumer to scan the bar code to check out the items without waiting for a librarian. The mechanical system includes a scanner that is connected to a computer. By passing a laser light across the bar code, the scanner records the information on the computer's hard drive and a receipt is printed.

Figure 6.14 Consumers can check out their own books using this machine.

The non-mechanical part of the system includes the instruction sheet posted at each machine. The instructions help the library patrons use the machine to check out their books. These machines increase productivity because more books can be checked out in a given amount of time. Does this mean that we no longer need librarians? Librarians provide many services that are vital to the operation of a library, other than checking out books. However, when a system is implemented to increase productivity, there is always a danger that the quality of service will decrease.

Mass Production

In the past, many consumer goods were made by hand. For example, a small group of employees would build an entire car. Today, some high-quality furniture and musical instruments are still hand crafted (Figure 6.15).

Nowadays, many consumer goods are produced by a system called mass production, in which each employee repeatedly performs a small task as the item moves past on a conveyor belt (Figure 6.16). The system — from raw materials to final product — is called an assembly line. Each item is made faster and for less cost, and is very similar in design and quality.

Increasing productivity by mass production may also have negative consequences. Goods manufactured on an assembly line are often of a lower quality than hand-crafted items are.

Figure 6.15 Hand-made products require many hours to complete.

Automated Systems

Another way to increase productivity is to replace the current system with an automated system. An **automated system** replaces human workers with machines that are controlled by a computer. Once the automated system is set up, the machines monitor and react to situations without human intervention. An automated system can be as simple as the thermostat that controls the heat in your home. Once it is set, the thermostat monitors the room temperature and reacts to control the temperature by turning the furnace on and off.

Automation is used for both simple tasks, like baking bread with a bread machine, and complex ones like assembling cars (see the chapter opener photo on page 154). Even professions such as farming have been automated. On modern poultry farms, thousands of chickens or turkeys are fed and watered by automated systems (Figure 6.17).

Figure 6.16 Many consumer goods are processed on an assembly line.

Figure 6.17 Many farms use automated feeding and watering systems.

The Impact of Automation

WORDS MATTER

The prefix "auto-" means self-operating. For example, "automobiles" are self-operating vehicles. "Automatic" means "working by itself," and an "automaton" is a human-like robot.

Over the past 20 years of computer development, many tasks traditionally done by workers have become fully automated. As with any change, this can be viewed both positively and negatively. To make up your own mind, you need to consider the social, economic, and environmental impacts that automation has on society. A social impact is how automation helps people live, work, and interact with each other in a society. Economic impacts of automation deal with the money aspects. Finally, environmental impacts include how automation affects both the biotic and abiotic elements of our ecosystems.

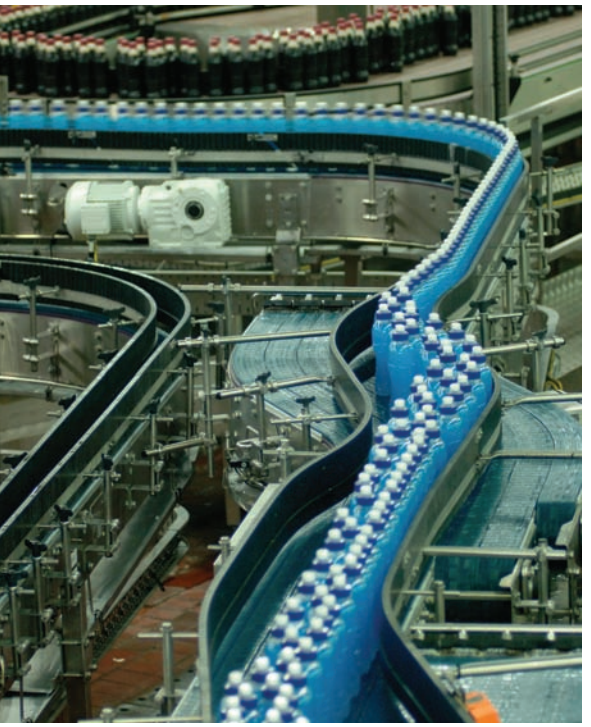


Figure 6.18 A fully automated bottling system.

Socially, many traditional jobs have been replaced by automated systems. Some people have lost their jobs to automation. However, automated systems have also been responsible for creating many new types of occupations. Thus, automated systems have changed the types of work that people do. Automated systems have definitely changed how society lives and works.

Economically, automating a system usually increases productivity. This means that the business can make the product at less expense and therefore can sell it at a lower cost. If automating a system reduces the number of employees required, this affects the economy of both the company and the community.

Environmentally, automating an assembly line may require an increase in the amount of energy used by the machines (Figure 6.18), which might have a negative environmental effect. Car manufacturers install an automated pollution control system in each car that decreases harmful emissions. This automated system has a positive environmental effect.

Take It *Further*

Automated teller machines (ATMs) replace some of the work done by a bank teller. A bank teller counts money visually. How do ATMs know the difference between a $10 bill and $20 bill? How do they count the correct amount of money? Begin your search at ScienceSource.

Assessing a System

When the needs of society change, the existing systems may no longer meet those needs. Either the existing systems must be changed or new systems must be developed. Before the changed system or the new system is put in place, the developers must evaluate the impact it will have on individuals, society, and the environment.

Using Criteria to Evaluate a System

Criteria (singular: criterion) are standard rules or tests on which a decision or judgement can be based. To assess systems, the developers often use the following criteria:

- efficiency
- cost
- safety
- environmental impact

Each of these criteria can be assessed quantitatively or qualitatively. A **quantitative assessment** involves analysis of numerical data. As we saw in Chapter 5 for a mechanical system, the quantitative efficiency is determined by:

Efficiency = (useful output work)/(input work)

Qualitative assessments are often made by observations. For example, "My car gets great gas mileage" is a qualitative assessment. Compare this qualitative assessment of the car's fuel efficiency with the quantitative assessment, "My car travels 10 km per litre of gas."

Assessing Systems for Transporting Groceries

Thousands of years ago, people grew or caught their food. They needed containers to transport the food to their villages and to store the food. Early containers were made from woven grass or twigs, animal skins, clay, and even animal organs (Figure 6.19). If we use the criteria listed above to assess these early containers, we might come to the following conclusions.

- Efficiency: Low since large amounts of time and effort were required to produce one container. It was also inconvenient to have to take the empty containers to the field.
- Safety: These containers were difficult to keep clean. As well, they did not provide protection against insects and rodents.
- Cost: Low since the materials were readily available in nature.
- Environmental impact: Low since the containers were made from natural materials and would decompose easily when discarded.

Figure 6.19 Sacks and baskets were used by our ancestors to carry things.

Figure 6.20 Paper grocery bags were used for many years.

From Paper to Plastic Bags

Society assessed these early containers as being inefficient, hard to store, and hard to keep clean. An efficiently produced, disposable bag was deemed a societal need. By the early 1900s, the system of making paper from wood products was well developed. Paper shopping bags soon replaced traditional methods of carrying groceries (Figure 6.20).

Applying the criteria to the paper bag, we find that paper bags were expensive to produce and not very strong. Since they were considered disposable, they were safe to use. Their environmental impact is questionable: the bags decompose easily, but paper is made from trees. For cost and efficiency, society wanted a cheaper bag that was light and strong, and could be given free to shoppers.

By the late 1970s, plastic shopping bags had almost totally replaced paper bags (Figure 6.21). It is estimated that Canada uses and discards about six billion plastic bags annually. Plastic bags are inexpensive to produce and can be re-used and recycled. However, they decompose extremely slowly.

Beyond Plastic Bags

The high efficiency of producing plastic bags and their low cost have made their use very appealing. Their safety is a concern, however, because of their potential to suffocate babies who play with them. Currently, society is again assessing our system for carrying groceries, mainly because of the impact of plastic bags on the environment. Most plastic bags are made of polyethylene, which is a type of plastic derived from oil. It is estimated that only about 1 percent of all plastic bags are recycled. The production, disposal, and environmental impact of plastic shopping bags must be considered when assessing our current system of transporting groceries.

Many shoppers are now bringing their own reusable bags every time they go to the store. The system for transporting groceries has gone full circle — from reusable containers, to disposable paper, to usually discarded plastic, and back to reusable containers.

Figure 6.21 Most stores use plastic bags now.

SKILLS YOU WILL USE
- Gathering information
- Summarizing information

My Opinion of Automation

Issue

Many jobs and tasks that used to be done by people are now being done by automated systems. Choose a job or task that has been automated and decide if this automation has had a positive or negative effect on society.

Background Information

The number of jobs that have become automated continues to grow. Jobs that have been automated include:

- phone-answering systems
- automated teller machine (ATM) (Figure 6.22)
- assembly lines (in manufacturing)
- autopilot on commercial airplanes
- checkouts at libraries or stores
- ticket-dispensing machines at movie theatres (Figure 6.22)
- farming (poultry, dairy, hydroponics)

Analyze and Evaluate

Choose any job that has been automated. Your task is to look at the positive or negative impacts the automation of that job has had on society, and decide whether the automation was positive or negative on the whole. Research evidence to support your argument. You will present your findings as either a report or a class presentation. Your teacher will provide more details about how to present your information.

As you research, answer the following questions.

- How was this task accomplished before it was automated?
- How is this task accomplished with automation?
- What is the social impact of this automation?
- What is the economic impact of this automation?
- What is the environmental impact of this automation?

1. Use the following resources for your research.
   - Go to ScienceSource to begin your search for information.
   - Look in print materials such as magazines, newspapers, and books for information on the automated job you have chosen.
2. Summarize the information you find in a short report for presentation. Be sure to include only information that supports your viewpoint or refutes the opposite view.

Figure 6.22 It seems like everything is automated these days!

6.2 CHECK and REFLECT

Key Concept Review

1. How does increased productivity change:
   (a) the time it takes to complete a task?
   (b) the number of tasks performed in a certain amount of time?
2. Explain what is meant by an automated system. Give two examples of automated systems.
3. What four criteria are often used when assessing a system?
4. Indicate which of the following is a qualitative assessment and which is a quantitative assessment.
   (a) 45 percent efficient
   (b) makes your clothes whiter

Connect Your Understanding

5. Baking bread at home can now be automated. Just add the ingredients to a bread machine and press a button (photo at right). Identify the mechanical and non-mechanical systems involved in this automation.

6. Use an example to explain how automating a system can have both positive and negative effects on society.
7. Explain how increasing the efficiency of a system can have a positive effect on society.
8. Give two reasons why people look for alternative ways of meeting the current needs of society.
9. Suppose the government passed a law saying, "Everyone must use an electric toothbrush." Use the four criteria to assess this change in the system of brushing your teeth.

Practise Your Skills

10. Explain why you think the figure below displays an automated system. List some positive and negative aspects of automating how we wash and dry our clothes.

For more questions, go to ScienceSource.

B44 *Thinking about Science, Technology, and Society*

Automating Your School's Recycling Program

At the beginning of this chapter, you examined the recycling program in your school. Suggest one component of this system that could be automated. Predict what effect this automation might have on your school community. If possible, predict the social, economic, and environmental impacts.

DAILY PLANET

Making Connections

Jay Ingram

Jay Ingram is an experienced science journalist and is the host of *Daily Planet* on Discovery Channel Canada.

The Trebuchet

Imagine it is 1304. You are a Scottish soldier defending Stirling Castle against the English. You've hung in for months as the English siege machines battered the castle walls with balls made of stone and lead. You are completely surrounded and you're running out of food. If all that weren't bad enough, the King of England, Edward I, has just ordered his chief engineer to build a massive trebuchet, called the Warwolf.

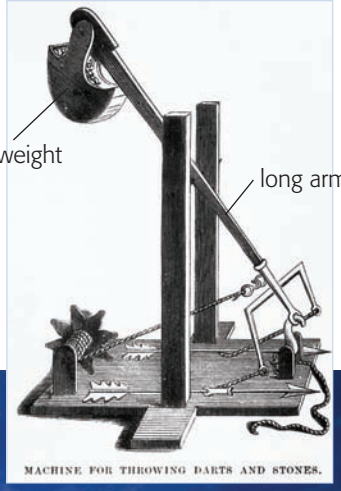
A trebuchet (pronounced treb-you-shay) is a mechanism, but its heart is a strange lever with one arm longer than the other. The short arm has a gigantic weight at the end. The long arm is pulled down to the ground and held there. Imagine a teeter-totter with a very large man sitting on the short end and a gang of kids holding down the long end. When they let go, the man comes crashing to the ground. The trebuchet is like that, except that the large man is replaced by a giant weight and the kids by a trigger.

There is one more thing. The long arm has a sling attached to it: a long cord with a stone ball cradled in a net at the end. When the trigger is released, the weight falls. The long arm of the lever swings up like lightning, whipping the sling and its ball overhead. At just the right moment, the sling releases the stone ball and it goes flying toward the target.

What's most amazing about trebuchets is this: they're ancient machines, yet they were capable of amazing power and accuracy. They could throw weights of up to 1000 kg more than 200 m. They were also much more accurate than other launching devices, such as catapults.

Fifty men took three months to build the Warwolf, but in the end, it didn't play a part in the English victory. The Scots surrendered before it was even used. However, King Edward refused to accept their surrender until the Warwolf had flung a few of its 140-kg weights at the castle wall and bashed it in. That was the trebuchet's specialty: breaking down walls.

Ready to trigger



Trigger released!

Figure 6.23 An old diagram of a trebuchet and a recently built one.

6.0 Chapter Review

Assess Your Learning

Key Concept Review

1. List three non-mechanical components of the school system. (a)
2. The postal service is a system for delivering mail. Who are the "consumers" of this system? (a)
3. What are two methods of support used to keep a system operating safely and efficiently? (k)
4. Explain how an automated system is different from a non-automated system. (k)
5. A bakery bakes 35 loaves of bread every hour. If the productivity of the bakery increases, how does the time to bake 35 loaves change? (a)
6. Identify each of the following as a qualitative measurement or a quantitative measurement. (a)

   (a) The water is at 66°C.

   (b) The creek had a strong current.

Connect Your Understanding

7. Your younger brother is given a toy that requires some assembly. Are the instructions for assembly a mechanical or a non-mechanical component of the toy system? Explain. (a)
8. Often, a system is developed to meet a need of society. Identify the needs that resulted in the development of the following systems: (a)

   (a) home alarm system

   (b) irrigation system

9. One year ago, a company stated: "We make 100 widgets every day." If the productivity of the company has increased in the past year, what statement(s) might the company make now? (a)

After Writing — Thinking Literacy

Reflect and Evaluate

Exchange your "Problem & Solution" writing piece with a classmate. Take some time to read your classmate's work. Provide each other with descriptive feedback, such as, what two things did he or she do well?

Did you learn something new about the impact of cars? Did you find new solutions to the negative impacts? Finally, share tips for writing a good "Problem & Solution" piece with the class.

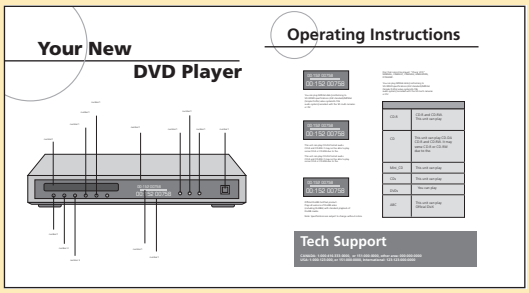
ACHIEVEMENT CHART CATEGORIES
(k) Knowledge and understanding (t) Thinking and investigation (c) Communication (a) Application

10. The Sweet Tooth chocolate company produces one-of-a-kind handmade chocolates. To increase productivity, they decide to automate chocolate making. Suggest two positive and two negative impacts that might result from the automation of this company. t

11. Explain how the furnace thermostat in your home or school is an example of an automated system. a

Practise Your Skills

12. You have just purchased a new DVD player. You also received an owner's manual, shown at the right. Identify at least two properties of this owner's manual that are designed to help you operate this DVD player efficiently. t



Question 12

13. The histogram to the right displays a company's productivity and the number of employees during a 10-year period. Use the histogram to answer the following. t

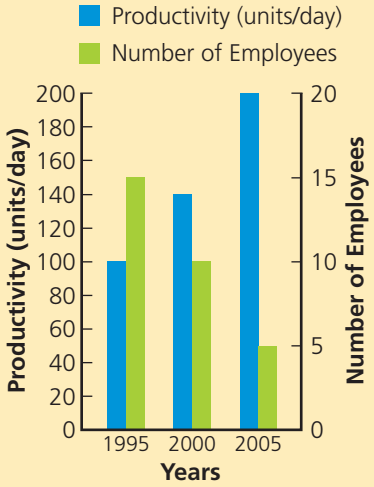
(a) Describe the changes from 1995 to 2005:

(i) in productivity

(ii) in the number of employees

(b) What is the relationship between productivity and the number of employees?

(c) Suggest a possible reason for these changes.



Question 13 Productivity and number of employees in 1995, 2000, and 2005

Unit Task Link

In your Unit Task, you will design, construct, and test a mechanical system that uses only the energy stored in a spring-bar mousetrap. The mousetrap machine you design must have a function other than catching mice. What is the need being met by your device? Using the four criteria, assess your mechanical system.

B45 Thinking about Science, Technology, and Society

Assessing the Change

Pollution caused by motor vehicles is a problem in all parts of the world. To address this problem, your local government decides to ban the use of any vehicle with a motor in your city or town.

Consider This

With a classmate or as a whole class, use the four criteria on page 169 to assess this new system of transportation.

UNIT B Summary

4.0 Mechanical systems use forces to transfer energy.

KEY CONCEPTS

- A force is a push or a pull on an object
- $W = F \times d$
- A machine is a mechanical system that makes doing work easier.
- $\text{MA} = \frac{F_{\text{out}}}{F_{\text{in}}}$
- Ideal mechanical advantage (IMA) assumes that the machine has zero friction.

CHAPTER SUMMARY

- The force of gravity (weight) is the product of the object's mass and the Earth's gravitational field.
- Work is done when a force causes something to move and energy is transferred.
- Machines make work easier by increasing the force applied to the object, by increasing the distance over which the force is applied, or by changing the direction of the force.
- The amount by which a machine can multiply the input force is called its mechanical advantage (MA).

5.0 Mechanical systems involve machines that are designed to do work efficiently.

KEY CONCEPTS

- A simple machine requires the application of a single force to do the work.
- Two or more simple machines that operate together form a mechanism.
- $\text{Efficiency} = \frac{W_{\text{out}}}{W_{\text{in}}}$
- Machines can be made more efficient by reducing friction.

CHAPTER SUMMARY

- The six types of simple machines are the lever, pulley, wheel and axle, inclined plane, screw, and wedge.
- The IMA of simple machines can be calculated as the ratio of lengths, the ratio of radii, or the number of support strings.
- The efficiency of a machine measures the useful work done by the machine compared to the work needed to operate the machine.
- Friction causes the input work to be transformed into heat, thus decreasing the efficiency of the machine.

6.0 Systems have an impact on our society.

KEY CONCEPTS

- A non-mechanical system is a procedure or process designed to perform a task.
- Systems develop from a need.
- Automating a system may have social, economic, and environmental effects.

CHAPTER SUMMARY

- Information and support are required to keep a non-mechanical system working efficiently.
- Productivity is the amount of output that is produced per unit of time.
- Automated systems replace human workers with machines that react without human intervention.
- The criteria for evaluating a system include efficiency, safety, cost, and environmental impact.

Mousetrap Machines

Getting Started

Successful machines carry out their functions consistently and efficiently. The best mechanical systems use the minimum component materials and are surprisingly simple in design.

The humble mousetrap evolved from an idea that was patented well over 100 years ago. Its job is simple: the instantaneous, painless, and humane dispatch of small rodents. The design that you can buy in any housewares store is virtually unchanged from the first working prototype.

Can you identify the components of this system? What is the role of each component? How do these parts work together to accomplish the desired result?

Your Goal

A spring-bar mousetrap will be your only source of power. You will design, construct, and test a mechanical system that uses the energy stored in the spring, to perform a task other than killing mice.

What You Need to Know

You have learned that systems are designed for specific functions. In this task, the mousetrap will power a system with a different function. How will you design your system so that the components work together to accomplish your new function? Check online at ScienceSource for mousetrap machine ideas or construction tips.

Review your notes dealing with mechanical advantage. Your chapter investigations will help you study the input and output forces acting on your system. Consider efficiency and friction in order to improve your initial prototype.

Steps to Success

1. As a class and under the strict guidance of your teacher, review the safe handling of a mousetrap.
2. Give your teacher a plan of your intended system (either CAD or technical drawing). Your teacher will give you the "proceed order" on your job.
3. Decide on the performance criteria that will determine if you have succeeded in your quest.
4. Construct your prototype. Keep an inventory of all materials used (including amounts) in a fabrication log.
5. Record in the log any problems or changes in plans as they occur.
6. Test your prototype's performance. Record your findings in your log. Modify components to determine the effect upon the system. Can you improve on the performance by changing one or more features? (Be sure to change only a single component each time.)
7. Present your final prototype, along with the design plans and fabrication log, in a gallery tour format. Be prepared to show the system in action.

How Did It Go?

8. Did your machine accomplish its stated function? Defend your answer using your results.
9. When you tested your machine, what component(s) worked as intended? Which did not?
10. Can you explain the problems that arose? Could they have been avoided?
11. Which component, when modified, caused the greatest change in performance of the system?
12. If possible, calculate the efficiency of your system.

UNIT B Review

Key Terms Review

1. Create a concept map that illustrates your understanding of the following terms. Begin with the term "Systems." (k)

- automated system
- efficiency
- energy
- force
- ideal mechanical advantage
- inclined plane
- lever
- mass
- mechanical advantage
- mechanical system
- mechanism
- non-mechanical system
- productivity
- pulley
- simple machine
- weight
- work

Key Concept Review

4.0

2. What is a mechanical system? (k)

3. Give an example of a force that is classified as a: (k)
(a) contact force
(b) action-at-a-distance force

4. Your friend steps on a bathroom scale and states, "I weigh 40 kg." Explain why this statement is incorrect. (k)

5. What is the difference between force and work? (k)

6. State the two classifications of energy. (k)

7. In what three ways can a machine make work easier? (k)

8. Describe the difference between mechanical advantage (MA) and ideal mechanical advantage (IMA). (k)

5.0

9. What is the difference between a simple machine and a mechanism? (k)

10. Identify six simple machines. (k)

11. Make sketches of a first-class, second-class, and third-class lever. Be sure to label the input force, output force, and fulcrum on each diagram. (k)

12. What type of simple machine is each item below? (a)
(a) inline skates
(b) your jaw
(c) screwdriver
(d) hammer

13. Explain why machines are not 100 percent efficient. (k)

14. What is one method of increasing the efficiency of a machine? (k)

6.0

15. You just purchased a new stereo system. What two services might the stereo company provide to ensure that the system works safely and efficiently? (k)

16. Define "increased productivity" in terms of the number of tasks and the amount of time. (k)

17. Explain how a telephone answering machine could be considered an automated system. (a)

18. What is the difference between a qualitative and a quantitative assessment? (k)

ACHIEVEMENT CHART CATEGORIES
(k) Knowledge and understanding (t) Thinking and investigation (c) Communication (a) Application

19. What four criteria are often used when assessing a system? (k)

Connect Your Understanding

20. A person travels to a distant planet that has a greater gravitational field than Earth. Describe the person's change in weight and mass. (a)

21. Fouad pushes on a wall with a force of 75 N for one hour. Is he doing any work on the wall? Explain. (a)

22. In a short paragraph and using examples, compare the scientific definitions with the everyday uses of the terms "work," "energy," and "efficiency." (t)

23. If you increase the efficiency of a simple machine, does the: (a)

(a) MA increase, decrease, or remain the same?

(b) IMA increase, decrease, or remain the same?

24. An Olympic track bike has an efficiency of 98 percent. By comparison a mountain bike has an efficiency of 85 percent. Suggest reasons for the Olympic bike's greater efficiency. (a)

25. You need to lift a box 1 m to put it in a truck. Lifting the box straight up requires a force of 100 N. On the other hand, you could push the box up a 5-m-long ramp. This requires a force of 30 N. (a)

(a) Which method of raising the box requires more work?

(b) Which method do you think would be easier? Why?

26. A cafeteria is a system designed to allow people to purchase a meal.

(a) List five components of a cafeteria system. (a)

(b) Explain how each of the five components contributes to the system. (a)

(c) List one factor that contributes to the system operating safely and one factor that contributes to the system working efficiently. (a)

(d) Suggest how automation could be used to provide the same service. (t)

27. What part of this unit did you find most difficult? What could you do to improve your understanding of that part? (c)

Practise Your Skills

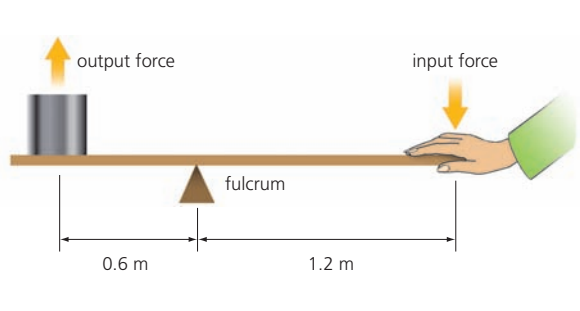
28. If the Earth's gravitational field is 9.8 N/kg, what is the force of gravity on a 5-kg mass? (t)

29. Michelle uses a force of 50 N to push a table 2.5 m across the floor. How much work did Michelle do on the table? (t)

30. Calculate the mechanical advantage (MA) for each situation in the chart below. (t)

	Input Force (N)	Output Force (N)	Mechanical Advantage (MA)
(a)	5	25	
(b)	15	5	
(c)	12	12	

31. Calculate the ideal mechanical advantage (IMA) of the lever shown below. (t)



Question 31

32. A pulley system lifts a 500-N weight a distance of 1.5 m. Marina pulls the rope a distance of 9.0 m, exerting a force of 100 N. (t)

(a) What is the MA of this pulley system?

(b) What input work did Marina do on the rope?

(c) What useful output work did the rope do on the weight?

(d) What is the efficiency of the pulley system?

Question 34

33. A box weighs 20 N. Sketch a pulley system that will lift this box using an input force of 10 N or less. (t)

Revisit the Big Ideas

34. A family currently uses a gas-powered lawnmower to cut their grass. They are thinking about switching to a human-powered push mower, like the one shown below left. Use the four criteria on page 169 for assessing a system to evaluate the new lawn-cutting system. (a)

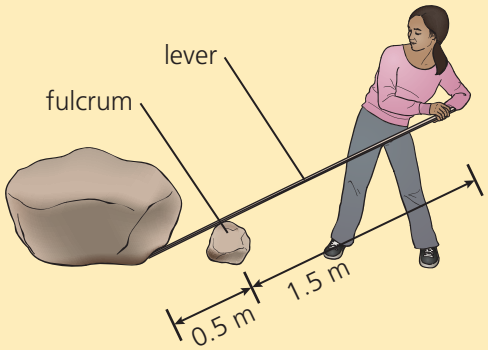
35. Explain the difference between a mechanical system and a non-mechanical system. (k)

36. What does "Systems develop from a need" mean? (k)

37. Using the illustration below, make a sketch of the lever.

(a) On your sketch, label the input force, the output force, and the fulcrum. (k)

(b) How could you move the smaller rock to increase the mechanical advantage of the lever? (t)



Question 37

ACHIEVEMENT CHART CATEGORIES
(k) Knowledge and understanding (t) Thinking and investigation (c) Communication (a) Application

38. The following are components of a school system. Identify each component as either mechanical or non-mechanical. a

(a) timetables

(b) staplers

(c) water fountains

(d) fire drill procedures

39. Suggest one positive and one negative outcome of increasing productivity. t

40. A box lifted from the floor to a desk gains 300 J of gravitational potential energy. Calculate the efficiency of each machine used to move the box. t

(a) An electric motor uses 400 J to lift the box.

(b) The rope on a pulley, attached to the box, is pulled a distance of 3 m using a force of 150 N.

(c) You push the box 5 m up a ramp using a force of 90 N.

B46 *Thinking about Science, Technology, Society, and the Environment*

Rethinking the Engine

Imagine that you are listening to a group of inventors in the 1880s describing their development of the internal combustion engine. This is the type of engine used in most cars today. During the discussion, you realize that they have not considered any of the social or environmental issues associated with the engine.

Consider This

With a classmate or as a whole class, discuss the following questions.

1. What need of society does the engine fulfill?
2. What are the social impacts of producing an internal combustion engine?
3. What are the environmental impacts of producing an internal combustion engine?
4. Why do you think the inventors in the 1880s ignored the social and environmental aspects of their invention?