Good design, materials, and construction make structures stable and strong.

Inuit people built this inukshuk to help travellers find their way. "Inukshuk" means "something that performs the function of a person."
What You Will Learn

In this chapter, you will:
- describe factors that make a structure stable
- describe the centre of gravity of structures
- describe the symmetry of structures
- predict the stability of a structure based on its centre of gravity

Skills You Will Use

In this chapter, you will:
- investigate how structures support loads
- design, build, and test structures

Why This Is Important

When designing a structure, you must consider the properties of the materials and the construction techniques you will use. Both affect the strength and stability of the final structure. Combined with your understanding of form and function from chapter 4, this will help you choose and build better structures.

Before Reading

K-W-L Chart

Make a three-column chart with the headings “What I Know,” “What I Wonder,” and “What I Learned.” Think about the chapter title and fill in the first two columns. You will complete the third column at the end of the chapter.

Key Terms

- structural components
- structural stress
- structural fatigue
- structural failure
- symmetry
- stability
- centre of gravity
- product recall
- prototype
- ergonomics
Your classroom contains many different structures (Figure 5.1). Each structure has a form and a function. If you examine some of the structures, you will notice that the structures in your classroom are made up of many types of materials.

If you examine each structure even more closely, you will see that those materials are held together by different types of fasteners, such as bolts and welds (Figure 5.2), wire (Figure 5.3), and thread and glue (Figure 5.4).

The combinations of materials and fasteners used to build or manufacture structures can affect their stability and strength. Stability is the ability of a structure to maintain or resume its position when an external force has been applied to it. Look at several different bookcases. You may notice that some of them sag in the middle and others do not. This may be due to the material they are made from. A shelf that does not bend may
have been built using stronger or thicker material. On the other hand, the shelf may be supported with another structural component, for example, an extra piece of material.

Structures must be strong enough for their intended functions and to be able to withstand the forces that might affect them. This might mean adjusting the design, choosing different materials, or altering construction techniques. Time and effort are needed in order to design effective structures.

In this chapter, you will learn how structures are designed for strength, stability, function, and form.

### B22 Quick Lab

**Materials and Fasteners Hunt**

**Purpose**
To generate a list of as many materials and fasteners as possible in 1 min

**Materials & Equipment**
- stopwatch or watch with a second hand
- paper and pencil

**Procedure**
1. Write “Materials” on your sheet of paper.
2. When your teacher gives you the signal, start writing a list of all of the different types of materials you see around your classroom. Stop when the teacher gives you the signal that 1 min is up.
3. Turn your paper over and write “Fasteners” on your sheet of paper.
4. When your teacher gives you the signal, start making a list of all of the different types of fasteners you see in your classroom. Stop when the teacher gives you the signal that 1 min is up.

**Questions**
5. Look at your list of materials and your list of fasteners. How do the lists compare?
6. What do you notice about materials and their effect on form and/or function?
7. What do you notice about fasteners and their effect on form and/or function?
8. Choose a structure in your classroom. Imagine that it was made from a different material and put together with different fasteners. Would it have the same form or function? Would you be able to use it in the same way you do now?
Most of us have sat on a wobbly seat at some time in our lives. Every time you shift in your seat, you get a little wobble. You could fold up some paper or cardboard and put it under one of the legs of the chair. Why does this stop the wobbling? Because you have balanced the chair.

You might have seen a bookcase shelf that sags in the middle. The sag shows that the structure is having trouble withstanding the weight of the books. What you can do to fix the sag depends on your situation. You could take some of the books off. However, if you have no other place to put the books, you might have to strengthen the bookcase itself (Figure 5.5).

In this section, you will look at what happens when structures are unstable and explore ways of stabilizing them.
Structural Strength

Some structures seem to stand the test of time. You may have seen the Colosseum in Rome or the pyramids of Egypt on television. These structures were built thousands of years ago and are still standing. On the other hand, some buildings may have to be demolished less than a century after they were built, because they have become unsafe (Figure 5.6).

Structural Shapes

Some of the strength of a structure lies in the shapes used in its design. You may have heard that the triangle is a very strong shape and is found in many structures. Squares and rectangles are not as strong as triangles. Three-dimensional triangular prisms and pyramid shapes are also stronger than three-dimensional rectangular prisms.

Learning Checkpoint

Triangular Strength

Triangles are stronger than squares. Test this out for yourself using a few straws and some tape.

Bend one straw into a square (Figure 5.7a), one into a rectangle (b), and one into a triangle (c). Tape the ends of each straw together.

Rest each structure upright on the table. Gently push in the same plane as the shape on an upper corner of the structure. Which is the strongest?

Good design, materials, and construction make structures stable and strong.
Structural Components

When you look at buildings, notice that many of the same features appear in many different buildings. Arches, beams, and columns are used over and over again in building design because these **structural components** can add strength. Also, many people find them aesthetically pleasing. Several different structural components are shown in Figure 5.8.

A **beam** is a flat structure that is supported at each end. If too much weight is put on a beam, it will bend in a u-shape or even break in the middle.

An **I-beam**'s shape gives it strength. I-beams have less weight than solid beams of the same length. Because they have less of their own weight to support, I-beams can support larger loads.

A **column** is a solid structure that can stand by itself. Columns can be used to support beams and I-beams.

A **truss** is a rigid framework of beams joined together. Trusses are usually in the form of interlocking triangles.

A **cantilever** is a flat structure that is supported only at one end. When weight is placed on the other end of the cantilever, the cantilever bends in an n-shape to resist the load.

Girders, or **box beams**, are long beams in the shape of hollow rectangular prisms.

An **arch** is a curved structure that can support a lot of weight. The force of weight on an arch is carried along the sides of the arch to its supports. This spreads out the effect of any load.

When a sheet of metal or cardboard is shaped into a series of pleats or triangles, it is called **corrugated metal** or **corrugated cardboard**. A corrugated sheet is stronger than a flat sheet.
Structural components can be used alone or in combination. For example, the windows and door of the Hockey Hall of Fame building (Figure 5.9) are in the shape of an arch. The arch shape spreads the force of the load through both sides of the arch and into the foundation. The columns between the windows support beams on top. The triangle above the beam is similar to a truss.

**Structural Materials**

Imagine two bookcases, one of tissue paper and one of concrete. Both seem silly, but for different reasons. A tissue paper bookcase would be too flimsy to withstand the load of the books. A concrete bookcase would be strong but heavy and difficult to move. It is important to choose appropriate materials when designing and building structures.

**Centre of Gravity**

Can you balance a ruler on one finger? The only point where this can happen is at the exact middle of the ruler. Each half of the ruler is exactly the same, or symmetrical. This point is called the **centre of gravity**. The centre of gravity is the point at which a body’s mass is concentrated. The body is equally balanced in all directions at this point.

Every structure has a centre of gravity. This is the point that gravity seems to act on. The location of the centre of gravity in a structure helps to determine how stable the structure is. Think of a chair (Figure 5.10 on the next page). When you sit on the chair, the centre of gravity of the chair plus the human is different from those of the chair and the human by themselves. That is why some stools tend to tip over only when someone sits down on them.

Good design, materials, and construction make structures stable and strong.
Figure 5.10 The legs of the highchair are more splayed than those of an ordinary chair because its centre of gravity is higher. The splayed legs make the highchair more stable.

Figure 5.11 The clown falls over when you punch it, but returns to its upright position quickly. The clown did not really knock the person down!

Stability

Stability depends on materials and construction techniques as well as the centre of gravity. A table has a high centre of gravity but is usually stable if it has four legs relatively far apart. The closer together the legs are, the less stable it becomes. Stability is also determined by whether the structure is solid, frame, or shell — a solid structure with a high centre of gravity can be less stable than a frame table is.

Some structures are designed to be unstable (for example, the clown punching bag in Figure 5.11). Others are designed to be weak like the front ends of cars and the water-filled plastic barrels at highway off-ramps that absorb a lot of energy (Figure 5.12). Other objects, such as bales of straw, can also absorb energy (Figure 5.13).

Figure 5.12 A car would lose a lot of its energy hitting the barrels. It would be a lot less damaged than if it hit the pillar directly.

Figure 5.13 Many racetracks use bales of straw to protect the drivers and the audience from crashes.
When Things Go Wrong

**Structural Stress and Fatigue**

When a structure is poorly designed or built, it may not be able to withstand all of the forces it has to face. When a structure has to face large combinations of internal and external forces over a long period of time, the structure might weaken. This may result in **structural stress**. At first, signs of structural stress may disappear when the internal and external forces are reduced.

For example, if you place an abnormally large book on the middle of a bookshelf, the shelf might bend. The bend in the shelf is a sign of stress. When the book is removed, the shelf may go back to its original shape. However, if the shelf cannot withstand the stress, it might crack. Permanent changes, like the bookshelf cracking, are signs of **structural fatigue** (Figure 5.14).

**Structural Failure**

If you ignore the structural fatigue and place more large books in the middle of the shelf, the shelf may collapse. This is called structural failure. **Structural failure** is the breakdown of a structure due to the internal and external forces acting on it. However, in this case, the failure would not be a surprise. The structure had already shown structural stress by bending, structural fatigue by cracking, and finally structural failure by collapsing.

**WORDS MATTER**

"Fatigue" means extreme tiredness. Both people and structures can be fatigued or tired out.

**Take It Further**

Demolition companies use several methods to demolish structures. Small buildings are bulldozed, very large buildings are imploded. Find out about these businesses, the equipment and procedures they use, and their safety records. Start your search at ScienceSource.

**B25 During Reading**

**Inferring**

Sometimes the answer to a question can’t be found in the text. Readers often have to draw conclusions using what they already know and new information or clues from the text to answer a question. This is called inferring or making an inference.

Have you ever heard the expression “It was the straw that broke the camel’s back”? How could something as light and as small as a straw break a strong animal’s back? Think about this and relate it to the activity you did with the textbooks on your arms. Share your inference with a partner.
Product Recalls

Despite all of the planning that goes into new structures, sometimes flaws are not discovered until the product is sold to the public. When the flaws are serious, manufacturers use a product recall. The manufacturers contact the media, who broadcast the recall on the news. They may also use their own advertising to alert the public. Consumers can take the affected product back to the store for a refund, for exchange for another model, or to have the affected structure fixed.

Sometimes, it is an issue with the materials used. For example, some children’s toys have been recalled because it was discovered that the paint had high levels of lead (Figure 5.15). Lead can cause brain damage.

Sometimes, parts of a larger structure break off too easily. This is also a concern with toys because small parts can be choking hazards.

Child and baby car seats have been recalled when harnesses have been found to be faulty. A large video game company re-issued the safety straps on their popular controllers because the original ones broke under regular use. And thousands of owners of laptop computers got new batteries when the batteries in some of the computers overheated or burst into flames.

Car Recalls

Cars are often the subjects of recalls. In this case, the owners take their cars back to the dealership for the necessary repairs at no charge to them.

Several years ago, a car model was recalled because of a poor design: its gas tank was too close to the rear end. If these cars were rear-ended, they often burst into flames. The bad design cost several people their lives. The manufacturer had to replace vehicles with the flaw and pay compensation to the injured and the families of the deceased. As well, the news reports were very bad publicity for the company. As you can see, it is better to design well in the first place than to pay for bad design later on.

Figure 5.15 Because children often chew on their toys, the paint must not contain lead.
Stability

Figure 5.16 Candles come in many shapes. Some are less stable than others.

When you balance something like a ruler, it is simple to find the centre of gravity. Usually, however, the centre of gravity is not as obvious. It is not always easy to determine the centre of gravity of an object, but generally speaking, the lower the centre of gravity is on an object, the more stable the object is.

Some of the candles in Figure 5.16 have a small base and a high centre of gravity. They are more likely to tip than shorter, fatter candles are.

Purpose
To investigate the centre of gravity of a variety of structures

CAUTION: Handle sharp objects like scissors very carefully.

Materials & Equipment
- pencil and paper for recording
- ruler
- scissors
- paper for constructing
- tape

Procedure
1. Roll one piece of paper into the shape of a fat cone and tape it closed.

2. Roll another piece of paper into a thinner cone the same height and tape it closed.

3. Roll a third piece of paper into an even thinner cone, also the same height, and tape it closed.

4. Cut the bottom of each cone so that it can stand on the table with the pointed side up.

5. Test to see which cone is the most stable by trying to tip each one over.

6. Record your results.

7. Make three cylinders with different widths but the same height as your cones. Repeat steps 5 and 6.

Questions
8. Which cone was the hardest to tip over? Why? Compare your results with those of the class.

9. Which cylinder was the hardest to tip over? Why? Compare your results with those of the class.

10. Which shape was harder to tip over, cones or cylinders? Why?

11. What can you conclude about the location of the centre of gravity of each cone and each cylinder?

12. How can you use this information to build more stable structures?
Structural Components and Materials

When designing and constructing a structure, you need to know about structural components and materials. In this lab, you will experiment with components and materials to learn more about their properties.

Questions
1. What are the properties of some structural components?
2. What is the effect of using different materials when building structural components?

Materials & Equipment
- various types of paper
- masking tape
- scissors
- a roll of coins for testing

CAUTION: Handle sharp objects like scissors very carefully.

Procedure
Part 1 The Components
1. Look at some of the structural components in Figure 5.8 on page 132. Choose three to build using photocopy paper and tape.
2. Build your components using as little tape as possible in each case.
3. Determine how strong each component is by using your coins.
4. Record your findings on a chart like the one in Table 5.1.

Part 2 The Materials
5. Choose one of the components you tested above.
6. Build the component three times using a different type of paper each time. Try to use the same amount of tape and paper for each one.
7. Determine how strong each sample is by using your coins.
8. Record your findings in a table.

Analyzing and Interpreting
9. What did you find out about components in Part 1? Compare your results with those of another group.
10. What did you find out about materials in Part 2? Compare your results with those of another group.
11. Which component resisted the forces the best?
12. Which material resisted the forces the best?

Skill Builder
13. Could any parts of this test be made fairer? Explain how.

Forming Conclusions
14. What are some of the properties of the structural components you tested? Where would this component be useful?
15. What are some properties of the materials you tested? Where would these materials be useful?
5.1 CHECK and REFLECT

Key Concept Review

1. Define "structural strength" and "stability" in your own words.

2. Briefly describe how each of the following contributes to structural strength.
   (a) structural shapes
   (b) structural components
   (c) structural materials

3. Use the words "structural stress," "fatigue," or "failure" to describe each situation below.
   (a) a bend in a plastic cup
   (b) a melted plastic cup
   (c) a hole in a plastic cup
   (d) a crack in a glass
   (e) a chip in a glass
   (f) pieces of shattered glass on the floor

Practise Your Skills

6. Explain why a triangular shape is stronger than a rectangular shape.

7. Think of the form and function of an inukshuk (Chapter 5 opener), an igloo (Figure 4.11), and a kayak (Figure 5.17). Choose one of these structures and do the following.
   (a) Draw a diagram to show its form.
   (b) Label any structural components present in the structure.
   (c) Describe the materials that are used to build it.
   (d) Repeat (a) to (c) for a structure of your choice.

Connect Your Understanding

4. Think of an ancient structure that exhibits one of the structural components. Compare it to a modern structure that uses the same structural components.

5. Think about a crumpled-up takeout paper cup. What factors could have contributed to that structure's failure?

8. Use commercial building materials such as interlocking blocks to build the tallest stable structure you can. Measure its height. Dismantle the structure. Using the same pieces, try to make the structure even taller. Is the second structure as stable as the first?

For more questions, go to ScienceSource.

B28 Thinking about Science, Technology, and Society

News Flash

Think about a recent product recall you heard about on the news. Determine the issue that prompted the recall. With a group of classmates, discuss the product recall. Use scientific terms from this chapter in your explanation.
Elements of Design

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

- A good design takes into account the function of the structure.
- Good design considers the strength and stability needed by a structure.
- Symmetry is often used in good design.
- Ergonomic design of objects makes them easier to use.

Many structures, such as bicycles and ladders, are built to be strong and sturdy. If you use them properly, they will last a long time. Proper use includes not overloading them. For example, tricycles are not built to withstand the weight of a full-grown adult. The axle of a toy wagon is not designed to be as strong as the axle on a truck. Even stepladders meant for everyday use may come with warnings about the maximum load and the danger of standing on the top rung (Figure 5.18).

Well-designed structures are safe, easy, and comfortable to use, and are strong enough for the job they are designed for. In this section, you will learn some of the elements of good design.

Figure 5.18 It is not safe to stand on the top rung of a stepladder.

Bicycles Built for Two

Work with a partner to identify structural differences in the two cycles in Figure 5.19. Suggest reasons for differences in the design and construction of these two structures. Communicate your results to another pair.

Figure 5.19 These two structures have the same function, but they were built to withstand different forces.
Elements of Good Design

All structures are designed and built for specific functions. How do you know if your structure has a good design? To find out, ask yourself these questions as you are designing and building.

Does my design link the structure to its function?

Sometimes this question is not as easy to answer as it might seem. Designing a simple structure for a simple function is quite easy. For example, a coffee table is a small structure designed to support small loads and add to the décor of a home. Designing a structure to fit a more complex function, such as a machine to pick peaches without bruising them, is much more complicated.

Can my design withstand the forces that the structure will encounter?

Good designers consider both the static and the dynamic loads that might affect the structure. Structures with similar forms may serve different functions. A coffee table made from pressed wood might withstand the forces in a home with a small child. A delicate glass coffee table may not.

Is my design easy to build with the materials I want to use?

If you were asked to build a coffee table out of wood, another out of glass, and a third out of metal, would that affect your designs? Of course it would. Some materials are easier to cut and join together than others. Some materials can be bent while others cannot.

Is my design ergonomic?

Ergonomics is the science of designing equipment that people can use more efficiently and safely. An ergonomic structure minimizes stress on the user's body. The design and layout of office furniture and supplies often involve ergonomics. People who do repetitive jobs may suffer from repetitive strain injury if they are not using proper equipment and techniques to reduce the stress on their bodies (Figure 5.20).
Ergonomics can be thought of as the science of people-structure relationships. An ergonomically designed structure is easy to use. It might be adjustable for different sizes of bodies. It might also support the body while the structure is in use. For example, some chairs offer extra back support so that the user avoids back pain if sitting for long periods of time.

Ergonomic designers also design special structures for people with disabilities. For example, someone with a broken arm might use a fork that has a cutting edge. Wheelchairs are often designed specifically for their riders, so they ride in comfort and can work the controls easily. And controls have been designed that can be operated by fingers, toes, eye movements, or even puffs of air (Figure 5.21).

Is my design aesthetically pleasing?

If you could choose any coffee table for your home, which would you choose? You might like either of the two shown in Figure 5.22, or you might hate both! All coffee tables have the same function, so why are there so many different forms? The main reason is that different people find different forms and shapes more aesthetically appealing than others. Some people find symmetry appealing. Symmetry is a balanced arrangement on opposite sides of a structure. Others may enjoy something a little more unusual. Some may find a particular material more appealing because of its texture or colour. No matter what the structure, it will not be equally appealing to all people because aesthetic appeal is highly personal.

**Inferring**

Readers can make inferences based on written or visual information. By connecting to their prior knowledge and experiences, readers can draw conclusions as to what is happening, why, what came before, or what will come next. Use your inferring skills to suggest why someone might buy either of the coffee tables in Figure 5.22.
Do I want my design to be symmetrical?
You may have noticed that many structures seem to have equal halves. This means that they are designed symmetrically. There are a number of reasons for this. Humans tend to like things to look symmetrical. It is aesthetically pleasing. Symmetrical things are usually also stable. Think about the wobbly chair. The wobble is caused because one of the chair legs is not the same length as the others. Symmetrical structures can spread the load more evenly. Humans and many other animals are also symmetrical in form (Figure 5.23).

Prototypes
When you are happy with the answers to all of these questions, you may have a good design. However, this does not mean that it is the best design possible. Something that looks fine on paper may not be as practical when you are using it. You often cannot know everything you need to know until you test your design. This is why manufacturers often make prototypes of a structure before they commit to a design.

A prototype is a model used to test and evaluate a design. If you are designing something really big, test a smaller prototype as much as possible before building the full-scale version. You should also test prototypes if you are designing something that you want to produce in large quantities. It would be awful to manufacture a million new pens and then find out that they are uncomfortable to hold!

**B31 Learning Checkpoint**

**Design and Function**
In the last chapter, you learned about solid, frame, and shell structures. This was a way of thinking about structures based on how they were designed and constructed. You also considered packaging as a structure. This was a way of thinking about structures based on their function. How do you think design and function influence each other? Jot down a few ideas and share them with a partner. Then, join with another pair and continue the conversation.

"Proto" in the word "prototype" means first in time, earliest, or original. So a prototype is the first of its type ever made.
Supporting a Load

Procedure
1. Put the schoolbooks and materials in the backpack.
2. Carry the backpack on one shoulder and record your observations of the internal forces you feel in your body.
3. Carry the backpack on both shoulders and record your observations.
4. Adjust the shoulder straps a little at a time to try to minimize the stress on your body. Record your observations.
5. Repeat the procedure with the school bag and with the shopping bag.

Questions
6. What is the best way for you to support the load of your schoolbooks and materials? Compare your choices with those of your classmates.
7. How does the best position relate to the centre of gravity of your body plus the bag?
8. What features of different bags are important when supporting a load?
9. What features would you put in the ideal bag for yourself?

Purpose
To explore ways to carry a load

Materials & Equipment
- a backpack with adjustable straps
- a school bag (not a backpack)
- a shopping bag
- a typical load of books and school materials

Figure 5.24 Students use several different containers to carry their books to school.

Every day, you use your body as a structure to support a load when you carry things. Many students use a backpack or other type of bag to carry their material for school (Figure 5.24).
Newspaper Bookcase

Recognize a Need
You have been asked to design and build a bookcase using only newspaper and masking tape.

Problem
Can a bookcase be made from newspaper and masking tape that will support a textbook?

CAUTION: Handle sharp objects like scissors very carefully.

Materials & Equipment
- newspapers
- masking tape
- textbook
- scissors
- ruler

Criteria for Success
- The bookcase must stand up by itself.
- The bookcase must be constructed of newspaper and masking tape only.
- The bookcase must support at least one textbook for 1 min.
- The best bookcase must satisfy the first three criteria above and be built with the least amount of material.

Brainstorm Ideas
1. What shape should the bookcase have?
2. How big should the bookcase be?
3. What structural components should be incorporated into the design?

Build a Prototype
4. Draw sketches of a few different designs for your bookcase. Discuss the pros and cons of each design with your group.
5. Decide on the design you would like to build and check your design with your teacher.
6. Gather the materials you will need and build your bookcase.

Test and Evaluate
7. Place the books on the bookcase. Check the time to see if your bookcase meets the design criteria. Keep working until you have a design that works.
8. When you have a design that works, study it to decide how you can improve it. Could you use less material? Could you make it stronger? Could you make it more aesthetically pleasing?
9. Modify your design and build another model.

Communicate
10. Create a chart with a diagram of your finished bookcase. Highlight the structural components and the materials you used that made your design a good one.
Key Concept Review

1. Why must a good design take into account the function of the structure?

2. What is symmetry and how might it affect the design of structures?

3. What might be the consequences of ignoring the strength and stability needs of a structure?

4. List the elements of design and describe how each might have been considered by the designer of the desk you are sitting at.

6. Prototypes are often expensive to build because each component must be made specifically for the prototype. Why would manufacturers invest in the development of a prototype?

Practise Your Skills

7. In this section, you built a newspaper bookcase to support one book. Rebuild your bookcase using different shapes, different components, or different materials in order to improve its form and function.

8. If you could choose to build any type of bookcase, what would you choose? Outline the design features that you think would be the most important in your decision.

For more questions, go to ScienceSource.

An Aging Population

As consumers age, they look for structures that are easier to use. People with arthritis in their fingers may find it easier to use kitchen utensils with larger, more ergonomically designed handles.

What to Do

1. Gather several examples of one type of kitchen utensil.

2. Hold and pretend to use each kitchen utensil. In one sentence, describe how easy it is to use each one.

Consider This

3. Share your findings with a classmate or the whole class.

4. Identify trends in the findings.

5. How does each utensil exhibit the elements of good design? Do well-designed utensils function more effectively than poorly designed utensils do?

6. What role do aesthetics play in kitchen utensil design?
Beth Anne Currie, Children's Environment and Health Consultant

Green Roof Design
Green roofs are made from different materials and need to be stronger than traditional roofs. They can reduce the volume of storm water run-off, improve air quality, and reduce the roof surface temperature. This makes the building cooler.

While Currie designs the roofs, it takes a team of people to build and maintain them. The tradespeople and horticulturists must understand green roof construction. Informational technology experts regulate the irrigation system through the use of sensors and specialized computer programs.

Currie's advice to people interested in a job like hers is to get advanced training in health care or the environment. An interest in ecology is essential. Asked what keeps her motivated, she replied, 'When you're committed to ensuring we protect our environment, there's usually so much happening on the opposite side of that issue that you can't help but be fired up about how you can help, or who you can write a letter to, or where you can get funding to support something good.' Learn more at ScienceSource.

Questions
1. How might knowledge of structures help in the design of green roofs?
2. Why would an interest in ecology be an asset to someone interested in this type of work?
3. In the future, if you consider building a green roof, what other information would you need in order to help you make the decision?
Key Concept Review

1. Describe several factors that contribute to a structure's stability.

2. What is the role of symmetry in the design of structures?

3. (a) Explain why knowledge about the centre of gravity of structures is important to designers.
   (b) How does changing the location of the centre of gravity of a structure affect it?

4. Name three structural components and explain how they contribute to a structure's strength and stability.

5. Explain how each of the following affects the strength and stability of a bicycle.
   (a) choice of materials
   (b) structural shapes
   (c) structural components

Connect Your Understanding

6. Why might a designer choose a material that is not the strongest available?

7. Describe a structure in your home that makes use of several different structural components. Include a sketch and label the components.

8. Many structures, such as clothes, furniture, and cars, change as fashion changes. Why do you think this is?

9. Most consumers do not design, construct, and test their own bookcases. Some buy ready-to-assemble furniture; others buy furniture already assembled. What are the advantages and disadvantages of these two types of furniture?
10. Describe one local structure that is a good example of the effective use of structural components. Explain why you think the components are used well.

11. Using the Elements of Good Design as a guide, describe what you feel to be the best-designed structure in your classroom and in your school.

Practise Your Skills

12. Using straws and tape, build a structure that stands by itself and shows at least two structural components at work.

13. Estimate the maximum load that your desk was designed for. How could you test this?

**Thinking about Science, Technology, and Society**

**Car Sales**

Once consumers decide to buy a car, they have to choose which car to purchase.

**What to Do**

1. List three car models that you know.
2. Access consumer information about these cars either on the Internet or from another source.
3. Prepare a chart comparing the three cars based on the factors of cost, fuel efficiency, and safety rating.

**Consider This**

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

4. What might prompt a consumer to decide to purchase a car?
5. How might each of the factors listed in your chart influence a buyer’s decision?
6. Relate the car’s safety rating to the terms “structural stress” and “structural failure.”
7. What product recalls, if any, have affected the cars you researched?
8. If you were asked to design a new and improved car, discuss a change you would make to increase safety and one you would make to improve aesthetics.
6.0 The lifespans of structures need to be considered to make responsible decisions.

People buy things, use them for awhile, then discard them. Scrap metal (shown here), aluminum, paper, glass, and plastic are separated from each other and recycled.
What You Will Learn
In this chapter, you will:
• describe factors that make a structure aesthetically appealing
• recognize and describe the lifespan of familiar structures

Skills You Will Use
In this chapter, you will:
• analyze the role of consumers in the manufacture of structures
• make a personal plan of action with respect to lessening your impact on the environment

Why This Is Important
Every decision you make about purchasing something can affect Earth. Many purchases come in some kind of packaging. Sometimes we purchase things we do not really need. Most of our purchases end up as waste. Understanding these issues will help you make responsible decisions.

Question and Answer Pattern
Writers of nonfiction use a variety of organizational patterns to communicate information and ideas. They try to choose a pattern that will give readers what they want or need to know about a topic. Sometimes writers use the pattern of asking and answering questions. Scan Unit B for headings that appear as questions. Do answers directly follow the questions? Why might the writer have chosen this pattern for organizing this topic? Where else have you seen this pattern used?

Key Terms
• consumer
• manufacturer
• market research
• lifespan

The lifespans of structures need to be considered to make responsible decisions.
It is difficult to imagine a time without telephones! In the 1870s, Elisha Gray and Alexander Graham Bell experimented with devices that could transmit speech electronically. Bell was the first to patent the invention. Back then, no one could walk around outside while talking on the phone (Figure 6.1). Early phones were large and bolted to the wall (Figure 6.2).

These days, many families have more than one telephone. There may be an extension in every room. Some families have a cellphone for each member. What happens to all of the old phones? Landfill sites contain many old phones, along with television sets, computers, clothes, and plastic toys (Figure 6.3).
Many of these products still worked when they were discarded. Perhaps they were replaced by newer models. Perhaps they outgrew their usefulness to their owner but could have been useful to someone else.

What makes someone buy a new phone? For some people, it is because the old phone broke. For other people, it is because a newer model came along. In this section, you will consider some of these issues.

Some of the ideas in this chapter will generate different points of view. It is important to think about each idea. Discussing ideas openly and respectfully, especially with people who may not agree with you, is a good way to gain insight.

Figure 6.3 Old cellphones end up in landfill sites.

B36 Quick Lab

How Many Phones?

Purpose
To examine the impact of one technology on the environment

Materials & Equipment
- an old telephone
- paper and pencil

Procedure
1. Examine the phone and make a list of the materials you observe in its construction.
2. Write how you think phones are disposed of when they are no longer useful.
3. Estimate the number of phones your family owns at the present time.

Questions
4. How might you estimate the number of phones owned by the families in your class? How might you do this for your entire school?
5. Estimate the number of telephones that are owned by families in Canada.
6. How do you think you could estimate the number of business phones in Canada? Should it be half, the same, double, or more? Imagine a pile of all the phones in Canada. What would it look like?
7. Find out if phones can be recycled when no longer useful.
Determining Consumer Need

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

- Manufacturers try to determine consumer need in order to make good decisions about products.
- Consumers make purchases based on needs and wants.
- Ergonomics may be a consideration in some purchases.
- Consumers can influence manufacturers to make good products.

You are a **consumer**, a buyer of things (Figure 6.4). Each time you buy something, you have made a decision. Sometimes the decision is small, such as the type of drink you would like with your lunch. At other times, your decision might be bigger, such as an item of clothing or a bicycle. Some day, you may make a decision to buy (or not buy) a car. You may purchase a home. How do people make these decisions, and why are manufacturers so interested in your decision making?

In this section, you will answer these questions and learn about the relationship between manufacturers and consumers.

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**Reading Advertisements**

Collect advertisements for jeans from magazines, newspapers, and flyers. If you could pick any one of the pairs of jeans to have for your own, which one would you pick? Why? Discuss the reasons for your choice with a partner.
Manufacturers

Manufacturers are interested in what you think. They want to produce products that you will want to buy. They hope that, even if you are not in charge of buying a particular product, your family will be influenced by what you think.

Manufacturers have to sell their products in order to remain in business (Figure 6.5). However, there are many manufacturers, and each one wants you to choose its product. You, as the consumer, have to make the decisions about how you will spend your money. Manufacturers know that each consumer has a limited amount of money to make purchases, so they compete for “the consumer dollar” through advertising campaigns.

Market Research

Before manufacturers design a new product, they need to be reasonably sure that someone will want to buy it. They do not want to commit a lot of time and resources to manufacturing the product just to find that no one wants it. Shoes are an example. Before designing yet another brand of running shoes, the manufacturer has to gather and evaluate some data. This is called market research (Figure 6.6).

You may have been asked to answer questions for a survey at a mall, on the telephone, or on the Internet. Market researchers ask people to give an opinion so that they understand what consumers are thinking. The researchers report to the manufacturer on whether they think that people will buy those shoes.

These days, technology is an important part of gathering market research. Each time a consumer uses a credit, debit, or point collection card, information is entered into an enormous database. This information reveals important trends, such as the popularity of certain brands or colours.

Consumers are becoming increasingly concerned about the environment, so many manufacturers have designed products to meet this demand. Your favourite stores may have switched to reusable shopping bags instead of thin, disposable plastic bags. You can also find clothing made from materials such as seaweed and bamboo.

The lifespans of structures need to be considered to make responsible decisions.
Advertising

Manufacturers use many different ways to convince you that their product is best. Some advertise on radio or television, in magazines, and on the Internet (Figure 6.7). Some provide incentives such as mail-in rebates to try to convince consumers that they are getting a good deal. Some hire famous people to endorse their products. They think that consumers will feel that products endorsed by celebrities have more status.

Figure 6.7 Internet use has brought new forms of advertising: pop-up ads, banner ads, and hover ads.

B38 During Writing

Anticipating Readers' Questions

Throughout this chapter, you will consider the impact of choosing "greener options" in your everyday life. Researchers in science and technology have developed many ways to recycle used and discarded products into new, useful materials and products.

Work with a partner to create a list of possible questions and answers you think readers may have about recycled materials and products. You will need to make some decisions about audience and format before you begin. Will your audience be the other students in your class, parents in the community, or someone else? Will you use a poster, brochure, or other format? The choices you make will help you decide on the questions you will ask. Develop an outline or graphic organizer to record possible questions. As you read more of this chapter, use this organizer to keep track of information and ideas that will help you answer your questions.

Being a Wise Consumer

When consumers are faced with decisions about what to buy, they need to use certain skills in order to make good choices. If you were interested in buying a car, you would probably take the car for a test drive. If the car will be used by your whole family, you may take everyone with you to make sure the car has enough space for car seats or pets.

Even with small purchases, you should take the item for a "test drive." If you were buying a cellphone, you may hold different phones in your hands to see how they feel. You may dial a few numbers to see if the keypad is easy to use (Figure 6.8). You might call a friend to test the sound quality. All of these tests give you more information so that you can make a wise decision.

WORDS MATTER

"Wise" is an adjective that is related to the noun "wisdom." Some people say that wisdom is a combination of knowledge plus experience.
Another part of being a wise consumer is to let manufacturers know if you are unhappy with a purchase. Most manufacturers are eager to improve products if people have problems with them. Perhaps the running shoes you bought came with weak laces that broke the third time you tied them. Maybe you accidentally turn your cellphone off every time you put it into your pocket. You could let the manufacturers know about these issues by phoning, e-mailing, or writing them.

**Needs and Wants**

Have you ever asked for something by saying “Please, please, I really need it”? Your mom or dad may have disagreed with you about whether you actually “needed” the expensive running shoes or just “wanted” them (Figure 6.9). Sometimes you have to decide whether you need something or just want it.

It is easy to become confused about whether something is a need or a want. People need certain things to stay alive. The basic needs are food, water, oxygen, energy, and a suitable habitat. Where do fancy shoes fit in?

**Take It Further**

Organizations such as Industry Canada or Consumers Union try to make it easier for consumers to make decisions about buying products. They often test products to see if they live up to their claims or prepare questions for consumers to consider when they are deciding to buy certain items. Find out what one of these organizations (or a similar one) says about cellphones. Begin your search at ScienceSource.

**Suggested Activity**

B40 Quick Lab on page 160

**Figure 6.8** Some people prefer a large keypad while others prefer a smaller one.

**Figure 6.9** Often, it is difficult to tell one brand of shoe from another.

The lifespans of structures need to be considered to make responsible decisions.
Aesthetics

Sometimes it is not the strength or stability of a structure that makes a consumer decide to buy it. Sometimes it is “just something about the way it looks.” You might like the colour. You might like the shape. You might pick it because it has an aesthetic quality that appeals to you. Antique cars, like the one shown in Figure 6.10, appeal to some people, while other people just want a car that will get them from one place to another.

Figure 6.10 Some people like antique cars because of their aesthetic quality.

Ergonomics

A well-designed product is a pleasure to use. When scientific research is used in the design of the product, manufacturers often add the label “ergonomically designed” to the packaging. Some consumers consider this very important, especially for products that are used over and over again. Items from pens to seats can be designed to minimize stress on the human body when they are used.

Universal Design

Designers have become much more conscious of the concept of universal design. The term “universal design” refers to structures that can be useful to many different users. For example, in the past, people thought that ramps and doors that open at the push of a button were just for people in wheelchairs (Figure 6.11). However, these features are equally useful to older people, people pushing strollers, and people carrying large loads.

Figure 6.11 Many buildings have ramps leading to the doorways.
Surveying the Market

Surveys. You may get them in the mail. Your school might send them home to gather information. You might be sent one by e-mail after visiting a retailer. Manufacturers often survey the general public to find out if a new product will sell.

Question

To develop a survey to collect information that would be useful to a manufacturer who is developing a product to meet a societal need.

Materials & Equipment

- pencil
- paper
- access to computer
- examples of surveys

Design and Conduct Your Investigation

1. Look over examples of surveys to see how other people write them.

2. Work with a partner to think of a societal need, such as the need to increase home composting, the need to reduce the use of electricity, the need to prevent injury when using electronic devices, or something else that interests you.

3. Design a survey form that you could use to gather information about whether this need concerns your peers and what product they would require to meet this need.

4. Make a draft of your survey questions, paying attention to the following:
   (a) Does your form protect people's privacy and encourage honest reflection?
   (b) Will your questions provide data that you can analyze and graph?

(c) Is there a way for people to give you "comments"?
(d) Will people be able to complete the survey quickly and accurately?
(e) Will you leave the survey with people for them to complete on their own, or will you ask each individual the questions and record the answers yourself?
(f) Will you provide an incentive for people to respond to your survey?
(g) Can you use a method that does not involve pencil and paper to collect the information?

5. Design a one-page form in an attractive, easy-to-use format. You may use a computer and word processing software.

6. Decide with your teacher who you will ask to fill out your survey. Conduct the research.

7. Examine your completed surveys. Decide on a method to organize your data so it can be analyzed.

8. Complete the data analysis.

9. Write a paragraph that summarizes your findings.

10. Based on your findings, what course of action would you follow in the development of your product?
Wise Choices

**Procedure**

1. On a piece of paper, make a list of all of the things you would like your ideal cellphone to do (Figure 6.12). For example, you may want your phone to act as a camera too.

2. On the same piece of paper, make a list of all the physical features you would like your ideal phone to have. For example, you may want your phone to have a durable shell because you may drop it.

3. Highlight each item on your list that is a "need." For example, you need to be able to make reliable phone calls. However, a cellphone's ability to play music may not be a need. Although it is a nice feature, it is not essential to the functioning of the phone. Usually, extra features add to the overall cost of an item. However, they may make a product seem more appealing.

**Questions**

4. Consider your list with a classmate. Do you have similar needs and wants? Why do you think this is?

5. Some cellphones have many features. Could some of these features be neither a need nor a want?

6. Based on your research, would it be better to buy a telephone plan that includes a free phone, or to buy a cellphone and pay a monthly fee? Are there any other things you should consider?
6.1 CHECK and REFLECT

Key Concept Review

1. Explain the concepts of "ergonomics" and "universal design." How might they affect buying decisions?

2. Describe how each of the following factors relates to being a wise consumer. (a) advertising (b) needs and wants (c) aesthetics

3. What do you think it means when an object is described as "aesthetically pleasing"? Give three examples of objects you find aesthetically pleasing.

Connect Your Understanding

4. In order for them to be wise consumers, why should people be aware of how manufacturers think?

5. Think of items your family uses every day, like facial tissues, soap, or bread. Make a list of the items and list the brands your family usually buys next to each item. If you do not always stick to the same brand, note that too. Why does your family make those purchasing decisions?

6. When you read advertisements, it is sometimes useful to maintain "healthy scepticism." Why might this be the case?

Practise Your Skills

7. Imagine that you have been hired to do market research for a manufacturer of sun hats. Prepare three questions you would include in your survey.

For more questions, go to ScienceSource.

B41 Thinking about Science, Technology, and Society

Science and Advertising

Advertisers often use so-called "scientific" claims in order to promote their products.

What to Do

1. Recall three advertisements that use scientific claims.

2. Make a three-column chart to summarize these ads. Use the headings Product, Scientific Claim, and Expert Cited.

Consider This

As a class, discuss the following questions.

3. Why might manufacturers use these types of claims in their advertising?

4. When do you think these types of claims are the most effective?

5. When do these claims make you doubtful?

6. How do scientific claims affect your buying decisions?
6.2 Lifespans of Common Structures

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

- Every structure has a lifespan.
- Structures are designed with the lifespan in mind.
- Responsible manufacturers and consumers consider the safe disposal of structures in their decision-making.
- Disposal of structures can affect the environment.

When you were born, your parents likely purchased a crib, a highchair, a car seat, and several other things. When you grew older, what became of these items? Perhaps your younger brothers and sisters are using them. Maybe the items were sold or given away when they were not needed anymore.

Some items, such as the highchair, serve a function for a set amount of time. Young children need highchairs from the time they can sit up until they can sit at the table on a regular chair. With other items, the decisions on how to dispose of them are not as easy.

People have several ways of disposing of unwanted products. They can sell them at a garage sale, give them to a friend, or give them to a charity rummage sale (Figure 6.13). They can re-use boxes, jars, and other containers. They can compost organic waste or put it in a green bin. They can recycle glass, paper, plastic, and metal. On the other hand, they can just throw everything out with the garbage.

In this section, you will learn about the lifespans of different structures. You will find out how people decide when and how to dispose of those structures when they no longer need them.

B42 Starting Point

Where Did It Go?

Think back to your favourite thing when you were young. Did you have a special stuffed animal or a special blanket? You may have photographs of you with your favourite thing, or you may still have it. Write down as much about your favourite thing as you can. When did you get it? How did you use it? Has it changed since you first got it? If you do not have it any more, why not? Share your memories with a partner.
Learning Checkpoint

Everything Has a Lifespan

You may be familiar with the term "lifespan." Perhaps you learned about lifespans when you studied living things in the past. You understand that every living thing is born, lives, and dies. Did you know that structures have lifespans too?

Think about the lifespan of a pencil or your school building. How are they alike? How are they different? Discuss your ideas with a partner. Be prepared to share your thoughts with the class.

The Lifespan of a Product

Every product has a lifespan. This lifespan starts as an idea and goes through several steps before it is even available to consumers. More steps in the lifespan take the product through its use to its disposal. Not all products go through every step in the lifespan, however, as illustrated by the windshield wiper example in Table 6.1 on the next page.

How Long Should a Product Last?

When manufacturers plan a product, they have to answer this question. If a shoe manufacturer made shoes that wore out quickly, consumers would feel that they did not get their money’s worth. If it made shoes that never wore out, the shoes might cost too much and people would not buy them. If people did buy them, the manufacturer might never sell any more shoes!

When a manufacturer deliberately designs a product with a limited lifespan, it is called planned obsolescence. The materials and technology used guarantee that the product will not last as long as the consumer might want. Also, fashion often dictates how long a product will be used. Many people have unfashionable clothing in their closets that they don't wear any more.

Suggested Activity

B45 Decision-Making Analysis on page 167

WORDS MATTER

The noun "obsolescence" comes from the adjective "obsolete," which means discarded or out of date.

Figure 6.14 These windshield wipers are over 50 years old.

Figure 6.15 Modern windshield wipers are stronger than the old ones.
<table>
<thead>
<tr>
<th>Step in the Process</th>
<th>Description of Process</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea</td>
<td>The inventor thinks of a new idea for a product or a modification to an existing product.</td>
<td>In 1902, Mary Anderson was riding a streetcar in New York City during a snowstorm. She watched the streetcar driver try to see by leaving the windshield open and letting the cold weather into the car.</td>
</tr>
<tr>
<td>A model</td>
<td>The inventor creates designs to try out to decide which one is best.</td>
<td>Mary Anderson made sketches for a windshield wiper that showed a lever on the inside that was attached to a wiping mechanism on the outside.</td>
</tr>
<tr>
<td>Choosing materials</td>
<td>Materials are chosen for the components of the product.</td>
<td>She hired a company to make a model out of wood and rubber strips.</td>
</tr>
<tr>
<td>Research</td>
<td>The inventor may need to learn more about materials or how to improve the design of the product.</td>
<td>In 1903, Mary Anderson was awarded a patent for the windshield wiper design.</td>
</tr>
<tr>
<td>Improving the design</td>
<td>After research, it might be necessary to change the design so that it lasts longer, is easier or cheaper to make, or uses different materials.</td>
<td>After Anderson's patent expired in 1920, car manufacturers improved the design. Figure 6.14 shows an old car with its windshield wipers.</td>
</tr>
<tr>
<td>The prototype</td>
<td>With some products, designers make working models instead of a full-scale version of the final product. This prototype is made to ensure that everything works as planned and that the final product will be easy to manufacture.</td>
<td>There is no record of Anderson's prototypes.</td>
</tr>
<tr>
<td>Market research</td>
<td>Information is gathered to find out how much of the item should be produced. Researchers also find out how much people are willing to pay for the item.</td>
<td>Anderson wrote to a large company to sell them her design but they were not interested.</td>
</tr>
<tr>
<td>Production</td>
<td>The manufacturer decides where and how the product will be made and starts making it.</td>
<td>Anderson was discouraged and did not develop the idea herself. However, some car companies did use it, and she received royalties for her invention until the patent expired. Today, windshield wipers are installed on every automobile manufactured.</td>
</tr>
<tr>
<td>Advertising</td>
<td>The public is informed that there is a new product for them to buy. Sometimes, this step happens months before the product is even available to the public.</td>
<td>Since the windshield wipers come on automobiles, there is not much direct advertising. However, replacement wiper blades are heavily advertised.</td>
</tr>
<tr>
<td>Distribution</td>
<td>The product is sent to retailers or directly to the consumer. Figure 6.15 shows windshield wipers on a new car.</td>
<td>Most windshield wipers are manufactured for automobile manufacturers. Replacement wipers and blades are sold to car dealerships and automotive stores.</td>
</tr>
<tr>
<td>Consumer's choice</td>
<td>For each product they buy, consumers often have to choose among several different brands.</td>
<td>Some companies advertise specialty wipers for different seasons so that consumers can change them to suit local weather conditions.</td>
</tr>
<tr>
<td>Disposal</td>
<td>When the product breaks, wears out, or is no longer needed, it is discarded. It may be composted, re-used, recycled, or sent to a landfill.</td>
<td>When wipers wear out, they are generally sent to landfill.</td>
</tr>
</tbody>
</table>
Something like a game system might be designed to last a few years (Figure 6.16). Manufacturers know that the technology used in the games is always changing. In a few years, the consumer may be ready to buy something new.

Even buildings are not designed to last forever. Home-owners and building maintenance people know that their buildings must be cleaned, maintained, and occasionally renovated to keep them in good shape. The eavestroughs have to be cleaned regularly. The shingles and siding might have to be replaced every 20 years.

**Product Disposal**

When people make purchasing decisions, they do not always think about what will eventually happen to the product when it breaks or they don’t want it anymore.

Many people think that the lifespan of a product ends when the garbage truck picks it up. However, it doesn’t actually end until the product breaks down. This can take years, even at a landfill. Recycling, re-using, and composting are often better than a landfill site is.

If you know that a product is recyclable after use, would you choose to buy it instead of a similar item that is not recyclable? Some items can be sold to another owner. Cars, clothing, and toys often get resold instead of thrown out (Figure 6.17). Eventually, however, items wear out and become unusable. Then they end up in landfills or recycled.

*Figure 6.17* People often sell bicycles or cars privately.

*Take It Further*

"Manufacturing" means to organize the way something is made. Usually, this is done to make a large number of the same item. Manufacturing might involve the use of machinery or it might involve breaking down the steps of making something into parts that different people can do. Some manufacturing practices are better for the environment than others. Investigate two ways in which a familiar item might be manufactured and report your findings in the form of a T-chart. Begin your search at ScienceSource.
Research a Lifespan

In this section, you have read about the lifespan of windshield wipers. Find out about the lifespan of a product you are interested in. Figure 6.18 might give you some ideas.

**Purpose**
To research the lifespan of a familiar product

**Materials & Equipment**
- paper and pencil
- access to the library and/or Internet

**Procedure**

1. Pick a product from the photographs here or choose your own.

2. Write down the steps in a product's lifespan. (See Table 6.1 for the steps.)

3. Fill in the steps you already know. Go to ScienceSource to do some research to fill in the steps you do not know.

**Questions**

4. Did anything surprise you about the lifespan of your product?

5. Can you think of ways in which the lifespan might be lengthened or shortened?

6. Suggest some ways to lessen the environmental impact of making, using, and disposing of this product.

*Figure 6.18 Each of these products has a lifespan.*
Altering a Product Lifespan

Issue

Many things affect the lifespan of a structure. One factor you can control is how you care for the structure. Sometimes it is possible to repair a structure rather than purchase a new one.

Background Information

Buildings are designed to have a long lifespan. When a home, school, or factory is built, it is designed to last from many decades to centuries. However, ideas and materials change over time. Many buildings across the country are abandoned; they are no longer being used. Perhaps there is an abandoned building in your neighbourhood. What should be done with these buildings when people want to use the land that they sit on?

Consider these two viewpoints on the issue (Figure 6.19).

- Some people feel that old buildings have historical and architectural value. They feel that the old building should be saved if possible and perhaps incorporated into a new structure.

- Other people feel that it is better to demolish the old building because newer materials are available and safety standards are now higher. It is often quicker and less expensive to demolish a building and start over with new materials than to restore an old building.

Your task is to choose one side of the argument and research the issue. You will present your findings as either a debate or a class presentation. Your teacher will provide more details about how to present your information.

Analyze and Evaluate

Begin your research using the following resources.

1. Go to ScienceSource to begin your search for information.

2. Look in print materials such as magazines, newspapers, and books for information on historical buildings in your neighbourhood.

3. Summarize the information you find in a short report for presentation to your class or for use in a debate. Be sure to include only information that supports your viewpoint and refutes the opposite view.

Figure 6.19 Some people would preserve the old school while others would tear it down and build a modern school.
Key Concept Review

1. Every product has a lifespan. Is this statement true? Explain your answer.

2. Describe the concept of planned obsolescence. How might this affect the planning and design of a product?

3. Think of a three-ring binder. Describe each of these stages in the product-planning process.
   (a) choosing materials
   (b) improving the design
   (c) advertising
   (d) disposal

4. Why should product disposal be considered when you make buying decisions?

Connect Your Understanding

5. Compare the design of a product whose lifespan is purposely short (for example, a paper cup) with the design of a similar structure with a longer lifespan (for example, a china mug). What decisions would the designers of each item make?

6. Think about the oldest thing your family owns, perhaps a memento from an ancestor or something that travelled with your family from another country. Describe the item. What steps does your family take to extend the lifespan of this item?

Practise Your Skills

7. Think of a product you use every day, such as an item of clothing, a bicycle, or a computer. Write a paragraph or draw a labelled diagram to describe the steps in planning this product from idea to disposal.

For more questions, go to ScienceSource.

Product Disposal

When you discard a product, you decide whether to put it into a compost collector, a recycling container, or a garbage can. However, not all of these containers are always available.

Consider This

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

1. Where are the waste containers in your school?

2. How do the waste containers vary in form when their function is different?

3. Are all three types of containers present at each waste collection site?

4. What happens to people's waste when one or more of the containers are missing?
Exploring Greener Options

Here is a summary of what you will learn in this section:
- Minimizing impact on the environment should be a key consideration in purchasing decisions.
- Buying products that are locally made and need less energy to produce can help the environment.
- Recycling or composting products that are no longer useful means less garbage in the landfill.
- Consumer demand has encouraged manufacturers to explore greener options.

When you decide to buy a scoop of ice cream, you still have a few other decisions to make. You decide on the flavour, then the server asks, “Is that in a cone or a cup?”

This simple decision can have an impact on the environment. Ice cream in a cone is completely edible (Figure 6.20). If you choose a cup, you get a disposable container and a plastic disposable spoon that often cannot be recycled. Even though it is just one little container and one little spoon, think of the number of people who each get a container and a spoon. The amount of garbage produced in this way has started to concern many consumers. This has encouraged some manufacturers to design biodegradable containers and utensils.

In this section, you will look at how the structures we purchase and dispose of affect the environment. Writing a personal action plan will help you make some important decisions.

Figure 6.20 Canadians do like their ice cream!

Suggested Activity
B49 Quick Lab on page 172

B47 Starting Point

Take Stock

Think about your family’s fast food habits and the types of fast food your family eats.

1. What is your family’s favourite fast food? How is it packaged?

2. How might this type of packaging affect the environment?

3. Can you do something to lessen its impact on the environment? Discuss your ideas with a classmate.
How Structures Affect the Environment

Humans will always need and want things. However, the things we need and want can have an impact on the environment. As responsible citizens, we need to examine our decisions and try to lessen our impact on Earth and its resources.

Every product you buy requires raw materials and energy to manufacture. Fuel is needed when the product is transported. And the product will need to be disposed of when you no longer need it.

If you choose products made from renewable materials, and then recycle or compost them, you are lessening your impact on Earth. Using renewable resources, such as the plants shown in Figure 6.21, means that others in the future will be able to enjoy the same things you have now. By recycling or composting, you send fewer items to the landfill.

Using Less Energy

If you choose products that need less energy to manufacture, you are lessening your impact on Earth. Generating energy (electricity, heat, etc.) is expensive and can release pollutants. If the products you choose need less energy to manufacture, you reduce the cost and the amount of pollution produced.

If you purchase structures that operate on less energy than similar structures, you are lessening your impact on Earth. Figure 6.22 shows two flashlights. One uses batteries, which are an expensive and wasteful source of energy. The other uses a hand crank, which is a renewable source of energy as long as you eat your meals!

If you buy locally produced items, you are lessening your impact on Earth. Since locally produced items don’t have to be transported long distances, this saves on energy and minimizes pollutants. Many people eat locally produced food, and some purchase that food at roadside stands (Figure 6.23).

Figure 6.21 Clothing made from cotton or bamboo is recyclable. Nylon and rayon are not recyclable.

Figure 6.22 Both of these flashlights use energy to produce light. One uses batteries for energy. The other uses your energy when you turn the crank.
If you change your behaviour in order to conserve energy, you are lessening your impact as well. For example, you could turn the heat down a degree or two in your home in winter. If you put on warmer clothing, your family will save money and help reduce the total amount of energy it uses.

Consumers are also growing more conscious of the need to think about the products they buy. They consider:

- how raw materials are managed
- the working conditions of people who make the products
- the consequences of buying goods intended to last only a short time

As consumers make these concerns known to manufacturers, changes are being made. You may have noticed labels like “organic,” “fair trade,” or “produced from materials in a sustainable way.” Sometimes products that bear these labels cost more than products that do not. Would you be willing to pay more for something, like a T-shirt, made in an environmentally responsible way?

**Suggested Activity**

B50 Decision-Making Analysis on page 173

**Take It Further**

You may live in an apartment or a house. Your home is most likely made out of wood, concrete, and/or brick. These are traditional building materials for homes in Canada.

However, some interesting housing materials may have less impact on the environment. Some people are building houses out of old cans and tires. Others are using straw bales. Investigate an alternative housing method and report back to your class. Begin your search at ScienceSource.

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**Thinking Literacy**

**Reorganizing Ideas: ARMS**

Writers revisit their work to add, change, or delete ideas and information. One strategy they use to help reorganize is called "ARMS" (add, remove, move, substitute).

Revisit your "Question and Answer" organizer on recycled materials and products and think about changes you want to make. Is there a question you would like to add or remove? Are there better words you can substitute in a question or answer? Now, write your draft.
Personal Action Plan

Throughout this unit, you have learned about structures, their classification, and the forces that act upon them. You have thought about consumer needs and wants. You understand that every purchasing decision has an impact on Earth. It is time for you to put what you have learned into action in your own life (Figure 6.24). You may not make all of the decisions about what to buy for your family, but you do have influence. You also make choices for your own purchases.

**Purpose**

To prepare a personal plan of action for making wiser consumer decisions

**Materials & Equipment**

- pencil and paper

**Procedure**

1. Make a list of the purchasing decisions you make for yourself or have influence over. You may pick your own clothes. You may have a say in what your family buys at the grocery store. You might buy your own batteries for your electronic gear.

2. Consider products and practices. What are the different ways to lessen your impact on Earth? For each item on your list, propose a way to make it more environmentally responsible. You might organize your list in a chart like the one in Table 6.2.

<table>
<thead>
<tr>
<th>Purchasing Decision</th>
<th>Proposed Change</th>
<th>Change Immediately, Discuss, Find Out More?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. For each decision, decide whether it is something you can change immediately or discuss with your family, friends, and classmates, or whether you need more information.

**Questions**

4. Look over your list and make sure there is at least one change you can make immediately. Why will this action lessen your impact on Earth?

5. Consider the items you need to discuss with your family. What information do you think your family will want to consider before they make a decision?

6. Consider all of the items you want to find out more about. How will you get your information?

7. Write a letter to yourself outlining your personal action plan. This personal action plan is a commitment you are making to yourself and Earth.
How Green Can We Be?

Consider these two viewpoints on this issue.

- Some people feel that it is enough to make inexpensive changes to lessen the impact on the environment. Changes in behaviours such as turning off the lights when not needed and keeping the building at a moderate temperature do not cost much money.

- Others feel that changes in behaviour are just the start. Changes in infrastructure, such as increased insulation and the use of low-wattage light bulbs, must be made in order to be more environmentally responsible.

Your task is to choose one side of the argument and research the issue. You will present your findings as either a debate or a class presentation. Your teacher will provide more details about how to present your information.

Analytics and evaluate

Begin your research using the following resources.

1. Go to ScienceSource to begin your search for information.

2. Look in print materials, such as magazines, newspapers, and books, for information on reducing your impact on the environment.

3. Summarize the information you find in a short report for presentation to your class or for use in a debate. Be sure to include only information that supports your viewpoint and/or refutes the opposite view.
6.3 CHECK and REFLECT

Key Concept Review
1. Describe how every buying decision can affect the environment.
2. Describe how modifying your buying decisions can lessen your impact on Earth.
3. For each of the items below, describe the buying decisions that would have the least impact on the environment.
   (a) cleaning supplies
   (b) fresh fruit and vegetables
   (c) clothing

Connect Your Understanding
4. Describe why it is important to consider greener options every day, even when making “small” decisions such as buying ice cream.
5. Why is it considered better to reduce or re-use than to recycle?
6. Noted environmentalist David Suzuki has warned against “green-washing,” a trend that businesses have adopted to convince consumers that their practices are more environmentally responsible than their competitors’ practices. Why do you think he might be concerned?

Practise Your Skills
7. To make the greenest possible purchase decisions at your local grocery store, you might ask questions such as “How far has this food been transported to get it here?” Make a two-column table that lists this question and four others you could ask. Explain the kind of answer you are looking for in each case.

For more questions, go to ScienceSource.

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B51 Thinking about Science, Technology, Society, and the Environment

Re-structures
Science and technology have discovered many ways to use recycled items. For example, polyester fleece is made from recycled plastic bottles. Think of the future of one recycled material, such as aluminum, paper, plastic, or glass.

Within a group, choose one recycled material and answer the following questions.

1. What products is that recycled material made into?
2. What are the benefits of choosing those products?
3. What are the drawbacks of choosing those products?
A Changing Centre of Gravity

Where is your centre of gravity? In this unit, you learned that it is the point within a structure that gravity seems to act on. So if you are balanced on the tip of one toe, your centre of gravity is directly over that toe. Otherwise you would fall over, pulled to one side or the other by gravity. But how high up is it? Probably just about in the middle, where there’s as much of you above it as there is below.

The thing is, your centre of gravity can move, sometimes even outside your body! When you crouch down and wrap your arms around your knees, your centre of gravity drops down with you. It may actually leave your body to float somewhere in the space between your arms, legs, and head.

In the 1960s, an Olympic high jumper named Dick Fosbury became famous for shifting his centre of gravity (Figure 6.26). Up to that time, high jumpers ran parallel to the bar, then kicked one leg up and rolled over the bar (trying not to touch it), dragging the other leg behind. Some people were really good at this, and could clear a bar that was well over 2 m high.

Fosbury used a completely different technique that became known as the “Fosbury Flop.” He ran at the bar, then at the last minute turned his back and jumped head first and backward over the bar. At the very last second, he kicked both legs up and over. Fosbury won the high jump at the 1968 Olympics in Mexico City in this way. He jumped 2.24 m.

Today almost every high jumper uses the Fosbury Flop because it is so effective. With other techniques, jumpers have to get their centre of gravity over the bar. But Fosbury was able to sneak his centre of gravity under the bar, even though he was going over it. Picture him flopping: at first, only his head was over the bar, then only his torso (with his arms and legs under) and finally, only his legs were over. At no time was most of his body over the bar; his centre of gravity stayed under the whole time.

Figure 6.26 Dick Fosbury changing his centre of gravity
6.0 Chapter Review
Assess Your Learning

Key Concept Review
1. Describe the relationship between manufacturers and consumers.
2. Use the basic steps in the lifespan of a product to trace the development of a new type of water bottle.
3. Why do manufacturers take consumer preferences seriously?
4. Write a short paragraph that shows how these words relate to one another: consumer, market research, advertising.
5. Which of the following statements are true and which are false? Rewrite the false statements to make them true.
   (a) Many products are sent to the landfill, even when they are in usable condition.
   (b) Technology is never used when gathering market research.
   (c) A well-designed product is unpleasant to use.
   (d) Eventually, all products end up in landfills or are recycled into other products.
   (e) If you choose products that need less energy to manufacture, you are increasing your impact on Earth.

Connect Your Understanding
6. The lifespan of similar products can vary greatly. Some items, such as a special piece of furniture or china, have been handed down for generations, while similar items last only a short time. Why might this be?
7. Why should consumers consider the lifespan of structures in order to make responsible decisions? Give an example of a time you have considered (or would consider) the lifespan of a structure before making a purchasing decision.
8. How can the desire to minimize the impact on the environment influence buying decisions?
9. What role(s) can consumers play in ensuring that green choices are available?

Achievement Chart Categories
Knowledge and understanding
Thinking and investigation
Communication
Application
10. Sometimes the “greener option” is not always obvious. What would you need to think about when deciding if it is better to:
(a) use cloth or disposable diapers?
(b) buy plastic or cardboard containers for storing items?
(c) use a product that lasts several years and then has to be sent to the landfill or a similar product that lasts half the time but can be composted or recycled?

11. (a) What do you think consumers can do to encourage manufacturers to produce “greener” products?
(b) Some would say that this is only part of the solution and that consumers need to learn to live less materialistically. What do you think?

12. A family you know is thinking about buying a new washing machine. Suggest three questions they should ask to ensure that they make a wise choice.

**Practise Your Skills**

13. If you could modify a pen to be sold to students your age, what modifications would you make and why? Draw a labelled diagram to show these changes. What key points would you emphasize in an advertisement?

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

**What’s in a Bag?**

These days, many purchases are carried home in plastic bags. However, plastic bags take a big toll on the environment. They take a long time to break down and can also harm animals that try to eat them.

**What to Do**

1. Estimate the number of plastic bags your family takes home in a week.

**Consider This**

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

2. When you are shopping, when do you need to use a plastic bag? When could you make do without one?

3. What alternatives to plastic bags are being offered? Who is offering these alternatives?

4. What are the drawbacks to using plastic bag alternatives? Suggest solutions to these drawbacks.

5. Challenge your family to reduce the number of plastic bags it uses by considering other alternatives.
### 4.0 Designers consider the form and the function of a structure and the forces that act on it.

**KEY CONCEPTS**
- Every structure can be described and classified.
- Forces act on structures.
- Structures need to be designed with safety in mind.

**CHAPTER SUMMARY**
- Structures can be classified by their function.
- Structures can be classified by their form as solid, frame, or shell structures.
- Internal and external forces act on structures.
- Designing a structure requires an understanding of the forces and loads that act on it.

### 5.0 Good design, materials, and construction make structures stable and strong.

**KEY CONCEPTS**
- Structural strength is affected by many factors.
- Good design involves many elements.

**CHAPTER SUMMARY**
- Structural shapes, structural components, and structural materials are the main things to consider for structural strength.
- The centre of gravity of a structure affects its stability.
- Structural stress, fatigue, and failure affect structures.
- Designers must ask themselves questions about the elements of design throughout the design process.
- Some of the questions have definite answers. Others are a matter of personal taste.

### 6.0 The lifespans of structures need to be considered in order to make responsible decisions.

**KEY CONCEPTS**
- Manufacturers and consumers have responsibilities.
- The lifespan of a product can be traced.
- Decisions made about structures can affect the environment.

**CHAPTER SUMMARY**
- Manufacturers determine consumer need by using market research, and try to influence consumer thinking with advertising.
- Being a wise consumer involves identifying personal needs and wants.
- The lifespan of a product might include planned obsolescence.
- Product disposal should be a factor in buying decisions.
- Conserving energy in each phase of the lifespan of a product, from idea to disposal, affects Earth positively.
- Modifying their personal behaviour to reduce their impact on Earth is the responsibility of every citizen.
Everything Old Can Be New Again

Getting Started
Many of our buildings — our homes, schools, and offices — are getting older. When they were constructed, the cost of energy was not a concern. Designers chose the technology and materials based upon how the building should look, not how it should conserve energy. Many older buildings are poorly insulated or have inefficient electrical systems.

However, in today's world, energy conservation is crucial. Can we make our older buildings more energy efficient? Creative ways to renovate aging buildings will lessen their impact upon the environment.

Your Goal
You will design and build a prototype (or a model) of a structure that could lessen the environmental impact of your home or school. Choose one of the following three options.
- Modify an existing structure to make it work more efficiently.
- Invent the next great "green" invention!
- Do research and build a model of a recent innovation that is not yet used widely.

What You Need to Know
Consider your own home, apartment building, or school. Think of how you could lessen its environmental impact. Think of some things you might design and build, or some things you might modify, to achieve your goal of greener living.

Steps to Success
1. With a small group, tour a home or your school. Outside, examine the architecture, the materials, and the surrounding property. Inside, look in the rooms, hallways, and other features. Make a list of any ideas you have to improve the energy efficiency of the building. This is the brainstorming stage, so the more ideas, the better!
2. With your group, pick one idea that you think would efficiently lessen the environmental impact of the building.
3. Talk about the materials you will choose. Will you build a model or a working prototype?
4. Construct your prototype or model. Follow the safety rules you have learned in this unit.
5. Test and evaluate your final product.

How Did It Go?
6. Are there any safety concerns related to either the construction or the testing of your structure?
7. How could you improve upon your model or prototype? What materials would you use if money were not an issue?
8. If you were designing for an actual structure, who might be opposed to the use of your idea? Why might they be concerned?
9. How environmentally friendly are the building materials?
10. Consider the lifespan of your product. Will this be a long-term investment?
11. In your whole class, combine all ideas that are best suited to homes. Form a committee to write a report that lists and explains each structure. Include digital pictures of each structure. Predict what the total energy savings might be if all of the innovations were installed in a single home.
12. Form a second committee to write a report related to the structures that are best suited to your school. Present this report to the principal and custodian of your school. Have all of the structures available for viewing. Record their feedback in a report response.
Key Terms Review

1. Create a word web that illustrates your understanding of the following terms.
   • centre of gravity
   • consumer
   • failure
   • fatigue
   • force
   • frame
   • function
   • lifespan
   • load
   • magnitude
   • manufacturer
   • market research
   • product recall
   • prototype
   • shell
   • solid
   • stress
   • structural components
   • structure
   • symmetry

2. Explain how you find structures all around you by making a list of eight indoor structures and eight outdoor structures. Describe the form and function of each.

3. Describe the types of forces that can affect structures. Explain how designers consider these effects in their designs.

4. Describe how designers minimize the risk of failure in structures.

5. Some structures are designed to support small loads, and other structures are designed to support large loads. How are these types of structures similar, and how are they different?

6. Why might structures that serve the same function have very different forms?

7. Sketch the illustration in your notebook and label the dynamic load(s) and the static load(s).

8. Using mainly diagrams, describe three different types of internal forces.

9. No structure can be designed to be 100% failure proof. How might a designer decide that a structure is “safe enough”?

10. Describe and then relate the terms “centre of gravity” and “stability.”

11. Why do manufacturers issue product recalls, even when they know that they can cost their business millions of dollars?

12. List the structural components that you see in the photograph.

13. Describe three structures that include triangular shapes in their design. Why did the designers use triangles rather than rectangles?

14. Explain how each of the following contributes to structural strength. Describe how all of these factors relate to the design and construction of a bridge.
   (a) structural shapes
   (b) structural components
   (c) structural materials
15. Which of the following statements are true and which are false? Rewrite the false statements to make them true.

(a) The design for a structure is related to its function.

(b) Good structures consider the dynamic loads only.

(c) All materials are the same when it comes to cutting and joining them.

(d) Ergonomics can be thought of as the science of people-structure relationships.

(e) A prototype is the last product to be manufactured.

16. Explain why the concept of aesthetics in design is a personal one.

17. Symmetry can add to structural stability. Explain why this is so. When might this be desirable? When would it not be desirable?

18. Think about each element of good design. Make a chart with the headings “Element” and “Connection to Stability or Strength.” For each element, describe how strength and stability might factor into the designer’s thinking.

19. Compare the thinking of a wise consumer with one who is not so wise.

20. Why is it difficult to design and build a structure that will last forever?

21. How are designing, building, buying, and disposing of structures related to the use of energy?

22. In order to make responsible decisions, why should you consider the lifespan of structures?

23. Describe the reasons to conduct market research.

24. Describe a building in which you have observed the principles of universal design in use.

(a) What was the form of the design?

(b) How did the form affect the function of the building?

25. What are the pros and cons of “planned obsolescence”?

26. List three choices you have made in the past week that reflected a “greener option.”

27. How could you be encouraged to make even more “greener options”?

28. Describe which parts of the following “combination structures” are solid, frames, and shells.

(a) MP3 player

(b) umbrella

(c) car

(d) house

(e) canoe

(f) human body

29. Consider the items listed in question 28 (a) to (c). How is each structure designed for safety?
30. Compare the different chairs you sit on at school (lab stool, chair, gym bench) in terms of centre of gravity and stability.

31. List the different types of material that clothing and shoes can be made from. What are the trends in the relationship between the type of material and the type of clothing or shoe?

32. Think of something you are using right now. It could be this textbook, your binder, or your pen. How could you extend the lifespan of this product?

33. What products that you use have the shortest and longest lifespans? How might these lifespans be altered in length?

34. Using your knowledge of the concepts in this unit, what do you think is the best type of structure to do the following tasks? Explain why for each one.
   (a) hold up a large mass
   (b) span a gap
   (c) act as a container

35. You have been asked to design a riding toy for a small child. How would you decide what materials and methods of construction to use? How might you modify the design to make it more suitable for an adult? Use diagrams to show your ideas.

37. Pick one of the building activities you did in this unit and re-do the activity with different materials, different shapes, or different structural components to increase the structure's efficiency.

38. Consider how manufacturers listen to consumers. Write a letter to the manufacturer of a product that you think could be improved to lessen its impact on Earth.

39. Your class is going to have a building competition to see who can build the strongest bridge out of craft sticks and glue. Prepare a handout sheet with instructions and criteria for success for this competition.

40. The environmental club at your school has been given funding to build some seating in the yard for an outdoor classroom. You can use concrete or wood to build the seating. Create a chart that demonstrates the strengths and weaknesses of each choice. How would you make the final decision?

Revisit the Big Ideas

41. Give possible functions for each of these descriptions of form.
   (a) a large piece of glass in the shape of cylinder with a bottom but no top
   (b) a soft piece of foam covered in fabric
   (c) a hard, heavy hunk of metal in the shape of a dog
   (d) a reflective piece of material in a flat, rectangular shape

Practise Your Skills

36. If you had to redesign something in your home to increase its safety, what would it be? Why do you think it needs to be improved? How would you redesign it?
42. Make up four more descriptions of form to share with a partner.

43. The form of a structure depends on its function. Study the photographs and explain how you think the forms of these buildings relate to their functions.

44. You have installed a new bookshelf in your room. How might you monitor it to make sure that the structure is standing up to the forces it experiences?

45. As you walk down the street, you notice a small crack in the sidewalk. How might the crack change if it were left over a long period of time? Would the season make any difference to your answer?

46. In what types of structures (if any) would you consider:
   (a) form more important than function?
   (b) function more important than form?

47. Building and maintaining structures such as roads and bridges is a continuous task. Discuss why this statement is true using the terms “forces,” “structures,” and “interactions.”

Question 43 Left: The addition to the Royal Ontario Museum was built to house artifacts. Right: The Ontario College of Art and Design is a school for future artists and designers.

**B53 Thinking about Science, Technology, Society, and the Environment**

**Structures and You**

When you design, modify, choose to buy, and dispose of structures, you are using science and technology. Your decisions about these issues can impact society and the environment.

**What to Do**

1. Pick a structure you use every day.
2. Think of a way to reduce your impact on society and the environment by changing how this structure was designed and modified, and how you choose it and dispose of it.

**Consider This**

3. Share your plan with a classmate.
4. Make a plan to meet in the near future and a little farther in the future to check on each other’s progress.
5. Meet to celebrate your success or modify your plans as necessary.