CHAPTER 8

ACTIVITIES

CROSS-CURRICULAR EXTENSIONS

1. **MATHEMATICS** Figure out the gear ratios for a bicycle.

2. **SCIENCE** Design and build a test circuit to check for materials that are conductors or insulators.

3. **COMMUNICATION** Write or e-mail an oil-refining company and ask for information on oil refining and petrochemicals.

EXPLORING CAREERS

Have you ever wanted to take something apart to find out what makes it work? Following are two careers that require that you ask how a product works.

Data Processing Equipment Repairer When a computer crashes, an equipment repairer determines the cause of the problem. These workers install and repair computers and peripheral equipment, such as printers. They use a variety of hand tools to adjust the mechanical parts. Equipment repairers have computer knowledge and a strong interest in fixing things. They must also have good customer-service skills.

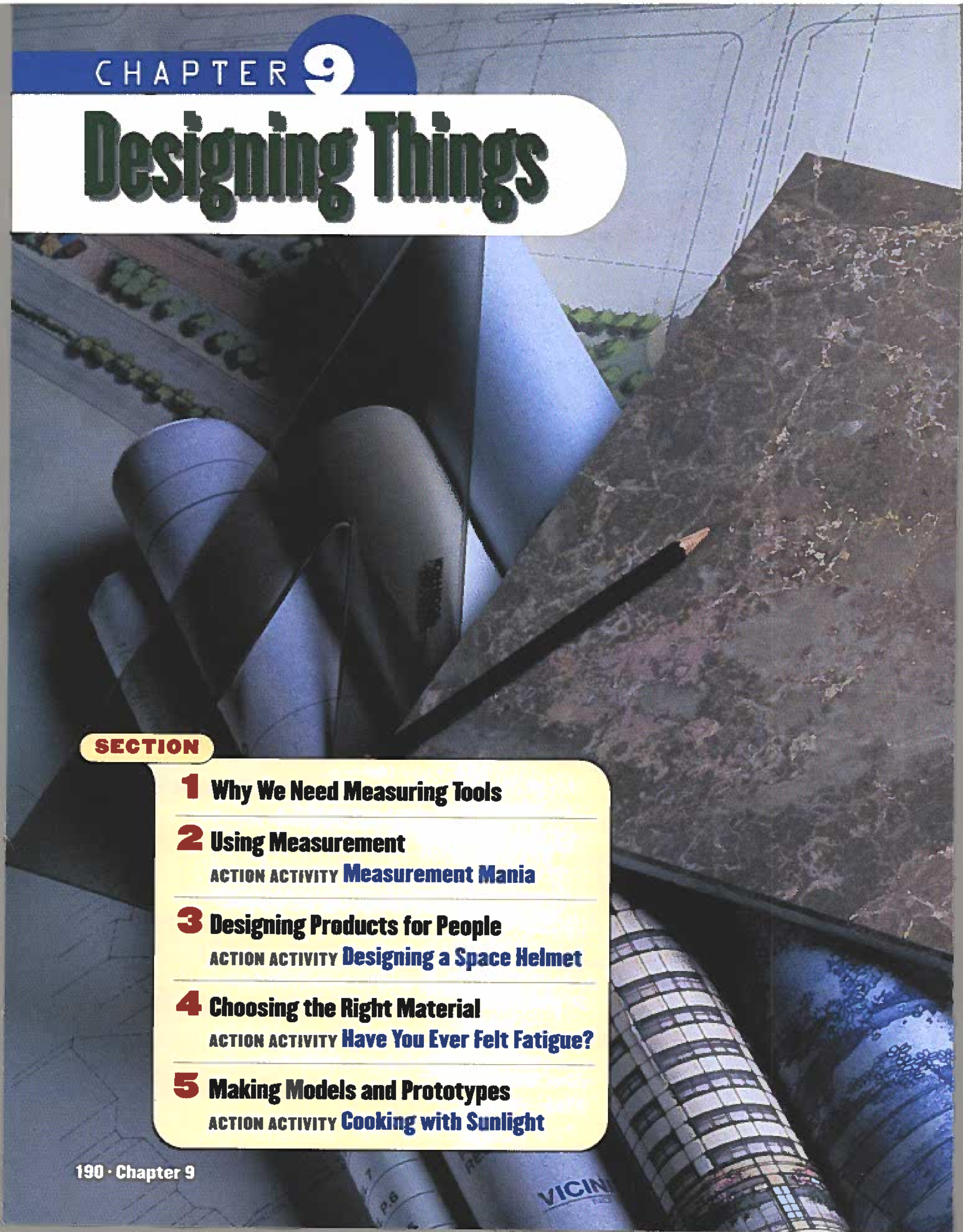
Data Retrieval Specialist Many companies have large computer databases where they keep information (data) that is often needed for reports. Data retrieval specialists spend hours and sometimes days searching for a particular piece of information, such as sales figures from a specific day three years ago. They often write computer programs to assist them in locating the information, so programming skills are also needed. This is a good career for someone who is persistent when faced with solving a problem.

ACTIVITY

Find instructions that came with a product that include a troubleshooting chart. Would the chart be helpful in fixing the product? Explain.

CHAPTER 9

Designing Things



SECTION

1 Why We Need Measuring Tools

2 Using Measurement

ACTION ACTIVITY Measurement Mania

3 Designing Products for People

ACTION ACTIVITY Designing a Space Helmet

4 Choosing the Right Material

ACTION ACTIVITY Have You Ever Felt Fatigue?

5 Making Models and Prototypes

ACTION ACTIVITY Cooking with Sunlight

Why We Need Measuring Tools

SECTION 1

THINGS TO EXPLORE

- Explain why precise measuring tools were developed.
- Compare old ways of measuring with today's measurement tools.
- Tell what a standard is and why standards are used.

TechnoTerms
precision
standard

When you design and make things, measurement tools can help you be as accurate as possible. You've used rulers before, but there are many other measurement tools used in technology. Tools such as stopwatches, thermometers, multimeters (meters that measure electricity), and meter sticks are devices that you will use in designing, building, and testing things. Fig. 9-1.

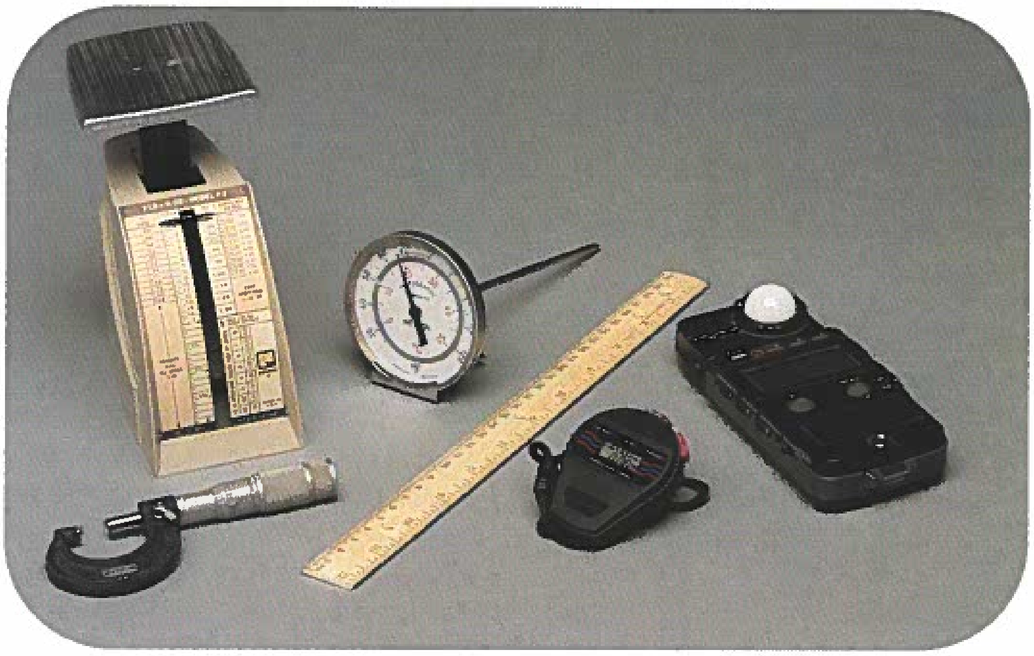


Fig. 9-1. These measuring instruments include (from left to right) a micrometer, scale, cooking thermometer, ruler, stopwatch, and photographic light meter.

OPPOSITE Design is where all products start. Design requires imagination!

Fig. 9-2. Compare this man's foot to a one-foot ruler. How does your own foot compare?

Early Measurements

Early measurements were often based on human dimensions. For instance, a foot was the length of an average man's foot. Fig. 9-2. Other measurements, such as an acre and a furlong, were built around practical activities like plowing. An acre was the amount of land two yoked oxen could plow in one day. A furlong was the distance a horse could pull a plow without stopping to rest. Can you see some problems with these early systems of measuring? They were not very *precise*, or accurate.

TechnoFact

OH! MY SPACESUIT IS TOO TIGHT! It is difficult to make one product that will work for everyone. NASA, for example, used to design a special spacesuit for each astronaut, but this was very expensive. NASA now designs its new spacesuits, called *extravehicular mobility units* (EMU), in a few standard sizes.

Standard Measurements

Scientists in particular needed more precise **standards** (exact units used by everyone) of measurement so they could build on one another's findings. This need for **precision** and standards produced the measurement systems we use today. We use standard measurements for such things as the speed of light and the amount of electricity used by an appliance.

SECTION 1 TechCHECK

1. Why do we need to make precise measurements?
2. How did people measure things in times past?
3. What are standards?
4. **Apply Your Knowledge.** Measure 50 feet using a rule or yardstick. Then measure the same distance using your foot as the measuring tool. How close is the measurement taken with your foot to that taken with the standard tool?

Using Measurement

SECTION 2

THINGS TO EXPLORE

- Explain the difference between the English system of measurement and the metric (SI) system.
- Use the English and metric systems to measure accurately and quickly.
- Tell what measuring to scale is and how it is useful.

TechnoTerms

drawing to scale
estimate
International System of Units (SI)
metric system

Designing things often means using measurement in different ways. In this section you'll learn about metric measurement, drawing to scale, and estimating.

Metric Measurements

You've probably learned about the **metric system** (base 10) of measurement in mathematics classes. Parts of the metric system make up the **International System of Units** (called **SI**, for the French name, Système International) which is used internationally for trade. SI makes it easier for scientists, engineers, and construction industries all over the world to work with materials and parts that are interchangeable.

Commonly used metric base units are meters, liters, and grams. Fig. 9-3. All metric measures are based on multiples of ten, which makes them easy to calculate with.

Fig. 9-3. This chart shows English and metric equivalents. Using information shown here, convert 6 ounces to grams.

	English Unit	Abbrev.	SI Equivalent	Abbrev.
Distance 1 Inch	Inch	In. or "	25.4 Millimeters	mm
	Foot	Ft. or '	304.8 Millimeters	mm
	Yard	Yd.	.914 Meter	m
Area 1" 1" 1 Square Inch	Square Inch	Sq. In. or In.^{2}	645 Square Millimeters	mm^2
	Square Foot	Sq. Ft. or Ft.^{2}	.0929 Square Meter	m^2
	Square Yard	Sq. Yd. or Yd.^{2}	.836 Square Meter	m^2
Volume 1" 1" 1" 1 Cubic Inch	Cubic Inch	Cu. In. or In.^{3}	16,387 Cubic Millimeter	mm^3
	Cubic Foot	Cu. Ft. or Ft.^{3}	.0283 Cubic Meter	m^3
	Cubic Yard	Cu. Yd. or Yd.^{3}	.7646 Cubic Meter	m^3
Mass 1 Pound	Ounce	Oz.	28.35 Grams	g
	Pound	Lb.	453.6 Grams	g

TechnoFact

COMPUTER SPEEDS What are nanoseconds, MIPS, and flops? These are standard measurement terms used in computer technology. A nanosecond (one-billionth of a second) is a unit of measurement for computer speed. MIPS stands for *m*illions of *i*nstructions *p*er *s*econd. Flops stands for *fl*oating point *o*perations *p*er *s*econd. Both MIPS and flops are used as a measurement of how fast supercomputers can process information.

At one time, the United States planned to switch completely to the metric system, but it never did. We still use the English system, which is based on the foot, the pound, and the quart. However, many products now show both English and metric measurements.

When you are designing and building, you will find it easier if you stick to one system rather than mixing metric and English units.

Drawing and Making Things to Scale

Sometimes things are too large or too small to draw in their actual size. For instance, you couldn't make a full-sized drawing of a house because paper isn't made large enough! Fig. 9-4. You also would have a difficult time drawing the parts of an integrated circuit in their actual sizes because they are too small. Can you imagine drawing more than 1,000 circuits in a space smaller than a pencil eraser?

To solve this problem, objects are often drawn to scale. **Drawing to scale** means that the object is drawn larger or smaller than it really is, but all its parts are still in the correct proportion.

MATHEMATICS CONNECTION

Measuring Electricity

Measuring electricity is important in designing the electrical circuits found in many products. The three basic units used to measure electricity are the volt, the amp, and the ohm.

- **Volt.** Electricity flowing through wires in a circuit is very similar to water flowing through a hose. The voltage that pushes electrons through the wire is similar to the pressure that pushes the water. *Voltage* is a unit of electrical pressure.
- **Amp.** The amount of water flowing through a hose might be measured in gallons. In an electrical system,

Estimating

To **estimate** a measurement means to figure closely but not exactly. For example, you have probably learned about how long an inch or a centimeter is in your mathematics classes. Now you can estimate about how long something is in inches or centimeters. It is important in technology to be able to estimate the size of objects without actually measuring them.

Fig. 9-4. The structure being built on this site requires many drawings. All of them are drawn to scale. Draw your desk at a scale of 1" = 1/4".

SECTION 2 TechCHECK

1. What is the difference between the English and metric systems of measurement?
2. Name three base units used in the metric system.
3. Why do architects draw to scale?
4. **Apply Your Knowledge.** Design and build a scale model of a car.

the amount of electrons flowing through the wire is measured in amperes (amps). *Amperage* is a measure of quantity.

- **Ohm.** A nozzle at the end of a hose resists (holds back) the flow of water. The higher the resistance in an electric circuit, the more electrons are held back. The resistance in electrical systems is measured in *ohms.*

There is a simple mathematical relationship between volts, amps, and ohms. This special formula is known as *Ohm's Law.*

amps = volts ÷ ohms

ACTIVITY

All three units—volts, amps, and ohms—can be measured with a multimeter. Use a digital multimeter to measure the voltage in different batteries.

ACTION ACTIVITY

Measurement Mania

Be sure to fill out your TechNotes and place them in your portfolio.

Real World Connection

The ability to estimate and measure quickly and accurately is an important skill in technology. Fig. A. In this activity, you will first exercise your ability to use English and metric measurement. After you are able to measure accurately, you will be challenged to estimate and measure objects quickly and accurately.

Design Brief

Demonstrate your ability to measure accurately and quickly using both English and metric measurement. Put your measurement skills to use in a measurement test.

Materials/Equipment

- string
- miscellaneous materials for measurement game
- rulers, tape measures
- calculator (optional)

SAFETY FIRST

Follow the safety rules listed on pages 42-43 and the specific rules provided by your teacher for tools and machines.

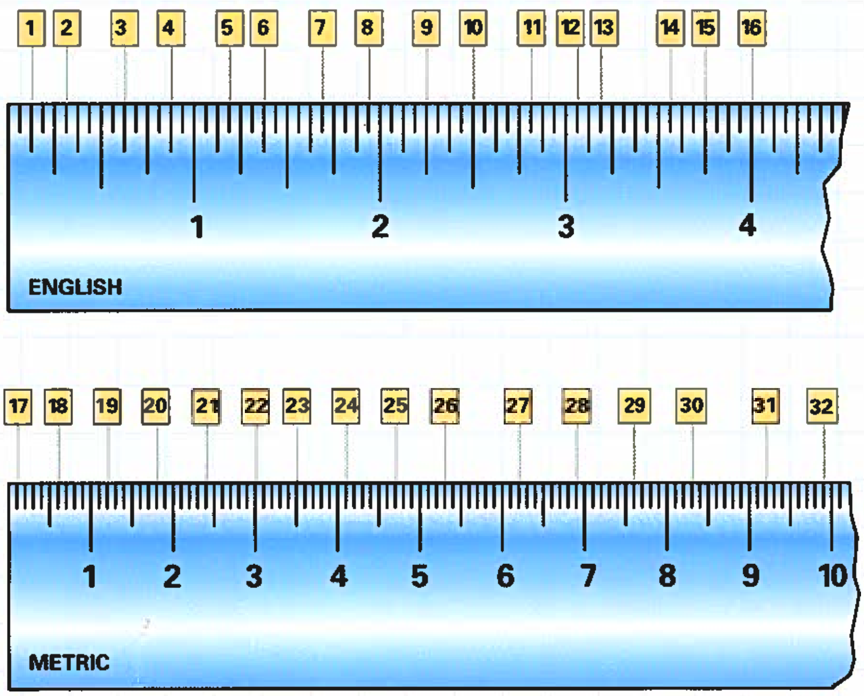


Fig. A

Procedure

Part 1 • Measurement Test

1. Complete the measurements for 1 through 32 shown in Fig. A. Write your answers on a separate sheet of paper. You must reduce all fractions and use decimals where needed.
2. Ask your teacher to check your test. If you missed even one of the answers, you must take the test again.
3. If you missed some answers, your teacher will help you understand your mistakes.
4. When you are sure you know how to measure in both English and metric (SI) units, go on to the next part of this activity.

Part 2 • Estimating and Measuring

1. Using a separate sheet of paper, write your estimate of both the English and metric size of each object in the list shown in Fig. B.
2. Using the proper measurement tools, make accurate measurements of each object and record them on your sheet.
3. Find the difference between your estimate and the actual size by subtraction. You may use a calculator.
4. Figure the total of the differences between your estimates and the actual sizes of the objects in both the English and metric (SI) sections. Check with your teacher on how to make an English total.

Evaluation

1. Which measurement system is easier for you to use? Why?
2. List three occupations that require fast and accurate measurement.
3. How is measurement important in sports such as volleyball, football, basketball, and baseball?
4. **Going Beyond.** Do other countries use the English measurement system? Do some research to find out.
5. **Going Beyond.** Find out the meaning of the following units: newton, furlong, joule, light-year.

Fig. B

	Name of Object	Estimate	Actual Size	Difference
English	Width of sheet of paper			
English	Diameter of a globe			
English	Thickness of a pencil			
English	Height of a desk			
English	One Meter			
			TOTAL	
Metric (SI)	Width of classroom door			
Metric (SI)	Height of this book			
Metric (SI)	One Inch			
Metric (SI)	Circumference of globe			
Metric (SI)	Width of computer disk			
			TOTAL	
			ENGLISH TOTAL	
			GRAND TOTAL	

SECTION 3

Designing Products for People

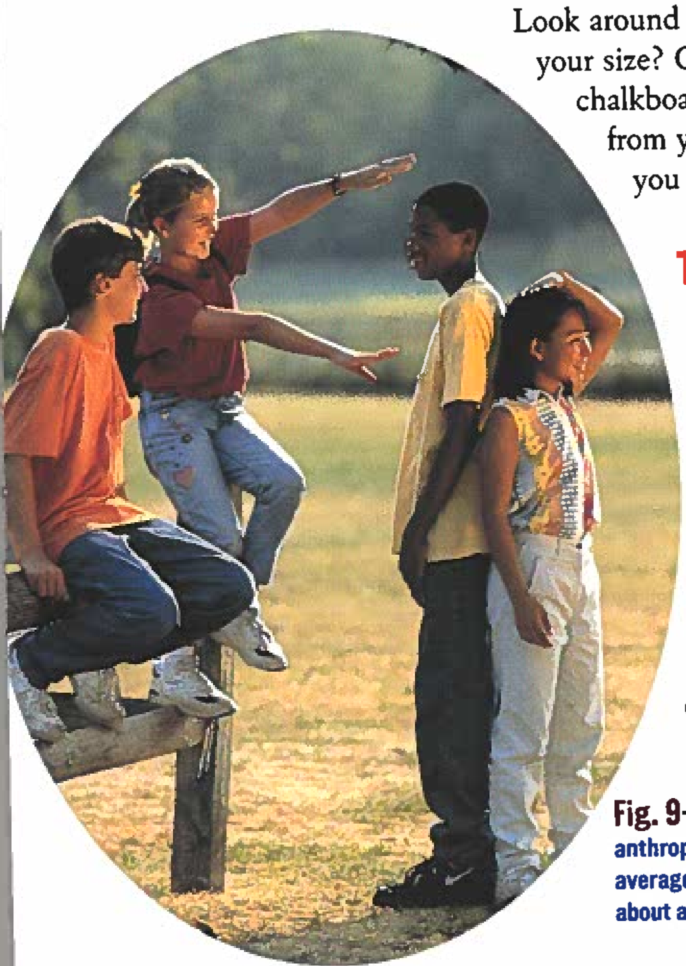
TechnoTerms
- anthropometric data
- carpal tunnel syndrome
- ergonomics

THINGS TO EXPLORE

- Define ergonomics and tell how it affects the way things are designed.
- Explain how anthropometric data is used in design.
- Design a space helmet based on anthropometric data.

Have you ever tried on gloves and found the sizes either too large or too small? Have you ever sat in a chair that hurt your back? Simple everyday things like water faucets and door knobs can sometimes be hard to use because they weren't designed with people in mind.

Look around you. Is the room you're in designed to fit people your size? Can you reach all the shelves? Are the chalkboards at a proper height so you can easily see them from your desk? Can you easily reach all the materials you need to do your work?



Tradition

Many times products are designed just for looks. Tradition also plays a part. Scissors are an example. Originally, they were designed for right-handed people. That design has not changed much, although special versions are made for left-handed people.

The products you use and the places where you live, work, and play are safer, easier to use, and more comfortable if they are designed based on how a real human body is made and works.

Fig. 9-5. People come in all shapes and sizes. Gather anthropometric data for people in your family. What is the average height and weight of your family members? How about arm reach?

Human Sizes

Have you ever wondered how designers decide on what size things should be? When designers made the chair you are sitting in, for example, they used anthropometric data. **Anthropometric data** is size information collected from many people. Fig. 9-5. Designers use this data to determine the dimensions of products such as clothing, furniture, sporting goods, car interiors, and even spacesuits. In most cases, they create a size that "fits" about 90 percent of a product's users. That means for five percent of the people it will probably be too large and for another five percent it will be too small.

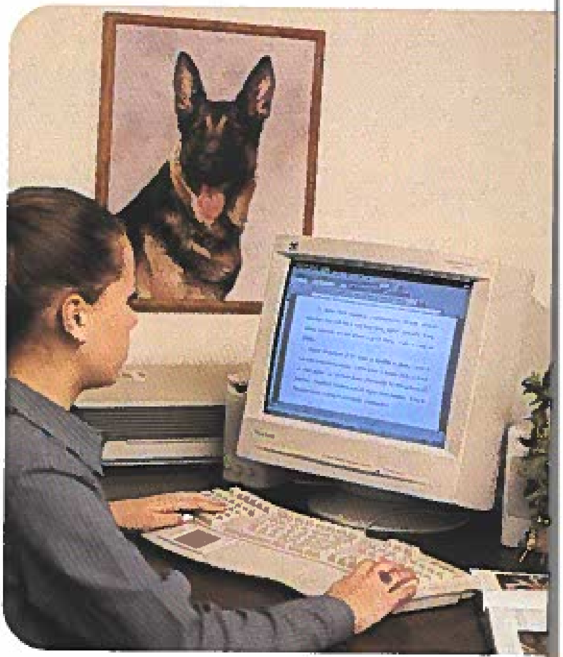


Fig. 9-6. Ergonomic design makes products, such as computer keyboards, easier to use.

Ergonomics

Ergonomics is the study of how the human body relates to things around it, such as furniture and clothing. It is also called "human engineering."

Ergonomics plays an important part in today's high-tech workplace. For example, many people spend long hours using computer keyboards. But nerves in the wrist can be damaged by repeating a simple movement like pressing the keys over and over again. The result is **carpal tunnel syndrome**. To help prevent this problem, designers have come up with wrist braces, adjustable chairs, and even specialized keyboards. Fig. 9-6.

Part of ergonomic design is to make products safer. For instance, special dashboard and ceiling padding, seatbelts, harnesses, and other safety features are built into today's automobiles. Even the seats are designed so you will sit in a proper driving position.

TechnoFact

ERGONOMIC CHALLENGE Ergonomic design is important in equipment and products for physically challenged people. *Prosthetic devices* (artificial body parts), wheelchairs, furniture, and bicycles can all be specially designed to help people who are disabled carry out their daily activities.

SECTION 3 TechCHECK

1. What is ergonomics?
2. What kinds of anthropometric data can be gathered to help designers?
3. How are anthropometric data and ergonomics used to design things?
4. **Apply Your Knowledge.** Design a chair that best fits all the students in your classroom.

SECTION 3 **ACTION ACTIVITY**

Designing a Space Helmet

Be sure to fill out your TechNotes and place them in your portfolio.

Real World Connection

Scientists, technologists, designers, architects, and engineers all use anthropometric data to help them design and make products for people to use comfortably. Special attention must be given to high-tech equipment such as spacesuits. In this activity, you will gather anthropometric data and use it to design a space helmet.

Design Brief

Research and design a space helmet that can be used easily and comfortably. Your design must consider the following:

- Proper size. Your team will determine the best size by gathering anthropometric data.
- Appropriate materials. The helmet should be able to withstand impacts. The visor should protect astronauts from the blinding glare of the sun.
- Weight. Even though things are "weightless" in space, the helmet must be light enough to wear during training on Earth.
- Comfort and safety. Your helmet should be comfortable to work in for many hours. Ventilation and a microphone for communication should be provided.

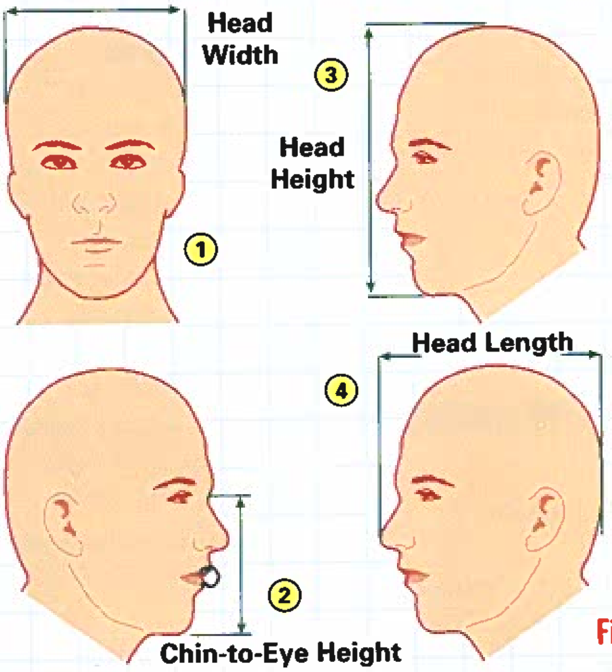


Fig. A

Materials/Equipment

- graph paper, pencil
- large calipers
- ruler or tape measure
- computer with spreadsheet and graphics software (optional)

SAFETY FIRST

Follow the safety rules listed on pages 42-43 and the specific rules provided by your teacher for tools and machines.

Procedure

1. Work in groups of four or five. Read through the steps in the procedure and divide the tasks so that everyone in your group is helping to design the space helmet. Use a tape measure or calipers and a ruler to take the measurements shown in Fig. A. These measurements will be the anthropometric data you need for this activity.
2. Record the measurements for each member of your group on a chart similar to the one in Fig. B. You could use a computer and spreadsheet software to create your chart. Remember, however, that computers do not handle fractions very well. You might want to use the metric system to avoid problems.
3. Using graph paper, sketch a head to scale using the largest dimensions obtained in step 1. Then sketch your designs to scale. Make a front view and a side view of the helmet.
4. Label each part of your space helmet design. Give each part a name, such as visor, sealing neck-ring, microphone, air vents, padding, and antenna.
5. Choose the right materials for your helmet. Following is a list of materials and their properties that may be of help:
   - *Fiberglass:* Fiberglass is made of very thin glass strands glued together with a liquid plastic that hardens. The glass fibers go in every direction and give fiberglass its strength.
   - *Polycarbonate:* Polycarbonate is a clear, strong thermoplastic material that can be bent or shaped with heat. It is used to make safety glasses and windshields for snowmobiles and motorcycles.
   - *Aluminum:* This is a very strong, lightweight metal that conducts heat and electricity easily. Aluminum can be formed into almost any shape, from very thin foil to thick castings.
   - *Acrylic:* Acrylic plastic is clearer than glass. It is a thermoplastic that is easy to cut, bend, or shape with heat. It expands and contracts with temperature change but can be very brittle in thin sections.

Fig. B

ANTHROPOMETRIC DIMENSIONS					
	1	2	3	4	
Student 1					
Student 2					
Student 3					
Student 4					
Student 5					
Total					
Average					
Maximum					

Evaluation

1. How could your design be improved?
2. What is your estimate of how much your helmet design would weigh? What do you think it would cost to make? How could the cost and weight be reduced?
3. List two other examples in which anthropometric data are used to design products.
4. **Going Beyond.** Use a computer and CAD software to make a final design for your helmet.

INFOLINK

See Chapter 5 for more information about computer-aided design (CAD).

SECTION 4

Choosing the Right Material

TechnoTerms
- composite
- compression strength
- fatigue strength
- synthetic
- tensile strength
- thermoplastic
- thermosetting plastic

THINGS TO EXPLORE

- Explain why it is important to select the right material to make products.
- Distinguish between synthetic and natural materials and give examples of each.
- Identify different properties of materials that you can test.
- Test a material for fatigue strength.

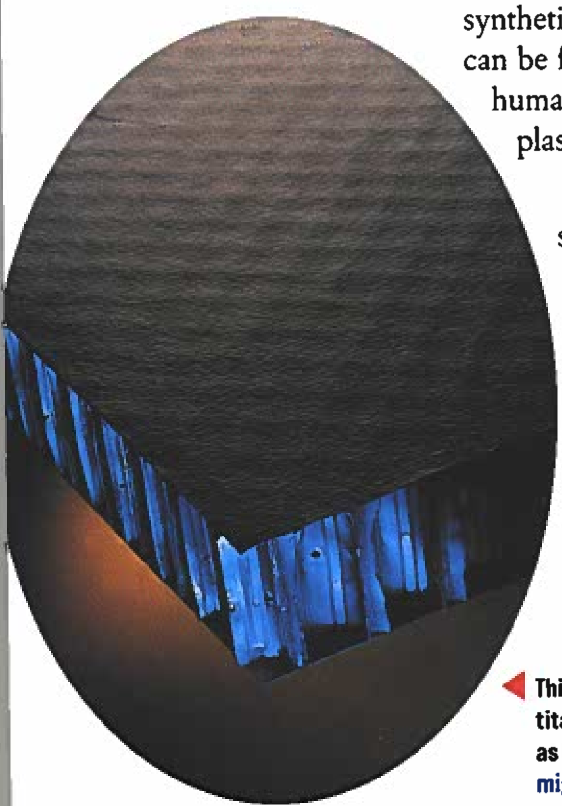
Since the earliest times, people have been researching new materials and new uses for old materials. The materials chosen for a product can make it either useful and long-lasting or dangerous and short-lived.

Classifying Materials

Basically, materials can be divided into two major groups, synthetic and natural. Natural materials, such as copper and wood, can be found in nature. **Synthetic** refers to a material made by humans that cannot be found in nature. The many kinds of plastics are examples of synthetics.

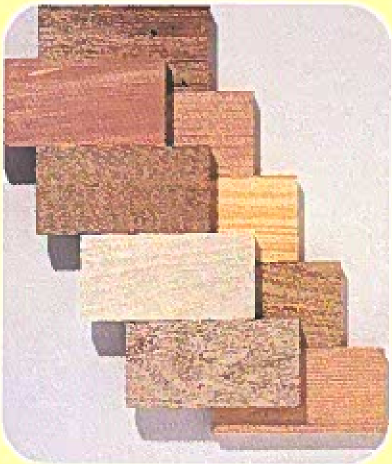
Products often are combinations of both natural and synthetic materials. For example, a television set has a picture tube made of glass, a cabinet made of plastic or wood, and wires made of copper.

Did you know that materials can be further divided into categories based on their origin? In general, they fall into four main groups: woods, metals, plastics, and composites. Fig. 9-7.



This "sandwich" is made from a compound of the metals titanium and aluminum. Intermetallic compounds such as this are strong at high temperatures. What products might need a material with that property?

FIG. 9-7. CLASSIFYING MATERIALS



- **Woods.** Woods are either hardwoods or softwoods. Sounds simple, but the words *hard* and *soft* often have little to do with the hardness of the wood. The difference is in the tree that the wood came from. Hardwoods come from trees that have broad leaves, such as walnut and maple. Softwoods come from trees that have needles, such as pine and fir.
- **Metals.** Metals are either ferrous or nonferrous. *Ferrous* is a Latin word for iron. Ferrous metals contain iron and nonferrous metals do not. Ferrous metals include iron and the many types of steel. Nonferrous metals include copper, tin, lead, aluminum, gold, and silver.

- **Plastics.** Plastics are either thermoplastic or thermosetting plastic. The difference is very simple. **Thermoplastics** can be melted and remelted many times using heat. Acrylic plastic is an example. It can be reheated many times to change its shape. **Thermosetting plastics** change chemically when they set. They cannot be remelted. Bakelite is a common thermosetting plastic used for electrical plugs and cooking-pot handles.

- **Composites.** By combining different materials, new and often better properties can be obtained. Composite materials, such as fiberglass and carbon graphite (graphite-epoxy), are often lightweight and strong. They are used to make high-performance aircraft wings and lightweight sporting goods such as tennis racquets.

Properties of Materials

Materials are chosen for products based on their properties, or characteristics. Fig. 9-8. Each material has special properties that make it useful for certain things. When you are designing products, you should consider using more than one kind of material to take advantage of their different properties. The following properties are found in many common materials:

- **Hardness:** The ability to resist dents
- **Tensile (tension) strength:** The ability to resist stretching or being pulled apart
- **Compression strength:** The ability to resist being squashed or smashed
- **Fatigue strength:** The ability to resist breakage after being bent back and forth

Testing Materials

Some materials have surprising uses. Would you ever consider building a boat out of cement or glass? Some very large boats are made of a cement mixture, called ferrocement, that is sprayed over wire mesh. And the boats float! Many boats are also made of fiberglass, which contains glass fibers.

Materials are first tested before they are used to make products. Fig. 9-9. This is done in order to learn if a material will be appropriate for the product. There are many different properties of materials that can be tested. Hardness, tensile strength, compression strength, and fatigue strength are some of the most common. Testing a material until it breaks or is destroyed is called *destructive testing*.

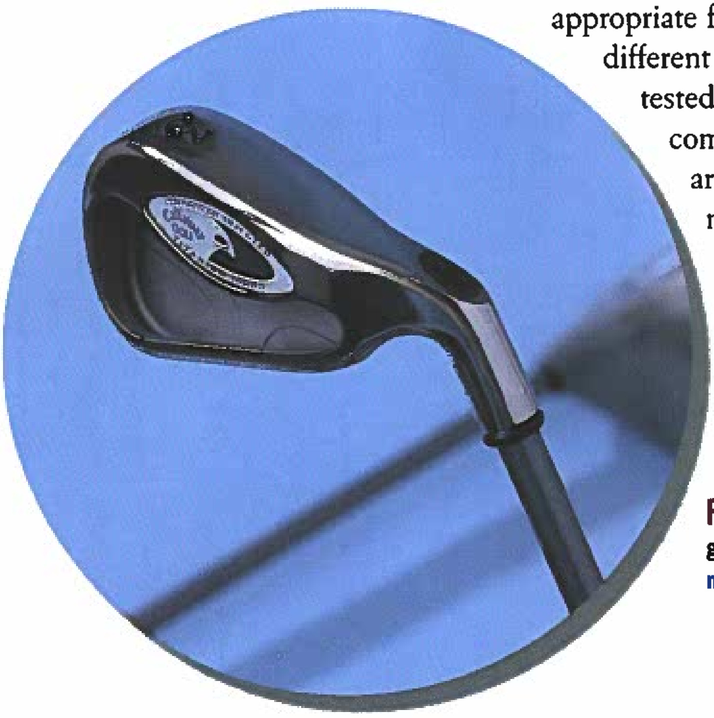


Fig. 9-8. The bend in this ergonomically designed golf club makes aiming easier. **What properties must the materials used in golf clubs have?**

Fig. 9-9. This engineered-wood beam will be tested for compression strength. The metal beam will press down on top of the wooden one. **Why do you think a beam would need to withstand compression?**

SECTION 4 TechCHECK

1. Why is it important to choose the proper materials to make a product?
2. What is the difference between a synthetic material and a natural material?
3. What kinds of tests can you do on materials?
4. **Apply Your Knowledge.** Test a rubber band, a pencil, and a soda can for the four properties. Make a chart showing the results of your test.

SECTION 4

ACTION ACTIVITY

Have You Ever Felt Fatigue?

Be sure to fill out your TechNotes and place them in your portfolio.

Real World Connection

Fatigue strength can be a lifesaving property. Airplanes, for example, are sometimes damaged by metal fatigue. The metal in the wings flexes as the airplane flies. The metal fuselage (body) expands and contracts as the plane changes altitude. If they are not detected, small cracks caused by fatigue around rivets can cause the plane to break up. Fig. A.

In this activity, you will do a destructive test to determine the fatigue strength of a steel paper clip.

Design Brief

Design and perform a test that will determine the fatigue strength of a paper clip. Use mathematics to find the average fatigue strength of at least 10 paper clips.

Materials/Equipment

- paper clips
- pencil, paper
- computer with spreadsheet and word-processing software (optional)

SAFETY FIRST

Follow the safety rules listed on pages 42-43 and the specific rules provided by your teacher for tools and machines.

Fig. A. This photo (magnified 280 times) shows a welded joint between two steel plates in an aircraft wing. Metal fatigue caused a stress fracture in the joint (brown area).

Procedure

1. Work in groups of five or six. Discuss the possible ways a paper clip might be tested by bending it until it breaks. Experiment with a few paper clips to see if your idea will work.
2. As a group, decide which test method will be used. Write the procedure for your method using a computer. Your procedure should be detailed enough so that another group could follow your directions. Fig. B.

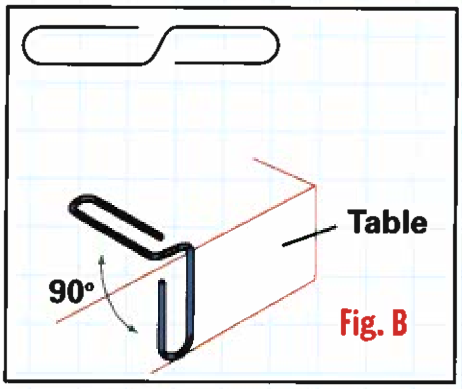


Fig. B

3. Have each person in your group test two or three paper clips. Each tester should write down the number of bending cycles the paper clip went through before it broke.
4. Each tester should add up the number of bending cycles for each paper clip and find the average number of bends required. (To find the average, divide the total number of bending cycles by the number of paper clips tested.) If possible, use a computer and spreadsheet software to help you find the average.
5. Compare the average number in your test with the average numbers of others in your group. Find an average number for the entire group by adding all the individual averages together and dividing by the number of people in your group.

Evaluation

1. Were the average numbers of bending cycles the same for every person in your group? If not, why do you think some people got different numbers?
2. What is the relationship between the size of the bending angle and the number of bending cycles that can be completed before breaking?
3. **Going Beyond.** Compare the average obtained by your group with the averages of other groups. Make a bar graph showing the results. You can use a computer to help make the graph.
4. **Going Beyond.** Design a test procedure to test other materials for fatigue strength.

SECTION 5

Making Models and Prototypes

THINGS TO EXPLORE

- Tell what a prototype is.
- Explain why designers, engineers, and architects often make prototypes or models.
- Make a prototype of a solar cooker.

TechnoTerm
wind tunnel

You know what a model is. Do you remember what a prototype is? A prototype is a model of a product being designed for production. Companies can't build thousands of products without being sure that all the defects or problems have been corrected. Without planning and testing by using models, expensive mistakes can be made. Instead, models and prototypes help them decide whether the product will fit their needs before they spend a great deal of time and money.

Using Prototypes

Prototypes are used by designers, engineers, and architects. When architects design a new skyscraper for a large city, for example, they often build models so people can visualize the shape of the building. Fig. 9-10A. The model lets people see what the building will look like better than a drawing can. Models are usually made to scale. Also, the model of a new building is sometimes placed in a model of the entire city to see how it fits in.

Fig. 9-10A. Notice the drawing the architect is using. Which would give a client a better idea of the completed building, the drawing or the model? Explain.

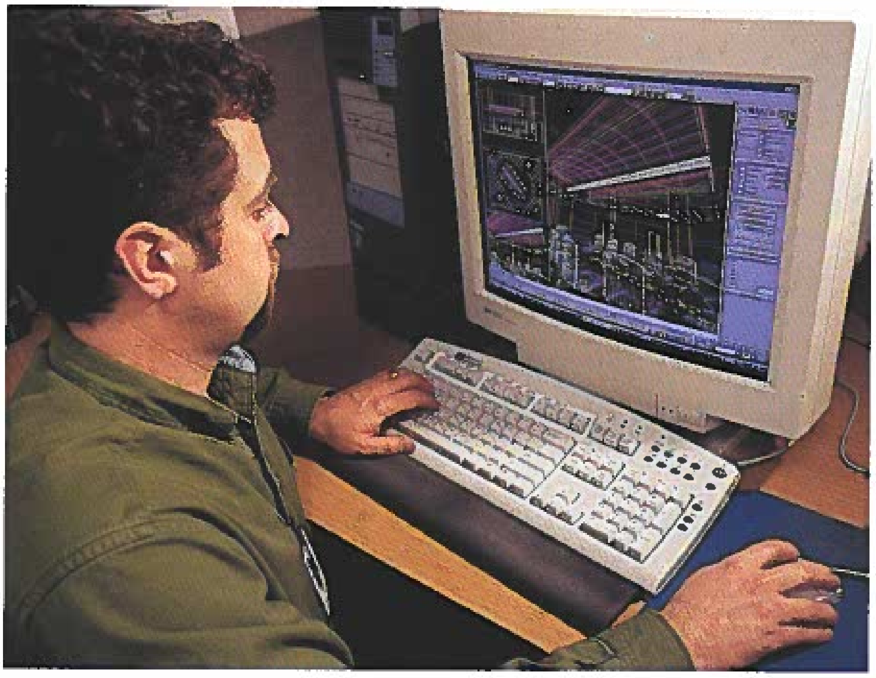


Fig. 9-10B. A true 3D model can be tested on the computer for strength and other properties.

In some cases, a structural model is placed in a **wind tunnel** to see how the building will be affected by wind currents. Some buildings have been built where wind currents were so strong that they sucked the windows out!

Some products, such as airplanes, buildings, and cars, can be modeled as three-dimensional images on a computer. Fig. 9-10B. In this way, you can save even more time because you don't have to build a real model. You can even test some products using computer simulations.

INFOLINK

See Chapter 5 for more information about computer simulations.

SECTION 5 TechCHECK

1. What is a prototype?
2. What is the purpose of making a prototype for a product?
3. Why do architects make models?
4. **Apply Your Knowledge.** Design and build a scale model of a house.

ACTION ACTIVITY

Cooking with Sunlight

Be sure to fill out your TechNotes and place them in your portfolio.

Real World Connection

Solar cookers use the energy of the sun to cook food. They are a much-needed product in developing countries. They would prevent people from cutting down so many trees for fuel and could even save lives. Many young children die each year because they do not have clean water to drink. A solar cooker could be used to *pasteurize* (purify) water and kill the harmful bacteria.

In this activity you will design and build a prototype of a solar cooker. Your design will be tested to see what temperature can be reached. Fig. A.

Design Brief

Design, build, and test a solar cooker that will cook food. You may use such materials as recycled cardboard boxes, newspapers, and aluminum foil to make your prototype.

Materials/Equipment

- recycled cardboard boxes, newspapers, foil, as needed
- clear acrylic or polycarbonate plastic (Plexiglas acrylic plastic or Lexan plastic)
- flat black spray paint
- hand and power tools, as needed
- one-quart container for water
- thermometer

SAFETY FIRST

- **Follow the safety rules listed on pages 42-43 and the specific rules provided by your teacher for tools and machines.**
- **If you use food in your solar cooker, be sure to follow proper food safety and sanitation rules.**
- **Handle hot items with care.**

Procedure

1. You will be working in groups of four or five. You should consider some of the following facts before starting your design:
   - The cooking area should be insulated so the heat gathered is not lost.
   - As more sunlight is reflected into the cooking area, a higher temperature will be produced.
   - A flat black surface absorbs heat energy rather than reflects it.
   - Clear plastic, like glass, helps to trap heat by the *greenhouse effect*. (The greenhouse effect is a natural buildup of heat trapped by atmospheric gases, mainly carbon dioxide. The gases let in visible light but keep some infrared radiation from leaving the Earth's surface.)
2. When your group has decided on a design, divide up the work needed to complete the cooker. Follow your teacher's safety rules when using any machines.
3. When you finish your prototype, test it by placing a one-quart container of water with a temperature of 72°F. inside your cooker.
4. Place a thermometer in the water, and point your cooker toward the sun.
5. After one hour, record the temperature of the water.
6. Continue to test your cooker for 4 hours. Move it each hour so it continues to point toward the sun.

Evaluation

1. What are the advantages of using solar energy to cook?
2. What are the disadvantages?
3. **Going Beyond.** Make a graph showing the temperatures and cooking times of your solar cooker.
4. **Going Beyond.** How could solar cookers be made more efficient using high-tech materials?

Fig. A

REVIEW &

CHAPTER SUMMARY

SECTION 1

- As you design and build things, you need to make accurate measurements.
- The need for more precision, as well as standard ways to measure things, produced the measurement systems we use today.

SECTION 2

- The SI (metric) and English systems are standard measurement systems used today.
- Drawings and models of things that are very large or very small are often made to scale.

SECTION 3

- Ergonomics involves designing products or places that fit human needs and sizes.
- Designing with ergonomics in mind means products will be more useful and safer for people.

SECTION 4

- Choosing the right material can determine whether a product will be useful and good for the environment.
- All materials can be classified into two major groups, synthetic and natural.
- Special properties of materials, such as hardness, tensile strength, compression strength, and fatigue strength can be tested.

SECTION 5

- Prototypes and models help people see what the actual products will look like.

REVIEW QUESTIONS

1. What is the purpose of measurement standards?
2. Why do engineers make prototypes?
3. Give an example of a synthetic material and a natural material.
4. What kind of anthropometric data would you use in designing a chair?
5. Name several materials that would be good choices for making a house.

CRITICAL THINKING

1. List some synthetic materials you might use to build a model car.
2. Research the composite materials used in making a space shuttle and jet fighters.
3. Design a nondestructive test method for a material.
4. What properties of aluminum make it a good choice for beverage cans?
5. Collect anthropometric data from students in your class to use in designing a student desk.