5.0 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

Thinking Literacy

K-W-L Chart

Make a three-column chart with the headings "What I **K**now," "What I **W**onder," and "What I **L**earned." 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

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

5.0 Getting Started

Figure 5.1 Your classroom has many structures that are made of different materials and held together by different fasteners.

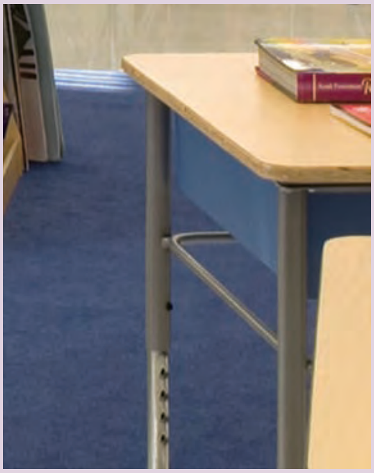


Figure 5.2 The desk leg is welded to the horizontal bar, and the length of the leg can be adjusted with a bolt.

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.

Figure 5.3 These beads are strung together with wire.

Figure 5.4 Book pages are sewn together with thread, then glued into the binding.

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?

5.1 Stabilizing Structures

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

- A structure is stable if forces are balanced.
- Unbalanced forces can cause stress and fatigue in structures.
- Proper materials can be used to stabilize structures.
- Building techniques can be used to stabilize structures.

Figure 5.5 When the shelf looks bent, it is under stress.

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.

B23 *Starting Point* Skills A C

The Tipping Point

Hold your arms out in front of you at chest level, palms up, making a platform with your arms. Have a classmate put one textbook on your arms near your palms. Do you feel a slight urge to put your arms down? Have the classmate put another textbook on top of the first. Is the urge stronger? How many textbooks do you think you could support like this? In the end, would adding just one book cause you to drop all of the books? What if your classmate stopped at two textbooks? How long do you think you could hold your arms up?

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).

Figure 5.6 Some structures last thousands of years while others do not.

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.

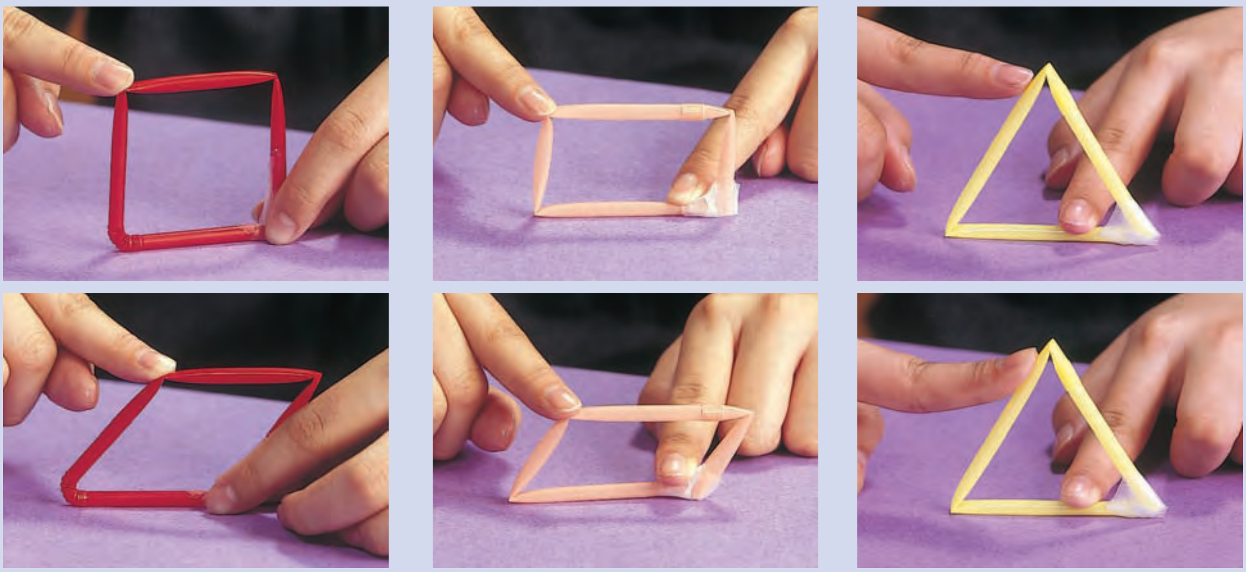
B24 *Learning Checkpoint*

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?



(a) (b) (c)

Figure 5.7

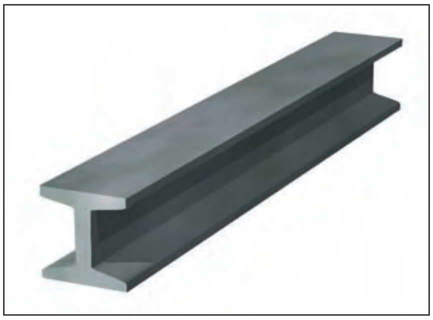
Structural Components

Suggested Activity
B27 Inquiry Activity on page 138

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.

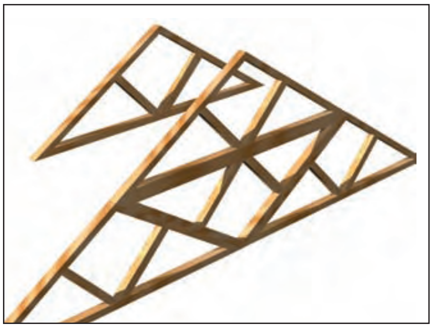
Figure 5.8 Structural components

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.

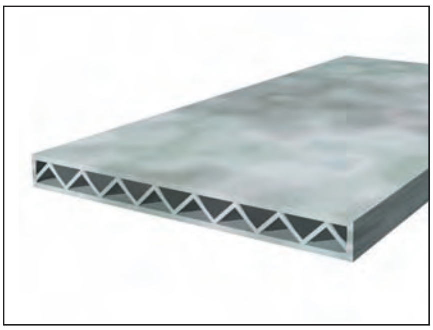


A **truss** is a rigid framework of beams joined together. Trusses are usually in the form of interlocking triangles.

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.

Figure 5.9 The Hockey Hall of Fame in Toronto

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.

Take It ***Further***

Wood is an important building material. It is renewable if managed properly and can be used for many different structures. Recently, bamboo, a type of grass, has become a popular building material. Find out more about its advantages and disadvantages. Begin your search at ScienceSource.

Suggested Activity

B26 Quick Lab on page 137

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.

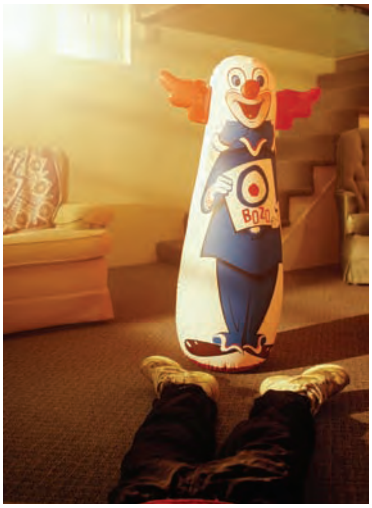


Figure 5.11 The clown falls over when you punch it, but returns to its upright position quickly. The clown did not really knock the person down!

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

Figure 5.14 This old house shows structural fatigue. However, it may take several more wind storms before it fails completely.

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).

WORDS MATTER

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

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.

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* — Thinking Literacy

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.

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

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.

B26 Quick Lab

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?

B27 *Inquiry Activity* Toolkit 2

SKILLS YOU WILL USE
- Designing a fair test
- Recording and organizing data

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.

Table 5.1 Results of Components Test

Name of Component	Sketch	Results

Part 2 The Materials

5. Choose one of the components you tested above.
6. Build the componenet 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

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

Practise Your Skills

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.

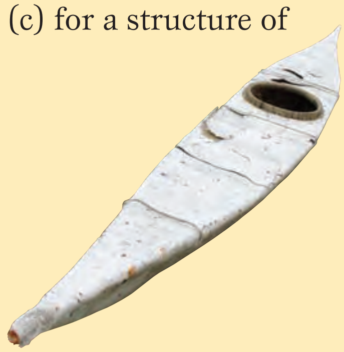


Figure 5.17

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.

5.2 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.

B29 *Starting Point*

Skills A C

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.

Suggested Activity •
B33 Problem-Solving Activity on page 145

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.

Take It Further

After a designer or an inventor designs a new structure, he or she applies for a patent. The patent is a legal document that says that the inventor owns the idea and can sell it. Find out about patents. Start your search at ScienceSource.

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).

Figure 5.20 This keyboard has an ergonomically designed wrist support. It helps prevent repetitive strain injury.

Figure 5.21 This boy controls his computer by moving his head from side to side.

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).

Figure 5.22 What is aesthetically pleasing to one person may not be to another.

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.

B30 *During Reading*

Thinking Literacy

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).

Figure 5.23 The line of symmetry divides the object into two equal halves.

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!

WORDS MATTER

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

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.

B32 *Quick Lab*

Supporting a Load

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).

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

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?

B33 *Problem-Solving Activity* Toolkit 3

SKILLS YOU WILL USE
- identifying possible solutions
- carrying out a plan

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.

5.2 CHECK and REFLECT

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.

Connect Your Understanding

5. Think about the structures you use every day. Which structure do you think is an example of good design? Which structure is an example of poor design? What design question(s) do you think the designer could have answered better?
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.

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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

Figure 5.25 Beth Anne Currie

Beth Anne Currie works for Canadian Partnership for Children's Health and the Environment (Figure 5.25). In her role as a children's environment and health consultant, she works to protect children from exposure to environmental contaminants. Her specialty is the design and marketing of green roofs and living walls. These elements can improve the environmental conditions for people who live in cities.

This is a long way from — but connected to — Currie's start as an emergency room nurse. She helped people then and still does. After working through a water-borne disease outbreak, she decided to go back to university to study the environment.

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?

5.0 Chapter Review

Assess Your Learning

Key Concept Review

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

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

3. (a) Explain why knowledge about the centre of gravity of structures is important to designers. (k)

   (b) How does changing the location of the centre of gravity of a structure affect it? (k)

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

5. Explain how each of the following affects the strength and stability of a bicycle. (a)

   (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? (t)

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

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

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? (t)

After Reading — Thinking Literacy

K-W-L Review

At the beginning of this chapter, you created a K-W-L chart. Now that you have completed the chapter, take a few minutes to record information in the "What I Learned" column. You probably have more questions too. Write at least three more things you would like to learn more about. Make a plan for how you could find out more about each of these things.

ACHIEVEMENT CHART CATEGORIES

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

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?

Unit Project Link

As you think about what you would like to design to improve your home's energy efficiency, consider the role of stability in your structure. Review the elements of good design as you consider each of your ideas. Can you make use of other designers' ideas to help you with your decisions?

B35 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.