ACTIVITIES

CROSS-CURRICULAR EXTENSIONS

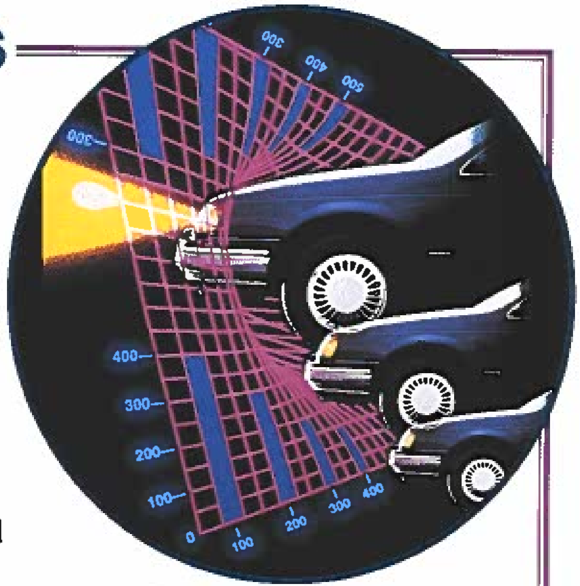
1. **SCIENCE** Compare the properties of steel, aluminum, and titanium. Which metal would be best for a bicycle frame? Why?

2. **MATHEMATICS** Collect anthropometric measurements such as height, head circumference, and arm reach for your class. Calculate an average for each measurement.

3. **COMMUNICATION** Write or call a business that makes a product. Find out what materials they use and how they choose those materials to make the product.

EXPLORING CAREERS

When the telephone was first developed, engineers measured hundreds of people's faces to ensure that the handsets would be comfortable for most people to use. How do you think human factors are involved in the following two design careers?



Commercial and Industrial Designer These designers develop products like cars, home appliances, and toys. They combine their artistic talent with research findings to create the most useful and appealing design. Have you ever wondered why a shampoo bottle is shaped a certain way? Designers help create a product that will appeal to potential buyers.

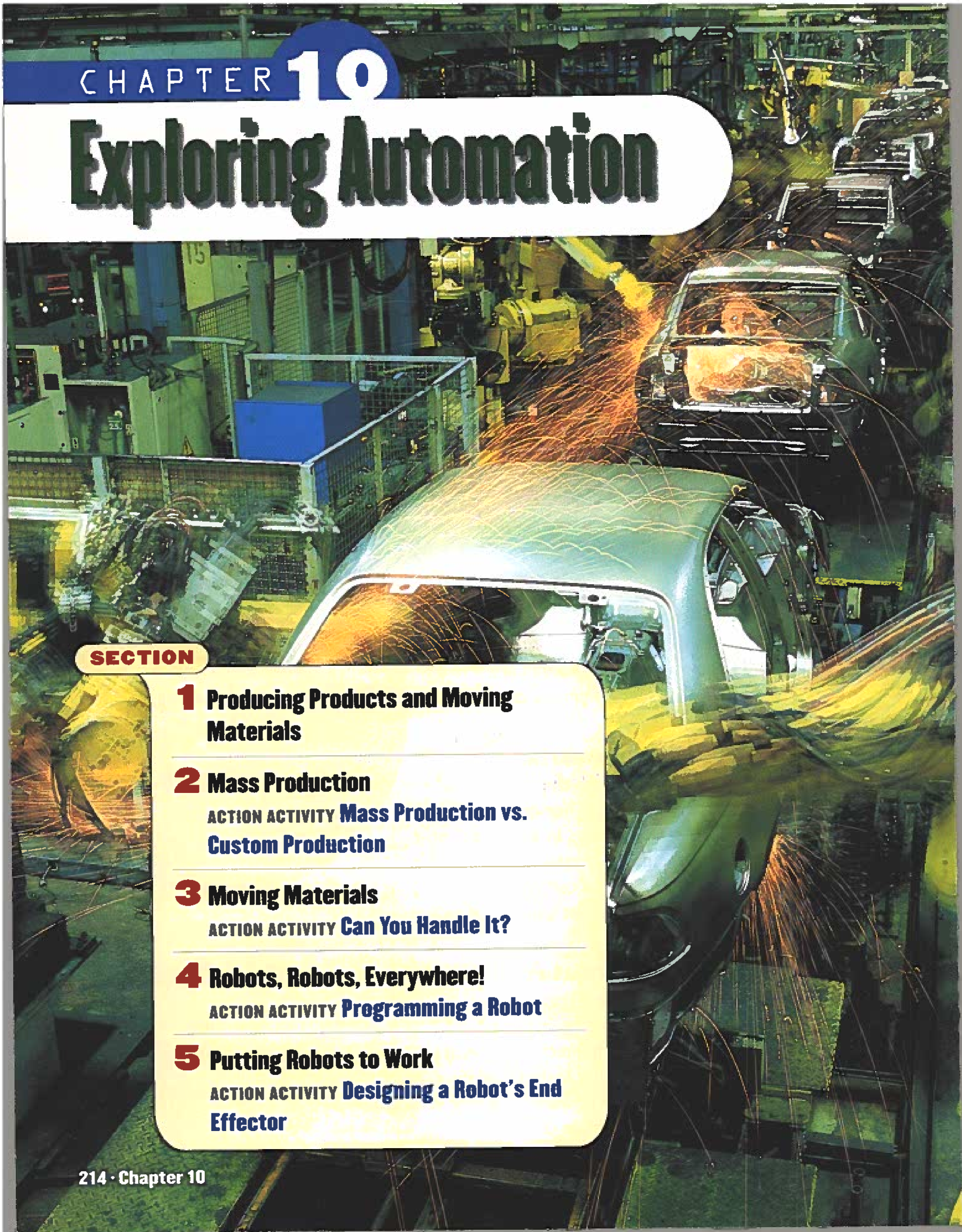
Computer Game Animator Animators create the lifelike characters, backgrounds, and 3-D graphics that make up computer games. This is a job that requires a great imagination and strong artistic and technical skills. Animators must have the ability to work well under pressure in order to meet tight deadlines.

ACTIVITY

Design an animated character for a computer game or develop a design for a liquid-soap dispenser. Share your results. Explain why you chose this character or design.

CHAPTER 10

Exploring Automation



SECTION

Producing Products and Moving Materials

SECTION 1

THINGS TO EXPLORE

- Define automation and give examples.
- Relate how automation has affected the modern workplace.

TechnoTerms

- automation
- manually
- robot

After you have solved design problems and picked the right resources and materials for your product, you need an efficient way to produce and move materials. That's where automation comes in.

Automation

Automation is the automatic control of a process by a machine. Today, **robots** (highly advanced, computer-controlled machines) do welding and other dangerous tasks automatically. Even soft drinks can be made using automated sensors that control the mixture of syrup and water.

Automation has really affected the modern workplace. Automation does away with jobs that are boring or dangerous. Fig. 10-1. It also creates more need for highly skilled people to control, repair, and program machines. Automation can speed production in many instances and can also save time and money.

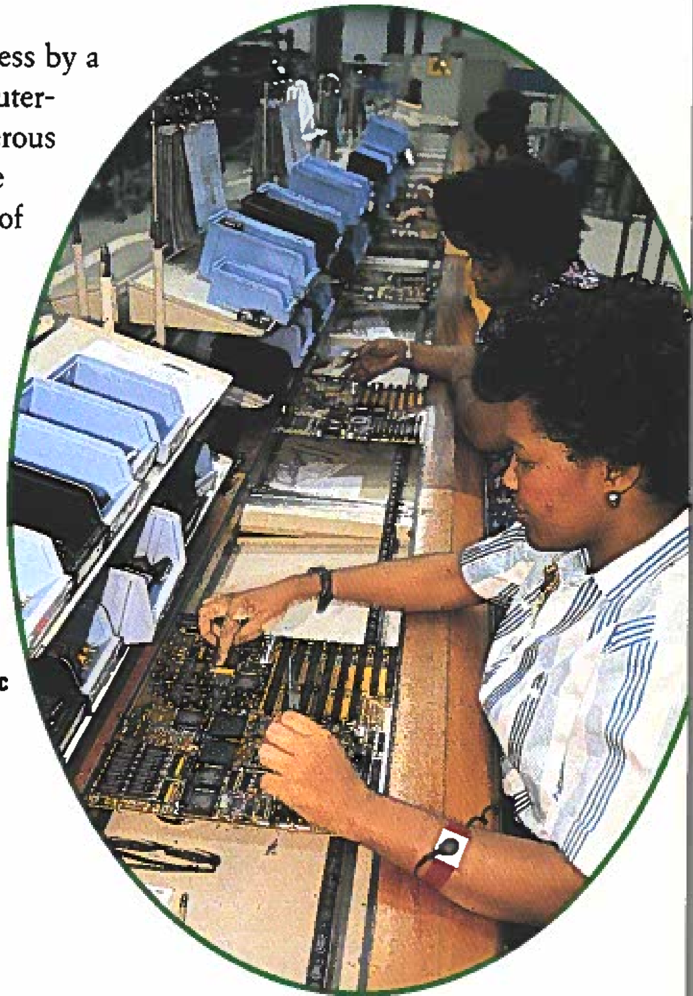


Fig. 10-1. These workers are assembling electronic products. What parts of their job might be boring? Could a robot do them as well?

OPPOSITE The movement of robots is only a blur in this auto assembly line.

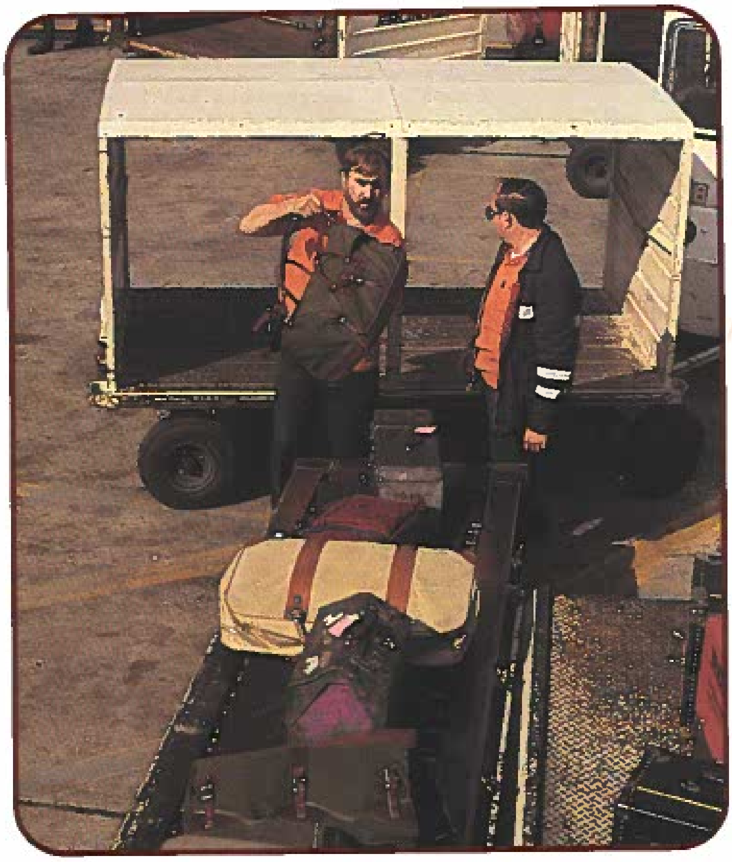


Fig. 10-2. An automated conveyor speeds up the delivery of baggage at an airport. What do you think would happen if this equipment broke down?

Automation also has problems. It tends to take jobs that require less skill away from workers. Sometimes these workers cannot be retrained to do higher-skilled jobs. In addition, automated machines are expensive to buy and maintain.

It would be hard for us to live without automation now. Fig. 10-2. Think about the automatic clothes washer and dryer your family uses. Do they go through the cycles automatically, or do you have to run them **manually** (by hand)? What about the copy machine or the bell system used in your school?

SECTION 1 TechCHECK

1. What is automation?
2. How has automation affected the modern workplace?
3. Describe a problem created by automation.
4. **Apply Your Knowledge.** Working in small groups, make a list of things that are automated. Share your list with other groups.

Mass Production

SECTION 2

THINGS TO EXPLORE

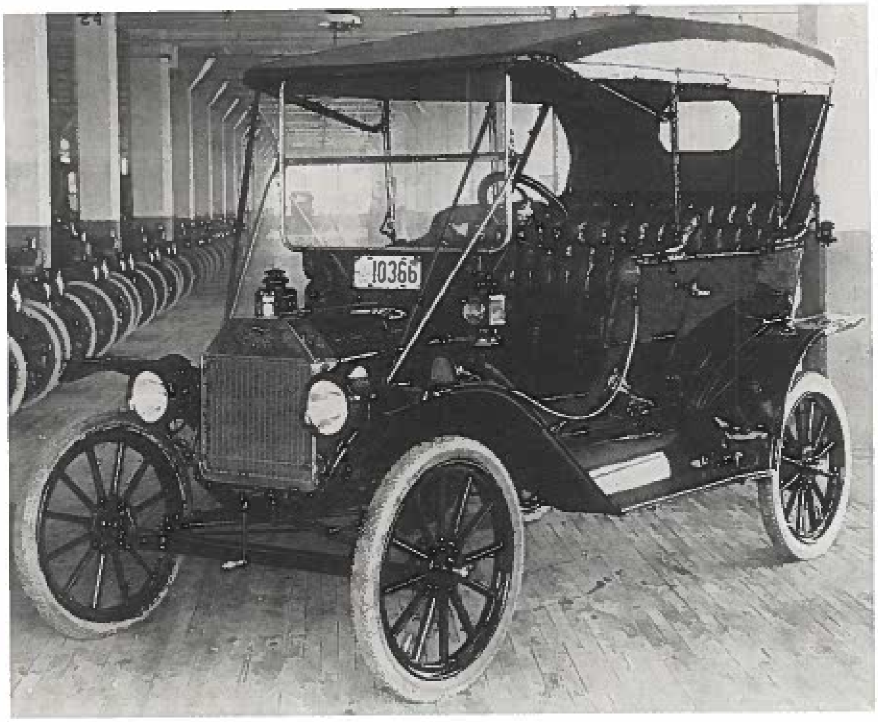
- Define mass production and give examples.
- Explain how mass production has changed manufacturing.
- Use mass production to produce a product.

TechnoTerms
- assembly line
- custom manufacturing
- manufacturing
- mass production

Before factories as you know them existed, people made products in their homes. Different households made different products and had different skills or crafts. Each item was produced by one person. Today this process of making items one at a time is called **custom manufacturing**. Fig. 10-3. It often takes a very long time to complete one item.

Fig. 10-3. Large airplanes like this Boeing 747 are made with custom production methods. What other types of products are still produced this way?

Fig. 10-4. Although Chrysler was first to use assembly lines, Ford improved them by moving the product past the workers. As a result, Ford cars could be made faster and cheaper. Do some research on other cars made at the time. How did their designs differ?



TechnoFact

AUTOMATION REDUCES COSTS The first automobiles were too expensive for most people to buy. It was the assembly line and mass production that made them affordable to the average person.

Mass Production

Later, groups of craftspeople began to work in factories **manufacturing** (making) products faster. In the 1700s, Eli Whitney and others developed the system of **mass production**. Mass production uses **assembly lines**, where products move past a worker who does a specific job. Henry Ford later improved this system. Fig. 10-4. Automation has helped increase the efficiency of mass production in today's factories.

SECTION 2 TechCheck

1. What is custom manufacturing?
2. How were products made before factories became common?
3. What is mass production?
4. **Apply Your Knowledge.** Give examples of items you think are *not* made by mass production.

ACTION ACTIVITY

Mass Production vs. Custom Production

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

Real World Connection

Today, we rely on mass production to make products from cars to cookies faster, more accurately, and more economically. Is it really faster than custom production? In this activity, you will see for yourself!

Design Brief

Determine the difference in efficiency between custom production and mass production. You will be assigned a specific job in either the custom production or mass production factory. Fig. A. Your job is to work as fast and as accurately as possible.

Materials/Equipment

- vanilla wafer cookies (plain)
- assorted flavors of frosting (squeeze tubes)
- M&M candies (plain)
- napkins or paper towels
- plastic gloves
- measuring tools

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

(Continued on next page)

Procedure

1. Divide the class into two groups. Flip a coin to see which group will be the custom workers and which will be mass-production workers.
2. As a class, decide on a design for the finished cookies.
3. Divide the supplies of cookies, candy, and frosting equally among each group. Each of the craftspeople will need a supply of each item.
4. Your teacher will assign a job in the assembly line to each person in the mass-production group. The mass-production workers should sit at a long table or rearrange their desks so that each worker can easily pass the cookies on to the next worker.
5. All workers in both groups should wear plastic gloves to keep the cookies clean. When each group is ready, your teacher will tell you to start production. The custom workers will each make complete cookies. Each mass-production worker will do a specific job in the production process and pass the cookie down the assembly line until it is finished.
6. After a set time, your teacher will ask both groups to stop. At that time, you must stop where you are. Do not finish the cookie you were working on.
7. Each group should gather their completed cookies. All of the completed cookies will be inspected by your teacher and either accepted or rejected based on accuracy of design.

Evaluation

1. Which group produced the most cookies?
2. Which group had the most rejected cookies?
3. What do you think the advantages and disadvantages of custom production are?
4. What do you think the advantages and disadvantages of mass production are?
5. Did the production of cookies turn out the way you expected? Explain.
6. **Going Beyond.** Research to find out what products are custom made by craftspeople today.
7. **Going Beyond.** Try the production again with different products. Do you think you will get the same results?
8. **Going Beyond.** Try the production process again, but this time switch the groups. Do you think you will get the same results?

Moving Materials

SECTION 3

THINGS TO EXPLORE

- Explain what materials-handling systems do.
- Identify basic types of materials-handling equipment.
- Build a conveyor belt system to move materials and parts.

TechnoTerms

- automated storage and retrieval system (AS/RS)
- automatic guided vehicle system (AGVS)
- conveyor
- crane
- hoist
- materials handling

During the Industrial Revolution, which you learned about in Chapter 1, automation and assembly lines became part of the factory setup. This marked the beginning of a need for efficient **materials handling** (moving and storing materials). Today, various kinds of equipment are used in materials handling. Most systems usually include several basic types. Fig. 10-5.

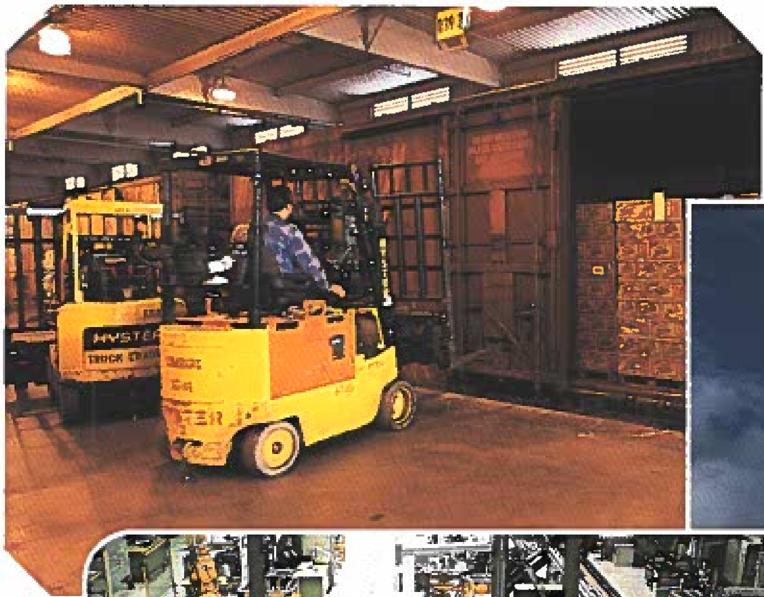


Fig. 10-5. Forklifts (top left) are used to carry pallets at this loading dock. A large crane (right) lifts a container onto the deck of a ship. Computers (bottom left) help schedule delivery of materials to a production area.

TechnoFact

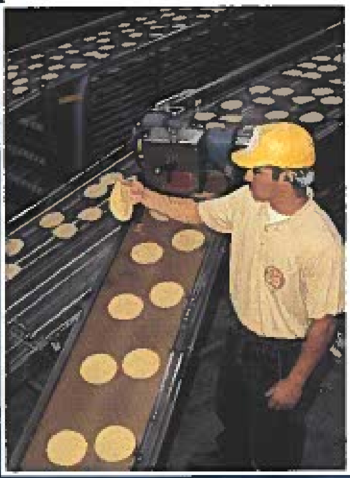
MEET PHILLIP CARTRIGHT Phillip Cartright is a robot so named because it always fills up medicine carts correctly. It is one of the first automated robotic systems used to sort and dispense medications. With its suction-cup "hand" and bar code scanner, the robot can fill prescriptions in half the time it takes people to do the same job.

Equipment Used for Materials Handling

- **Conveyors.** Conveyors move materials and parts from one place to another. They always travel over a fixed path. Examples include roller conveyors, skate-wheel conveyors, and belt conveyors. In automated assembly lines, parts are often moved by conveyor from one workstation to another.
- **Trucks.** Materials-handling trucks are different from the trucks you normally see on the highways. An example is a *forklift.* Forklifts have forks on the front and are used to carry heavy loads.
- **Containers.** Large parts are moved onto *pallets,* or special platforms. The pallets can then be stacked in racks. Small parts are moved in containers such as trays or tubs.
- **Hoists and cranes.** Hoists are used for lifting heavy loads. Cranes are really hoists that move in a limited area. For example, an overhead crane lifts large items from above. A monorail crane is a hoist that moves on one overhead rail.
- **Automated storage and retrieval system (AS/RS).** This system uses a computer-controlled crane. It travels between pallet racks and automatically loads and unloads them.

MATHEMATICS CONNECTION

Determining the Speed of a Conveyor



The speed of a conveyor is often measured in parts per minute or feet per second. You can measure these speeds by doing the following:

How to Determine Parts Per Minute

- Set the drill or motor to a constant speed.
- Have one or two classmates feed the input end of your conveyor with small parts such as washers or nuts.
- Space the products (washers or nuts) evenly and close together.
- Count the number of products as they start coming off the end of the conveyor for one minute.

- **Automatic guided vehicle system (AGVS).** In this system, a computer controls the movement of several driverless carts called AGVs. These carts follow wire paths that are built into the floor. The computer keeps track of the location of all the carts so they don't run into each other as they move materials around a factory. What do you think would happen if one cart got off track?

TechnoFact

CONVEYORS Have you used the people-mover walkways at an airport? These conveyors make it easier for people to get from one place to another. Even supermarkets have conveyors at checkout counters to make it easier and faster for you and the clerk.

SECTION 3 TechCHECK

1. What is materials handling?
2. Name six different ways to move materials.
3. What is a pallet?
4. **Apply Your Knowledge.** If you had to move all the chairs in your school to another school, what type of materials-handling equipment would you use?

How to Determine Feet Per Second

- Set the drill or motor to a constant speed.
- Put a mark or piece of tape on the edge of the conveyor belt. This mark will be used to measure how fast the belt is moving.
- Make another mark on the side board as a point of reference.
- Have someone count the number of times the tape passes the marked point in a set period of time, such as 30 seconds.
- To calculate the speed in feet per second, measure the length of the belt and multiply by the number of passes. Divide by the number of seconds.

Example:

6 passes × 3 feet each = 18 feet

18 feet ÷ 30 seconds = .6 feet per second

ACTIVITY

What was the speed of your conveyor in feet per second?

ACTION ACTIVITY

Can You Handle It?

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

Real World Connection

Materials handling is an important part of designing factories that can make high-quality products quickly. In this activity, you will work in groups to make a set of conveyor belts that can be used to simulate an assembly line. Fig. A.

Design Brief

Build and test a conveyor belt system that will transport parts from one point to another in your classroom. The conveyor system must be safe to operate and have adjustable speeds so it can meet the needs of future activities.

INFOLINK

See Chapter 11 for more information about mass production.

Materials/Equipment

- curtain pleating tape
- 1/8" tempered hardboard
- 1/4"-20 threaded rod
- 1/4"-20 nuts
- 1/8" acrylic sheet (Plexiglas)
- 1 1/2" PVC pipe
- 1/4" x 1 1/2" fender washers
- masking tape
- wood glue, screws
- scroll or band saw
- disk or belt sander
- hacksaw
- adjustable wrench
- power hand drill
- sewing machine (optional)

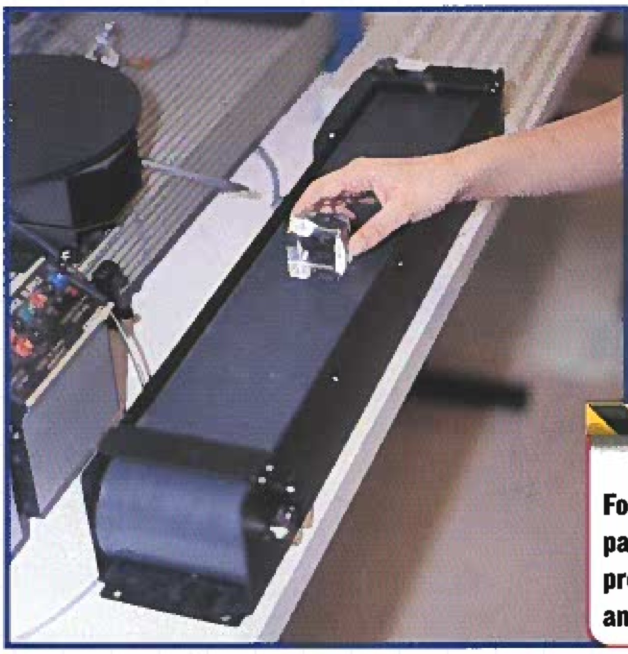


Fig. A

SAFETY FIRST

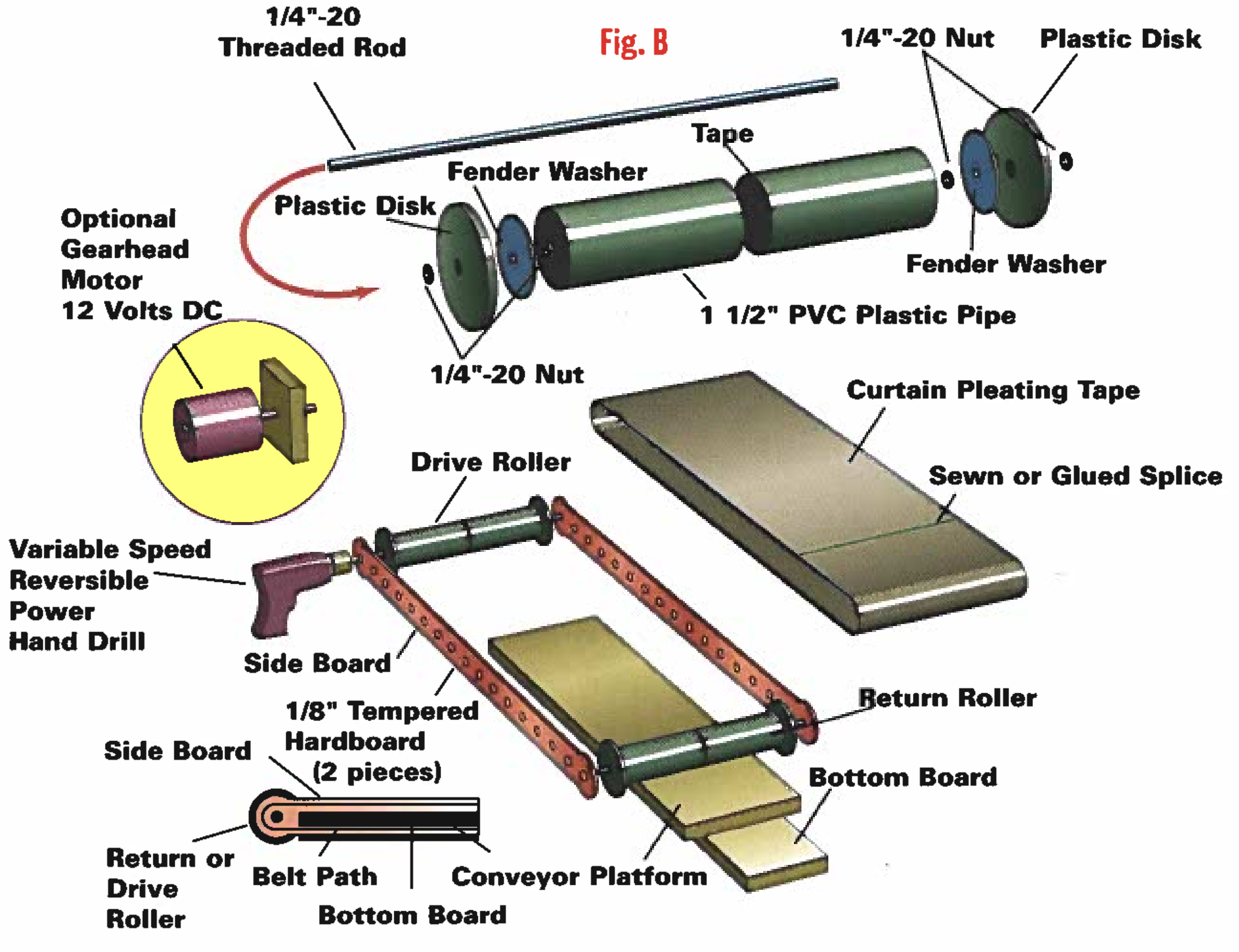
Follow the safety rules listed on pages 42-43 and the specific rules provided by your teacher for tools and machines.

Procedure

1. This activity will require you to work in large groups. There are many parts that need to fit together to make your conveyor belt. Your class will need two or three conveyors for the mass-production activity in Chapter 11.
2. Your group or your teacher might decide to change the design of your conveyor system to meet the needs of your classroom. The illustration in Fig. B will help you get a start on a design. Note that the length of the conveyor is up to you and your teacher. The width of the conveyor is determined by the material you use for the belt. The minimum size should be 4".
3. The design that you choose will be used by all the groups so the conveyors will match. Divide the tasks in building the conveyor among your group. Some jobs might require two students.
4. With your teacher's help, use a hacksaw to cut the 1/4"-20 threaded rod to length for the drive roller and the return roller. (The lengths will depend on the width of your conveyor belt.)

SAFETY FIRST
This activity requires all students to wear eye protection at all times.

Fig. B



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5. Cut the 1 1/2" PVC pipe to length with the hacksaw. Wrap and tape a piece of paper around the place where you are cutting to guide the saw for a square cut.
6. Wrap the center of each PVC pipe with two layers of masking tape. This will make the center of the pipe larger in diameter than the ends. This helps the belt track properly without going off to one side.
7. Cut four acrylic (Plexiglas) disks 3" in diameter using the scroll saw.

SAFETY FIRST

Ask your teacher to help you cut the disks on the scroll saw. Remember to keep your fingers away from the front of the blade.

8. Assemble the drive and return rollers as shown in the drawing. The fender washers are used inside the PVC pipe to keep the threaded rod centered. You might want to put a drop of glue on the threads near the nuts to keep them from coming loose.
9. Cut the conveyor platform and bottom board to length and width on the band saw. The length of the boards depends on your design.
10. Cut and sand the 1/8" tempered hardboard to make the sides of the conveyor. Round the ends to match the plastic disks on the rollers.
11. Temporarily assemble the rollers, sides, conveyor platform, and bottom board as illustrated. Check to see if the axles are parallel to each other. This is important for the belt to track properly. You might want to file the return roller holes into slots to make it adjustable.
12. Use a piece of string or a tape measure to find the proper length of the belt. Add 4" for the pleating tape to overlap at the splice. Cut the curtain pleating tape to the proper length.
13. Sew or glue the splice together at the proper distance for your conveyor. Be sure the edges of the pleating tape remain straight.
14. Glue and screw the completed conveyor system together.
15. Attach the power hand drill to the drive roller. (Your teacher may want to use a special gearhead motor for your conveyor instead of a drill.) Slowly start the drill or motor. Watch carefully to see if your conveyor belt stays on track. Make adjustments as needed.

Evaluation

1. Determine the speed of your conveyor belt system. How many parts per minute did it deliver?
2. List two other possible materials that could be used for the conveyor belt.
3. **Going Beyond.** Can you think of another way to measure the speed or capacity of a conveyor belt system? Explain.
4. **Going Beyond.** What would determine the speed of a gravity-fed roller conveyor system?

Robots, Robots Everywhere!

SECTION 4

THINGS TO EXPLORE

- Explain the difference between a true robot and an automated machine.
- Identify jobs robots can do best and tell why.
- Relate how robots affect people's jobs.
- Program a robot to do a job.

TechnoTerms

cost-effective
industrial robot
pick-and-place maneuver
programmed
teach pendant
work envelope

Robots, robots everywhere! Robots are one of the most exciting inventions in technology. They are entertaining you in the movies. They are doing jobs for you that you don't want to do or that are too dangerous for you. Fig. 10-6. Today's robots are highly advanced machines **programmed** (computer controlled) to do special jobs.

What Can Robots Do?

How would you like a robot that could do all your homework? You would have to program the robot with the correct answers. In other words, you would have to do your homework first and then program the robot to do it! That would be true for every different assignment. Doesn't sound like much help to you, does it? But robots cannot think for themselves yet. In fact, a true robot is controlled by a computer and must be reprogrammed to do different jobs.

Fig. 10-6. This robot used to deliver food and other items in a hospital navigates by means of a map stored in its memory. In what ways would a robotic delivery system make your own life easier?

TechnoFact

TRUE ROBOTS The word *robot* comes from a play by a Czech writer named Karel Capek. Robot means "to work" in Czech. But the idea of robots was around long before Capek used it in the 1920s. Originally, a robot was simply any machine that could do work without a person running it. By that definition, many devices such as clock radios, clothes washers, microwave ovens, and mechanical toys are robots. But they are really not. True robots can be reprogrammed over and over to do different jobs!

Robots can do many jobs that make life easier for us. They are used to help physically challenged people in hospitals. They are used in homes for entertainment as well as for doing specialized jobs such as walking the dog. They explore space and underwater locations in the oceans. In factories, robots are helping to produce goods more efficiently and **cost-effectively** (saving money). In one Japanese factory *only* robot workers are used! As technology advances, robots will be used in many new ways. Can you think of jobs robots can do that you wouldn't want to do?

Robots are like humans in that they can only move their arm or wrist a certain distance. The maximum distance that each part of a robot arm can move is called its **work envelope**. When a robot picks up a part and moves it somewhere else, the action is called a **pick-and-place maneuver**. Robots are sometimes programmed with a remote keypad called a **teach pendant.**

Robots Are Not All the Same

INFOLINK

See Chapters 17 and 18 about the use of robots in outer space.

How robots look depends on the jobs they do. Robotic arms are used in manufacturing cars, for instance. These are called **industrial robots**. On an auto assembly line, a robotic arm can be programmed to pick up a door and place it in a certain spot. Another robotic arm fastens it while a third robotic arm spray paints or spot welds certain pieces. Fig. 10-7.

The *Viking* landers that NASA sent to Mars are other types of robots. They moved around on the surface like huge bugs, picking up soil and doing experiments. Still other kinds of robots handle dangerous materials such as radioactive wastes.

Fig. 10-7. Metal produces a shower of sparks as a robot cuts through it using a laser. Why do you think a robot would be ideal for this kind of job?

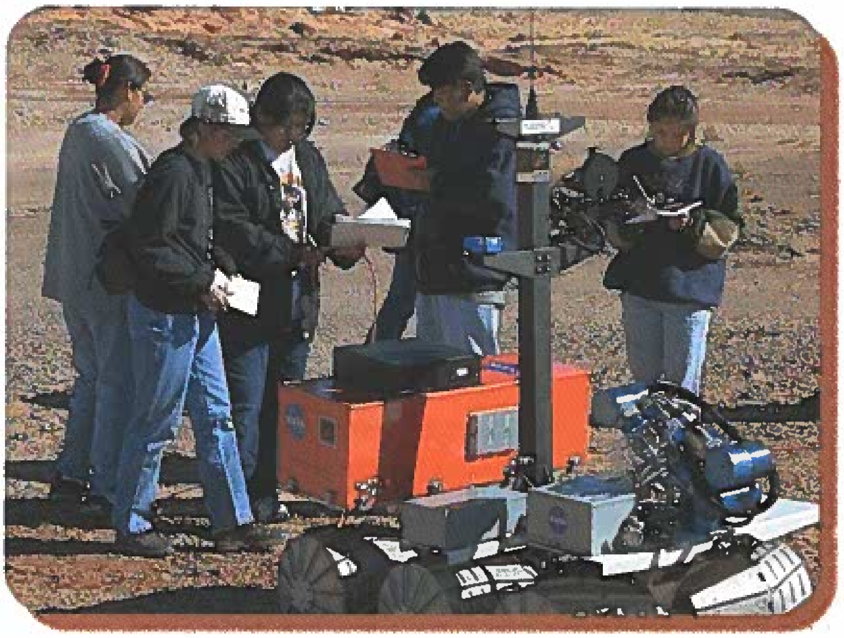


Fig. 10-8. Although robots do take some jobs from people, they also help create new jobs. These students are learning to be programmers. What other robot-related jobs might they learn?

How Robots Affect People's Jobs

Have you heard that robots are taking jobs away from people? In many instances, robots do jobs that people don't want to do. These jobs are either too boring or too dangerous for humans. Sometimes robots can do a better job because they can be programmed to do the exact same thing over and over and still be *precise* (accurate) to one-thousandth of an inch.

Often, people replaced by robots can be retrained to become robot programmers. Fig. 10-8. For example, the best person to program or train a robot to weld is a welder.

TechnoFact

ROBOT POWER

Industrial robots can run on different power systems. Some move with electric motors, including special motors that turn a little bit at a time, called stepper motors. Pneumatic robots run on compressed air. Hydraulic robots use oil pumped under pressure to make the robot operate. The type of energy system used depends on the size of the parts being moved or lifted.

SECTION 4 TechCHECK

1. What is the difference between a true robot and an automated machine?
2. What jobs can robots do?
3. How do robots affect people's jobs?
4. **Apply Your Knowledge.** List jobs you think could best be done by robots in a car production factory and tell why.

ACTION ACTIVITY

Programming a Robot

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

Real World Connection

People have long dreamed of making machines that can follow instructions. Telling machines what to do is now possible, thanks to automation and robotics. In this activity, you will first control a simulated robot arm to move objects. When you understand the controls of the robot, you will learn to program it to work for you automatically.

Design Brief

Design a flowchart showing the movements the robot will make step by step. Determine the robot's work envelope. Program a simulated robot arm to perform a pick-and-place maneuver.

Materials/Equipment

- conveyor belt system developed for Section 3
- programmable robot arm
- wood or plastic blocks (sized for the robot to grasp)
- graph paper
- tape measure
- protractor

SAFETY FIRST

- **Always be careful with any electrical equipment. Keep liquids away, and place extension cords so that people will not trip.**
- **Most educational robots operate on low voltage, but always ask your teacher before changing any electrical connection.**
- **Do not attach or unplug equipment from computers while they are turned on. Computer circuits are easily damaged.**
- **Follow the safety rules listed on pages 42-43 and the specific rules provided by your teacher for tools and machines.**

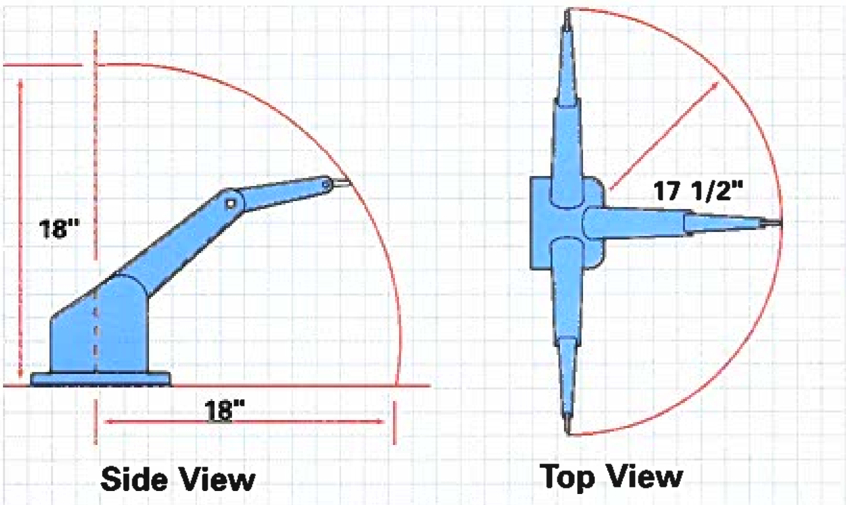


Fig. A

Procedure

1. Work in groups of three or four. To program a robot, you must understand each of its movements. Ask your teacher to show you how to safely operate a simulated robot arm, or use the robot arm you made in Chapter 8. Each of the joints of a robot arm has a name such as base, shoulder, or wrist. Make a list of names of each joint in the robot arm you are using. Next to each name, write the maximum movement possible. Your list might look like this:
   - base, 180°
   - shoulder, 120°
   - elbow, 110°
   - wrist rotation, 360°
   - pitch, 180°
   - gripper, 0" to 3"
2. Your next job is to determine the work envelope of your robot. Use graph paper to make a sketch to scale of the top and side views of your robot arm. Choose a scale that will let you draw the robot and its maximum movements. Your sketch might look like the one in Fig. A.
3. Use a tape measure to find the maximum reach for the robot. Make a line on your sketch to show the work envelope. Show the work envelope in both the top and side views.
4. Now that you know the limits of your robot, it's time to put it to work. From your sketch, determine the best place to put your conveyor system. You will be using the robot arm to off-load (take parts off) your conveyor belt in a pick-and-place maneuver.
5. Set up the conveyor and robot according to your plan. Ask your teacher to show you how to program the robot arm. Each robot has a slightly different way of putting steps into memory. Your robot may be programmable directly, or it might require the use of a computer or teach pendant.
6. Make a flowchart of each step you are programming into the robot's memory.
7. When you have learned to program the robot arm, adjust your conveyor to a slow speed.
8. Have one student in your group place simulated products (wood or plastic blocks) on the conveyor belt at an even rate. Try to program the robot to grab the parts at the end of the conveyor and drop them into a box.
9. You might find it hard to place the parts on the conveyor belt in the exact spot the robot expects to find them. One solution might be to design and build an attachment for the conveyor that will direct the products to the center of the belt. You could also have a stop at the end of the conveyor that will give the robot time to grab each product.

INFOLINK

See Chapter 3 for more information about flowcharts.

Evaluation

1. What was the hardest part of this activity? How could it have been made easier?
2. What do you think would happen if the products on the conveyor were all different sizes?
3. What would be the advantage of having one computer control the robot and the conveyor belt?
4. **Going Beyond.** Design an electrical system that will start and stop the conveyor belt so that products don't pile up at the end of the belt.

SECTION 5

Putting Robots to Work

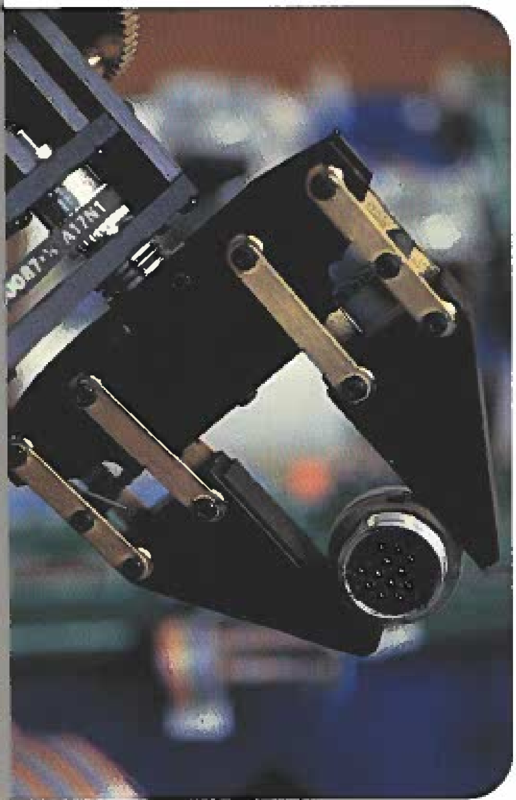
TechnoTerms
- end effector
- robotic vision
- sensors
- universal gripper

THINGS TO EXPLORE
- Tell what an end effector is.
- Explain why special end effectors are necessary for certain jobs.
- Explain what robotic sensors are and give examples.
- Design and build an end effector for a robot.

Robots have changed manufacturing. Special equipment like end effectors and robotic sensors help them do many useful things.

The End Effector

The **end effector** of a robot is the device at the working end of a robot arm. Fig. 10-9. Designing a **universal gripper** that will work for every object gets tricky with some materials. Your fingers can pick up small pins and needles, catch a football, or grasp a tennis racket. But it is not easy for a single robot gripper to work as a pair of "hands" to pick up very small or large objects. If the robot has to pick up liquids, hot parts, radioactive materials, or glass sheets, the design must be changed.



Specialized end effectors can be made for robots to work with specific materials. An electromagnet might be used to attract metals such as steel. The electromagnet can be turned on and off by the robot's controlling computer. However, this method would not work for materials that are not attracted to magnets. Aluminum, copper, glass, plastics, or wood would require a different kind of end effector such as a suction cup. The controlling computer can start or stop a vacuum pump that creates the suction to pick up parts. Most robots are designed to do many jobs. The end effector can be changed depending on the job.

Fig. 10-9. This robot is used for testing. Its end effector can do things a human hand cannot.

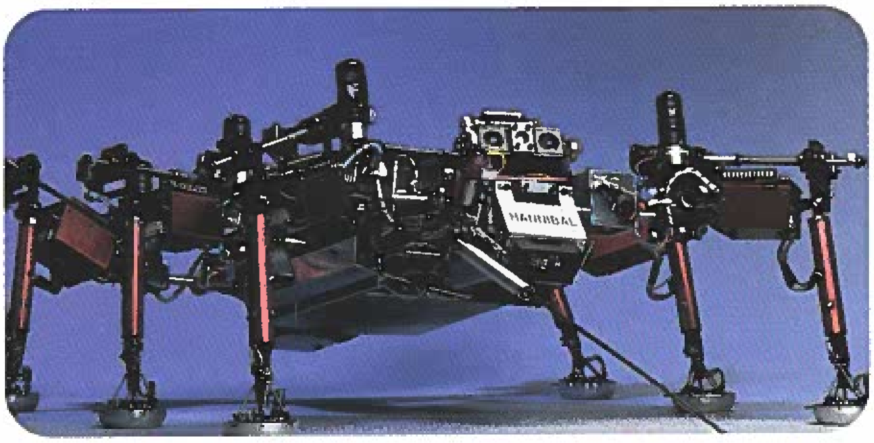


Fig. 10-10. Small microbots like this one can crawl across the floor. The blue "eyes" are sensors. Why do you think it has so many?

Robotic Sensors

Robots can be equipped with special **sensors** (electronic input devices) to help them do jobs. Some robots can hold fragile parts with just the right pressure so they do not drop them or squeeze them too tightly. Light sensors can guide robots along pathways. Fig. 10-10.

Some robots use television camera eyes to help them "see." This is called **robotic vision**. With eyes, robots can tell the difference between parts with different shapes. Vision systems also help robots perform tasks such as installing automobile windows or making sure packages are lined up in the right order to be labeled. Robots with vision do jobs that are often too detailed for humans to carry out. For example, they inspect hundreds of microscopic connections on semiconductor chips. Can you imagine doing that kind of close-up work over and over without making any mistakes? Robots can.

TechnoFact

ROBOTIC RIN TIN TIN What about a robot guide dog for the blind? A robot guide dog will be easier to train than a real guide dog. It will have a synthetic voicebox that talks instead of barks. That way it can tell its owner about potholes, bus stops, red lights, and where elevator buttons are. To be able to do these things, the robot will have an "outdoor data base." This means its computer will recognize sounds from the outside environment as well as those from inside a house. The robot dog will be about the size of a German shepherd and will have one paw that can pick things up.

SECTION 5 TechCHECK

1. What is an end effector?
2. Why do robots need specialized end effectors?
3. What are sensors? Give examples.
4. What is meant by robotic vision?
5. **Apply Your Knowledge.** Research the types of sensors used by robots moving materials in a factory.

ACTION ACTIVITY

Designing a Robot's End Effector

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

Real World Connection

Did you ever have trouble grabbing a bar of soap in the bathtub? Imagine that the thing you are trying to grab is worth hundreds or millions of dollars and the slightest wrong move would destroy it. This is part of the difficulty in using robots. Their end effectors must be sensitive and able to grab without causing damage. Satellites, for example, that need repair in orbit require careful handling by astronauts in the Space Shuttle. The grapple device on the shuttle's robot arm was designed for this purpose.

The robot arm is called the Remote Manipulator System (RMS). Eventually, it will find uses in manufacturing or in underwater robotic exploration. It will be used to grip large, delicate objects and materials.

In addition to a gripper with fingers, special cup-shaped devices can make it much easier to grab objects.

INFOLINK

See Chapter 18, "Living and Working in Space."

Design Brief

Design, build, and test a gripping device that might be used on a robot arm.

Materials/Equipment

- plastic cups
- sharp knife
- tape
- string

SAFETY FIRST

Follow the safety rules listed on pages 42-43 and the specific rules provided by your teacher for tools and machines. Use hand tools such as sharp knives with caution.

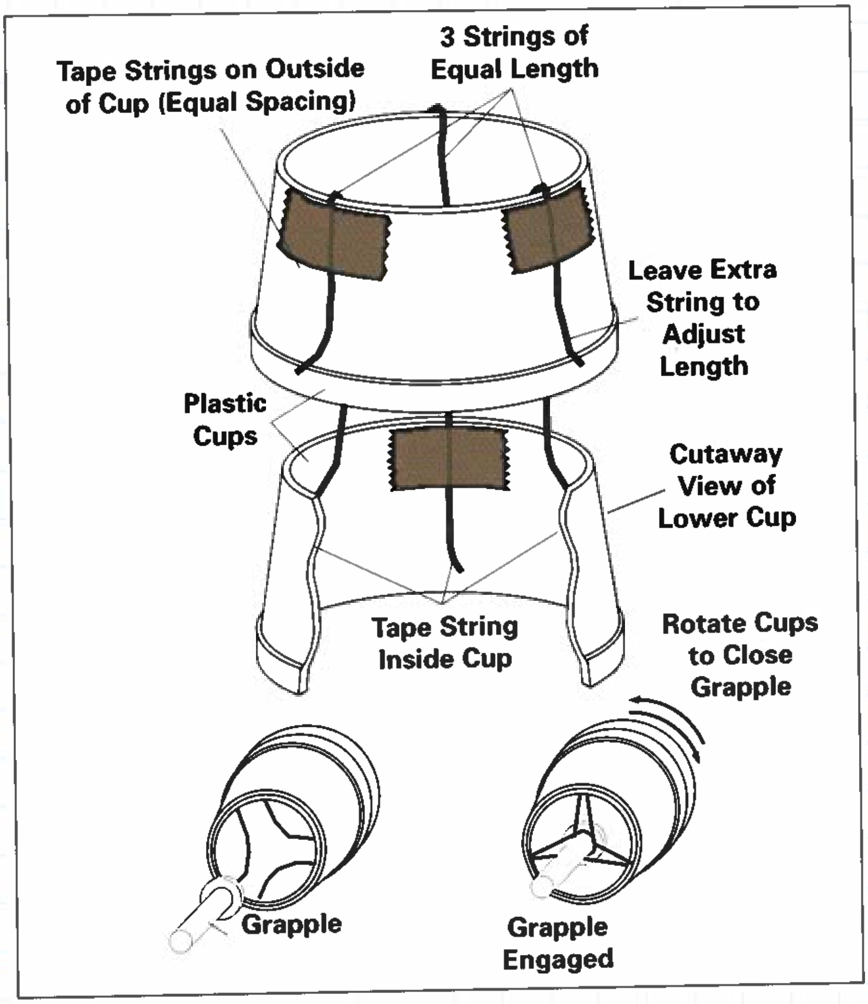
Procedure

1. Put two plastic cups together and cut them as shown in Fig. A.
2. Cut three pieces of string 5 inches long.
3. Tape the strings to the outside of one cup and the inside of the other cup as shown.
4. Put the cups together and adjust the lengths of the strings to cross the diameter of the cup.
5. Test your end effector by turning one cup in the opposite direction of the other. The strings should cross in the center.
6. Try to grab a pencil or other object using your grapple device. (The pencil simulates the grapple point on an object such as a satellite.)

Evaluation

1. What makes this device better than a gripper?
2. What does it mean to grapple something?
3. Why is it important for astronauts to be able to grab satellites in orbit?
4. **Going Beyond.** Design, build, and test a grapple device like the one in this activity that would fit on a robot arm in your school.
5. **Going Beyond.** Research other types of end effectors. Make a chart or a poster of various types and describe their uses.

Fig. A



CHAPTER 10

REVIEW &

CHAPTER SUMMARY

SECTION 1

- Automation is the automatic control of a process by a machine. We depend on automation in our homes, schools, and workplaces.

SECTION 2

- Mass production uses assembly lines, where products move past a worker who does a specific job.
- Automation has helped improve the efficiency of mass production in today's factories.

SECTION 3

- The Industrial Revolution marked the beginning of a need for efficient materials handling.
- Basic materials-handling equipment includes conveyors, trucks, containers, hoists, cranes, monorails, and computer-controlled systems.

SECTION 4

- Robots are highly advanced computer-controlled machines programmed to do special jobs that are often too dangerous or too boring for people to do.
- In factories, robots are helping to produce goods more efficiently and cost-effectively.

SECTION 5

- Specialized end effectors are made for robots to work with specific materials or to do certain jobs.
- Robots can be equipped with special sensors to help them have a sense of touch or hearing. Robotic vision helps them do jobs that are often too detailed for humans to carry out.

REVIEW QUESTIONS

1. Are any of the automated machines in your home or school robots? Explain.
2. How do assembly lines and automation affect the cost of many things you buy?
3. What kinds of materials-handling equipment might you see at a construction site?
4. What makes a robot different from an automated machine?
5. What kind of sensor might a robot have if its job was to pick up light bulbs and pack them?

CRITICAL THINKING

1. Design and build an easy method for adjusting the tension and tracking of a conveyor belt on the rollers.
2. Research how mass production in Japan is different from that in the United States.
3. Design a people-mover conveyor system that could help students move faster in your school.
4. Research the safety hazards of industrial robots.
5. Describe a factory that you think could run efficiently with only robot workers.