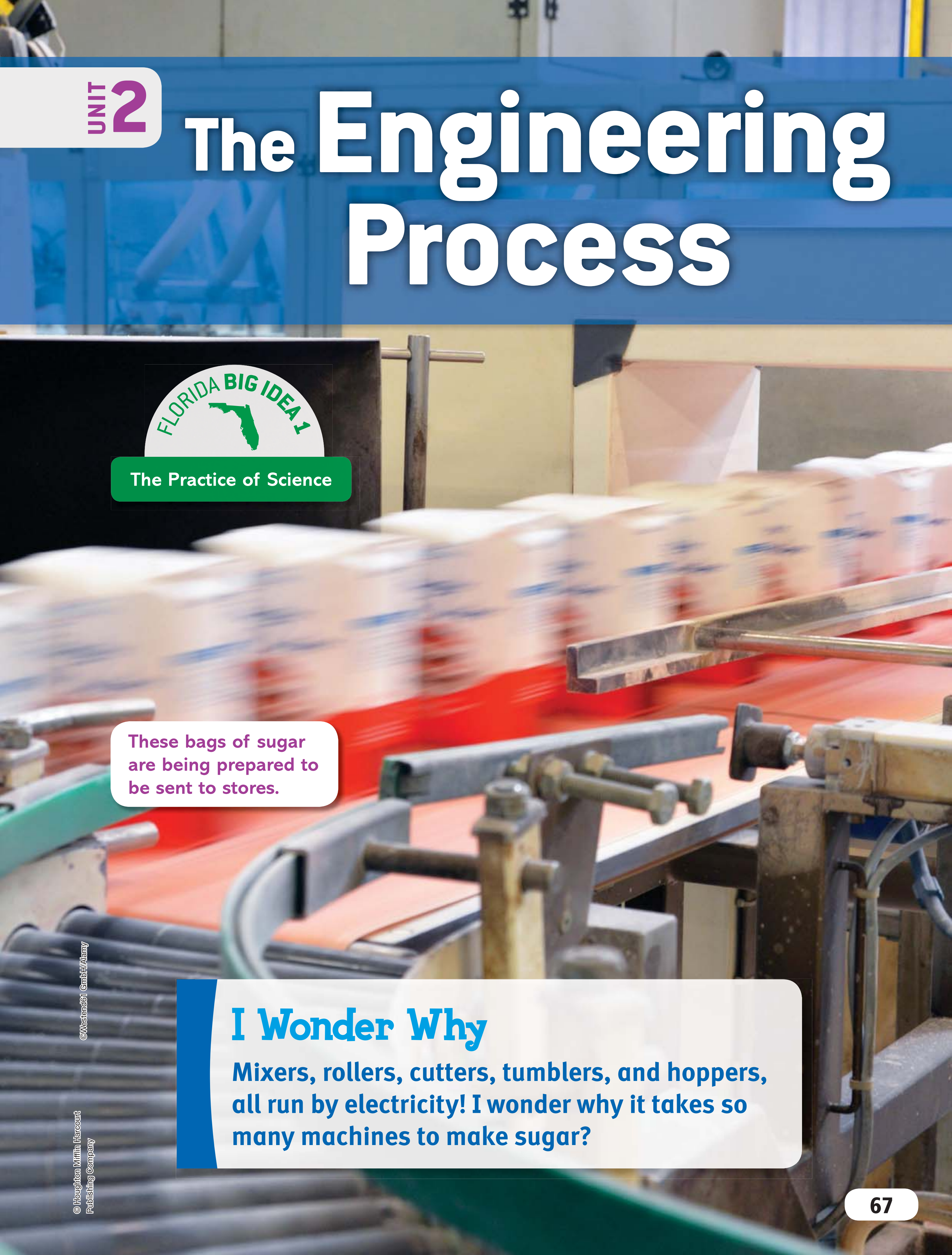
UNIT 2

The Engineering Process

FLORIDA BIG IDEA 1

The Practice of Science



These bags of sugar are being prepared to be sent to stores.

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I Wonder Why

Mixers, rollers, cutters, tumblers, and hoppers, all run by electricity! I wonder why it takes so many machines to make sugar?

Here's Why

Food processing relies on technology. Machines produce treats that always have the same taste, color, smell, and size. When you buy sugar, you know exactly what you're getting!

Essential Questions and Florida Benchmarks

Science Notebook

Before you begin each lesson, write your thoughts about the Essential Question.

SC.5.N.1.1 Define a problem, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigations of various types such as: systematic observations, experiments requiring the identification of variables, collecting and organizing data, interpreting data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions. **SC.5.N.1.5** Recognize and explain that authentic scientific investigation frequently does not parallel the steps of "the scientific method."

LESSON 1

ESSENTIAL QUESTION

What Is the Design Process?

Engage Your Brain

Find the answer to the following question in this lesson and write it here.

What are the steps for designing technology such as the robot arm you see here?

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ACTIVE READING

Lesson Vocabulary

List the terms. As you learn about each one, make notes in the Interactive Glossary.

______________ ______________

______________ ______________

Problem–Solution

Ideas in this lesson may be connected by a problem–solution relationship. Active readers mark a problem with a *P* to help them stay focused on the way information is organized. When multiple solutions are described, they mark each solution with an *S*.

Works of Ingenuity

Did you brush your teeth this morning? Did you run water from a faucet? Did you ride to school in a car or bus? If you did any of those things, you used a product of engineering.

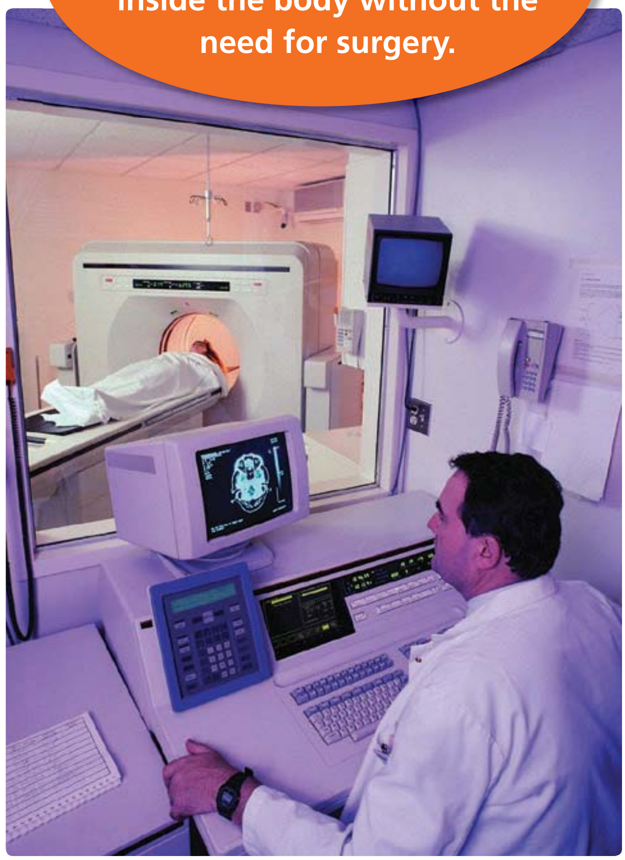
ACTIVE READING As you read these pages, underline the names of engineered devices.

Engineered devices, such as computers, help us solve many problems. Engineers use computers and hand-drawn diagrams to plan their designs.

Engineers are problem solvers. They invent or improve products that help us meet our needs. Engineers use their knowledge of science and mathematics to find solutions to everyday problems. This process is called **engineering**.

From the start of each day, we use the products of engineering. Engineered devices are found all around us. They include simple tools and complex machines.

Engineers work in many fields. Some design and test new kinds of materials. Some work in factories or on farms. Others work in medical laboratories. Engineers also design the engines that may one day fly people to Mars!



Devices like this CT scanning machine allow doctors to see inside the body without the need for surgery.

Sometimes engineers design devices with many purposes in mind.

Engineering Diary

List some of the engineered devices you use every day. Explain the need that each device meets.

Device	Need

The Right Tool for the Right Job

When you see or hear the word *technology*, you may think of things such as flat screen TVs, computers, and cell phones. But technology includes more than just modern inventions.

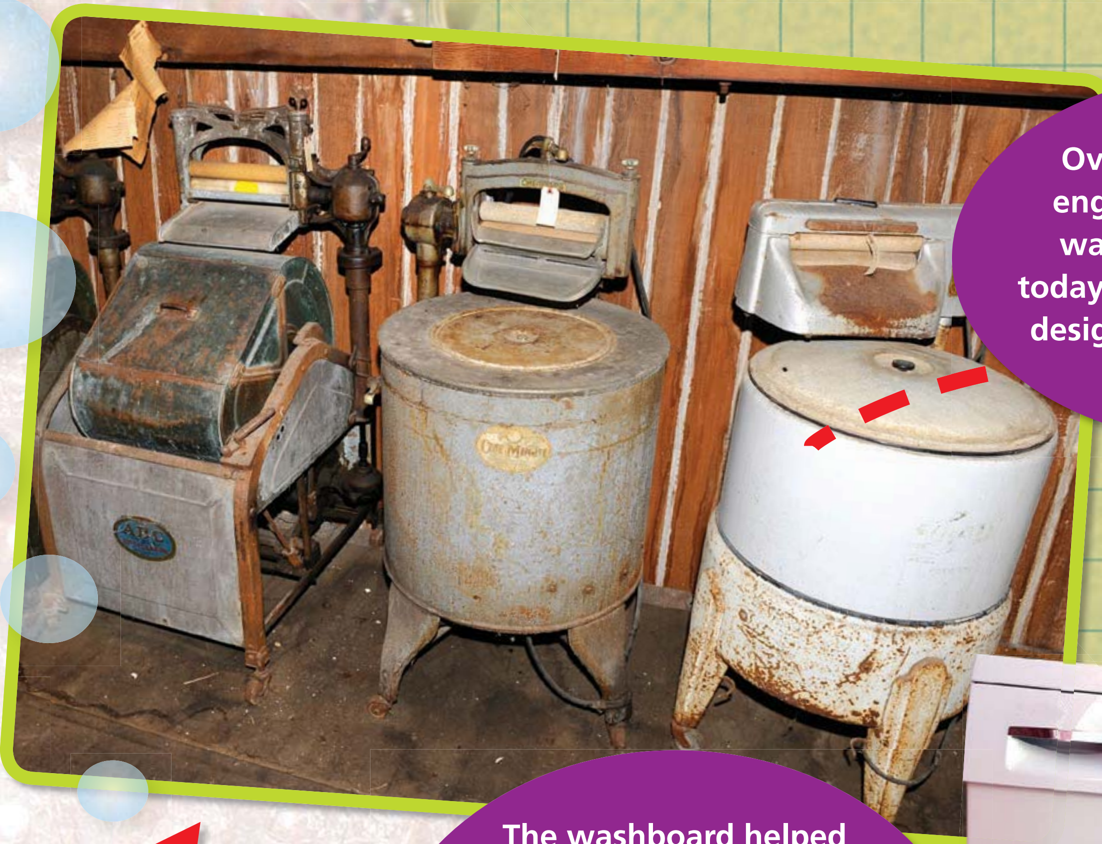
ACTIVE READING As you read these two pages, underline sentences that describe how technology affects our lives.

Stone tools, the wheel, and candles were invented a long time ago. They are examples of technology. **Technology** is any device that people use to meet their needs and solve practical problems.

Technology plays an important role in improving our lives. Tools and machines make our work easier or faster. Medicines help us restore our health and live longer. Satellites help us predict weather and communicate.

Technology changes as people's knowledge increases and they find better ways to meet their needs. For example, as people's knowledge of materials increased, stone tools gave way to metal tools. As people learned more about electricity, washboards and hand-cranked washing machines gave way to electric washers.

Centuries ago, many people washed their clothes on rocks in a river. The invention of the washboard allowed people to wash their clothes at home.



Over the past 150 years, engineers have improved washing machines. Even today, new washers are being designed to work faster and more efficiently.

The washboard helped make washing clothes easier, but it was still hard work. In the 1800s, engineers designed machines that could be filled with water and had a hand-cranked wringer to wash the clothes. The wringer made getting the water out of the clothes easier.

▶ **Complete this table to tell how the washing machines shown here are alike and different.**

Similarities	Differences

The Design Process (Part 1)

Technology is all over—video games, 3D TVs, microwaves. But technology doesn't just happen. It comes about through a step-by-step process.

ACTIVE READING As you read these pages, bracket sentences that describe a problem. Write *P* in the margin. Underline sentences that describe a solution. Write *S* by them.

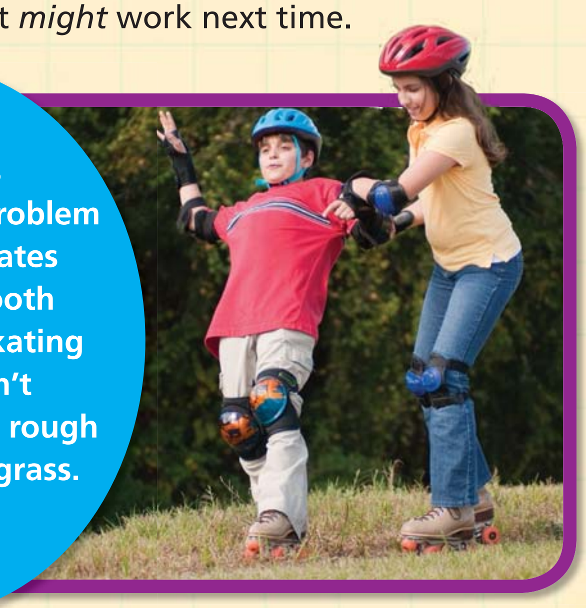
When engineers design new technologies, they follow a *design process.* The process includes several steps. Here's how the process starts.

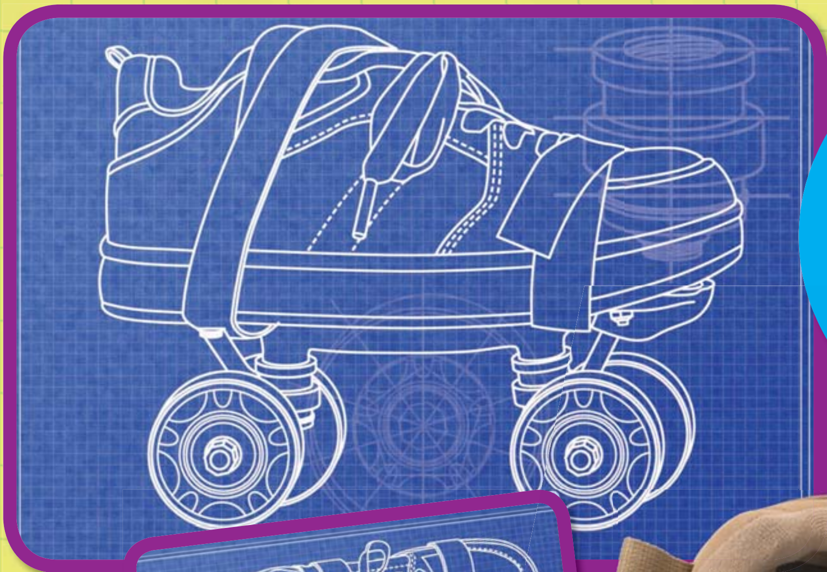
1. Find a Problem Engineers must first identify a need, or a problem to be solved. They brainstorm possible solutions. There may be more than one good solution.

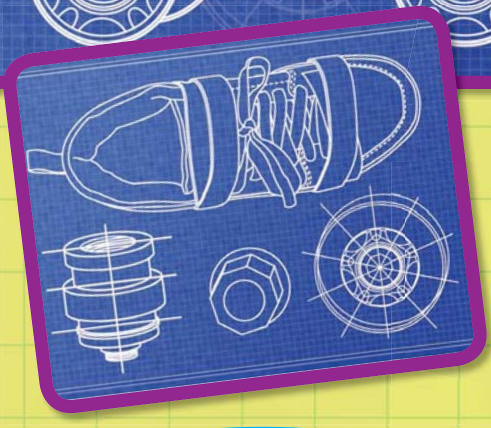
2. Plan and Build Engineers choose the solution they think is most practical. They build a working model, or **prototype**, to test.

Throughout the design process, engineers keep careful records. Good records include detailed notes and drawings. Records help them remember what they have done and provide information to others working on similar problems. If the prototype doesn't work, the records can provide clues to a solution that *might* work next time.

The design process begins with finding a problem to solve. Roller skates work great on smooth surfaces, like the skating rink floor. They don't work very well on rough surfaces such as grass.







Engineers make detailed drawings for their prototypes, as well as notes about the materials they plan to use. The notes and drawings are a record that they can study as they build and make changes to the prototype.

Engineers use their notes and drawings to build the first prototype. This prototype is a skate that is designed to work on rough surfaces.

Problem Solved!

The first step in the design process is identifying a problem and thinking up solutions. Complete the table with a problem or a solution.

Problem	Solution
Cord for the computer mouse keeps getting tangled	
	Watch face that lights up
	Hand-held electronic reader
Injuries in car crashes	

The Design Process (Part 2)

Do you get nervous when you hear the word *test*? A test is a useful way to decide both if you understand science and if a prototype works.

ACTIVE READING As you read these two pages, draw boxes around clue words that signal a sequence or order.

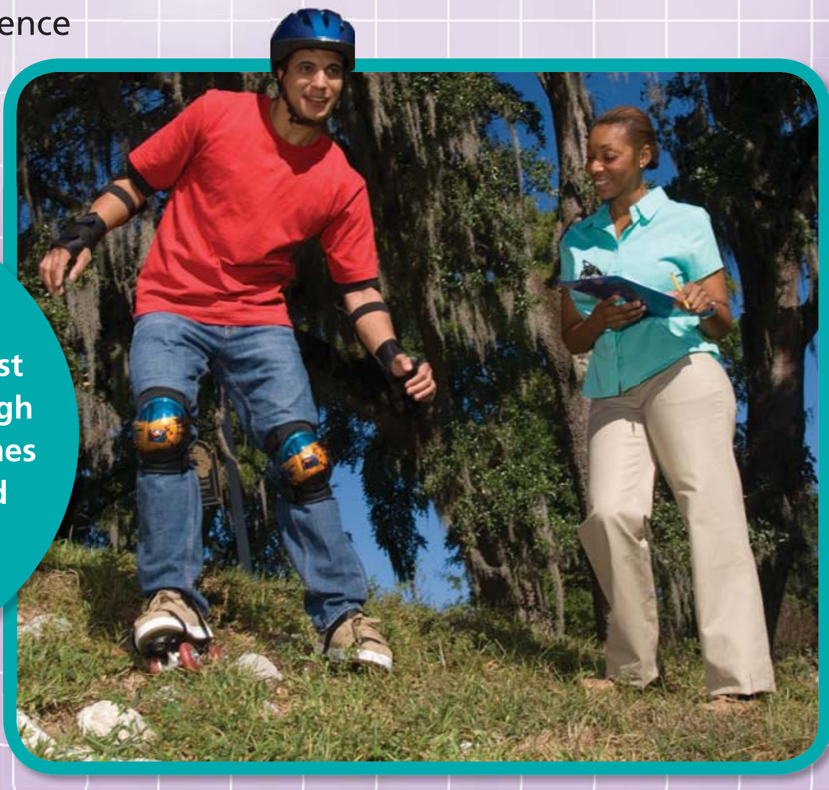
The skate designers are steadily working through the steps of the design process. They have found a problem and built a prototype. What's next?

3. Test and Improve After engineers build a prototype, they test it. **Criteria** are standards that help engineers measure how well their design is doing its job. The tests gather data based on the criteria. The data often reveal areas that need improvement.

4. Redesign After testing, engineers may decide that they need to adjust the design. A new design will require a new prototype and more testing.

A prototype is usually tested and redesigned many times before a product is made on a large scale and sold to consumers.

5. Communicate Finally, engineers communicate their results orally and in written reports.



Engineers use criteria to test a prototype. They may gather data on how fast someone can skate on a rough surface or the number of times the person falls. Speed and safety are two criteria in the test you see here.

The design is modified if it doesn't meet all criteria. An unsafe design will be reworked even if the design meets all other criteria. The engineers focus on improvements. They revise their drawings and keep notes on design changes.

This is the redesigned skate. It has larger wheels that work better on rough surfaces. The skater can skate faster for longer distances without falling.

DO THE MATH

Solve a Problem

Engineers tested a wheel that was 100 mm in diameter. Then they tested a wheel that was 15% larger.

Convert 15% to a decimal.

____

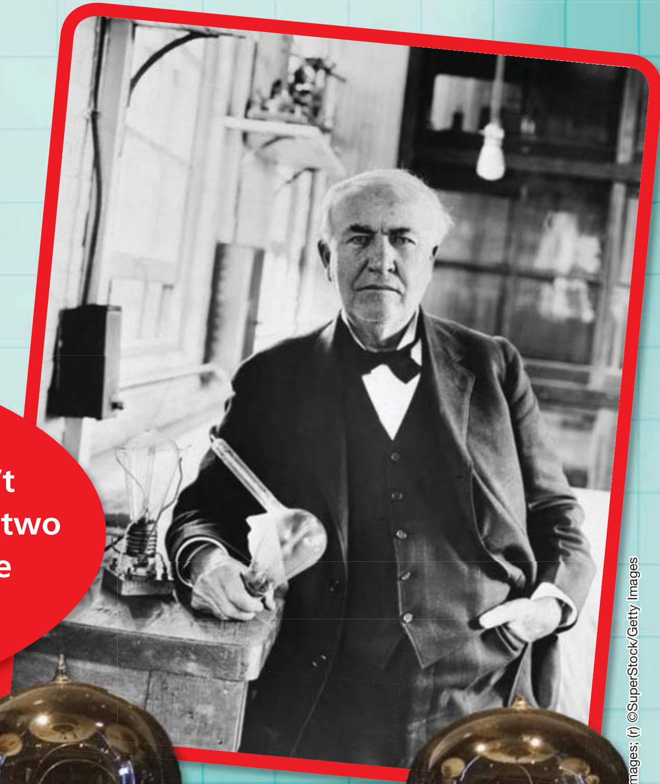
What is the size of the larger wheel?

____

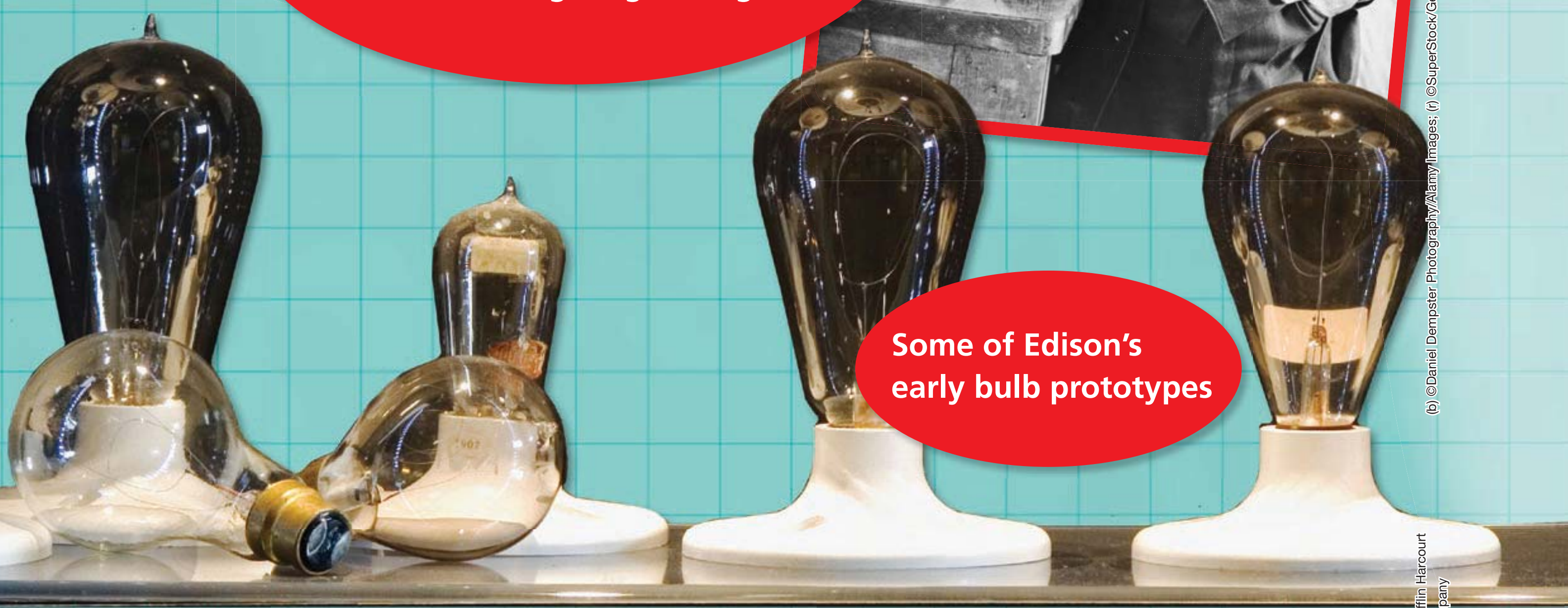
If At First You Don't Succeed...

Suppose Thomas Edison asked himself, "How many times must I make a new prototype?" What do you think his answer was?

Many things affect how long it takes to reach the final product for new technology. The kinds of materials needed, the cost, the time it takes to produce each prototype, and safety are just some of the criteria engineers consider.



Thomas Edison tried 1,000 times to develop a light bulb that didn't burn out quickly. It took him nearly two years to develop a bulb that met the criterion of being long-lasting.



Some of Edison's early bulb prototypes

Cars must pass crash tests before they can be sold to the public.

Cars of the future may look different or run on fuels different from those of today. Years of testing and redesign occur before a new car is brought to market.

Finding materials that work well affects the design process. Edison found that the materials used to make light bulbs must stand up to heat.

Some technologies cost a lot of money to develop. For example, prototypes for many electronic devices are expensive to build. The cost of building the prototype, in turn, affects the cost of the final product.

It may take many years to develop new cars, because they must undergo safety and environmental testing. Environmental laws limit the pollutants that a car may release and determine the gas mileage it must get.

Criteria Match Up

Draw a line from the technology to criteria that must be considered during the design process.

Technology	Must Be Considered
Hydrogen car	Lightweight, sturdy
Laptop computer	Finding fuel
Bicycle	Portable, long battery life

Sum It Up »

In the blanks, write the word that makes the sentence correct.

engineering	technology

1.The things that engineers design to meet human needs are ______________

2. ________________is the process of designing and testing new technologies.

3.Toothbrushes, washing machines, and computers are examples of ___________

4.________________uses math and science to test devices and designs.

Fill in the missing words to explain how engineers conduct the design process. Use the words in the box if you need help.

communicating	engineering	keep good records
needs	problem	prototype

5. ________________ is the use of science and math to solve everyday problems. Engineers invent and improve things that meet human 6. ________________. The design process that engineers follow includes finding a 7. ________________, building and testing a 8. ________________, and 9. ________________ results. During each step of the design process, engineers 10. ________________.

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Brain Check

Name ____________________

Vocabulary Review

1 **Beside each sentence, write *T* if the sentence is mostly about using technology. Write *E* if the sentence is mostly about the engineering design process.**

____ 1. Sarah sent a text message to Sam on her cell phone.

____ 2. The nurse used a digital thermometer to measure the patient's temperature.

____ 3. Henry tested three brands of blender. He wanted to see which one made the creamiest smoothies.

____ 4. Workers at the factory use machines to bottle spring water.

____ 5. Jessica invented a better mousetrap. She patented her invention.

____ 6. Eli used math to figure out how much weight a bridge could hold.

____ 7. The nurse is using a new x-ray machine.

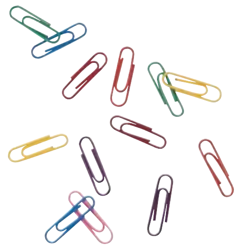
____ 8. Mayling is designing a refrigerator that uses less electricity.

____ 9. Guillermo's new snowblower makes snow removal faster and easier.

____ 10. Laptop computers are designed to be smaller, lighter, and easier to carry.

Apply Concepts

2 **Match the picture of the technology to the need it fulfills. Draw a line from the picture to the matching need.**



go to school

get up on time

see clearly

make a cake

fix a broken bone

keep papers together

3 **Write the missing words in the sentences below. Use the word box if you need help.**

brainstormed	**good records**	**problem**	**prototype**

Jeremy had a ________________ that he wanted to solve—his go-cart was too slow. Jeremy and his friend Todd ________________ ideas to make it faster. Together, they designed a ________________ and tested it. They kept ________________ that showed that the go-cart really was faster.

4 Circle the words or phrases that are criteria for designing skates that will be safe. Cross out those that are ***not*** criteria for safety.

roll smoothly

brake easily

come in different styles

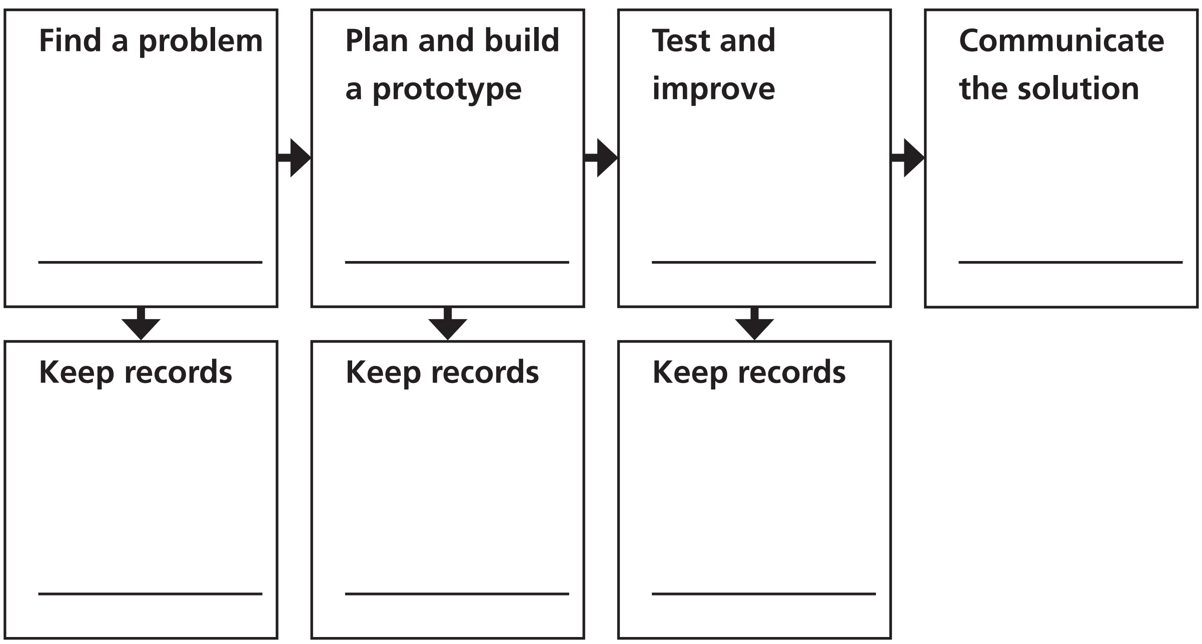
fit snugly

come in different colors

sturdy

5 Look at the flow chart showing the steps of the design process. Then read the list of steps for designing a thermos. These steps are not in order. Write the letter of each step in the appropriate box of the flow chart.

The Design Process



Steps for Designing a Thermos

A Keep data tables.

B Write a report

C Write down ideas.

D Make drawings.

E Measure the temperature inside the container.

F Keep hot things hot and cold things cold.

G Use insulating materials to make a container.

6 Sylvia is an engineer. Her friend Martin is an artist who paints with oil paints. Martin tells Sylvia that cleaning oil paint out of brushes takes a lot of time. It's messy, too. Write three or more sentences explaining what Sylvia would do to engineer a solution to Martin's problem.

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____
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____

7 Michaela's grandparents used to have a record player. When they were her age, they listened to songs recorded on vinyl records. Michaela's parents listened to cassette tapes when they were young. Later, they got a CD player. Now, Michaela's family members upload music onto MP3 players.

Explain how these changes are examples of engineering and technology.

____
____
____
____

Take It Home!

See *ScienceSaurus*® for more information about science and engineering.

SC.5.N.1.1 Define a problem, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigations of various types such as: systematic observations, experiments requiring the identification of variables, collecting and organizing data, interpreting data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

Name ____________________

ESSENTIAL **QUESTION**

How Can You Design a Solution to a Problem?

Materials

balance
modeling clay
plastic container with water in it
10 or more pennies
paper towels

EXPLORE

Suppose you wanted to build a raft to carry a heavy load. What would you do? In this activity, you will design and test a model of a raft.

Before You Begin—Preview the Steps

1. Measure 60 grams of modeling clay. Shape the clay into a raft. Test your raft in water. If your raft doesn't float, reshape it until it does.
2. Float your raft on water. Test it to see how much cargo it can hold. Carefully add pennies, one at a time, to your raft until it sinks.
3. In your notebook, sketch a diagram of your raft loaded with pennies.
4. Record how may pennies you added before your raft sank.
5. Find a way to carry more pennies. Try a different design for your raft, or place the pennies in a different way. Test your new design and record your observations.

Set a Purpose

What is the purpose of this investigation?

State Your Hypothesis

Sketch a raft with pennies on it to show what you think will be the best design. Write a brief description of your raft's key features.

Think About the Procedure

What variables can affect the results of this investigation?

Name ______________________________

Record Your Data

In the space below, make a table in which you record your results. Be sure to include information about each raft design and the number of pennies and their placement.

Draw Conclusions

Why did some of your model rafts work better than others?

____

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____

____

Claims • Evidence • Reasoning

1. Sketch a raft design you claim would NOT float. Provide evidence about why it will not float and explain your reasoning.

2. Mary and Sarah built identical raft models. Mary's raft sank after adding only 6 pennies. Sarah's raft held 12 pennies before it sank. Make a claim about a possible reason for the difference.

3. Scientists often build and test models to solve problems. What are the advantages of solving problems in that way?

4. Think of other questions you would like to ask about designing solutions to a problem.

SC.5.N.1.1 Define a problem, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigations of various types such as: systematic observations, experiments requiring the identification of variables, collecting and organizing data, interpreting data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

LESSON 3

ESSENTIAL **QUESTION**

How Does Technology Improve Our Lives?

Engage Your Brain

Find the answer to the following question in this lesson and record it here.

It looks like a map of a city with streets and buildings of all sizes. But all those bumps and lines are actually the "brain" of a computer! How has the invention of technology such as computers changed the way people communicate?

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____

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ACTIVE **READING**

Lesson Vocabulary

List the terms. As you learn about each one, make notes in the Interactive Glossary.

____

____

Cause and Effect

Some ideas in this lesson are connected by a cause-and-effect relationship. Why something happens is a cause. What happens as a result of something is an effect. Active readers look for effects by asking themselves, What happened? They look for causes by asking, Why did it happen?

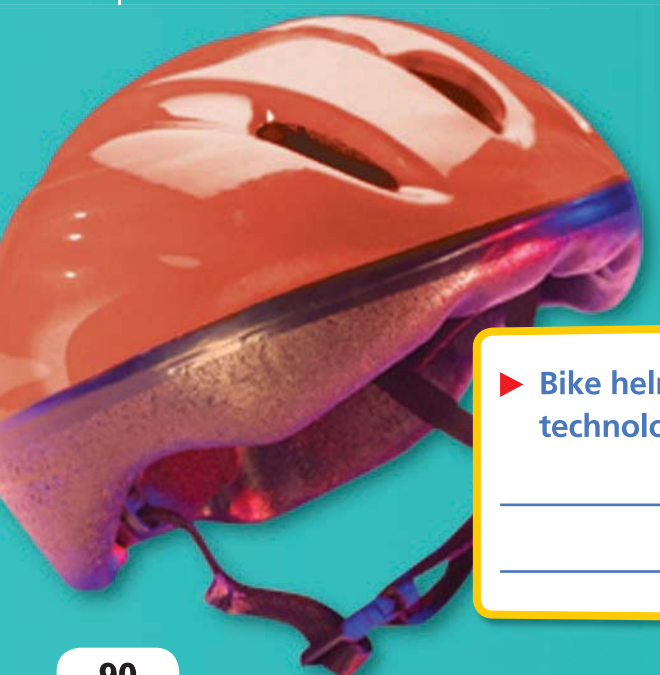
The Technology Zone

Pick up your pencil, and look at it carefully. You are holding technology in your hand.

ACTIVE READING As you read these two pages, draw boxes around the names of two things that are being compared.

Most of the things you use every day are *technology*. Pencils, bikes, light bulbs, even the clothes you wear are technology. Cooking food uses technology. What makes something technology is not how modern it is. Technology doesn't need to be complex or require electricity to operate.

What technology must do is meet a human need. A pencil lets you write your thoughts or work math problems. Think about what needs are being met as you read about the technologies on these two pages. How would you meet those needs without these items?



▶ **Bike helmets and doorknobs are both technology. What need does each meet?**

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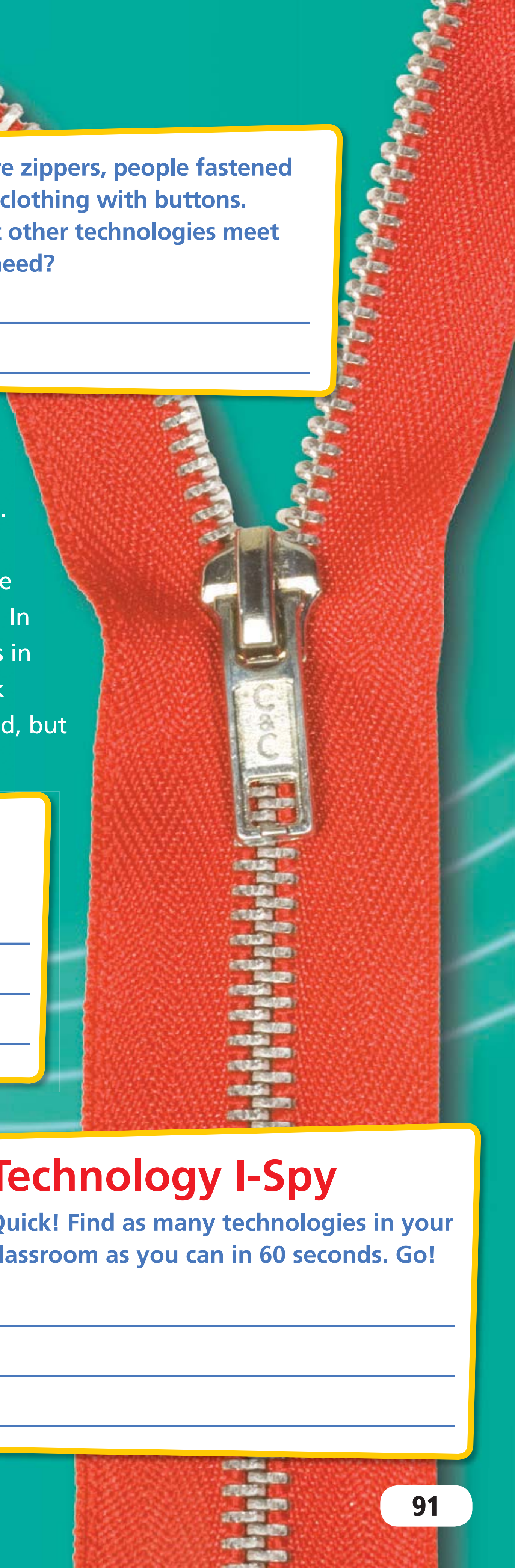
(br) ©Comstock/Getty Images



▶ Before zippers, people fastened their clothing with buttons. What other technologies meet this need?

____

____

The way people meet needs changes with time. Imagine a pioneer kitchen with a fireplace and no running water. Heavy iron pans provided the technology people needed to cook their meals. In a modern kitchen, people can use plastic dishes in microwave ovens to cook their meals or a quick snack. The need to prepare food hasn't changed, but the way people prepare it has.

▶ Some technologies are a lot of fun. What need does this technology meet?

____

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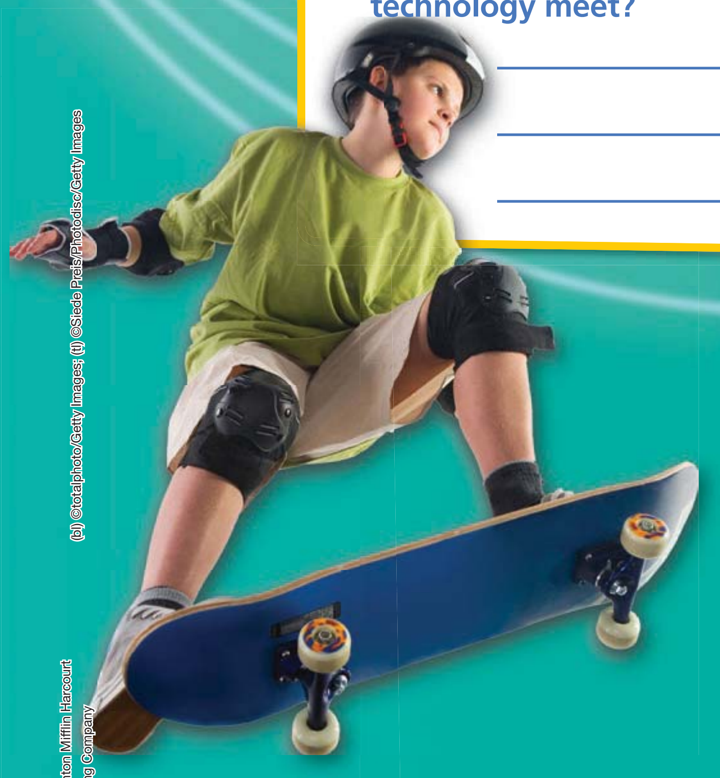

Technology I-Spy

Quick! Find as many technologies in your classroom as you can in 60 seconds. Go!

____

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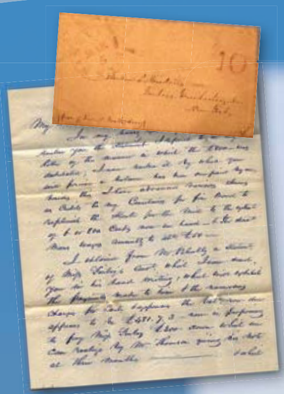
____

Meeting People's Needs

It's 1860. You want to contact a distant friend. Today, you might send a text message. What about then?

ACTIVE **READING** As you read these two pages, draw one line under a cause. Draw two lines under its effect.

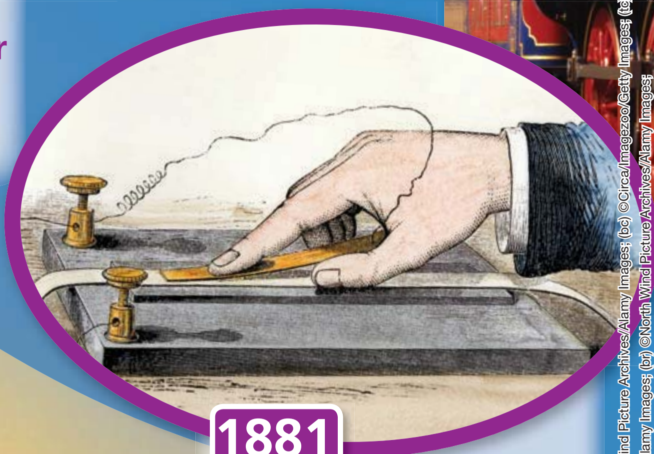


1858

In the early 1800s, long-distance mail was carried by horseback riders, steamboats, and stagecoaches. A stage coach took 25 days to carry a letter 3,000 km (1,700 mi) from St. Louis to San Francisco.

1869

When the transcontinental railroad opened, the time it took to move a letter across the country was cut down to a week or less.



1881

The time it took to send a message across the country was reduced to minutes with the invention of the telegraph.

In the early 1800s, communicating with someone far away might take weeks or months. Sometimes such communications were not possible at all. As people began to move westward across the growing United States, the need for reliable communication increased. The timeline on these pages shows ways technology changed in response to this need.

The time it took to communicate with someone across the country decreased as new technologies developed. What once took weeks, then days, then minutes now happens almost instantly! Today, people text back and forth almost as fast as they can talk in person. E-mails can be sent to many people at one time. New technologies for communicating seem to develop faster and faster. What could be next?

1915

Cross-country telephone service began in the United States.

1993

The first smart phone was developed.

DO THE MATH

Solve a Problem

Suppose you can send 2 text messages per minute. How many text messages could you send in the time it took to deliver a letter by stagecoach from St. Louis to San Francisco in 1858?

____

____

____

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Technology Risks and Benefits

A cell phone lets you communicate from almost anywhere. What happens when the phone dies or a newer, better model comes out?

ACTIVE **READING** As you read these two pages, **underline** the things that are being contrasted .

Technology can have both positive and negative effects. Positive effects are called *benefits*. Benefits are the ways that a technology fills a need. For example, a cell phone lets friends and family communicate with you wherever you are. It might let you surf the Internet or download useful applications, too.

Negative effects are called *risks*. Cell phone technology changes fast, and some people switch to new models after just a few months. More resources are used up, and the old phones sometimes end up in a landfill. This risk is environmental.

No matter what the technology, there are both risks and benefits. Think about how each technology described here impacts your life. Are the benefits worth the risks?

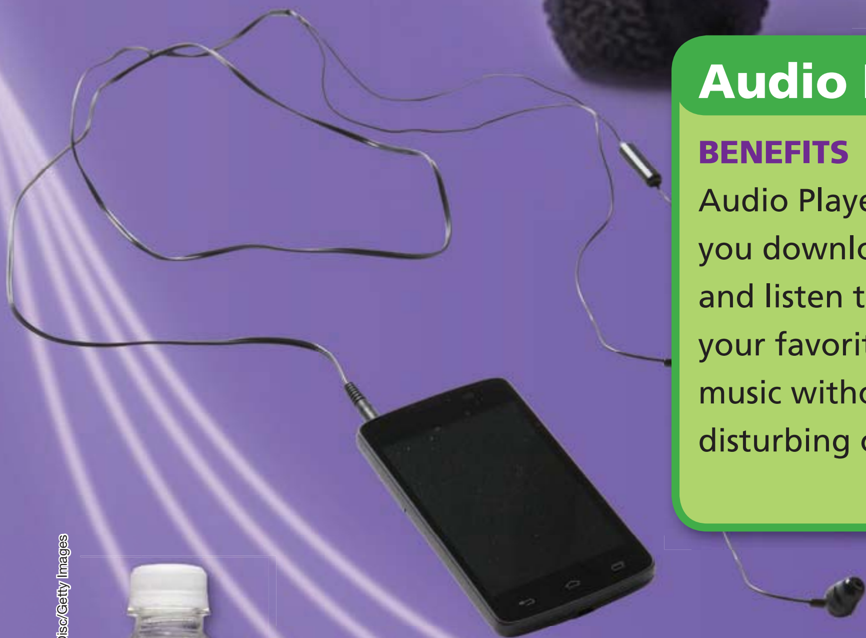
Computers

BENEFITS	RISKS
Computers let you communicate with friends and family. They let you surf the Internet for information that can help with homework, and they let you play games.	Computer technology changes quickly, and many computers end up in landfills. Computers are expensive, and using the Internet can expose you to sites that are unsafe.

Automobiles

BENEFITS
Cars allow personal freedom by letting you go almost anywhere. They carry heavy items that you could not move on your own.

RISKS
Cars use gasoline that is made from a limited resource—oil. They cause air pollution, and they can be dangerous if not driven properly.



Audio Players

BENEFITS
Audio Players let you download and listen to your favorite music without disturbing others.

RISKS
Turning up the volume can damage your hearing. You may not be able to download some songs.

Risks Versus Benefits

Frozen foods and canned foods come prepackaged. Write down some benefits and risks of using prepackaged foods.

BENEFITS

____

____

____

RISKS

____

____

____

Living Technology

The many branches of science are often connected. Engineered devices are sometimes used on living things. This connects engineering and biology.

This plant cleans waste water to make it safe to return to the environment.

Engineers who work with living things are called bioengineers. When bioengineers apply the engineering design process to living things, they are practicing **bioengineering**.

A bioengineer may design a fish farm to raise large numbers of fish for food or other uses.

An important part of bioengineering has to do with the environment. Bioengineers design tools to prevent or clean up pollution, for example. Any product used to benefit organisms or their environment is an example of **biotechnology**.

Bioengineering also deals with health and nutrition. For instance, plants can be engineered to grow faster or larger to feed more people. Food for livestock may be engineered to make the animals healthier.

Bioengineers also design biotechnology that helps detect or treat diseases. For example, scanners in hospitals can look inside the body. They let doctors see a diseased or damaged organ. Other devices help surgeons perform operations.

Some bioengineers design devices that replace human body parts. Artificial legs help people who have lost their own. Artificial skin helps people with burns. Bioengineers have even developed artificial hearts.

Surgeons today can use computer-assisted machines in delicate operations.

This artificial heart may not look like a real human heart, but it does the same job.

Bioengineering and Human Needs

Identify the human need met by each of these biotechnologies.

Biotechnology	Need
Water treatment plant	
Fish farm	
Robotic surgery	
Artificial heart	

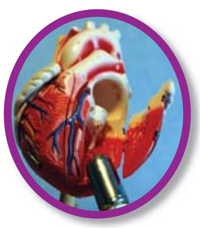
Sum It Up »

Fill in the missing words to explain how technology improves our lives. Use the words in the box if you need help.

benefits	bioengineering	risks
effect	need	technology

Technology may be simple or complex, but all technology meets a 1. ___________ 2. _______________ changes as the needs of people change. Technology may have both a positive and a negative 3. _____________ on people. Positive effects are called 4. _____________ . Negative effects are called 5. _________________ . The application of the engineering design process to living things is 6. ___________________ .

Draw a line from the picture to the statement that best summarizes what the picture shows.



7. Bioengineering may develop technologies that protect the environment, improve nutrition, or replace body parts.
8. A benefit of packaged food is convenience. A risk is an increase in the amount of trash.
9. Even a simple fastener is technology because it meets a human need.
10. Communication technology has changed greatly over time.

Brain Check

Name ______________________

Vocabulary Review

1 **Use the words in the box below to help you unscramble the highlighted words in each statement. Then, write the unscrambled word on the line.**

One irsk of using a computer is being exposed to unsafe Internet sites.

____

A fish farm is an example of hetooblyincgo.

____

otyleonchg is anything that meets a need or solves a problem. ____________________

Engineers work with living organisms in the process of nnneeeiiiggbor. ____________________

A nefetib of a car is that it allows personal freedom. ____________________

benefit	**bioengineering***	**biotechnology***
risk	**technology**	

* Key Lesson Vocabulary

Apply Concepts

2 Describe how changes in transportation have affected communication over long distances. Give an example.

3 **Name two benefits and two risks for each of these technologies.**

Plastic Grocery Bags

BENEFITS	RISKS

Internet

BENEFITS	RISKS

Light Bulb

BENEFITS	RISKS

Television

BENEFITS	RISKS

Take It Home! With a family member, identify five examples of technology in your home. Explain to the family member what needs are met by each of the technologies. Try to identify the risks and benefits of each one.

SC.5.N.1.1 Define a problem, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigations of various types such as: systematic observations, experiments requiring the identification of variables, collecting and organizing data, interpreting data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

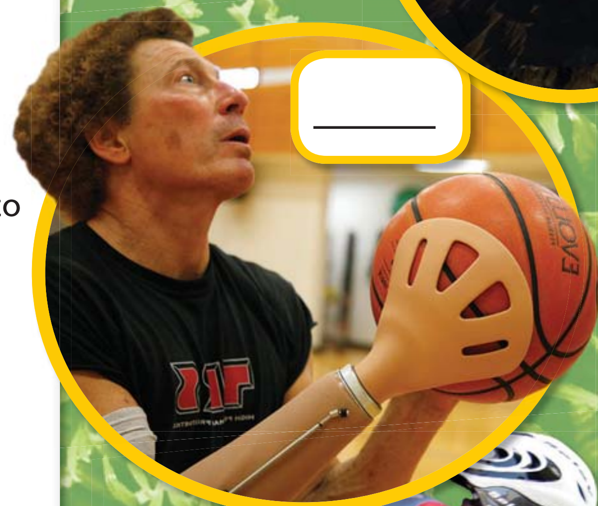
10 THINGS YOU SHOULD KNOW ABOUT Prosthetic Designers

1. Prosthetic designers help people who are missing a body part, such as a hand, arm, or leg.
2. The people they help may have lost a body part from an injury or a disease. Or it may have been missing from birth.
3. Prosthetic designers create the prosthesis that replaces the missing body part.
4. To design a prosthesis, prosthetic designers need to study how the human body moves.
5. A prosthetic designer looks for new ways to improve how a prosthesis is made.
6. They use both computers and traditional tools including drills.
7. A prosthesis is made to meet the needs of each user.
8. A person may need a special prosthesis to swim, run, bike, or golf.
9. A prosthesis is designed to move easily, naturally, and under the wearer's control.
10. Prosthetic designers can change people's lives!

Designing Sports Prostheses

For each image, write the number of the design criteria that meet each person's needs.

1. It should allow the leg to bend forward and the knee to lock.
2. It should fit comfortably at the knee and allow the ankle to rotate.
3. It should be lightweight, flexible, and resist high-force impacts.
4. It should be lightweight and able to rotate 180°.
5. It should be waterproof and allow the ankle to lock.
6. It should have attachments for gripping different objects.
7. It should be able rotate 90°and have good traction.



Name ______________________________

ESSENTIAL **QUESTION**

How Can You Use Engineering to Solve a Problem?

Materials

- 2 wood slats, with holes
- 2 pieces of sandpaper
- plastic tubing
- rubber belt
- masking tape
- glue
- wing nut and bolt
- small jar with lid
- medium jar with lid
- large jar with lid
- scissors

EXPLORE

You will use the engineering design process to design and build a prototype that solves the problem of a hard-to-open jar.

Before You Begin—Preview the Steps

1. With a partner, brainstorm how the materials provided could be used to make a jar opener. Sketch each of your ideas, and make notes as to how you think each design might work.

2. Choose the design you think will work best. Make a plan and build your prototype.

3. Test your prototype. Record how well it worked.

4. Make improvements to your design, if needed. Test your jar opener again.

Set a Purpose

What problem are you trying to solve?

____

____

Think About the Procedure

What is a prototype?

____

____

Describe two ideas for your prototype.

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____

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____

____

Name ___________________________

Record Your Data

Draw a detailed plan for your jar opener. Label the materials. Describe how it will work. Then, build and test your prototype.

Draw Conclusions

What criteria did you use to test your prototype?

____

____

____

Describe how you tested your prototype. Record any data you collected.

____

____

____

Claims • Evidence • Reasoning

1. Describe the improvements you made to the prototype and your reasoning for making the changes.

2. Summarize how you designed and tested your jar opener. Provide evidence that your design worked.

3. Make a claim about how the materials provided could be used to make a different jar opener.

4. Think of other designs you might make if you had different materials. How would that design work?

UNIT 2
Benchmark Review

Name ______________________________

Vocabulary Review

Use the terms in the box to complete the sentences.

bioengineering
biotechnology
criteria
engineering
prototype
technology

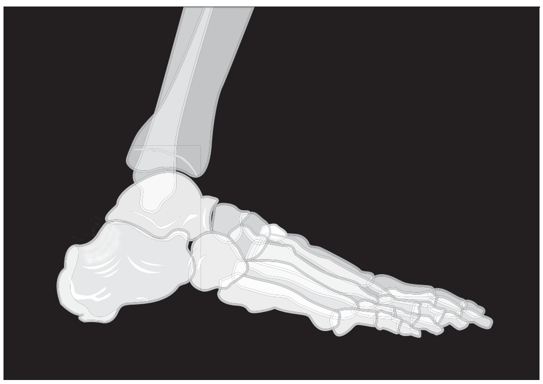
1. Any device that people use to meet their needs and solve practical problems is ____________________.
2. Using science and math for everyday purposes such as designing structures, machines, and systems is ____________________.
3. The standards for measuring how well a design does its job are ____________________.
4. The process of applying the engineering design process to living things is ____________________.
5. The working model on which tests are performed is a(n) ____________________.
6. Artificial legs are an example of ____________________.

Science Concepts

Fill in the letter of the choice that best answers the question.

7. Computer models, along with mathematical data, can help to provide which information to bioengineers?
   - (A) which prosthesis is more appealing
   - (B) which prosthesis would be less necessary
   - (C) what kinds of changes need to be made to a prosthetic device
   - (D) what kinds of adjustments need to be made to the marketing plan.

8. This foot x-ray is an example of which kind of science or engineering?



   - (F) biotechnology
   - (G) microbiology
   - (H) prototype design
   - (I) prosthetic devices

9. Suppose you are a bioengineer who is designing a prosthetic shoulder joint. You are building a prototype. Which is an **important** design criterion for a shoulder joint that you should include?

Ⓐ It should be realistic in color and appearance.

Ⓑ It should be capable of full movement within a shoulder socket.

Ⓒ It should keep the person for whom it is designed from injuring himself or herself again.

Ⓓ It should be stronger than a typical shoulder joint and support more weight.

10. A sports designer wants to produce a profitable product that will benefit the wearer. The data below show the result of a survey about students' favorite sport activities.

Sports Participation in High School	
Sport	**Percentage of students**
basketball	80
bicycling	60
soccer	50
swimming	30

Which can you infer would be the **most** needed product among the students surveyed?

Ⓕ a helmet to protect from accidental head injuries

Ⓖ high-impact, ankle-supporting shoes

Ⓗ water-repelling racing swim trunks

Ⓘ shorts with padded backs

11. You and your design team have designed a new waterproof wristwatch made of a soft, flexible, clothlike material. Which of the following prototypes could be tested to predict how well the watch would work in real life?

Ⓐ a graphic drawing of the watch

Ⓑ a computer model of the watch that actually moves

Ⓒ a wearable model of the watch made of plastic or cloth

Ⓓ a wearable version of the watch made of the new material

12. A company has developed a new skateboard that can more easily roll over gravel or grass. Some users of these new boards are wearing paths through the local park. What aspect of technology does this situation represent?

Ⓕ benefits and risks

Ⓖ design and redesign

Ⓗ computer models and prototypes

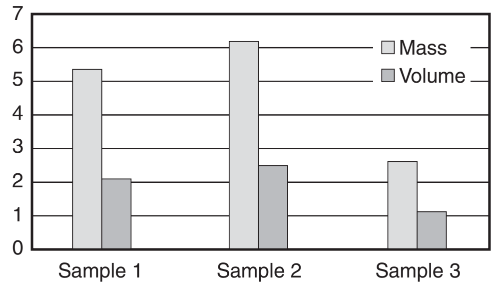
Ⓘ brainstorming and communication

Name ______________________________

13. Bioengineers designed a prosthetic hand that is capable of grasping small objects between the thumb and index finger. The thumb was not one of the prosthetic hand's original design criteria. Which process was most responsible for including this feature in the final design?
    - (A) troubleshooting after manufacture
    - (B) safety concerns among doctors
    - (C) brainstorming sessions within the design team
    - (D) prototype testing and redesigning

14. You are determining the criteria you will use to decide how well your prototype racecar works. Which units would you use to determine the distance your car traveled?
    - (F) grams
    - (G) degrees
    - (H) meters
    - (I) liters

15. Engineers are investigating several materials that they think might be suitable for use in an artificial knee joint. They need to select a strong material that has a density (mass ÷ volume) in the range of 2.3–2.6.



What can the engineers conclude using the data from the graph?
    - (A) All of the samples meet the density criteria that the engineers identified.
    - (B) Sample 3 has the least volume and should not be considered for the knee.
    - (C) Sample 2 has the greatest mass per volume and is the densest material.
    - (D) All samples are outside the acceptable range and show a mass of 5–6.

16. An engineering team is developing a device that will help individual farm families clean drinking water. The device must be inexpensive enough that families can afford to buy one. At what stage in the engineering process should the team take into account the need for the device to be affordable?
    - (F) before they build a prototype
    - (G) after the device is on the market
    - (H) before they identify the problem
    - (I) after the testing has been completed

Apply Inquiry and Review the Big Idea

Write the answers to these questions.

17. Building a prototype of a prosthetic human body part means that you must use materials in ways that will resemble the actions of the real body parts. For example, you can use rubber bands to simulate the action of muscles on bones in order to move them. Describe two ways that rubber bands can imitate muscles in a model of a human arm.

(1) ______________________________

____

(2) ______________________________

____

18. A fully loaded backpack should not exceed 20 percent of a student's weight. However, most doctors recommend a 15-percent weight limit. These data are shown in the table below.

Body weight (lb)	Recommended limit of 15% (lb) port	Maximum weight of 20% (lb)
70	$10\frac{1}{2}$	14
80	12	16
90	$13\frac{1}{2}$	18
100	15	20
110	$16\frac{1}{2}$	22
120	18	24

Materials that are often used to make backpacks have the following properties:

Material	Cost	Durability	Weight
plastic	low	low	low
canvas	moderate	average	medium
leather	high	high	high

a. What is the maximum weight a student who weighs 70 lb should carry?

____

b. What is the range of weights for a student who weighs 80 lb?

____

____

c. Make a claim about the best material for a backpack that will be used by a 70 lb student to carry 9 lb of books and materials. Give evidence for your answer.

____

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