CHAPTER 2

# Design and Problem Solving

## OBJECTIVES

- define design.
- explain how problem solving is part of designing.
- explain the forces that are involved in motion.
- explain the steps of the design process.
- describe a variety of modeling techniques.
- use the design process to solve real problems.

## KEY TERMS

**brainstorming**
**design**
**design brief**
**design process**
**ergonomics**
**innovation**
**invention**
**prototype**

Do you sometimes imagine a world without problems? Do design and problem solving sound like familiar activities? You have been practicing these activities for years. In everyday life, you must solve problems as you go along. You may not realize it, but you use problem solving whenever you make a decision.

Some decisions are easier to make than others. Because of this, you may not always be aware that you are using the problem-solving process. Problem solving is part of the design process.

## THE DESIGN PROCESS

A **design** is a plan for making something. Design is used to create technology. The **design process** is a process that uses problem solving to arrive at the best solution, or design. It is also used to improve products and services that are already in use. Fig. 2-1.

The process of designing new products is called **invention**. Thomas Edison was a very successful inventor. He conducted more than 800 experiments as he worked to develop a practical lightbulb.

Improving an existing technology creates innovation. **Innovation** (in-o-VAY-shun) occurs when something new is introduced. Today we are still trying to improve on Edison's invention. We are designing new bulbs that last longer and use less energy.

The process of designing may seem complicated. This is because so much information may have to be considered. In technology education you will do design-and-build activities. These experiences will help you become a successful designer and problem solver.

### FASCINATING FACTS

**In the 1960s, a long distance runner wanted shoes that didn't slip. He put a piece of rubber in a waffle iron. The rubber took on the waffle pattern. He attached it to his shoes. The runner, whose name was Phil Knight, went into business making these shoes. Knight named his shoes after the Greek goddess of victory, Nike.**

**Fig. 2-1** The design process frequently involves teamwork.

Being able to recognize and solve problems is a valuable skill. You will be able to use this skill in other classes and outside of school. A good way to solve problems is to use the design process. In this chapter the steps of the design process are explained in step-by-step order.

The steps in the design process are:

1. Identify the need.
2. Gather information.
3. Develop alternative solutions.
4. Select the best solution.
5. Implement the solution.
6. Evaluate the solution.

# Explore

## Design and Build a Floor Plan

### State the Problem

Design a bedroom in a house. The initial required drawing is a floor plan. This is a view of a room looking down from the ceiling. The scale of the drawing should be 1" = 1'-0". The bedroom will have the following:

- Floor area of 168 square feet
- One door (standard 30-inch width)
- Two outside walls
- Two windows, 12 square feet each
- One desk
- One desk chair
- One bed
- One dresser
- One bookcase
- One night stand

**Collect Materials and Equipment**

CAD program or graph paper
T-square
standard triangles
pencil
common templates (circles, furniture, etc.)
eraser

### Develop Alternative Solutions

Ask yourself a few questions. Are all rooms in a house the same size? Do all bedrooms have the same layout? How

The activities in this book will give you experience in design and problem solving. As you become an experienced problem solver, you may want to use the steps in the design process in slightly different ways.

## Identify the Need

Identifying the need is a good place to start. Some needs are easy to understand and lead to simple solutions. For example, you may want to keep together several sheets of paper. A paper clip or staple may be all that is needed.

Other needs are more complex. For example, many communities have problems with traffic congestion. This may show the need for more roads or a new mass transit system. Reducing traffic congestion may require changes that take years to put into practice. Difficult

important is the placement of windows and doors? Draw several floor plans for the bedroom. Remember that the room has 168 square feet. The floor plans will vary, depending on the length of the walls and where you place the door and windows.

### Select the Best Solution

Select a floor plan that you think will allow you to place your furniture as you want it. Determine standard sizes for the furniture you will have in your room.

### Implement the Solution

1. Cut out templates representing each piece of furniture. Label all furniture templates.
2. Place the templates on the floor plan. Move the templates until you have a pleasing arrangement. Seek comments from your classmates.
3. Sketch or draw the final floor plan.
4. Present your completed drawing to the class.

### Evaluate the Solution

1. Is the floor plan neatly drawn?
2. Are the furniture templates labeled?

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problems such as this affect many people. They are usually solved by people working together in teams. Each team member is expected to contribute to the solution to the problem.

Some needs are unique to one person. For example, suppose your family is moving to a new home. You are to help plan your new bedroom. What would you need to include?

As you know, some needs affect many people. Consider the needs of persons who are elderly. As we age we may need help with tasks like climbing stairs, turning faucets, and opening jars. Today people are living longer. This means that the population of elderly people is increasing. This is creating opportunities to design products and services to meet the needs of older citizens.

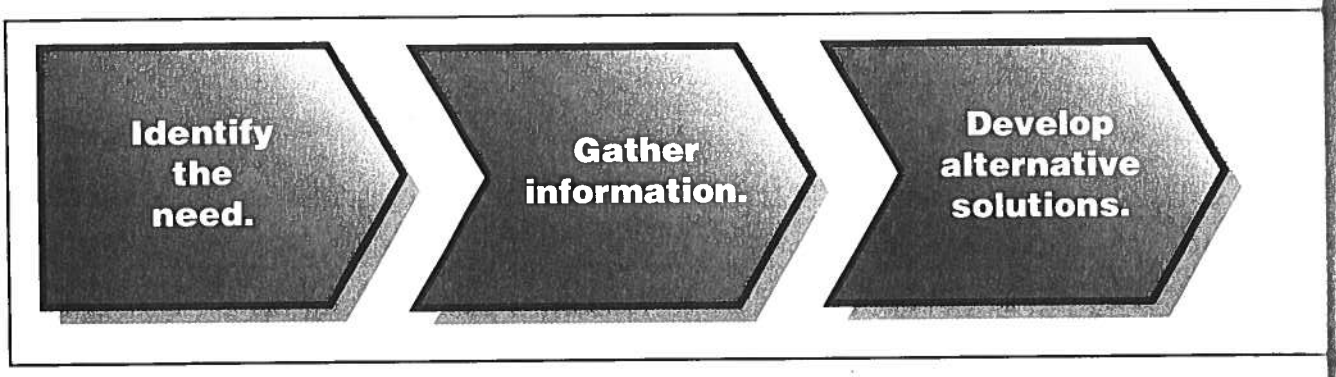



**Fig. 2-2** The design process.

The design process is shown in Fig. 2-2. Once a need is established, the designer should clearly state the problem that is to be solved. Fig. 2-3. A statement of the problem that is to be solved is called a **design brief**. The design brief should include all the information that the designer needs to understand the problem. It should include details about the materials to be used, how much can be spent, and when the solution is needed. Fig. 2-4.

## *Gather Information*

After you have a good understanding of the problem, look for information that will help you design a solution. Talk to people who have knowledge and experience that will help. Friends, parents, and teachers may offer good ideas. Engineers and other workers in local industry may be helpful. They often welcome the chance to help with a challenging technology activity. Ideas can also come from the library,

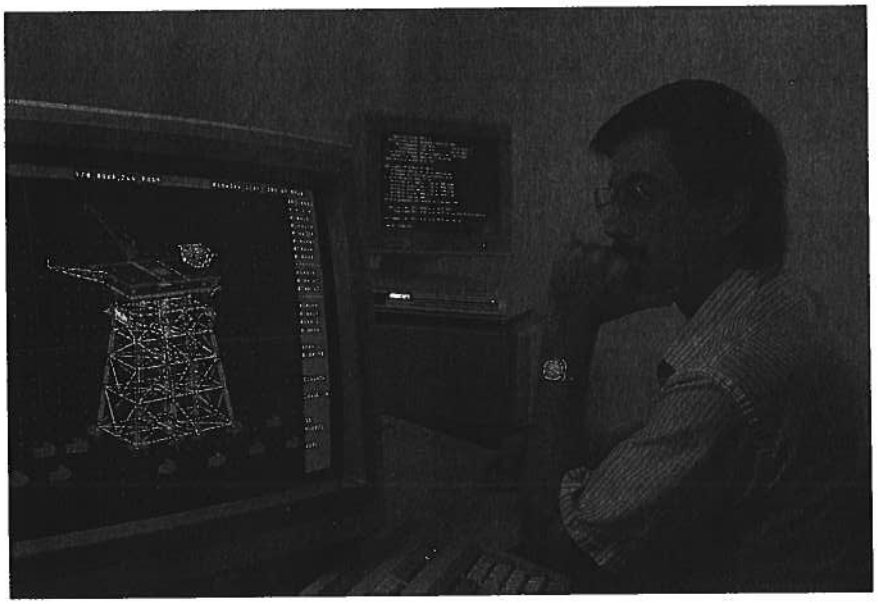
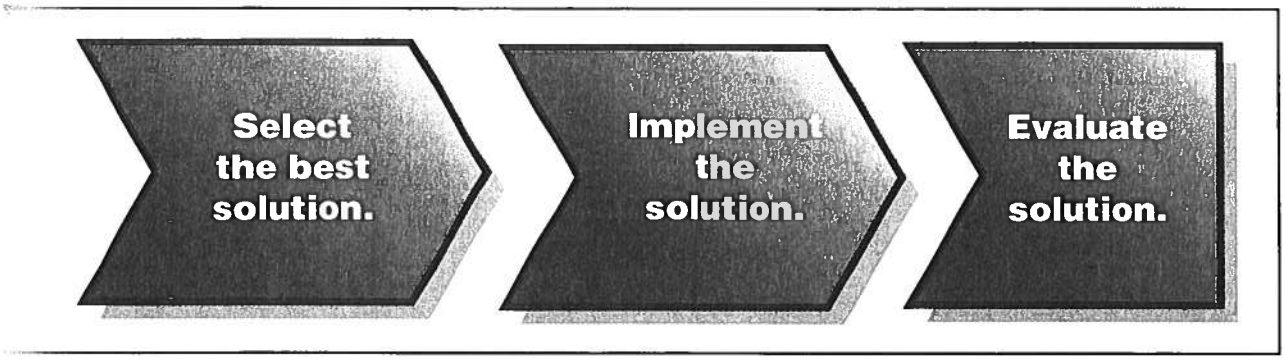


**Fig. 2-3** This engineer is studying the design of an offshore oil platform. This will help him suggest improvements.




stores, museums, and the Internet. (Chapter 6 discusses the Internet as a research tool.)

## Develop Alternative Solutions

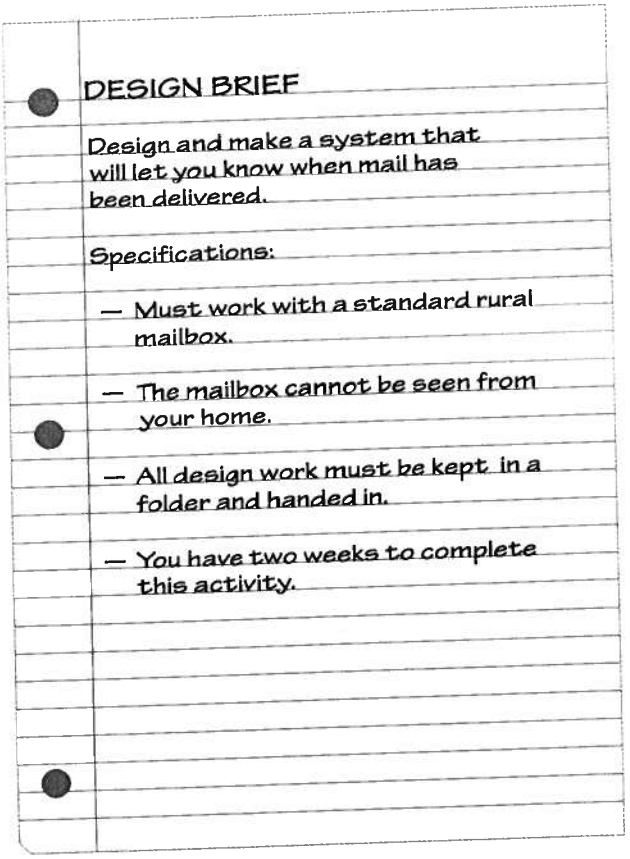
When you are working alone, sketching is a good way to explore possible solutions to a design problem. As you refine your ideas, add details to those sketches that represent ideas you think will work.

Most problems have more than one possible solution. One way to generate alternative ideas is to use brainstorming.

### Linking to COMMUNICATION

***The Effect of Design.*** Interview an older person. Ask that person to tell you about his or her buying habits. Ask what effect design had on his or her buying of various items. You might mention, for example, refrigerators, cars, and televisions. You might ask about books and magazines. Plan to record your interview on cassette or videotape. Include an introduction that states your purpose and identifies the person you interview. Conclude with a summary of the interview.

**Brainstorming** is a process in which group members suggest ideas as they think of them. It is a group problem-solving method. One member records the


DESIGN BRIEF

Design and make a system that will let you know when mail has been delivered.

Specifications:

- Must work with a standard rural mailbox.
- The mailbox cannot be seen from your home.
- All design work must be kept in a folder and handed in.
- You have two weeks to complete this activity.

**Fig. 2-4** A design brief should help you understand what is needed. The specifications give additional information that must be considered during the design process.

## FASCINATING FACTS

**It took the Census Bureau seven years to tally and analyze the 1880 census. The Bureau held a contest to find a better way to tally the census data. With the help of the winner, Herman Hollerith, the Census Bureau was able to count the population in about three years. Hollerith later went on to help form IBM in 1924.**

ideas. Usually a chalkboard or large pad is used so everyone can see the list. Each idea is then discussed. The team selects the ideas that show the greatest promise. Fig. 2-5.

## Select the Best Solution

Look at all possible solutions. Review the advantages and disadvantages of each idea. Then narrow the list of possible solutions. Models can help you choose the best solution.

### Modeling Techniques

Model building is a good way to develop and record ideas during the design process. Two-dimensional (2D) and three-dimensional (3D) models are useful. For many projects, both are needed.

Two-dimensional models include sketching, drawing, and rendering. Many good ideas start with quick pencil sketches. They help the designer change ideas as they are imagined. Later, more careful drawings can be prepared. As ideas become more specific, *renderings* (drawings) can be made. Colored pencils and markers are used. Renderings get the designer ready for 3D models. Fig. 2-6.

*Appearance models*, *scale models*, and *prototypes* are three-dimensional. Appearance models resemble finished products, but they do not work. Scale models are small, accurate representations of a finished product. Architects use scale models. These models help them communicate their design ideas to clients.

Good materials for scale models include clay, cardboard, foamboard, and foam block. These materials are easy to work with. They can be shaped using craft knives, abrasive paper, and files. Paint and markers can be used to add color and details.

A **prototype** (PRO-tow-type) is a working model. It looks and functions just like the finished product. Other useful modeling techniques include computer-aided design (CAD), computer simulations, mathematical models, and construction kits.

CAD systems enable designers to electronically draw anything that can be drawn on paper. Changes can be made quickly and easily. Drawings that used to take days may now take only hours.

Newly designed products can be tested using computers. For example, simulated wind-tunnel testing of a new airplane design can be done. Such testing may suggest changes in the wing shape.

Mathematical models include charts, graphs, and spreadsheets. Construction kits are useful for building working models of machines and manufacturing systems. The knowledge gained can be applied to building a full-size system.

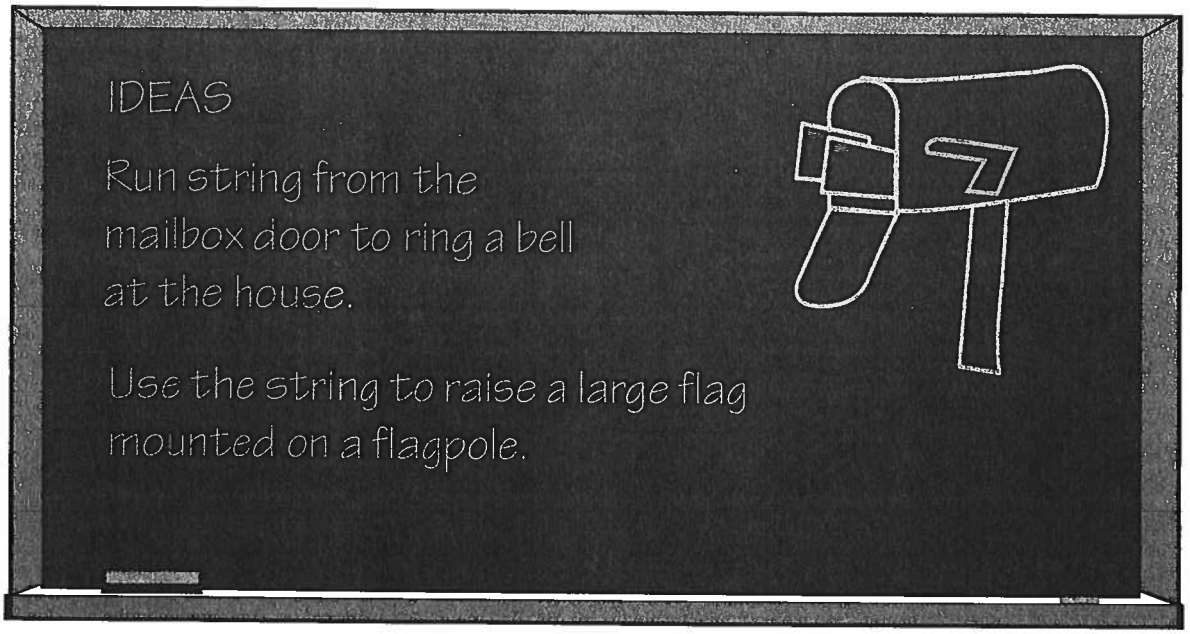



**Fig. 2-5** In brainstorming, accept all ideas. Later, you may want to combine some ideas and reject others.

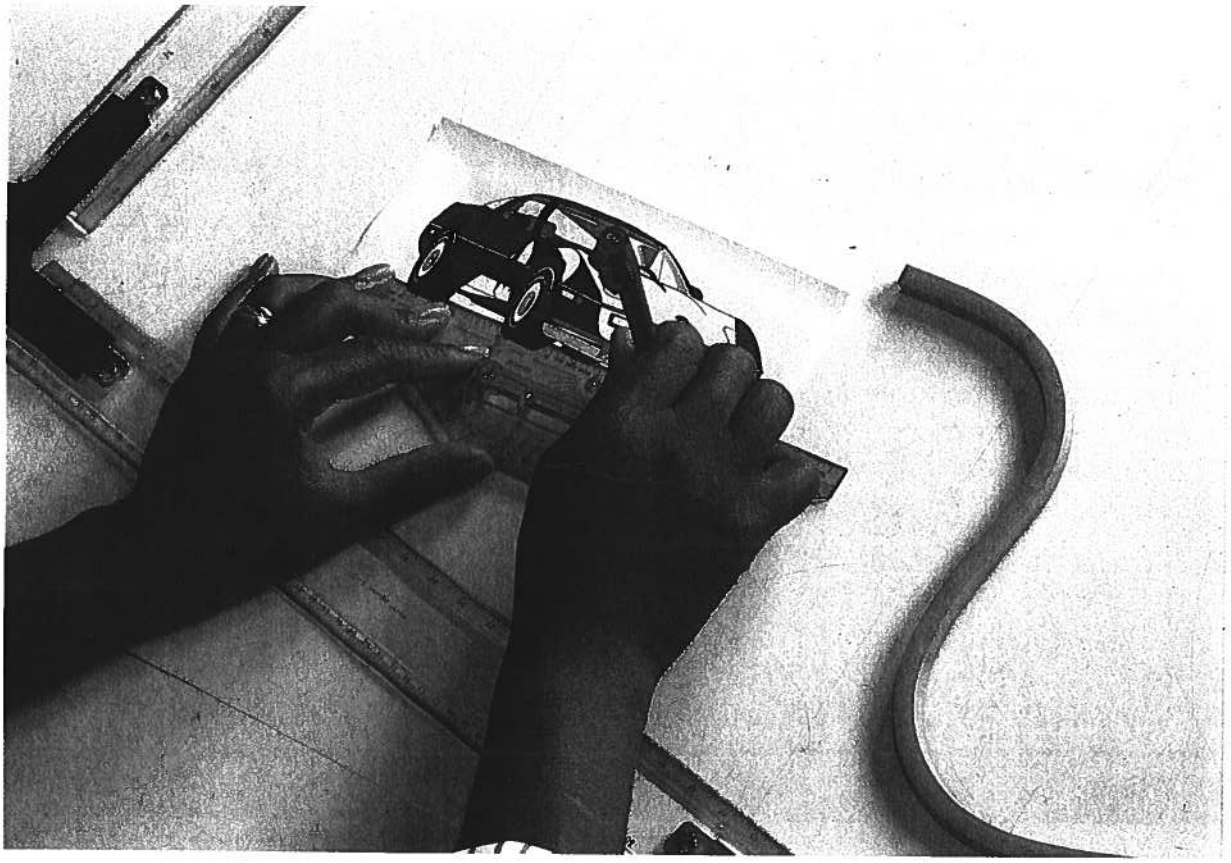


**Fig. 2-6** Two-dimensional modeling includes rendering, or making a realistic drawing.

# Explore

## Design and Build a Time-Keeping Device

| Collect Materials and Equipment |
| --- |
| Modeling materials and supplies: wood, plastic, metal, plastic containers, etc.<br>Standard material processing tools and machines |

### State the Problem

Technology has been used for thousands of years to keep track of time. From early sundials and sand clocks to modern atomic clocks, people have engineered time-keeping devices to help measure their time.

Design and model a time-keeping device that will accurately keep time for a one-hour period.

### Develop Alternative Solutions

Research early time-keeping devices. Devices developed before gear and spring-drive clocks used a variety of materials and methods to measure time.

Based on your research, develop some sketches showing possible methods of measuring elapsed time. Keep in mind that the device should be durable, accurate, and transportable.

### Select the Best Solution

Select the design that you feel is most appropriate.

### Implement the Solution

1. Gather the building materials.
2. Lay out any measurements or patterns.
3. Cut, drill, and perform any separation or forming processes that need to be done.
4. Assemble the device.
5. Test and modify the device.

### Evaluate the Solution

1. Use a stopwatch or clock to time the accuracy of the device.
2. How accurate was your device?
3. How could it be made more accurate?

## Implement the Solution

As models of possible solutions are considered, important questions need to be answered. Fig. 2-7. Some of these questions are:

- Aesthetics—Does it have a pleasing appearance?
- Function—Does it do what it is supposed to?
- Durability—Will it last as long as it needs to?
- Cost—Is the cost within acceptable limits?
- Ergonomics—Is it comfortable to use?

### Linking to MATHEMATICS

***Data Display.*** Use a computer and appropriate software to show how data you collect can be displayed in a chart, graph, or spreadsheet.

**Ergonomics** is the matching of design to human needs. Today ergonomics influences the design of many products. One example of an application of ergonomics is developing "user-friendly" computer software. Other examples include conveniently locating controls on an automobile dashboard and making desk chairs that are comfortable. Fig. 2-8.

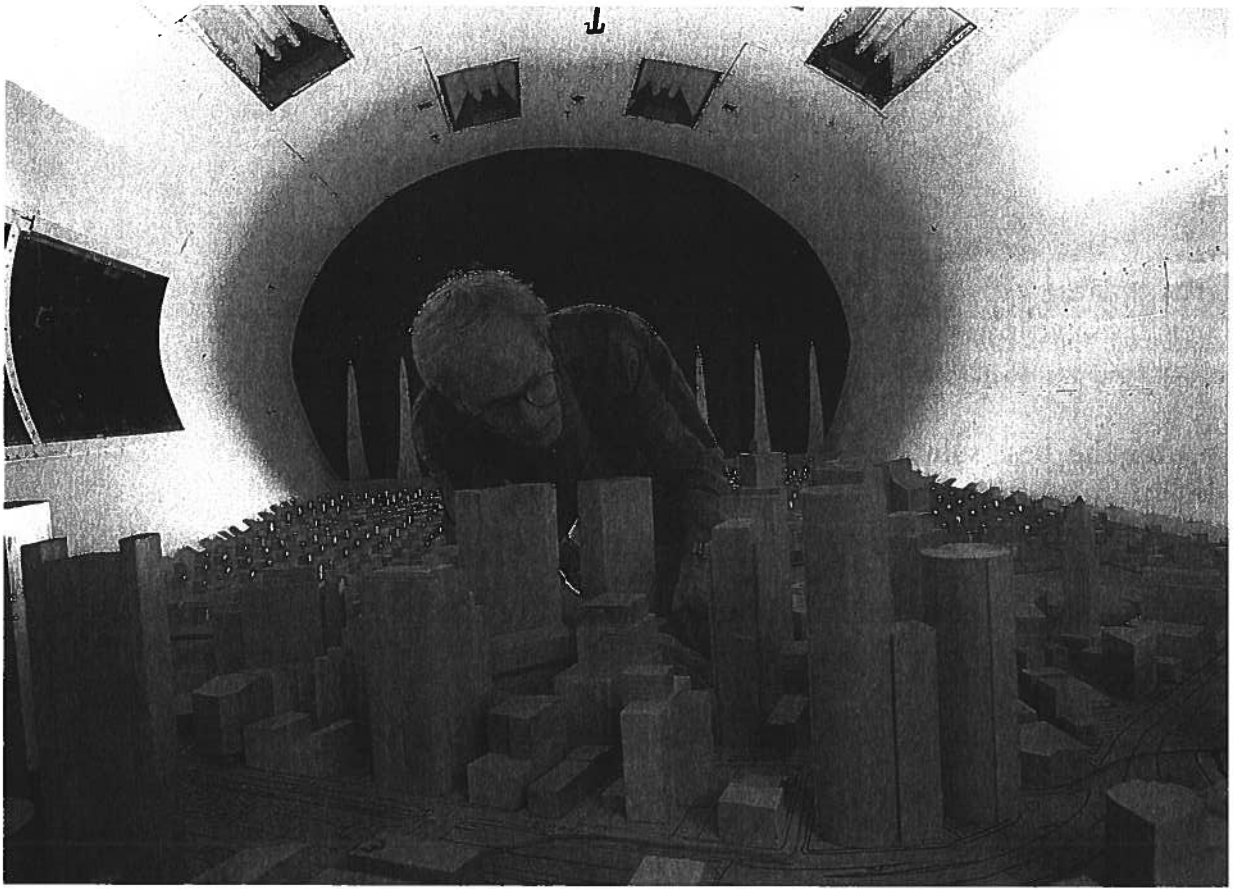


**Fig. 2-7** Wind tunnels can be used to test the design concepts represented by three-dimensional models.

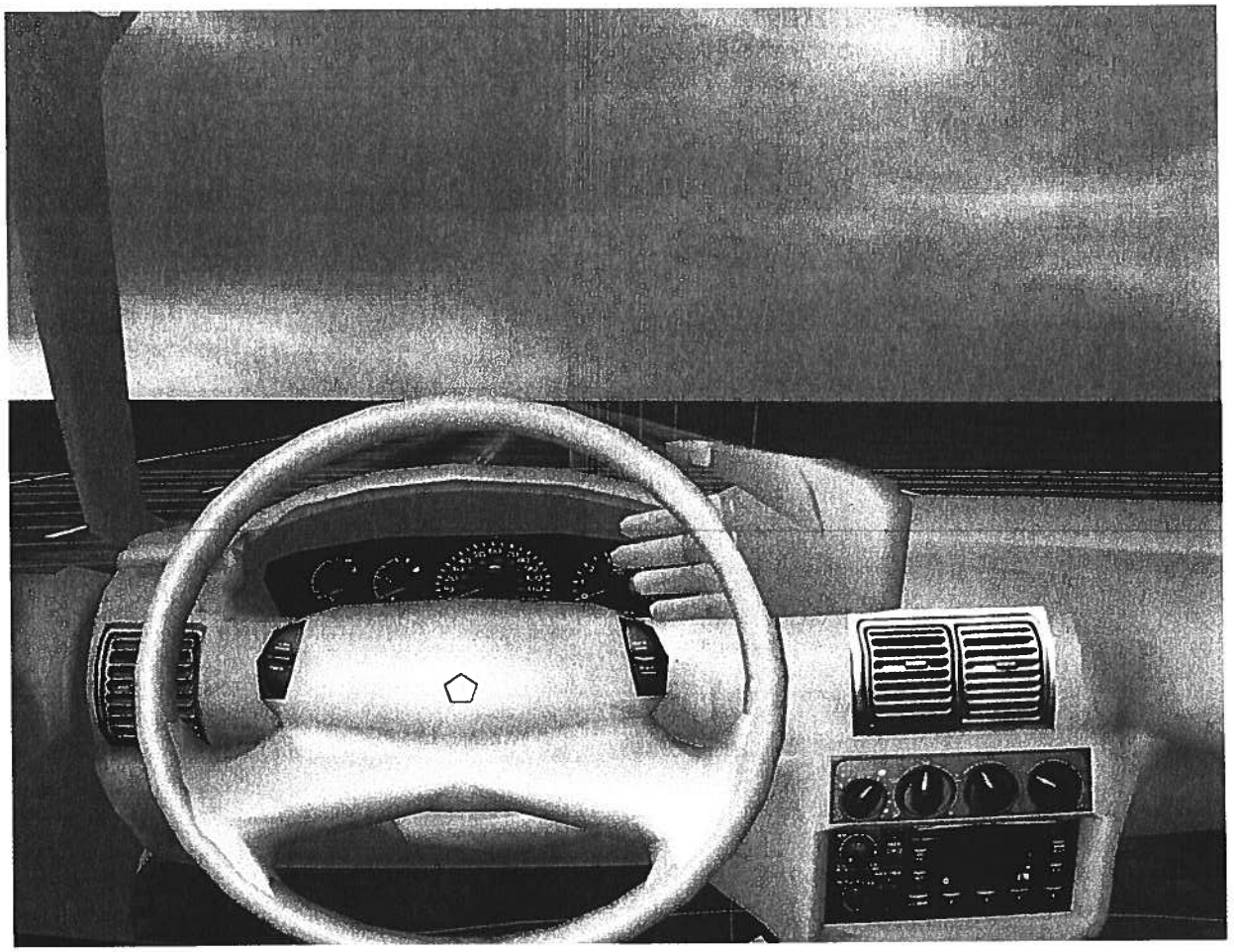


**Fig. 2-8** Virtual reality can be used in design. Here, it is being used to design an automobile dashboard. The position of the driver's hand is indicated at center by the electronic glove. The driver can operate the dashboard controls and make recommendations for design changes.

After the best solution is selected, the design may still need further testing. Government regulations require testing of products such as the pollution-control and safety systems of new automobile models. Firms such as Underwriters Laboratories test products to make sure they are safe to use. New computer programs are tested by persons who want to be among the first to use a piece of software. Their feedback can help improve the program.

Once testing is complete, the new product is ready for production.

## Evaluate the Solution

Even after a product or process is in use, it needs to be checked to see if it is working properly. Sometimes products are randomly selected from a production line for testing. Another way to evaluate products is to survey consumers. A consumer is a person who buys products or services. Consumers may be contacted to get their opinion about a product. Complaints and warranty claims also indicate that changes may need to be made in the product.

Evaluating the solution is the final step of the design process. This step can reveal information that will make the production more efficient. Fig. 2-9.

## USING THE DESIGN PROCESS

You can use the design process to develop solutions for problems of interest. Read the problem situations described below. Select one problem or get teacher approval to work on a different problem, either by yourself or as part of a team. Your solution should include sketches and an appearance model. Present your model to the class.

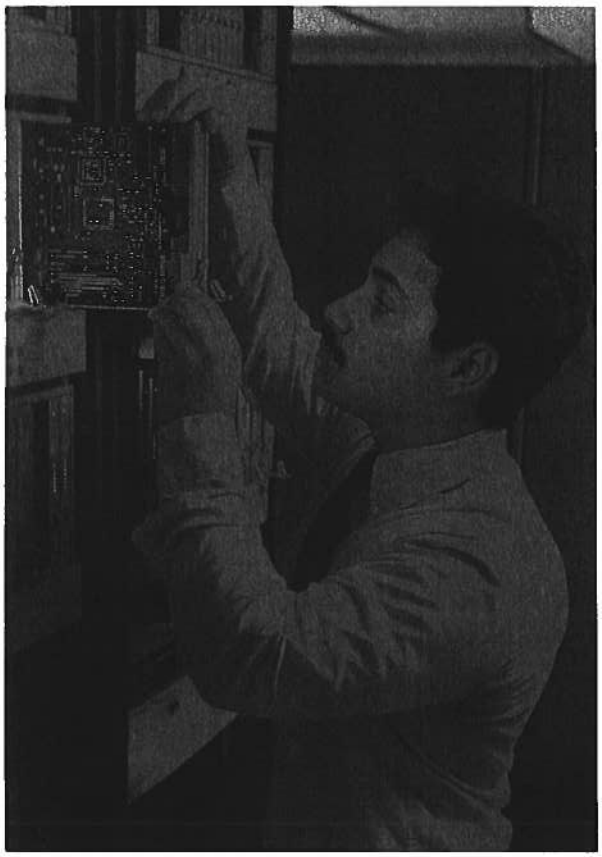


**Fig. 2-9** Evaluation requires a good knowledge of materials and processes.

1. Does your community have an intersection where a large number of crashes have occurred? If so, design and build a model that shows how the intersection can be improved. Consider the use of signs, signals, and turn lanes.
2. Help improve school spirit. Design and implement a system to keep students informed about upcoming events. You might want to use a newsletter, local television or radio program, a message board, or a combination of these.
3. Many people want to pick up a few items on their way home from work. Often they are in a rush. A local company wants to open a convenience store that offers only drive-through service. Select a name, design a logo, and build a scale model.
4. Imagine you are a snack food manufacturer. Recently you surveyed consumers and learned that they would switch to a new brand of potato chips if all chips in the package were large and unbroken. Design and build a new type of package that will protect the chips.

### *Linking to SCIENCE*

***The Scientific Method.*** If you have not already learned the scientific method, do research to identify its main steps. Then compare the steps in the design process with the steps in the scientific method.

# Apply What You've Learned

## Design and Build a Spreadsheet

### State the Problem

A *spreadsheet* is an accounting tool. It allows you to perform automatic calculations. Spreadsheets have columns, rows, and cells. A spreadsheet can help you efficiently estimate the cost of construction and furnishings for a residence. Design a spreadsheet that could be used to track the cost of building a small house.

**Collect Materials and Equipment**

A computer system equipped with spreadsheet software such as Lotus 1-2-3 or Excel. Your instructor will demonstrate how to set up a spreadsheet on the computer.

### Develop Alternative Solutions

Determine what services and items you will need to price. Place these services and items in the first column. There will be one item per cell. They might include:

- New construction
- Renovation work
- Kitchen appliances
- Bedroom furniture
- Living room furniture
- Bathroom
- Miscellaneous furniture

How will these services or items be sold—by the unit or the foot? At the top of each column add the appropriate categories. The spreadsheet should include column categories such as:

- Number needed
- Cost per unit/square foot
- Total cost

The spreadsheet should include formulas in the appropriate cells. After indicating the number of units for any service item, the total cost should appear in the desired cell. A grand total should also appear. This total should be clearly labeled. You may have several possible designs.

| | | A | B | C |
|---|---|---|---|---|
| | | Number Needed | Cost per Unit/ Square Foot | Total Cost |
| 1 | New Construction | 2000 sq ft | 140 sq ft | 280,000 |
| 2 | Renovation Work | 400 sq ft | 50 sq ft | 20,000 |
| 3 | Refrigerator | 1 | 500 | 500 |
| 4 | Gas Range | 1 | 450 | 450 |
| 5 | Freezer | 1 | 600 | 600 |
| 6 | Bed | 3 | 350 | 1050 |
| 7 | Dresser | | | |
| 8 | Desk | | | |
| 9 | Desk Chair | | | |
| 10 | Couch | | | |
| 11 | Chair | | | |
| 12 | TV Stand | | | |
| 13 | Coffee Table | | | |
| 14 | Bookcase | | | |
| 15 | GRAND TOTAL | | | |

### *Select the Best Solution*

Select the spreadsheet design that you think will be most effective.

### *Implement the Solution*

**1.** Set up the column and row headings.
**2.** Insert the individual row entries.
**3.** Insert formulas in the correct cells.
**4.** Insert the costs associated with each individual service or item. (Your instructor will offer guidance.)
**5.** Complete the entries for a typical single-family residence.

### *Evaluate the Solution*

**1.** Does your spreadsheet contain sufficient categories to estimate the cost of a residence?
**2.** Are the formulas correctly written and placed within the correct cells of the spreadsheet?
**3.** Is the grand total clearly labeled?

# CAREERS IN

## Design and Problem Solving

### SAFETY INSPECTOR

Manufacturing company seeks safety inspector with degree in industrial or mechanical engineering or business. Must be computer-literate with formal training in OSHA regulations, insurance regulations, and state EPA regulations. Prefer candidate with experience in health and safety programs in a manufacturing setting. Forward resume to: Rontech Manufacturing, Human Resources Manager, 8975 High Street, Dallas, TX 87120

### ECONOMIST

Private research company has opening for an experienced economist with ability to present findings clearly, both orally and in writing. Must have ability to make decisions and forecast trends based on data. Will assess economic trends for international trade. Computer experience helpful. Please send resume to: Lovett Research, Inc., 802 Oak Street, Bellevue, WA 92022.

### SYSTEMS ANALYST

Growing consulting company has created a new position in the development department. Use your design, development and testing skills to create quality systems. A computer science degree and 2+ years of programming experience required. We offer competitive salary and benefits with extensive growth opportunities. Please submit your resume to: Ava Technology, 4045 Embassy Parkway, Baltimore, MD 27786.

### HUMAN RESOURCES SPECIALIST

Health insurance company seeks HR specialist with expertise in personnel policies, wage, salary/benefit administration, and legal compliance. Must be able to recruit, interview and select staff. Strong communication and interpersonal skills required. Computer knowledge essential. We offer competitive salary and benefits. Please submit resume to: Corporate Health Insurance, Human Resources Department, 4848 Riverside Drive, Portland, OR 76555.

### MARKET AND RESEARCH ANALYST

High-tech company seeks market researcher for internal staff. Develop market reports by analyzing companies and forecasting future trends. Must be comfortable asking questions and making presentations. Requires four-year degree with strong math aptitude. Competitive salary and benefits. Submit resume to: Semiconductors, Inc., 3200 Phoenix Circle, Scottsdale, AZ 80022

## *Linking to the WORKPLACE*

Congratulations! You have just been promoted to Human Resources Specialist. You need to hire a new Systems Analyst. Make a list of ten words that describe the person you would hire for the job. After a class discussion about positive work habits, go back and identify those words on your list that you think describe your work habits. Are there any work habits you would like to improve? What are your best work habits?

# Chapter 2 Review

## SUMMARY

- Problem solving is a part of the design process.
- A design brief is a statement of the problem that is to be solved.
- Brainstorming is a process by which group members suggest ideas as they think of them.
- A prototype is a working model.
- Model building is a good way to develop and record ideas during the design process.
- Ergonomics is the matching of a design to human needs.

## CHECK YOUR FACTS

1. Define *design*.
2. How is problem solving used in designing?
3. Explain the difference between *invention* and *innovation*.
4. List the steps in the design process. Choose one step and explain what is done during that step of the process.
5. Identify several important items that should be included in a design brief.
6. Name three sources of information that may help solve a problem.
7. Name and describe 2D modeling techniques.
8. Explain the difference between an appearance model and a prototype.
9. What is *ergonomics*?

## CRITICAL THINKING

1. A group of students wants to design a new logo for their school. Name and describe a process that should help them get started.
2. Select a common product that you think needs to be redesigned. Express your ideas for improving it in writing and by using sketches.
3. Investigate the work of a famous inventor such as Alexander Graham Bell. If the inventor were alive today, what do you think he or she would be working on?
4. Identify a need that exists in your home, school, or community. Write an appropriate design brief. Use the design process to propose a good solution.