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."

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?

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.

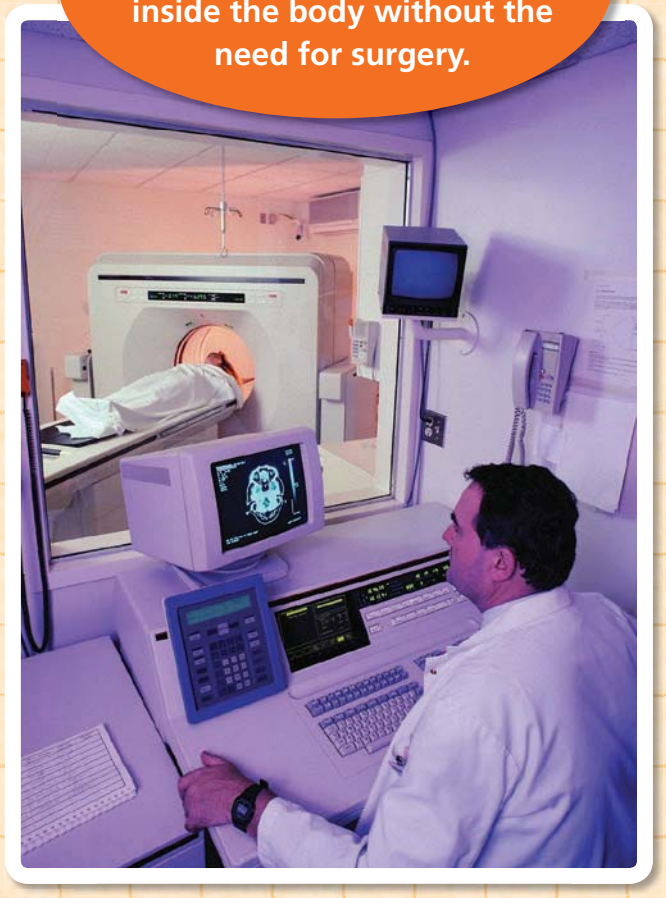
ACTIVE READING As you read these pages, underline the names of engineered devices.

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.

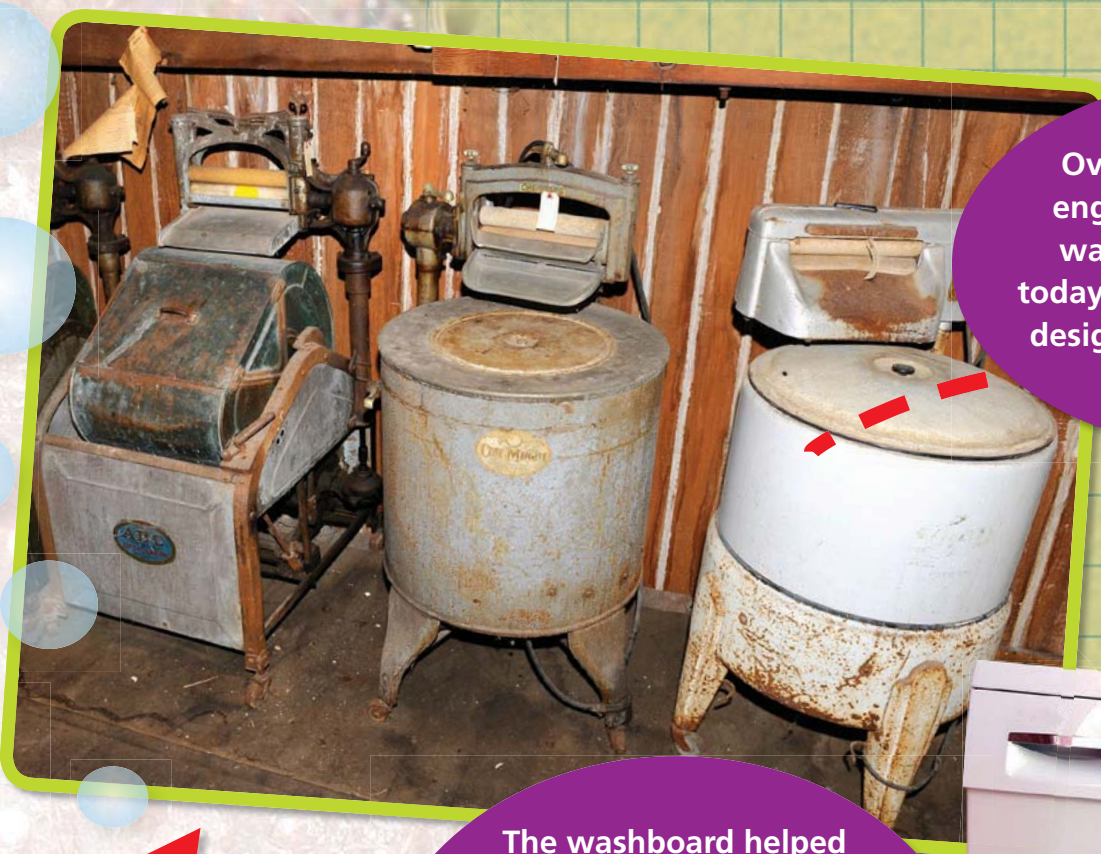
ACTIVE READING As you read these two pages, underline sentences that describe how technology affects our lives.

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.

(l) ©Ilene MacDonald/Alamy; (b) ©Directphoto.org/Alamy

▶ 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.

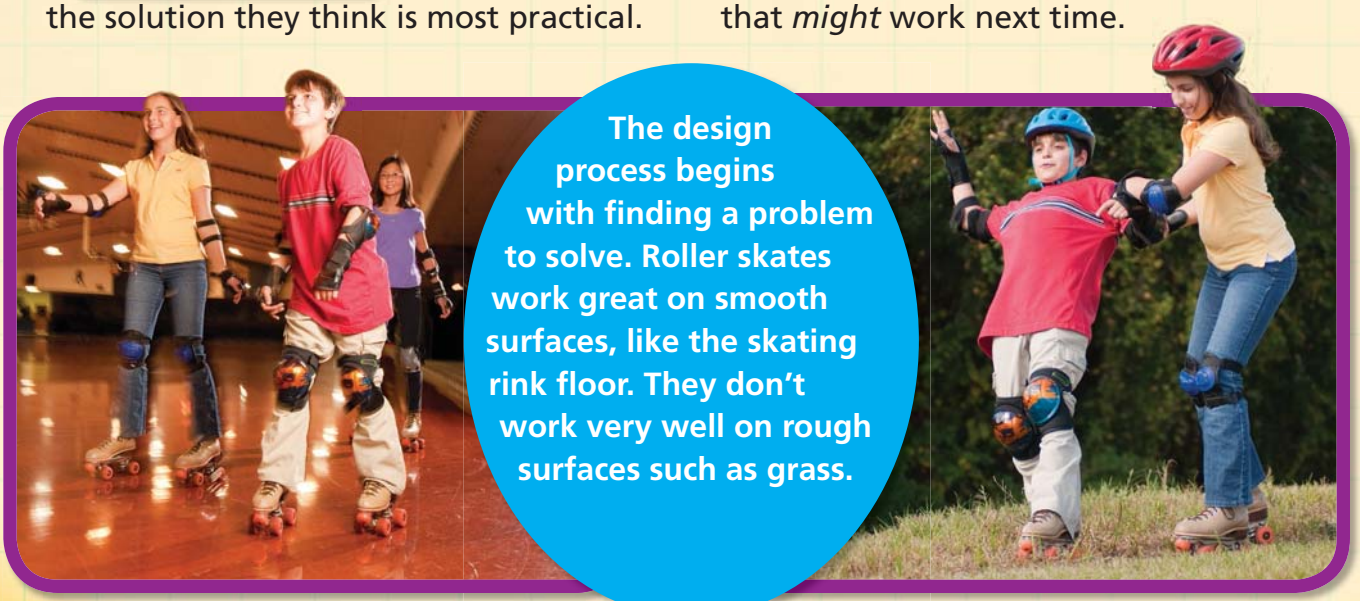
ACTIVE **READING** As you read these pages, bracket sentences that describe a problem. Write *P* in the margin. Underline sentences that describe a solution. Write *S* by them.

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

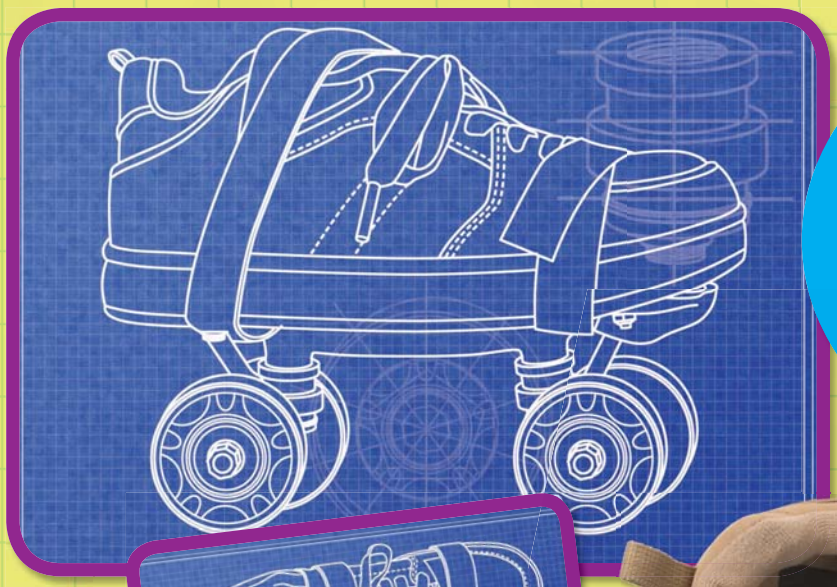
1. Find a Problem Engineers must first identify a need, or a problem to be solved. They brainstorm possible solutions. There may be more than one good solution.

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

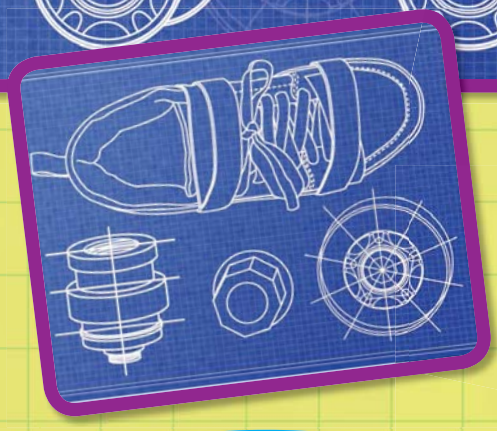
Throughout the design process, engineers keep careful records. Good records include detailed notes and drawings. Records help them remember what they have done and provide information to others working on similar problems. If the prototype doesn't work, the records can provide clues to a solution that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

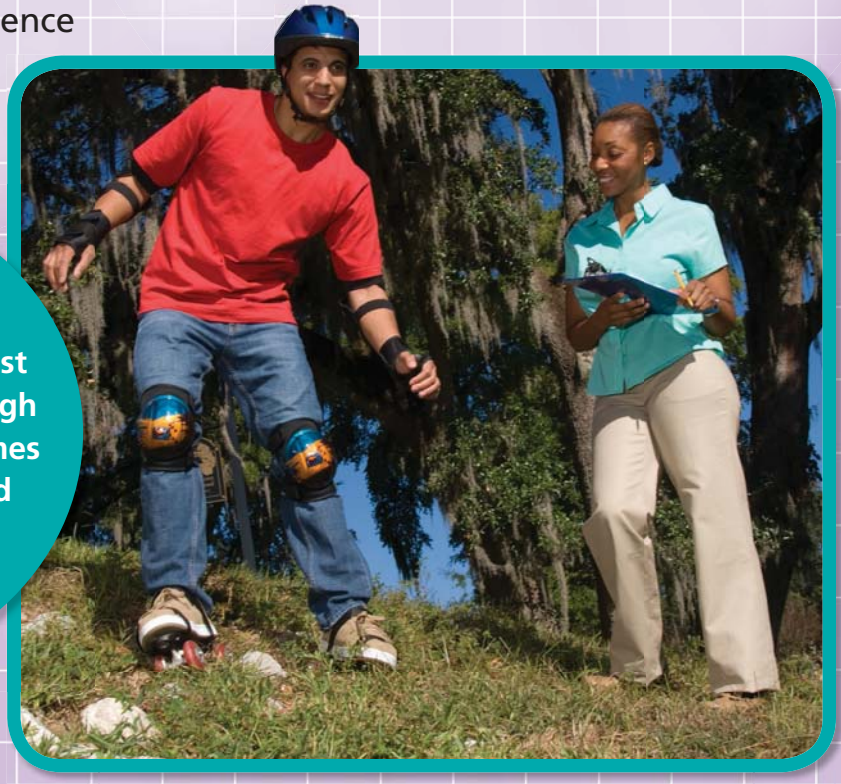
The skate designers are steadily working through the steps of the design process. They have found a problem and built a prototype. What's next?

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.

_____

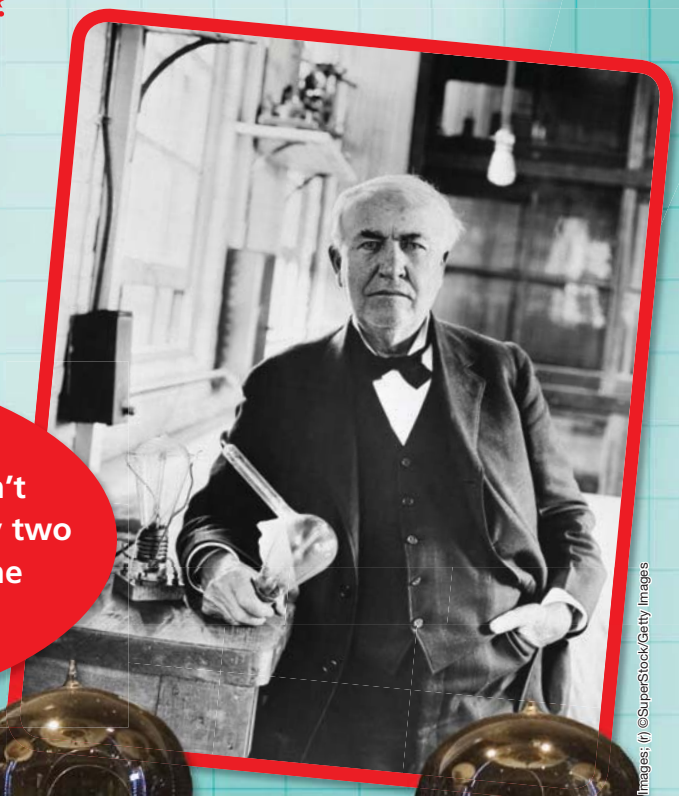
What is the size of the larger wheel?

_____

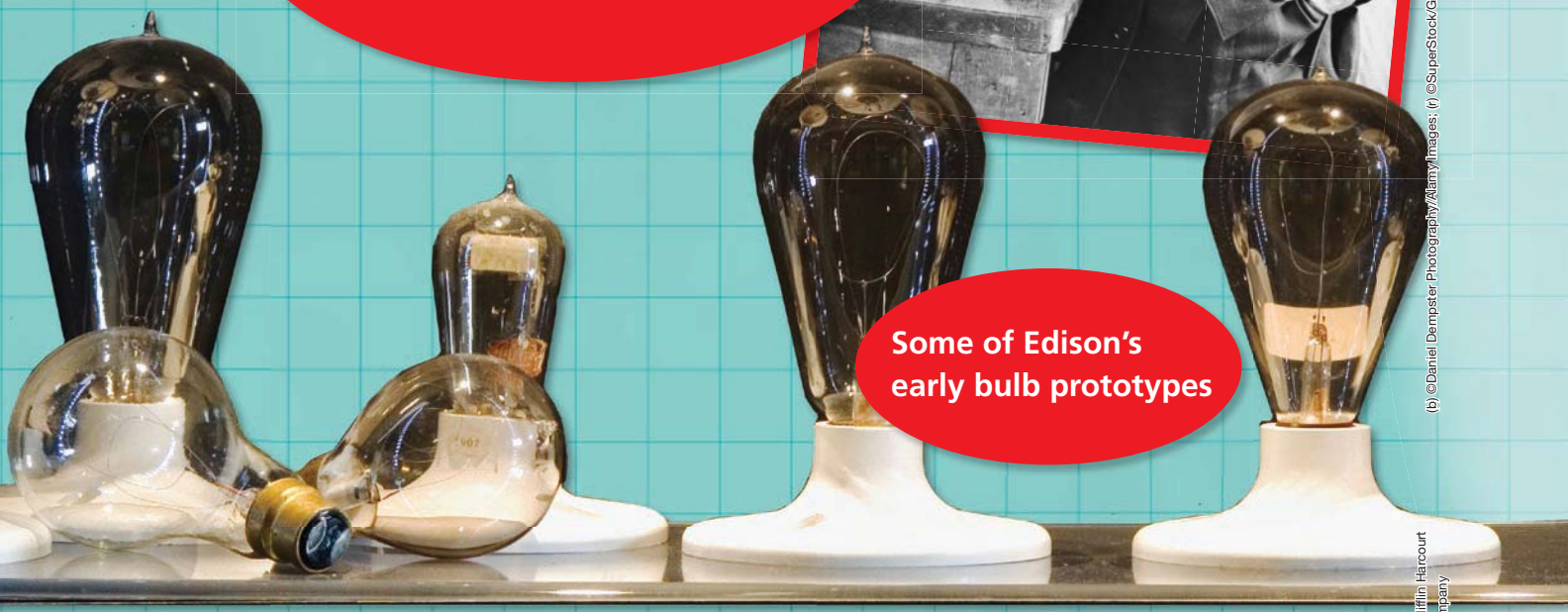
If At First You Don't Succeed...

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

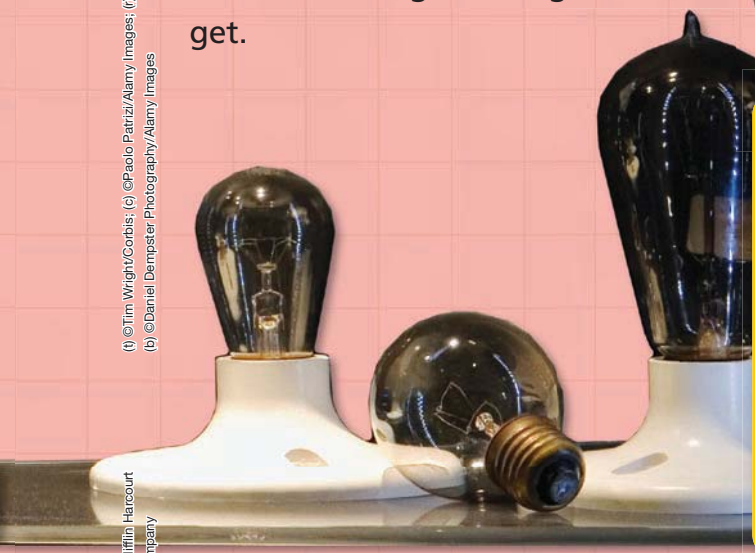
Cars must pass crash tests before they can be sold to the public.

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