Kickoff: (8/13/12)

You have an idea for an invention. What are some steps you should take to develop a prototype? What about after the prototype is developed?

CHAPTER 1 | Science in Our World

SECTION 4

Science and Engineering

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What is engineering?
- How does engineering help meet society's needs?
- How do engineers design new products?

TN Tennessee Science Standards

GLE 0607.T/E.1
GLE 0607.T/E.2
GLE 0607.T/E.3
GLE 0607.T/E.4

What Is Technology?

Imagine that you are in Antarctica, the coldest place on Earth. Icy winds could freeze your exposed skin in seconds. The first explorers to Antarctica used fur-lined clothing and sleeping bags. These were the best available at the time. However, once fur gets wet, it is very hard to dry it. Because of this, early explorers constantly struggled to stay dry and warm.

STUDY TIP

Ask Questions Read this section silently. In your notebook, write down questions that you have. Discuss them in a small group.

Engineers have developed high-tech fabrics that are waterproof. These fabrics and improved equipment make it possible for research teams to stay in Antarctica year-round. Scientists and engineers have problem-solved to create new technology that will help.

Technology refers to the products and processes that are designed to serve our needs. Technology also refers to the tools and methods for creating these products and processes. Technology is not just new products. The word applies to any product, process, or knowledge that is created to meet a need.

Telephones have changed over the years, becoming smaller and more mobile. Telephones like the one on the left were once considered advanced technology. One day the cell phone on the right will be considered old technology.

Say It

Discuss Think of some other examples of technology that have changed during your lifetime. How have they been improved? Discuss these changes with a group.

How Does Science Relate to Technology?

Science is knowledge of the natural world. Engineering is closely related to science, but it is not the same. Engineers use science and mathematics to create new technologies that serve human needs. [insert rc]

READING CHECK

1. Explain How is engineering related to science and math?

Engineering is the process of creating technology. When you think of an engineer, you might think of a person who designs bridges or skyscrapers. This is one type of engineer. There are also many other types of engineers who develop a variety of very different products.

Hybrid cars, waterproof fabric, and disease-resistant corn were all developed by engineers. Engineers also designed the tools and processes needed to make these new products. For example, engineers not only created waterproof fabrics but they also designed the machines that make the fabrics. They even created the computer programs that were used to design the materials. ☑

READING CHECK

2. Identify What are three categories of technologies that engineers create?

Professional engineers have produced a lot of technology. However, you don't have to be an engineer to participate in engineering. Scientists, inventors, artists, and even students have also engineered new technologies. Anyone can follow the engineering design process to solve a problem or address a need.

What Is the Engineering Design Process?

The **engineering design process** is similar to the scientific process. Like the scientific process, some steps may require repeating or modifying to fit different needs. Learning the process will help you understand how new technology is created.

Ask

STEP 1: IDENTIFYING AND RESEARCHING A NEED

The first step in the engineering design process is finding out a need or problem that engineers want to solve. Engineers define and write the need or problem they are trying to solve. For example, the problem may be to make clothing that repels water so explorers can work in Antarctica. To solve this problem, an engineer might research explorers' needs, the weather, environmental conditions, and existing materials.

Critical Thinki

3. Apply Concepts Supp
you were asked to desig
a new type of coat for
researchers in Antarctica.
What are two topics you
might research to get sta
on your project?

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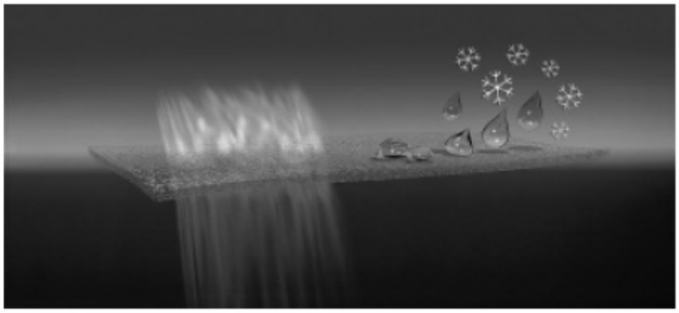
_____

STEP 2: DEVELOPING POSSIBLE SOLUTIONS

Once the need has been identified and researched, the second step is to think about possible solutions. This can include brainstorming. When people *brainstorm*, they get together in a group and share ideas. Brainstorming usually leads to ideas that no one would have thought of on his or her own. In other cases, it takes more time and thought. Sometimes people can get an idea from a product that already exists. ☑

STEP 3: MAKING A PROTOTYPE

After the best idea is chosen, the third step is building a prototype. A **prototype** is a model of the product. Engineers test prototypes to see if their design works the way they expect it to.



Some waterproof materials are made from a resin originally developed for making nonstick surfaces. Many new technologies are based on technologies that already exist.

READING CHECK

4. Define What is brainstorming?

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_____

_____

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Check

STEP 4: TESTING AND EVALUATION

Then engineers try to find out whether the technolog does the job it was designed to do. They test the prototype and evaluate how well it works.

Engineers also have to make sure the cost of designi and producing the new product is worth its benefit. Thi process is called a **cost-benefit analysis**. Waterproof and breathable fabric might be useful for many people. However, making these fabrics only makes sense if they are not too expensive for people to buy.

Math Focus

5. Calculate Engineers are working on a cost-benefit analysis for a new car model. They drive the car, use 3 gallons of gasoline, and travel 225 miles. How many miles per gallon does the car get?

_____

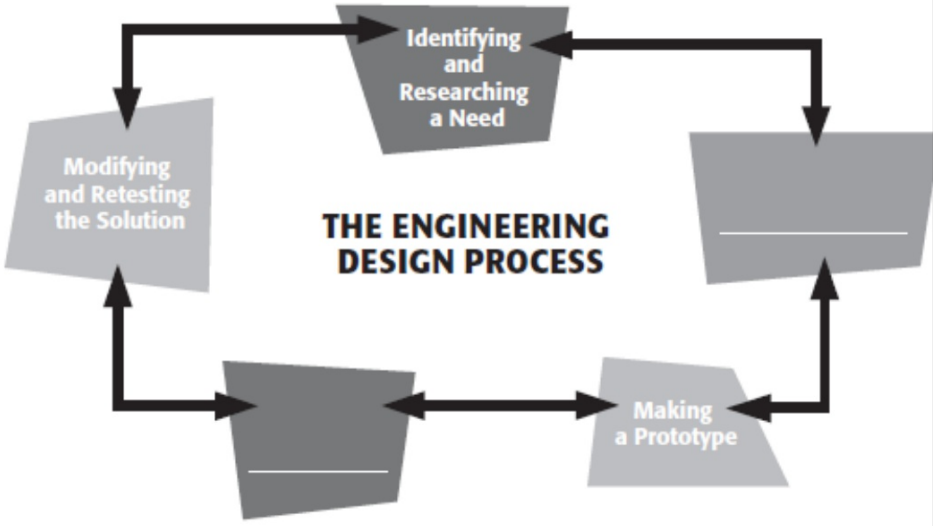
_____

Improve

STEP 5: MODIFYING AND RETESTING THE SOLUTION

When a prototype is not successful, engineers follow the fifth step in the engineering design process. They either modify their prototype or try a new solution. Whe something is modified, it is changed. It is important tha the engineers consider what they have learned from the first prototype. They begin the design process again wit their new knowledge and continue working on the proble

A new product can also be the beginning of a new engineering design cycle. Scientists and engineers may look for other possible uses for the new product. Engineers found other uses for the waterproof material that was used for expedition clothing. They used it in products as varied as medical implants and dental floss. The figure shows the five steps in the engineering design process.



TAKE A LOOK

6. Identify Fill in the blanks in the engineering design process diagram.

COMMUNICATION

Engineers need to share their successes, failures, and reasoning with others. They may explain and promote the technology to customers. They may also communicate with the public through news releases or advertisements. Engineers sometimes publish details of the design process in journals so other engineers can build on their work. ☑

READING CHECK

7. Identify List three ways which engineers might shar their results.

How Does Technology Affect Society?

Technology provides solutions for many types of social, political, and economic needs. City governments have a political need for information to improve police, firefighting, and medical services. To fulfill this need, computer engineers write software that makes collecting information from emergency calls easier.

Telephone companies have an economic need for less expensive telephone and radio towers. To solve this problem, electrical engineers have developed new materials that last longer. ☑

READING CHECK

TAKE A LOOK

11. Identify How did engineers solve the problem of safety in automobiles?

Technologies can have unintended consequences, such as the safety issues associated with automobile accidents. Frequently, engineers must use the engineering design process to fix problems that come from unintended consequences. In this case, engineers invented the air bag to make cars safer.

What Is Bioengineering?

The engineering design process can even be used to help living things. **Bioengineering** is the use of engineering to help living things, such as humans and plants. Bioengineers and scientists study problems that occur in living organisms and their environments. They use their skills, knowledge, and technology to find solutions to these problems. ☑

READING CHECK

12. Define What is bioengineering?

Section 4 Review

GLE 0707.T/E.1, GLE 0707.T/E.2, GLE 0707.T/E.3, GLE 0707.T/E.4 TN

SECTION VOCABULARY

adaptive bioengineering engineering that results in a product or process that changes living organisms

assistive bioengineering engineering that results in a product or process that helps living organisms but does not change them permanently

bioengineering the application of engineering to living things, such as humans and plants

cost-benefit analysis the process of determining whether the cost of doing something is worth the benefit provided

engineering the process of creating technology

engineering design process the process engineers use to develop a new technology

prototype a test model of a product

technology the products and processes that are designed to serve our needs

1. **Identify** List the five steps in the engineering design process.

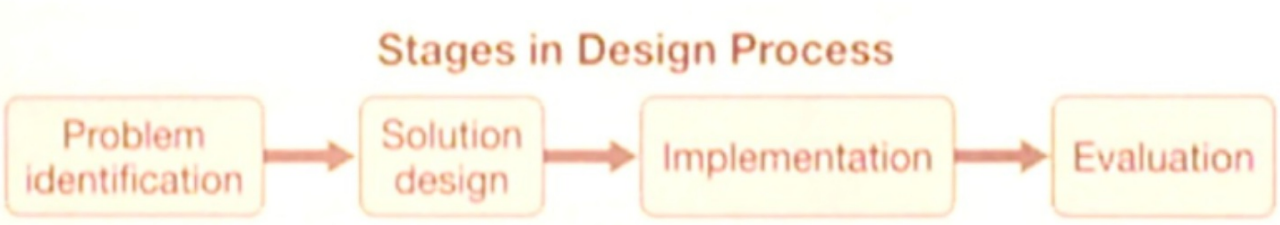
2. **Applying Concepts** In the engineering design process, why would you need to repeat the steps of the process?

3. **Consumer Focus** An accident or a disease may cause a person to lose some of his or her hearing. Name a bioengineered product that has been developed to deal with this need.

4. **Apply Concepts** What is one benefit that cell phones have had on society? What is one unintended negative consequence?

5. **Compare** How are the engineering design process and the scientific process alike?

What is the engineering design process?

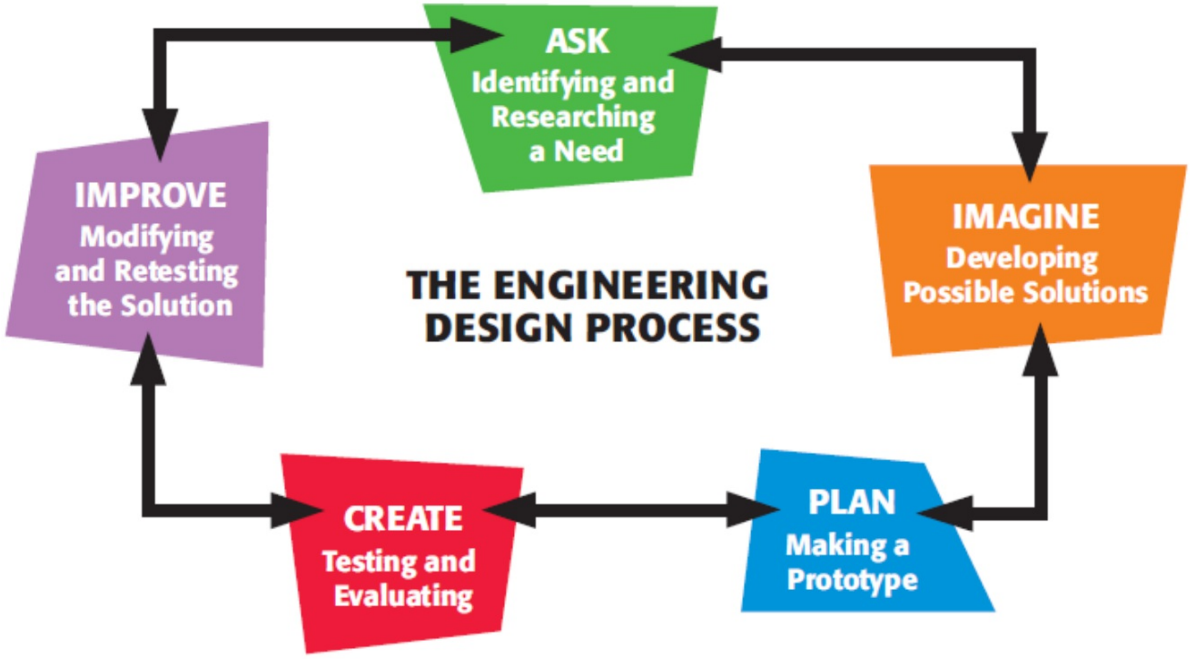


Step 1: Ask - Identifying and researching a need
Step 2: Imagine - Developing possible solutions
Step 3: Plan - Making a **prototype**
Step 4: Create - Testing and evaluation
Step 5: Improve - Modifying and retesting the solution

Analyze cost/benefit ratio or perform
risk/benefit analysis
design constraints

What is the engineering design process?

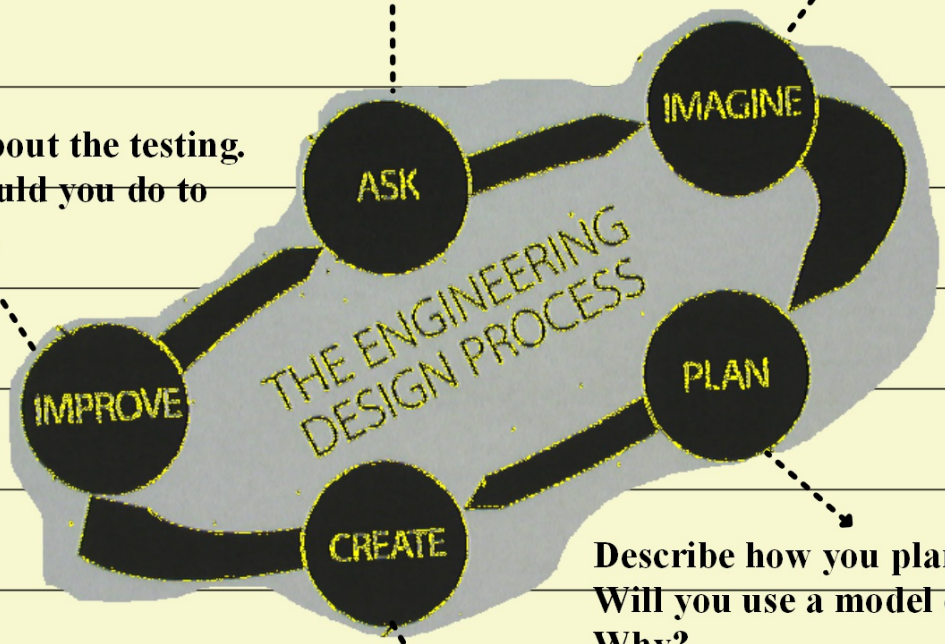
Figure 5 The Engineering Design Process



Did we do enough research?
Where could we have found
more information?

Describe your
brainstorming process.

Think about the testing.
What could you do to
improve.



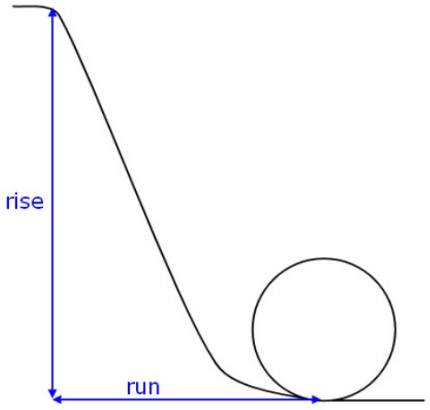
Describe how you plan.
Will you use a model or a prototype?
Why?

Describe your building process.
Will things change as you build?
Why?

A theme park consults you, an engineer, to build a roller coaster with the maximum loop size as possible.

Objective

The goal of this project is to build a prototype roller coaster for marbles using foam pipe insulation and to investigate how much height is needed in order for the marble to run through a loop of fixed size.



The money will go to the engineering firm with a successful marble run for the largest diameter loop.

Record your results and any adjustments you make.

Today, bioengineers work to improve crops. Researchers may want crops that are resistant to diseases. They may want crops that grow with less water or nutrients. They may want crops that taste better, stay fresh longer, or are more nutritious.

The best results have come from using bacteria that infect plants such as soybean, tobacco, and tomato. Bacteria can be altered to carry useful genes into the plants. A **gene** is a tiny part of a cell that gives a living thing a certain trait. The genes put into bioengineered plants help protect them against diseases, frost, and herbicides. **Herbicides** are substances used to kill weeds. However, these chemicals can also damage crops. If the crops are resistant to the herbicide, then only the weeds are killed.

Some plants are altered to stay fresh longer. Ripe tomatoes do not stay fresh long. To reach market before they rot, they must be picked before ripening. The tomatoes ripen as they are shipped to market. However, tomatoes that are picked early are less flavorful than tomatoes that ripen on the vine. Bioengineers have developed a type of tomato that can remain on its vine longer. These tomatoes ripen without rotting before reaching the markets.

Bioengineered food plants are tested for safety. But there are some risks from developing bioengineered crops. For example, crop plants that are made resistant to herbicides could turn into weeds elsewhere. Corn is a valuable crop, but wheat farmers do not want corn growing in their fields.

SECTION 1 Enrichment

Biomaterials

Biomaterials are materials foreign to the body that are used inside the human body. For example, tooth implants, heart-valve replacements, knee replacements, and artificial hips are just some examples of devices that are made of biomaterials. These materials include synthetic polymers, metals, and ceramics.

Finding materials to use inside the human body is especially difficult. These materials must have a variety of characteristics such as strength, flexibility, and chemical inactivity. The exact requirements will depend upon the use of the material. For example, a material used to make a knee-replacement joint must be very strong to support the weight of the body. It must be compatible with tissue inside the human body, and it must not initiate a rejection response in the body. The mate must maintain its properties over an exte period of time. It cannot release harmful chemicals that may be introduced during material's manufacturing process or as th material ages and begins to chemically degrade.

At times, a material that appears to be fect for an application turns out to be an unfortunate choice. For example, silicone ber once was used in artificial heart valve The rubber absorbed lipids from blood plasma and swelled. This caused the hear valve to malfunction. A new material wit similar properties had to be found to rep the silicone rubber in the heart valve. Th material could not absorb lipids.

1. What are biomaterials?

2. What are some examples of devices that are made from biomaterials?

3. Why is it difficult to find the right material to use inside the human body?

SECTION 2 Enrichment

Nanotechnology

Nanotechnology is the creation and use of materials on a very small scale. These materials range in size from 1 to 100 nanometers. A nanometer is equal to one-billionth of a meter. To give you some idea of how small this is, about ten atoms side by side would have a diameter of one nanometer.

Scientists have not been able to work with materials in this size range until recently. Many scientists are excited at the possibilities that this emerging technology brings. Some scientists envision tiny nano-size robots that can remove blockages from human arteries and nano-size computer chips that can go inside tiny devices.

Although nanotechnology is a relatively new field of science, some breakthroughs have already occurred. Nanotechnology has been used in catalytic converters in automobiles to remove pollutants, in contact lenses to improve strength and transparency, and in sunscreens and cosmetics to provide sunscreen protection. The list of uses for nanotechnology will continue to grow as more is learned about this emerging field of science.

1. What is nanotechnology?

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_____

2. List three nanotechnology products.

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_____

3. Why is nanotechnology a relatively new field of science?